Water and Power Resources Service

RESUMED ORIGINAL NAME

BUREAU OF RECLAMATION

MAY 1981

Project Data

A Water Resources Technical Publication

UNITED STATES DEPARTMENT OF THE INTERIOR

WATER AND POWER RESOURCES SERVICE

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PROJECT DATA

1981

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FOREWORD

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resoures and works to assure that their development is in the best interests of all our people.

The importance of this Nation's water resources is more evident than ever before; it is the purpose of this edition of *Project Data* to add to the understanding of the effort which is being made to conserve and use beneficially this most vital national asset.

Although this book contains considerable statistical and technical material, it is also intended to inform the increasing number of persons in all walks of life who realize that reclamation and conservation of our natural resources such as water is a job for everyone.

PREFACE

This 1981 edition of Water and Power's *Project Data* introduces the change in organization name, announced on November 6, 1979, from the Bureau of Reclamation to the Water and Power Resources Service. The new name more closely identifies the agency with its principal functions—supplying water and power. As the text and drawings used in this publication were prepared prior to the adoption of the new name, all references to the Bureau of Reclamation, or any derivative thereof, are to be considered synonomous with the Water and Power Resources Service.

Compilations of this kind of information have been published beginning in 1941 under the title *Summarized Data on Federal Reclamation Projects* to 1966 as *Reclamation Project Data* (Supplemental). These publications have served the continuing need for historical, statistical, and technical information on the projects of the Water and Power Resources Service by legislators, State and Federal officials, water users, engineers, educators, students, and others, in foreign countries as well as the United States, who are concerned about water resource development.

As you read about these individual projects, most of which are located west of the 100th Meridian, you will quickly realize that the original statement by the Congress in the Reclamation Act of 1902, " the construction and maintenance of irrigation works for the storage, diversion, and development of waters for reclamation of arid and semiarid lands. ," has been expanded by the concept of multiple-purpose development. By applying this concept, the Service assures the Nation that maximum benefits are being derived today and will be in the future as we manage our water resources.

Today attention is focused on the Nation's energy needs and concern for the quality of our environment. These factors have become major considerations in the making of decisions on how our water resources are allocated to agriculture, municipalities and industries, the development of hydroelectric power, fish and wildlife enhancement, and recreation.

In this publication, Service projects, substantially complete and in operation, are reviewed in detail with considerable attention to history, costs, beneficiaries, engineering, and productivity. Newer projects in the early stages of construction, and projects which are authorized but not yet started, have been treated briefly and can be expected to be covered more fully in a future edition.

The names of projects and their chief features are sometimes changed. Names used during the planning and development stages of projects may later be changed by action of the Congress or upon review by the Board on Geographic Names. Statistical data are also subject to change. Dimensions of structures may change because of structural alterations. Reservoir capacities are subject to revision as a result of siltation studies. Changes are sometimes introduced because of different methods of measurement, or because of revised definitions.

The contributions of the individual projects to the Nation's economic strength and recreation resource, when combined, are of major importance. As of September 30, 1978, the Water and Power Resources Service had constructed storage and distribution facilities to serve 11.4 million acres of land with irrigation water.

Crops harvested on farms receiving water from the Service in 1978 were valued at $4,993 million, and cumulative harvest values since the first project crop report was made in 1906 total in excess of $63,661 million.

Municipal and industrial water, 524,000 million gallons of it from Service projects, was delivered to areas populated by 16.6 million people in 1978.

The 50 hydroelectric powerplants constructed and operated by the Service in 1978 had an installed capacity of 10.4 million kilowatts. Within the next 5 years, it is planned that uprating units at existing plants will provide an additional 1-million-kilowatt capacity. The hydroelectric energy totaling 40.6 billion kilowatt-hours generated in the 1978 fiscal year was sufficient to supply the residential needs of over 14 million people.

There were 281 recreation areas, including reservoirs and other facilities, on Service projects at the end of 1978. Recreational use of these areas increased during 1978 to a new record of 69.9 million visitor days. Copies of reprints of individual projects presented in this edition can be obtained by writing to: Water and Power Resources Service, Attn D-922, P O Box 25007, Denver CO 80225.

The Water and Power Resources Service also produces nontechnical and technical publications and maps on its work which are available to the public. These are included in two listings, "Publications for Distribution Without Charge" and "Publications for Sale" which may be obtained by writing to this same address.

We invite your request for these materials. Increasing the public concern and awareness on the role of the Nation's natural resources in our future prosperity and well-being is a responsibility of the Department of the Interior.

R. Keith Higginson

Commissioner,
Water and Power Resources Service

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Animas-La Plata Project
(Proposed)

Colorado: La Plata and Montezuma Counties
New Mexico: San Juan County

Upper Colorado Region
Water and Power Resources Service

The Animas La Plata Project, located in southwest Colorado and northwest New Mexico, would develop water from the Animas and La Plata Rivers to provide 118,100 acre-feet for over 70,000 acres of land and 80,100 acre-feet for municipal and industrial uses. Water would be provided to non-Indians and to the Southern Ute, Ute Mountain Ute, and Navajo Indian Tribes in both States. Fisheries would be created and recreation facilities provided at both Ridges Basin and Southern Ute Reservoirs.

PLAN

The main storage feature, Ridges Basin Reservoir, would be located southwest of the city of Durango. The Durango Pumping Plant, south of Durango, would pump Animas River water to Ridges Basin Reservoir and the stored water would be released, as required, back to the Animas River for Aztec, Farmington, and other potential municipal and industrial users in New Mexico. Ridges Basin Reservoir would store industrial and irrigation water for the Ute Mountain Ute Indian Tribe and water for Colorado irrigators, as well as municipal and industrial water for Durango and the surrounding communities. The Ridges Basin Pumping Plant, located on the western edge of the reservoir, would pump water from the reservoir into Dry Side Canal. Southern Ute Reservoir would store La Plata River flows diverted into the reservoir through the Southern Ute Diversion Dam and Canal. Water stored in Southern Ute Reservoir would be released for full and supplemental service lands in New Mexico and for municipal and industrial water needs of the Southern Ute Indian Tribe.

Ridges Basin Dam and Reservoir

Ridges Basin Dam, to be located southwest of the city of Durango on the Basin Creek, a tributary to the Animas River, would be an earthfill structure, 313 feet above streambed with a crest length of 1,600 feet and a crest width of 30 feet. Ridges Basin Reservoir would be the main storage feature of the project, with a total capacity of 280,040 acre-feet, an active capacity of 130,000 acre-feet, and inactive capacity of 150,040 acre-feet. The normal high water surface area would cover 2,270 acres at an elevation of 6964.0 feet.

Releases from the reservoir would be made in three ways: Part of the water would be released back into the Animas River and subsequently diverted for municipal and industrial use in New Mexico; water would be released also to a proposed treatment plant to be constructed at the reservoir by water users in the Durango area; other water supplies would be pumped from the reservoir into a project canal and conveyed to La Plata River drainage. The canal would convey water for irrigation in Colorado and New Mexico, and for municipal and industrial uses by the Southern Ute and Ute Mountain Ute Indian Tribes.

Southern Ute Dam and Reservoir

Southern Ute Dam, located offstream near the Colorado-New Mexico State line, would be an earthfill structure 170 feet above streambed with a crest length of 2,900 feet, and a crest width of 30 feet. The reservoir capacity would total 70,000 acre-feet, an active capacity of 40,000 acre-feet, and inactive capacity of 30,000 acre-feet.

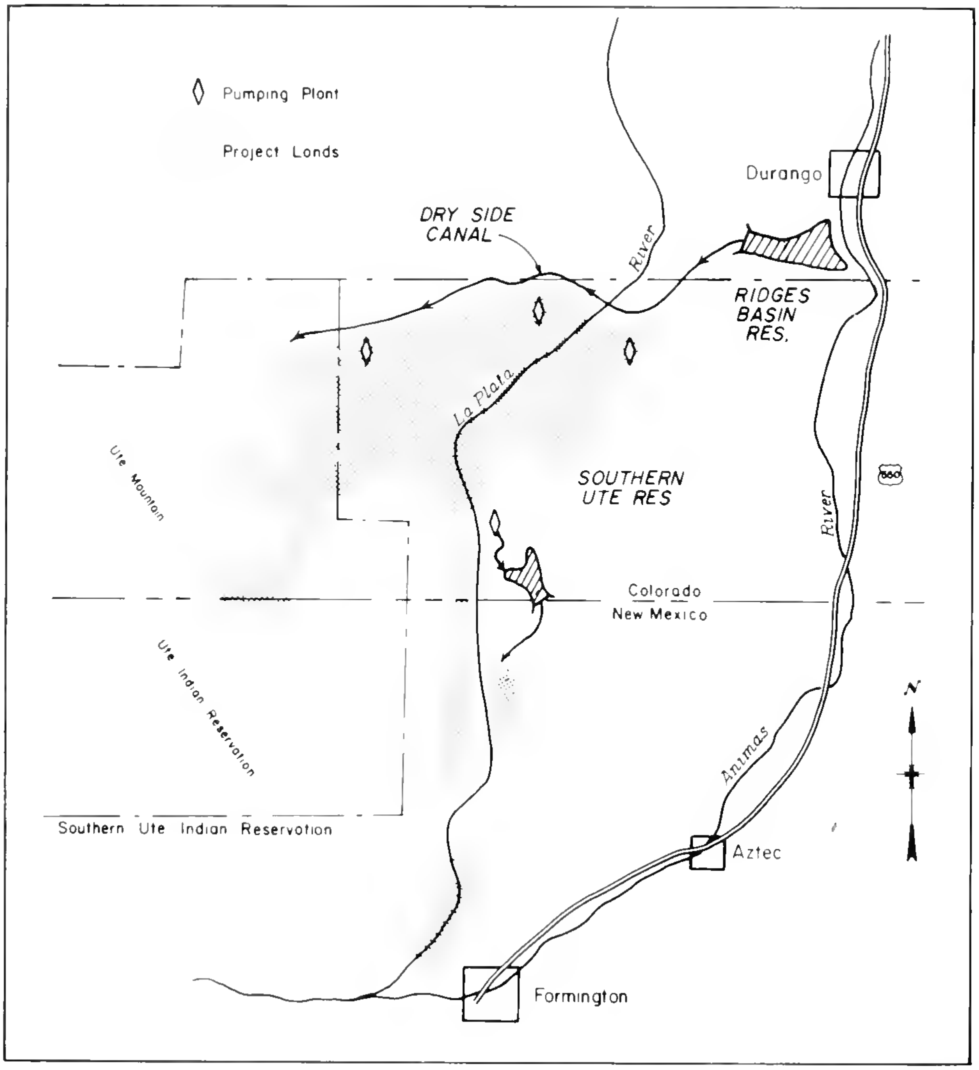
The normal high-water surface would cover 1,386 acres at an elevation of 6076.2 feet. The reservoir would store La Plata River floodflows, irrigation return flows, and releases from Dry Side Canal to La Plata River.

Durango Pumping Plant

The Durango Pumping Plant, south of Durango, would take water from the Animas River and pump it to Ridges Basin Reservoir through the Ridges Basin Inlet Conduit.

Ridges Basin Pumping Plant

Located on the western edge of Ridges Basin Reservoir, Ridges Basin Pumping Plant would pump water from the reservoir into the Dry Side Canal for irrigation, municipal and industrial uses, and for supplemental flows to the Southern Ute Reservoir. Other pumping



Animas-La Plata Project

Ridges Basin Reservoir Site

Southern Ute Dam Site

plants, which would provide pressure for sprinkler irrigation at farm turnouts where the ground slope cannot pressurize the pipeline, are the Red Mesa Pumping Plant, Alkali Gulch Pumping Plant, Ute Mountain Pumping Plant, Southern Ute Pumping Plant, and Third Terrace Pumping Plant.

Diversion Dams

Southern Ute Diversion Dam would have a diversion capacity of 375 cubic feet per second and would fill the Southern Ute Reservoir. La Plata Diversion Dam would have a diversion capacity of 150 cubic feet per second and would divert La Plata River water into the Dry Side Canal.

Canals, Conduits, Laterals

Ridges Basin Inlet Conduit, at a maximum capacity of 430 cubic feet per second, would convey Animas River water 2.1 miles into Ridges Basin Reservoir. The 27.5-mile-long Dry Side Canal would transport water onto Red Mesa, Dry Side, and Ute Mountain Ute full service and supplemental service lands. The canal's 710 cubic-foot-per-second initial capacity also would deliver municipal and industrial water to the Ute Mountain Ute Indian Tribe and to rural users in Colorado. Long Hollow Tunnel, part of the Dry Side Canal system, would be 3.2 miles long with a capacity of 710 cubic feet per second. The 3.3-mile-long Southern Ute Inlet Canal would convey La Plata River flows diverted by the Southern Ute Diversion Dam to land near the Colorado-New Mexico State line and to Southern Ute Reservoir. The 3-mile-long New Mexico Irrigation Canal would convey Southern Ute storage water to full and supplemental irrigation lands in New Mexico. Lateral systems, 198 miles long, would serve land along Dry Side Canal, and would vary in initial capacity from 45 to 174 cubic feet per second. The Durango Pipeline, to convey municipal and industrial water, would be 2.3 miles long with a capacity of 29 cubic feet per second.

The planned drainage system would total an estimated 66 miles.

DEVELOPMENT

Early History

The initial push of settlers into the area derived from mining efforts in the San Juan Mountains north of the project area. By 1877, the San Juan silver rush was underway. The town of Durango was laid out by surveyors of the Denver and Rio Grande Railroad in September 1880, and Durango rapidly became the major railhead and supply center for the area.

Mining also brought the first settlers to the broad, grass-covered Mancos Valley. However, by 1881, when the small ranching and farming community was surveyed, much of the choice land already had been homesteaded. The Rio Grande Southern Railroad arrived in 1891, and Mancos quickly became an active cattle shipping center.

Settlement of parts of the Southern Ute Indian Reservation by non-Indians took place in 1899 on land allotments not taken by Ute families, under the terms of the reservation establishment.

Investigations

The earliest Bureau of Reclamation investigations of the Animas and La Plata Rivers date back to 1904. Feasibility investigations were initiated in 1955 and a report was completed in February 1962. In March 1966, a supplement to the feasibility report of 1962 was prepared to present a modified plan for additional municipal and industrial water. Advance planning studies were initiated in 1971 with funds contributed by the State of Colorado and local water user organizations. In 1974, advance planning studies were curtailed by the Office of Management and Budget pending a review of the project's effect on salinity increases to the Colorado River system. Congressional write-in funds resumed advance planning activities.

Authorization

The project was authorized under the Colorado River Basin Project Act of September 30, 1968 (Public Law 90-537).

Construction

Completion of advance planning studies and preconstruction activities are scheduled through fiscal year 1979. Construction could begin as soon thereafter as construction funds are appropriated. A construction period of 10 years will be required to build proposed facilities.

Operating Agencies

La Plata Water Conservancy District in Colorado and La Plata Conservancy District in New Mexico have been organized to serve as contractual and operating agencies for the project.

BENEFITS

Irrigation

The project would supply 118,100 acre-feet of irrigation water for over 70,000 acres of both Indian and non-Indian lands in southwest Colorado and northwest New Mexico.

Municipal and Industrial Water

The project would supply 80,100 acre-feet of municipal and industrial water to Durango and other rural users in Colorado, and to Aztec, Farmington, and other New Mexico communities.

Recreation and Fish and Wildlife

Recreation facilities would be provided at the Ridges Basin and Southern Ute Reservoirs for boating, fishing, hiking, and other recreational activities. Land will be purchased to replace land required for the reservoir areas and thereby lost to wildlife.

PROJECT DATA

Land Areas (1977)

Irrigable area	70,100	acres
Full service	48,620	acres
Supplemental service	21,480	acres
Number of irrigated farms	420	

Climatic Conditions

Annual precipitation	9-18	in
Temperature:		
Maximum	105	°F
Minimum	−35	°F
Average	43-50	°F
Growing season	140-157	days
Elevation of irrigable area	6500-7200.0	ft

ENGINEERING DATA

Water Supply

Animas River

Drainage area at Durango	758	mi²
Annual discharge:		
Maximum (1941)	1,074,500	acre-ft
Minimum (1977)	208,100	acre-ft
Average	542,300	acre-ft

La Plata River

Drainage area at Hesperus	37	mi²
Annual discharge:		
Maximum (1941)	76,100	acre-ft
Minimum (1976)	6,700	acre-ft
Average	30,000	acre-ft

La Plata River

Drainage area at State line	331	mi²
Annual discharge:		
Maximum (1941)	92,500	acre-ft
Minimum (1976)	4,400	acre-ft
Average	22,800	acre-ft

Storage Facilities

Ridges Basin Dam

Type: Zoned earthfill
Location: 3 miles southwest of Durango.
Construction period: 6 years
Reservoir, Ridges Basin:

Average annual inflow	133,000	acre-ft
Total capacity to El. 6968	280,040	acre-ft
Active capacity to El. 6964	130,000	acre-ft
Surface area	2,270	acres
Dimensions:		
Structural height	313	ft
Hydraulic height (at maximum water surface)	306	ft
Top width	30	ft
Maximum base width	1,650	ft
Crest length	1,600	ft
Volume	7,620,000	yd³
Spillway: Emergency spillway, 100 ft, excavated to El. 6968.		
Outlet works: Capacity at El. 6968	2,160	ft³/s

Southern Ute Dam

Type: Zoned earthfill
Location: Offstream near Colorado-New Mexico State line.
Construction period: 5 years
Reservoir, Southern Ute:

Average annual inflow	51,000	acre-ft
Total capacity to El. 6078.6	70,000	acre-ft
Active capacity to El. 6076.2	40,000	acre-ft
Surface area	1,386	acres
Dimensions:		
Structural height	170	ft
Hydraulic height	162.6	ft
Top width	30	ft
Maximum base width	1,010	ft
Crest length	2,900	ft
Volume	2,640,000	yd³
Spillway: None		
Outlet works: Capacity at El. 6078.6	730	ft³/s

Diversion Facilities

Southern Ute

Location: 700 ft west of Colorado Highway 140 at a point 2.8 mi north of Colorado-New Mexico State line.

Concrete spillway dimensions:		
Length	100	ft
Height at crest	9.5	ft
Crest elevation	6130.5	ft
Protective dike dimensions:		
Maximum height	8	ft
Width	16	ft
Earth dike extending 500 ft on left abutment and 200 ft on right abutment.		
Diversion capacity	375	ft³/s

La Plata

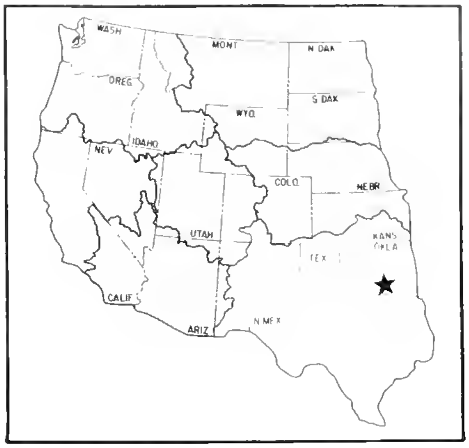
Location: 15 mi southwest of Durango.

Concrete spillway dimensions:		
Length	50	ft
Height	8.5	ft
Crest elevation	7194.5	ft
Protective dike dimensions:		
Maximum height	10	ft
Width	16	ft
Would extend 450 ft on both sides of the river at 30° angles.		
Settling basin dimensions:		
Length	1,000	ft
Width	75	ft
Depth	10	ft
Diversion capacity	150	ft³/s

Arbuckle Project

Oklahoma: Murray and Garvin Counties

Southwest Region
Water and Power Resources Service



The Arbuckle Project regulates flows of Rock Creek, a tributary of the Washita River in south-central Oklahoma. The project furnishes new or supplemental water supplies to Davis and Wynnewood, Okla., and to a major oil refinery near Wynnewood through project carriage facilities. Sulphur, Okla., also has a project water supply entitlement; however, conveyance facilities have not been constructed to serve that city. Municipal water also is furnished to Dougherty, Okla., and to the Ardmore Industrial Air Park near Ardmore, Okla., through conveyance facilities constructed by those entities. The project provides substantial flood control, fish and wildlife, and recreation benefits.

PLAN

Arbuckle Dam and Reservoir, called the Lake of the Arbuckles, are on Rock Creek, about 6 miles southwest of Sulphur, Okla. The regulated flows of Rock Creek are delivered to Davis, Wynnewood, and the oil refinery from the reservoir by the project aqueduct system through 17.9 miles of pipeline and one pumping plant.

Arbuckle Dam and Lake of the Arbuckles

The regulated flows are delivered also to the Ardmore Industrial Air Park through a pipeline constructed by the city of Ardmore, which plans to construct additional pipelines and treatment facilities for more efficient use of its water allocation. Two small pipelines deliver water from Arbuckle Dam to Dougherty and rural users.

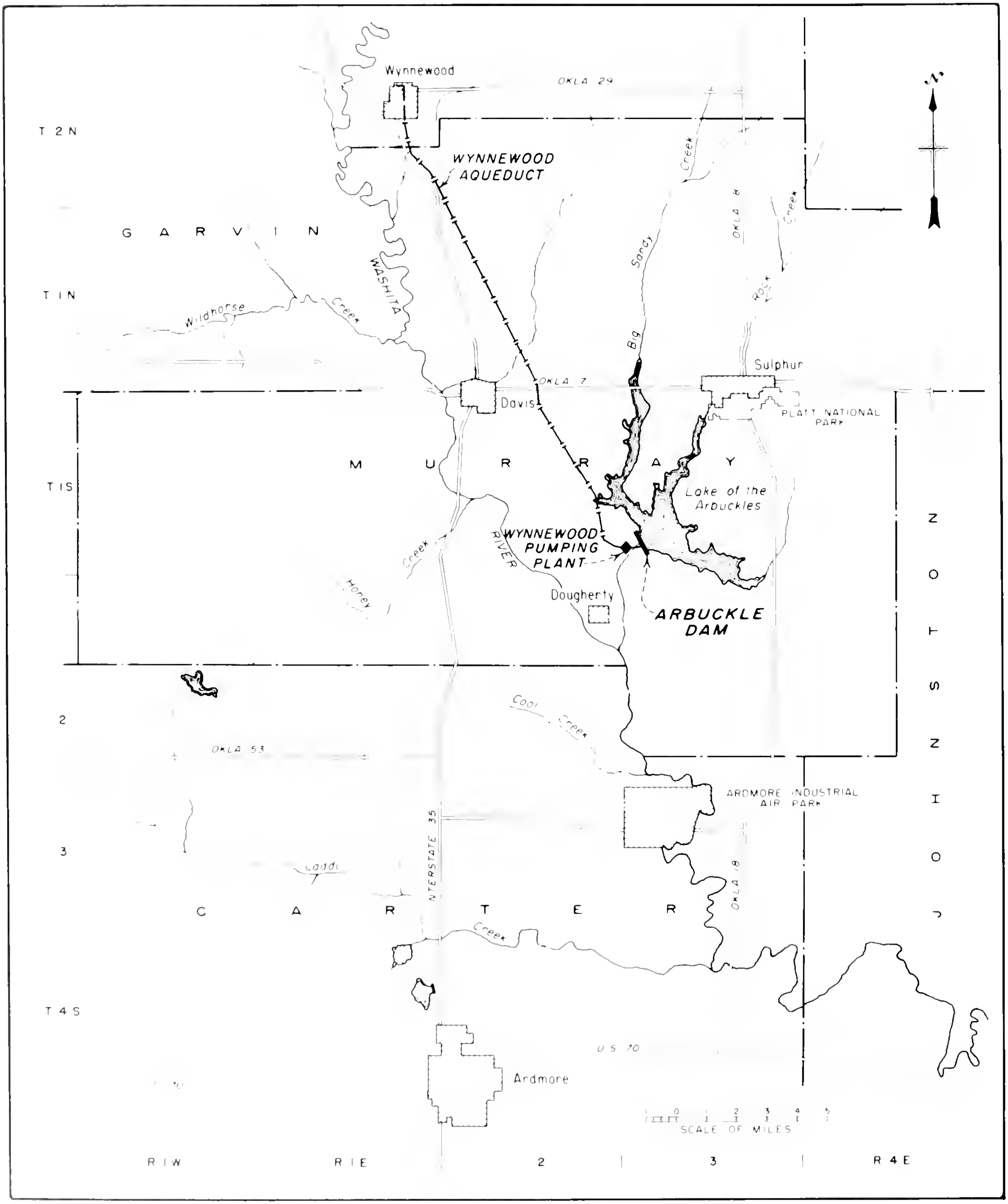
Arbuckle Dam and Reservoir

Arbuckle Dam is an earthfill structure having a structural height of 140 feet and a crest length of 1,890 feet. The volume of the dam and two dikes near its left abutment is 2,857,207 cubic yards.

The spillway consists of a morning-glory concrete inlet, concrete conduit, concrete chute and stilling basin, and an outlet channel which also serves the river outlet works. The river outlet works has a 7.5-foot-diameter upstream conduit, a gate chamber directly beneath the crest of the dam, and control gates that have a maximum design discharge of 2,340 cubic feet per second into a free-flow 9-foot-diameter flatbottom conduit and stilling basin. A municipal outlet works supplies domestic water.

The Lake of the Arbuckles has a total capacity of 108,839 acre-feet at elevation 885.3 and an active conservation capacity of 62,571 acre-feet at elevation 872.0. The surface area of the reservoir is 3,127 acres at elevation 885.3 and 2,346 acres at top of active conservation capacity, elevation 872.0.

In compliance with the State of Oklahoma, and for control of water quality in municipal water reservoirs, it was necessary to construct the Sulphur sewage effluent pumping plant and pipeline as a part of the project facilities to avoid possible contamination of water in storage at Arbuckle Dam. Before construction of Arbuckle Dam, effluent from the Sulphur sewage disposal plant drained into Rock Creek watershed. The pumping plant and disposal pipeline collect all effluent and convey it about 4 miles to the Dry Sandy Creek watershed. Operation and maintenance of the pumping plant and pipeline is a part of the dam and reservoir operation. The maximum capacity is 4 million gallons per day. The pumping plant



Arbuckle Project

is provided with three vertical turbine pumping units of equal rating. A chlorination station is provided for treating the effluent. The pipeline is 18-inch-diameter precast concrete approximately 4 miles long. Appurtenant structures include surge tank, air valves, blowoff structures, vent structures, and baffled outlet structure.

Wynnewood Pumping Plant and Pipeline

Wynnewood Pumping Plant is located just downstream from Arbuckle Dam. The pumps lift municipal water for delivery in the Wynnewood Aqueduct from the dam about 3.6 miles to the regulating reservoir. The regulating reservoir is a concrete-lined structure located on the high point of the aqueduct. Conveyance of water downstream of the regulating reservoir is by gravity.

Four pumping units are provided at Wynnewood Pumping Plant, with a rated unit capacity of 3.45 cubic feet per second. With one unit as a standby, the total capacity is 10.35 cubic feet per second. The pumping head range is 70 to 179 feet, depending on the storage elevation at the dam.

The Wynnewood Pumping Plant is unattended. A telemeter receives the water level from the regulating reservoir and automatically starts and stops pumps to maintain a water level in the regulating reservoir adequate to serve the turnout flow control stations.

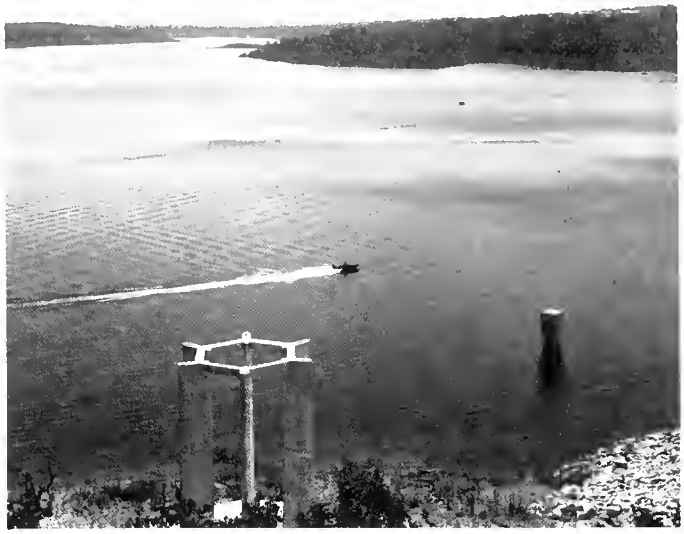
A 17.87-mile pipeline ranging from 10 to 27 inches in diameter conveys municipal water to Wynnewood. A turnout flow control station is provided at each turnout point to Davis, to the refinery, and at the Wynnewood terminal. A 580-foot lateral of 16-inch-diameter pipe is provided at the refinery turnout point.

Required appurtenant line structures, including a surge tank, air valve structures, manholes, blow-off structures, regulating tanks, and a chlorination plant are provided for the Wynnewood Aqueduct. The water at Wynnewood Pumping Plant is chlorinated only to the extent necessary to prevent algae and other growths from forming in the pipeline.

DEVELOPMENT

Early History

The first non-Indian settlements in the area were scattered trading posts and military posts. Fort Arbuckle was opened near Wildhorse Creek in Murray County in 1851. About 1865, the cattle industry became a factor in settlement of the area. Public lands in the territory were settled rapidly once they were opened to entry. The economy soon changed from the early cattle to a purely crop-based economy. A progressive lowering of the water table and deterioration in the quality of water withdrawn from the wells encouraged the local communities to seek supplemental water resources.



Lake of the Arbuckles

Investigations

The Arbuckle Project area has been the subject of investigations by various Federal, State, and local agencies since the mid-1930's. An inventory of land and water resources needs and problems of the Red River Basin was initiated by the Bureau of Reclamation in 1947. Increased use of municipal and industrial water by the communities in the project area, together with effects of the drought of the 1950's, caused a serious depletion of existing sources of water supplies in the cities and towns.

Early in 1956, local interests met with Reclamation representatives concerning potential development of the Arbuckle site. Members of the Oklahoma congressional delegation actively supported the Rock Creek Project and urged the Bureau of Reclamation to start investigations immediately. A reconnaissance investigation of the Arbuckle Project was initiated in 1956. Following review, the Southern Oklahoma Development Association adopted the report findings. The Bureau of Reclamation prepared a plan of development in 1961 and completed a definite plan report in 1963, which was revised in 1964.

Authorization

The Arbuckle Project was authorized by Public Law 87-594, approved August 24, 1962 (76 Stat. 395).

Construction

The contract for construction of Arbuckle Dam was awarded June 9, 1964, and was completed June 30, 1966. The contract for construction of the aqueduct and pumping plant was awarded August 27, 1965, and was essentially complete in August 1967. Minor contracts for final completion of construction at Arbuckle Dam and the Wynnewood Aqueduct and Pumping Plant were completed during 1967 and 1968. Operation and maintenance responsibility for the project was turned over to the Arbuckle Master Conservancy District on January 1, 1968.

BENEFITS

Municipal and Industrial Water

The municipal and industrial water needs of Davis, Wynnewood, Sulphur, Dougherty, and Ardmore, Okla., and a large oil refinery near Wynnewood are being served by operation of the completed Arbuckle Project.

The Lake of the Arbuckles provides for the future water requirements of project cities and the area industries.

Flood Control

Extensive flood control benefits are expected to accumulate as a result of project development. Early benefits have accrued by detention of floodflows in the Lake of the Arbuckles. After completion of Arbuckle Dam in June 1966, the Lake of the Arbuckles filled to the top of active conservation capacity for the first time on May 12, 1968, and flood control operations began.

Arbuckle Dam

On October 8, 1970, a heavy rainstorm flooded the city of Sulphur, upstream from the Lake of the Arbuckles. Flood inflow to the reservoir caused the water level to rise more than 12 feet in 8 hours and resulted in the first spill through the uncontrolled morning-glory spillway. Untold damages and possible loss of life were avoided by flood operations at Arbuckle Dam. Inflow to the reservoir following this storm, computed from increases in reservoir volume, exceeded 82,000 cubic feet per second.

Recreation and Fish and Wildlife

The Lake of the Arbuckles provides significant benefits in fish and wildlife and recreational uses. Located at the confluence of the Buckhorn, Guy Sandy, and Rock Creeks, the area presents unusual opportunities, combining recreational use with scenic, scientific, and historical values. The Arbuckle Mountains are the highest part of a large area of Precambrian granites and overlying sedimentary strata that were uplifted and deformed some 300 million years ago. Subsequent erosion has exposed features which make the area an outstanding laboratory for students of geology.

The Lake of the Arbuckles is one of the best fishing lakes in Oklahoma for catfish, perch, bass, and crappie. Protective coves are good for trotlines, the water is unusually clear, and trolling is popular. Since the primary need for withdrawal of water from the reservoir is for municipal and industrial water supplies, the lake is not subjected to drastic drawdowns during the summer months. The wildlife area is a habitat for turkey, deer, and small game birds. Hunting is allowed in season. Wildlife management includes over 1,100 acres of land and 60 acres of water surface.

The Lake of the Arbuckles has been a very popular recreation area since initial filling of the reservoir. During 1975-76, the annual visitation was over 200,000 visitor days, and watercraft use exceeded 24,000 boat days. There are 36 miles of shoreline and 2,346 acres of water surface at top of active conservation capacity, elevation 872.0. Land available for recreation adjacent to the reservoir includes some 3,400 acres. Recreation facilities include access roads, parking areas, campgrounds, trailer spaces, picnic areas, shelters, tables, public restrooms, drinking water, boat docks, ramps, and a swimming beach.

The National Park Service administers the recreation areas and the Oklahoma Department of Wildlife Conservation provides wildlife management.

ENGINEERING DATA

Water Supply

ROCK CREEK

Drainage area at Arbuckle damsite	126	mi²
Annual discharge:		
Maximum (1945)	228,800	acre-ft
Minimum (1956)	6,800	acre-ft
Average	67,600	acre-ft

Storage Facilities

ARBUCKLE DAM

Type: Zoned earthfill
Location: On Rock Creek about 6 mi southwest of Sulphur, Okla.
Construction period: 1964-66
Reservoir, Lake of the Arbuckles:
Storage in the reservoir is allocated as follows:

Dead capacity—Streambed to El. 800	779	acre-ft
Inactive capacity—El. 800 to 827	9,049	acre-ft
Active conservation capacity—El. 827 to 872	62,571	acre-ft
Exclusive flood control capacity—El. 872 to 885.3	36,440	acre-ft
Surcharge capacity—El. 885.3 to 911.2	123,185	acre-ft
Total capacity to El. 885.3	108,839	acre-ft
Surface area at El. 885.3	3,127	acres
Dimensions:		
Structural height	142	ft
Top width	30	ft
Maximum base width	780	ft
Crest length	1,890	ft
Crest elevation	920.0	ft
Volume[1]	2,857,267	yd³

Spillway: Morning-glory inlet, concrete conduit, concrete chute, stilling basin and outlet channel.

Capacity	3,410	ft³/s

Outlet works:
River outlet: Concrete conduit controlled by four 3- by 6.5-ft high-pressure gates.
Municipal outlet: Two-level concrete conduit controlled by two 2.75-ft-square high-pressure gates.

[1]Includes two dikes.

Carriage Facilities

WYNNEWOOD AQUEDUCT

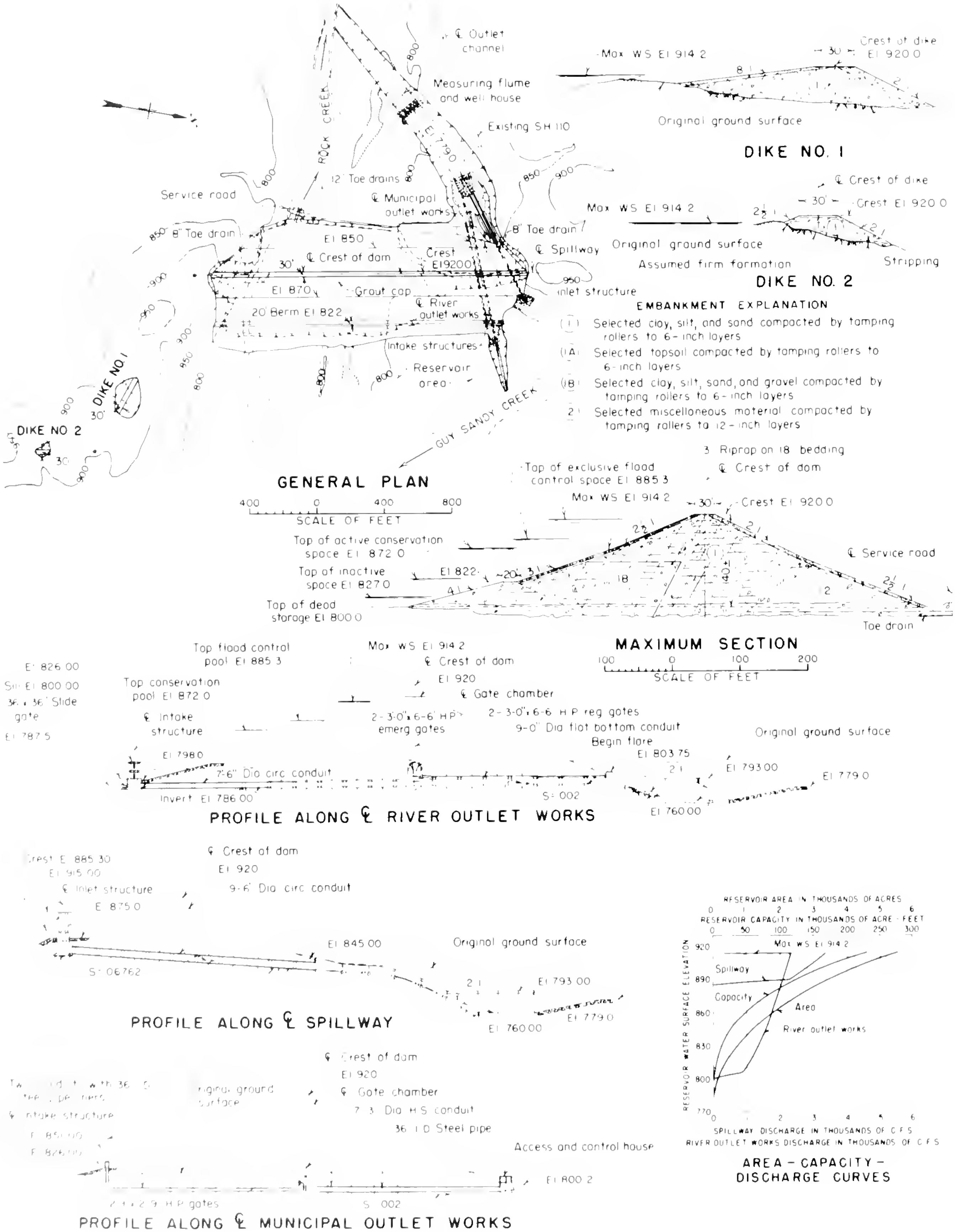
Length	17.87	mi
Diameter	10, 21, 24, 27	in

Type pipe: The 21-, 24-, and 27-in diameter pipe is concrete, mortar-lined steel pipe, reinforced concrete pressure pipe or pretensioned concrete. The 10-in-diameter pipe is asbestos cement.

WYNNEWOOD PUMPING PLANT

Designation	Number of units	Total capacity,[1] ft³/s	Total dynamic head, ft	Total horsepower
Wynnewood	4	10.35	179	500

[1]3 units at 3.45 ft³/s = 10.35 ft³/s
1 standby unit at 3.45 ft³/s

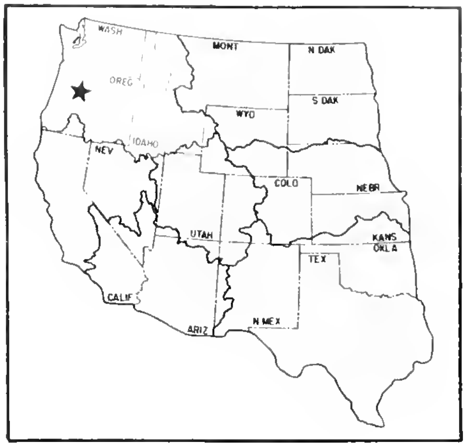


Arbuckle Dam, Plan and Sections

Arnold Project

Oregon: Deschutes County

Pacific Northwest Region
Water and Power Resources Service



The Arnold Project, originally a private development southeast of Bend, Oreg., diverts water from the Deschutes River a short distance above Lava Island Falls for 4,292 acres of irrigable land. Project features include Arnold Diversion Dam, Arnold Flume and Canal, and about 25 miles of laterals.

PLAN

Water is diverted from the Deschutes River by Arnold Diversion Dam, and is carried through the Arnold Flume and Canal in an eastward direction. Final delivery to the project lands is made through the lateral system. Storage is provided in Crane Prairie Reservoir.

Arnold Flume

Crane Prairie Dam

Crane Prairie Dam was constructed as a part of the Deschutes Project; data on the dam are given under that project.

Arnold Diversion Dam and Distribution System

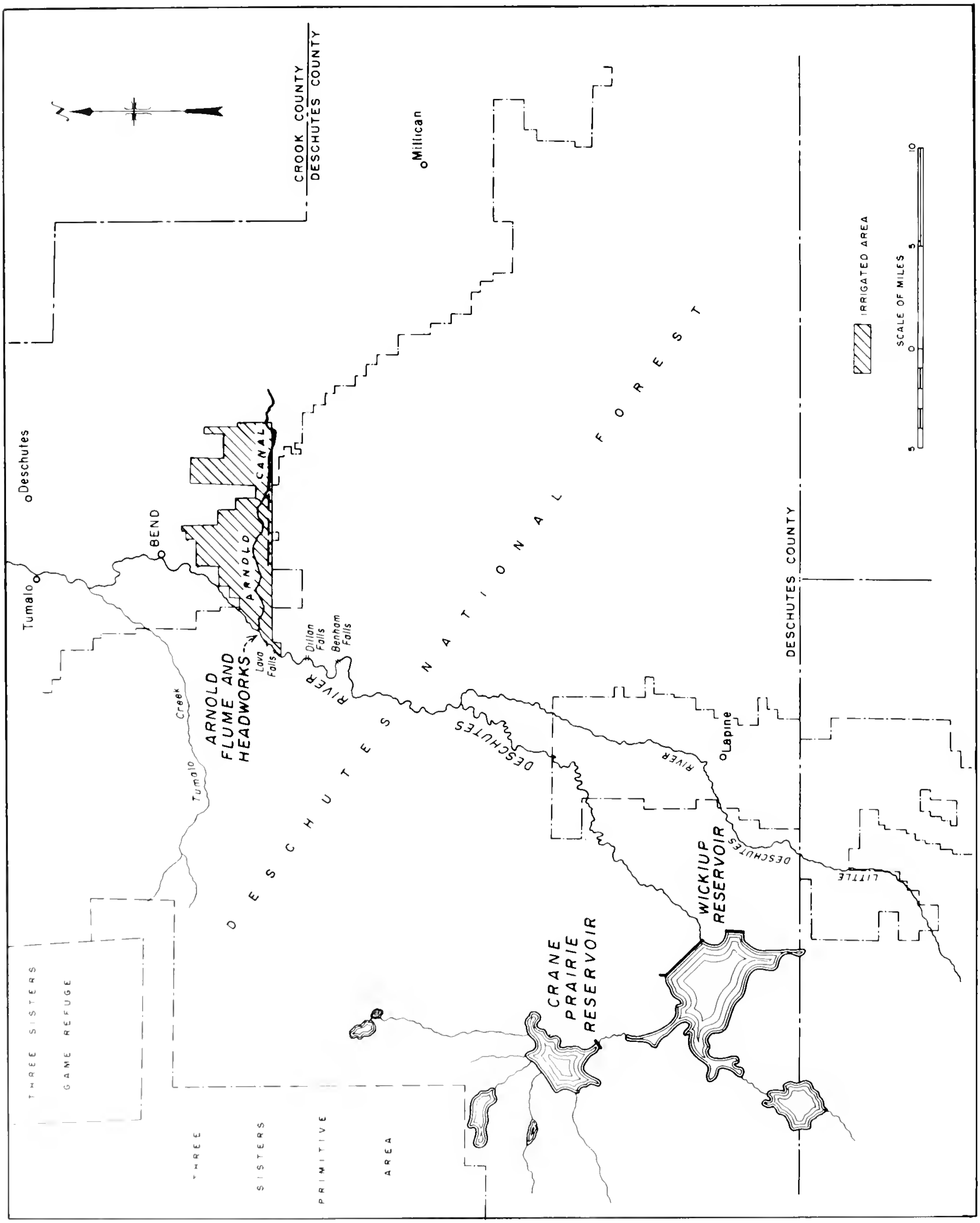
Arnold Diversion Dam is of the wing type, extending a short distance into the river from the east bank. The main structure of the distribution system is the 1-mile-long Arnold Flume. The original flume was made of wood, but was replaced with a semicircular steel flume and new concrete headworks by the Bureau of Reclamation. Two shorter wood-built flumes, the Suttong and O'Donnell, also were replaced. The Suttong Flume was replaced by 710 feet of pretensioned concrete pipe, and the O'Donnell Flume was replaced with a steel pipeline 265 feet long. The main Arnold Canal was originally 17 miles long, but since rehabilitation it has been reduced in length to about 11 miles. The canal has a capacity of 120 cubic feet per second at the diversion. Approximately 25 miles of laterals serve the project lands.

DEVELOPMENT

Early History

Irrigation in the Deschutes River Basin dates back to 1871 when individual farmers diverted water from Squaw Creek, a tributary of the Deschutes River. In 1895, construction of the Squaw Creek Canal was begun and, by 1905, the area had been developed by private interests to include the Swalley Canal, the Central Oregon Irrigation District canals, and the Arnold Canal.

The Arnold Irrigation Co. was organized in 1905, and by 1920 had consolidated with three other small irrigation companies, the Pine Forest Ditch Co., the Bend Co., and the North Irrigation Co. Since 1936, the group has been organized as the Arnold Irrigation District.



Arnold Project

Investigations

In 1934-35, the Bureau of Reclamation made a comprehensive study of all storage possibilities above the Crooked River, and published the results in the report upon which the Deschutes Project authorization was based. Meanwhile, local interests constructed a rockfilled timber crib dam at the Crane Prairie site and a diversion dam in the vicinity of Bend. The Crane Prairie Dam was later rebuilt by the Bureau of Reclamation as part of the Deschutes Project and now furnishes storage for the Arnold Project and for some units in the Deschutes Project. As most of the structures in the Arnold distribution system were built of wood, replacement became necessary. By 1948, the largest flume on the main canal just below the intake was in danger of failure, threatening serious loss to irrigated crops throughout the entire district. The irrigation district asked the Bureau of Reclamation to help rehabilitate this flume.

Authorization

The Deschutes Project, which included a supplemental water supply in Crane Prairie Reservoir for the Arnold Irrigation District, was authorized by a finding of feasibility approved by the President on November 1, 1937. The rehabilitation of the Arnold Project distribution works was authorized by the Interior Department Appropriation Act, 1948 (61 Stat. 460, 474; July 25, 1947).

Construction

The Bureau of Reclamation replaced the old wood flume with a semicircular steel flume and installed new concrete headworks. This work was started in 1948 and completed in 1949. Repairs to the diversion dam were completed in 1951. Replacement of the Suttong Flume and rehabilitation of the O'Donnell Flume and Siphon were completed in 1962.

Operating Agency

The project is operated and maintained by the Arnold Irrigation District.

BENEFITS

The project produces grain, alfalfa, grass hay, and pasture as the principal crops.

Arnold Flume and Deschutes River

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	1,292	acres
Number of irrigated farms	55	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	2,286	72,252
1969	2,617	93,765
1970	2,575	93,735
1971	2,522	97,891
1972	2,383	98,201
1973	2,158	117,534
1974	2,247	129,211
1975	2,247	123,681
1976	1,742	124,827
1977	1,752	142,892

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	11	mi
Laterals	25	mi

Climatic Conditions

Annual precipitation	11	in
Temperature:		
Maximum	102	°F
Minimum	−24	°F
Mean	46	°F
Growing season	93	days
Elevation of irrigable area	3700-3900.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	181
Other water service[1]	1,749
Total	1,930

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

DESCHUTES RIVER

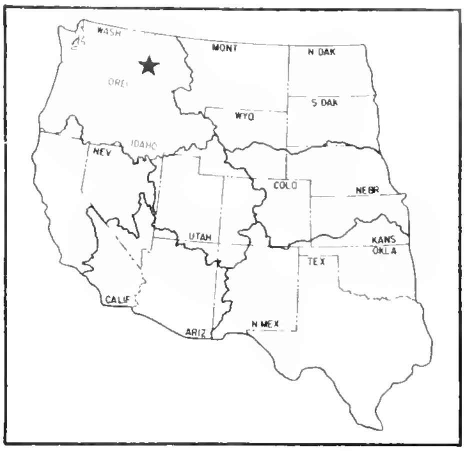
Drainage area above Crane Prairie Dam	251	mi²
Average annual inflow to reservoir	212,600	acre-ft
Maximum (1972)	313,400	acre-ft
Minimum (1968)	134,300	acre-ft
Average annual diversions by project[2]	25,410	acre-ft

[2]The Arnold Irrigation District has natural flow rights in the Deschutes River and Crane Prairie Reservoir as follows: The second 10,500 acre-ft and one-fifth of the first 15,000 acre-ft in excess of 30,000 acre-ft after Wickiup Reservoir has filled to 180,000 acre-ft.

Avondale Project

Idaho: Kootenai County

Pacific Northwest Region
Water and Power Resources Services



Rehabilitation of privately developed irrigation facilities on the 860-acre Avondale Project required the reconstruction of a pumping plant at the source of supply. Hayden Lake, and the construction of an elevated equalizing tank with a water main and distribution system for sprinkler irrigation. The water source is now three deep wells drilled by the irrigation district in lieu of Hayden Lake. Farming is on a part-time basis and subdividing continues since this is a popular resort area which also offers industrial employment.

PLAN

The water supply for the project had been pumped from Hayden Lake, which has a surface area of about 6 square miles and a surface elevation fluctuating between 2220.0 and 2242.0 feet. The lake has a drainage area of 62 square miles, with an average annual inflow of 45,000 acre-feet. Three small irrigation districts were using water from the lake, with the Avondale Irrigation District requiring an average of 1,200 acre-feet annually. There is no conflict in water rights among the irrigation districts using the Hayden Lake water, as the available supply exceeds the demand.

The reconstructed facilities, placed in operation in 1955, consisted of a pumphouse, two pumps, one 6,684-cubic-foot elevated steel equalizing reservoir, and 2,400 feet of 24-inch steel pipe for the main line, which delivered water to the distribution lines. Ninety-six irrigation turnouts were located so that a turnout was available for every 5 acres. An additional 12 zoning valves and 14 draining valves were installed for domestic water supply use.

The pumphouse, on Hayden Lake about 0.25 mile east of the district lands, houses two 6.7-cubic-feet-per-second-capacity horizontal centrifugal-type pumps. The pumps are designed to operate against a total dynamic head of 215 feet. The discharge line is 24 inches in diameter and 450 feet long.

The Avondale Irrigation District now receives its water supply from three deep wells drilled in 1977. Two wells are 380 feet deep, 20 inches in diameter, and equipped with 350-horsepower pumps, each rated at 4.7 cubic feet per second. The third well is 405 feet deep, 16 inches in diameter, and has a 200-horsepower pump capable of producing 2.7 cubic feet per second. Total capacity of the three wells is 12.1 cubic feet per second. The new 7,700-foot-long discharge line of 18- and 20-inch pipe delivers water to the equalizing reservoir. These facilities, placed in operation in 1977, were constructed by the district and replaced the pumping facilities on Hayden Lake. The State of Idaho, by court decree, issued a mandate that the water level of Hayden Lake is not to fall below 2230.0 feet in elevation. This action was instrumental in the district's decision to develop a groundwater supply; however, the district is retaining the Hayden Lake pumping plant as a standby facility.

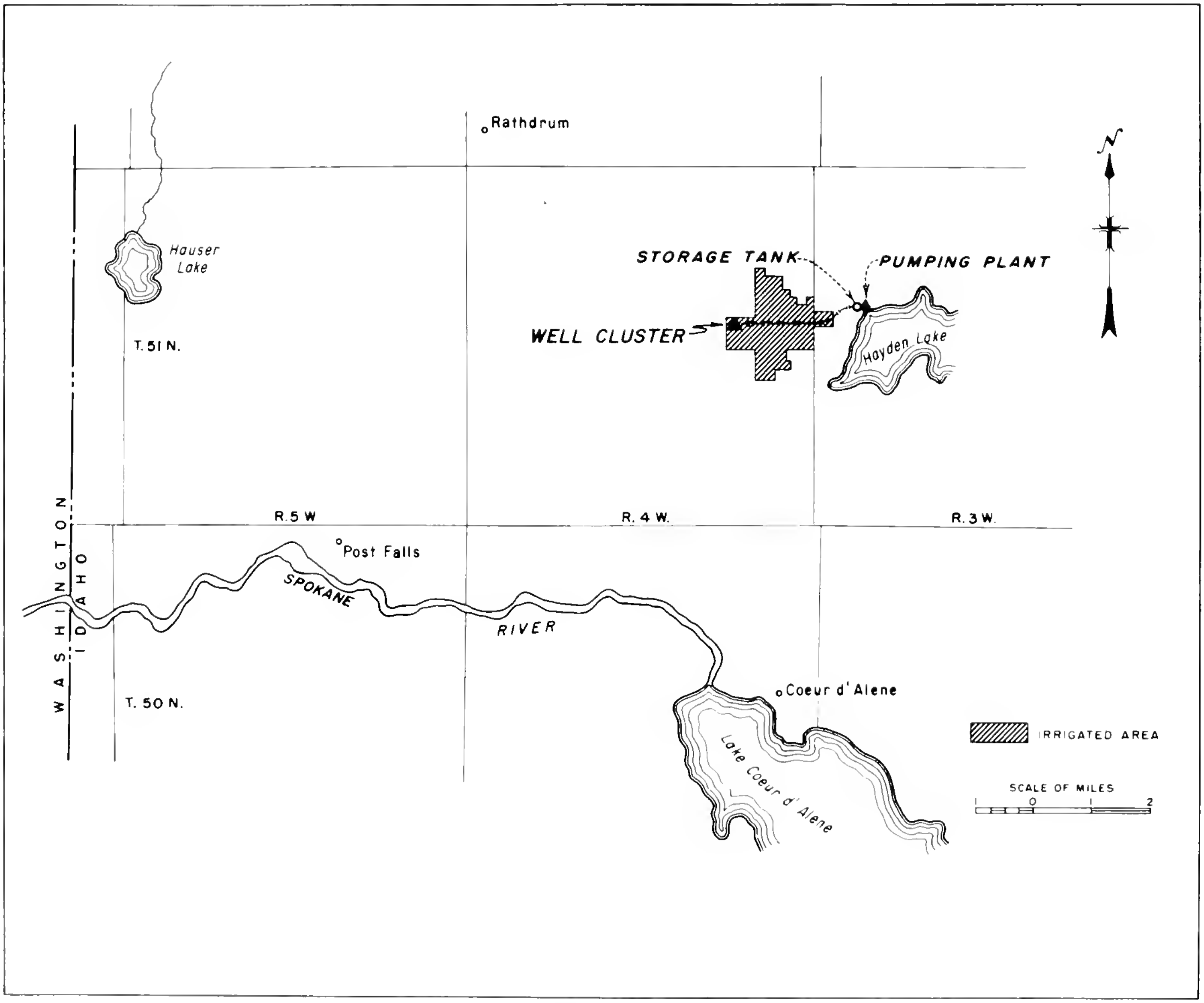
The reservoir is about 130 feet high and is equipped with automatic pump control facilities. The static head at the irrigation turnouts varies from 35 to 50 pounds per square inch, the pressure considered most desirable for sprinkler operation.

DEVELOPMENT

Early History

Logging, mining, and construction of the Northern Pacific Railroad brought settlers to the Hayden Lake area during the 1880's, expanding the market for local agricultural products. Although numerous irrigation schemes were promoted during the 1890's to stimulate land sales, little in the way of irrigation construction was accomplished until after 1900. The Avondale development was one of several small irrigation ventures undertaken by private interests in this vicinity during 1900-10. Like the others, it was developed as a fruit-raising area. The Avondale Unit originated in 1906 as the Avondale Stock Farms. It was organized in 1908 as the Avondale Irrigation Co., and a reorganization in 1912 established it as an irrigation district.

The original irrigated tracts consisted of 5 to 10 acres.



Avondale Project

Many of the tracts have been subdivided and resubdivided and only in a few instances have holdings been consolidated into ownerships exceeding 10 acres. Most of the tracts are now used as suburban residences or part-time farms.

Investigations

The original facilities, abandoned when the system was installed in 1954, consisted of a single pump having a capacity of 7 cubic feet per second, a 720-foot wood-stave, low-pressure discharge line connected to a concrete pipeline, three small low-head wooden storage tanks, and a low-pressure pipe distribution system. The pumping plant was installed at Hayden Lake in 1922 on the foundation of one installed in 1906.

Several plans for rehabilitation and betterment of the irrigation system were studied and submitted to the district's directors for selection of the most desirable plan to satisfy the needs of the water users.

The Avondale Irrigation District had been regarded by the Bureau of Reclamation as a possible unit of a much larger potential development known as the Rathdrum Prairie Project. The eastern divisions of this project consisted of three small irrigation districts that pumped their water supply from Hayden Lake—Avondale (860 acres), Dalton Gardens (979 acres), and Hayden Lake (1,577 acres). The appropriations act for fiscal year 1954 designated the Avondale and Dalton Gardens Projects for separate reconstruction.

During the 1953 irrigation season, frequent failure of the 50-year-old irrigation system brought an appeal for reconstruction assistance. Each district submitted a separate plan for reconstruction since a greater delay would ensue if applications were submitted concurrently.

Authorization

The Congress, through a provision in the Department of the Interior appropriations act for fiscal year 1954, authorized the Bureau of Reclamation to undertake the original rehabilitation. Authorization was dated July 31, 1953 (67 Stat. 261). Additional rehabilitation was authorized by the 1955 appropriation act of July 1, 1954 (68 Stat. 365). Further emergency pipe rehabilitation was authorized by act of September 22, 1961 (75 Stat. 588).

Construction

Rehabilitation of the irrigation works began July 22, 1954, and was completed June 10, 1955. Emergency pipe rehabilitation work began in 1962 and was completed in 1964. The three wells were drilled and pumps installed in 1977, with funds furnished by the irrigation district.

Operating Agency

Operation and maintenance is performed by the Avondale Irrigation District.

BENEFITS

Irrigation

Although fruit production was the major enterprise during the early years of the Avondale irrigation venture, there has been a gradual shift to pasture and hay crops. Most of the farm units are operated on a part-time basis and are used to produce food for the family or as rural homesites.

Recreation

The Avondale Project lands are adjacent to a popular resort and recreation area along Hayden Lake. There are many permanent residences along the lakeshore. Several nearby lakes and streams offer excellent recreation opportunities which attract tourists from all over the United States and Canada.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	860	acres
Number of irrigated farms	87	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	588	55,880
1969	601	63,857
1970	528	70,861
1971	525	71,257
1972	520	74,186
1973	540	96,875
1974	431	78,000
1975	410	91,820
1976	405	105,910
1977	363	69,306

Facilities in Operation

Main supply line	2,400	ft
Laterals	15.5	mi
Pumping plants	2	
Irrigation wells	3	

Climatic Conditions

Annual precipitation	25.6	in
Temperature:		
Maximum	104	°F
Minimum	−26	°F
Mean	48	°F
Growing season	180	days
Elevation of irrigable area	2250-2300.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	450
Other water service[1]	1,400
Total	1,850

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

HAYDEN LAKE

Drainage area above Hayden Lake	62.3	mi²
Estimated average annual inflow to lake	45,000	acre-ft
Average annual diversions by project	1,200	acre-ft

Storage Facilities

EQUALIZING RESERVOIR

Type: 6,684-cubic-foot elevated steel tank
Location: Near Hayden Lake, about 5 mi north of Coeur d'Alene, Idaho.
Construction period: 1954-55

Carriage Facilities

PUMPING PLANT INTAKE PIPE, DISCHARGE LINE, AND MAIN SUPPLY LINE

Location: From Hayden Lake west to Avondale Irrigation District.
Description: 24-in steel pipe
Construction period: 1954-55

Length	3,150	ft
Capacity	13.4	ft^3/s

PUMPING PLANT—AVONDALE (GOVERNMENT RECONSTRUCTED)

Number of units	2	
Total capacity	13.4	ft^3/s
Total dynamic head	215	ft
Total horsepower	400	

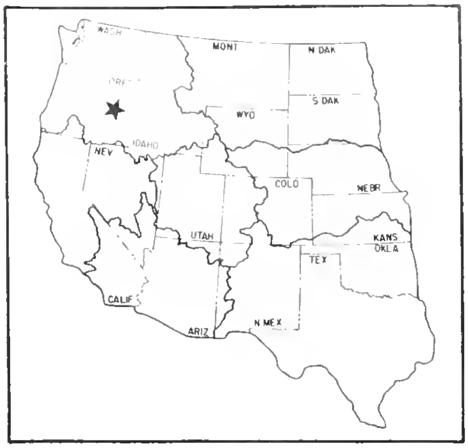
PUMPING PLANT (DISTRICT CONSTRUCTED, 1977)

Number of units	3	
Total capacity	12.1	ft^3/s
Total dynamic head	193	ft
Total horsepower	900	

Baker Project

Oregon: Baker and Union Counties

Pacific Northwest Region
Water and Power Resources Service



The Baker Project in east-central Oregon consists of two divisions, the Lower and the Upper. The Lower Division provides a supplemental water supply for about 7,300 acres along the Powder River about 10 miles northeast of Baker, Oreg. The Upper Division provides supplemental water for 18,500 acres, including some contiguous areas previously dry-farmed near the city of Baker.

PLAN

Lower Division

The irrigation supply for the Lower Division is stored by Thief Valley Dam, on the Powder River 16 miles north of Baker. Water from the reservoir is released into the river channel, from which it is diverted into the various canals of the district, some 8 miles downstream from the dam. All carriage and distribution facilities were privately constructed.

Thief Valley Dam is a reinforced concrete, slab and buttress (Ambursen) structure, 73 feet high and 390 feet long. Thief Valley Reservoir has a capacity of 17,600 acre-feet of water, and covers an area of 740 acres.

Upper Division

Facilities of the Upper Division furnish supplemental irrigation water to lands on both sides of the Powder River in Baker County, encompassing an area 7 miles wide and 16 miles long adjacent to and north of the city of Baker. Benefits include flood control, fish and wildlife, and recreation. Major features include Mason Dam, Phillips Lake, Lilley Pumping Plant, Lilley Relift Pumping Plant, and recreation facilities.

Mason Dam is a rolled-earth and rockfill structure 173 feet in height with a crest length of 895 feet. Phillips Lake, impounded behind the dam, covers 2,235 acres and has an active capacity of 90,500 acre-feet of water.

The main Lilley Pumping Plant, consisting of four vertical-shaft turbine-type pumps with a total capacity of 68 cubic feet per second, serves 3,450 acres with water.

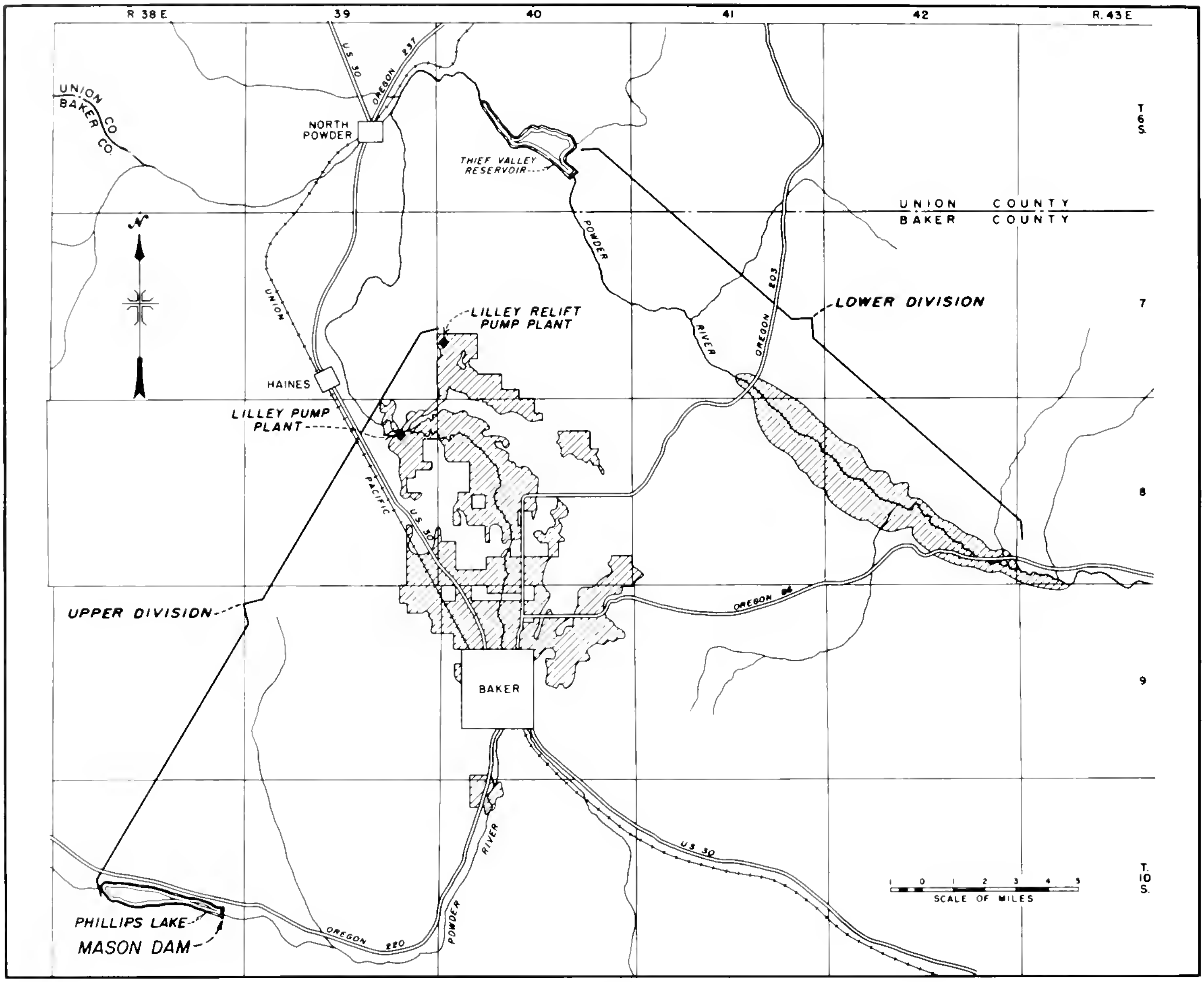
The Lilley Relift Plant has three vertical-shaft mixed-flow pumps totaling 34 cubic feet per second and capable of serving 670 acres.

DEVELOPMENT

Early History

The discovery of gold in Sumpter Valley in 1861 brought the first settlement of the area. Baker Valley attracted some of the homeseekers following the Oregon Trail toward western Oregon. Baker, situated where the old trail entered the valley, was first settled in 1863. Mining attracted many of the pioneers, but stockraising and farming were undertaken by others. Irrigation began in the 1870's, when farmers seeking to improve the native hay meadows made simple diversions from the streams. Construction of a railroad through Baker Valley in 1884 encouraged expansion of the livestock and lumbering industries.

Mason Dam



Baker Project

Investigations

The Lower Division of the Baker Project was first initiated as a Carey Act project by the Powder Valley Irrigation Company about 1909. After an inactive period of about 10 years, the Baker County Chamber of Commerce and a New York corporation sought the assistance of the Reclamation Service for investigations and studies. In 1921, the Director of Reclamation recommended that investigations of the Baker Project be undertaken. Surveys were begun in September 1921, resulting in a recommendation of the Thief Valley site for construction of a dam. The first phase of the project was approved in 1931.

The Upper Division had been under study since about 1930, with local interest and support continuing throughout the entire period. The present development of approximately 18,500 acres evolved from an earlier plan that contemplated a valley-wide irrigation district. This development, through storage of surplus flows, enhances and stabilizes the water supply for the lands in the Baker Valley Irrigation District, and provides the basis for and does not preclude future ultimate resource development of the basin.

Authorization

The Lower Division of the Baker Project was approved by the President on March 18, 1931. The Upper Division was approved by an act of Congress on September 27, 1962, (76 Stat. 634, Public Law 87-706).

Construction

Construction of the Thief Valley Dam of the Lower Division was started September 12, 1931, and completed on

May 6, 1932. Construction of Upper Division facilities started in 1965 and was completed in 1968.

Operating Agencies

The Lower Division is operated by the Lower Powder River Irrigation District and the Upper Division by the Baker Valley Irrigation District.

BENEFITS

Irrigation

Principal crops produced on both divisions are grain, alfalfa hay, grass hay, pasture, and some seed.

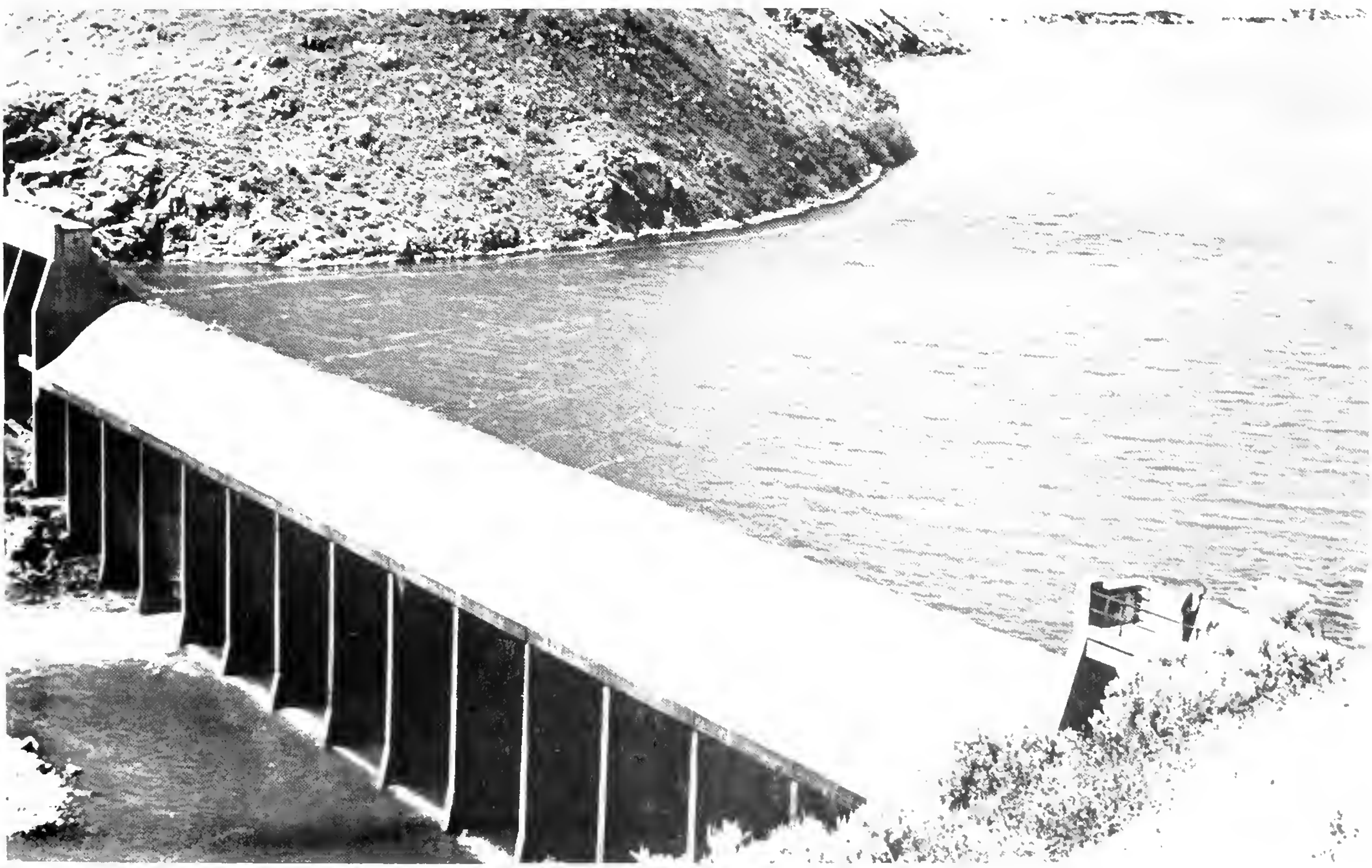
Flood Control

Nearly every year normal high water causes damage by inundation of some farm land in the Baker Valley. Less frequent but higher floodflows have caused considerable damage in the past to residential, municipal, and commercial property. Except for some of the lower-lying farm land, flood regulation is being accomplished through the use of 17,000 acre-feet of space in Phillips Lake assigned exclusively to flood control, and an additional 21,000 acre-feet assigned jointly to irrigation and flood control on a forecast of runoff basis.

Recreation and Fish and Wildlife

Most of the 909 acres of the Thief Valley Reservoir area are inundated, with 740 acres of water surface providing about 10 miles of shoreline. A portion of the reservoir area has been set aside for recreational use. Camping, picnicking, and boat launching and mooring facilities have been constructed. Union County administers this site. The reservoir has developed a reputation for excellent fishing for trout, largemouth bass, and black crappie which have been planted in the reservoir. Large numbers of waterfowl use the reservoir, and ducks have established nests.

A total of 5,038 acres in the Phillips Lake area is available for recreational use. There are 2,235 acres of water surface and a shoreline stretching almost 13 miles. Recreation facilities for camping, picnicking, swimming, and boat launching and mooring have been constructed and are administered by the Forest Service. The reservoir is stocked annually with several species of trout. Many waterfowl rest at the reservoir during migration, especially Canada geese.



Thief Valley Dam

PROJECT DATA

Land Areas (1977)

Irrigable area (Lower Division):		
Supplemental irrigation service	7,281	acres
Irrigable area (Upper Division):		
Supplemental irrigation service	18,532	acres
Total	25,813	acres

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,230	389,720
1969	23,260	1,614,092
1970	24,056	1,491,880
1971	23,958	2,161,038
1972	24,046	2,103,028
1973	24,216	3,141,615
1974	24,761	3,712,105
1975	25,258	3,763,377
1976	24,302	4,401,352
1977	24,454	3,114,420

Climatic Conditions

Annual precipitation	10.5	in
Temperature:		
Maximum	102	°F
Minimum	−22	°F
Mean	46	°F
Growing season	134	days
Elevation of irrigable area	3300-3470.0	ft

ENGINEERING DATA

Water Supply

Powder River

Drainage area above Thief Valley Dam	910	mi²
Annual discharge:		
Maximum (1971)	269,700	acre-ft
Minimum (1977)	37,000	acre-ft
Average	177,500	acre-ft
Drainage area near Sumpter, 1,200 ft downstream from Mason Dam	170	mi²
Annual discharge:		
Maximum (1974)	156,300	acre-ft
Minimum (1977)	17,600	acre-ft
Average	87,700	acre-ft

Storage Facilities

Thief Valley Dam

Type: Concrete slab and buttress
Location: On the Powder River 16 mi north of Baker, Oreg.
Construction period: 1931-32
Date of first storage: April 2, 1932
Reservoir, Thief Valley:

Total capacity to El. 3133	17,600	acre-ft
Active capacity to El. 3133	17,400	acre-ft
Surface area	740	acres
Dimensions:		
Structural height	73	ft
Hydraulic height	48	ft
Top width	7	ft
Maximum base width	85	ft
Crest length	390	ft
Crest elevation	3143.0	ft
Volume	6,300	yd³

Spillway: Uncontrolled overflow section in dam.

Crest length	268	ft
Crest elevation	3133.0	ft
Capacity at El. 3143	35,000	ft³/s

Outlet works: Two openings through face of dam in overflow section, controlled by two 4.8- by 6-ft slide gates.

Capacity at El. 3143	2,440	ft³/s

Foundation: Quartzite overlain in the abutments with seamy fractured lava-rock. A 6-ft-wide fault zone near right abutment dips 50° toward left abutment and strikes nearly parallel with stream channel.
Special treatment: Grout curtain beneath upstream cutoff trench and grouting of springs in fault.

Mason Dam

Type: Rolled earth and rockfill
Location: On the Powder River 11 mi southwest of Baker, Oreg.
Construction period: 1965-68
Date of first storage: Nov. 3, 1967
Reservoir, Phillips Lake:

Total capacity to El. 4070.5	95,500	acre-ft
Active capacity to El. 4070.5	90,500	acre-ft
Surface area	2,235	acres
Dimensions:		
Structural height	173	ft
Hydraulic height	159	ft
Top width	35	ft
Maximum base width	875	ft
Crest length	895	ft
Crest elevation	4082.0	ft
Volume	894,794	yd³

Spillway: Reinforced concrete chute, 20 ft wide from ogee crest at El. 4070.5 to reinforced concrete stilling pool at base of dam.

Capacity at El. 4070.5	1,210	ft³/s

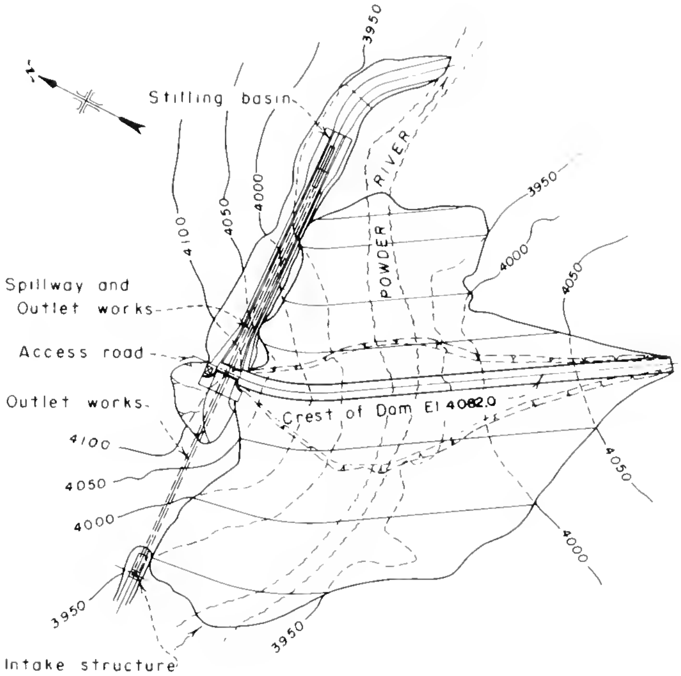
Outlet works: Controlled by two 2.75-ft pressure gates in the 56-in-diameter wyed steel outlet pipe, discharging into the downstream stilling pool.

Capacity at El. 4070.5	875	ft³/s

Carriage Facilities

Pumping Plants

Designation	Unit number	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Lilley Pumping Plant	1	22.28	101	350
	2	7.35	101	125
	3	15.60	101	250
	4	22.28	101	350
Lilley Relift Pumping Plant	1	9.80	35	60
	2	19.60	35	125
	3	4.90	35	30



GENERAL PLAN

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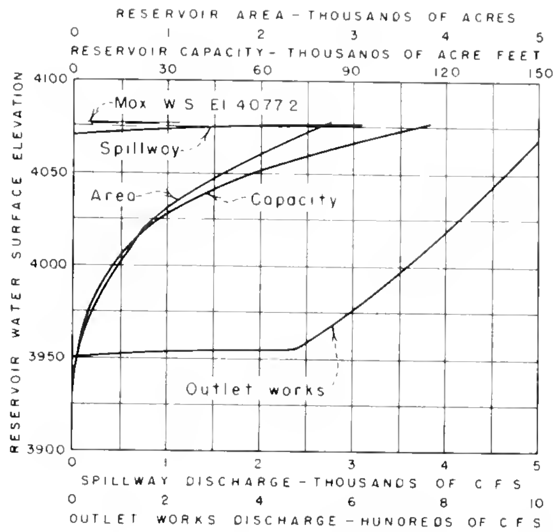
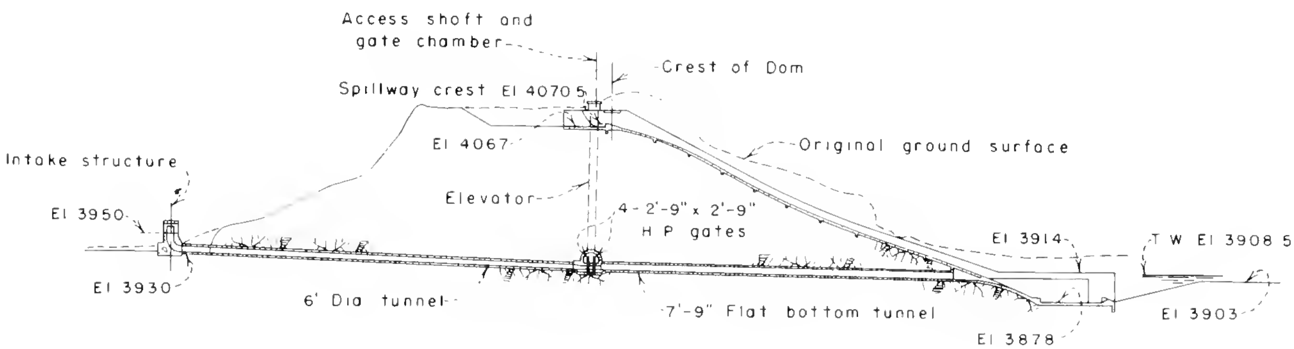
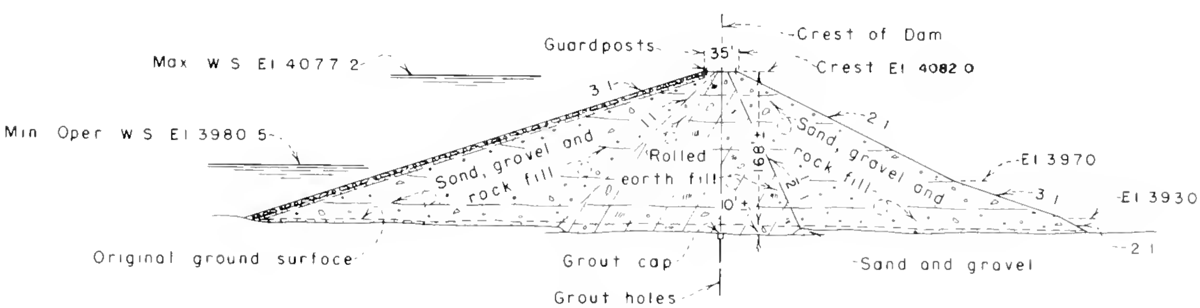
SCALE OF FEET



AREA – CAPACITY – DISCHARGE CURVES



PROFILE ON ℄ SPILLWAY AND OUTLET WORKS



MAXIMUM SECTION

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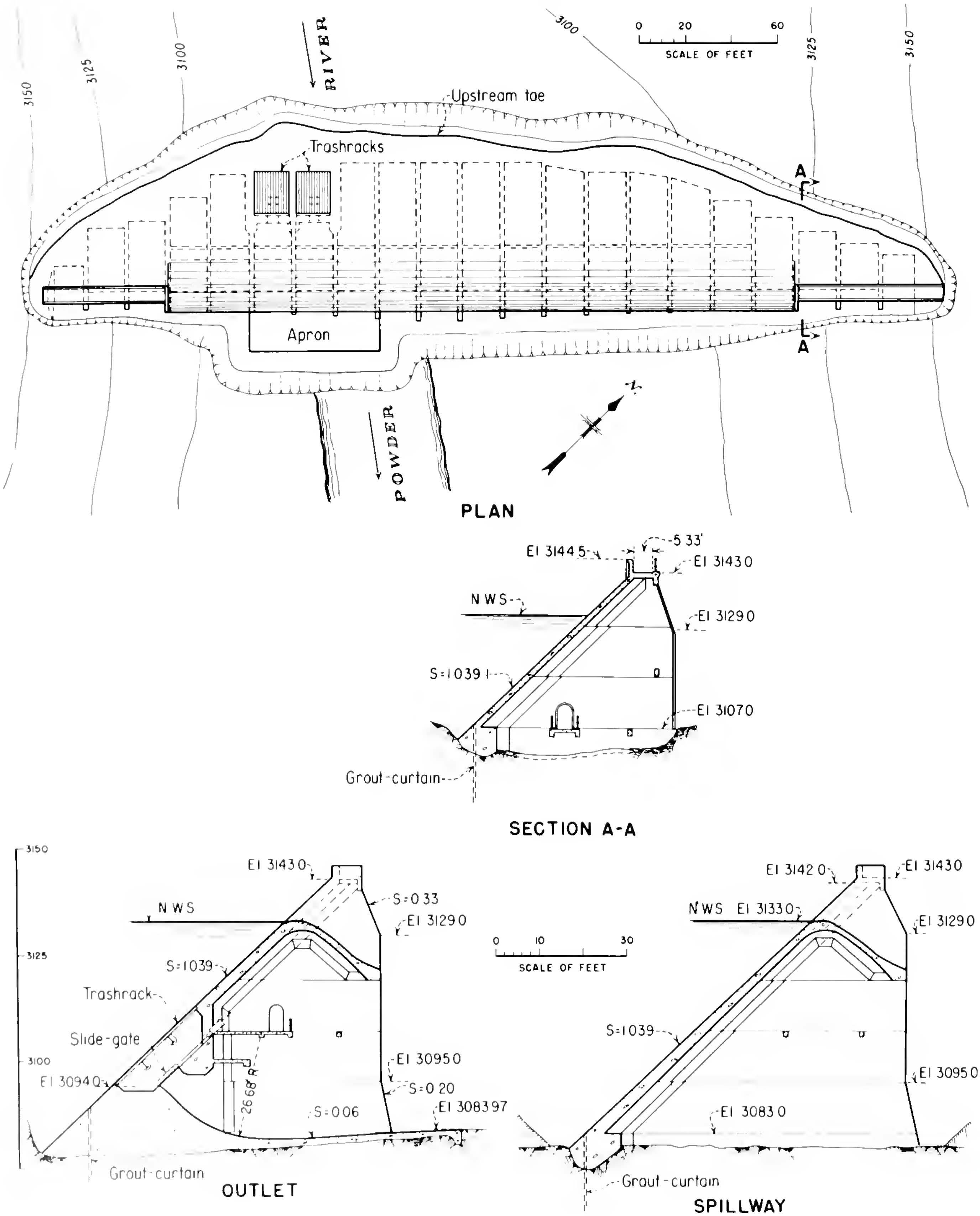
SCALE OF FEET

Mason Dam, Plan and Sections

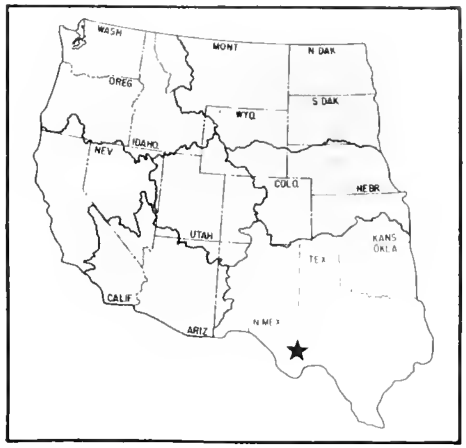


Thief Valley Dam, Plan and Sections

Balmorhea Project

Texas: Reeves County

Southwest Region
Water and Power Resources Service



The Balmorhea Project furnishes a supplemental irrigation water supply to about 10,600 acres extending 4 miles above and 11 miles below the town of Balmorhea, Tex. The land is on both sides of Toyah Creek, which flows northeasterly into the Pecos River. Originally developed by private interests, it has been reconstructed by the Bureau of Reclamation.

Project features include Phantom Lake Canal, which extends from Phantom Lake Spring to the District Main Canal in the vicinity of San Solomon Spring, the Inlet Feeder Canal from the Main Canal to the Lower Parks Reservoir, and the Madera Diversion Dam, which was built by private interests and repaired by the Bureau of Reclamation.

PLAN

Water rights to all flow from Phantom Lake Spring in excess of 3,337 acre-feet annually were purchased by the United States. Water from the spring is conveyed by a canal to the irrigation system of the Reeves County Water Improvement District No. 1. Storage of spring water is provided in the Lower Parks Reservoir, to which excess water is conveyed by the Inlet Feeder Canal. The rest of the distribution system was constructed by private organizations.

Phantom Lake Canal

The Phantom Lake Canal extends 4.2 miles from Phantom Lake Spring to the District Main Canal in the vicinity of San Solomon Spring. The canal is concrete lined and has a capacity of 25 cubic feet per second.

Inlet Feeder Canal

The Inlet Feeder Canal extends 2.8 miles from the main canal of the Reeves County Water Improvement District No. 1 to the Lower Parks Reservoir. This canal is concrete lined, and has a capacity of 100 cubic feet per second.

Madera Diversion Dam

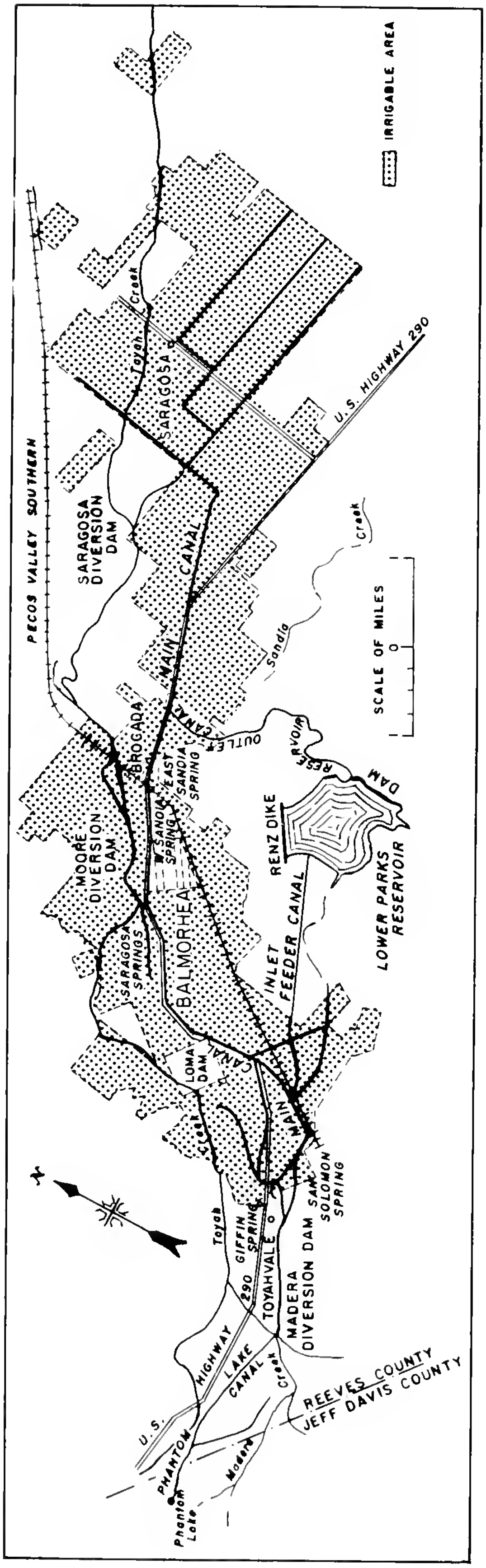
Repairs were made by the Bureau of Reclamation on this dam, which was built originally by local irrigators. The repairs included placing rubble mortar masonry near the right abutment, installing new gates on the headworks, replacing concrete paving and the stilling pool below the gates, channel grading above and below the dam, and constructing two dikes. The concrete weir dam is 13 feet high and has a crest length of 950 feet.

DEVELOPMENT

Early History

The project area is part of a broad expanse of plains intersected by widely separated mountain ranges and stream channels, most of which are dry for long periods every year. This region has been used almost entirely for production of cattle and sheep, but contains small irrigated areas that produce feeds for livestock.

Irrigation in the Madera Valley dates back to 1870 when vegetables and feed crops were produced for troops and livestock at nearby Fort Davis. After 1880, irrigation expanded rapidly, but reached its peak in 1909 when the area to be irrigated exceeded the water supply. In 1909, the Toyah Valley Irrigation Company was organized by consolidating several small, active canal systems. The local irrigators reorganized in 1914-15 under the name of the Reeves County Irrigation District, which was changed to the Reeves County Water Improvement District No. 1 in 1917. Local interests constructed the Lower Parks Reservoir in 1917. The Reeves County Water Improvement District No. 1 constrncted the Madera Diversion Dam across Madera Creek near Toyahvale to augment its water supply. The district's primary source of water is the San Solomon Spring and the smaller Griffen, Saragosa, and West Sandia Springs. The district also makes a small diversion at the Saragosa Diversion from Toyah Creek.



Balmorhea Project

Investigations

During World War II when food supplies became critical, the Bureau of Reclamation was requested to improve the water supply on the project lands to provide increased production. Investigations revealed that this could be accomplished in a relatively short time without the use of large quantities of critical materials.

Authorization

The project was authorized by the President on April 15, 1944, under the Water Conservation and Utilization Program (act of August 11, 1939, 53 Stat. 1418, as amended).

Construction

Reconstruction of the project was started in August 1946, and completed in 1947. The first water after rehabilitation was delivered on June 12, 1947.

Operating Agency

The project is operated by the Reeves County Water Improvement District No. 1.

BENEFITS

Irrigation

Principal crops are cotton, alfalfa, pasture, oats, and barley.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	10,608	acres
Number of irrigated farms	59	

Inlet Feeder Canal

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,927	832,727
1969	7,560	784,316
1970	7,213	750,741
1971	4,867	785,683
1972	5,946	677,773
1973	7,952	701,045
1974	6,800	734,146
1975	6,795	941,367
1976	5,905	646,351
1977	6,315	860,175

Climatic Conditions

Annual precipitation .... 9.1 in
Temperature:
Maximum .... 118 °F
Minimum .... −9 °F
Mean .... 66 °F
Growing season .... 230 days

Facilities in Operation

Storage dams[1] 1
Diversion dams[2] 2
Canals .... 7 mi

[1]Constructed by local irrigators.
[2]Madera Diversion Dam was rehabilitated by the Bureau of Reclamation.

Settlement

Number of persons served with project water (1977):
Farm irrigation service 500

ENGINEERING DATA

Water Supply

Water supply for the district is derived from the flow of San Solomon, Phantom Lake, and lesser springs and from floodflows of Madera and Toyah Creeks. Water not needed directly from spring flow is stored in the Lower Parks Reservoir.

Diversion Facilities

Madera Diversion Dam[3]

Type: Concrete weir with two earth dikes
Location: On Madera Creek near Toyahvale.
Year completed: 1914. Rehabilitated by Bureau of Reclamation 1947.

Dimensions:
Structural height .... 13 ft
Hydraulic height .... 13 ft
Crest length .... 950 ft
Crest elevation .... 3380.5 ft
Diversion capacity .... 750 ft³/s

[3]Constructed by local irrigators.

Carriage Facilities

Phantom Lake Canal

Location: Phantom Lake east to District Main Canal near San Solomon Spring.
Construction period: 1946-47
Length .... 4.2 mi
Capacity .... 25 ft³/s

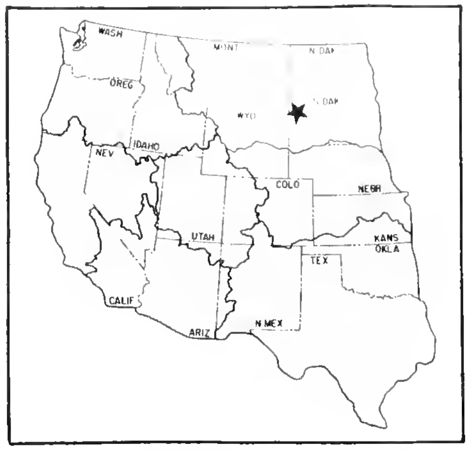
Inlet Feeder Canal

Location: From District Main Canal east to Lower Parks Reservoir.
Construction period: 1946-47
Length .... 2.8 mi
Capacity .... 100 ft³/s

Belle Fourche Project

South Dakota: Butte and Meade Counties

Upper Missouri Region
Water and Power Resources Service



Belle Fourche Project is located in western South Dakota northeast of the Black Hills. Principal structures include a diversion dam, storage dam, and a system of canals, laterals, and drains to irrigate 57,068 acres in the general area of Newell, Vale, and Nisland, S. Dak., along the valley of the Belle Fourche River. The project is a single-purpose development; however, flood control, fish and wildlife conservation, and recreation benefits are inherently provided.

PLAN

Water for irrigation is diverted from the Belle Fourche River and conveyed by means of the Inlet Canal to the Belle Fourche Reservoir for regulatory storage and delivery to the project lands. The Keyhole Unit of the Pick-Sloan Missouri Basin Program, consisting of Keyhole Dam and Reservoir on the Belle Fourche River in northeastern Wyoming, provides supplemental storage and a supply of irrigation water.

Belle Fourche Diversion Dam

The Belle Fourche Diversion Dam is on the Belle Fourche River about 1.5 miles northeast of the city of Belle Fourche, S. Dak. It has a concrete ogee weir 400 feet long, a structural height of 36 feet, and a 2,100-foot-long earth embankment on the right abutment.

Inlet Canal

The 6.5-mile Inlet Canal, with a capacity of 1,300 cubic feet per second, conveys water from the Belle Fourche Diversion Dam into off-channel regulatory reservoir storage in Belle Fourche Reservoir on Owl Creek behind the Belle Fourche Dam.

Belle Fourche Dam

Belle Fourche Dam (formerly Orman Dam), located about 10 miles northeast of Belle Fourche, is a homogeneous earthfill structure 6,262 feet long and 122 feet high. It was constructed across Owl Creek, an intermittent stream tributary to the Belle Fourche River. The act of October 27, 1974 (88 Stat. 1486), authorized modification of Belle Fourche Dam to include a new spillway and improvement of the upstream slope protection of the dam to ensure safety. The work was started during 1976 and completed in 1977.

The new earth-lined spillway has a discharge capacity of 4,500 cubic feet per second. It is located approximately 1 mile south of the right abutment of the dam.

The two controlled outlet works consist of two horseshoe-shaped conduits through the base of the dam, one each for the North and South Canals, with capacities of 600 and 300 cubic feet per second, respectively.

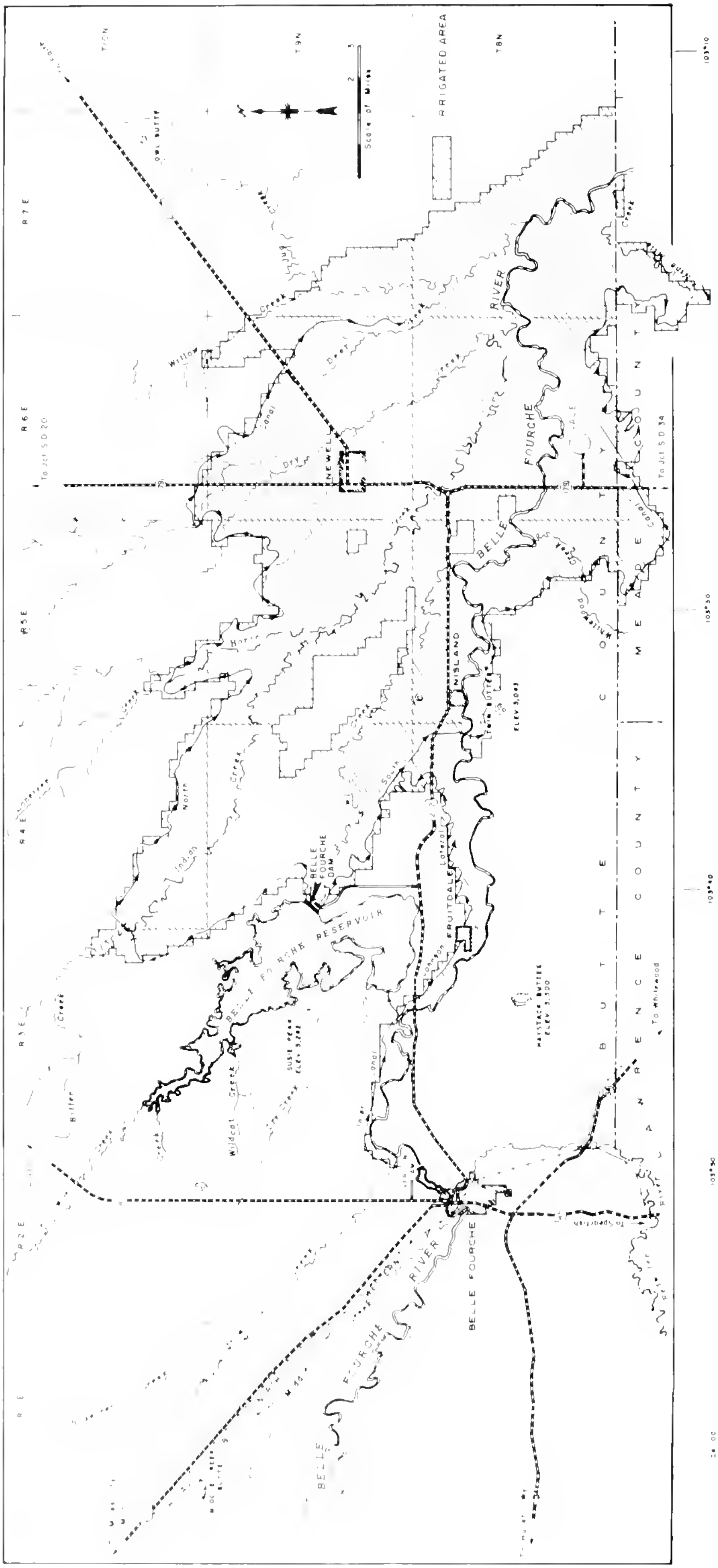
The dam forms Belle Fourche Reservoir which has an active conservation capacity of 185,200 acre-feet, and a water surface area of 8,000 acres. Dead storage is 6,800 acre-feet.

Supply, Distribution, and Drainage System

Supply, distribution, and drainage systems serving the irrigated lands consist of 94 miles of irrigation canals, 450 miles of irrigation laterals, and 232 miles of drains, including 7 miles of closed (pipe) drains.

Belle Fourche River Compact

A compact between the States of Wyoming and South Dakota, confirmed by the Congress of the United States in 1944, provides for the apportionment of Belle Fourche River waters upstream from the Wyoming-South Dakota boundary. This compact provides that the unappropriated flow of the Belle Fourche River shall be apportioned 10 percent to Wyoming and 90 percent to South Dakota, provided that Wyoming shall have unrestricted use of the water for domestic and stock purposes. The apportioned flow to South Dakota is the principal irrigation water source for the Belle Fourche Project.



Belle Fourche Project

Belle Fourche Dam

DEVELOPMENT

Early History

Belle Fourche, the name of the principal project town, means "Beautiful Forks" in French. The name has reference to the confluence of the Redwater and Belle Fourche Rivers. Frenchmen settled in this vicinity and reportedly engaged in fur trading with the Indians as early as 1854. The gold rush to the Black Hills in 1876 brought many people to the general area.

In the early days, raising livestock was the principal industry in the vicinity of the project. The Chicago and Northwestern Railway reached the town of Belle Fourche in 1891 and for the remainder of the century the town was considered to be the largest original shipping point for livestock in the United States.

Investigations

Survey of the Belle Fourche Project area for irrigation potential was initiated by the Reclamation Service in July 1903.

Authorization

The Secretary of the Interior authorized construction of the Belle Fourche Project on May 10, 1904, on the basis of the findings of the survey started in 1903.

Construction

Construction of the facilities for the Belle Fourche Project began in 1905 and had progressed sufficiently by 1908 to permit the delivery of irrigation water to 12,000 acres. The original project was completed in 1914. Some of the scheduled extensions of the original project were not constructed because of inadequate water supplies and adverse economic conditions.

Rehabilitation and Betterment

Rehabilitation and betterment construction was accomplished from 1950 to 1953. It consisted of replacement of the valves in outlet works of the dam, replacement of major structures in canals and laterals, and improvement of the drainage system.

Operating Agency

Belle Fourche Project, including Belle Fourche Diversion Dam, Belle Fourche Dam and Reservoir, and associated project facilities, is operated and maintained by the Belle Fourche Irrigation District at Newell, S. Dak. The Bureau of Reclamation operated and maintained the project prior to January 1, 1949, when the district assumed the responsibility.

BENEFITS

Irrigation

A full supply of irrigation water is provided to 57,068 acres of irrigable land. The principal irrigated crops grown on the project are alfalfa and corn. Other crops include barley, oats, and forage. Irrigated lands are dispersed throughout the project area and most farm units include both irrigated and dryfarmed lands.

Flood Control

There is no space in the Belle Fourche Reservoir allocated to flood storage; however, minimal flood control benefits are inherent in the overall operation by impounding floodflows in Owl Creek and diverting of water from Belle Fourche River as needed for the conservation storage.

Recreation

The primary recreation activity at Belle Fourche Reservoir is fishing, with limited boating and water skiing. Access roads, sanitary facilities, and boat ramp developments around the reservoir area and the reservoir fisheries are operated and maintained by the South Dakota Department of Wildlife, Parks and Forestry. There were 32,900 visitor days at Belle Fourche Reservoir in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable areas:		
Full irrigation service	57,068	acres
Number of irrigated farms	372	

Climatic Conditions

Annual precipitation	15.5	in
Temperature:		
Maximum	110	°F
Minimum	−38	°F
Mean	45	°F
Growing season	131	days
Elevation of irrigable area	2800.0	ft

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	53,598	2,855,203
1969	52,013	3,314,365
1970	51,616	2,709,941
1971	51,805	2,829,362
1972	51,267	3,751,536
1973	53,805	5,989,172
1974	54,450	8,431,816
1975	53,613	6,634,701
1976	54,181	8,780,885
1977	54,505	7,354,994

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	93.5	mi
Laterals	450	mi
Drains	232	mi

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,661
Municipal water service	1,385
Other water service[1]	164
Total	3,210

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

INLET CANAL FROM BELLE FOURCHE RIVER

Drainage area above inlet canal	4,310	mi²
Annual discharge through inlet canal:		
Maximum (1962)	173,600	acre-ft
Minimum (1961)	50,400	acre-ft
Average	116,600	acre-ft

OWL CREEK[2]

Drainage area	170	mi²
Annual discharge:		
Maximum (1941)	53,400	acre-ft
Minimum (1934)	3,500	acre-ft
Average	24,200	acre-ft

[2]Gaging station on Owl Creek is no longer in operation.

Storage Facilities

BELLE FOURCHE DAM

Type: Homogenous earthfill. Upstream face protected by rock riprap.
Location: On Owl Creek, 10 mi northeast of Belle Fourche.
Construction period: 1906-11
Date of closure (first storage): May 1910
Outlets modified in 1915, dam in 1931, 1939, and 1977.

Reservoir, Belle Fourche:

Average annual inflow	104,000	acre-ft
Total capacity to El. 2975	192,000	acre-ft
Active conservation capacity, El. 2927-2975	185,200	acre-ft
Surface area	8,000	acres

Dimensions:

Structural height	122	ft
Hydraulic height	91	ft
Top width	19	ft
Maximum base width	650	ft
Crest length	6,262	ft
Crest elevation	2990.0	ft
Total volume	1,783,000	yd^3

Spillway: Grass-lined channel with crest 7,000 ft south of right abutment discharging into series of channels and structures leading to Owl Creek.

Crest length	30	ft
Crest elevation	2977.4	ft
Capacity at El. 2984.4	4,500	ft^3/s

Outlet works: Horseshoe-shaped conduits through base of dam, one each for North and South Canals. North outlet is controlled by two 2.25- by 4.25-ft slide gates; South by one gate, same dimensions. Each control gate is backed up by an emergency gate.

Capacity at El. 2975	900	ft^3/s

Diversion Facilities

Belle Fourche Diversion Dam

Type: Concrete gravity ogee weir with flanking earth dikes
Location: On Belle Fourche River, 1.5 mi northeast of Belle Fourche, S. Dak.
Year completed: 1907
Dimensions:

Structural height	36	ft
Weir crest length	400	ft
Total length	2,523	ft
Weir crest elevation	2998.0	ft
Volume	35,700	yd^3
Diversion capacity	1,300	ft^3/s

Sluice gates: Three slide gates, each 5 by 10 ft.
Outlet works: Seven slide gates, each 5 by 10 ft.

Capacity	3,150	ft^3/s

Carriage Facilities

Inlet Canal

Location: Belle Fourche Diversion Dam generally east to Belle Fourche Reservoir.
Construction period: 1905-06

Length	6.5	mi
Diversion capacity	1,300	ft^3/s

Typical maximum section in earth:

Bottom width	40	ft
Side slopes	1:1	
Water depth	10	ft

North Canal

Location: From Belle Fourche Dam north about 5 mi, then generally southeast about 19 mi to vicinity of Newell, S. Dak.
Construction period: 1908-16

Length	43	mi
Initial capacity	600	ft^3/s

Typical maximum section in earth:

Bottom width	30	ft
Side slopes	2:1	
Water depth	5	ft

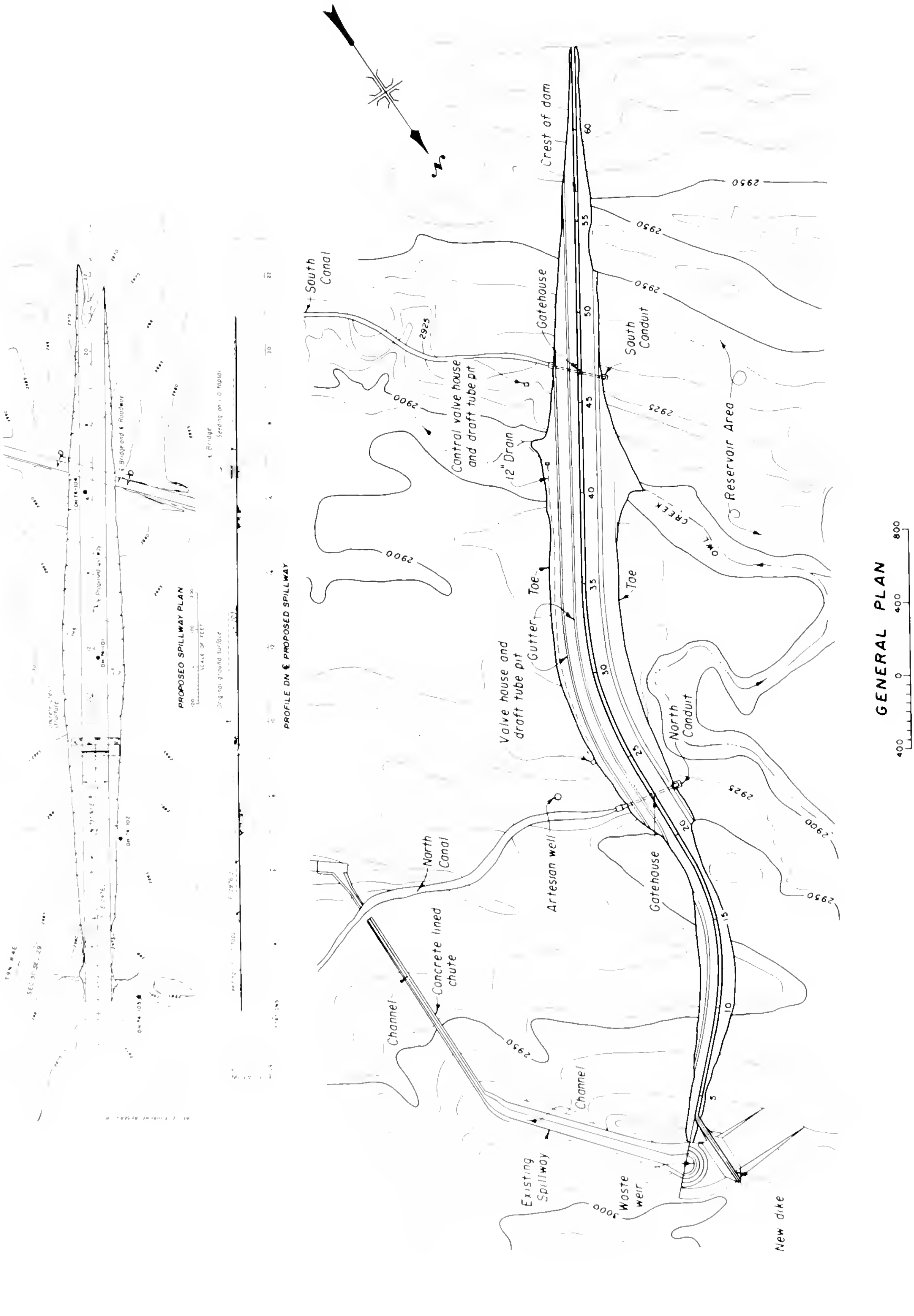
South Canal

Location: From Belle Fourche Reservoir generally southeast about 20 mi.
Construction period: 1906-10

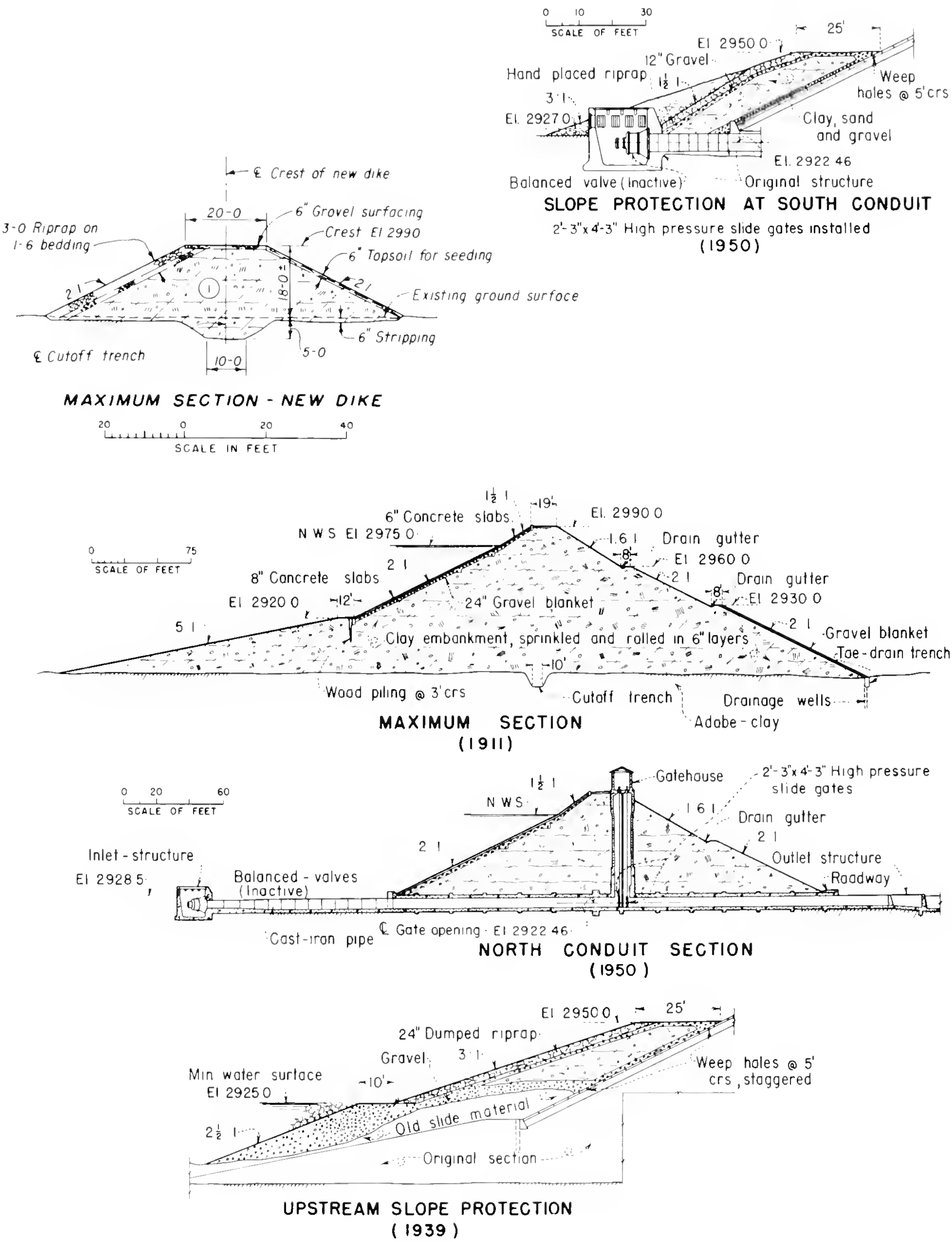
Length	44	mi
Initial capacity	325	ft^3/s

Typical maximum section in earth:

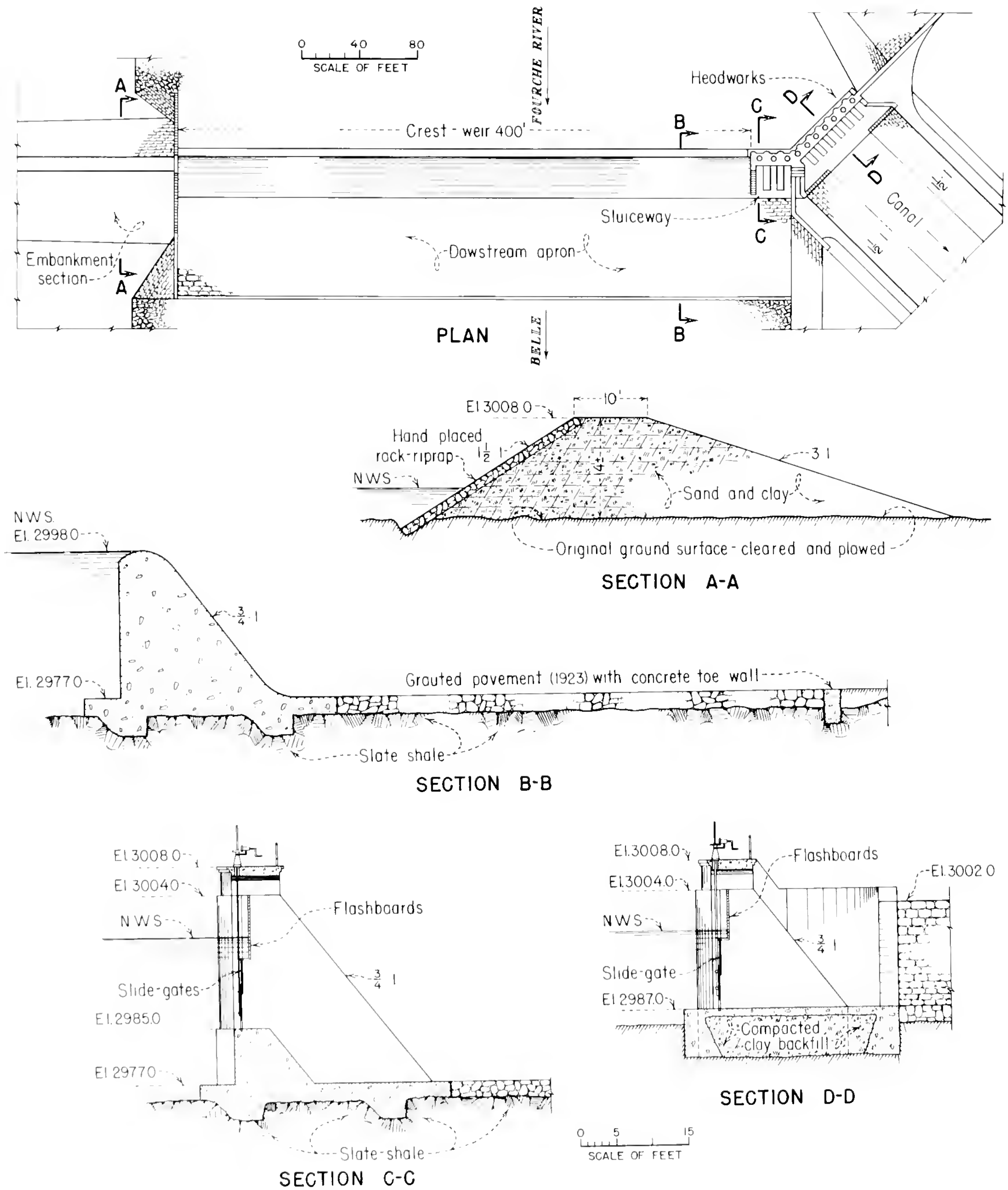
Bottom width	18	ft
Side slopes	1.5:1	
Water depth	5	ft



Belle Fourche Dam, Plan



Belle Fourche Dam, Sections

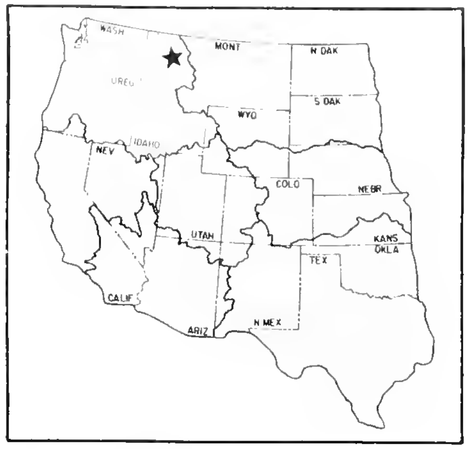


Belle Fourche Diversion Dam, Plan and Sections

Bitter Root Project

Montana: Ravalli County

Pacific Northwest Region
Water and Power Resources Service



Facilities to serve the land in the Bitter Root Project were constructed originally by private interests. The Bureau of Reclamation was authorized in 1930 to rehabilitate the irrigation system and to liquidate its indebtedness.

The project provides irrigation water for 16,665 acres of benchlands surrounding the town of Stevensville on the east side of the Bitterroot River[1] in west-central Montana. Project facilities include a storage dam and reservoir, a diversion dam, and a distribution system.

PLAN

Water is stored in Lake Como on Rock Creek, one of the west side tributaries of Bitterroot River. Rock Creek Diversion Dam, 1 mile below Lake Como, diverts water into the Bitter Root Irrigation District Canal. A feeder canal from Lost Horse Creek enters the main canal about a mile below the diversion dam, from which point the water flows northerly along the upper edge of the benchlands, generally parallel to and east of the Bitterroot River. The rehabilitated distribution system serves the project lands which lie between the canal and the river.

Como Dam

Completed in 1910 by local irrigators and rehabilitated on its crest and upstream face by the Bureau of Reclamation in 1954, this semihydraulic earthfill dam is 70 feet high and contains 1,114,000 cubic yards of earth and rock. In 1976, the district built concrete protection walls on each side of the spillway section up to elevation 4249.0, the same elevation as the crest of the dam. Under the Safety of Dams Program, designs for the walls were furnished to the district to correct low points in the dam fill adjacent to the spillway. The reservoir, Lake Como, is on Rock Creek about 5 miles northwest of Darby and 15 miles south of Hamilton, Mont. The total capacity of Lake Como is 36,900 acre-feet.

[1]The official name of the river is Bitterroot; the official name of the project and irrigation district is Bitter Root.

Diversion Dam and Canal System

Rock Creek Diversion Dam is a rockfill structure with timber sheet piling diaphragm and is 10.5 feet high. The canal has an initial capacity of 330 cubic feet per second and is 60 miles long. There is also a 7-mile-long feeder canal that diverts water from Lost Horse Creek and delivers it into the district canal about a mile below Rock Creek Diversion Dam. Extensive rehabilitation to the main canal, flumes, siphons, and distribution system was completed during 1963-67. On June 15, 1974, floods damaged Siphon No. 1 on the main canal and the supporting steel trestle crossing the Bitterroot River. The damage was repaired and water deliveries were resumed. Some 77 miles of laterals complete the distribution system.

DEVELOPMENT

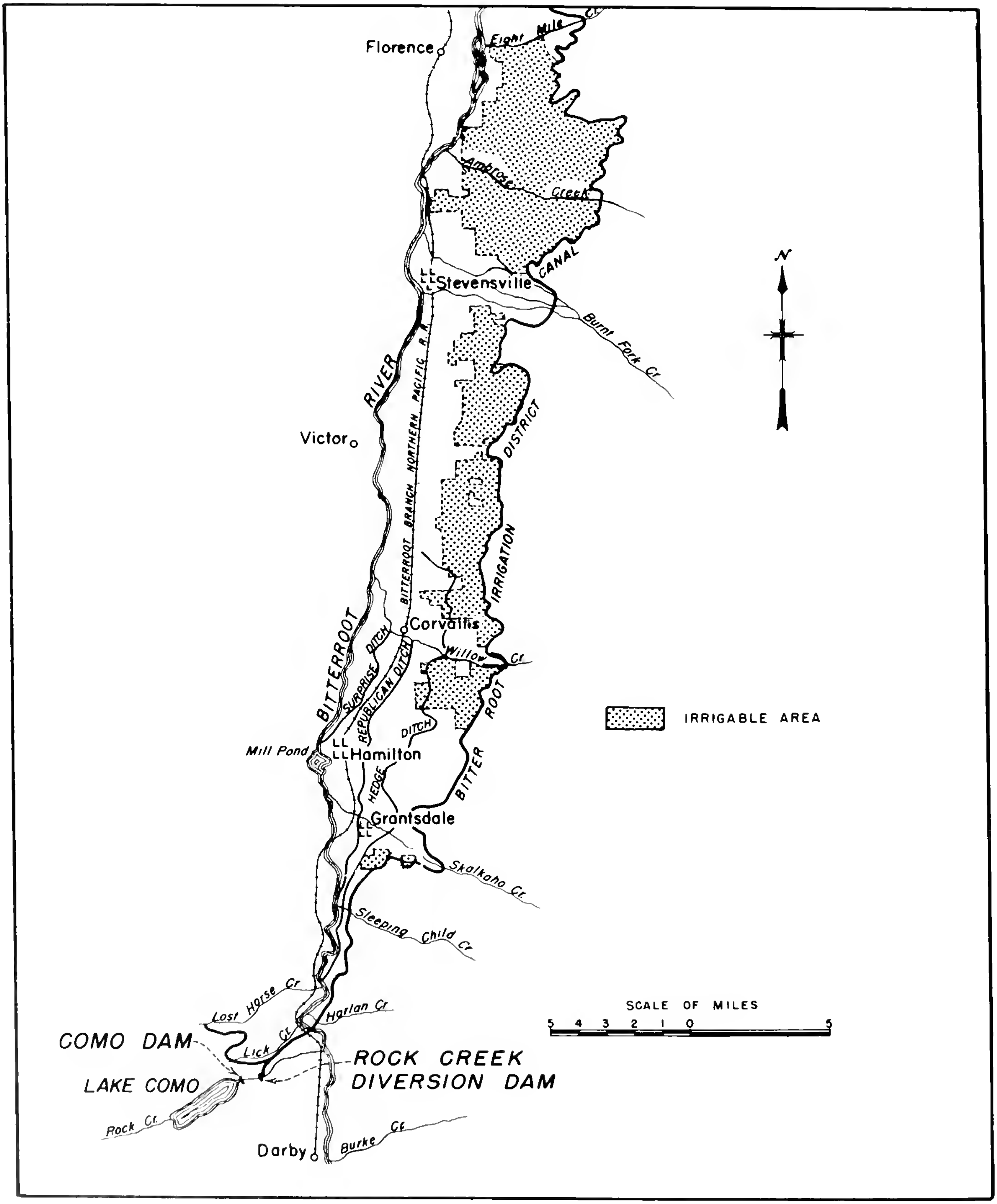
Early History

In 1805, when Lewis and Clark passed through the Bitterroot Valley, they found the Flathead Indians living there. In 1841, Catholic missionaries came to the valley and established St. Mary's Mission near the town of Stevensville. The missionaries were responsible for creating interest in the production of crops and livestock. Later, the development of mining, construction of the main line of the Northern Pacific Railway, and establishment of logging camps throughout nearby timber areas created a demand for agricultural products. A thriving community was well established by 1883.

By treaty dated July 16, 1855, and ratified on March 8, 1859, the Flathead Indians agreed to move from the Bitterroot Valley to the Jocko Valley. By passage of the act of June 5, 1872, the Congress provided for relocation of the Indians to the Jocko Reservation and for the survey and settlement of 15 townships in the Bitterroot Valley.

Investigations

Following the agreements with the Indians, the Bitterroot



Bitter Root Project

Como Dam and Lake

Valley experienced many stages of irrigation development which made use of Lake Como and involved rather large-scale construction on the east side of the valley.

In 1920, following a period of generally unsatisfactory irrigation promotion, financial maneuvering, and reorganization, the Bitter Root Irrigation District was formed in accordance with Montana law. In 1923, the district issued bonds to purchase water rights and storage and distribution works.

The district experienced difficulty in retiring its debts, and in 1930 the Congress authorized measures to be undertaken by the Bureau of Reclamation to liquidate the indebtedness, to rehabilitate the project structures, and to loan funds to the district for construction, betterment, or repair work necessary to place the project in good operating condition.

Authorization

Rehabilitation of the irrigation system of the Bitter Root Irrigation District and the liquidation of its private indebtedness were originally authorized by the act of July 3, 1930 (46 Stat. 852). Major rehabilitation of the project facilities was authorized under the Rehabilitation and Betterment Act of October 7, 1949 (63 Stat. 724). Flood damage in 1974 was repaired under the Emergency Fund Act of June 26, 1948 (62 Stat. 1052).

Construction

The project was originally constructed by the Bitter Root Valley Irrigation Company between 1908 and 1910; the Bureau of Reclamation rehabilitated the project beginning in 1930. Additional funds for rehabilitation work were provided in 1936, 1948, and 1956.

Extensive rehabilitation to the canal and distribution system was initiated in 1963 and completed in 1967. Using emergency funds provided by Reclamation, the flood damage of June 15, 1974, was repaired within a few weeks. This work was performed by a contractor hired by the irrigation district. In 1976, the district constructed protective walls on each side of the spillway section with its own funds.

Operating Agency

The Bitter Root Irrigation District maintains and operates the project.

BENEFITS

Irrigation

Principal crops produced are grain, hay, and pasture.

Recreation

Lake Como is in a beautiful setting in the Bitterroot National Forest. Cabin sites are available through the Forest Service. The reservoir and immediate area are used for camping, picnicking, swimming, and boating, and there is fishing for native and rainbow trout.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	16,665	acres
Number of irrigated farms	549	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	16,316	770,063
1969	16,110	691,171
1970	16,248	798,590
1971	16,192	823,394
1972	16,350	998,120
1973	16,120	1,307,651
1974	14,350	1,092,702
1975	16,298	1,223,930
1976	14,933	1,230,722
1977	15,680	1,508,093

Facilities in Operation

Storage dams[2]	1	
Diversion dams	1	
Canals	67	mi
Laterals	77	mi

[2]Rehabilitated by the Bureau of Reclamation.

Climatic Conditions

Annual precipitation	13.3	in
Temperature:		
Maximum	103	°F
Minimum	−31	°F
Mean	46	°F
Growing season	148	days
Elevation of irrigable area	3500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,772
Other water service[3]	630
Total	2,402

[3]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

ROCK CREEK

Drainage area above Lake Como	54.6	mi²
Annual discharge:		
Maximum (1972)	170,500	acre-ft
Minimum (1977)	49,300	acre-ft
Average	92,800	acre-ft
Average annual diversions by project (1963-77)	95,250	acre-ft

Storage Facilities

COMO DAM

Type: Semihydraulic earthfill
Location: On Rock Creek, about 15 mi south of Hamilton, Mont.
Construction period: 1908-10. Reclamation rehabilitated crest and upstream face in 1954.

Reservoir, Lake Como:		
Average annual inflow, 1963-77	92,800	acre-ft
Total capacity to El. 4242.7	36,900	acre-ft
Active capacity, El. 4188.5 to 4242.7	35,100	acre-ft
Surface area at El. 4242.7	976	acres
Dimensions:		
Structural height	70	ft
Hydraulic height	62.5	ft
Top width	25	ft
Maximum base width	400	ft
Crest length	2,550	ft
Crest elevation	4249.0	ft
Total volume	1,114,000	yd³
Spillway: Concrete-lined crest and channel; open cut at left abutment with removable stoplog control.		
Crest length	75	ft
Crest elevation	4236.85	ft

Outlet works: Concrete conduit through base of dam controlled by one 5.5-ft-diameter gate valve for service and one for emergency.

Diversion Facilities

Rock Creek Diversion Dam[1]

Type: Timber sheet piling, concrete weir cap, rockfill
Location: On Rock Creek, about 15 mi south of Hamilton, Mont.
Year completed: 1950
Dimensions:

Structural height	10.5	ft
Hydraulic height	4.5	ft
Crest length	80	ft
Crest elevation (assumed)	98.0	ft
Volume	600	yd^3
Diversion capacity	330	ft^3/s

Headworks: Concrete, three 48-in-square steel slide gates.

[1]Dam replaced timber-crib weir constructed in 1910.

Carriage Facilities

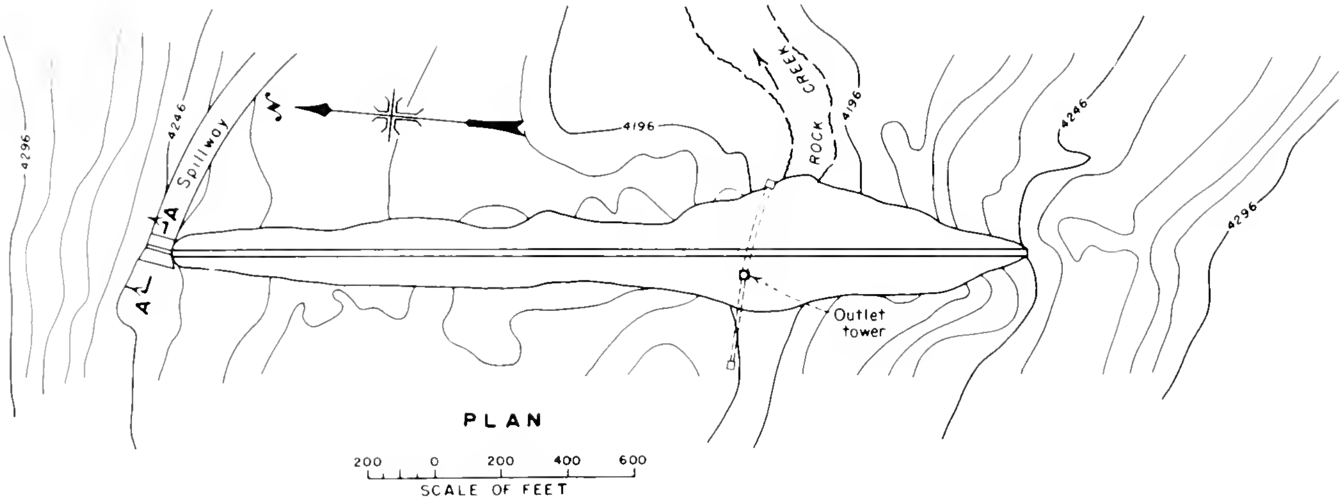
Bitter Root Irrigation District Canal

Location: From Rock Creek Diversion Dam on Rock Creek about 15 mi south of Hamilton, Mont., generally north along east side of Bitterroot River to a point about 5 mi northeast of Florence, Mont.
Construction period: 1907-10

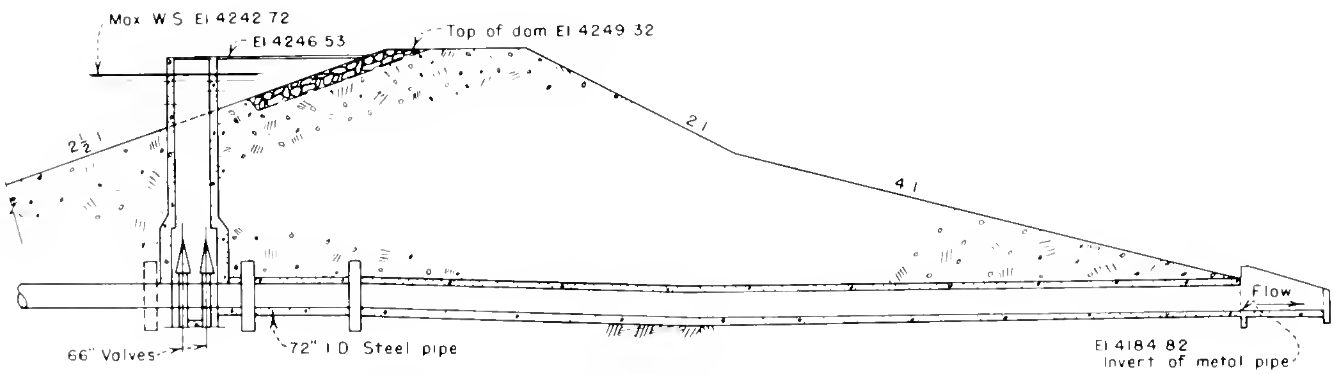
Length	72	mi
Diversion capacity	330	ft^3/s

Typical maximum section in earth:

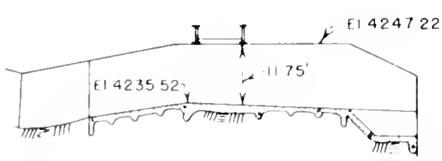
Bottom width	22	ft
Side slopes	1.5:1	
Water depth	5.25	ft



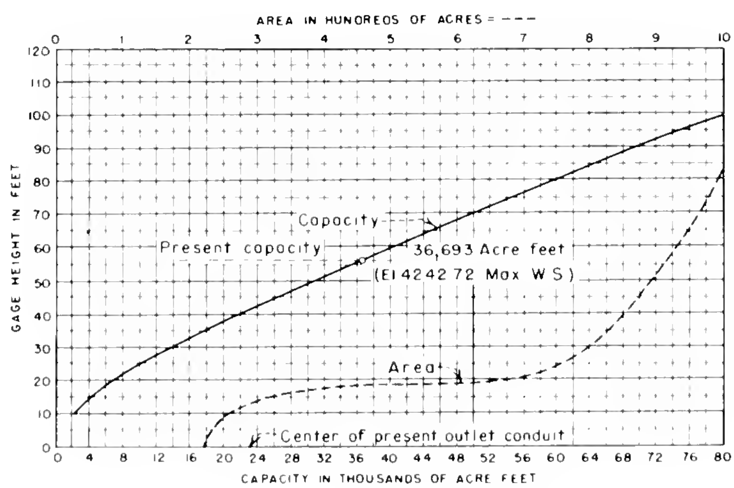
PLAN



MAXIMUM SECTION AND PROFILE ON ℄ OUTLET WORK



SPILLWAY - SECTION A-A



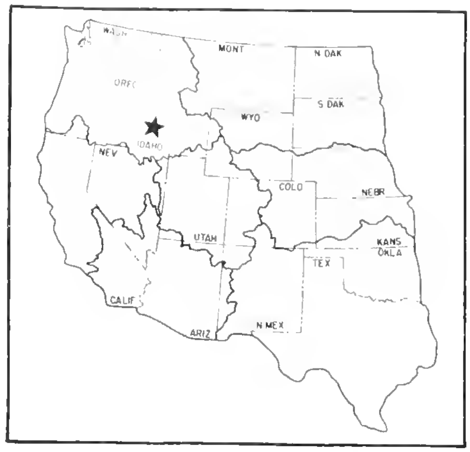
AREA - CAPACITY - CURVES

Como Dam, Plan and Sections

Boise Project

Idaho: Elmore, Ada, Boise, Canyon, Gem, and Payette Counties
Oregon: Malheur County

Pacific Northwest Region
Water and Power Resources Service



The Boise Project furnishes irrigation water to about 225,000 acres of project lands and 165,000 acres under special and Warren Act contracts. The irrigable lands are in southwestern Idaho and eastern Oregon.

Principal facilities include five storage dams which form reservoirs with a total active capacity of 1,693,900 acre-feet, two diversion dams, three powerplants with a combined capacity of 36,500 kilowatts, 721 miles of canals, seven pumping plants, 1,323 miles of laterals, and 649 miles of drains.

To facilitate organization of the administrative and operating procedures, the irrigable project lands are divided into the Arrowrock and Payette Divisions. Some of the features serve only one division; other features serve both divisions as well as other nearby projects.

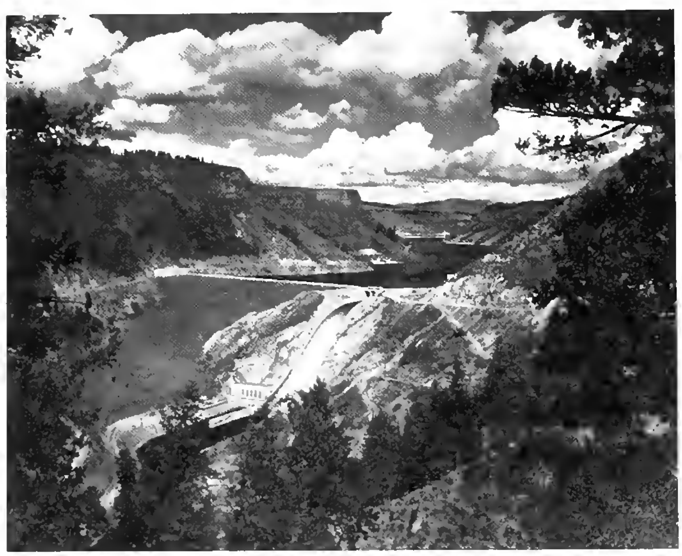
PLAN

The Arrowrock Division consists of 164,680 irrigable acres, and an additional 111,115 acres are furnished supplemental water. Water for the division is stored in Anderson Ranch Reservoir on the South Fork of the Boise River, Arrowrock Reservoir on the Boise River, and in Lake Lowell, an offstream lake in a large depression. Anderson Ranch Dam is 42 miles upstream from Arrowrock Dam. Boise River Diversion Dam, 16 miles downstream from Arrowrock and 7 miles southeast of the city of Boise, diverts water into the New York Canal, which delivers the water to Arrowrock Division lands.

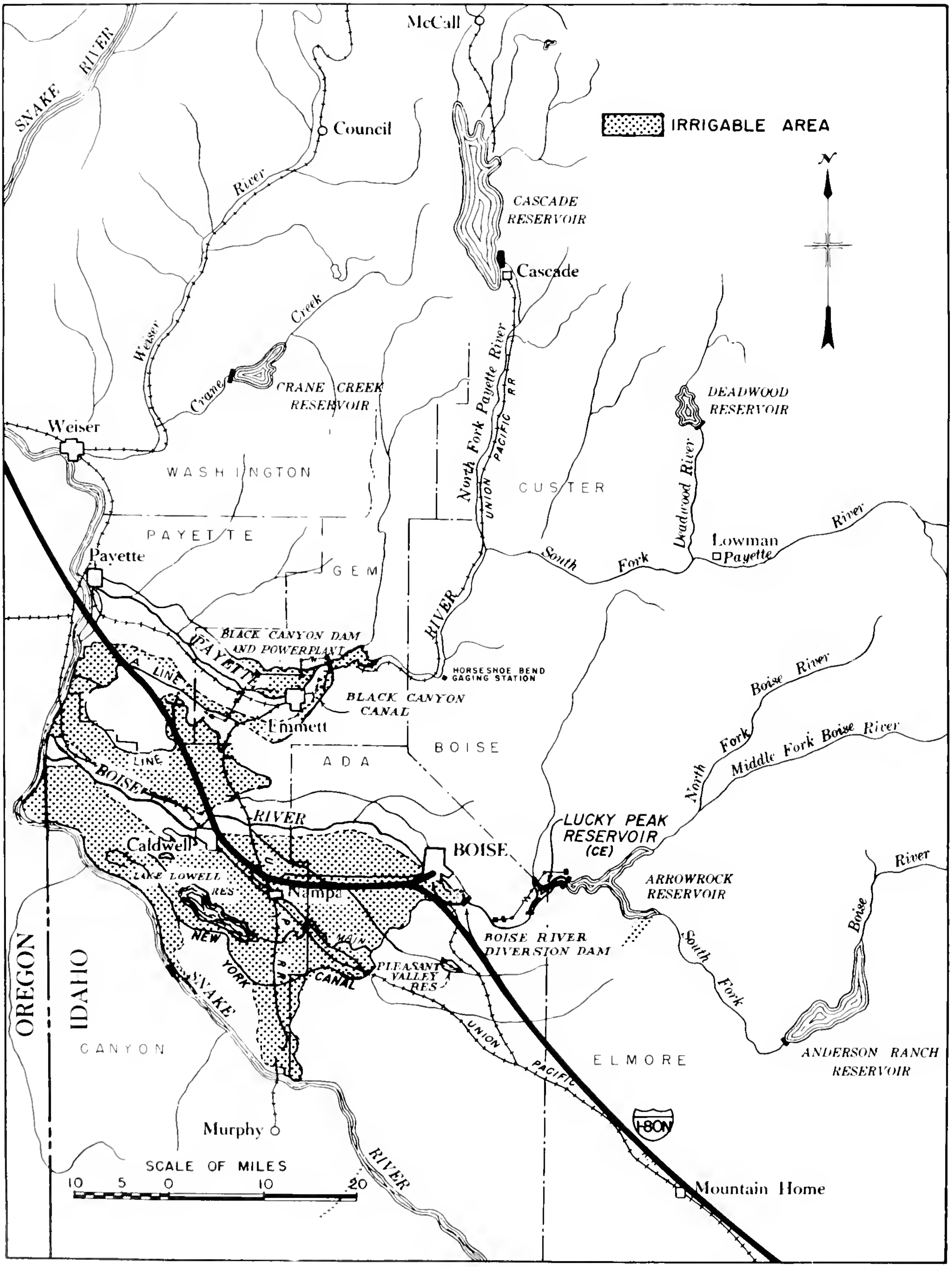
During the nonirrigation season, the New York Canal carries a portion of the water released from Anderson Ranch and Arrowrock Dams to fill Lake Lowell for use in the division during the irrigation season. Water from Lake Lowell is carried to project lands by the Deer Flat Low Line, Deer Flat North, Deer Flat Nampa, and Deer Flat Caldwell Canals. There are 5 regular irrigation districts within the Arrowrock Division receiving water from the project, and 11 districts receiving water from the division under the Warren Act. Power is produced at Boise River Diversion Dam and Anderson Ranch Dam.

Lucky Peak Dam, built by the Corps of Engineers, is about 1 mile upstream from Boise River Diversion Dam and backs water up to Arrowrock Dam. Lucky Peak Reservoir has an active capacity of 278,200 acre-feet and was built for flood control purposes. By agreement among the Corps of Engineers, Boise Project Board of Control, and the Bureau of Reclamation, the Anderson Ranch, Arrowrock, and Lucky Peak storage reservoirs on the Boise River are operated jointly for the benefit of irrigation, power, and flood control. These three reservoirs have a total active capacity of 988,000 acre-feet.

Lands in the Payette Division receive water from the Payette River and surplus drainage from the Arrowrock Division. Storage features are Deadwood Reservoir on Deadwood River, a tributary of the South Fork of the Payette River, and Cascade Reservoir on the North Fork of the Payette. Water is diverted into the Black Canyon Canal (south side) and then into the distribution system. In the project area, the main canal separates into two supply lines which serve 27,186 acres by gravity flow. About 20 miles below Black Canyon Dam, a pumping plant lifts water from the main canal into a lateral system



Anderson Ranch Dam and Powerplant



Boise Project

serving 26,014 acres. The 6,881-acre Notus Unit of the Payette Division obtains water from two Arrowrock Division drains south of the Boise River near Caldwell. The three acreages are in the Black Canyon Irrigation District. The 25,000-acre Emmett Irrigation District, outside the project area, receives water under a Warren Act contract, partially from the Black Canyon Canal but primarily from the Emmett Canal (north side). Both canals divert water from the Payette River at Black Canyon Dam. Power is produced at Black Canyon Dam.

Anderson Ranch Dam and Powerplant

Anderson Ranch Dam and Powerplant is a multiple-purpose structure that provides benefits in irrigation, power, and flood and silt control. Situated on the South Fork of the Boise River 20 miles northeast of Mountain Home, the dam is 456 feet high, was the world's highest earthfill dam at the time of its construction, and has a total storage capacity of 493,200 acre-feet. The power-plant has an existing rated capacity of 27,000 kilowatts with two units installed. By rewinding, the rated capacity can be increased to 20,000 kilowatts each for a total of 40,000 kilowatts. These modifications are scheduled for fiscal year 1981, or as soon as funding can be arranged.

Arrowrock Dam

Arrowrock Dam, on the Boise River 42 miles down-stream from Anderson Ranch Dam and 22 miles up-stream from Boise, is a concrete thick-arch structure 350 feet high. The reservoir has a storage capacity of 286,600 acre-feet. When constructed in 1915, the dam was recorded as being the highest in the world. The structure was repaired and raised 5 feet during 1935-37, increasing its storage by 9,000 acre-feet. The original construction involved the use of a rather high proportion of sand-cement, and by 1935 the concrete on the downstream face of the structure showed deterioration due to climatic conditions. Repairs included refacing the downstream face and spillway channel.

Boise River Diversion Dam and Powerplant

The Boise River Diversion Dam, on the Boise River about 7 miles southeast of Boise, Idaho, is a rubble-concrete, weir-type structure with a hydraulic height of 39 feet, and was originally built to supply power for the construction of Arrowrock Dam. The dam diverts water into the New York Canal which serves distributing laterals and feeds Lake Lowell. A small canal known as the Penitentiary Canal, also heading from the diversion dam, distributes water on the north side of the Boise River to a small area of land east of Boise. The power-plant consists of three 500-kilowatt units that began operation in 1912.

Arrowrock Dam

Lake Lowell

Lake Lowell, originally known as Deer Flat Reservoir, is formed by three earthfill dams that are 16, 46, and 74 feet high, enclosing a natural depression. The lake lies offstream within the project area near Nampa, stores 190,000 acre-feet, and is filled during the nonirrigation season from the Boise River Diversion Dam through the New York Canal.

Arrowrock Division Canal System

The New York Canal is about 40 miles long and has a diversion capacity of 2,800 cubic feet per second. It consists of the enlarged old New York Canal, a section of new canal, and a part of the channel of Indian Creek.

The Deer Flat High Canal is 22 miles long and has a diversion capacity of 130 cubic feet per second. The Deer Flat Low Canal has a length of about 37 miles and diversion capacity of 1,200 cubic feet per second.

Deadwood Dam

Deadwood Dam, 25 miles southeast of Cascade, Idaho, on the Deadwood River, is a concrete-arch structure. It has a structural height of 165 feet and stores 162,000 acre-feet of water that provides a regulated flow for the powerplant at Black Canyon Dam and for irrigation in the Payette Division and Emmett Irrigation District.

Cascade Dam

Cascade Dam, near Cascade, Idaho, on the North Fork of the Payette River, is a zoned earthfill structure 785 feet across the crest. The total storage capacity is 703,200 acre-feet.

Black Canyon Dam and Powerplant

Black Canyon Dam, on the Payette River near Emmett, Idaho, is a concrete gravity type dam with an ogee overflow spillway. The dam has a structural height of 183 feet and serves to divert water to the Payette Division through the Black Canyon Canal. Two direct-connected turbine-driven pumps, located in the powerhouse, serve the Emmett Irrigation District Canal on the north side of the river. The powerplant has a capacity of 8,000 kilowatts. The plant supplies power to the Boise Project, and, by wheeling over facilities of the Idaho Power Company, to Owyhee and Minidoka Projects. Surplus power is delivered to the Bonneville Power Administration. A short transmission line connects the Black Canyon Powerplant with the lines of the Idaho Power Company while another line supplies the "C" Line Canal Pumping Plant.

Pumping Plants

The pumping plants are: (1) Black Canyon at the Black Canyon Dam; (2) "C" Line Canal at station 1064 on the Black Canyon Canal; and (3) Willow Creek at station 1111 on "C" Line Canal East, about 4 miles northeast of Middleton, Idaho. There are also four small relift pumping plants.

The Black Canyon Pumping Plant contains two pumps directly connected to turbines; the "C" Line Canal plant has five pumps; and Willow Creek has two motor-driven pumps lifting water from the "C" Line Canal East.

Payette Division Canal System

The Black Canyon Canal is 29 miles long and extends from the Black Canyon Dam south and west along the Payette River. The canal has a diversion capacity of 1,300 cubic feet per second.

The "C" Line Canal East, with diversion capacity of 469 cubic feet per second, begins at "C" Line Canal Pumping Plant on the Black Canyon Canal and is 21 miles long. The "C" Line Canal West branches from the "C" Line Canal East, extends 24 miles, and has a diversion capacity of 60 cubic feet per second.

The "A" Line and "D" Line Canals begin at the terminus of the Black Canyon Canal. The "A" Line Canal is 33 miles long and has a diversion capacity of 226 cubic feet per second; the "D" Line Canal, 39 miles long, has a diversion capacity of 254 cubic feet per second.

DEVELOPMENT

Early History

The first right to divert water from the Boise River for irrigation purposes was granted in 1864. The water irrigated the townsite of Boise and supplied Fort Boise. Agricultural activity in the Boise and Payette Valleys started in the early 1880's when settlers began filing on desert lands under private irrigation enterprises. By 1900, about 148,000 acres had been placed under irrigation.

Since its first authorization in 1905, the Boise Project has expanded in accordance with an orderly program of development that has included the construction of five

Black Canyon Dam

Cascade Dam and Reservoir

major reservoirs, two principal diversion dams, three sizable pumping plants, three powerplants, and related facilities. In addition, several structures that were constructed in the early stages of development have been rehabilitated or repaired to improve operations and extend the life of the facilities.

Investigations

Diversion from the river with simple ditches served adequately to irrigate lands in the vicinity of the river, but development of additional lands at higher elevations proved too difficult and costly to be undertaken by private capital. In response to petitions by local irrigators, the Boise Project was initiated by the Reclamation Service shortly after the passage of the first Reclamation Act in 1902. Subsequent investigations have resulted in completion of many structures as need arose.

Deadwood Dam and Reservoir

Studies are underway for inclusion of a third generating unit in the Anderson Ranch Dam Powerplant. The present proposal is considering a 30,000-kilowatt unit. Report of feasibility is targeted for 1980. Congressional authorization will be necessary before construction is implemented.

Authorization

Authorization for construction of the original Boise Project (now the Arrowrock Division) was made on March 27, 1905; the Arrowrock Dam on January 6, 1911; and Black Canyon Dam on June 26, 1922, all by the Secretary of the Interior under provisions of the Reclamation Act of June 17, 1902 (32 Stat. 388). Deadwood Dam and Reservoir were approved on October 19, 1928, and Payette Division on December 19, 1935, by the President under section 4 of the act of June 25, 1910 (36 Stat. 836). Anderson Ranch Dam and Reservoir were found feasible and authorized on August 12, 1940, by the Secretary of the Interior under the Reclamation Project Act of 1939 (53 Stat. 1187).

Construction

The 276,000-acre Arrowrock Division serves that portion of the Boise Project lands situated between the Boise and Snake Rivers. Lake Lowell was completed by June 1911; Arrowrock Dam and Reservoir commenced storing water in 1915; Boise River Diversion Dam was completed by October 10, 1908, and Anderson Ranch Dam was completed in 1950. The powerplant at Boise River Diversion Dam, built originally to supply power for construction of Arrowrock Dam, was placed in operation in 1912. As the reservoirs were built, a system of canals, laterals, and drains was constructed.

The 114,000-acre Payette Division includes lands between the Payette and Boise Rivers and lands north of the Payette River in the Emmett Irrigation District that are irrigated from the Payette River and from drains operated within the Arrowrock Division. Black Canyon Dam on the Payette River, which heads the gravity distribution system, was completed in 1924; Deadwood Dam and Reservoir on the Deadwood River in 1931; and Cascade Dam and Reservoir on the North Fork of the Payette River in 1948. The gravity distribution system was constructed during 1936-40. Supplementing this system, a combination pump-gravity canal, designated the "C" Line, was completed in 1948.

Operating Agencies

The operating organization for the Arrowrock Division of the project is the Boise Project Board of Control, which was formed in 1926 by contracts between the Bureau of Reclamation and the five irrigation districts representing the water users that make up the project.

The Bureau of Reclamation operated the project until April 1, 1926, when the operation was turned over to the newly organized irrigation districts under the act of December 5, 1924, known as the Fact Finders' Law. However, Reclamation retained the operation and maintenance of certain parts of the system, referred to as the "reserved works," which include Arrowrock and Anderson Ranch Reservoirs, the Boise River Diversion Dam and Powerplant, and headworks of the main canal.

In the Payette Division, Reclamation operates and maintains Deadwood and Cascade Reservoirs, and Black Canyon Dam and Powerplant. All irrigation carriage and distribution systems are operated by the water users.

Boise River Diversion Dam

BENEFITS

Irrigation

The project area, comprising about 390,000 acres, was once desert land except for small sections of river bottom. Principally through facilities provided by the Bureau of Reclamation, irrigation farmers have turned the desert into a productive agricultural area with thriving cities and towns.

A major portion of the Nation's requirement for sweet corn seed is grown on the Boise Project. The project also produces large quantities of grain, alfalfa hay, pasture, sugar beets, corn, potatoes, onions, apples, prunes, and alfalfa seed. The hay and forage crops support a large number of dairy and beef cattle.

Hydroelectric Power

On the Boise Project, as a multiple-purpose feature, hydroelectric power is produced at three powerplants: A 27,000-kilowatt installation at Anderson Ranch Dam; a 1,500-kilowatt plant at the Boise River Diversion Dam; and an 8,000-kilowatt plant at Black Canyon Dam.

The Black Canyon and Boise River Diversion Dam Powerplants provide energy for pumping to the Payette Division lands and the Emmett Irrigation District. Anderson Ranch power serves pumping loads in the Minidoka and Owyhee Projects. Surplus power from these plants is turned over to the Bonneville Power Administration for marketing.

Flood Control

A formal flood control operating agreement for the Boise River system has been signed by the Corps of Engineers and the Bureau of Reclamation. Sufficient space is maintained in Anderson Ranch, Arrowrock, and Lucky Peak Reservoirs on a forecast basis to prevent the riverflow through Boise from exceeding 6,500 cubic feet per second.

Cascade and Deadwood Reservoirs are operated on an informal forecast basis to control the flow of the Payette River through Horseshoe Bend so as not to exceed 12,000 cubic feet per second.

Recreation and Fish and Wildlife

The six project reservoirs are located in the most populous portion of Idaho, and are used extensively by recreationists. The reservoirs provide a variety of settings. Anderson Ranch, Arrowrock, and Deadwood Reservoirs are located in the mountains. Cascade Reservoir is in a broad, mountain-encircled valley. Black Canyon Reservoir fills a narrow canyon at the foot of massive Squaw Butte, and Lake Lowell is located in an area of agricultural development. A total of 21,635 acres of land and 48,230 acres of water surface are included in these reservoir areas.

Cascade Reservoir, the largest of the six with 27,550 acres of water surface, offers excellent warm- and cold-water fishing as well as ice fishing, and is used by numerous waterfowl in the spring and fall. Anderson Ranch Reservoir offers excellent fishing for trout and smallmouth bass, and provides exciting fishing for kokanee salmon during their spawning runs. About one-third of the land has been established as a game management area. Arrowrock Reservoir is heavily drafted to supply irrigation water but is still used extensively by ducks and is stocked annually with trout. Deadwood Reservoir is nestled among forested mountain slopes and offers good trout fishing. The Lake Lowell area contains the Deer Flat National Wildlife Refuge which is used by millions of waterfowl annually. There is excellent warm-water fishing as well as both upland game bird and waterfowl hunting. The lake also has heavy boating use. The long, narrow Black Canyon Reservoir has little fluctuation in water level and is used for boating and water skiing. About 1,100 acres of the Montour Valley above the reservoir have been acquired and are managed as a recreation and wildlife area. Camping facilities have been constructed at all areas except Black Canyon Reservoir and Lake Lowell.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	224,761	acres
Supplemental irrigation service	165,365	acres
Total	390,126	acres
Number of irrigated farms	8,502	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	344,999	48,946,476
1969	343,411	52,671,563
1970	342,528	52,885,242
1971	340,333	58,443,534
1972	336,851	65,162,659
1973	340,613	87,467,937
1974	339,738	120,241,514
1975	337,944	109,418,576
1976	338,087	91,181,716
1977	327,815	104,624,655

Power Generation

Fiscal year	Anderson Ranch Powerplant, kWh	Black Canyon Powerplant, kWh	Boise River Diversion Powerplant, kWh	Total, kWh
1968	136,025,000	71,820,700	2,029,100	209,874,800
1969	153,351,000	73,707,700	2,510,900	229,569,600
1970	161,066,000	76,552,800	287,900	237,906,700
1971	165,775,000	71,984,500	0	237,759,500
1972	188,054,000	73,866,200	0	261,920,200
1973	137,984,000	72,497,200	2,093,830	212,575,030
1974	188,331,000	73,696,900	4,923,080	266,950,980
1975	161,261,000	81,153,900	3,902,460	246,317,360
1976	220,567,000	90,357,300	7,694,500	[1]318,618,800
1977	115,461,000	44,038,600	6,473,210	165,972,810

[1]15-month period. Transitional quarter July-September 1976 included. Fiscal year changed from July-June to October-September.

Facilities in Operation

Storage dams	5	
Diversion dams	2	
Canals	721	mi
Laterals	1,323	mi
Pumping plants	7	
Drains	649	mi
Powerplants	3	
Transmission lines	31.8	mi
Substations	7	

Climatic Conditions

Average annual precipitation	11.7	in
Temperature:		
Maximum	108	°F
Minimum	−23	°F
Mean	52	°F
Growing season	177	days
Elevation of irrigable area	2500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	26,806
Other water service[2]	101,304
Total	128,110

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

BOISE RIVER

Drainage area above Boise River Diversion Dam	2,680	mi²
Annual discharge (1963-77):		
Maximum (1965)	3,663,000	acre-ft
Minimum (1977)	659,000	acre-ft
Average	2,171,000	acre-ft

PAYETTE RIVER

Drainage area above Horseshoe Bend, Idaho	2,230	mi²
Annual discharge (1963-77):		
Maximum (1974)	4,048,800	acre-ft
Minimum (1977)	741,400	acre-ft
Average	2,486,900	acre-ft
Average annual diversions (1963-77)	2,263,580	acre-ft

Storage Facilities

ANDERSON RANCH DAM

Type: Zoned earthfill
Location: South Fork Boise River, 20 mi northeast of Mountain Home, Idaho.
Construction period: 1941-50
Date of closure (first storage): Dec. 15, 1945.
Reservoir, Anderson Ranch:

Annual inflow (1963-77):		
Maximum (1965)	1,297,000	acre-ft
Minimum (1977)	225,000	acre-ft
Average	770,000	acre-ft
Total capacity to El. 4196	493,200	acre-ft
Active capacity	423,200	acre-ft
Surface area	4,740	acres
Dimensions:		
Structural height	456	ft
Hydraulic height	332	ft
Top width	40	ft
Maximum base width	3,000	ft
Crest length	1,350	ft
Crest elevation	4206.0	ft
Volume	9,653,000	yd³

Spillway: Concrete-lined chute at left abutment controlled by two 25- by 22-ft radial gates.
Outlet works:
Service: Tunnel and steel penstock and outlet pipes through left abutment controlled by five 72-in hollow-jet valves.
Power: Three 90-in steel penstocks from outlet pipe.

Capacity at El. 4198	10,000	ft³/s

Foundation: Granite overlaid with clay, gravel, sand, and silt to a depth of 120 ft in the floor of the canyon.
Special treatment: Grout curtain beneath, and blanket grouting between cutoff walls.

ARROWROCK DAM

Type: Concrete thick arch
Location: On Boise River, 13 mi east of Boise, Idaho.
Construction period: 1911-15
Dam and spillway crest raised 5 ft in 1937.
Date of closure (first storage): Oct. 22, 1914.
Reservoir, Arrowrock:

Annual inflow (1963-77):		
Maximum (1965)	3,179,000	acre-ft
Minimum (1977)	635,000	acre-ft
Average	1,926,000	acre-ft
Total and active capacity to El. 3216	286,600	acre-ft
Surface area	3,100	acres
Dimensions:		
Structural height	350	ft
Hydraulic height	261	ft
Top width	15.5	ft
Maximum base width	223	ft
Crest length	1,150	ft
Crest elevation	3216.0	ft
Volume	636,000	yd³

Spillway: Side channel spillway at right abutment controlled by six 62- by 6-ft drum gates.

Elevation, top of gates	3216.0	ft
Crest elevation	3210.0	ft
Capacity at El. 3219.75	40,000	ft³/s

Outlet works: Twenty conduits through dam controlled by 58-in balanced valves for service; and five conduits through dam controlled by 5-ft-square slide gates for sluicing.

Capacity at El. 3210	28,600	ft³/s

Foundation: Hard, sound but seamy, broad zone of granite porphyry, capped in left abutment with 50-ft basaltic lava flow.
Special treatment: Grout curtain beneath upstream cutoff trench; lava cap removed.
Mass concrete: Natural aggregate from pit 13 mi downstream from dam, with boulders up to 20 percent of volume added when available. Standard portland cement used with 45 percent pulverized granite for interior and 34 percent for exterior.

Volume	578,053	yd³
Maximum size aggregate	1.5	in
Average net water-cement ratio by weight	0.65	
Cement content:		
Interior	0.96	bbl/yd³
Exterior	1.05	bbl/yd³

DEER FLAT UPPER AND LOWER DAMS[3]

Type: Zoned earthfill
Location: Offstream, 22 mi southwest of Boise, Idaho.
Construction period: 1906-08. Upper Dam modified in 1909 and 1913; both dams modified in 1911 and 1938.
Date of closure (first storage): Spring, 1909.
Reservoir, Lake Lowell:

Total capacity to El. 2530.5	190,100	acre-ft
Active capacity	169,000	acre-ft
Surface area	9,840	acres
Dimensions:		
Structural height:		
Upper	71	ft
Lower	46	ft
Crest length:		
Upper	4,000	ft
Lower	7,200	ft
Crest elevation:		
Upper	2538.0	ft
Lower	2538.0	ft
Volume:		
Upper	1,245,000	yd³
Lower	1,240,000	yd³

Outlet works: Five concrete conduits through base of Upper Dam and three through base of Lower Dam, controlled by a 5- by 6-ft slidegate at each dam.

Capacity at El. 2530.5	400	ft³/s

[3]A 16-ft-high embankment (Deer Flat Middle) closes the reservoir near the Lower Dam.

DEADWOOD DAM

Type: Concrete thick arch
Location: On Deadwood River, 25 mi southeast of Cascade, Idaho.
Construction period: 1929-31
Date of closure (first storage): Nov. 2, 1930.
Reservoir, Deadwood:

Annual inflow (1963-77):		
Maximum (1974)	303,000	acre-ft
Minimum (1977)	52,000	acre-ft
Average	187,000	acre-ft
Total capacity to El. 5334	162,000	acre-ft
Active capacity	161,900	acre-ft
Surface area	3,000	acres
Dimensions:		
Structural height	165	ft
Hydraulic height	147	ft
Top width	9	ft
Maximum base width	62	ft
Crest length	749	ft
Crest elevation	5340.0	ft
Total volume	56,400	yd³

Spillway: Uncontrolled overflow section near center of dam.

Crest length	100	ft
Crest elevation	5334.0	ft
Capacity at El. 5343.5	11,300	ft³/s

Outlet works: Two pipes through base of dam, controlled by two 54-in needle valves at downstream end.

Capacity at El. 5334	1,980	ft³/s

Foundation: Hard, sound granite, massive at left abutment and fissured with sheet and block joints at right abutment. Two tightly filled fault-zone seams cross foundation on right side.
Special treatment: Cement grout curtain beneath upstream cutoff trench; supplementary grouting along downstream toe at right abutment; fault zone excavated and backfilled with concrete.
Mass concrete: Aggregate, natural from pits near damsite, oversize crushed; standard portland cement, diatomaceous earth added.

Volume	55,463	yd³
Maximum size aggregate	6	in
Average net water-cement ratio by weight	0.51	
Cement content	1.33	bbl/yd³

CASCADE DAM

Type: Zoned earthfill
Location: On North Fork of Payette River near Cascade, Idaho.
Construction period: 1946-48
Date of closure (first storage): 1947
Reservoir, Cascade:
Annual inflow (1963-77):

Maximum (1974)	1,292,000	acre-ft
Minimum (1977)	200,000	acre-ft
Average	771,000	acre-ft
Total capacity to El. 4828	703,200	acre-ft
Active capacity	653,200	acre-ft
Surface area at El. 4828	26,500	acres
Dimensions:		
Structural height	107	ft
Hydraulic height	75	ft
Top width	35	ft
Maximum base width	630	ft
Crest length	785	ft
Crest elevation	4840.0	ft
Total volume	395,000	yd³
Spillway: Concrete-lined chute at right abutment controlled by two 21- by 20-ft radial gates.		
Elevation top of gates	4828.0	ft
Crest elevation	4808.0	ft
Capacity at El. 4828	12,000	ft³/s
Outlet works: Concrete-lined tunnel through right abutment controlled by two 5-ft-square high-pressure slide gates.		
Capacity at El. 4828	2,530	ft³/s

Diversion Facilities

BOISE RIVER DIVERSION DAM

Type: Concrete and masonry weir, with provision for flash boards
Location: On Boise River, 7 mi southeast of Boise, Idaho.
Year completed: 1908

Dimensions:		
Structural height	68	ft
Hydraulic height	39	ft
Crest length	500	ft
Crest elevation	2812.84	ft
Volume	26,100	yd³
Spillway: Ogee overflow		
Capacity	40,000	ft³/s
Headworks: New York Canal heading; eight 5- by 6-ft motor-operated slide gates.		
Diversion capacity	2,815	ft³/s

BLACK CANYON DAM

Type: Concrete gravity, gated ogee spillway
Location: On Payette River, 5 mi northeast of Emmett, Idaho.
Year completed: 1924

Dimensions:		
Structural height	183	ft
Hydraulic height	111	ft
Crest length	1,039	ft
Crest elevation	2500.0	ft
Volume	81,200	yd³
Spillway: Ogee overflow		
Capacity	40,000	ft³/s
Headworks: Black Canyon Canal heading, 30- by 10.42-ft radial gate at south end of dam. Pumping plant at north end of dam.		
Diversion capacity	1,360	ft³/s

Carriage Facilities

NEW YORK CANAL

Location: From Boise River Diversion Dam generally west to Lake Lowell.
Construction period: 1906-08 (Enlarged 1909-12)

Length	40	mi
Diversion capacity	2,800	ft³/s
Typical maximum section in earth:		
Bottom width	70	ft
Side slopes	1.5:1	
Water depth	8	ft
Typical maximum section, concrete lined:		
Bottom width	40	ft
Side slopes	1.5:1	
Water depth	8	ft
Lining thickness	4	in

MORA CANAL

Location: From point on New York Canal about 13 mi west of Boise River Diversion Dam, then northwest past Lake Lowell.
Construction period: 1909-11

Length	56	mi
Diversion capacity	1,300	ft³/s
Typical maximum section in earth:		
Bottom width	55	ft
Side slopes	1.5:1	
Water depth	4.5	ft

DEER FLAT HIGH LINE CANAL

Location: Near northwest end of Lake Lowell.
Construction period: 1909-10

Length	22	mi
Diversion capacity	130	ft³/s
Typical maximum section in earth:		
Bottom width	20	ft
Side slopes	1.5:1	
Water depth	3.5	ft

DEER FLAT LOW LINE CANAL

Location: From Lake Lowell northwest about 10 mi, then generally southwest along Snake River.
Construction period: 1907-08 (Enlarged from 800 to 1,000 cubic feet per second in 1915-16)

Length	36.7	mi
Diversion capacity	1,200	ft³/s
Typical maximum section in earth:		
Bottom width	45	ft
Side slopes	1.5:1	
Water depth	6	ft

Golden Gate Canal

Location: From point on Deer Flat Low Line Canal about 5 mi from Lake Lowell, then northwest about 10 mi.
Construction period: 1908-09
Length .... 18.8 mi
Diversion capacity .... 500 ft³/s
Typical maximum section in earth:
Bottom width .... 40 ft
Side slopes 1.5:1
Water depth .... 3.4 ft

Black Canyon Canal

Location: From Black Canyon Dam south, then generally west along Payette River.
Construction period: 1936-40
Length .... 29 mi
Diversion capacity .... 1,300 ft³/s

"A" Line Canal

Location: From point on Black Canyon Canal about 15 mi from Black Canyon Dam generally west to vicinity of Snake River.
Construction period: 1938-40
Length .... 33 mi
Diversion capacity .... 226 ft³/s
Typical maximum section in earth:
Bottom width .... 12 ft
Side slopes 1.5:1
Water depth .... 5.4 ft

"D" Line Canal

Location: From point on Black Canyon Canal about 15 mi from Black Canyon Dam generally west to vicinity of Snake River.
Construction period: 1938-40
Length .... 39 mi
Diversion capacity .... 254 ft³/s
Typical maximum section in earth:
Bottom width .... 12 ft
Side slopes 1.5:1
Water depth .... 5.4 ft

"C" Line Canal East

Location: From "C" Line Canal Pumping Plant on Black Canyon Canal generally southwest about 10 mi to vicinity of Willow Creek Pumping Plant.
Construction period: 1946-48
Length .... 21 mi
Diversion capacity .... 469 ft³/s
Typical maximum section in earth:
Bottom width .... 16 ft
Side slopes 1.5:1
Water depth .... 7.5 ft

"C" Line Canal West

Location: From about Mile 1 on "C" Line Canal East, then generally west.
Construction period: 1946-47
Length .... 24 mi
Diversion capacity .... 60 ft³/s
Typical maximum section in earth:
Bottom width .... 7 ft
Side slopes 1.5:1
Water depth .... 3 ft

Notus Canal

Location: Near Caldwell, Idaho.
Construction period: 1919-20
Length .... 25 mi
Diversion capacity .... 120 ft³/s
Typical maximum section in earth:
Bottom width .... 16 ft
Side slopes 1.5:1
Water depth .... 3 ft
Typical maximum section, concrete lined:
Bottom width .... 12 ft
Side slopes 1.5:1
Water depth .... 3 ft
Lining thickness .... 3 and 3.5 in

Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
"C" Line Canal	5	600	92	7,250
Black Canyon	2	270	27	1,250
Willow Creek	2	27	39	160
"C" Line Relift Plants No. 7, 8, 10, and 11		8.5	16-24	

Power Facilities

Black Canyon Powerplant

Location: Black Canyon Dam
Year of initial operation: 1925
Year last generator placed in operation: 1925
Nameplate capacity .... 8,000 kW
Number and nameplate capacity of generators .... (2) 4,000 kW
Maximum head .... 93.5 ft

Boise River Diversion Powerplant

Location: Boise River Diversion Dam
Year of initial operation: 1912
Year last generator placed in operation: 1912
Nameplate capacity .... 1,500 kW
Number and nameplate capacity of generators .... (3) 500 kW
Maximum head .... 33.25 ft

Anderson Ranch Powerplant

Location: Anderson Ranch Dam
Year of initial operation: 1950
Year last generator placed in operation: 1951

Nameplate capacity:		
Existing	27,000	kW
Ultimate	70,000	kW
Number and nameplate capacity of generators:		
Existing (2)	13,500	kW
Ultimate (2)	20,000	kW
(1)	30,000	kW
Maximum head	324	ft

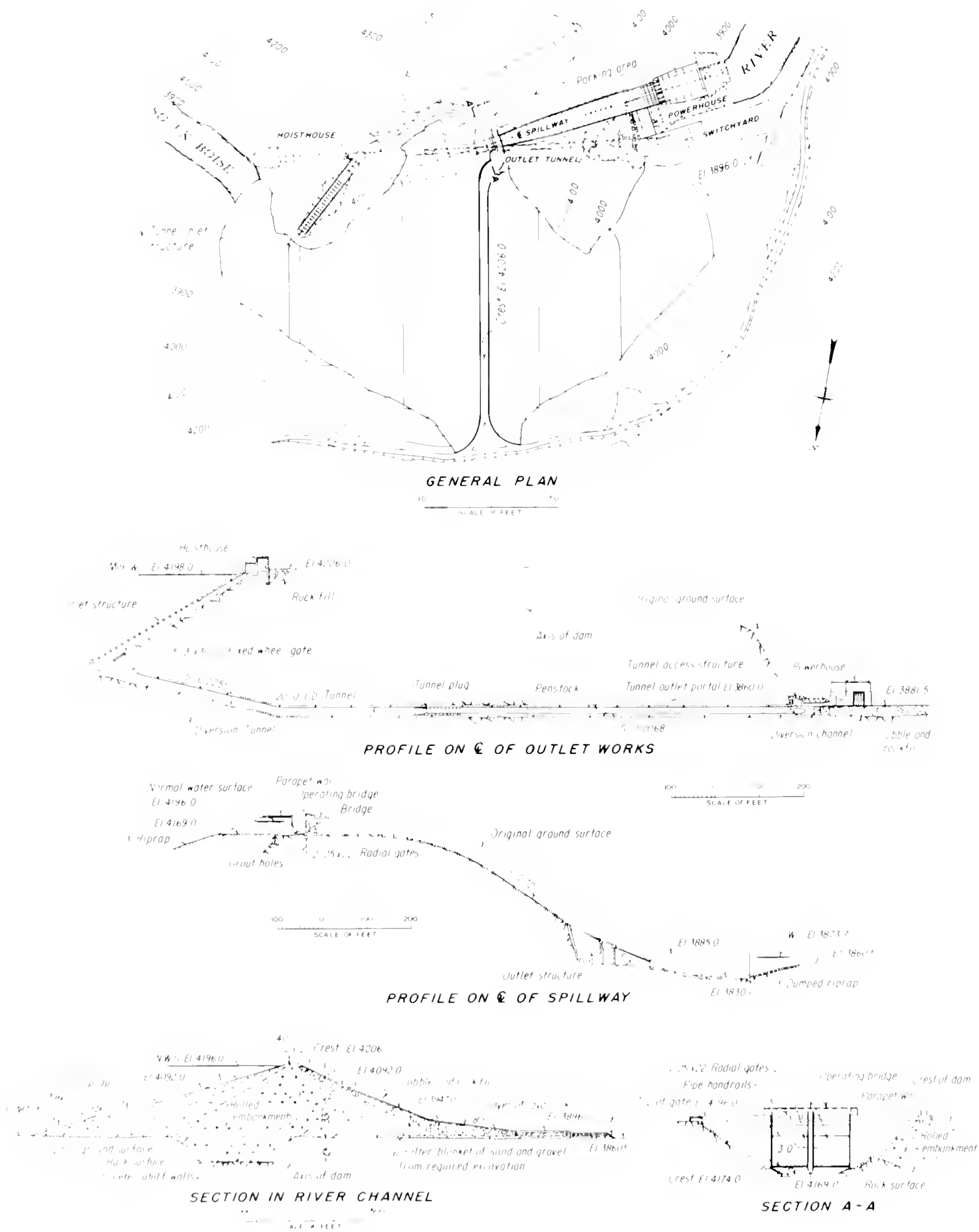
SUBSTATIONS

Number in operation	7	
Total capacity of transformers	53,715	kVA

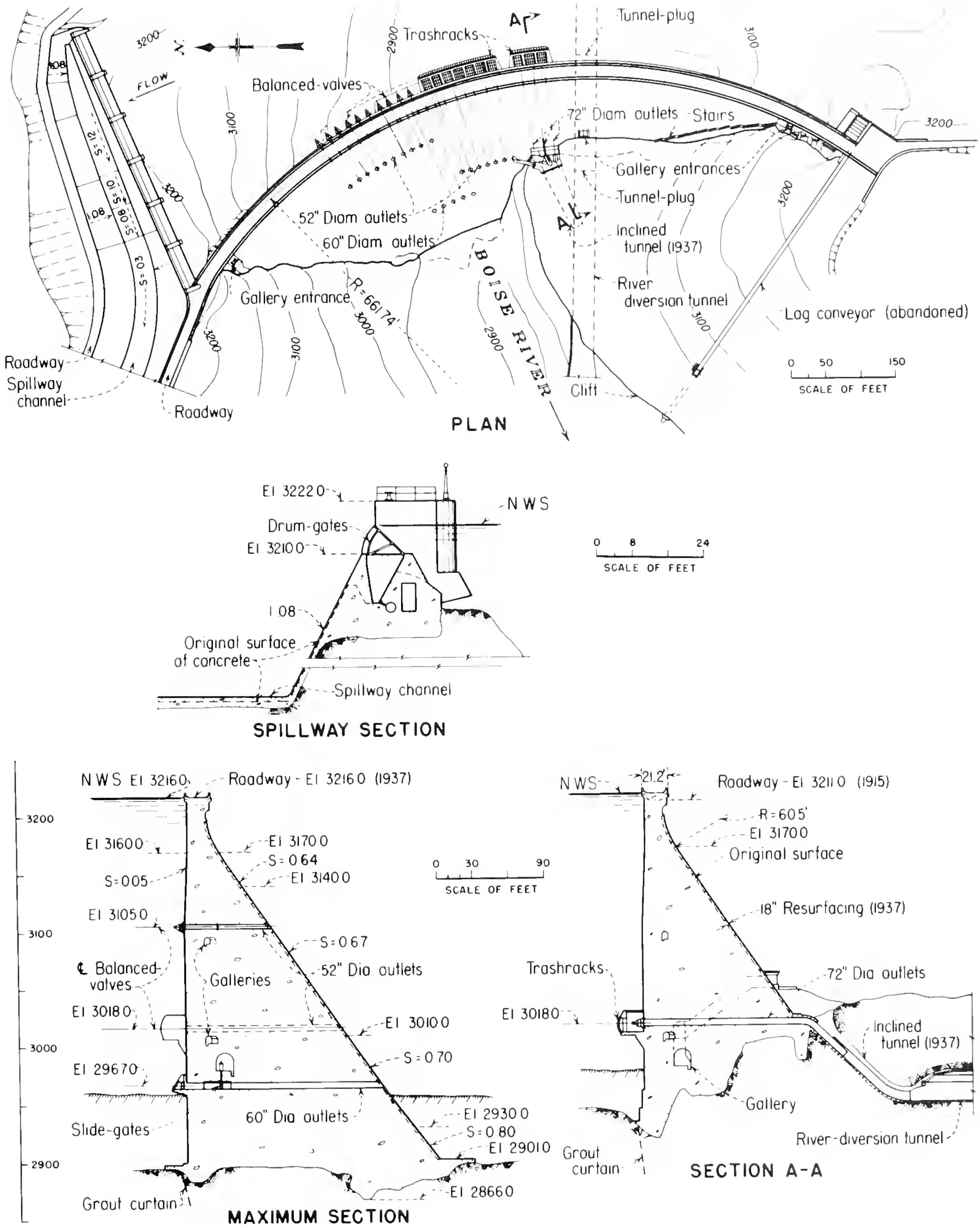
TRANSMISSION LINES

Number of lines	4
Total circuit miles	31.8

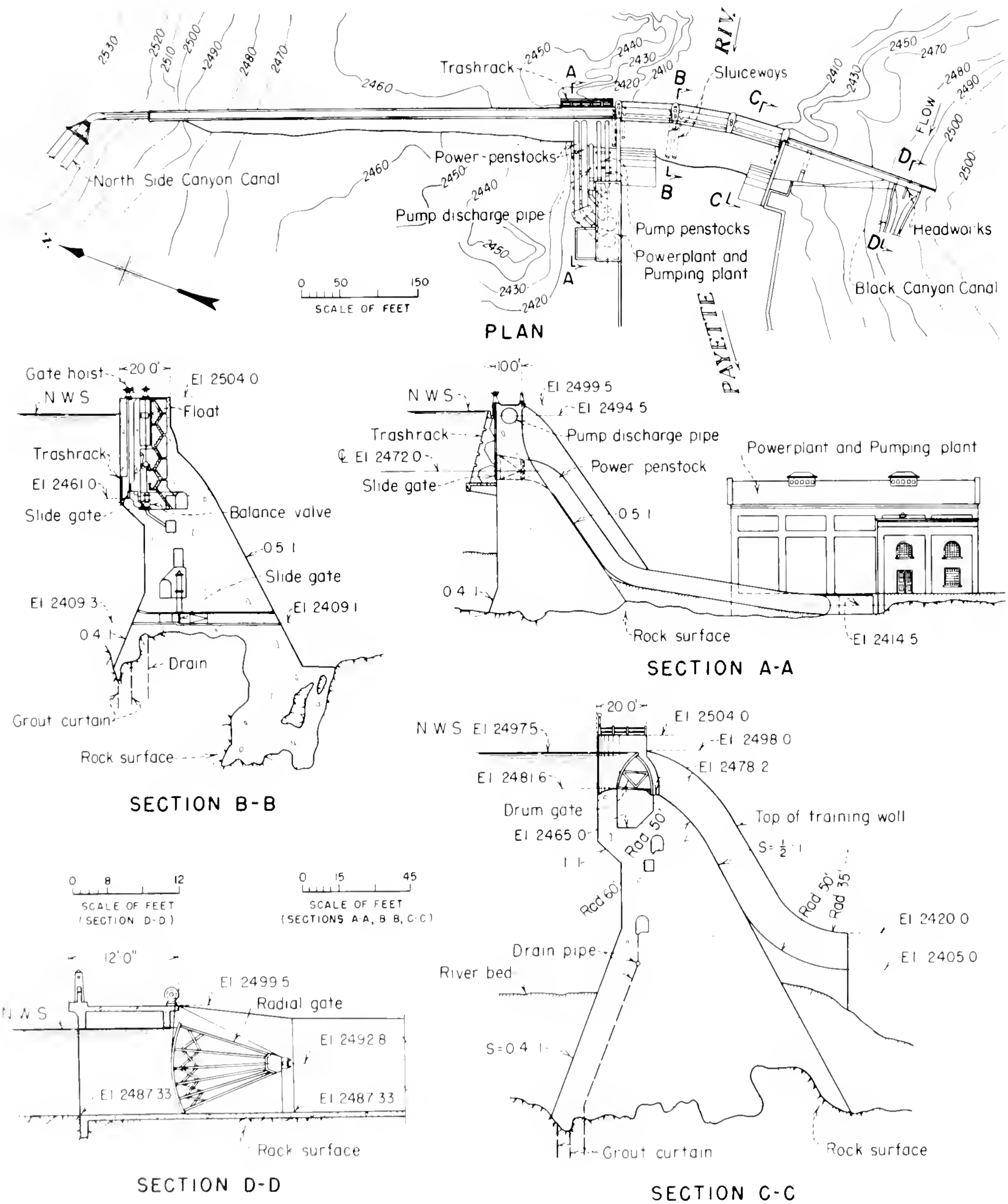
Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Black Canyon Powerplant—C Line Substation	69	10,000	17.65	1948
Boise River Diversion Powerplant—Barber Interconnection	23	2,000	0.70	1912
Boise River Diversion Powerplant—Arrowrock Substation	23	1,000	11.75	1954
Black Canyon C Line Trans. Line Tap—Black Canyon I.D. PP	69	10,000	1.75	1968



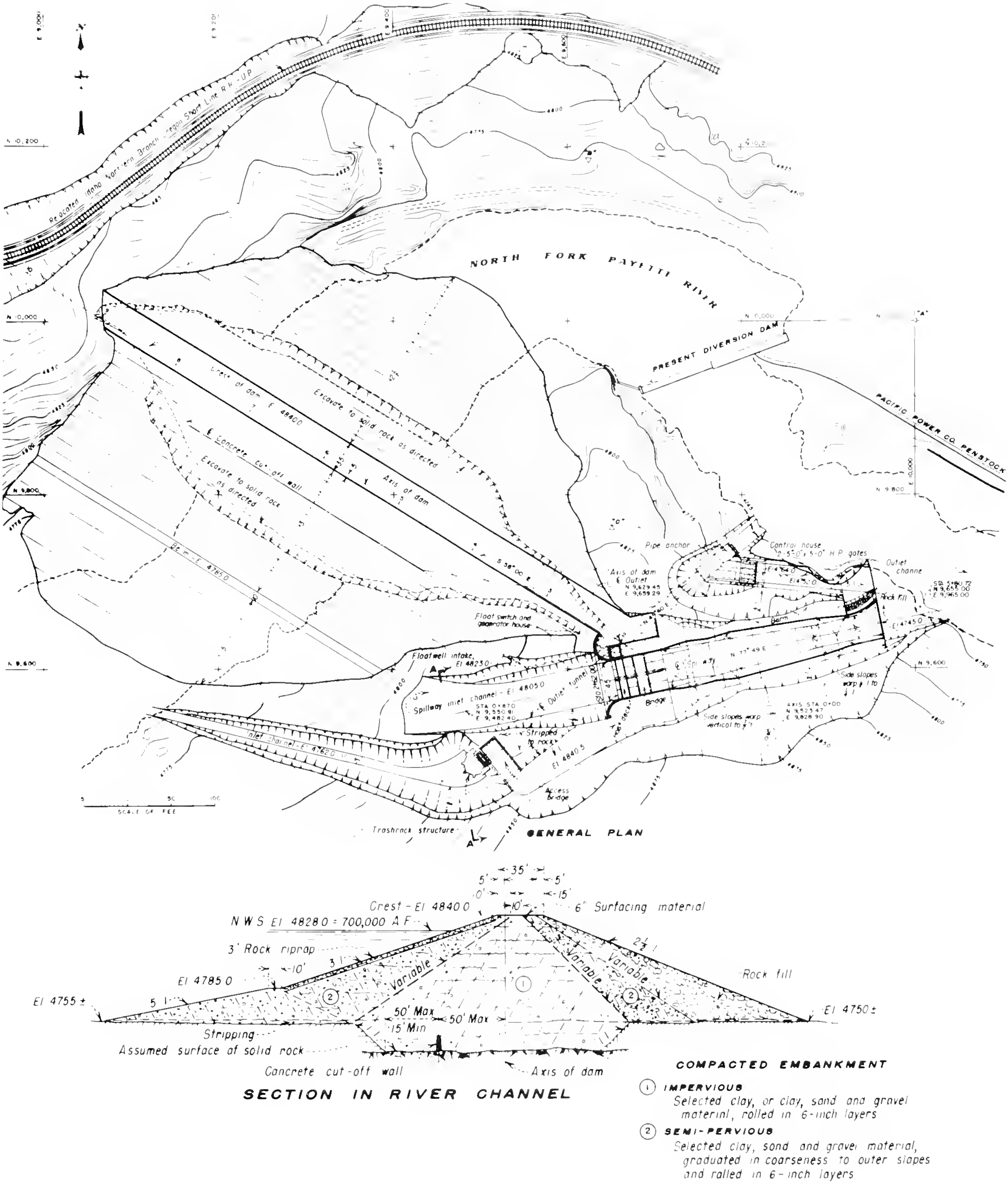
Anderson Ranch Dam, Plan and Sections



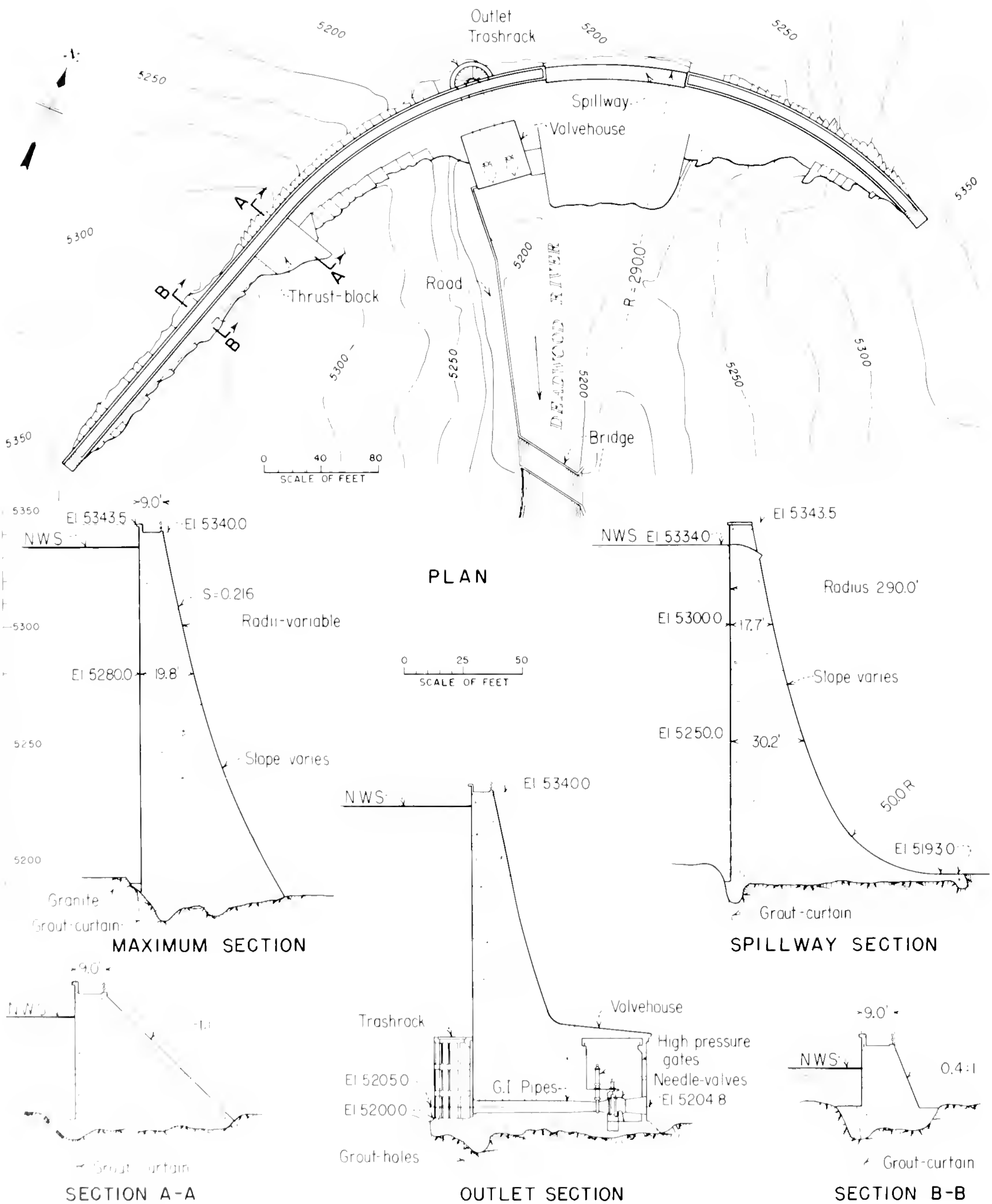
Arrowrock Dam, Plan and Sections



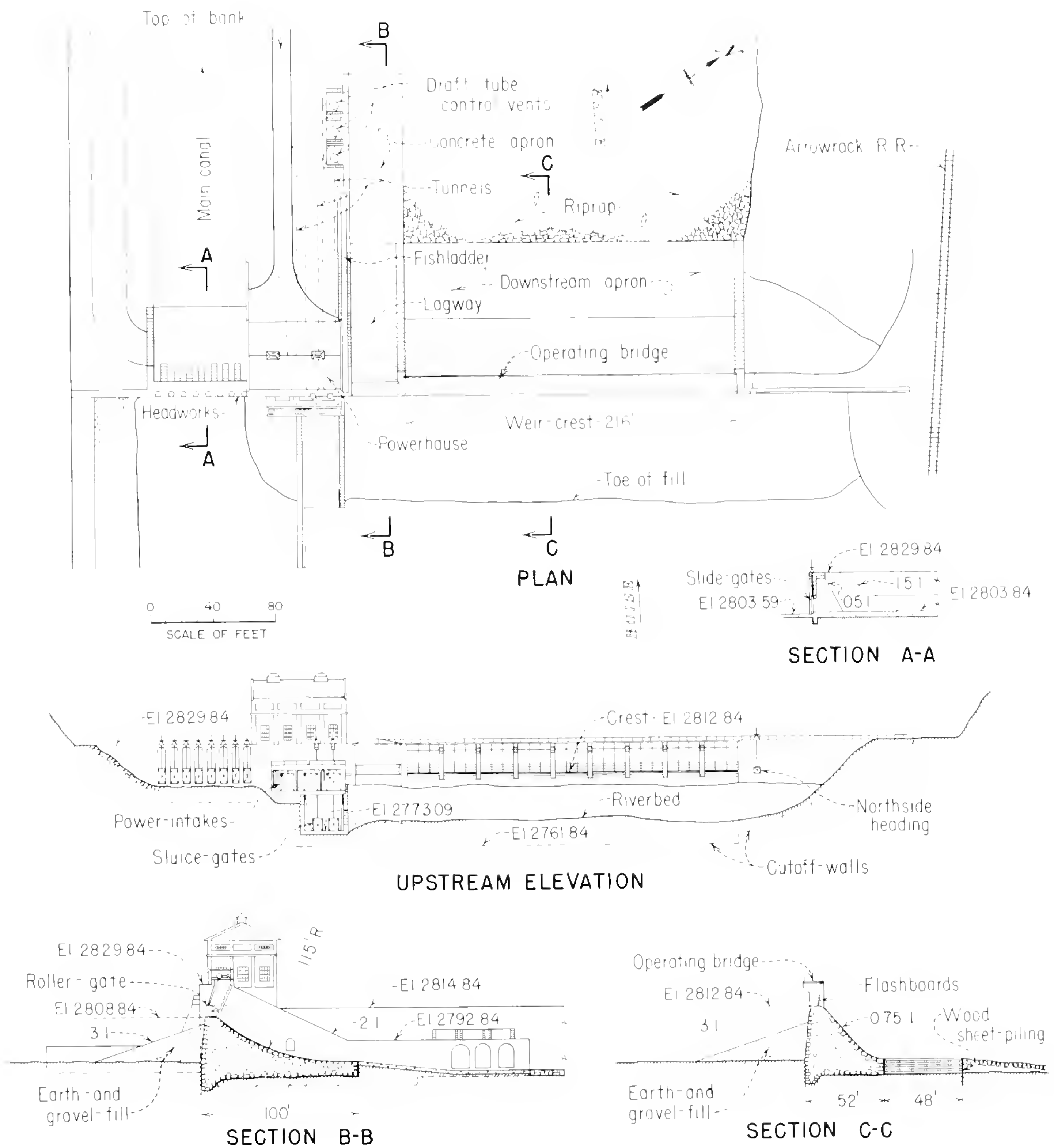
Black Canyon Dam, Plan and Sections



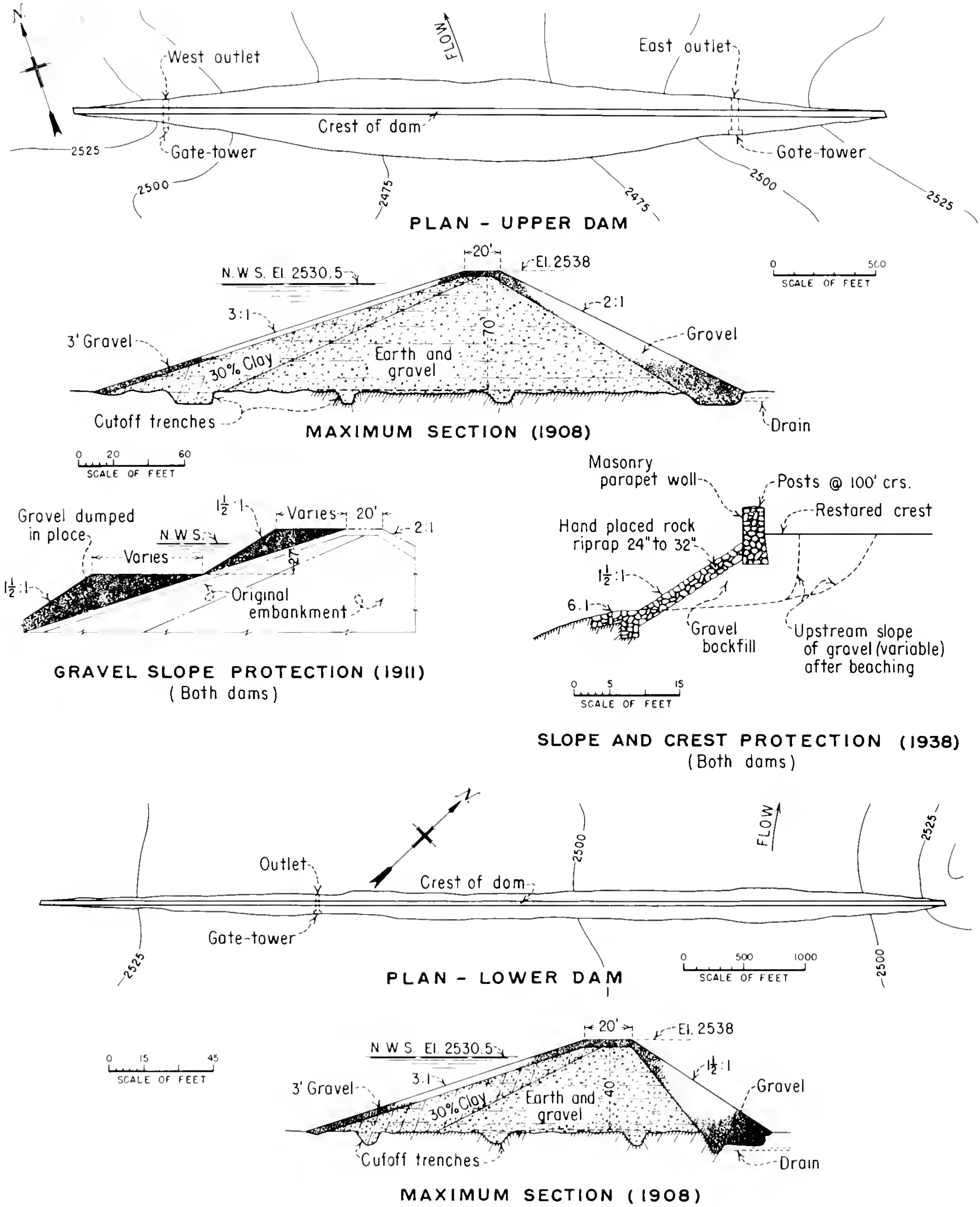
Cascade Dam, Plan and Section



Deadwood Dam, Plan and Sections



Boise River Diversion Dam, Plan and Sections

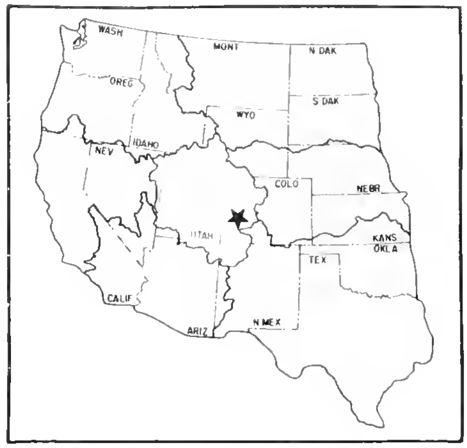


Deer Flat Upper and Lower Dams, Plans and Sections

Bostwick Park Project

Colorado: Montrose and Gunnison Counties

Upper Colorado Region
Water and Power Resources Service



The Bostwick Park Project is in west-central Colorado near the city of Montrose. The project develops flows of Cimarron Creek, a tributary of the Gunnison River, for irrigation and for benefits to sport fishing and recreation. A full and supplemental supply of irrigation water is available for 5,608 acres of land. Recreation opportunities and important fishery benefits are provided at Silver Jack Reservoir.

PLAN

Storage regulation is provided by Silver Jack Dam and Reservoir, constructed on Cimarron Creek. Project water is released from the reservoir to Cimarron Creek. The releases, along with usable natural flows, are diverted from the creek into the existing Cimarron Canal 2.5 miles below the dam, and conveyed 23 miles to the vicinity of the project lands. Some water is released from the canal and used on lands in the Cimarron area. Most of the water is conveyed to the canal terminus at Cerro Summit and then delivered to the Hairpin and Vernal Mesa Ditches. The project-constructed Bostwick Lateral diverts water from the Vernal Mesa Ditch and conveys it across Bostwick Park through an 18-inch siphon to lands above the West Vernal Mesa Lateral.

Silver Jack Dam and Reservoir

Silver Jack Dam and Reservoir

Silver Jack Dam is located on Cimarron Creek about 20 miles above the junction with the Gunnison River. The rolled-earthfill dam has a structural height of 173 feet. Its crest is 1,050 feet long and 30 feet wide. Total volume is 1,278,140 cubic yards of material. The outlet works to Cimarron Creek in the right abutment has a capacity of 280 cubic feet per second with the reservoir at the normal water surface elevation of 8926.0 feet and a capacity of 160 cubic feet per second at the minimum water surface elevation of 8840.0 feet. The spillway on the right abutment is an uncontrolled ogee section with a capacity of 6,220 cubic feet per second at maximum water surface elevation. The reservoir has a total capacity of 13,520 acre-feet, including 12,820 acre-feet of active capacity and 700 acre-feet of inactive capacity. When filled to its normal water surface elevation, the reservoir has a surface area of 293 acres.

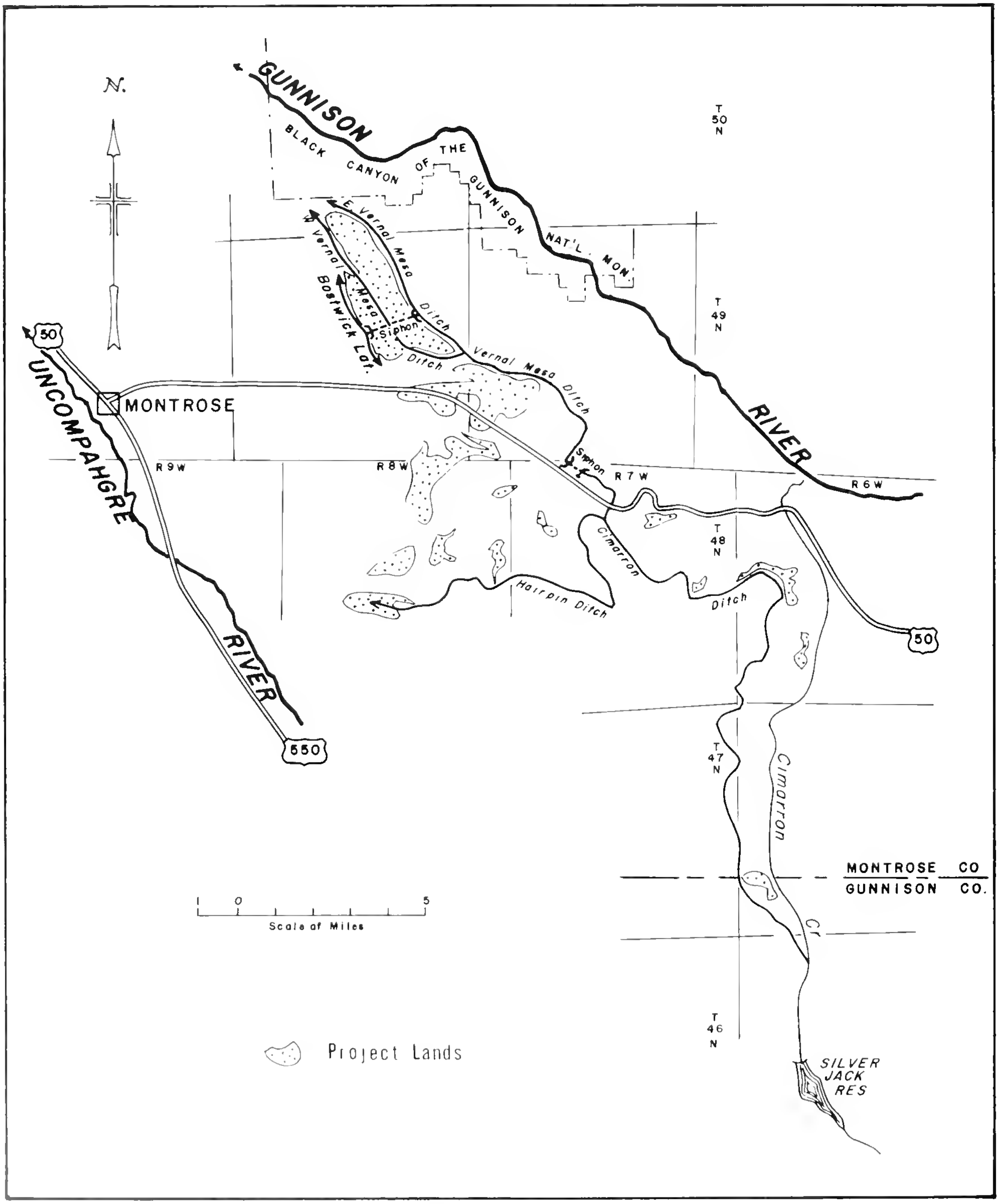
Bostwick Lateral and Drains

The 3.6-mile Bostwick Lateral was constructed to deliver water to full service lands above the West Vernal Mesa Lateral. Repair, extension, and some new construction of about 7.2 miles of drains were completed by the water users.

DEVELOPMENT

Early History

The Bostwick Park area was settled in the early 1880's, followed by a second influx at the time of irrigation development in 1910. By 1930, the population had



Bostwick Park Project

Morning-glory spillway intake structure

reached a peak of 75 to 80 families, but in 1960 decreased to about 40 families because of the trend toward larger farm units, use of modern labor-saving farm equipment, and drought conditions.

Investigations

The Bureau of Reclamation first reported on the Bostwick Park Project in a 1951 reconnaissance report on the Gunnison River Project. The plan presented in the 1961 feasibility study, upon which authorization was based, was essentially the same as the 1951 plan.

Authorization

The project was authorized as a participating project of the Colorado River Storage Project by Public Law 88-568, September 2, 1964 (78 Stat. 852).

Construction

Construction commenced at Silver Jack Dam late in 1966 and was completed in 1971. Silver Jack Reservoir was filled on June 10, 1971, and project water was made available to supplemental service lands from existing ditches on a water rental basis during the 1971, 1972, and 1973 irrigation seasons. A negative declaration of environmental impact was filed July 21, 1972, for drainage rehabilitation and for replacement of the Vernal Mesa conduit. Construction of these facilities was completed during fiscal year 1974.

Operating Agency

Project irrigation facilities were turned over to the Bostwick Park Water Conservancy District for operation and maintenance on January 1, 1976.

BENEFITS

Irrigation

The project furnishes a dependable late-season supply of irrigation water. Nonproject supplies are generally abundant until the latter part of the irrigation season, but then fall off resulting in serious curtailment of crop yields. Project water from Cimarron Creek and in small part from tributaries of Cedar Creek is used as a full irrigation supply for lands not previously irrigated and as a supplemental supply for lands inadequately served.

Beef cattle and sheep raising are the major enterprises in the project area. Irrigated lands are used chiefly for the production of alfalfa, grass hay pasture, and small grains for livestock feed.

Recreation

Plans are being completed for development of recreation facilities by the Forest Service under a cooperative arrangement with the Bureau of Reclamation. Development includes access roads, campgrounds, a boat dock, trails, fences, landscaping, and an administration site. There were 31,680 visitor days to the reservoir area in 1977.

Grain field in Bostwick Park Project

PROJECT DATA

Land Areas (1977)

Irrigable area	5,608	acres
Number of farms irrigated	46	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1971	2,913	273,595
1972	3,925	472,540
1973	3,968	595,412
1974	4,086	504,042
1975	4,732	673,616
1976	4,395	580,308
1977	4,395	[1]257,283

[1]Spring runoff was the lowest in 61 years of record throughout the Intermountain West and in most areas of Colorado precipitation for the year was considerably below average resulting in lower yields because of the drought.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	23	mi
Laterals	49	mi
Drains	7.2	mi

Climatic Conditions

Annual precipitation	14	in
Temperature:		
Maximum	106	°F
Minimum	−27	°F
Mean	47	°F
Growing season	165	days
Elevation of irrigable area	6500-7700.0	ft

ENGINEERING DATA

Water Supply

CIMARRON CREEK

Drainage area above Cimarron Canal	66.8	mi²
Annual discharge:		
Maximum (1957)	115,700	acre-ft
Minimum (1954)	37,100	acre-ft
Average	68,800	acre-ft
Average annual water supply	11,100	acre-ft

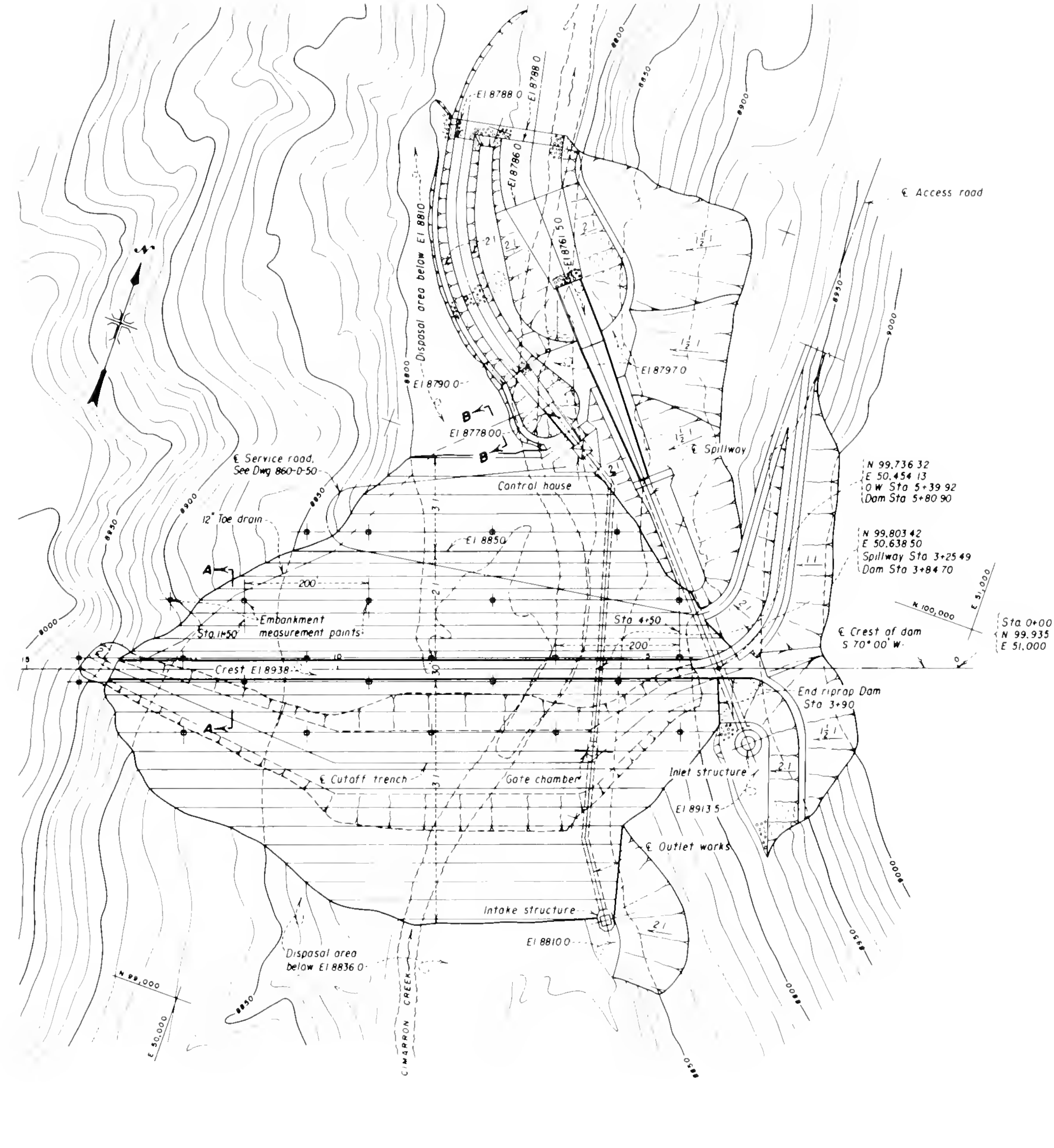
Storage Facilities

SILVER JACK DAM

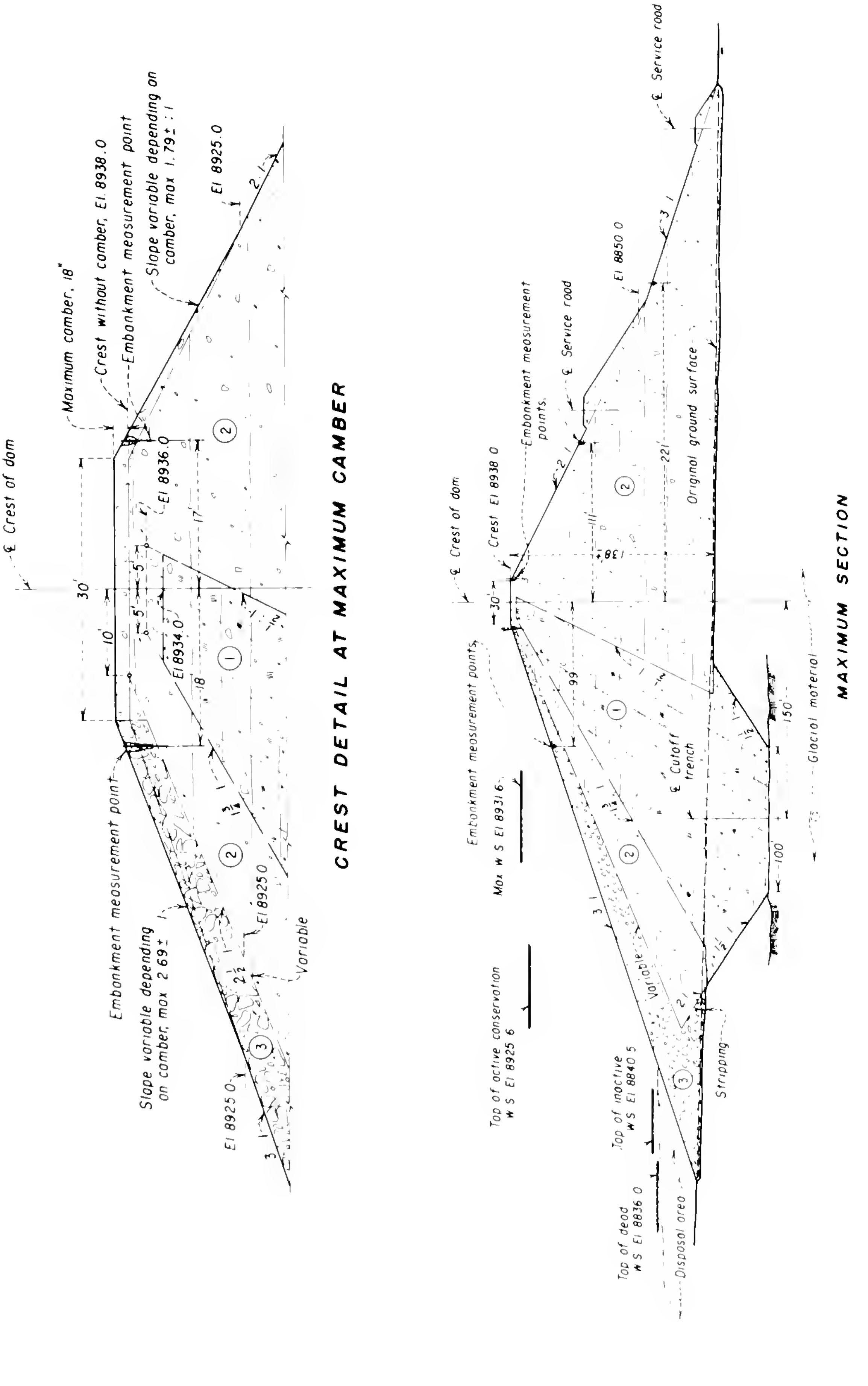
Type: Zoned earthfill
Location: Cimarron Creek about 20 mi above junction with Gunnison River.
Construction period: 1966-71
Reservoir. Silver Jack:

Total capacity	13,520	acre-ft
Active capacity	12,820	acre-ft
Surface area	293	acres
Dimensions:		
Structural height	173	ft
Width	30	ft
Crest length	1,050	ft
Volume	1,278,140	yd³

Outlet works: To Cimarron Creek in right abutment, capacity 280 ft³/s at normal surface elevation of 8926 ft; capacity of 160 ft³/s at minimum surface elevation of 8840 ft. Spillway on right abutment is an uncontrolled ogee section with 6,220 ft³/s capacity at maximum surface elevation.



Silver Jack Dam, Plan



Silver Jack Dam, Sections

Boulder Canyon Project
All-American Canal System

California: Imperial and Riverside Counties

Lower Colorado Region
Water and Power Resources Service

The All-American Canal System, located in the southeastern corner of California, consists of the Imperial Diversion Dam and Desilting Works, the 80-mile All-American Canal, the 123-mile Coachella Canal, and appurtenant structures. The system has the capacity, through water diversions from the Colorado River at Imperial Dam, to irrigate about 530,000 acres of fertile land in the Imperial Valley and about 78,530 acres in the Coachella Valley. No power is developed on the system by the Federal Government. The Imperial Irrigation District has constructed powerplants at Pilot Knob Check and Wasteway, and Drop Nos. 2, 3, and 4 of the All-American Canal.

PLAN

Water for irrigation is diverted at Imperial Dam into the All-American Canal. The canal and its main branch, the Coachella Canal, carry water to the project areas where it is delivered to the land through distribution systems.

Imperial Dam and Desilting Works

The Imperial Dam and Desilting Works are situated on the main channel of the Colorado River 303 miles south of Hoover Dam and 18 miles northeast of Yuma, Ariz. The dam raises the water surface 23 feet and is designed to pass an assumed maximum flood of 180,000 cubic feet per second. This feature provides diversion and desilting facilities for 15,155 cubic feet per second in the All-American Canal on the California side and for 2,200 cubic feet per second in the Gila Gravity Main Canal, for the Gila Project on the Arizona side.

Although Imperial Dam creates a reservoir that originally had a capacity of 85,000 acre-feet, this storage was not considered a project feature and, as anticipated, the reservoir quickly filled with sediment. This condition requires intermittent dredging and sluicing of the reservoir to maintain 1,000 acre-feet of storage for maximum delivery of water to the Gila Project.

The dam is a reinforced concrete structure of the monolithic slab-and-buttress type, consisting of an overflow weir with canal headworks at each end and a sluiceway between the weir and the California end. The dam is 3,475 feet long, including a 510-foot rockfill dike at the Arizona end. The overflow section of the dam is 1,198 feet long.

A sluiceway controlled by radial gates was installed on the California side of the river between the overflow weir and the headworks for the All-American Canal. The sluiceway channel, into which the silt removed by the desilting works is discharged, extends about 3,000 feet downstream from the sluice gates and has rockfill training dikes on each side of the channel. Diversion into the channel is controlled by four roller gates, each 75 feet long and 23 feet high.

The desilting works consist of six settling basins, arranged in pairs. Each pair of basins is fed by an influent channel. The silt is returned to the California sluiceway channel by gravity flow. Removing most of the sediment from the water as it leaves the dam prevents clogging of the canals and associated difficult and expensive maintenance problems.

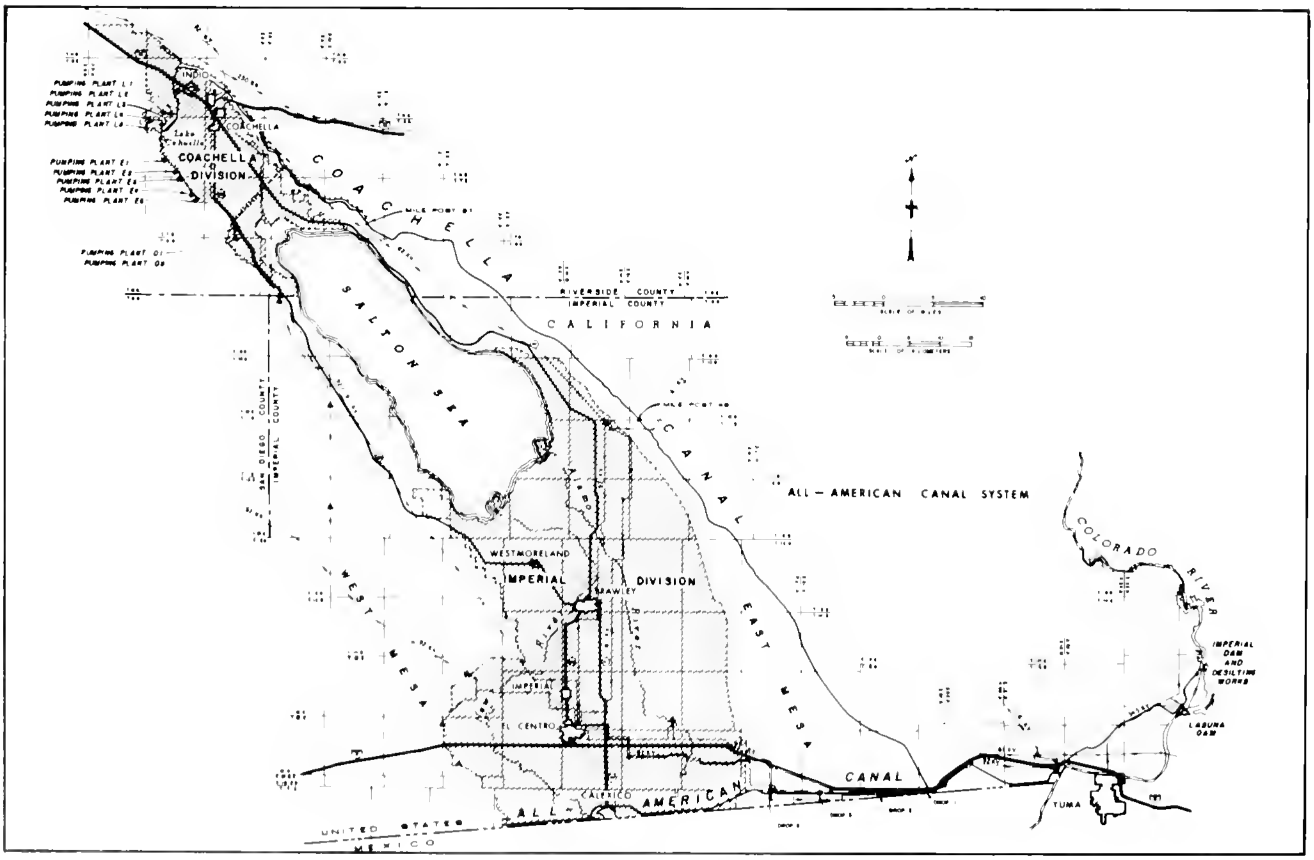
All-American Canal

The All-American Canal serves the Imperial and Coachella Valleys in southern California and the Yuma Project in both California and Arizona. Colorado River water is discharged through the headworks into a concrete-lined channel approximately 360 feet wide which is divided into four channels directing the water into desilting basins. The initial capacity of the canal is 15,155 cubic feet per second (approximately 30,060 acre-feet per day). It has a width of 232 feet at normal water surface and the bottom width is 160 feet. The depth is 21 feet and the quality of the water diverted at Imperial Dam in 1976 averaged 823 parts per million.

The initial capacity remains unchanged for a distance of 14.7 miles to Siphon Drop, at which point 2,000 cubic feet per second of water can be delivered to the Yuma Project through Siphon Drop Powerplant.[1]

[1] The Siphon Drop Powerplant was shut down in December 1972.

Imperial Dam Desilting Works, All-American Canal Head Works, and the Gila Valley Canal Headworks



All-American Canal System

From this powerplant to Pilot Knob, about 6 miles, the capacity of the All-American Canal is 13,155 cubic feet per second. At Pilot Knob, the water may be discharged into the Colorado River through the Pilot Knob Wasteway. Mexican Treaty water and other water which would otherwise pass down the river at Imperial Dam may be diverted through the All-American Canal to Pilot Knob, and there be discharged through the Pilot Knob Powerplant back to the Colorado River in the United States. From Pilot Knob, for 15.5 miles to the takeout point of the Coachella Canal, the All-American Canal has a capacity of 10,155 cubic feet per second. Continuing west, parallel to the Mexican border for approximately 44 miles, the canal gradually reduces in capacity from 7,755 to 2,655 cubic feet per second where it connects with Imperial Irrigation District's previously constructed Westside Canal, about 10 miles west of Calexico and 80 miles from Imperial Dam. In addition, the required irrigation capacity of the All-American Canal was designed to carry 155 cubic feet per second of Colorado River water for the City of San Diego, Calif.

The total length of canals and drains operated and maintained by the Imperial Irrigation District is about 8,213 miles. The distribution system was constructed by the district and consists of 1,474.5 miles of laterals. The drainage system consists of about 106 miles of closed drains and 1,348 miles of open drain. The district has constructed hydroelectric powerplants at Pilot Knob and Drop Nos. 2, 3, and 4 with capacities of 33,000, 10,000, 9,800, and 19,600 kilowatts, respectively.

Coachella Canal

After its turnout from the All-American Canal at Drop No. 1, the original Coachella Canal proceeds in a northwesterly direction for a distance of 123 miles, of which the first 86 miles are unlined. The remaining 37 miles are concrete lined. Initial diversion capacity of the unlined section was 2,500 cubic feet per second.

Shortly after the canal's completion in 1948, seepage losses developed as a result of the first 86 miles of waterway length being unlined. The problem was further aggravated by the fact that the initial 49 miles traversed the coarse sandy soils of the Imperial East Mesa, where the most severe seepage occurred. During 1955-70, the average seepage loss in this 49-mile reach of the canal was 141,000 acre-feet per year, or a 28.3 percent loss of the total canal flow.

As part of the Colorado River Basin Salinity Control Project, Title I, Public Law 93-320, June 24, 1974, the Congress provided for lining of the first 49 miles of the canal to recover most of the water lost by seepage.

Construction of the new concrete-lined canal will extend from the turnoff point on the All-American Canal to milepost 49, where it will rejoin the present canal just upstream from Siphon No. 7. The Coachella Canal replacement is scheduled for completion in fiscal year 1981. The existing reach of the original 49 miles of unlined canal from the All-American Canal to Siphon No. 7, together with irrigation turnouts, drop structures, siphons, and other unsalvageable components, will be abandoned or buried.

The Coachella Valley County Water District's distribution system, designed and constructed by the Bureau of Reclamation, is largely underground. It consists of gravity flow concrete pipelines, with a few small pumping plants serving the higher areas. The network of laterals totals about 495 miles.

Completed in 1949, the protective floodworks along the east side of the Coachella Valley consist of two detention dikes along the canal and three wasteways to carry floodwaters impounded by the dikes to natural drainage channels, and protect the main canal and distribution system from possible storm damage.

DEVELOPMENT

Early History

The Imperial Valley lies between the Mexican boundary and the Salton Sea, bounded on the east by sandhills and on the west by the foothills of the San Diego Mountains.

Coachella Valley is located in the Salton Sea Basin. It lies partly in Riverside County and partly in Imperial County, California. The valley is surrounded on all sides but the south by mountains and is about 50 miles long, 1 mile wide at the northern end, and 11 to 12 miles wide in the center. Ground water is present and before the Coachella Canal was constructed the land was irrigated with water from private wells.

In 1853, interest was aroused in the possibility of irrigating these lands from the Colorado River. The legislature of California, in 1859, asked the Congress to cede 3 million acres to the State of California for reclamation by irrigation. The Public Lands Committee of the House of Representatives acted favorably on this application, but in 1862 the bill failed to pass. The route proposed for the canal was practically the same as that used 40 years later for the Alamo Canal.

The Colorado River Irrigation Company was formed in 1891-92 and the entire problem of irrigating the Colorado River delta was carefully examined and important features worked out, but financial difficulties brought about failure of this company. The California Development Company, formed in 1896, succeeded where the original company had failed and construction was begun in 1900.

The first project to irrigate Imperial Valley was Alamo Canal. The canal delivered water to the upper channel of the Alamo River, which flows north toward the Salton Sea in the valley center, offering suitable opportunities for developing auxiliary distribution structures. By September 1904, nearly 8,000 valley settlers were operating 700 miles of canals and irrigating 75,000 acres.

The Alamo Canal, however, was difficult to operate without upstream control of the Colorado River. The channel required almost constant dredging to control silt, and an extensive levee system was constructed for protection from flood damages. In spite of these precautions, the Colorado River, while carrying a major flood from the Gila River Basin, washed out the Alamo Canal heading in 1905. The river partially changed its course to follow the canal and the Alamo River into the Salton Sea. Water flowed into the interior for nearly 2 years and inundated some 330,000 acres. The Southern Pacific Railroad Company, alarmed about the threat to the prospering Imperial Valley and to the railroad through the basin, finally returned the Colorado River to its natural channel on February 10, 1907, and controlled diversion of irrigation water through the Alamo Canal was resumed.

Investigations

Although the feasibility of constructing a canal wholly within the United States was studied as early as 1876, a report in 1919 covered the first complete survey and cost estimate for an All-American Canal. The Congress, desiring additional information, authorized an examination which resulted in a report which recommended control of the Colorado River by a multiple-purpose reservoir project at or near Boulder Canyon, and the construction of a high-line canal, together with a diversion dam and desilting works, to carry diverted water into the Imperial Valley.

Authorization

The All-American Canal System was authorized under the Boulder Canyon Project Act of December 21, 1928 (45 Stat. 1057).

Construction

Construction of the All-American Canal began in 1934, following the construction of Hoover Dam. The first irrigation water was delivered in 1940. The construction of Imperial Dam and Desilting Works began in January 1936 and was completed in July 1938. Coachella Canal was built during the period from August 11, 1938, to June 1948. Construction was interrupted by World War II, and work stopped from 1942 to 1944. Construction of the Coachella distribution system was initiated in 1948 and completed in 1954.

Operating Agency

The All-American Canal, below Pilot Knob Check and Wasteway at Station 1098, was transferred to the Imperial Irrigation District for operation and maintenance on March 1, 1947. Imperial assumed operating responsibility for those works above Pilot Knob Check and Wasteway and for the first 49 miles of the Coachella Canal (Station 0 to 2604) on May 1, 1952.

The Coachella Canal and protective works below Station 2604 were transferred to the Coachella Valley County Water District on March 25, 1949. The distribution system in the Coachella Valley was transferred to the Coachella District for operation and maintenance in 1954.

BENEFITS

Irrigation

With an assured water supply, the increase in production of farm crops in the Imperial and Coachella Valleys has been phenomenal. The soils of these two valleys, combined with a favorable climate, have long been noted for production of fruits and vegetables that reach the market during the winter season when shipments from other areas are either nonexistent or at a minimum. The Nation's domestic date gardens are concentrated primarily in the Coachella Valley, with 90 percent of this country's production originating there. Other principal crops on irrigated farms are alfalfa, lettuce, cotton, carrots, citrus fruits, cantaloupes, watermelons, barley, tomatoes, flax, sugar beets, grapes, sweet corn, and bell peppers.

Recreation

Imperial Dam forms a reservoir area with a nearly stable water surface elevation of 181 feet above sea level. Camping, hunting, picnicking, swimming, boating, and year-round fishing for bass, catfish, bluegill, and crappie are popular activities in the reservoir area.

PROJECT DATA

Land Areas (1977)

Full irrigation service:		
Service available	598,036	acres
Ultimate service	632,562	acres
Number of irrigated farms	5,658	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	493,437	226,671,077
1969	494,856	223,540,625
1970	482,976	213,898,853
1971	487,234	251,308,615
1972	490,457	276,610,521
1973	498,245	385,108,295
1974	504,704	471,461,272
1975	511,659	513,825,849
1976	514,546	503,292,216
1977	515,540	435,347,931

Facilities in Operation

Storage dams[2]	0	
Diversion dams	1	
Canals[3]	203	mi
Laterals[3]	463	mi
Coachella distribution system	495	mi
Imperial distribution system[4]	1,474	mi
Pumping plants[5]	17	
Drains, Coachella[3]	16	mi
Drains, Imperial[4]	1,454.5	mi
Powerplants[6]	4	

[2]See Boulder Canyon Project statistics.
[3]Reclamation constructed. (Onfarm drains in 1976, 2,038 mi, drains maintained by the district include 163 mi of pipeline and 20 mi of open ditch.)
[4]Imperial Irrigation District construction.
[5]Seventeen constructed by Reclamation. Five additional pumping plants have been constructed by the CVCWD.
[6]Imperial Irrigation District powerplants.

Climatic Conditions

Annual precipitation	3	in
Temperature:		
Maximum	107	°F
Minimum	26	°F
Mean	73	°F
Growing season	365	days
Elevation of irrigable area	75 to −229.0	ft

Settlement

Number of persons served with project water (1977):[7]	
Farm irrigation service	14,446
Other water service[8]	39,576
Municipal water service	65,752
Total	119,774

[7]Boulder Canyon Project water.
[8]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Diversion Facilities

Imperial Dam

Location: Colorado River, 18 mi northeast of Yuma, Ariz.
Construction period: 1936-38
Type: Concrete slab and buttress, ogee weir

Dimensions:

Structural height, overflow section	31	ft
Structural height, nonoverflow section	85	ft
Hydraulic height	23	ft
Base width of weir	76	ft
Crest width, nonoverflow section	12	ft
Crest length, overflow section	1,198	ft
Total length	3,475	ft
Crest elevation, overflow section	181.0	ft
Crest elevation, nonoverflow section	196.25	ft
Volume	196,800	yd³

Spillway: Overflow ogee weir.
Overflow capacity at reservoir stage 191 ..... 180,000 ft³/s

All-American Canal Headworks: Adjacent to California abutment. Concrete-lined channel 360 ft wide, controlled by four 75- by 23-ft roller gates. Downstream from the gates, four channels direct water into the desilting basins.
Diversion design capacity ..... 15,155 ft³/s

Sluiceway: Just east of the All-American Canal Headworks. (Concrete-lined channel, bottom width ranges from 241.5 to 216 ft, controlled by twelve 16- by 8-ft radial gates.
Design capacity:
Upstream water surface at El. 191 ..... 42,500 ft³/s
Upstream water surface at El. 179.5 ..... 31,000 ft³/s

Gila Gravity Main Canal Headworks: Adjacent to Arizona abutment. Concrete-lined channel controlled by three 35.67- by 14.5-ft radial gates.
Design capacity ..... 2,200 ft³/s

Service bridge consists of a concrete deck carried by 4 plate-girder spans 91.5 ft long overall and 76 ft between bearings. The single lane has design load of 20 tons. Maintenance bridge consists of eight 37-ft spans supported on concrete pile bents with concrete caps.

All-American Canal Desilting Works

Adjacent to the All-American Canal Headworks, three desilting basins are laid off at an angle of 60 degrees from the intake canal and each is divided into half by a long V-shaped influent channel. The dimensions of each half-basin are 269 ft wide by 769 ft long. Each basin is designed to handle a maximum of 2,000 ft³/s and each pair of basins is fed by an influent channel. Twelve rotating scraper mechanisms are installed in each half-basin to collect and remove the silt that settles out of the water. The water depth is 12.5 ft. The velocity of water is about 0.25 ft/s. Silt deposited in the basins during the passage of water from influent to effluent channels is removed by means of 72 rotary-type scrapers, each 125 ft in diameter, which force the deposited silt into collecting trenches from which it is flushed into a system of sludge disposal pipes, to the sluiceway channel, and then into the Laguna Settling Basin about 2 mi south of Imperial Dam.

The designed desilting capacity at a canal discharge rate of 12,000 ft³/s equals 70,000 tons per day; 600,000 to 700,000 yd³ of sediment are removed annually.

Gila Canal Desilting Works, Gila Gravity Main Canal

The Gila Canal Headworks were constructed at the Arizona end of Imperial Dam. Downstream from this structure, the desilting works for the Gila Gravity Main Canal were installed. The Gila desilting works consists of one concrete-lined basin with space allowed for the construction of two additional basins. This basin was designed for desilting a maximum flow of 2,200 ft³/s. It is formed by two levees extending perpendicularly to the axis of Imperial Dam on either side of the third gate structure of the Gila Canal Headworks. The basin is roughly 1,175 ft long, including inlet and outlet transitions. The bottom width ranges from about 115 to 104 ft between the transitions. The average depth of water is about 20 ft, and the average velocity is 0.66 ft/s. Flow from the basin is controlled by two sets of eight 7- by 16-ft fixed wheel gates, one set located above the other. The upper eight are for diverting and the lower eight are used during sluicing operations. The sluicing water is returned to the river by a curved channel 1,800 ft long. The Gila Canal desilting works are capable of removing about 8,130 tons per day.

Carriage Facilities

All-American Canal, Imperial Division

Location: From Imperial Dam west-southwest about 80 mi to the vicinity of Calexico, Calif.
Construction period: 1934-40

Length	80 mi
Diversion capacity	15,155 ft³/s
Typical maximum section (earth lined):	
Bottom width	160 ft
Side slopes	1.75:1
Water depth	21 ft

Lining: 4-in compacted clay on bottom; 6-in loose clay on sides.

New River Siphon (All-American Canal)

Location: At the New River, about 2 mi west of Calexico, Calif.
Construction period: 1937-38
Description: Twin barrels welded 0.5-in thick, plate-steel pipes on reinforced concrete piers resting on reinforced concrete pile footings.

Length of the double-barrel facility	374 ft
Diameter each barrel	15.5 ft
Capacity	2,700 ft³/s
Distribution system:[9]	
Main canals open channel 276.1 mi, concrete lines 8.4 mi	284.5 mi
Lateral canals open channel 777.57 mi, concrete-lined 688.68 mi, pipeline 8.25 mi	1,474.5 mi

Coachelle Canal, Coachella Division

Location: From Drop No. 1 on All-American Canal, about 18 mi west of Yuma, Ariz., northwest to vicinity of Indio, Calif.
Construction period: 1938-48

Length	123 mi
Diversion capacity	2,500 ft³/s
Typical maximum section (earth lined):	
Bottom width	40-60 ft
Side slopes	2:1
Water depth	10.3 ft
Lining, clay-blanket	12 in
Typical maximum section (concrete lined):	
Capacity, Milepost 86	1,300 ft³/s
Bottom width	12 ft
Side slopes	1.5:1
Water depth	10.8 ft
Lining thickness	3.5 in

[9]Constructed and operated by the Imperial Irrigation District.

Coachella Canal Replacement[10]

Distribution system, underground concrete pipe. Pipe sizes range from 1 to 7 feet in diameter	495 mi

Pumping Plants (Coachella Valley Distribution System)

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Unit 8:				
L-1	3	16.8	45	120
L-2	4	39	37	230
L-3	3	11.4	17-32.5	47.5
L-4	4	46.8	40	300
L-5	6	36.9	35-37	160
L-6	2	9	37	50
Unit 5:				
Coachella 0-1	2	21	38	120
Coachella 0-2	2	6	42	40
Unit 3:				
Small relift plants	4	12	7-11	
Unit 7:	5	30.8	11.5-48	

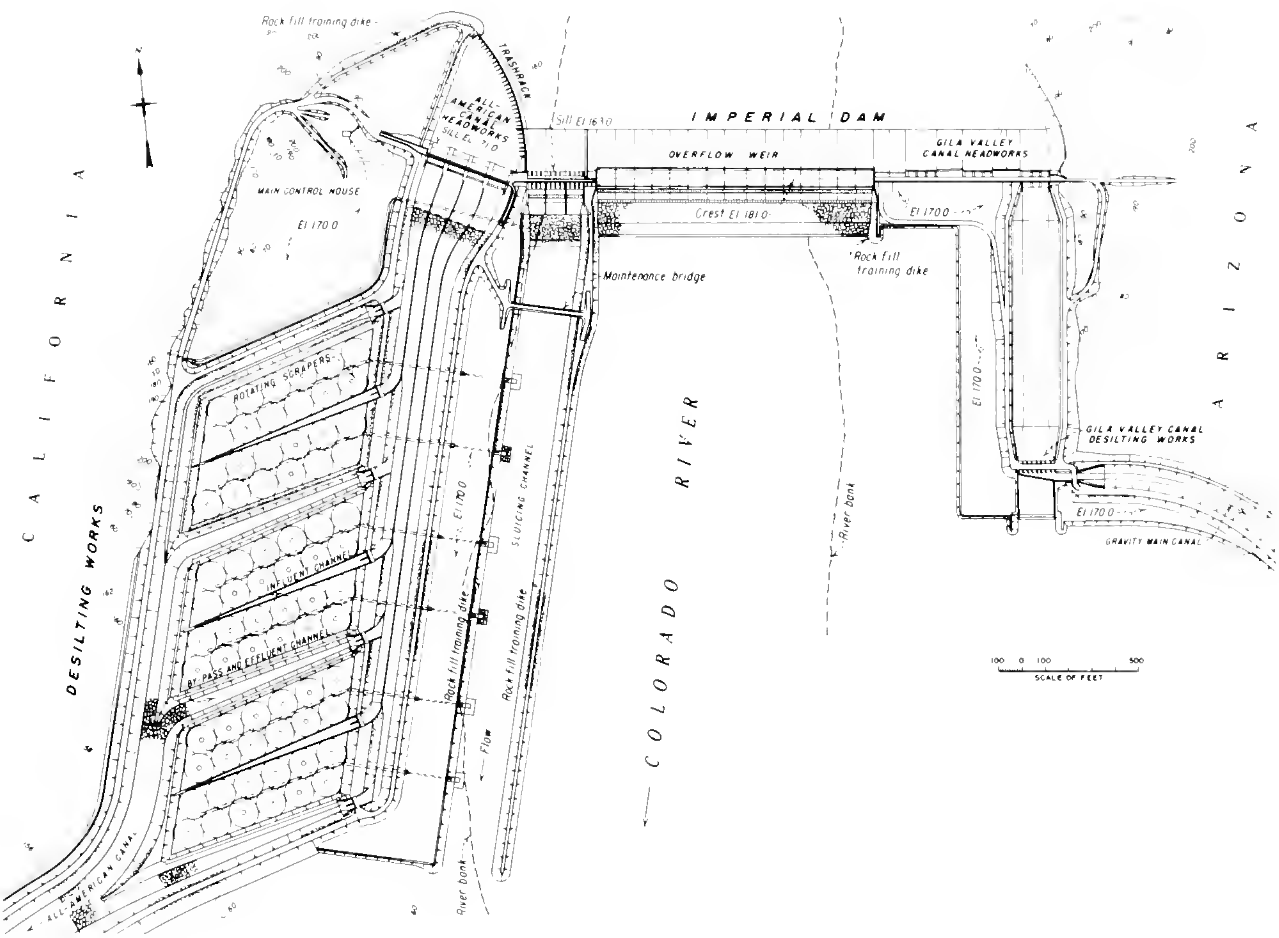
[10]For data on the Coachella Canal Replacement of the first 49 mi, see the Colorado River Salinity Control Project, Title I.

Power Facilities

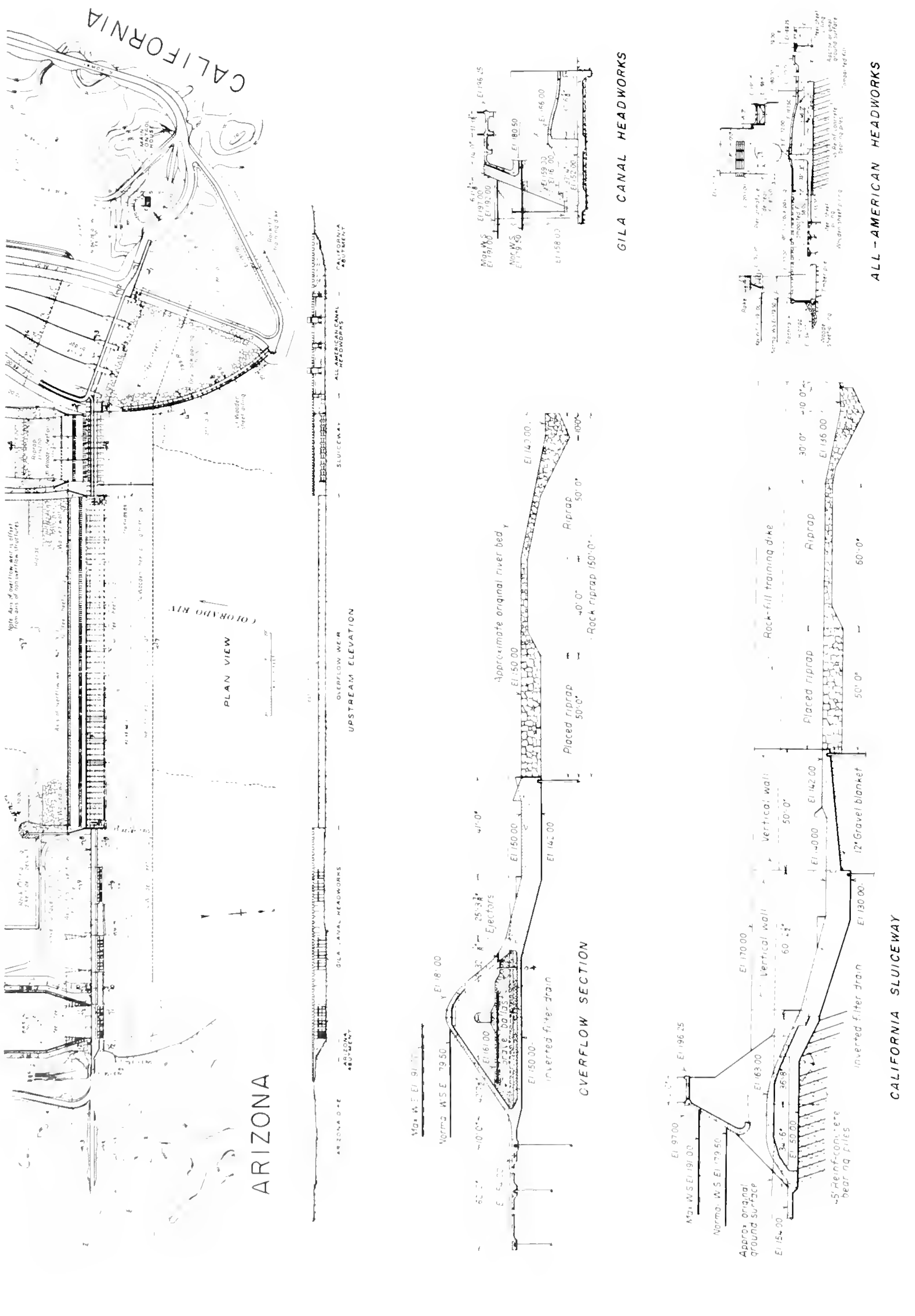
The Imperial Irrigation District has constructed powerplants at Pilot Knob Check and Wasteway, and at Drop Nos. 2, 3 and 4 of the All-American Canal. Installed capacities of these plants are:

Pilot Knob	33.0 MW
Drop No. 2	10.0 MW
Drop No. 3	9.8 MW
Drop No. 4	19.6 MW

The district also operates the 189.1-MW steam plant at El Centro. The 75-MW axis steam plant at Yucca is operated by the Arizona Public Service Company, but the Imperial Irrigation District has rights to 25-MW of the plant's production. Imperial's electrical distribution system interties with the Department of Energy's Parker-Davis system.



Imperial Dam, Plan



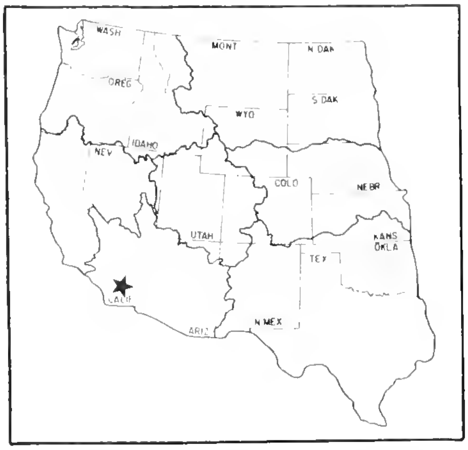
Imperial Dam, Plan and Sections

Boulder Canyon Project

All-American Canal System, Coachella Division Rehabilitation and Betterment Program

California: Imperial and Riverside Counties

Lower Colorado Region Water and Power Resources Service



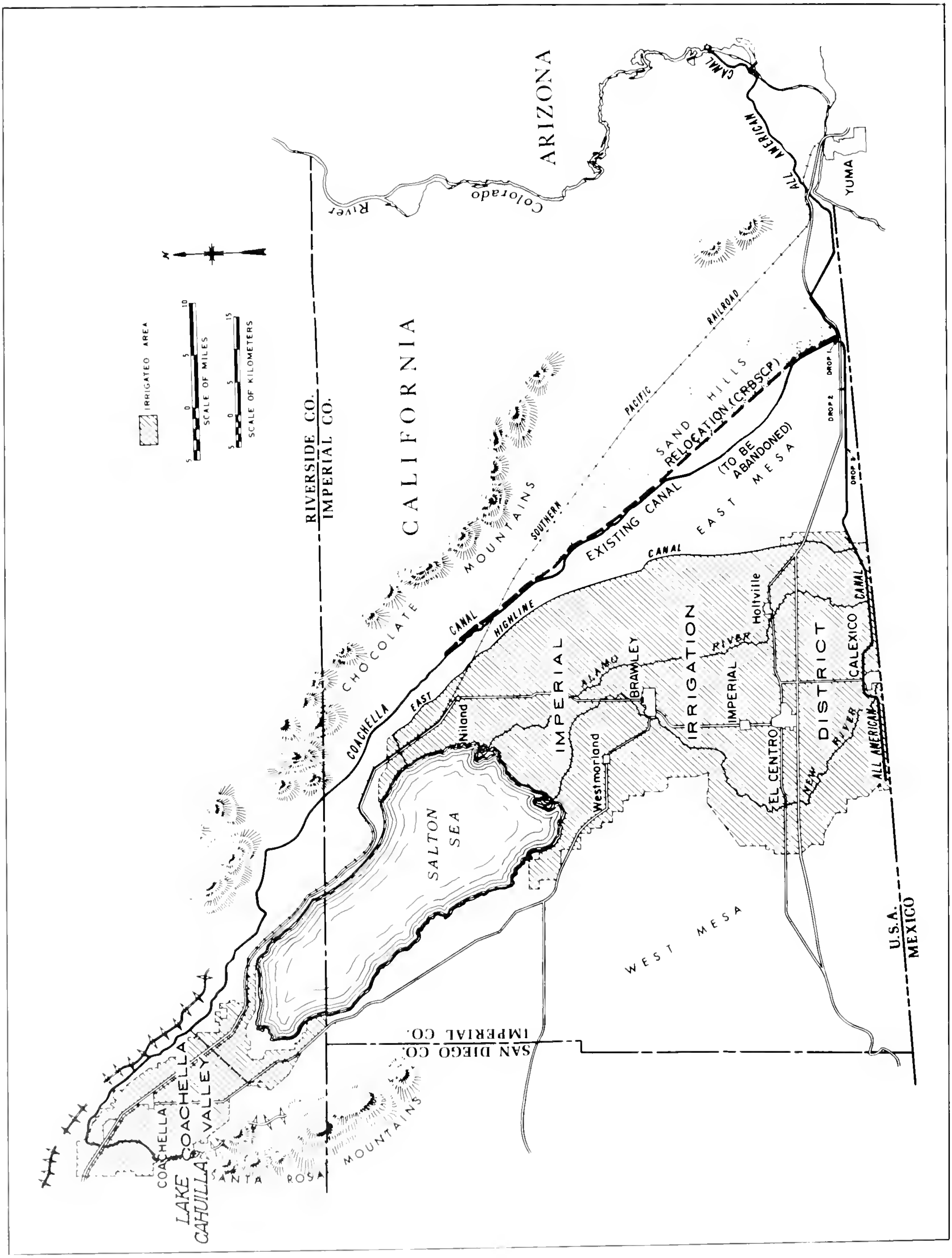
Experience in operating the irrigation facilities serving the Coachella Valley has revealed several deficiencies inherent in the canal and distribution system as constructed. The most serious were the lack of regulatory storage reservoirs along the main canal; lack of fine control on water movement through the main canal due to the distance between check structures and inability to reach those structures under certain conditions; the inability to get designed deliveries through farm turnout structures; and unexpected operating problems caused by accumulation of moss and debris in the main canal.

PLAN

The general nature and purpose of the rehabilitation and betterment (R&B) program was to install a supervisory remote control and telemetering system for operating the canal and distribution system; to construct a terminal reservoir, dikes No. 2 and 4, and Avenue 64 Evacuation Channel; and to install a traveling demossing screen, a new check gate, and rehabilitate an existing check gate in the canal. Dike No. 2 extends from near Avenue 58 to the north end of Coral Reef near Avenue 59. Dike No. 4 extends from the south end of Coral Reef from below Avenue 59 to below Avenue 65. These dikes protect the area from floodwaters discharged from the upstream canyons and provide detention reservoirs to store the floodwaters. The excess flows are released through the Avenue 64 Evacuation Channel, which extends about 6 miles to the Whitewater Storm Channel.

The terminal reservoir, Lake Cahuilla, at the end of the Coachella Canal on the west side of the valley, provides regulatory storage of irrigation water and impounds

Lake Cahuilla and Flood Control Dikes No. 2 and 4



All-American Canal, Coachella R&B

stormwaters from the mountains to the west. It also serves as a temporary reservoir for La Quinta area floodwaters. The lake is 3,960 feet long by 1,980 feet wide and 11 to 12 feet deep. It is lined with soil cement to prevent seepage.

DEVELOPMENT

History

The Boulder Canyon Project Act of December 21, 1928, authorized construction of an All-American Canal system to deliver irrigation water to Imperial and Coachella Valleys, California, and a distribution system in Coachella Valley. Construction of the underground distribution system, the first of its size and magnitude constructed by the Bureau of Reclamation, was completed in 1954.

The distribution system was transferred to the Coachella Valley County Water District for operation and maintenance on a section-by-section basis as each construction unit was completed. Formal transfer of the system was made in July 1954.

The facilities being operated and maintained by the district include 74 miles of the Coachella Canal and appurtenant flood control works, and an underground distribution system capable of serving about 78,530 irrigable acres. The system can serve about 70,000 acres; the remaining 8,530 acres are primarily Indian lands to which extensions and turnouts are being constructed by the district under contract of October 14, 1958, entered into with the Secretary of the Interior (Bureau of Indian Affairs) pursuant to the act of August 28, 1958 (72 Stat. 968). At the end of calendar year 1977, about 55,611 acres in the valley had been developed and were receiving Colorado River water through the federally constructed system. Several hundred additional acres under the system are irrigated entirely with ground water from private wells.

Investigations

The Coachella Valley County Water District initiated preliminary surveys and investigations in 1960 to develop a program of betterment and improvement which would eliminate most of the inadequacies and deficiencies in the original system. These investigations were followed by an application to the Bureau of Reclamation for a Federal loan to undertake the R&B on the irrigation system. A favorable report was completed in February 1961.

Authorization

The loan was authorized under the provisions of the Rehabilitation and Betterment Act of October 7, 1949 (63 Stat. 74), as amended March 3, 1950 (64 Stat. 11).

Construction

The R&B work was begun by the district in January 1964 and was essentially completed in 1977.

Operating Agency

The entire distribution system and the last 74 miles of the Coachella Main Canal are operated and maintained by the Coachella Valley County Water District (CVCWD).

BENEFITS

Benefits to the district are: (1) reduced operation and maintenance costs, (2) more reliable water service, (3) water conservation, (4) increased returns from crop production, and (5) flood control.

Recreation

The recreation facilities at Lake Cahuilla were developed by the Riverside County Department of Parks under a lease agreement with the CVCWD. Picnicking, swimming, camping, boating, and fishing for trout, bass, and catfish are popular activities.

PROJECT DATA

Land Areas (1977)

Full irrigation service:		
Available for service[1]	78,530	acres
Ultimate service	102,562	acres
Number of irrigated farms	578	

[1]Irrigable area not in service is 24,032 acres.

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	52,282	55,409,808
1969	52,867	51,396,104
1970	52,276	50,905,861
1971	52,371	59,725,882
1972	52,787	67,610,977
1973	54,082	67,569,464
1974	54,731	72,793,016
1975	55,369	94,050,538
1976	56,160	105,003,874
1977	55,611	107,213,284

Facilities in Operation

Canal length operated by CVCWD - 37 mi lined - 37 mi unlined	74	mi
Distribution system underground concrete pipe size varies from 1 to 7 ft diameter	495	mi
Pumping plants	22	
Drains:		
Open	27	mi
Underground - size 10- to 24-in - buried 7.5 to 15 ft	95	mi
Regulating reservoir	1	

Automatic traveling demossing screens (5 constructed under the R&B program)	10	units
Central control headquarters building	1	
Telemetering control (microwave and UHF circuits linking the panel in the headquarters building with more than 150 responsive stations including the 10-bank automatic debris screens).		

Climatic Conditions

Annual precipitation	3	in
Temperature:		
Maximum	120	°F
Minimum	20	°F
Mean	73	°F
Growing season	365	days
Elevation of irrigable area	75 to −230.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	4,671
Other water service[2]	36,253
Municipal water service	0
Total	40,924

[2]Urban, suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Coachella Canal

Terminal Reservoir, Lake Cahuilla.
Type: Earthen dike impoundment
Location: In Riverside County, Calif., near the Santa Rosa Mountains, about 8 mi from Indio on the west side of Coachella Valley.
Construction period: 1968-69

Dimensions:		
Structural height	18.6	ft
Top width	100	ft
Maximum base width	193	ft
Crest length	6,276	ft
Crest elevation	4.0	ft
Shoreline	5.25	mi
Slope (shore side)	2:1	
Slope (lake side)	3:1	
Reservoir capacity	1,300	acre-ft

Reservoir lining: Soil cement

Dike No. 2

Type: Earthen dike
Location: Southwesterly end of Lake Cahuilla between Avenue 58 and Coral Reef near Avenue 59.
Construction period: 1967-68

Dimensions:		
Structural height	20	ft
Top width	20	ft
Maximum base width	100	ft
Crest length	5,128	ft
Crest elevation	30.0	ft
Slope	2:1	

Dike No. 4

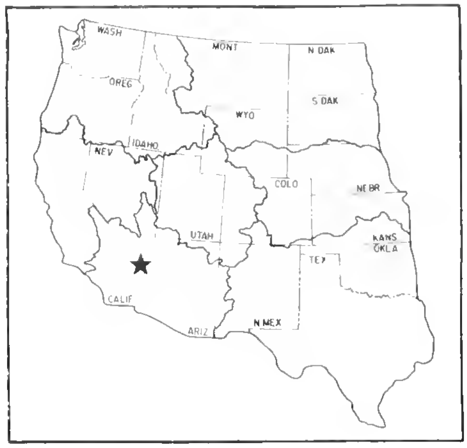
Type: Earthen dike
Location: From Coral Reef to Avenue 66 near Martinez Canyon west of the terminus of Avenue 66.
Construction period: 1967-68

Dimensions:		
Structural height	30	ft
Top width	20	ft
Maximum base width	140	ft
Crest length	18,480	ft
Crest elevation	26.0	ft
Slope	2:1	

Boulder Canyon Project
Hoover Dam

Arizona: Mohave County
Nevada: Clark County

Lower Colorado Region
Water and Power Resources Service



Hoover Dam is the highest and third largest concrete dam in the United States; the 1,344,800-kilowatt powerplant and high-voltage switchyards are located in the Black Canyon of the Colorado River, on the Arizona-Nevada State line. Lake Mead, the reservoir behind Hoover Dam, will hold the entire flow of the river for 2 years. This storage, in addition to providing for improvement of navigation, river regulation, and flood control, provides for the delivery of stored water for irrigation and other beneficial consumptive uses, and for the generation of electrical energy.

PLAN

Floodwaters of the Colorado River are impounded by Hoover Dam and released when needed for irrigation and power generation. Irrigation water stored in the reservoir is used in the All-American Canal System, the Gila, Yuma, Yuma Auxiliary, and Palo Verde Projects, and on the Colorado River Indian Reservation. A dependable supply of municipal, industrial, and irrigation water can be provided to the semiarid southern California coastal region. This supply is released from Lake Mead, diverted at Lake Havasu, and transported through the Metropolitan Water District's Colorado River Aqueduct to the district's area of use.

Hoover Dam and Lake Mead

Hoover Dam, located in the Black Canyon of the Colorado about 36 miles from Las Vegas, Nev., is a concrete thick-arch structure, 726.4 feet high and 1,244 feet long at the crest. The dam contains 3,250,000 cubic yards of concrete; total concrete in the dam and appurtenant works is 4,400,000 cubic yards. The reservoir behind the dam, Lake Mead, originally had a total capacity of 32,471,000 acre-feet. Based on the 1963-64 sedimentation survey with the water surface at elevation 1221.4 feet, the reservoir capacity had been reduced to 28,537,000 acre-feet, 88 percent of the original volume.

Diversion Works

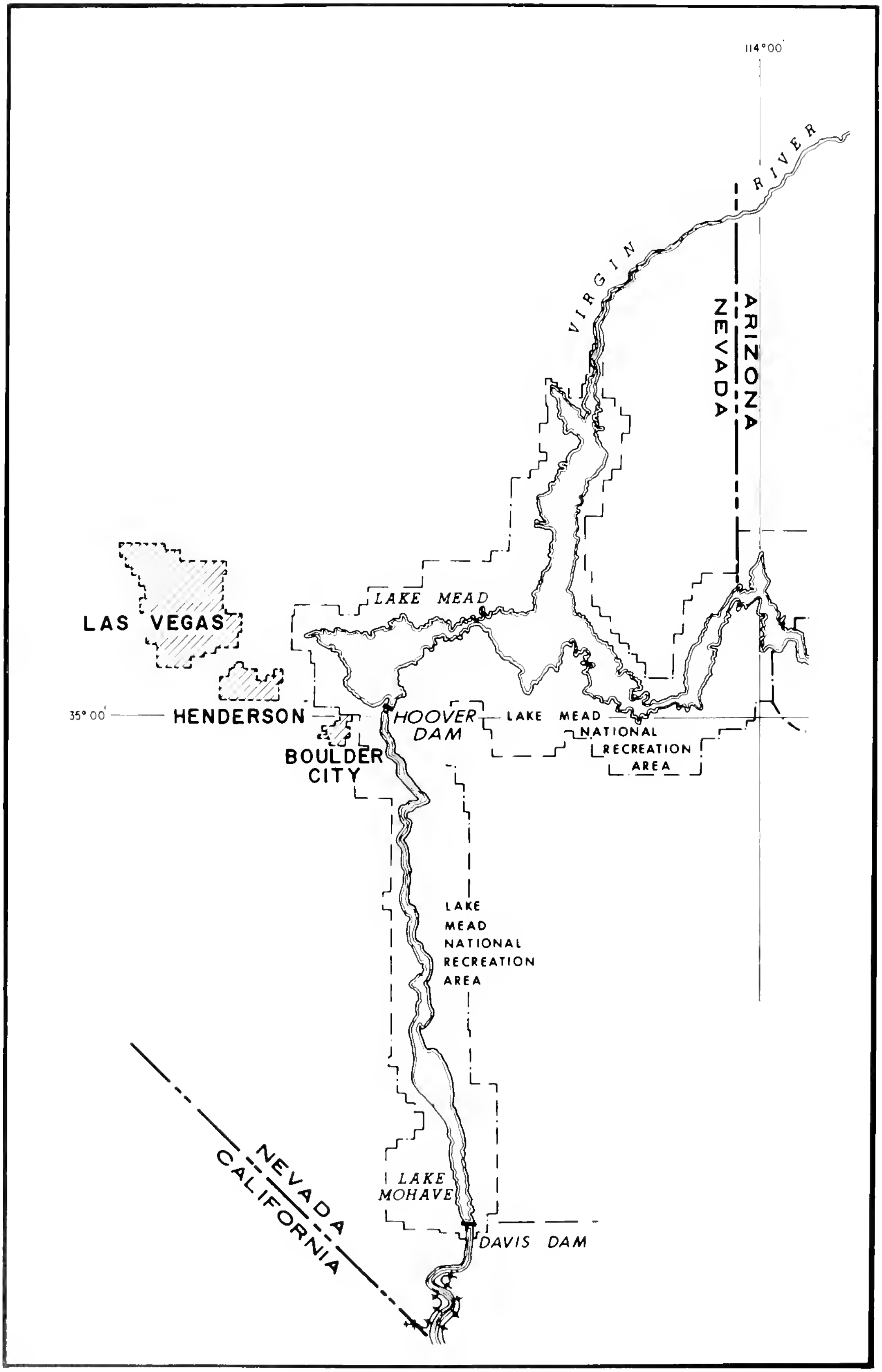
To bypass and control the river during construction, four 50-foot-diameter, concrete-lined tunnels, having an average length of about 4,000 feet, were constructed, two on each side of the river. When no longer needed for diversion purposes, the tunnels were plugged near the midpoints; the downstream sections were intercepted by and made a part of the spillway and outlet works tunnels. A total of 315,000 cubic yards of concrete was used to line the diversion tunnels.

Spillways

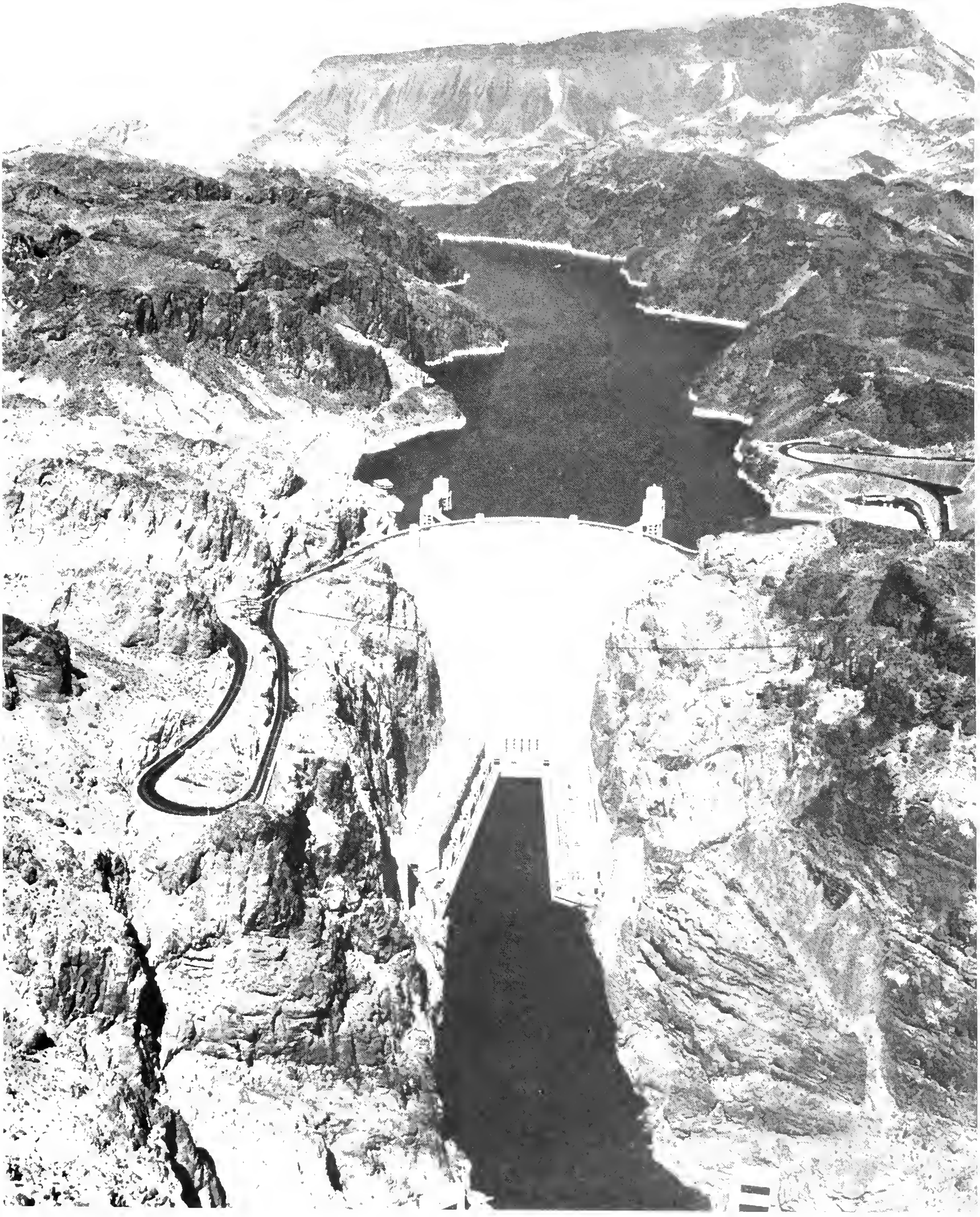
There are two drum-gate controlled, side channel spillways, one on each side of the canyon, each of which discharges through an inclined, concrete-lined tunnel connecting with the adjacent outer diversion tunnel downstream from the tunnel plug. The crest of each spillway is surmounted by three piers that divide it into four 100-foot sections, each equipped with a 16- by 100-foot automatically controlled drum gate. The combined capacity of the spillways is 63,000 cubic feet per second at reservoir surface elevation 1229.0 with gates in raised position, increasing to 400,000 cubic feet per second at elevation 1232.0 with gates in lowered position.

Outlet Works

Four combination penstock and outlet units are provided, each originating at one of the four intake towers upstream from the dam, and installed in a tunnel back of the dam abutments. The penstock and outlet units originating at the upstream intake towers are installed in the inner pair of the four tunnels originally used for river diversion. The two penstock and outlet units originating at the downstream intake towers are installed in tunnels located approximately 170 feet above the lower units. Beyond the penstock outlets, each downstream unit branches into six outlet pipes which terminate in the Arizona and Nevada canyon-wall valve houses.



Hoover Dam, Boulder Canyon Project



Hoover Dam

The capacity of canyon-wall and tunnel-plug outlets at reservoir water surface elevation 1221.4 feet is 44,800 cubic feet per second. The total capacity, including the powerplant penstocks, at elevation 1221.4 is 72,400 cubic feet per second.

Powerplant

The powerplant is located at the toe of the dam, and extends downstream 650 feet along each canyon wall. The turbines are designed to operate on heads ranging from 420 to 590 feet. With the installation in 1961 of the final generating unit, N-8, there are 17 main turbines in Hoover Powerplant with a rated capacity of 1,850,000 horsepower. Two station-service units, rated at 3,500 horsepower each, bring the plant total up to 1,857,000 horsepower. In terms of electrical energy, the total rated capacity for the plant is 1,344,800 kilowatts. This includes the two station-service units, rated at 2,400 kilowatts each.

DEVELOPMENT

Early History

By the treaty concluding the Mexican War in 1849, and by the Gadsden Purchase of 1853, the United States acquired the territories of New Mexico, Arizona, and California. Discovery of gold in California in 1849 brought hordes of adventurers westward. They crossed the Colorado River near Yuma, Ariz., and at Needles, Calif. In 1857, Lieutenant J. C. Ives traveled 400 miles up the river by boat to the Black Canyon, present site of Hoover Dam. He reported the region to be valueless.

In 1869, Major J. W. Powell of the Geological Survey succeeded in leading a river expedition down the canyon of the Colorado. The expedition traveled from Green River in Utah to the Virgin River in Nevada, over a thousand miles of unknown rapids and treacherous canyons.

Investigations

In 1875, a route was mapped for a canal to irrigate southern California's rich but arid land. Construction of the canal began about 20 years later, and in 1901 the first water from the Colorado River flowed through the Imperial Canal into the Imperial Valley.

The river, annually fed by melting snows in the Rocky Mountains, swelled to a raging flood in the spring, then dried to a trickle in the late summer and fall, so crops were frequently destroyed. Farmers built levees to keep out the river. Even when the levees held, however, crops withered and died during the months when the river ran too low to be diverted into the canals.

In 1905, a disastrous flood burst the banks of the river, which caused it to flow for nearly 2 years into what is now known as the Salton Sea. The river was eventually turned back into its original channel, but the continuing threats of floods remained.

Faced with constantly recurring cycles of flood and drought, residents of the Southwest appealed to the Reclamation Service to solve the problem. Engineers began extensive studies of the river in search of a feasible plan for its control. In 1918, a plan was conceived for regulation of the river by building a single dam of unprecedented height in Boulder Canyon. The Colorado River Compact, signed at Santa Fe, N. Mex., on November 24, 1922, allocated most of the river's flow between the upper and lower basins of the river and provided for later division of the surplus waters.

Authorization

The project was authorized by the act of December 21, 1928 (45 Stat. 1057), subject to the terms of the Colorado River Compact. The act authorized the construction of a dam and powerplant in either Boulder or Black Canyon, and the All-American Canal System in southern California. The Boulder Canyon Project Adjustment Act (54 Stat. 774), dated July 19, 1940, provided for certain changes in the original plan.

On October 1, 1977, in conformance with Public Law 95-91, the Department of Energy Organization Act of August 4, 1977, the power marketing function (including transmission lines and attendant facilities) of the Bureau of Reclamation was transferred to the Department of Energy. The operation and maintenance of the Federal hydroelectric generating plants along the Colorado River remain under the jurisdiction of the Bureau of Reclamation. Effective October 9, 1977, administration of the Boulder Canyon Project (Hoover Dam) and portions of the Parker-Davis Project was combined into one operational unit. This unit is administered by the Lower Colorado Dams Project Office.

Construction

The Boulder Canyon Project is characterized by the extraordinary. The height and base thickness of the dam, the size of the power units, the dimensions of the fusion-welded, plate-steel pipes, the novel system of artificially cooling the concrete, the speed and coordination of construction, and other major features of the project were without precedent. The magnitude of the construction introduced many new problems and intensified many usual ones, requiring investigations of an extensive and diversified character to ensure structures representing the utmost in efficiency, safety, and economy of construction and operation. Construction was begun in Black Canyon in 1931 and the dam was dedicated on September 30, 1935. The first generator of the powerhouse was in full operation on October 26, 1936. The last generator went into operation on December 1, 1961. In 1962, the construction railroad spur from Boulder City, Nev., to the dam was sold and removed.

Operating Agencies

The dam and powerplant building and their appurtenances are owned, operated, and maintained by the United States. The generating, transforming, and switching facilities are owned by the United States, but are operated and maintained by the Department of Water and Power of the city of Los Angeles and the Southern California Edison Company.

BENEFITS

Hoover Dam changed the once unruly Colorado River from a natural menace into a national resource. It is an outstanding example of the Reclamation multiple-purpose project. Its benefits encompass the whole concept of river control and provide protection from floods, water conservation for irrigation and other purposes, power generation, recreation, and preservation of fish and wildlife.

Irrigation

The project assures a dependable water supply for irrigating about 650,000 acres of land in southern California and southwestern Arizona, and over 400,000 acres in Mexico. An additional 150,000 to 250,000 acres may be brought under cultivation with full development of presently authorized projects. Each winter, lands irrigated by water from the Colorado supply large amounts of produce for the Nation's markets.

Hydroelectric Power

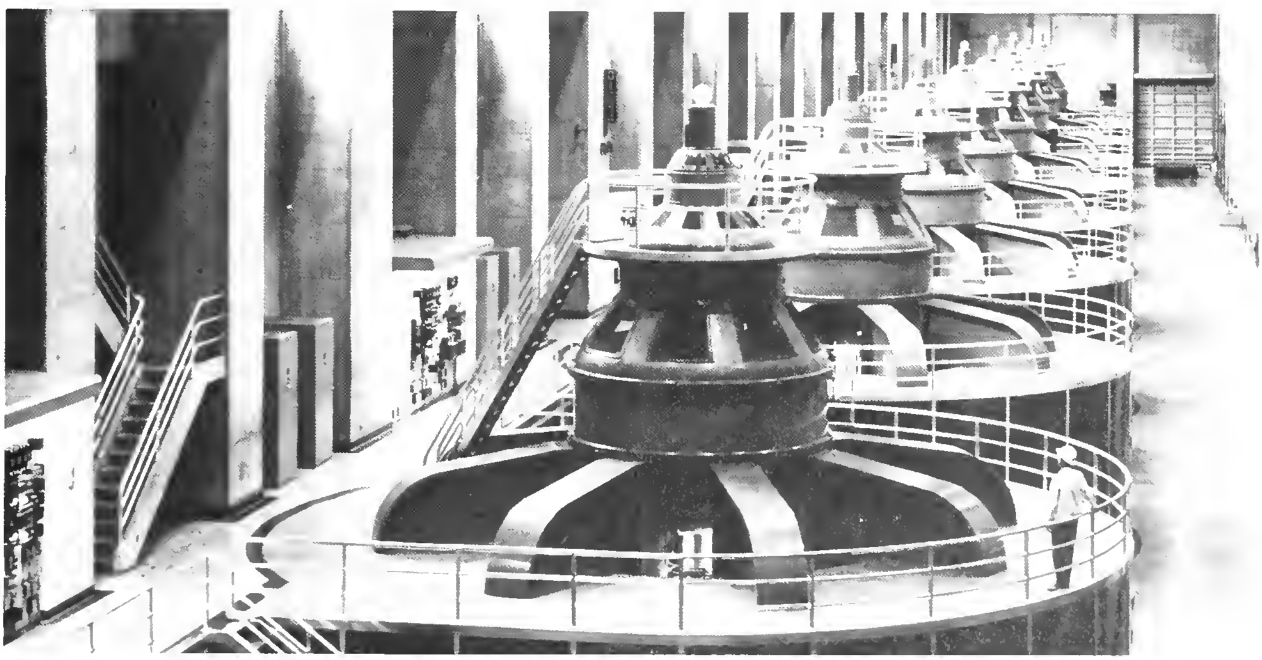
Hoover Dam is one of the world's largest producers of electric power. Energy generated at the Hoover Powerplant has been a boon to industrial expansion and has made living more comfortable in thousands of homes. The firm energy output approximates 4 billion kilowatt-hours annually.

Flood Control

Hoover Dam has virtually ended the possibility of devastating floods striking the lower reaches of the river as they did prior to project construction. The benefits from controlling floods are reflected in the $25 million of the project cost that was allocated by the Congress to flood control.

Recreation and Fish and Wildlife

Surrounded by rugged mountains and canyon walls, Hoover Dam and Lake Mead are outstanding scenic and recreation attractions. In 1978, the Lake Mead National Recreation Area, administered by the National Park Service, was visited by 6,879,870 people. Concessions provide facilities such as lodge and trailer accommodations, boats for hire, and sightseeing boat trips. Other popular activities are camping, picnicking, swimming, boating, water skiing, and year-round fishing for largemouth black bass and other game fish. A large part of the area is open to hunting.



Hoover Powerplant generators

PROJECT DATA

Land Areas (1977)

(These data are shown under the All-American Canal System and other projects on the lower Colorado River.)

Facilities in Operation

Storage dams	1	
Powerplants	1	
Transmission lines	16.40	mi
Substations	8	

Power Generation

Fiscal year	Hoover Powerplant output (kWh)
1968	2,881,016,000
1969	3,030,211,000
1970	3,168,732,000
1971	3,197,714,000
1972	3,284,946,000
1973	3,131,608,000
1974	3,582,007,000
1975	3,494,254,000
1976	3,567,733,000
1977	3,420,159,000

ENGINEERING DATA

Water Supply

Colorado River

Drainage area above Hoover Dam[1]	167,000	mi²
Annual discharge near Grand Canyon[2]:		
Maximum (1929)[3]	19,850,000	acre-ft
Minimum (1963)	1,629,000	acre-ft
Average	11,270,000	acre-ft
Discharge near Grand Canyon:		
Momentary maximum (July 2, 1927)[4]	127,000	ft³/s
Momentary minimum (December 28, 1924)	700	ft³/s
Average	15,570	ft³/s

[1]137,800 square miles near Grand Canyon.
[2]Grand Canyon Station is located 267.2 mi upstream from Hoover Dam.
[3]Recorded maximum. Estimated maximum of 25,200,000 acre-ft occurred in 1909.
[4]Other estimated maximums are 300,000 ft³/s on July 8, 1884, and 220,000 ft³/s on June 19, 1921.

Storage Facilities

Hoover Dam

Type: Concrete thick-arch
Location: On Colorado River, 7 mi northeast of Boulder City, Nev.
Construction period: 1931-36
Reservoir, Lake Mead:

Average annual inflow, 1923-78	12,600,000	acre-ft
Total capacity to El. 1229[5]	32,471,000	acre-ft
Total capacity to top of spillway gates, El. 1221.4[5]	31,250,000	acre-ft
Active capacity, elevations 1229 to 895[5]	29,248,000	acre-ft
Dead storage below El. 895[5]	3,223,000	acre-ft
Surface area at El. 1229	162,700	acres
Length	115	mi
Shoreline	550	mi
Maximum width	8	mi
Maximum depth	589	ft
Dimensions:		
Structural height	726.4	ft
Hydraulic height	576	ft
Top width	45	ft
Maximum base width	660	ft
Crest length	1,244	ft
Crest elevation	1232.0	ft
Total volume	4,400,000	yd³

Spillway: Concrete lined, side-channel gate-controlled overflow weir on each side of canyon discharging into inclined tunnel leading to portion of original diversion tunnel discharging downstream from dam. Each spillway is controlled by four 16- by 100-ft drum gates.

Elevation at top of gates	1221.4	ft
Crest elevation	1205.4	ft
Capacity both spillways:		
El. 1229, gates raised	63,000	ft³/s
El. 1232, gates lowered	400,000	ft³/s

Outlet works: Combination power and river outlet works consist of four intake towers, each controlled by two 32-ft-diameter cylinder gates, discharging into a portion of original diversion tunnel and another tunnel through each abutment. The four tunnels branch into a total of 16 power penstocks leading to powerplant sections on each side of the river, and a total of 12 outlet pipes terminating in outlet houses on each side of the stream.[6] In addition, a total of 8 outlet valves are installed in the diversion tunnels near the tunnel plug, and discharge through the tunnel to its downstream opening. Altogether, river releases are controlled by four 84-in needle valves and eight 72-in needle valves.

Capacity at El. 1221.4:		
River outlets	44,800	ft³/s
Power outlets	27,600	ft³/s

Foundation: Thoroughly cemented, dense, strong, durable andesitic breccia overlain by latite flow breccia, with inactive transverse faults upstream and downstream from the dam, and minor healed faults and shear zones within the foundation area.

Treatment: Upstream cement grout curtain with adjacent drainage holes; special grouting of nearby upstream shear zones; abutments grouted with arch under full-load deflection.

Mass concrete: Aggregate from terrace, 8 mi upstream; low-heat portland cement, 60:40 blend of low-heat and standard in winter.

Volume	3,251,140	yd³
Cement content	1.02	bbl/yd³
Water-cement ratio by weight	0.53	
Slump at mixer	3.5	in
Contraction joints:		
Radial spacing	25-60	ft
Circumferential spacing	30-50	ft

Joints grouted after cooling to ±10 °F below stable temperature.

Temperature control: Artificial, through embedded pipe system using first air-cooled water, then refrigerated water.

[5]Original capacities. Do not reflect siltation subsequent to construction. The 1948 resurvey of Lake Mead showed total capacity to El. 1229 of 31,047,000 acre-ft. Original total included 1,221,000 acre-ft flood control capacity between El. 1229 (top of flood control) and 1221.4 (top of spillway gates). Capacity at El. 1221.4 is 28,537,000 acre-ft (1963-64 sedimentation survey).
[6]Of the 12 outlet pipes, only four have valves. Seven are blocked and one supplies water to Boulder City, Nev.

Power Facilities

Hoover Dam Powerplant[7]

Location of powerhouses: At toe of Hoover Dam.
Year of initial operation: 1936
Year last generator placed in operation: 1961
Nameplate capacity:

Existing	1,344,800	kW
Number and nameplate capacity of generators:		
Existing (14) 82,500; (1) 95,000; (2) 2,400; (1) 50,000; (1) 40,000		kW
Maximum head	585	ft

Substations[8]

Number in operation	8	
Total kilovolt-ampere capacity of transformers	1,566,250	kVA

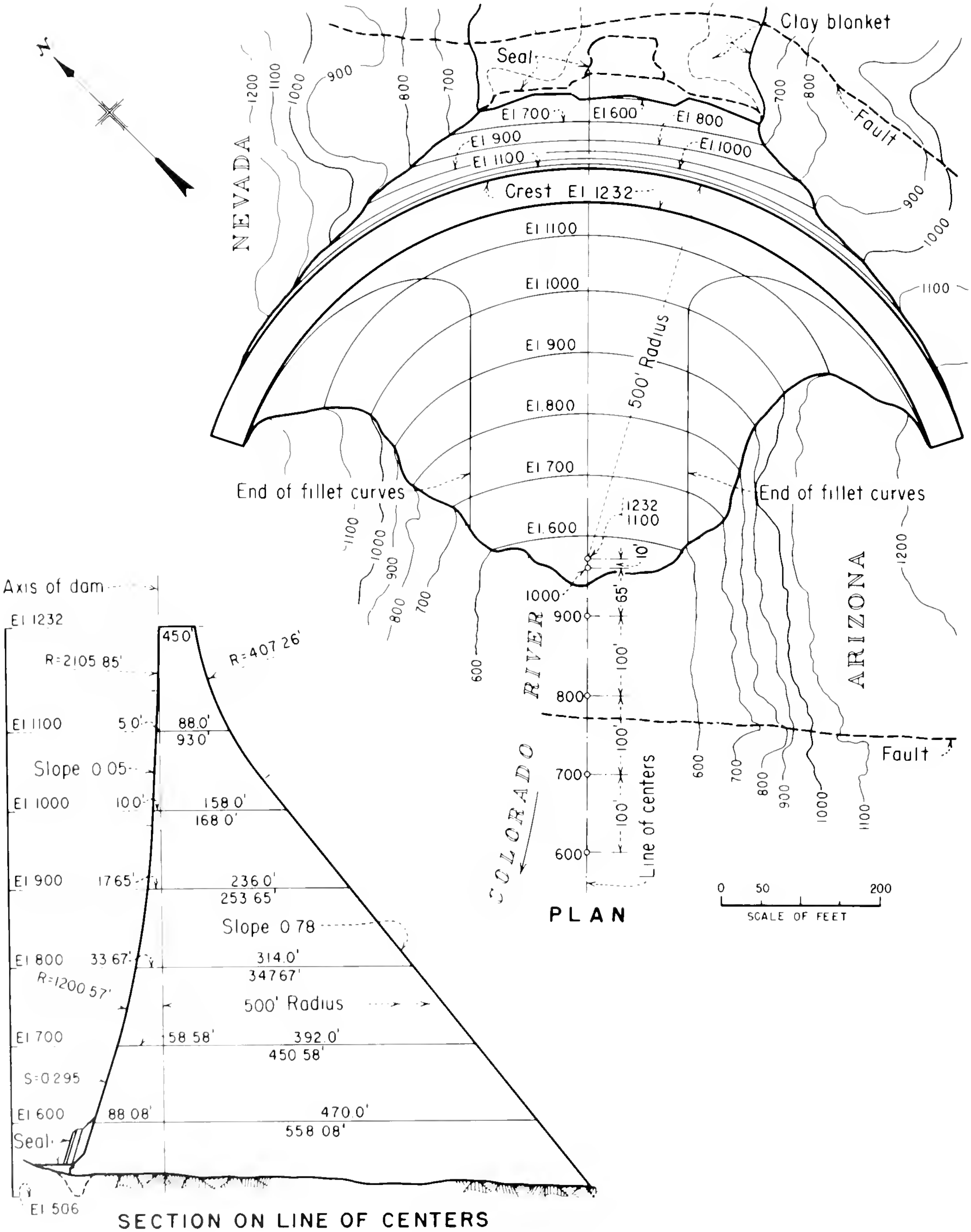
Transmission Lines

Total number of lines	18	
Total circuit miles	16.40	mi

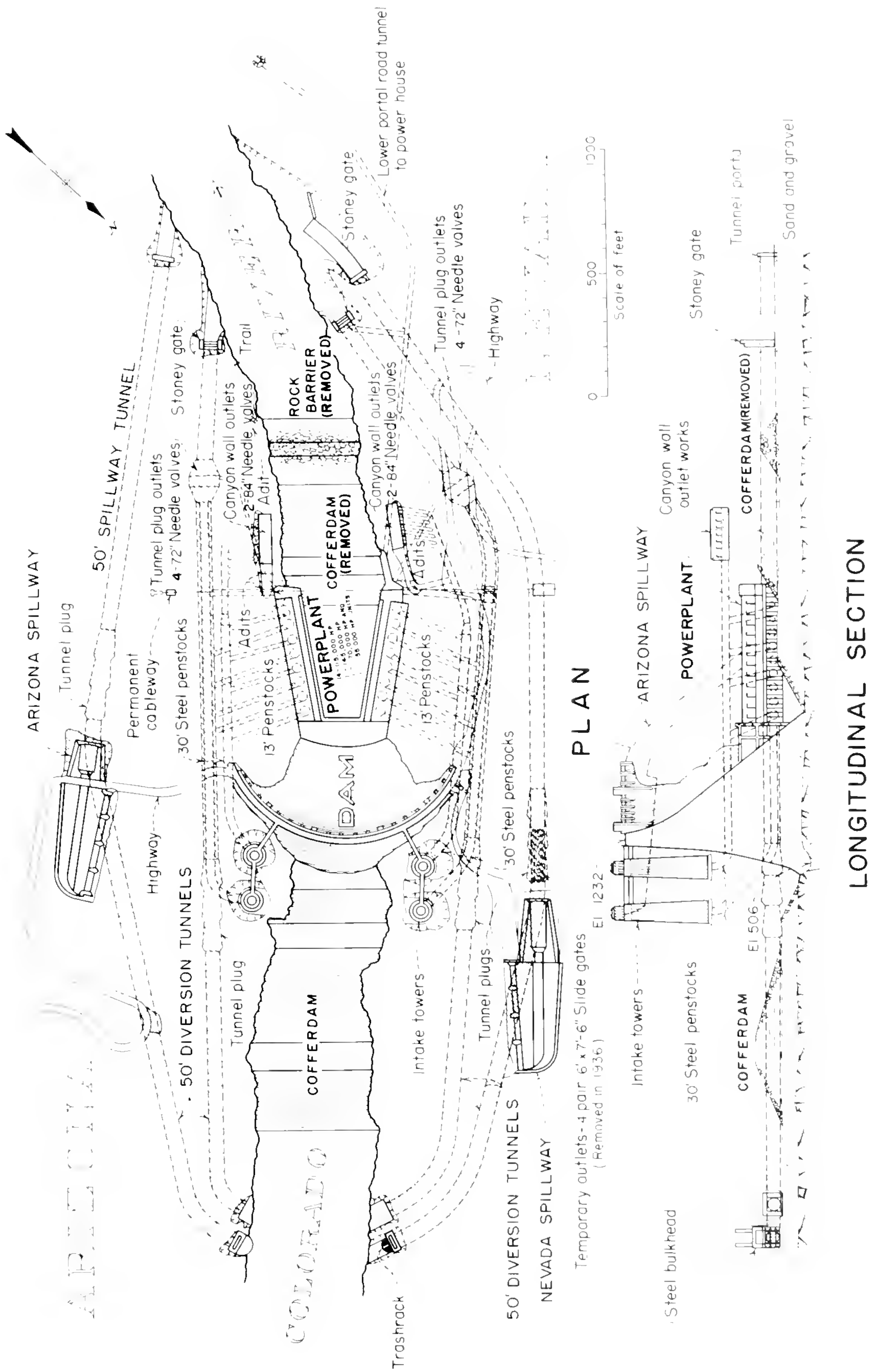
[7]Powerplant units are operated by two power allottees under agency contract.
[8]Two substations are operated and maintained by the City of Boulder City.

Designation	Capacity		Circuit miles	Year placed in service
	Kilovolts	Kilowatts		
Hoover Powerplant—City of Los Angeles Switchyard[9]	287.5	--	0.96	1936-40
Hoover Powerplant—M.W.D. Switchyard[9]	230	--	0.82	1938-61
Hoover Powerplant—Arizona-Nevada 230-kV Switchyard[9]	230	--	1.77	1952
Hoover Powerplant—S.C.E. Co. Switchyard[10]	230	--	1.89	1939-42
Hoover Powerplant—S.C.E. Co. Switchyard[10]	138	--	0.59	1937
S.C.E. Co. Tap—Boulder City Substation[11]	138	15,000	0.50	1942
Hoover Powerplant—Nevada State 69-kV Switchyard[9]	69	--	2.68	1938-64
Nevada State 69-kV Switchyard—Boulder City Substation[11]	69	15,000	6.99	1948
No. 2A Pumping Plant Tap—No. 2A Pump Plant[11]	69	3,000	0.20	1949

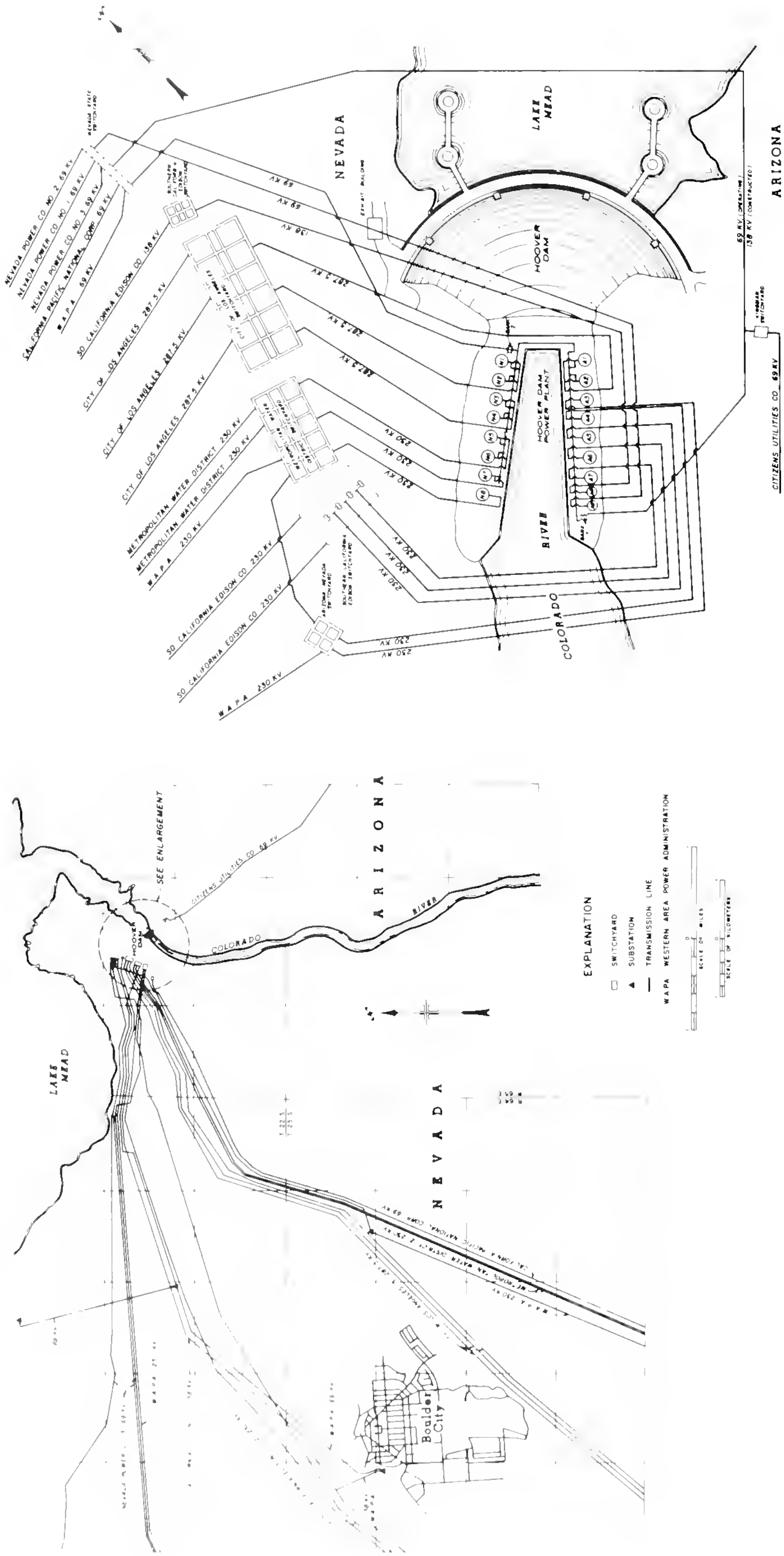
[9]Operated by City of Los Angeles.
[10]Operated by Southern California Edison Company.
[11]Operated and maintained by the City of Boulder City.



Hoover Dam, Plan and Section



Hoover Dam, Plan and Section

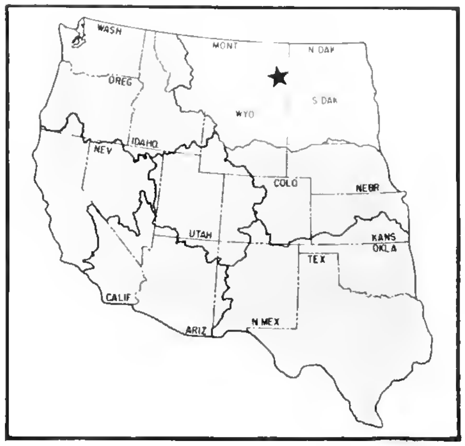


Hoover Dam Transmission Lines and Switchyard Layout

Buffalo Rapids Project

Montana: Custer, Dawson, and Prairie Counties

Upper Missouri Region
Water and Power Resources Service



The Buffalo Rapids Project, in southeastern Montana, is divided into the First and Second Divisions. Principal structures include five pumping plants that pump water directly from the Yellowstone River and one relift pumping plant to provide irrigation water for 22,719 acres of land in the vicinity of Glendive, Fallon, and Terry, Mont.

PLAN

The First Division consists of the Glendive Unit and its extension. It serves 13,254 acres of irrigable land extending from Fallon to Glendive along the west bank of the Yellowstone River. No storage is provided as the water is pumped directly from the Yellowstone River to the Main Canal by motor-driven pumps.

The Second Division serves 9,465 acres of irrigable land along the south bank of the Yellowstone River between Miles City and Fallon, Mont. Three separate tracts of irrigable land are designated as the Shirley, Terry, and Fallon Units. Water is pumped directly from the Yellowstone River for each unit.

Glendive Pumping Plant

Pumping Plants

Glendive Pumping Plant Nos. 1 and 2 serve the First Division. Shirley, Terry, Fallon, and Fallon Relift Pumping Plants serve the Second Division. All the pumps are operated electrically with power supplied from the Pick-Sloan Missouri Basin Program.

Distribution System

Each unit has a separate canal and lateral system with appurtenant water control structures to provide for distribution of water to the land. A total of 63 miles of canals and 83 miles of laterals is included in the project.

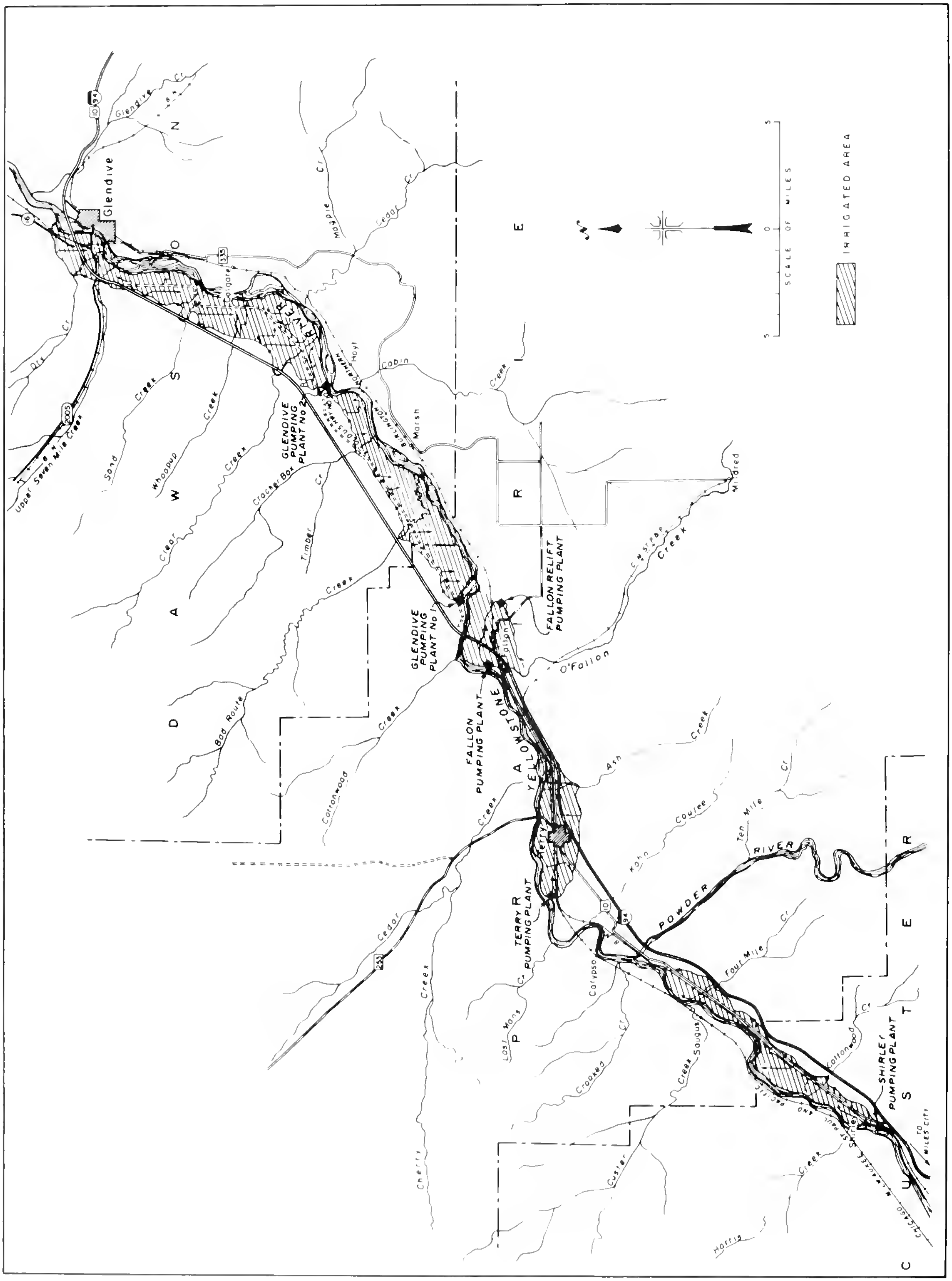
DEVELOPMENT

Early History

Settlers along the Yellowstone River between Miles City and Glendive first attempted irrigation of two tracts of land, one by diversion and the other by pumping. The diversion scheme failed because a suitable diversion dam was not provided. The pumping unit, driven by a fuel-operated powerplant, proved to be too costly. The greater part of the area, therefore, reverted to dry farming, which encountered serious difficulties during the extended drought of the 1930's.

Investigations

In an effort to combat the depressed conditions, the local businessmen formed the Mid-Yellowstone Recovery Association in 1933 and obtained National Industrial Recovery Act funds for the Bureau of Reclamation to conduct an investigation. Based on the report of this investigation, the Glendive Unit was authorized to be constructed by the Bureau of Reclamation.



Buffalo Rapids Project

Authorization

The Glendive Unit was approved by the President on September 17, 1937, to irrigate an estimated 15,500 acres with funds provided under the Emergency Relief Appropriation Act of 1937. Glendive Extension was approved by the President on May 15, 1940, for 3,000 acres under the Water Conservation and Utilization Act of May 10, 1939 (53 Stat. 685). The Glendive Unit and Extension constitute the First Division.

The Shirley, Terry, and Fallon Units of the Second Division were approved by the President on October 11, 1939, as well as a revised plan on May 15, 1940, under the Water Conservation and Utilization Program.

Construction

Construction of the Glendive Unit, First Division, was initiated in 1937 by the Bureau of Reclamation. The Main Canal and portions of the laterals of this unit were completed in the spring of 1941. In 1942 and 1943, the Farm Security Administration completed the irrigation laterals and necessary concrete structures on the First Division. A third pumping unit at the Glendive Pumping Plant was installed by the Bureau of Reclamation in 1944 to increase the capacity of the pumping plant and furnish irrigation water for an additional 6,000 acres. Glendive Pumping Plant No. 2 for the First Division was completed in 1978. The plant was financed under the Small Reclamation Projects Act of 1956. The pumping plant supplies supplemental irrigation water to the Main Canal to meet peak demand situations.

The Second Division comprises the Shirley, Terry, and Fallon Units along the east bank of the Yellowstone River. Construction of the Second Division began in September 1940 and proceeded, with some delays, throughout World War II, although work on the Fallon Unit did not begin until August 1945. Construction of the Second Division was essentially completed in 1948.

Operating Agency

The project is operated by the Buffalo Rapids Board of Control as the agent of Buffalo Rapids Irrigation District No. 1 and Buffalo Rapids Irrigation District No. 2.

BENEFITS

Irrigation

Project soil is fertile and produces a large variety of crops when irrigated. Principal crops produced are alfalfa, sugar beets, beans, flax, potatoes, and wheat.

Shirley Pumping Plant

PROJECT DATA

Land Areas (1977)

Irrigable area:	
Full irrigation service	22,719 acres
Number of irrigated farms	219

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	21,360	2,578,855
1969	21,376	2,306,377
1970	21,091	2,529,791
1971	21,118	2,604,297
1972	21,139	3,436,471
1973	20,282	4,396,342
1974	20,161	6,267,960
1975	20,219	6,373,991
1976	20,344	4,486,898
1977	20,953	4,983,981

Facilities in Operation

Canals	63 mi
Laterals	83 mi
Pumping plants	6
Drains	23 mi

Climatic Conditions

Annual precipitation	13.9 in
Temperature:	
Maximum	117 °F
Minimum	−50 °F
Mean	44 °F
Growing season	145 days
Elevation of irrigable area	2150.0 ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	745
Other water service[1]	590
Total	1,335

[1]Urban and suburban, residential, commercial, and industrial lands

ENGINEERING DATA

Water Supply

Yellowstone River

Drainage area at Miles City, Mont:	48,253 mi²
Annual discharge:	
Maximum (1943)	12,064,500 acre-ft
Minimum (1934)	4,445,700 acre-ft
Average	8,328,600 acre-ft

Carriage Facilities

Fallon Main Canal

Location: Near Fallon, Mont., from Fallon Pumping Plant east about 3 mi.

Construction period: 1946-48

Length	3 mi
Diversion capacity	72 ft³/s
Typical maximum section in earth:	
Bottom width	6 ft
Side slopes	1.5:1
Water depth	3.7 ft

Fallon Relift Canal

Location: Near Fallon, Mont., from Fallon Relift Pumping Plant at the end of Fallon Main Canal, south-southwest about 3 mi.

Construction period: 1946-48

Length	3.5 mi
Diversion capacity	34 ft³/s
Typical maximum section in earth:	
Bottom width	4 ft
Side slope	1.5:1
Water depth	2.7 ft

Glendive Canal

Location: From Glendive Pumping Plant near Fallon, Mont., northeast about 26 mi along the Yellowstone River to vicinity of Glendive, Mont.

Construction period: 1937-41

Length	34.1 mi
Diversion capacity	330 ft³/s
Typical maximum section in earth:	
Bottom width	13 ft
Side slopes	1.5:1
Water depth	7 ft

Shirley Main Canal

Location: From Shirley Pumping Plant, about 20 mi southwest of Terry, Mont., northeast about 12 mi along Yellowstone River to a point 8 mi southwest of Terry.

Construction period: 1940-43

Length	13.3 mi
Diversion capacity	105 ft³/s
Typical maximum section in earth:	
Bottom width	8 ft
Side slope	1.5:1
Water depth	4 ft

Terry Main Canal

Location: Vicinity of Terry, Mont., from Terry Pumping Plant east about 6 mi.

Construction period: 1940-44

Length	7.7 mi
Diversion capacity	60 ft³/s
Typical maximum section in earth:	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	3.5 ft

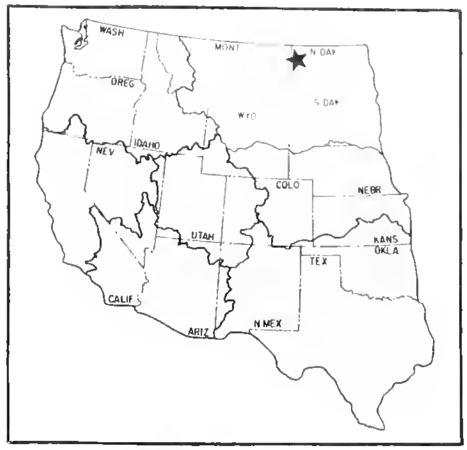
Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
First division:				
Glendive No. 1	3	330	103	3,500
Glendive No. 2	2	80	143	1,600
Second division:				
Shirley	3	111	51	750
Terry	3	61.5	109	900
Fallon	3	72	45	450
Fallon Relift	2	40	90	500

Buford-Trenton Project

North Dakota: Williams County

Upper Missouri Region
Water and Power Resources Service



The Buford-Trenton Project lands lie along the north bank of the Missouri River adjoining the towns of Buford and Trenton, N. Dak. The Great Northern Railroad parallels the project and is roughly the north boundary of the development area. Water is supplied to 7,655 acres of irrigable land by pumping directly from the Missouri River into a main canal and laterals. No storage facilities are required.

PLAN

Water for the project is pumped from the Missouri River at a point about 1.5 miles above its confluence with the Yellowstone River. The plant has three pumps, each having a capacity of 80 cubic feet per second and an average lift of 29 feet.

The pumps discharge into the main canal, which is 11.5 miles long and has an initial capacity of 250 cubic feet per second. The canal is unlined except for a 2-mile section of clay lining around Trenton Lake. The distribution and drainage systems include 34 miles of laterals and 31.6 miles of drains.

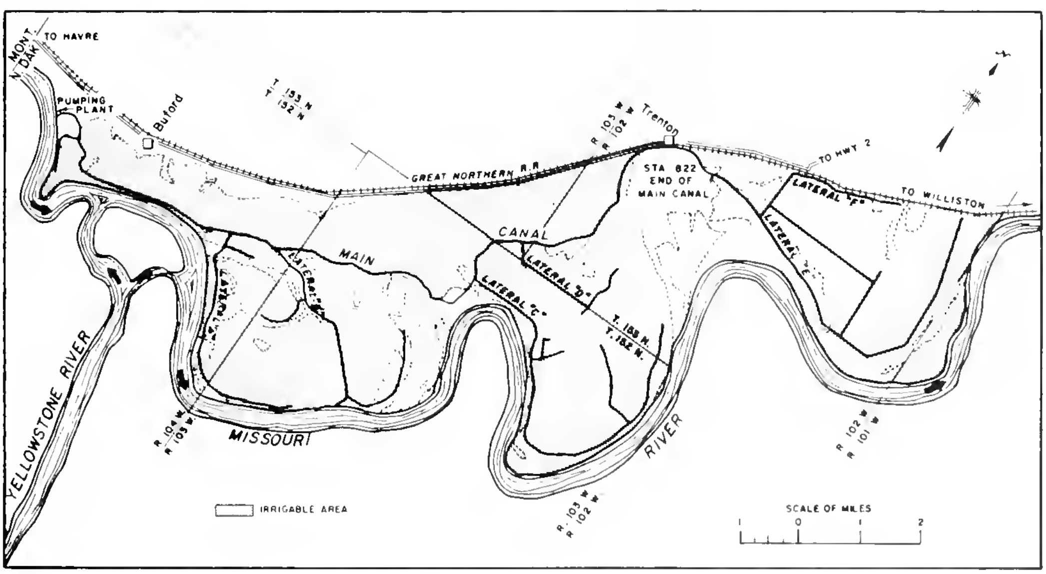
DEVELOPMENT

Early History

Irrigation possibilities in the project area were recognized as early as 1902. The Reclamation Service initiated a pumping project in 1907 to irrigate benchlands at a higher elevation than those in the present project. This early project, also known as the Buford-Trenton Project, pumped water from the Missouri River with electrical energy obtained from the Reclamation powerplant at Williston. Poor soil qualities in the lands to be irrigated and a series of wet years caused the landowners in the area to lose interest in irrigation and the project was discontinued.

Investigations

Investigations of the area were carried out in the 1930's by several Government agencies. Based on those studies and reports, the present Buford-Trenton Project was authorized.



Buford-Trenton Project

Authorization

The initial project was found feasible and authorized on November 18, 1904, by the Secretary of the Interior. Construction of the present project was authorized under the Water Conservation and Utility Projects section of the Interior Department Appropriations Act of 1940. The finding of feasibility was transmitted to the President by the Secretary of the Interior on August 23, 1939, and the new project was approved for construction September 23, 1939. A new finding of feasibility enlarging the project area was approved by the President on August 7, 1942.

Construction

The Bureau of Reclamation constructed the irrigation and drainage system in 1940-43. The Department of Agriculture supervised the land preparation, settlement, and agricultural planning. Labor was supplied by the Works Projects Administration, the Civilian Conservation Corps, and the Civilian Public Service.

Operating Agency

Operation and maintenance of the irrigation system is by the Buford-Trenton Irrigation District. On January 28, 1955, the district assumed full management responsibilities from the Buford-Trenton Mutual Aid Corp.

BENEFITS

Irrigation

Principal crops produced are sugar beets, alfalfa, wheat, barley, oats, and pasture. The project has a stabilizing influence on the livestock industry in the area through the production of feed crops.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	7,655	acres
Number of irrigated farms	30	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,192	1,010,055
1969	7,188	2,223,300
1970	6,687	952,140
1971	7,060	1,399,888
1972	7,130	1,085,321
1973	6,937	2,038,749
1974	7,179	3,108,083
1975	7,077	2,688,641
1976	7,083	1,904,686
1977	7,455	1,683,556

Facilities in Operation

Canals	11.5	mi
Laterals	34	mi
Pumping plants	1	
Drains	31.6	mi

Climatic Conditions

Annual precipitation	14.5	in
Temperature:		
Maximum	110	°F
Minimum	−50	°F
Mean	40	°F
Growing season	133	days
Elevation of irrigable area	1860-1890.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	148

ENGINEERING DATA

Water Supply

MISSOURI RIVER

Drainage area at Culbertson, Mont.	91,557	mi²
Annual discharge at Culbertson:		
Maximum (1975)	12,004,000	acre-ft
Minimum (1960)	4,431,700	acre-ft
Average	8,050,200	acre-ft
Average annual diversion, 1973-77	23,700	acre-ft

Carriage Facilities

MAIN CANAL

Location: From Buford-Trenton Pumping Plant near Buford, N. Dak., about 12 mi northeast along Missouri River to vicinity of Trenton, N. Dak. Construction period: 1940-42 Portions of canal relocated in 1948, 1950, and 1954.

Length	11.5	mi
Diversion capacity	250	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	5.9	ft
Typical maximum section, clay lined:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	4	ft
Lining thickness	9	in

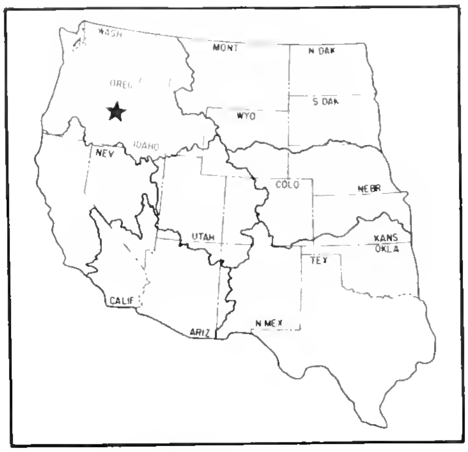
BUFORD-TRENTON PUMPING PLANT

Number of units	3	
Total capacity	240	ft³/s
Total dynamic head	26-31	ft
Total horsepower	800	

Burnt River Project

Oregon: Baker County

Pacific Northwest Region
Water and Power Resources Service



The Burnt River Project in east-central Oregon consists of a storage dam and reservoir that provide water for supplemental irrigation of about 15,000 acres which formerly depended entirely on the natural flow of the Burnt River.

PLAN

Floodwaters of the Burnt River are stored in Unity Reservoir for later release when the natural flow of the river is insufficient for irrigation purposes. The reservoir assures an adequate water supply for project lands below and above the dam by exchange of stored water for natural streamflow during the summer months.

Unity Dam

Unity Dam, located about 40 miles southwest of Baker, Oreg., is a rolled, zoned earthfill-type structure, 82 feet high above its foundation. The dam contains 254,000 cubic yards of earth and rock. The active capacity of the reservoir is 25,200 acre-feet.

Unity Dam and Reservoir

DEVELOPMENT

Early History

Early settlers in the Burnt River Valley became cattle raisers, and used the bottom lands to produce hay for winter feed. The first attempts at irrigation consisted of direct run-of-the-river diversions into farm ditches, without the benefit of storage. As the valley developed, the river usually dried up during July and August, leaving no water to mature crops.

Investigations

In 1933, the Bureau of Reclamation, in cooperation with the State of Oregon, investigated the possibility of developing a storage structure on Burnt River to provide a late summer water supply. The project was constructed following the plan developed from this investigation.

Authorization

The project was found feasible by the Secretary of the Interior on September 25, 1935. Funds were provided by the President on August 13, 1935, under the Emergency Relief Act.

Construction

Construction began on August 13, 1936, and was completed in January 1939.

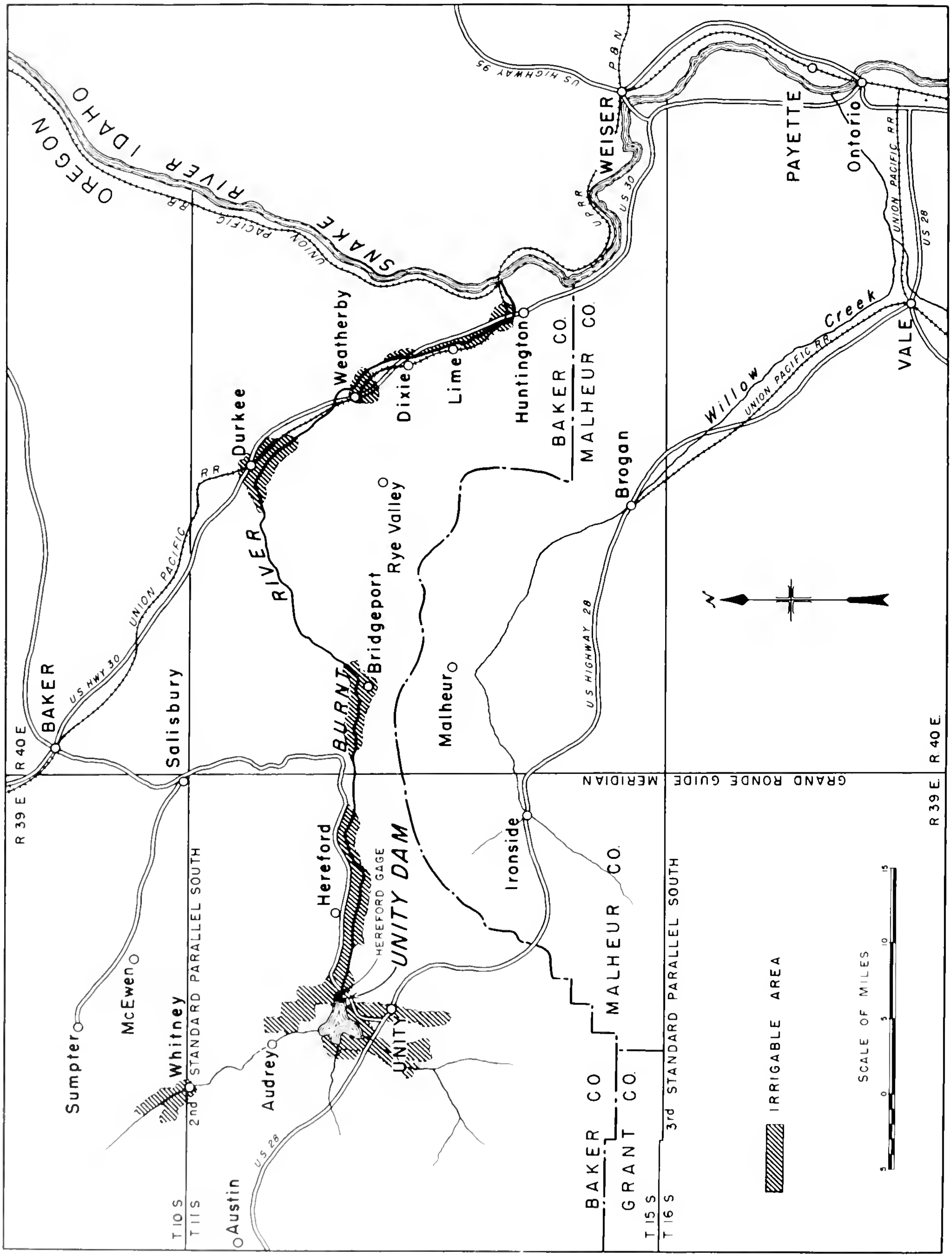
Operating Agency

The project is operated and maintained by the Burnt River Irrigation District.

BENEFITS

Irrigation

Principal crops produced are alfalfa, wild hay, barley, wheat, and pasture.



Burnt River Project

Recreation

Unity Reservoir has limited use for picnicking, swimming, and boating. Fishing in season for rainbow trout provides the greatest recreational use of the reservoir.

Unity Dam spillway

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	15,616	acres
Number of irrigated farms	89	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	15,050	1,056,180
1969	15,056	744,454
1970	15,066	983,286
1971	15,026	1,248,282
1972	15,096	1,380,118
1973	15,096	1,786,162
1974	15,076	1,348,050
1975	15,071	1,445,279
1976	15,061	1,699,482
1977	15,046	1,559,914

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	11.2	in
Temperature:		
Maximum	100	°F
Minimum	−29	°F
Mean	45	°F
Growing season	102	days
Elevation of irrigable area	2600.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	450
Other irrigation service[1]	1,190
Total	1,640

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

BURNT RIVER

Drainage area at Hereford Gage about 0.25 mi below Unity Dam	309	mi²
Annual discharge:		
Maximum (1965)	121,950	acre-ft
Minimum (1977)	17,400	acre-ft
Average	64,300	acre-ft
Average annual diversions by project (1963-77)[2]	92,690	acre-ft

[2]Includes return flows to Burnt River.

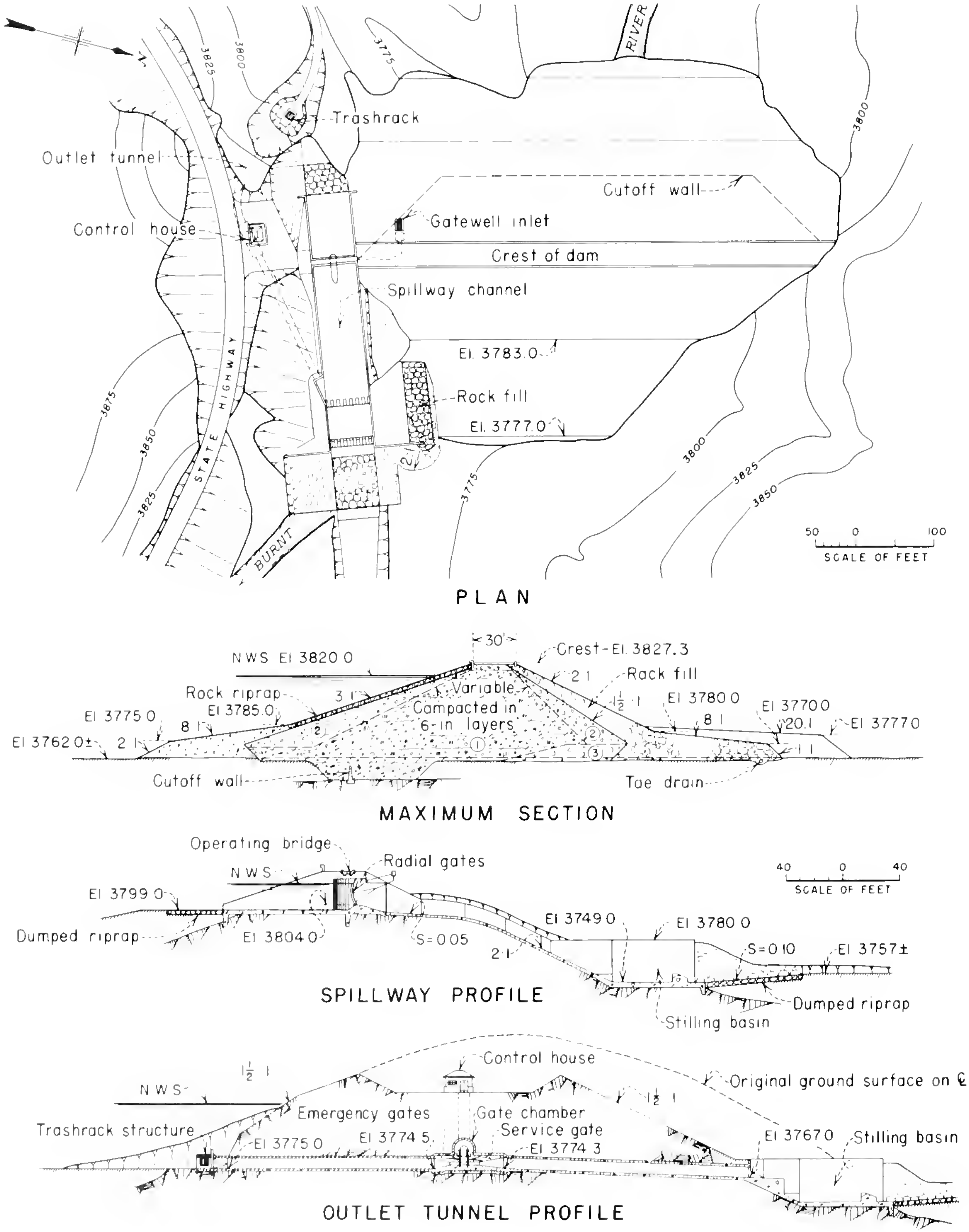
Storage Facilities

UNITY DAM

Type: Zoned earthfill
Location: On Burnt River 40 mi southwest of Baker, Oreg.
Construction period: 1936-38

Reservoir, Unity:		
Total capacity at El. 3820	25,800	acre-ft
Active capacity	25,200	acre-ft
Surface area	926	acres
Dimensions:		
Structural height	82	ft
Hydraulic height	62	ft
Top width	30	ft
Maximum base width	560	ft
Crest length	694	ft
Crest elevation	3827.3	ft
Total volume	254,000	yd³
Spillway: Concrete-lined open channel in the right abutment controlled by two 24- by 16-ft radial gates.		
Elevation, top of gates	3820.0	ft
Crest elevation	3804.0	ft
Capacity at El. 3820	10,000	ft³/s
Outlet works: Concrete-lined circular tunnel through right abutment controlled by two 2.75-ft-square high-pressure slide gates.		
Capacity at El. 3820	620	ft³/s

Foundation: Firmly cemented tuff-breccia overlain with unconsolidated alluvial valley-fill and compacted terrace deposits.
Special treatment: Cement grout curtain beneath cutoff wall.

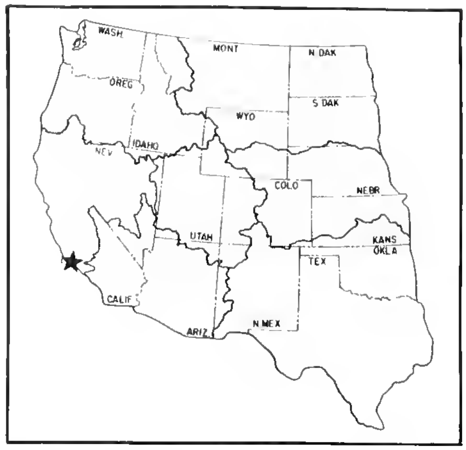


Unity Dam, Plan and Sections

Cachuma Project

California: Santa Barbara County

Mid-Pacific Region
Water and Power Resources Service



The Cachuma Project in southern California lies along the west coast in the vicinity of Santa Barbara. It provides a supplemental supply of irrigation water to approximately 38,000 acres of land and a supply of municipal water to the city of Santa Barbara and other urban areas located in Santa Barbara County on the southern slope of the Santa Ynez Mountains. Construction of the project, which was authorized in 1948, began in 1950 and was completed in 1956. The rapid urban growth that has taken place since completion of the project is encroaching on large acreages of previously irrigated and nonirrigated arable lands, especially in the Goleta Valley.

PLAN

Bradbury Dam[1] stores floodwaters of the Santa Ynez River which would otherwise waste to the ocean. Water is diverted from the reservoir through the Tecolote Tunnel to the south coast area. From the tunnel outlet the water is carried through the South Coast Conduit. Lateral systems distribute water from the conduit to croplands of the Goleta, Montecito, Summerland, and Carpinteria Water Districts, and to municipal users in the city of Santa Barbara.

Bradbury Dam and Lake Cachuma

Bradbury Dam and Lake Cachuma

Bradbury Dam is located on the Santa Ynez River approximately 25 miles northwest of Santa Barbara. It is a zoned earthfill structure, 279 feet high, containing 6,695,000 cubic yards of material. The reservoir, Lake Cachuma, has a capacity of 205,000 acre-feet.

Tecolote Tunnel

Tecolote Tunnel extends 6.4 miles through the Santa Ynez Mountains from Lake Cachuma to the headworks of the South Coast Conduit. The horseshoe-shaped tunnel is 7 feet in diameter, concrete lined, and has a capacity of 100 cubic feet per second.

South Coast Conduit

The South Coast Conduit, a high-pressure concrete pipeline, extends from the Tecolote Tunnel outlet to the lower end of the Carpinteria service area, a distance of some 24 miles, and includes four regulating reservoirs.

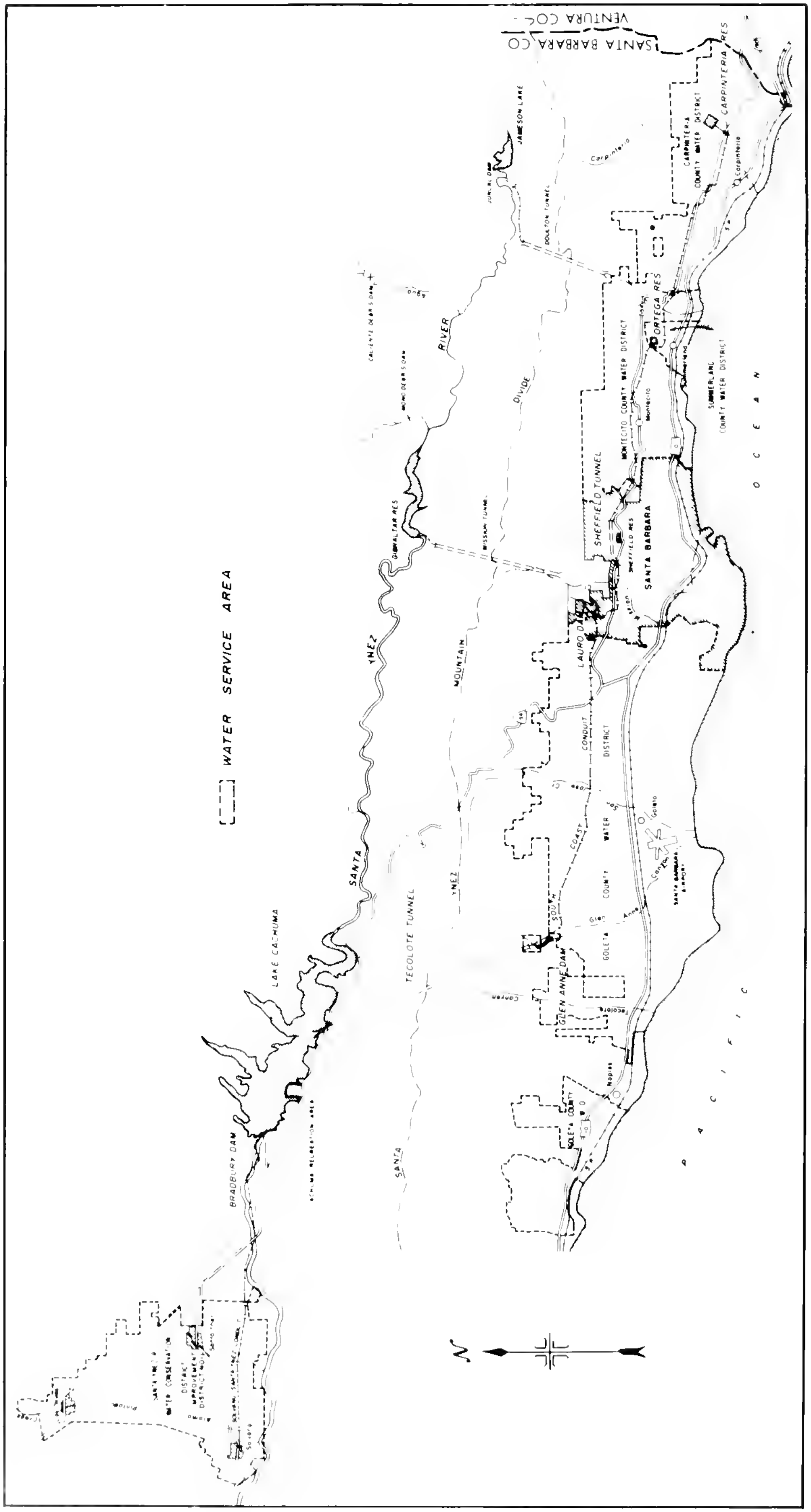
Glen Anne Dam and Reservoir

Glen Anne Dam is an earthfill structure with a crest length of 240 feet and a height of 135 feet. The Glen Anne Reservoir, with a capacity of 470 acre-feet, is located on the West Fork of Glen Anne Canyon Creek below the outlet of Tecolote Tunnel. A portion of the land included in the Goleta County Water District is served directly from this reservoir.

Lauro Dam and Reservoir

Lauro Dam and Reservoir are located on Diablo Creek near Santa Barbara. The dam is an earthfill structure

[1]Formerly Cachuma Dam.



Cachuma Project

Glen Anne Dam and Reservoir

with a crest length of 540 feet and a height of 137 feet. The reservoir has a capacity of 640 acre-feet.

Ortega Dam and Reservoir

Ortega Reservoir on Picay Creek near Summerland is a concrete-lined basin with a capacity of 60 acre-feet. The dam is an earthfill structure 131 feet high with a crest length of 430 feet.

Carpinteria Reservoir

Carpinteria Reservoir near Carpinteria serves as a terminal reservoir. It is a concrete-lined basin with a capacity of 40 acre-feet.

Sheffield Tunnel

Sheffield Tunnel, horseshoe-shaped and 6 feet in diameter, was bored through a high ridge within the city limits of Santa Barbara. The South Coast Conduit, 30 inches in diameter at this point, extends through the 5,968-foot-long tunnel.

DEVELOPMENT

Early History

The coast of the Santa Barbara region was first visited in 1542 by navigators under the Spanish Crown. However, no attempt was made to settle the land until 1782 when the Presidio of Santa Barbara was founded at the present location of the city of Santa Barbara. The Santa Barbara Mission was built in 1786. By 1802, the mission was the center of extensive grain fields and fruit orchards and the home range for great herds of livestock. By 1840, cattle raising was the most important industry. Following the decline of the cattle industry after droughts in the 1860's, several of the large ranches were subdivided and sold to eastern immigrants. This started the gradual transition from ranching to intensive farming of smaller acreages. Dry farming of wheat, barley, corn, hay, beans, peas, potatoes, garden vegetables, and fruit expanded rapidly. At the turn of the century irrigation began to develop, first for growing sugar beets and alfalfa, then for vegetables and other crops.

Gibraltar Dam on the Santa Ynez River was completed in 1920. Prior to construction of the dam, the city of Santa Barbara had used local streams and tunnels in the Santa Ynez Mountains and ground-water pumping for its water supply. In 1930, Montecito County Water District, to the east of Santa Barbara, completed construction of Juncal Dam upstream from Gibraltar Dam on the Santa Ynez River.

Investigations

The increasing withdrawal of water from underground sources throughout the southern portion of Santa Barbara County caused the ground water level to start dropping at an alarming rate. In 1941, the Santa Barbara County Board of Supervisors requested the Bureau of Reclamation to study the water problem. In 1945, the State of California created the Santa Barbara County Water Agency. This agency entered into a master contract with the Federal Government for development of the project. It also entered into subcontracts with the city of Santa Barbara, the Goleta, Montecito, Summerland, and Carpinteria County Water Districts, and the Santa Ynez River Water Conservation District, which were all designated as member units of the agency.

In 1947, after 6 years of extensive investigations and conferences with the Santa Barbara County Water Agency,

City of Santa Barbara beyond Lauro Dam

Lauro Dam

the Bureau of Reclamation submitted a plan recommending the construction of Cachuma Dam, Tecolote Tunnel, and the South Coast Conduit. The plan included proposed rates for furnishing water and an allocation of water to the water districts and to the city of Santa Barbara.

Authorization

The project was authorized on March 4, 1948, by the Secretary of the Interior pursuant to section 9(a) of the Reclamation Project Act of 1939.

Construction

Construction of Tecolote Tunnel began on March 30, 1950, and was completed in 1956. Construction of Cachuma Dam and the South Coast Conduit was started in 1950 and completed in 1953. The four regulating reservoirs, Glen Anne, Lauro, Ortega, and Carpinteria, were built during 1951-54. Distribution systems for the Goleta, Carpinteria, and Summerland County Water Districts were constructed by Reclamation during 1952-56.

Operating Agencies

Operation of the project, exclusive of the distribution systems and Bradbury Dam, is being performed by the member units acting through an operation and maintenance board. Each individual district for which a distribution system was constructed is responsible for its operation and maintenance. Bradbury Dam is operated by the Bureau of Reclamation.

BENEFITS

Irrigation

Principal irrigated crops are citrus and other fruits, irrigated pasture, alfalfa hay, and other hay. Most of the products are packed locally and shipped to markets in the eastern States through Los Angeles and San Francisco.

Municipal and Industrial Water

The project supplies water to approximately 130,000 municipal users in the city of Santa Barbara and environs.

Recreation

The Lake Cachuma recreation area, administered by the Santa Barbara County Parks Department, provides camping, fishing, picnicking, hiking, and boating opportunities. The recreation area has a store, sanitary facilities, swimming pool, and potable water. For the convenience of visitors, boats are available to rent for fishing or cruising on the lake.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	539	acres
Supplemental irrigation service	38,151	acres
Total	38,690	acres
Number of irrigated farms	625	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	10,891	12,772,323
1969	10,771	13,753,288
1970	10,601	13,061,509
1971	10,384	17,466,685
1972	11,796	20,607,936
1973	11,577	25,694,168
1974	11,997	33,241,765
1975	11,841	33,748,933
1976	12,563	34,980,894
1977	12,096	50,933,150

Facilities in Operation

Storage dams	5	
Pipelines	24.3	mi
Tunnels	7.5	mi
Laterals	97.2	mi

Climatic Conditions

Annual precipitation	17.9	in
Temperature:		
Maximum	115	°F
Minimum	20	°F
Mean	60	°F
Growing season	365	days
Elevation of irrigable area	0-500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,942
Urban/suburban irrigation service	40,427
Municipal and other water service	129,900
Total	172,269

ENGINEERING DATA

Water Supply

Santa Ynez River

Drainage area at Bradbury Dam	417	mi²
Annual discharge at Bradbury Dam:		
Maximum (1969)	525,365	acre-ft
Minimum (1961)	795	acre-ft
Average	66,014	acre-ft
Annual diversion	27,800	acre-ft

Storage Facilities

Bradbury Dam

Type: Zoned earthfill
Location: On Santa Ynez River about 25 mi northwest of Santa Barbara, Calif.
Construction period: 1950-53
Reservoir, Lake Cachuma:

Average annual inflow, 1953-70	77,700	acre-ft
Total capacity	205,000	acre-ft
Active capacity	202,000	acre-ft
Surface area	3,100	acres
Shoreline	42	mi
Dimensions:		
Structural height	279	ft
Hydraulic height	190	ft
Top width	40	ft
Maximum base width	1,373	ft
Crest length	3,350	ft
Crest elevation	760.0	ft
Total volume	6,695,000	yd³

Spillway: Concrete-lined channel in left abutment controlled by four 50-by 30-ft radial gates.

Elevation, top of gates	750.0	ft
Crest elevation	720.0	ft
Capacity, El. 760.0	159,000	ft³/s

Outlet works: Concrete-lined tunnel through base of dam controlled by two 30-in hollow-jet valves and one 10-in butterfly valve.
Foundation: Siltstone and siliceous shales overlain by alluvial materials up to 125 ft deep and highly pervious in the streambed.
Special treatment: Main and supplementary grout caps beneath cutoff trench and grout curtain beneath caps; grout cap beneath concrete cutoff at upstream side of spillway gate structure; formation around outlet tunnel grouted.

Carpinteria Dam

Type: Earthfill, concrete lined
Location: On Carpinteria Creek near Carpinteria, Calif.
Construction period: 1953-54
Reservoir, Carpinteria:

Total capacity	40	acre-ft
Active capacity	40	acre-ft
Surface area	2.6	acres
Dimensions:		
Structural height	31	ft
Hydraulic height	17	ft
Top width	20	ft
Maximum base width	170	ft
Crest length	1,350	ft
Crest elevation[2]	385.25	ft
Total volume	41,000	yd³

[2]Top of concrete curb; roadway elevation is 382.75 ft.

Glen Anne Dam

Type: Zoned earthfill, asphaltic concrete on upstream slope
Location: On the west fork of Glen Anne Canyon Creek 10 mi northwest of Santa Barbara, Calif.
Construction period: 1951-53
Reservoir, Glen Anne:

Total capacity	470	acre-ft
Active capacity	385	acre-ft
Surface area	16	acres
Dimensions:		
Structural height	135	ft
Hydraulic height	86	ft
Top width	30	ft
Maximum base width	610	ft
Crest length	240	ft
Crest elevation	402.0	ft
Total volume	328,000	yd³

Spillway: Uncontrolled concrete-lined open channel in right abutment.

Crest elevation	385.0	ft

Outlet works: Concrete conduit through right abutment controlled by 24-in ball plug valve.

Lauro Dam

Type: Zoned earthfill
Location: On Diablo Creek near Santa Barbara, Calif.
Construction period: 1951-52
Reservoir, Lauro:

Total capacity	640	acre-ft
Active capacity	620	acre-ft
Surface area	22	acres
Dimensions:		
Structural height	137	ft
Hydraulic height	99	ft
Top width	30	ft
Maximum base width	880	ft
Crest length	540	ft
Crest elevation	567.0	ft
Total volume	469,000	yd³

Spillway: Uncontrolled 30-in concrete pipe at right abutment.
Outlet works: Concrete conduit enclosing 36-in steel pipe through base of dam, controlled automatically at Lauro control house.

ORTEGA DAM

Type: Earthfill, concrete lined
Location: On Picay Creek near Summerland, Calif.
Construction period: 1953-54
Reservoir, Ortega:

Total capacity	60	acre-ft
Active capacity	60	acre-ft
Surface area	4	acres
Dimensions:		
Structural height	131	ft
Hydraulic height	83	ft
Top width	20	ft
Maximum base width	405	ft
Crest length	430	ft
Crest elevation	460.85	ft
Total volume	146,000	yd³

Carriage Facilities

SOUTH COAST CONDUIT

Type: Reinforced concrete
Location: Generally east along the Pacific Coast from Tecolote Tunnel outlet portal near Goleta, Calif., to vicinity of Carpinteria.
Construction period: 1950-53

Length	24.3	mi
Capacity	70	ft³/s
Diameter	48-27	in

SHEFFIELD TUNNEL

Location: On the South Coast Conduit within city limits of Santa Barbara, Calif.
Construction period: 1951-53

Length	5,968	ft
Capacity	22	ft³/s
Cross section: Horseshoe		
Diameter	6	ft
Lining thickness	3-7	in

TECOLOTE TUNNEL

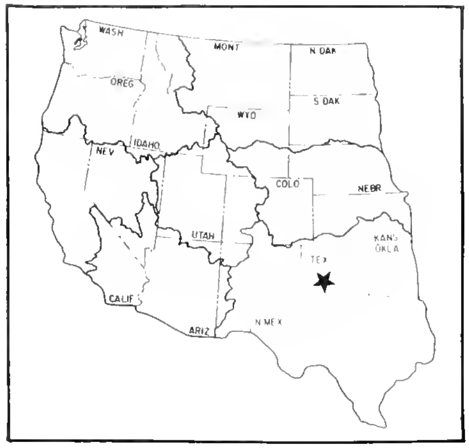
Location: From Cachuma Reservoir to Glen Anne Reservoir, northwest to Goleta, Calif.
Construction period: 1950-56

Length	33,557	ft
Capacity	100	ft³/s
Cross section: Horseshoe		
Diameter	7	ft
Lining thickness	4-8	in

Canadian River Project

Texas: Hutchinson, Carson, Gray, Moore, Potter, Randall, Swisher, Hale, Lubbock, Hockley, Terry, Lynn, and Dawson Counties

Southwest Region
Water and Power Resources Service



The Canadian River Project is in the northwest corner of Texas, providing municipal and industrial water for 11 cities and towns throughout the High Plains area. Primary purpose of the project is to supply water to the Texas cities of Borger, Pampa, Amarillo, Plainview, Lubbock, Slaton, Tahoka, O'Donnell, Lamesa, Levelland, and Brownfield. Principal structure is Sanford Dam on the Canadian River about 37 miles northeast of Amarillo. Additional features include 322 miles of pipelines, 10 pumping plants, and 3 regulating pools.

PLAN

Lake Meredith, the reservoir formed by Sanford Dam, has sufficient capacity to store the flows of the Canadian River available to the project under provisions of the Canadian River Compact. The water impounded in Lake Meredith is pumped to the 11 cities participating in the project, all of which are at elevations higher than the reservoir. The available water supply has been allocated to the project cities according to agreements negotiated by the Canadian River Municipal Water Authority. The cities will supplement project deliveries through continued use of ground water.

Sanford Dam and Lake Meredith

Sanford Dam and Lake Meredith

Sanford Dam is on the Canadian River 8 miles west of Borger, Tex., and 37 miles northeast of Amarillo. It is a zoned earthfill structure with a crest width of 40 feet, a crest length of 6,380 feet, and a structural height of 228 feet. The spillway has an ungated morning-glory entrance structure, a 22-foot-diameter concrete conduit, and a chute and stilling basin.

The reservoir formed by Sanford Dam, named Lake Meredith, has a surface area of 30,466 acres at maximum water surface and a total capacity of 1,407,572 acre-feet. The reservoir provides flood control, fish and wildlife, recreation, and municipal and industrial water supply.

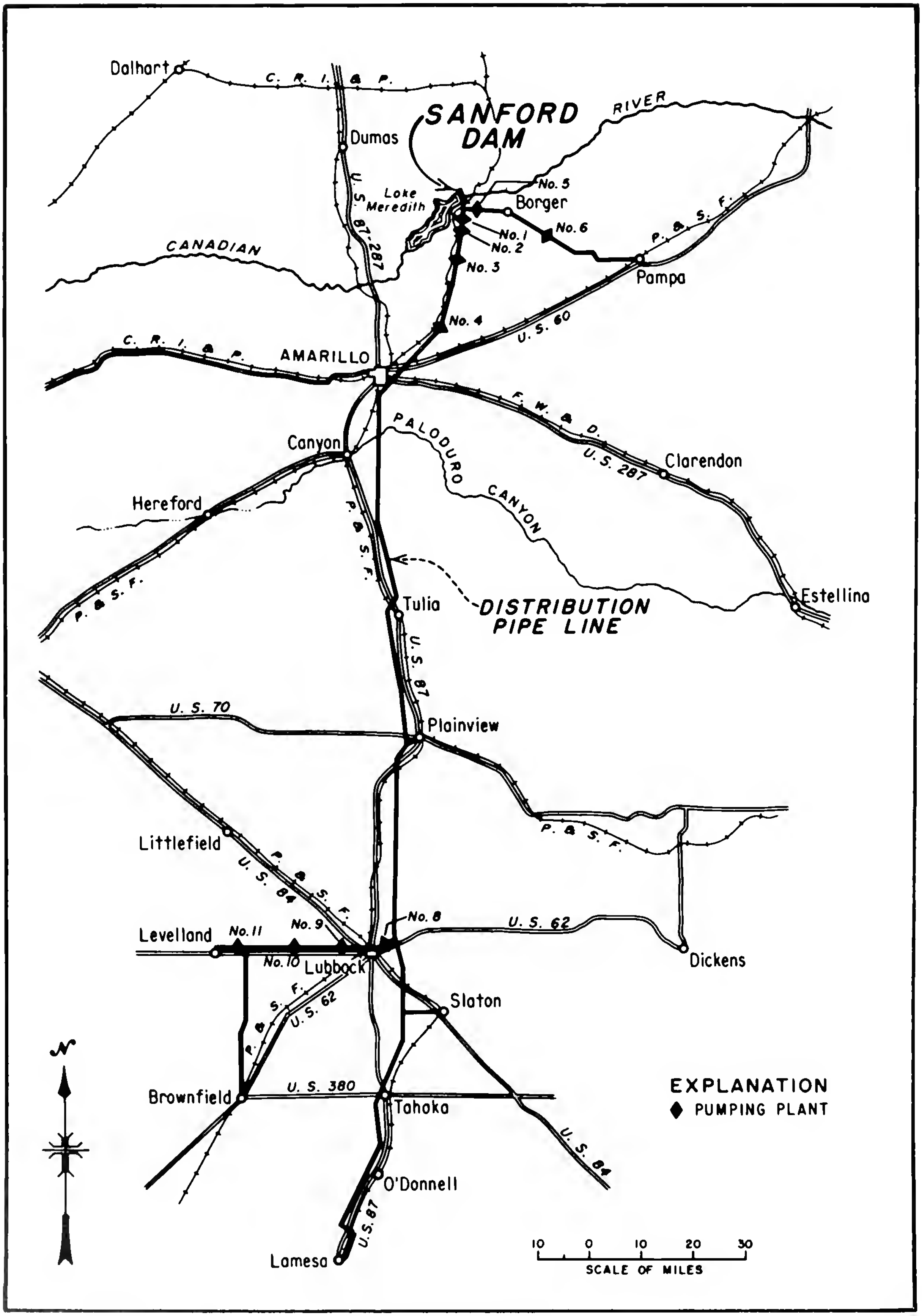
Aqueduct System

The aqueduct system includes about 322 miles of pipeline, consisting of reinforced concrete and steel cylinder pipe ranging in size from 15 to 96 inches. Ten pumping plants; regulating reservoirs at the high points of the system near Amarillo, Lubbock, and Borger; several regulating tanks; and chlorinating facilities to prevent algae growth in the pipelines comprise the principal features of the system. Water treatment facilities are the responsibility of the cities.

DEVELOPMENT

Early History

After Texas entered the Union in 1845, the United States established a line of camps and forts, passing through the vicinity of Abilene, from the Red River to the Rio Grande. The frontier was pushed rapidly westward during the 1850's, but military protection was withdrawn during the Civil War. Confusion attending the reconstruction period retarded westward immigration and development, but in 1876 the counties of the Texas Panhandle were formed and cattle raising started. This constituted the first agricultural effort of the region. As settlement progressed, it was supplemented by production



Canadian River Project

Amarillo Regulating Reservoir

of forage and other crops for local consumption. Irrigation from wells began in 1911, but development was relatively slow until the drought of the 1930's. An estimated 52,000 irrigation wells are now in operation in the 42-county High Plains. The principal crops grown under irrigation in this region are cotton, feed crops, and vegetables which are irrigated in the spring, summer, and fall, and winter wheat which is irrigated in the fall, winter, and spring. Prior to opening of the Panhandle oil and gas fields in 1921, industrial development was limited to the railroads and various establishments producing goods for local consumption. At present, the principal industrial establishments are those engaged in extracting, processing, and distributing oil, natural gas, and helium and their products.

Investigations

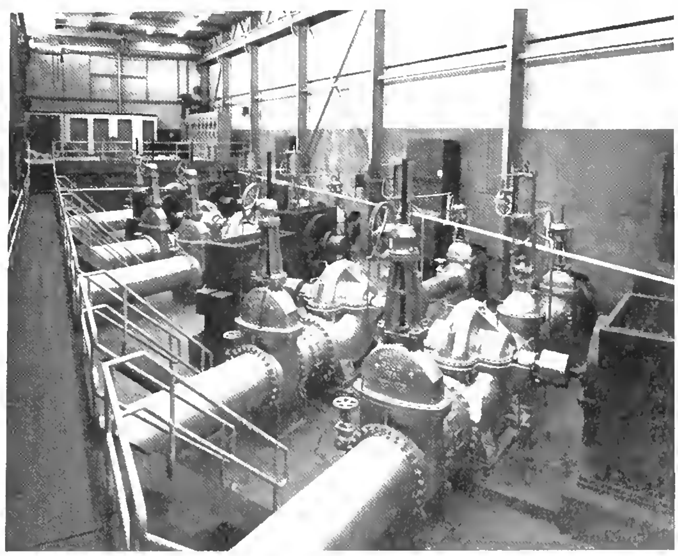
Beginning in 1900, the Geological Survey made several reports about ground water in the area. From 1935 to 1946, the Corps of Engineers made flood control and related investigations of the Canadian River. In 1941, the Bureau of Reclamation initiated an investigation of the Arkansas River Basin that included the portion of the Canadian River identified with the project. In a letter dated May 3, 1948, the Department of the Interior was asked to investigate and report on the possibilities of developing the water and related resources in the Texas Panhandle, with special attention to the area in the Canadian River Basin. Later, the Texas congressional delegation requested that the Bureau of Reclamation, as the Federal agency primarily responsible for water conservation activities, expedite its investigation and report upon the feasibility of developing the Canadian River as a source of municipal and industrial water in northwest Texas. A series of meetings was held and representatives of local interests were advised to submit estimated requirements with an awareness that they would be required to assume contractual obligations prior to project construction to pay for the water desired. The Bureau of Reclamation prepared a feasibility report in 1949. The Texas Legislature created the Canadian River Municipal Water Authority and authorized it to contract with the Federal Government under the Federal reclamation laws. A definite plan report was prepared by Reclamation in November 1960.

Authorization

The Canadian River Compact Commission, composed of representatives from Texas, Oklahoma, New Mexico, and the Federal Government, was organized on June 30, 1950, in accordance with provisions of Public Law 491, 81st Congress, 2d session, approved April 29, 1950, granting the consent of the Congress to negotiations between the States for division of the waters of the Canadian River. The compact was ratified by the three States by May 10, 1951, and given Federal ratification in Public Law 345, 82d Congress, 2d session, approved June 2, 1952. The project was authorized by Public Law 898, 81st Congress, 2d session, December 29, 1950 (64 Stat. 1124).

Construction

Construction of the Canadian River Project began with the award of a contract for Sanford Dam in February 1962. Continuation of construction involved award of many contracts for the aqueduct system, including various components such as segments of the pipelines, pumping plants, structures, building control systems, relocations, crossing agreements, and chlorination stations. Construction of the aqueduct system was suffi-



Pumping Plant No. 1

ciently complete to initiate water deliveries in April 1968 and to transfer operation and maintenance responsibility to the Canadian River Municipal Water Authority on July 1, 1968. Subsequent completion of minor construction items was accomplished by the Canadian River Municipal Water Authority and the Bureau of Reclamation.

BENEFITS

Municipal and Industrial Water

The project works provide for storage and delivery of water supplies to supplement the municipal and industrial needs of 11 cities in the High Plains area of Texas. In addition, several industries located near the project facilities are provided with water through contractual arrangements with the cities and the Canadian River Municipal Water Authority.

Water has been supplied to these entities from project facilities since completion of construction of the aqueduct system in 1968. Water deliveries by the project have varied to meet the demands, from about 29,000 acre-feet in 1968 to more than 64,000 acre-feet in 1976. The project works will deliver water to meet future needs of up to 103,000 acre-feet per year, which is the firm annual reservoir yield.

The four northernmost cities in the project area receive untreated water and each provides its own water treatment facilities. The seven cities in the southern portion of the project, through agreement, use a water treatment facility at Lubbock, Tex. The aqueduct system delivering water to the seven cities in the southern area is designed, constructed, and operated to convey potable, treated water supplies.

Flood Control

Flood control benefits are included in the project. Historically, the damsite has experienced a number of major damaging floods. No major floods have occurred at Sanford Dam since construction was completed and storage of water began.

Conchas Reservoir, an upstream Canadian River reservoir in New Mexico, was constructed by the Corps of Engineers. Additionally, the New Mexico Interstate Stream Commission has constructed Ute Reservoir on the Canadian River near the New Mexico-Texas State line. Flood control operations at Sanford Dam will involve cooperation between the Corps of Engineers, the Canadian River Municipal Water Authority, and the Bureau of Reclamation. Flood control operations to control storage above elevation 2941.3 are under the direction of the Corps of Engineers.

Recreation and Fish and Wildlife

Lake Meredith provides excellent recreation opportunities to residents of Texas, Oklahoma, New Mexico, and others traveling to the area. The recreation areas are administered by the National Park Service, under an agreement among the Park Service, the Canadian River Municipal Water Authority, and the Bureau of Reclamation. The lake provides over 100 miles of shoreline and over 16,000 acres of water surface (at elevation 2936.5) surrounded by 200-foot-deep steep-walled canyons and broken grassland. It is open year-round for fishing which includes bass, crappie, walleye, and several species of catfish.

Recreation facilities provided in the reservoir area include access roads, parking areas, picnic tables and shelters, drinking water, boat launching ramps, boat docks, a floating "Fish-O-Rama", a swimming area, and public restrooms. During 1976, the National Park Service reported over 1,800,000 visitor days and some 86,300 boat days of recreational use by the public.

Among the animals in the Lake Meredith recreation area are deer, pronghorn, coyotes, rabbits, porcupines, skunks, turkeys, quail, and dove. In the winter, there are ducks, geese, and sandhill cranes. Hunting is allowed in special areas in season.

ENGINEERING DATA

Water Supply

CANADIAN RIVER

Drainage area above Sanford Dam	9,090	mi²
Annual discharge:		
Maximum (1941)	2,113,500	acre-ft
Minimum (1964)	34,900	acre-ft
Average	294,600	acre-ft

Storage Facilities

SANFORD DAM

Type: Zoned earthfill
Location: Canadian River, 37 mi northeast of Amarillo, Tex., and 8 mi west of Borger, Tex.
Construction period: 1962-65
Reservoir, Lake Meredith:
Storage space in the reservoir is allocated as follows:

Dead capacity—Streambed to El. 2850	43,049	acre-ft
Inactive capacity—El. 2850 to 2860	36,191	acre-ft
Active conservation capacity—El. 2860 to 2936.5	785,157	acre-ft
Active conservation and flood control capacity—El. 2936.5 to 2965	543,175	acre-ft
Surcharge capacity—El. 2965 to 3004.9	1,026,643	acre-ft
Total capacity to El. 2965	1,407,572	acre-ft

Surface area at top of conservation and flood control capacity—El. 2965 .... 21,639 acres

The 50-year accumulation of sediment is estimated to total approximately 477,500 acre-ft between streambed and El. 2965, of which about 398,500 acre-ft is above El. 2860.

Dimensions:

Structural height	228	ft
Top width	40	ft
Maximum base width	1,900	ft
Crest length	6,380	ft
Crest elevation	3011.0	ft
Volume	15,308,000	yd³

Spillway: Concrete conduit, chute, and stilling basin.

Capacity .... 19,300 ft³/s

Outlet works: A 46-in gate-controlled aqueduct supply conduit and a gate-controlled 102-in-diameter river outlet conduit.

Capacity .... 3,400 ft³/s

Flood control outlet: 3-barrel concrete conduit controlled by 12- by 15-ft radial gates, chute, and stilling basin.

Capacity .... 38,400 ft³/s

Carriage Facilities

Pipeline: Reinforced concrete

Length .... 322 mi

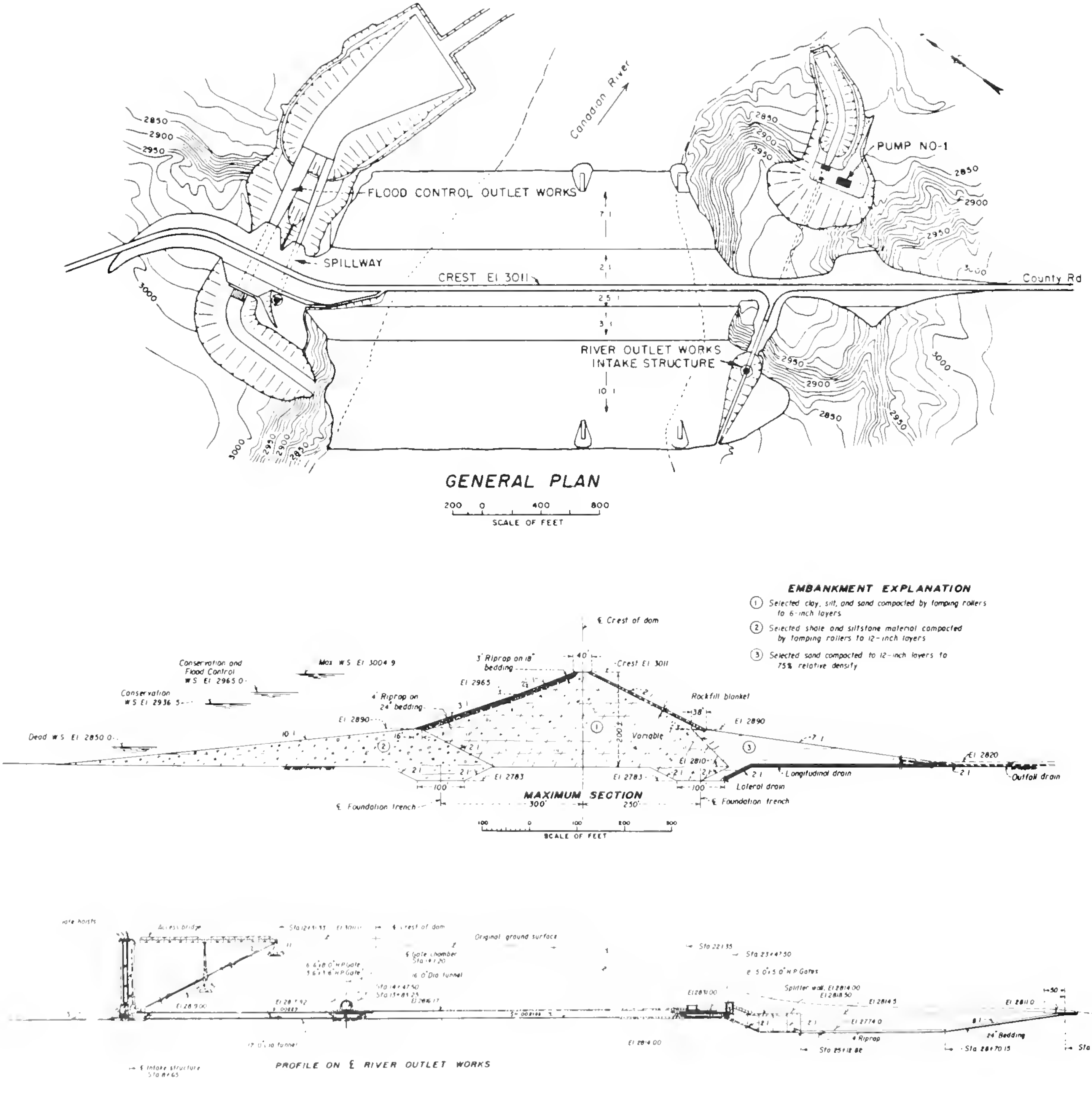
Size:

Maximum .... 96 in

Minimum .... 15 in

Pumping Plants

Designation Number	Number of units	Standby	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
1	5		189	296	8,750
2	4	1	165	228	5,000
3	4	1	165	228	5,000
4	4	1	165	228	5,000
5	3	1	24.1	98	375
6	3	1	13.6	256	600
8	3	1	9.6	114	180
9	3	1	9.6	114	180
10	3	1	9.6	114	180
11	3	1	5.4	89	90

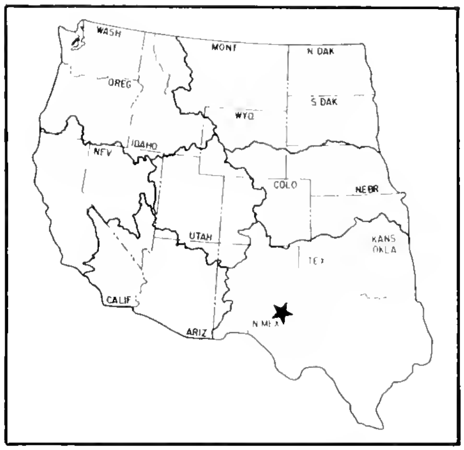


Sanford Dam, Plan and Sections

Carlsbad Project

New Mexico: De Baca, Eddy, and Guadalupe Counties

Southwest Region
Water and Power Resources Service



The Carlsbad Project is in southeastern New Mexico near the city of Carlsbad. Project features include Sumner Dam and Lake Sumner (previously Alamogordo Dam and Reservoir)[1], McMillan Dam, Avalon Dam, and a drainage and distribution system to irrigate 25,055 acres of land. Sumner Dam and Lake Sumner also provide flood control and recreation benefits although there is no storage allocated for those purposes.

PLAN

The irrigation plan for the project provides for storage of water in Lake Sumner, McMillan Reservoir, and Avalon Reservoir, with diversion of water from Avalon Reservoir into a canal system to irrigate project lands on both sides of the Pecos River near Carlsbad.

McMillan Dam and Reservoir[2]

Rehabilitated in 1908, this zoned earthfill dam is 57 feet high and has a volume of 234,000 cubic yards. The reservoir capacity as built was 82,600 acre-feet but siltation has reduced the active capacity to about 33,600 acre-feet.

Avalon Dam

(Based on survey of September 1964.) The dam is located about 14 miles northwest of Carlsbad.

Avalon Dam and Reservoir

In addition to forming a storage and regulating reservoir, Avalon Dam serves as the diversion dam for the project by diverting water into the Main Canal. The dam is located on the Pecos River 5 miles north of Carlsbad, N. Mex. It is a zoned earthfill structure constructed in 1907. The height was increased in 1912, and again in 1936. It has a structural height of 58 feet and a volume of 202,000 cubic yards. The storage capacity of the original reservoir was 7,000 acre-feet; current capacity is about 4,980 acre-feet.

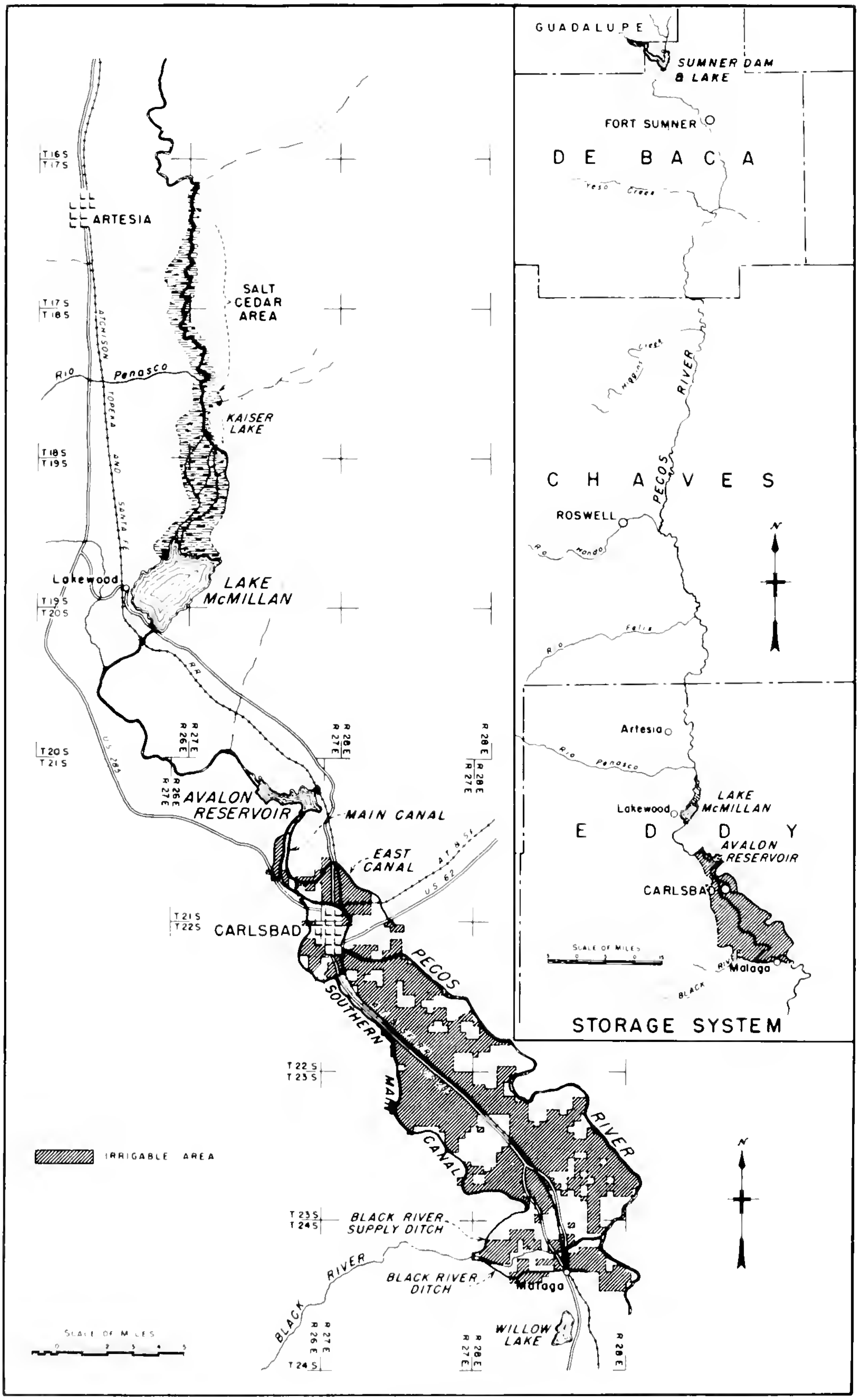
Sumner Dam and Lake Sumner

Sumner Dam and Lake Sumner are on the Pecos River about 250 river miles north of Carlsbad and about 16 miles northwest of Fort Sumner, N. Mex. It is a zoned earthfill structure 164 feet high with a volume of 2,250,000 cubic yards. The reservoir has a capacity of 110,650 acre-feet. In addition to storage for irrigation, the dam provides some control of seasonal floods of the Pecos River.

Irrigation and Drainage System

From the east end of Avalon Dam, the Main Canal extends generally south along the Pecos River for about 3 miles below the dam, where it divides into the East Canal and the Southern Main Canal. The East Canal continues for about 6 miles. The Southern Main Canal runs south to the Pecos River, which it crosses about 1 mile northwest of Carlsbad through a concrete aqueduct, and continues in a generally southerly direction for about 21 miles to its terminus in the Black River Canal about 3 miles northwest of Malaga. The diversion capacities of the Main, East, and Southern Main Canals are 450, 35,

[1]Redesignated by Public Law 93-447, October 17, 1974 (88 Stat. 1363).
[2]See also "McMillan Delta Project".



Carlsbad Project

and 400 cubic feet per second, respectively. The Black River Canal empties into the Black River just above a concrete diversion dam that supplies water to the Black River Ditch. This ditch irrigates lands south of the Black River and west of the Pecos River. Seepage and drainage water from Carlsbad Project lands is returned through a drainage system to the Pecos River. There are 151 miles of laterals, 37 miles of canals, and about 24 miles of drains.

DEVELOPMENT

Early History

The Spanish started irrigating the land when they settled in the Pecos River Basin around 1600. Irrigation in the early 19th century flourished under the Spanish land grant colonization system and was continued after 1850 by the American settlers. The early irrigation systems were community ditches which diverted the normal flow of the river without the benefit of permanent diversion structures. In 1888, a large ranch was located in the general area of the present Carlsbad Project. The ranch manager initiated the first large-scale irrigation attempt. Since the natural characteristics of the area required a more comprehensive treatment than the enterprise could afford, it failed. For the next 17 years, various private interests attempted to make this project financially profitable, but without success.

During this period, project facilities were built to include McMillan Dam for water storage, Avalon Dam for both storage and diversion, the Main Canal, and a distribution system which irrigated 15,000 acres. Private operation of the project ended in 1904 when a Pecos River flood destroyed the central canal and much of the irrigation system and swept away Avalon Dam. Without water for the land, the project settlers faced complete ruin. Upon their request, in 1905 the Reclamation Service was authorized to purchase the system. Reclamation then began investigations prior to rehabilitating the project.

Investigations

By 1907, the system was repaired and extended to permit the irrigation of approximately 25,000 acres. McMillan Dam was rehabilitated in 1908, but by 1932 silt accumulation had reduced the storage capacity of the reservoir and leakage through gypsum and limestone strata had reduced its effectiveness. As siltation advanced, about 13,000 acres of salt cedars grew in the upper reservoir area. After a careful analysis of all factors involved, it was decided to construct a new reservoir at a different site rather than to attempt correction of the defective conditions at Lake McMillan. Detailed investigations resulted in the selection of Sumner Dam site.

Authorization

The original Carlsbad Project was authorized by the Secretary of the Interior on November 28, 1905. Sumner Dam was authorized for construction by the President on November 6, 1935, initial funds having been approved on August 14, 1935, under the Emergency Relief Appropriations Act of 1935. Section 7, Flood Control Act of August 11, 1939, declared Sumner Dam and Lake Sumner were to be used first for irrigation, then for flood control, river regulation, and other beneficial uses.

Brantley Dam and Reservoir were authorized on October 20, 1972, by Public Law 92-514, to replace the depleted capacity of McMillan Reservoir and provide flood control, fish and wildlife, and recreation benefits.

Construction

Avalon Dam was rebuilt and the project distribution system repaired and extended by 1907. McMillan Dam was rehabilitated in 1908. Sumner Dam was built during 1936-37.

The spillway capacity of Sumner Dam was enlarged during 1954-56. The alteration work included the construction of an auxiliary spillway in the left abutment, enlargement of the existing dam and dike, and modification of the spillway and stilling basin.

Sinkholes had developed along the eastern edge of the McMillan Reservoir to such an extent that extensive storage capability was being lost. The construction of an extended dike, approximately 10,000 feet long, was initiated in July 1954 to cut off the largest of these sinkholes. The dike was completed in 1955.

In 1967, the Carlsbad Irrigation District entered into a rehabilitation and betterment program with the Bureau of Reclamation for concrete lining and improvement of the irrigation distribution system. This program resulted in concrete lining and improvements to some 79 miles of laterals, which significantly reduced water losses and provided a more efficient delivery of water. The Carlsbad Irrigation District has received an extension of the rehabilitation and betterment program to line another 16 miles of laterals and about 9 miles of canals with concrete.

Brantley Dam has been authorized for construction and foundation exploratory work is underway.

Operating Agencies

The Carlsbad Irrigation District operates and maintains the project with the exception of the Sumner Dam, which is operated and maintained by the Bureau of Reclamation.

BENEFITS

Irrigation

A long growing season, good soil, favorable markets, and irrigation facilities make intensive diversified farming practices attractive and profitable. Cotton and alfalfa are the principal crops, although wheat, barley, oats, and vegetables are produced in abundance.

Flood Control

Sumner Dam contributes materially to the economy of the area by controlling seasonal floods of the Pecos River.

Recreation

Lake Sumner is in a semidesert area and furnishes year-round recreation benefits. There are camping and picnic grounds, cabin sites, and boat docks with small boats for hire. The reservoir provides good bass and catfish fishing in season.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	25,055	acres
Number of irrigated farms	155	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	18,727	3,731,502
1969	22,216	3,118,351
1970	22,190	3,795,288
1971	20,545	4,483,274
1972	21,271	3,449,592
1973	21,529	6,255,046
1974	21,850	5,699,926
1975	21,453	5,633,880
1976	21,490	6,053,137
1977	20,999	5,960,133

Facilities in Operation

Storage dams	3	
Canals	41.1	mi
Laterals	137.6	mi
Drains	31.8	mi

Climatic Conditions

Annual precipitation	12.1	in
Temperature:		
Maximum	111	°F
Minimum	−16	°F
Mean	63	°F
Growing season	212	days
Elevation of irrigable area	3100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	701
Other water service[3]	30,000
Total	30,701

[3]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

PECOS RIVER

Drainage area at Artesia	15,300	mi^2
(Drainage area for Lake McMillan is 16,990 mi^2.)		
Average annual discharge	192,000	acre-ft

BLACK RIVER

Drainage area at Malaga	343	mi^2
Average annual discharge	10,070	acre-ft

Storage Facilities

MCMILLAN DAM

Type: Zoned earthfill
Location: On Pecos River, 14 mi northwest of Carlsbad, N. Mex.
Construction period: Constructed in 1893 by private interests. Rehabilitated by Bureau of Reclamation in 1908, and embankments modified in 1909, 1916, 1937, and 1954.

Reservoir, McMillan:		
Active capacity, El. 3267.7 to 3241.6	33,600	acre-ft
Surface area at El. 3266.6	5,060	acres
Dimensions (main embankment):		
Structural height	57	ft
Hydraulic height	14.7	ft
Top width	25	ft
Maximum base width	250	ft
Crest length	2,144	ft
Crest elevation (nonoverflow)	3280.0	ft
Total volume	234,000	yd^3
Spillway: Two uncontrolled concrete overflow weir spillways northwest of dam.		
Crest length No. 1 and No. 2	1,400 and 350	ft
Crest elevation No. 1 and No. 2	3267.7 and 3266.5	ft
Total capacity	60,000	ft^3/s
Outlet works: Five 4- by 8-ft slide gates in concrete sluiceway section of dam.		
Capacity	5,000	ft^3/s

AVALON DAM

Type: Zoned earthfill
Location: On the Pecos River about 5 mi north of Carlsbad, N. Mex.
Construction period: 1907. Crest raised in 1912 and 1936.

Reservoir, Avalon:		
Active capacity, El. 3177.1 to 3157	5,100	acre-ft
Surface area	930	acres
Dimensions:		
Structural height	58	ft
Hydraulic height	34	ft

Top width	34	ft
Maximum base width	255	ft
Crest length	1,025	ft
Crest elevation	3194.0	ft
Total volume	202,000	yd³

Spillway: Vertical buttressed concrete overflow weir at left abutment (No. 1); circular concrete overflow weir at right abutment (No. 2); and masonry overflow weir about 4,000 ft west of the dam (No. 3).

	No. 1	No. 2	No. 3
Crest length	233	393	400 ft
Crest elevation	3177.8	3177.4	3177.8 ft
Capacity at El. 3192	34,000	65,000	46,000 ft³/s

Outlet works: Two 21-ft-diameter cylinder gates discharging through tunnel into river.

Capacity at El. 3190	23,600	ft³/s

Diversion works: Six 4- by 6-ft slide gates in headworks structure at left abutment.
Capacity controlled by capacity of canal.

Sumner Dam

Type: Zoned earthfill
Location: On Pecos River 16 mi northwest of Fort Sumner, N. Mex.
Construction period: 1936-37. Crest raised 16 ft, spillway modified, and emergency spillway constructed in 1955-56.
Reservoir, Sumner:

Average annual discharge at Puerto De Luna (Puerto De Luna represents inflow to Lake Sumner. About 15 mi upstream from Sumner Dam — has a drainage area of 3,970 mi²)	154,300	acre-ft
Total capacity including surcharge at El. 4297[1]	258,650	acre-ft
Active capacity, El. 4200 to 4275	110,650	acre-ft
Surface area at El. 4275	4,560	acres

Dimensions:

Structural height	164	ft
Hydraulic height	147	ft
Top width	30	ft
Maximum base width	925	ft
Crest length	3,084	ft
Crest elevation	4301.0	ft
Total volume	2,250,000	yd³

Spillway: Concrete-lined open channel in right abutment controlled by three 45- by 21-ft radial gates and 500-ft-wide emergency spillway with earth plug in left abutment.

Elevation top of gates	4275.0	ft
Crest elevation	4254.0	ft
Capacity at El. 4297:		
Service spillway	56,000	ft³/s
Emergency spillway	150,000	ft³/s

Outlet works: Concrete-lined tunnel through right abutment controlled by two 54-in needle valves.

Capacity at El. 4275	1,700	ft³/s

Foundation: Hard grayish sandstone underlain by lensing "red beds" of the streambed, dominantly shale, friable, but massive silty red sandstone and lenses of limestone.
Special treatment: Cement grout curtain under cutoff walls; supplementary grouting in left abutment area.

[1]Total original capacity was 304,750 acre-ft, including 8,750 acre-ft of dead storage, 148,000 acre-ft active storage, and 148,000 acre-ft surcharge added in 1955-56.

Carriage Facilities

Main Canal

Location: From Avalon Dam south to vicinity of Carlsbad, N. Mex.
Construction period: Private construction. Rehabilitated by Reclamation Service in 1906.

Length	3.1	mi
Diversion capacity	450	ft³/s
Typical maximum section:		
Bottom width	45	ft
Side slopes	1.5:1	
Water depth	4.5	ft

East Canal

Location: Near Carlsbad, N. Mex., on east side of Pecos River.
Construction period: Private construction. Rehabilitated by Reclamation Service in 1906.

Length	5.8	mi
Diversion capacity	35	ft³/s
Typical maximum section, lined:		
Bottom width	3	ft
Side slopes	1.25:1	
Water depth	2.2	ft
Lining thickness	3	in
Length	4.1	mi
Typical maximum section, unlined:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	2	ft

Southern Main Canal

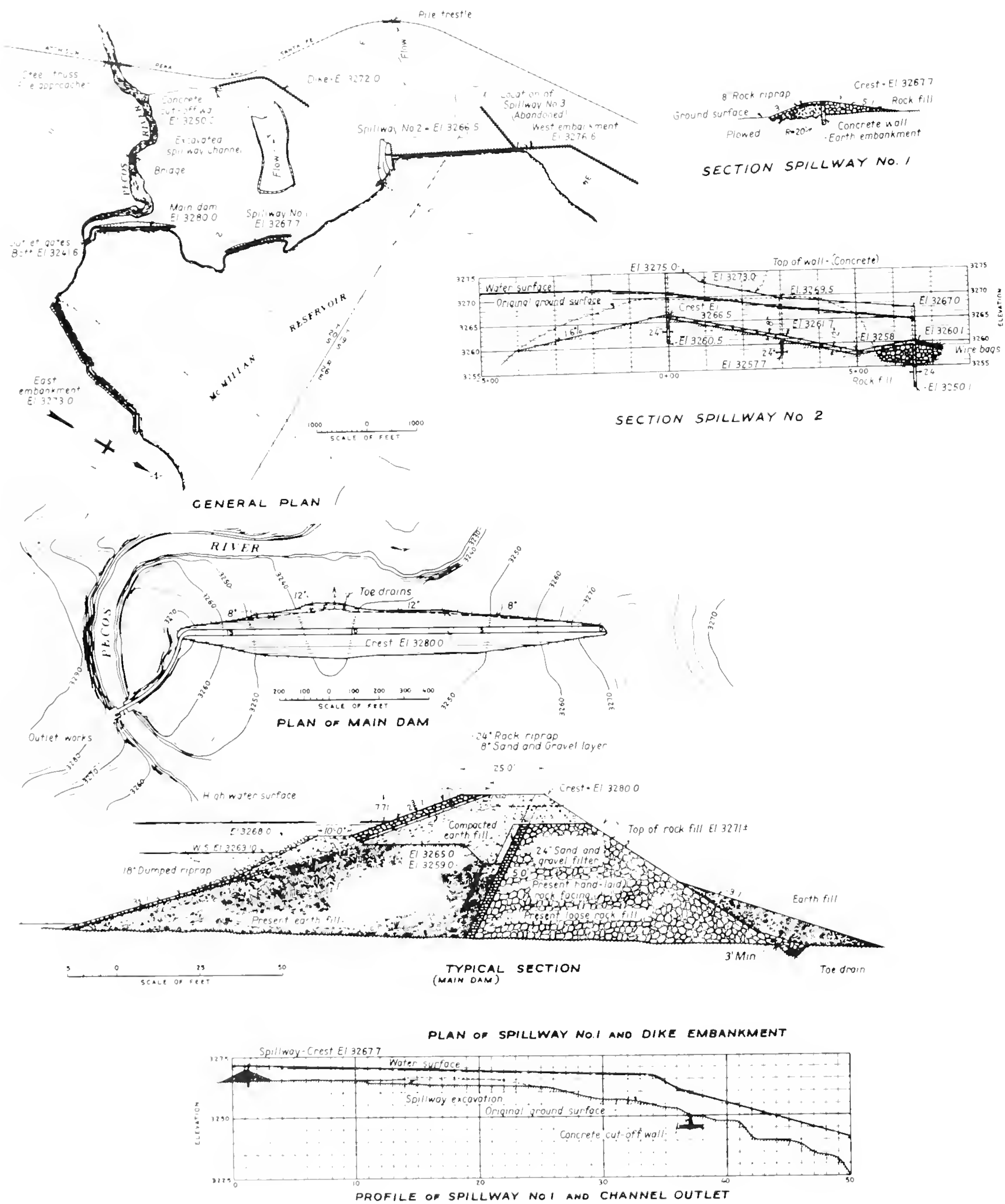
Location: From near Carlsbad, N. Mex., southeast along Pecos River.
Construction period: Private construction. Rehabilitated by the Reclamation Service in 1906-07.

Length	21.5	mi
Diversion capacity	400	ft³/s
Typical maximum section, unlined:		
Bottom width	30	ft
Side slopes	1.5:1	
Water depth	3.5	ft
Length	13.6	mi
Typical maximum section, lined:		
Bottom width	12	ft
Side slopes	1.25:1	
Water depth	3.5	ft
Lining thickness	3	in
Length	7.9	mi

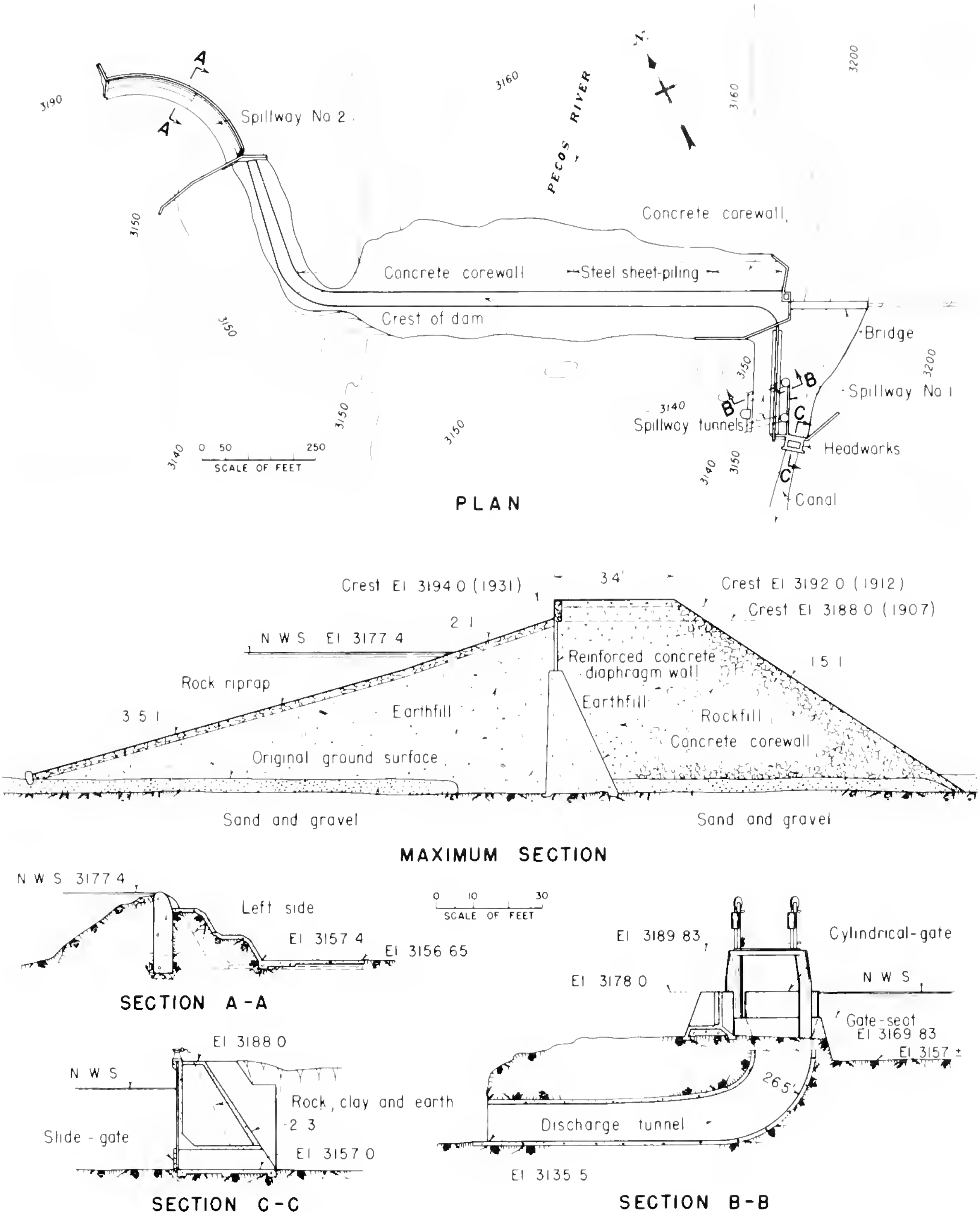
Black River Canal

Location: Near Pecos River, about 15 mi southeast of Carlsbad, N. Mex.
Construction period: Private construction. Rehabilitated by the Reclamation Service in 1906.

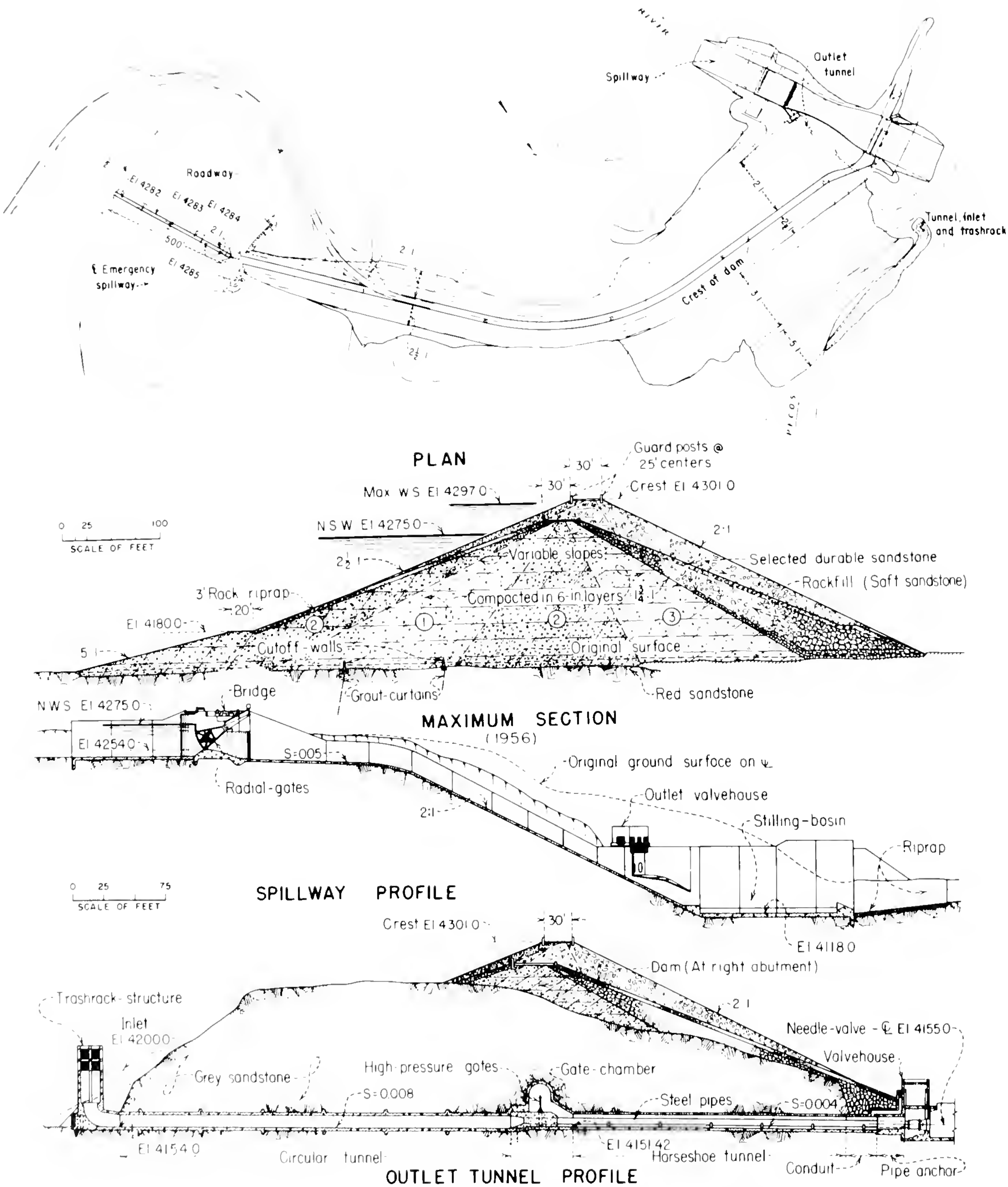
Length	6.6	mi
Diversion capacity	80	ft³/s
Typical maximum section, lined:		
Bottom width	8	ft
Side slopes	1.25:1	
Water depth	2	ft
Lining thickness	3	in
Length	5.1	mi
Typical maximum section, unlined:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	2.5	ft
Length	1.5	ft



McMillan Dam, Plan and Sections



Avalon Dam, Plan and Sections

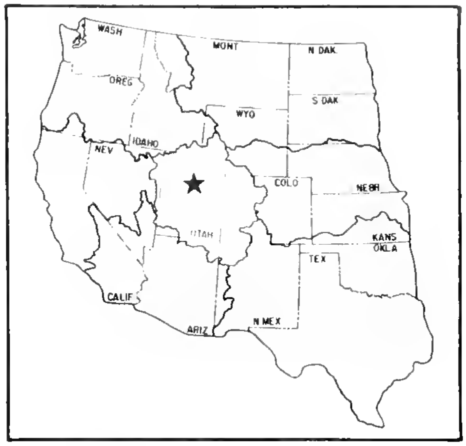


Sumner Dam (previously Alamogordo Dam), Plan and Sections

Central Utah Project

Utah: Duchesne, Garfield, Juab, Millard, Piute, Salt Lake, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch Counties

Upper Colorado Region
Water and Power Resources Service

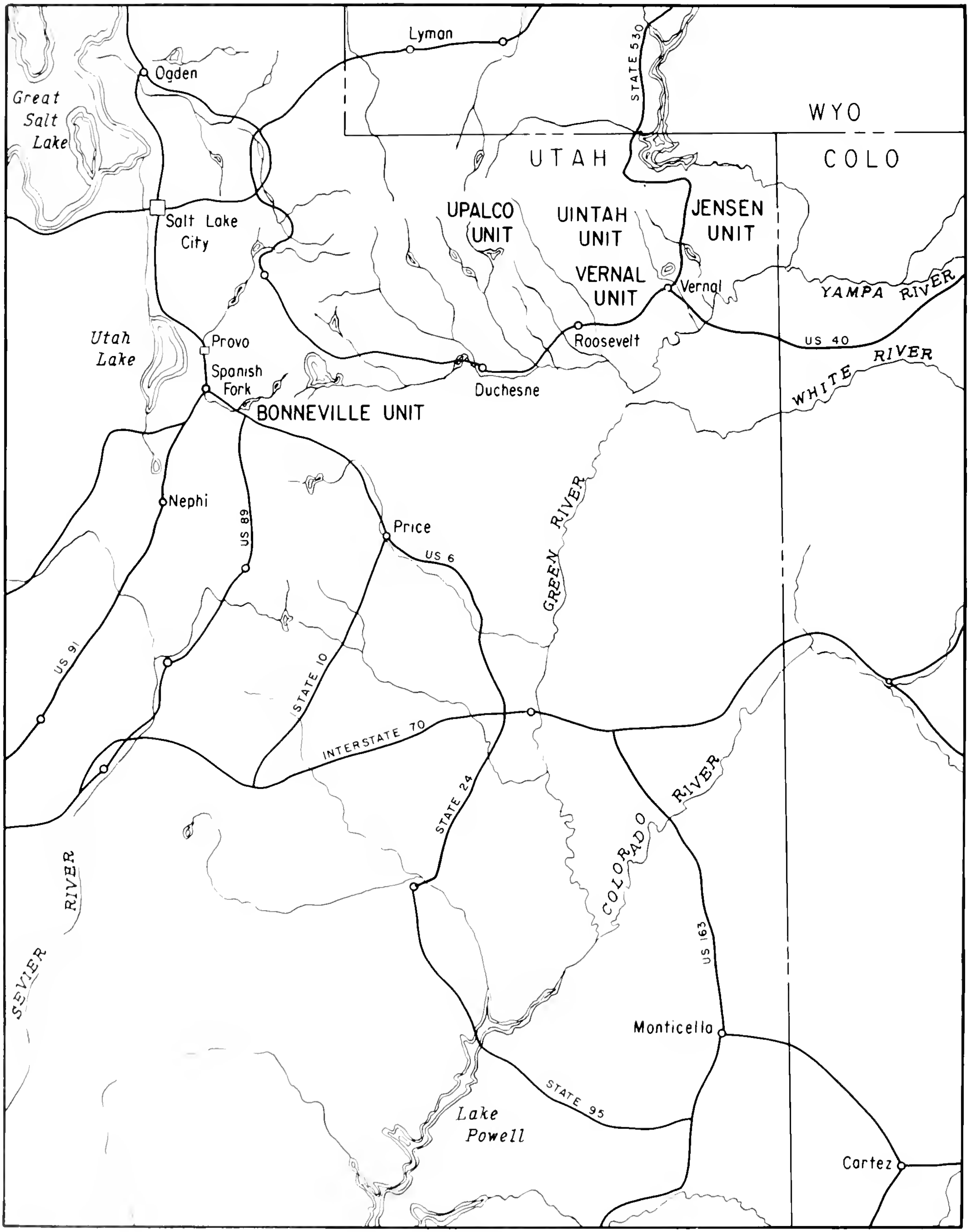


The Central Utah Project will develop water from Utah Lake, the Provo River, and water tributary to the Colorado River for use in the Uinta Basin (a portion of the Colorado River Basin) and in the eastern part of the adjoining Bonneville Basin. Water developed is now or will be used for irrigation, municipal and industrial uses, and production of hydroelectric power. The project also will benefit fish and wildlife and recreation as well as improve water conservation and flood control and assist in water quality control.

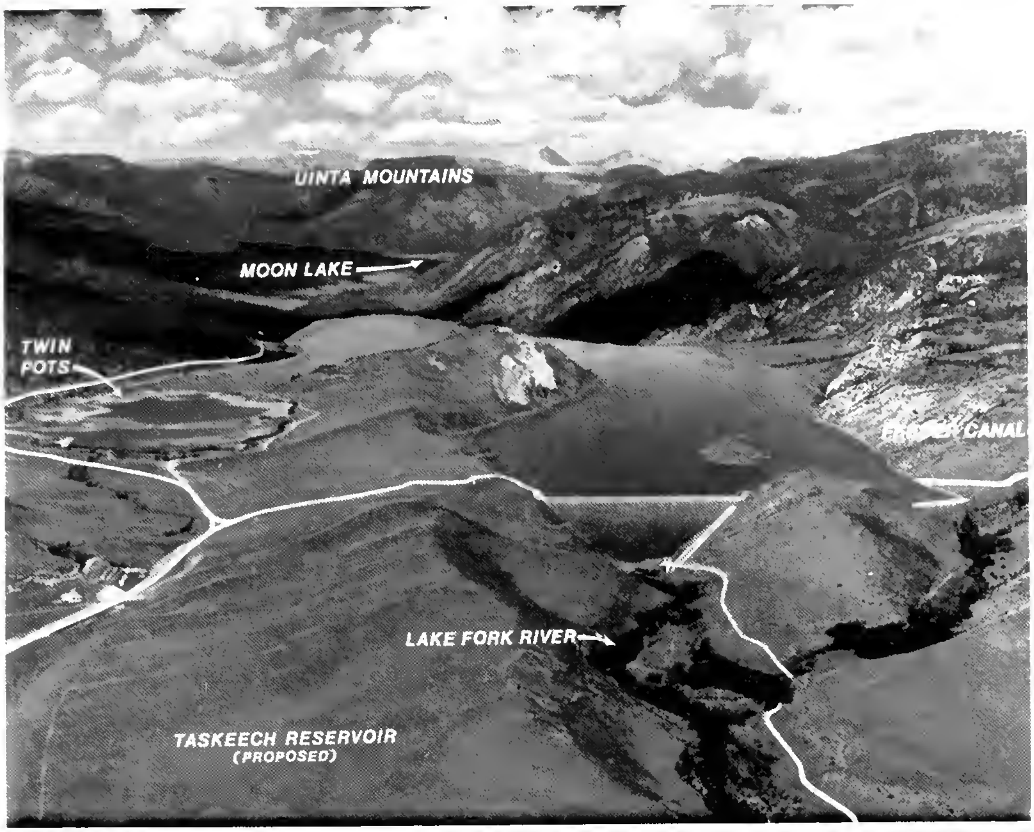
PLAN

The Central Utah Project is divided into six units: Vernal, Bonneville, Jensen, Upalco, Uintah, and Ute Indian. Only the Vernal Unit is completed; it was finished in 1962. The Bonneville Unit, the most comprehensive of the six units, is under construction. It involves water collection and distribution in both the Uinta and Bonneville Basins with a diversion of Uinta Basin water to Bonneville Basin. The Jensen Unit, also under construction,

Artist's conception of Red Fleet Dam and Reservoir, Jensen Unit



Central Utah Project



Artist's conception of Taskeech Dam and Reservoir, Upalco Unit

will provide water for northeastern Utah in Ashley Valley and the area extending east of the valley to the Green River. The Upalco Unit would provide supplemental irrigation water for Indian and non-Indian lands along the Lake Fork River. The plan also includes municipal and industrial water and will provide benefits for recreation, fish and wildlife enhancements, and flood control. The Uintah Unit, in the final stages of planning, will store the high flows of the Uinta and Whiterocks Rivers for irrigation of Indian and non-Indian lands, for municipal and industrial use, for recreation, for flood control, and for fish and wildlife purposes. A concluding report on the Ute Indian Unit was recently completed that delays further development of the unit until future needs of the Central Utah Project can be more thoroughly deter

Vernal Unit

See separate section for a description of this unit.

Bonneville Unit

See separate section for a description of this unit.

Jensen Unit

The Jensen Unit, currently under construction in Uintah County in northeastern Utah, will serve Ashley Valley and the area extending east of the valley to the Green River. This multipurpose project will develop about 22,600 acre-feet of water annually: 18,000 acre-feet for municipal and industrial uses and 4,600 acre-feet for irrigation. Some 400 irrigable acres will receive a full service water supply and 3,640 acres will receive a supplemental water supply. Initially, the reservoir will provide water primarily for irrigation. As demands for municipal and industrial water increase, the reservoir water will be made available to meet the demand. The project will also benefit fish and wildlife, recreation, and flood control.

Major features of the unit are Red Fleet Dam and Reservoir, Tyzack Pumping Plant, Tyzack Aqueduct, and Burns Pumping Plant. Construction started on the main project feature, Red Fleet Dam, in the fall of 1977 and is scheduled for completion in 1980. Project water will be pumped from Red Fleet Reservoir by Tyzack Pumping Plant and carried past Steinaker Reservoir to Ashley Creek by the Tyzack Aqueduct for exchange with water in the Ashley Valley municipal and industrial system. Red Fleet Reservoir operation will be coordinated with operation of Steinaker Reservoir of the nearby Vernal Unit to avoid winter operation of Tyzack Aqueduct. Some municipal and industrial water users also can be served by using exchange water from Big Brush Creek. Storage water to be used for irrigation downstream from Red Fleet Reservoir will be released from the reservoir to

Big Brush Creek and conveyed in the Brush Creek Channel for subsequent diversion. Project water will be pumped from the Green River at Burns Pumping Plant for irrigation of lands near Jensen, Utah. Irrigation water will be distributed by existing canals, whether supplied from the reservoir or the pumping plant. Only minor extension of existing irrigation distribution facilities will be required, which will be modified and extended by the water users as the need arises.

Red Fleet Dam and Reservoir

Red Fleet Dam is on Big Brush Creek about 10 miles northeast of Vernal, Utah. It is an earthfill embankment nearly 1,750 feet long and 130 feet high with outlet works and a spillway structure. Red Fleet Reservoir will have a total capacity of 26,000 acre-feet and an active capacity of 24,000 acre-feet. Recreational facilities will be provided at the reservoir, and provisions for fish and wildlife will include a fishery pool in the reservoir.

Tyzack Pumping Plant

Tyzack Pumping Plant, located at Red Fleet Dam, will lift municipal and industrial water from Red Fleet Reservoir to Tyzack Aqueduct which will convey the water southwesterly to Ashley Creek where it will be exchanged for high quality water from Ashley Springs.

Burns Pumping Plant

Burns Pumping Plant will be located on the west bank of the Green River about 2.5 miles upstream from Jensen, Utah. The pumping plant will lift water through four separate discharge lines to the four existing canals in the area.

Tyzack Aqueduct

The 11.7-mile-long Tyzack Aqueduct will convey water from Red Fleet Reservoir to Ashley Creek west of Steinaker Reservoir in the Vernal Unit. High quality Ashley Creek water will then be freed for municipal and industrial use and will be replaced by water from Red Fleet Reservoir. The buried Tyzack Aqueduct will have a capacity of 46 cubic feet per second and will range in size from 27 to 36 inches in diameter.

Upalco Unit

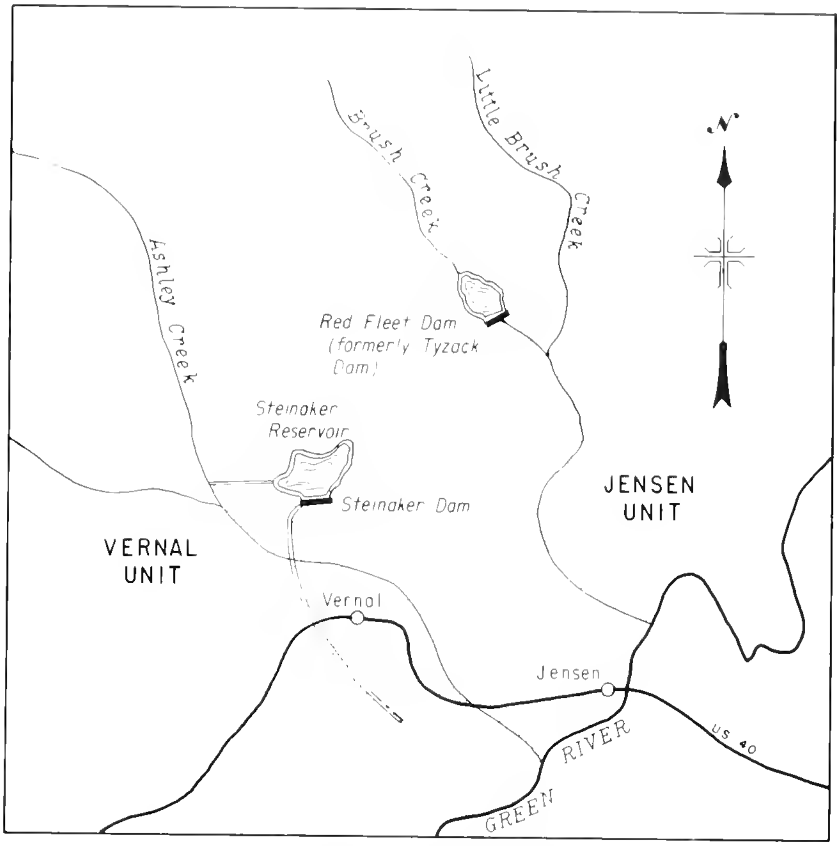
The Upalco Unit, located in northeastern Utah in Duchesne County, would develop flows of the Lake Fork and Yellowstone Rivers, with minor contributions from other small streams such as Big Sand Wash. The unit would develop almost 18,000 acre-feet of water for the supplemental irrigation of 42,520 acres of Indian and non-Indian land. Water would also be available for municipal and industrial use, recreation, fish and wildlife purposes, and flood control.

Artist's conception of Uintah Dam and Reservoir, Uintah Unit

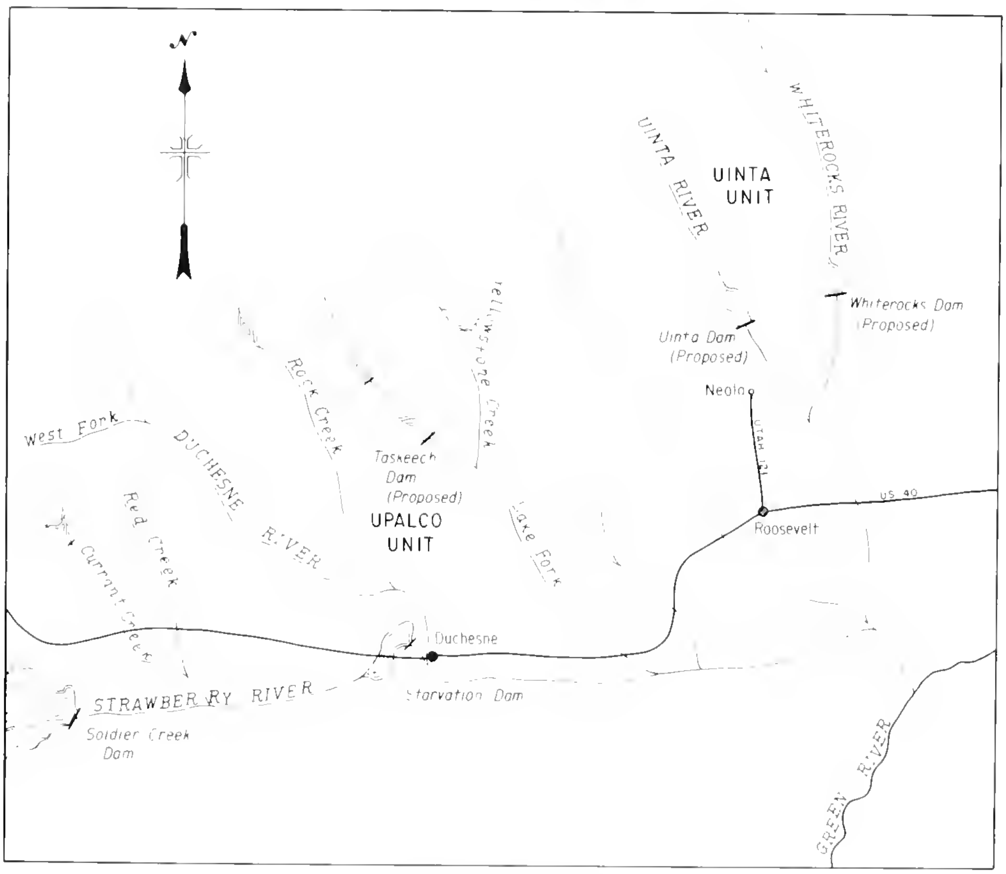
Project irrigation water would be made available from storage regulation of surplus flows of Yellowstone and Lake Fork Rivers, from savings of excessive seepage losses through rehabilitation of existing canals, and increased use of return flows. Storage regulation would be provided in Taskeech Reservoir on the Lake Fork River located within both the Uintah and Ouray Indian Reservations and the Ashley National Forest. Diversion of water from Yellowstone River would be accomplished by Boneta Diversion Dam on the river, and Taskeech Feeder Canal would convey water back to the river. Irrigation supplies, averaging 17,900 acre-feet annually, would be released from Taskeech Reservoir to the stream channel below and then distributed through existing canal systems and through the Taskeech Service Canal.

Municipal and industrial water would be made available from Taskeech Reservoir for use by the city of Roosevelt, Utah, and other smaller communities in the area. Treatment and distribution of the water would be the responsibility of the water users.

Part of the storage in Taskeech Reservoir, which would have a total capacity of 78,400 acre-feet, would be used to replace the irrigation supply presently obtained from 14 high country lakes located within Ashley National Forest and from Twin Pots Reservoir located on the Indian reservation. The 14 lakes and Twin Pots Reservoir would be stabilized as fishery lakes under the project. A permanent pool for fish would be provided in Taskeech Reservoir, and the fishery would be improved in the upstream Moon Lake Reservoir by coordinated operation of the two reservoirs. Stream improvements for fish would be provided in the Lake Fork River downstream of the reservoir, and a stretch of the Yellowstone River



Vernal and Jensen Units



Uinta and Upalco Units

Artist's conception of Whiterocks Dam and Reservoir, Uintah Unit

would be opened to fishery access by purchase of private lands. Some Indian-owned rangelands in the Uintah and Ouray Indian Reservations would be revegetated and some private lands purchased for public use to mitigate losses to big game resulting from reservoir inundation. Recreational facilities would be provided at Taskeech Reservoir and three upstream sites on the Lake Fork and Yellowstone Rivers.

Uintah Unit

The Uintah Unit, located in Duchesne and Uintah Counties in northeastern Utah, would develop flows of the Uinta and Whiterocks Rivers for the supplemental and full service irrigation of over 67,000 acres of both Indian and non-Indian lands. Water for municipal and industrial uses, recreation, fish and wildlife, and flood control would also be provided.

Irrigation water would be made available from storage regulation of surplus flows of the Uinta and Whiterocks Rivers, from savings of excessive seepage losses through rehabilitation of existing canals, and increased use of return flows. Storage regulation would be provided in Uinta Reservoir on the Uinta River within the Uintah and Ouray Indian Reservations and in Whiterocks Reservoir on Whiterocks River within the Ashley National Forest. Irrigation supplies would be released from both reservoirs to the stream channels below and distributed through new and existing canal systems. Municipal and industrial water would be made available from storage in the Uinta Reservoir for use by the city of Roosevelt, Utah.

Part of the storage in Uinta and Whiterocks Reservoirs would be used to replace the irrigation supply presently obtained from 12 high country lakes and Paradise Park Reservoir, all situated within the Ashley National Forest. The 12 lakes would be rehabilitated and stabilized as fishery lakes, and part of the storage capacity of Paradise Park Reservoir would be maintained as an inactive fishery pool. Permanent pools for fish would also be provided in the Uinta and Whiterocks Reservoirs. Recreational facilities would be provided at Uinta and Whiterocks Reservoirs and at five sites upstream.

Uinta Dam and Reservoir

Uinta Dam and Reservoir would be located on the Uinta River about 8 miles north of the town of Neola. The dam would be an earthfill embankment 226 feet high with a crest length of 3,550 feet. The reservoir would have a total capacity of 47,030 acre-feet and a surface area of 736 acres.

Whiterocks Dam and Reservoir

Whiterocks Dam and Reservoir would be located within the Ashley National Forest about 8 miles north of the town of Whiterocks. The dam would be an earthfill embankment 218 feet high with a crest length of 1,550 feet. The reservoir would have a total capacity of 32,000 acre-feet and a normal water surface area of 400 acres.

DEVELOPMENT

Early History

Father Escalante and his party of Spanish soldiers entered the project area in 1776 as the first explorers. Many traders, trappers, and explorers entered the area from 1820 to 1845. Names prominent in that period and still borne by local towns and features include General William Henry Ashley, Captain Benjamin L. E. Bonneville, Jim Bridger, Peter Skene Ogden, Jedediah S. Smith, Kit Carson, Etienne Provost, and John C. Fremont.

Settlement of the area began in 1847 in the Salt Lake Valley with the arrival of Brigham Young and his company of Mormon pioneers. Entering the valley on July 24, the first group of pioneers launched a program of softening the sun-baked soil for plowing by diverting water from City Creek, and then planted crops. This marked the first large-scale irrigation in the United States. By the fall of 1847, Salt Lake Valley was inhabited by 2,000 settlers. The following years brought a great influx of colonizers, who settled in all of the fertile valleys in the region.

The greater part of the Uinta Basin was established as an Indian reservation in 1861. During the period from 1890 to 1905, the lands required by Indians were allotted to them in severalty, and in 1905, the remaining lands were opened to homesteading by settlers.

The Central Utah Project development has been considered by local groups and Government agencies since about the turn of the century. In 1902, farmers and civic leaders first investigated the feasibility of diverting water from the Colorado River to the Bonneville Basin in central Utah.

Agriculture is the basic industry throughout the project area, except that in the Salt Lake City-Provo vicinity, mining, smelting, and manufacturing are of great importance economically. Livestock raising is also a principal agricultural pursuit. A favorable base for the livestock operations are the feed crops extensively produced on irrigated lands, and the vast range resources that are available on nearby mountains and plains. Although feed crops are a principal product, diversified crops are grown in parts of the project area, particularly in the Bonneville Basin.

Investigations

The Central Utah Project plan has evolved from investigations of various independent projects. Continuous investigations have been conducted by the Bureau of Reclamation since 1945 from a plan which started in 1902 on the Strawberry Valley Project. It was recognized early in the investigations that the project was of such magnitude and complexity that it should be divided into separate units to facilitate planning and construction. A feasibility report was published in February 1951.

Authorization

Four units, Vernal, Bonneville, Jensen, and Upalco, were authorized for construction in 1956 by the Colorado River Storage Project Act. The Colorado River Basin Project Act of 1968 authorized the Uintah Unit, and approved the Ute Indian Unit for feasibility investigation.

PROJECT DATA

Climatic Conditions

Annual precipitation	7-17.5	in
Temperature:		
Maximum	110	°F
Minimum	−35	°F
Growing season	125-150	days
Elevation of project lands	4300-7000.0	ft

Project Lands (Acres)

	Supplemental	Full Service	Total
Duchesne River area[1]	26,450		26,450
Heber-Francis area	22,040		22,040
Spanish Fork area	47,880	1,590	49,470
Peteetneet area	1,850	3,010	4,860
Mona-Nephi area	8,960	9,480	18,440
Elberta-Mosida area	2,890	12,040	14,930
Provo Bay area	2,720	6,780	9,500
Sevier River area	100,000		100,000
Total	212,790	32,900	245,690

[1]Includes the equivalent of 10,000 acres of Midview Exchange land.

Irrigation

	Area	Volume
Bonneville:		
New land	29,000 acres	
Existing land	213,000 acres	
Jensen:		
Full service	400 acres	
Supplemental service	3,640 acres	(Tot.) 4,600 acre-ft
Upalco:		
Non-Indian supplemental	27,450 acres	
Indian supplemental	15,070 acres	(Tot.) 17,900 acre-ft
Uintah:		
Full service (Indian)		7,820 acre-ft
Indian supplemental		34,160 acre-ft
Non-Indian supplemental		25,150 acre-ft
Vernal:		
Supplemental		14,700 acre-ft

Municipal and Industrial Water

Bonneville	100,000	acre-ft
Jensen	18,000	acre-ft
Upalco	2,000	acre-ft
Uintah	1,000	acre-ft
Vernal	1,600	acre-ft

Water Supply Diverted from Uinta Basin to Bonneville Basin (Acre-feet)

Diverted by Strawberry Aqueduct:	
Rock Creek (including the South Fork)	79,900
Hades Creek	4,800
Wolf Creek (including Twin)	4,800
West Fork Duchesne River	22,900
Currant Creek	15,800
Layout Creek	1,300
Water Hollow	2,900
Total	132,400
Strawberry River	19,000
Strawberry Reservoir Inflow	151,400
Less Evaporation Loss	−7,700
Less Spills	−7,100
Strawberry Reservoir Releases (CUP Only)	136,600

ENGINEERING DATA

Storage Facilities

RED FLEET DAM (JENSEN UNIT)

Type: Zoned earthfill
Location: On Big Brush Creek, 10 mi northeast of Vernal, Utah.
Construction period: 1977-(Under construction)
Dimensions:

Structural height	130	ft
Crest length	1,750	ft
Embankment volume	2,212,000	yd³
Total storage capacity	26,000	acre-ft
Active storage capacity	24,000	acre-ft

TASKEECH DAM (UPALCO UNIT)

Location: On the Lake Fork River, within Duchesne County, Utah.
Construction period: Proposed

Total reservoir capacity	78,400	acre-ft

UINTA DAM (UINTAH UNIT)

Type: Zoned earthfill
Location: On the Uinta River, about 8 mi north of Neola, Utah.
Construction period: Proposed
Dimensions:

Structural height	226	ft
Crest length	3,550	ft
Total reservoir capacity	47,030	acre-ft
Reservoir area	736	acres

WHITEROCKS DAM (UINTAH UNIT)

Type: Zoned earthfill
Location: On the Whiterocks River, about 8 mi north of Whiterocks, Utah.
Construction period: Proposed
Dimensions:

Structural height	218	ft
Crest length	1,550	ft
Total reservoir capacity	32,000	acre-ft
Reservoir area	400	acres

Diversion Facilities

BONETA DIVERSION DAM (UPALCO UNIT)

Location: On the Yellowstone River in Duchesne County, Utah.
Construction period: Proposed

Carriage Facilities

TASKEECH FEEDER CANAL (UPALCO UNIT)

Location: Will originate at Boneta Diversion Dam.
Construction period: Proposed

TASKEECH SERVICE CANAL (UPALCO UNIT)

Location: Downstream of Taskeech Dam.
Construction period: Proposed

TYZACK AQUEDUCT (JENSEN UNIT)

Location: From Red Fleet Reservoir, 10 mi northeast of Vernal, Utah, to Ashley Creek, 6 mi northwest of Vernal.
Construction period: Under construction

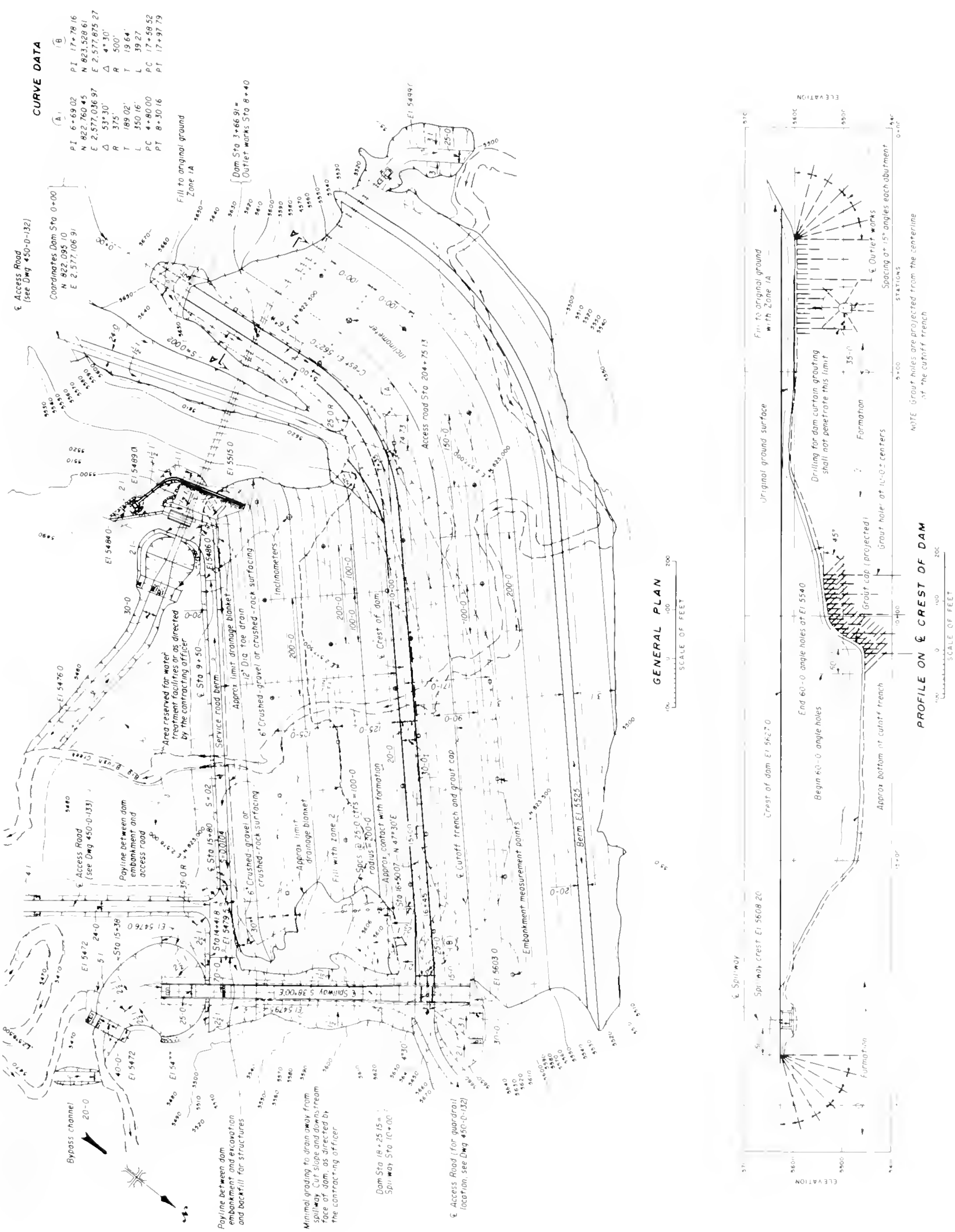
Length	11.7	mi
Capacity	46	ft^3/s
Diameter	27 to 36	in

BURNS PUMPING PLANT (JENSEN UNIT)

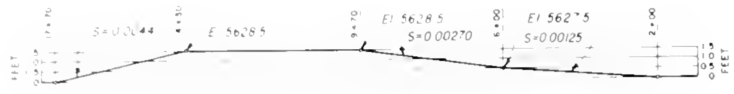
Location: About 2.5 mi upstream from Jensen, Utah, on the Green River.
Construction period: Proposed

TYZACK PUMPING PLANT (JENSEN UNIT)

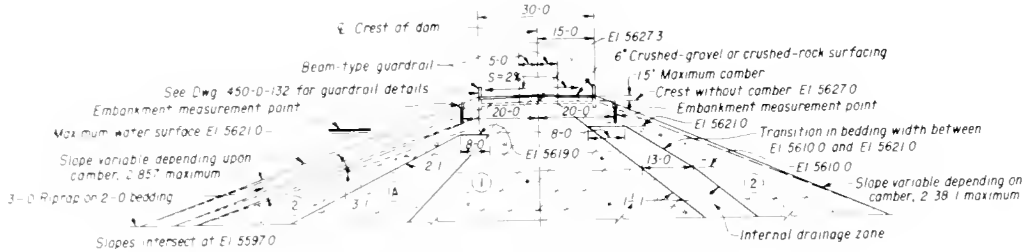
Location: Red Fleet Dam, 10 mi northeast of Vernal, Utah, on Big Brush Creek.
Construction period: 1977–(Under construction)



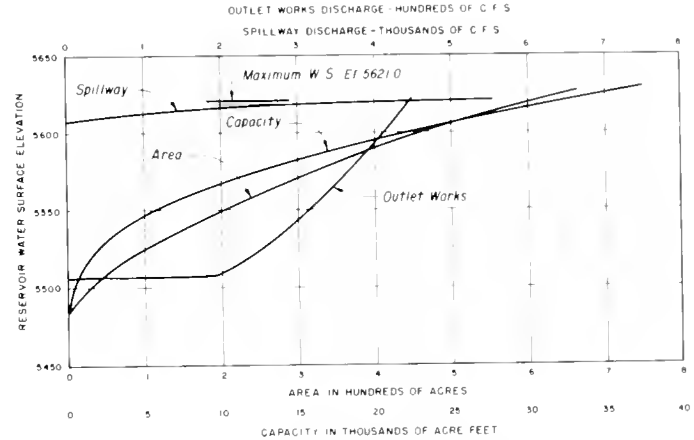
Red Fleet Dam, Plan and Profile



CAMBER ON CREST OF DAM



CREST DETAIL AT MAXIMUM CAMBER



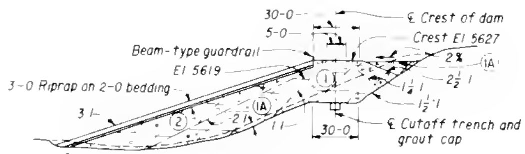
AREA-CAPACITY-DISCHARGE CURVES

EMBANKMENT EXPLANATION

(1) Selected clay, silt, and sand compacted by tamping rollers to 6 inch layers

(1A) Selected clay, silt, sand, and gravel compacted by tamping rollers to 6 inch layers

(2) Selected clay, silt, sand, gravel, and cobbles compacted by pneumatic-tired rollers from 12 in loose layers

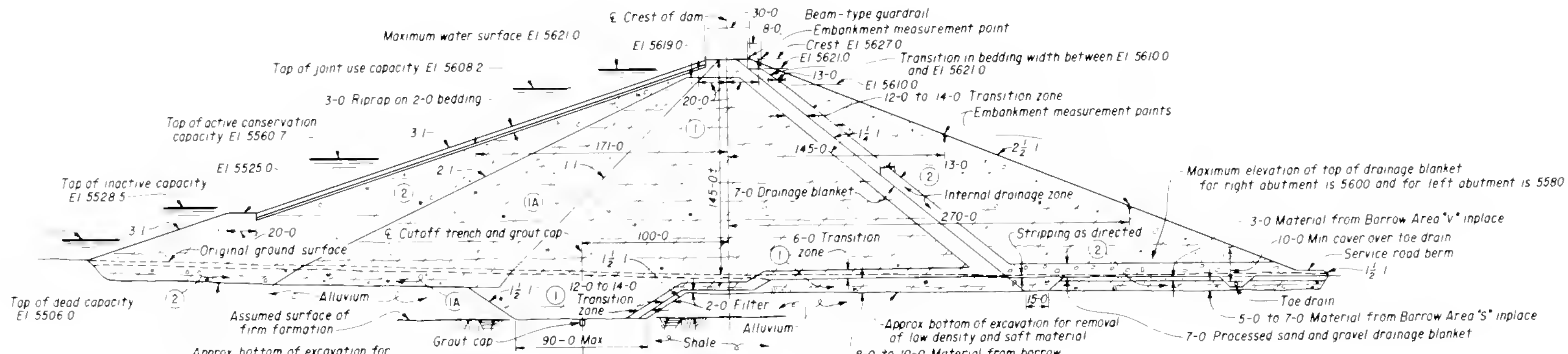


SECTION A-A

RESERVOIR CAPACITY ALLOCATIONS

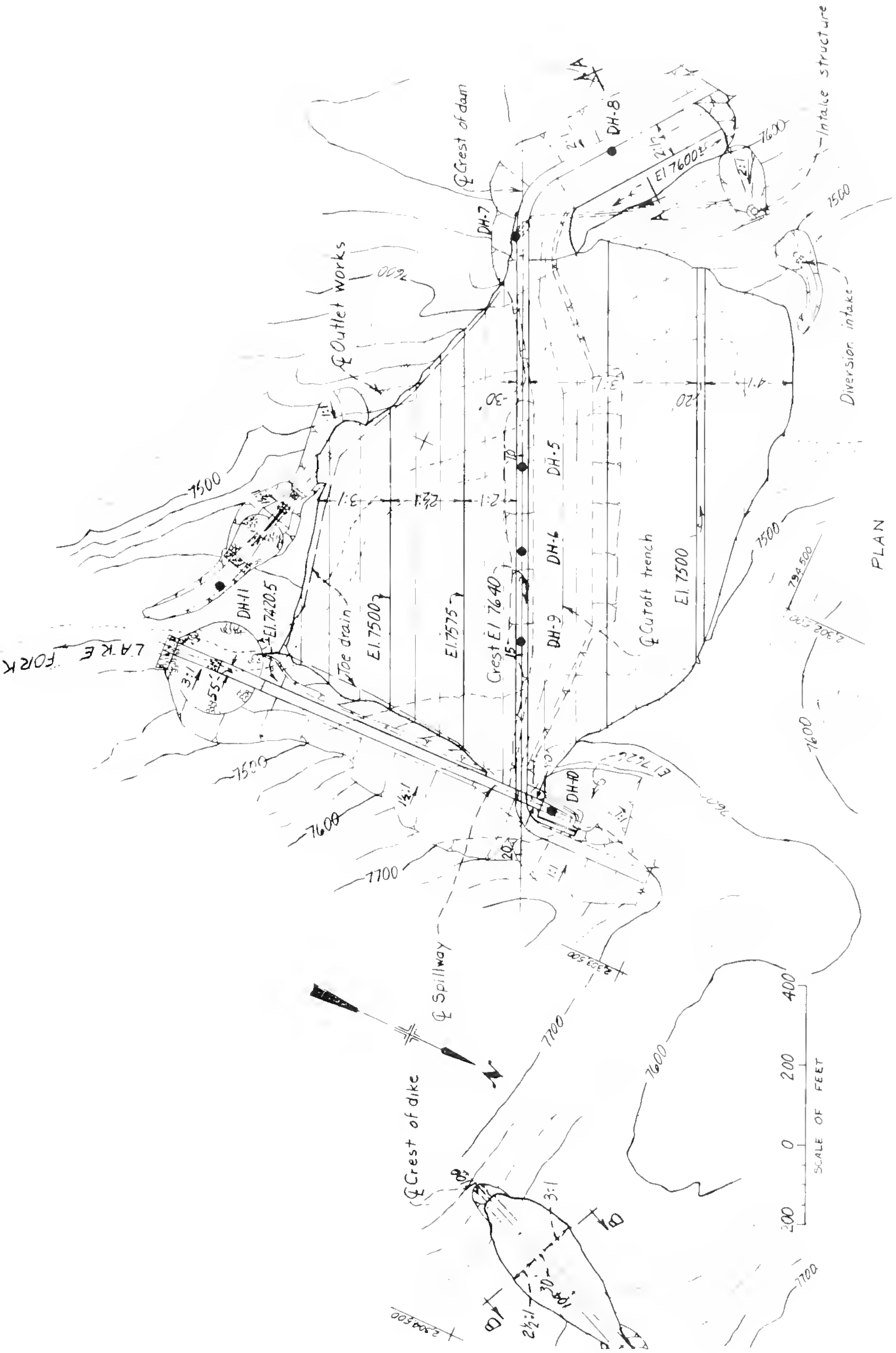
PURPOSE	ELEVATIONS	CAPACITY ACRE-FEET
Joint use	5560.7 to 5608.2	18,000
Active conservation	5528.5 to 5560.7	6,000
Inactive	5506.0 to 5528.5	1,700
Dead	Streambed to 5506.0	300
Total reservoir capacity		26,000*

* Includes 580 acre feet allowance for 100 year sediment deposition. A surcharge of 7,270 acre feet (Max W S El 5621.0) in combination with a spillway discharge of 5510 cubic feet per second and an outlet works discharge of 450 cubic feet per second is provided to protect against the inflow design flood which has a peak of 18,500 cubic feet per second and a two-day volume of 12,300 acre feet

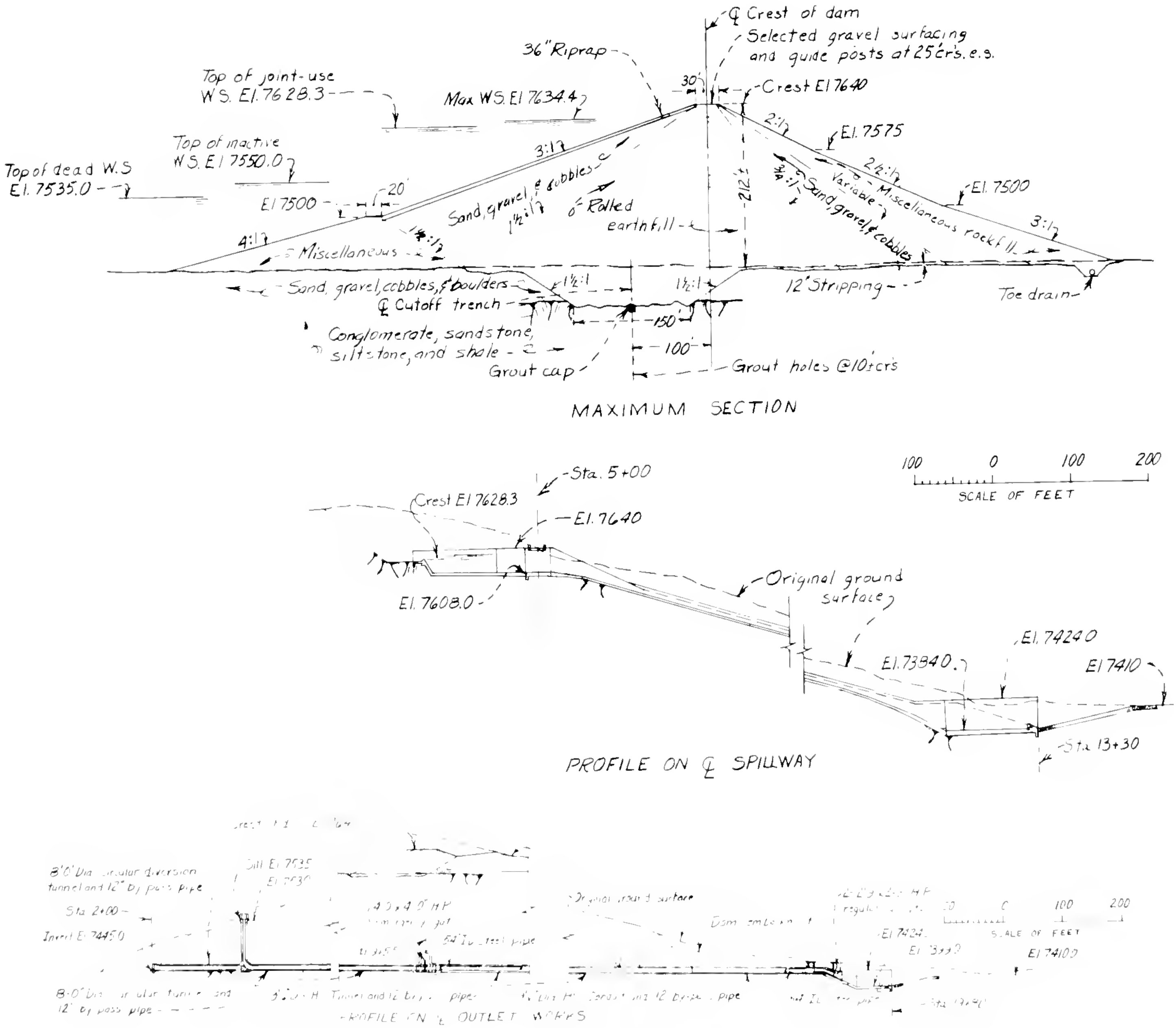


MAXIMUM SECTION

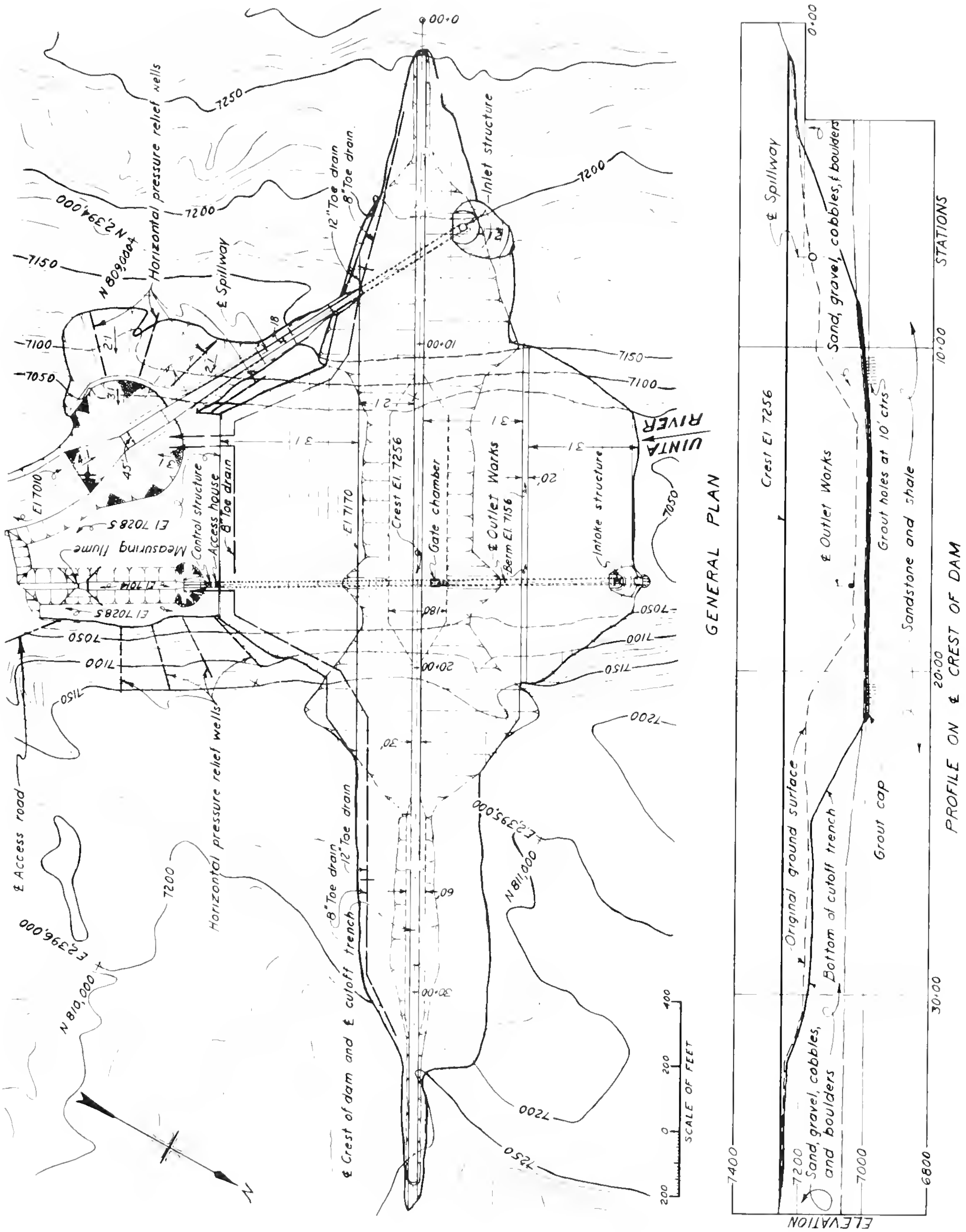
Red Fleet Dam, Sections



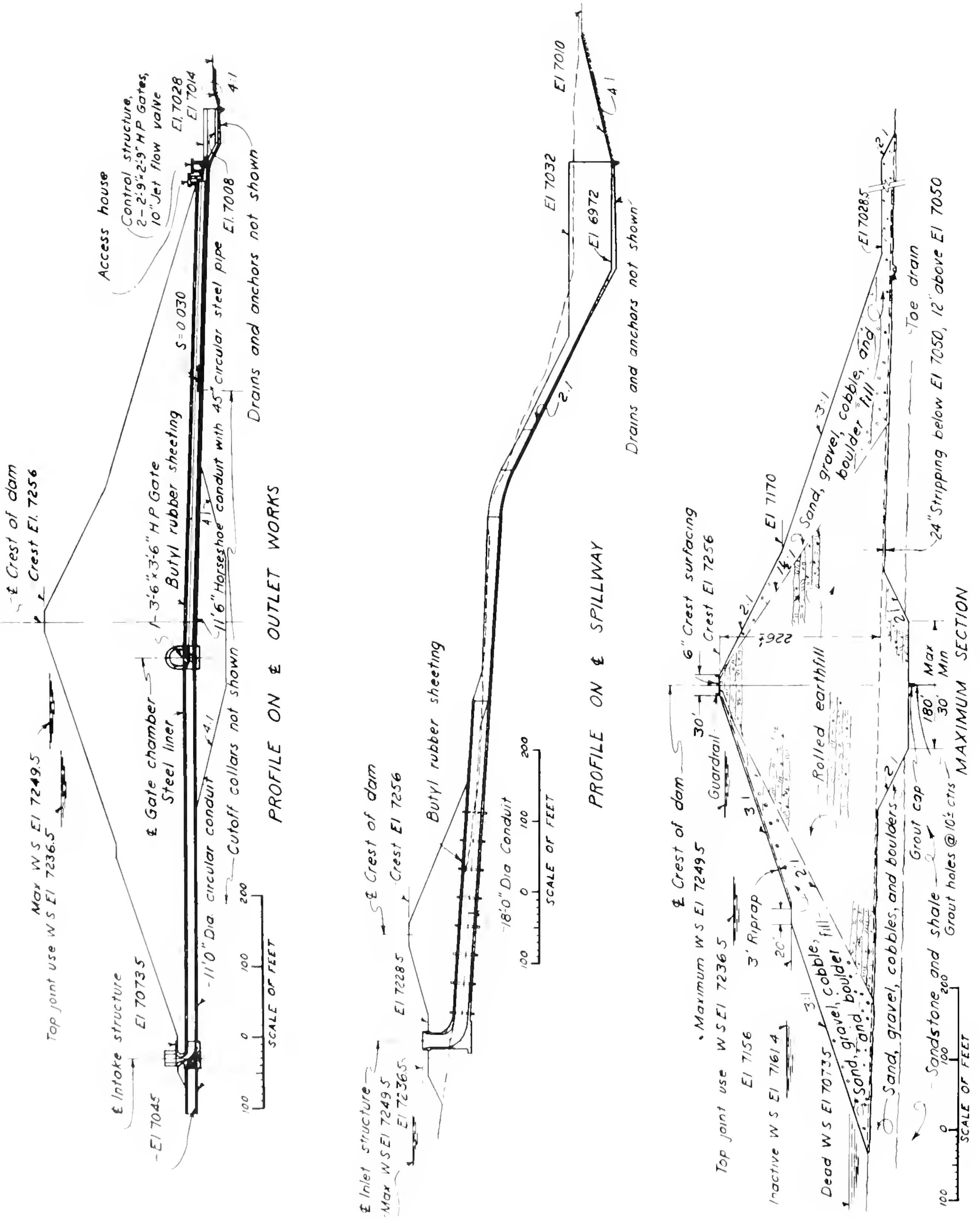
Taskeech Dam, Plan



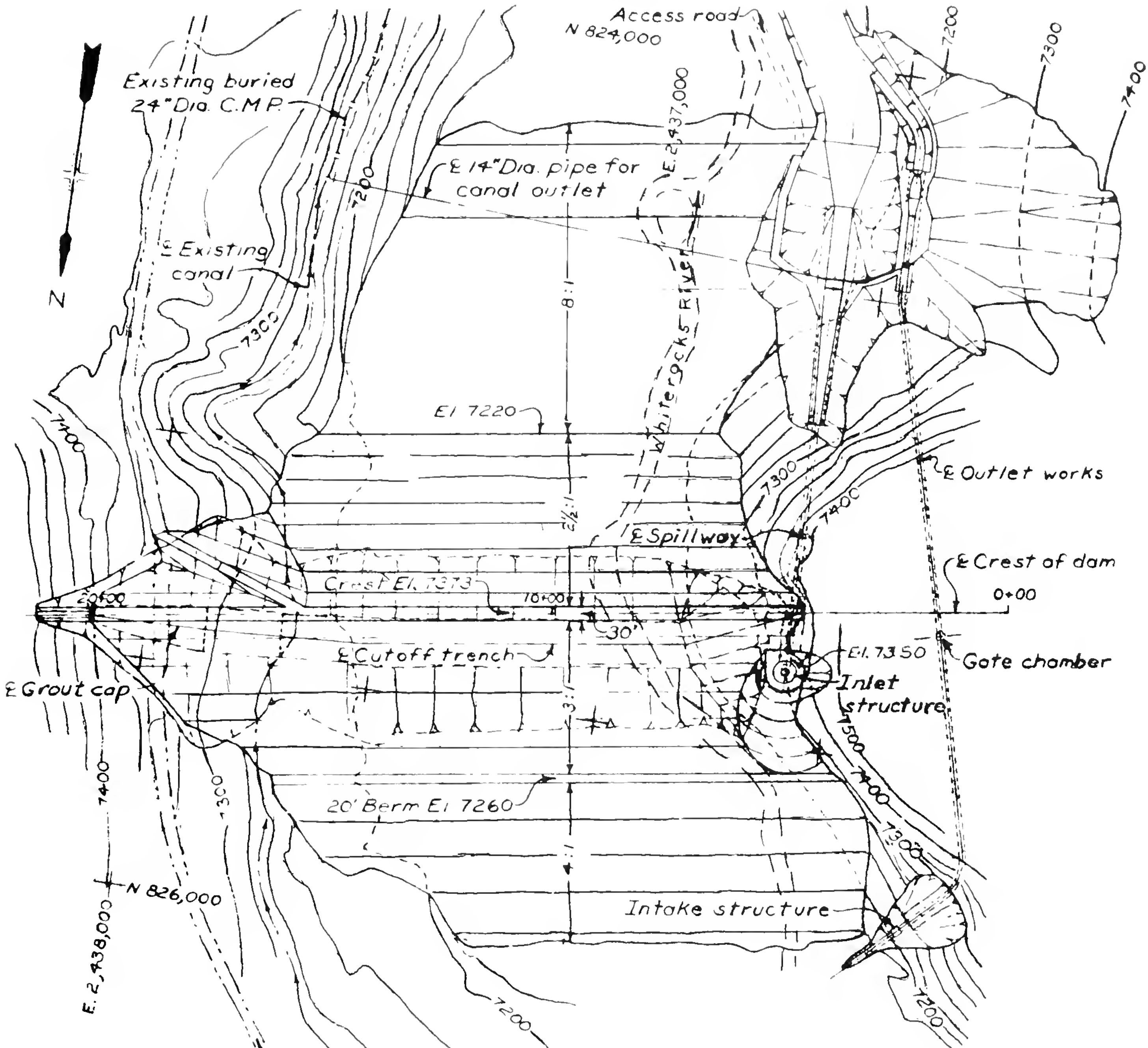
Taskeech Dam, Sections

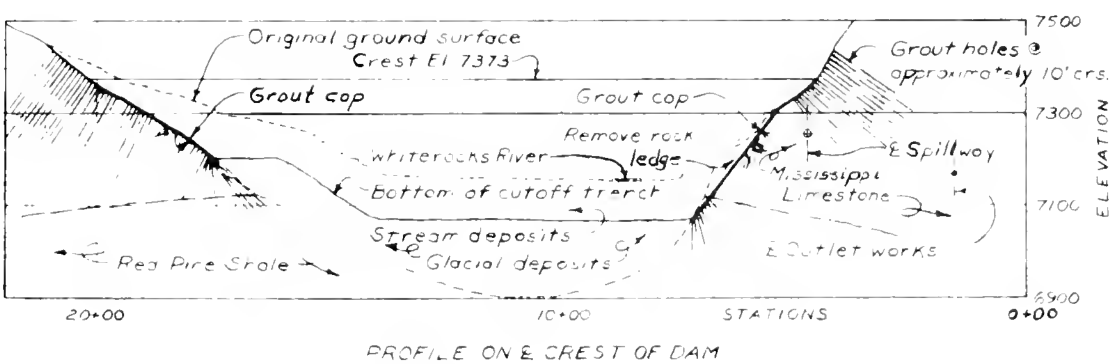


Uinta Dam. Plan and Profile

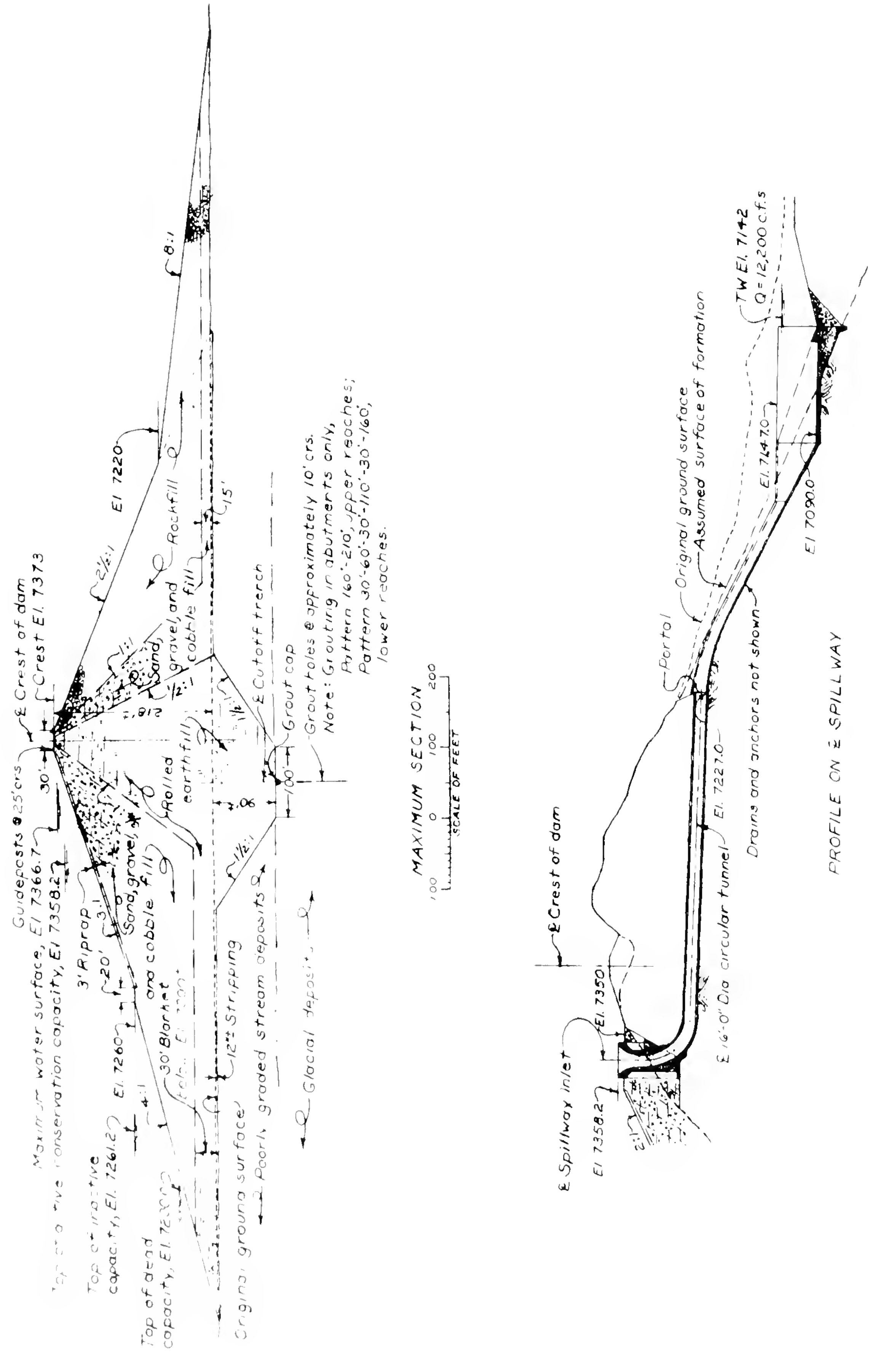


Uintah Dam, Sections





Whiterocks Dam, Plan and Profile

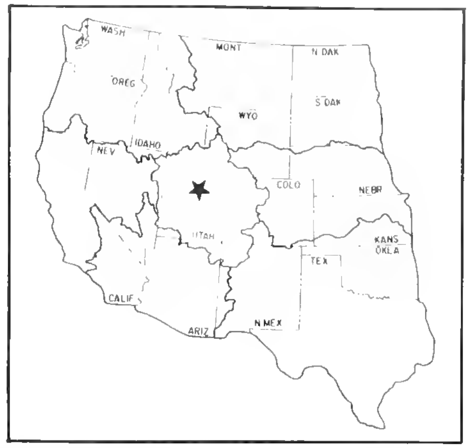


Whiterocks Dam, Sections

Central Utah Project
Bonneville Unit

Utah: Duchesne, Garfield, Juab, Millard, Piute, Salt Lake, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch Counties

Upper Colorado Region
Water and Power Resources Service



The Bonneville Unit is the most comprehensive of the six units in the Central Utah Project. This unit consists of water collection and distribution in the Uinta and Bonneville Basins with a diversion of Uinta Basin water to the Bonneville Basin.

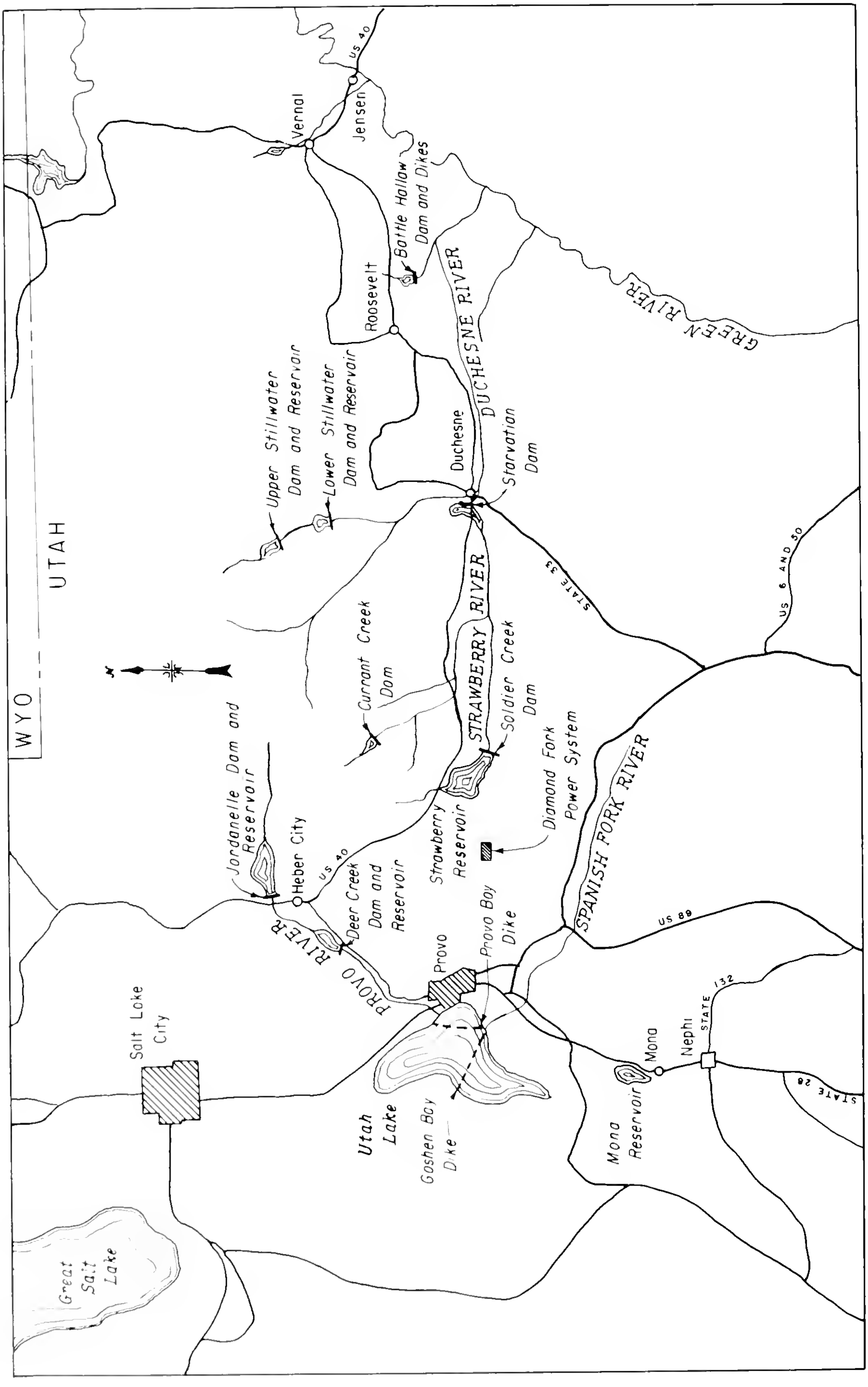
This unit, under construction since 1967, will include 10 new reservoirs; the enlargement of 2 existing reservoirs; more than 140 miles of aqueducts, tunnels, and canals; 3 powerplants; 9 pumping plants; and 200 miles of pipe drains. For convenience in planning and coordination, the unit was divided into six systems: Starvation Collection System, Strawberry Aqueduct and Collection System, Diamond Fork Power System, Irrigation and Drainage System, Municipal and Industrial Water System, and the Indian Commitments System. Water will be made available to meet present and future economic, industrial, municipal, agricultural, and recreational needs in Utah by providing about 100,000 acre-feet of municipal and industrial water; about 205,000 acre-feet of irrigation water for 29,000 acres of new farmland and 213,000 acres of existing farmland now periodically short of water; and 6,500 acre-feet for stream fisheries. A total of about 133,000 kilowatts of power will be produced to supply the power needs of approximately 100,000 people. Recreational developments to be provided at the reservoirs will furnish fishing, boating, water skiing, and camping.

Starvation Collection System

Starvation Reservoir on the Strawberry River is filled by surplus winter and spring flows from the Duchesne and Strawberry Rivers. Flows are released during the summer and fall months to supplement irrigation supplies in the Duchesne River area and replace water diverted to the Bonneville Basin by the Strawberry Aqueduct. Water from the Duchesne River is diverted by the Knight Diversion Dam into Starvation Feeder Conduit and delivered to Starvation Reservoir. The conduit consists of nearly a mile of pipeline and the mile-long Starvation Tunnel.

Starvation Reservoir

Bridge crossing Starvation Reservoir



Central Utah Project. Bonneville Unit

Knight Diversion Dam

Strawberry Aqueduct and Collection System

The Strawberry Aqueduct and Collection System will consist of Upper Stillwater Reservoir, Currant Creek Reservoir, the Strawberry Aqueduct with its various diversion structures and feeder pipelines, and Strawberry Reservoir enlargement. The system will intercept and regulate the flows from nine streams - Rock Creek, South Fork of Rock Creek, Hades Creek, Twin Creek, Wolf Creek, West Fork of the Duchesne River, Currant Creek, Layout Creek, and Water Hollow Creek - tributary to the Duchesne and Strawberry Rivers and convey the water by gravity about 37 miles in the southwesterly direction to be stored in the enlarged Strawberry Reservoir.

Strawberry Reservoir, capable of eventually storing 1,106,500 acre-feet of water, is the primary storage facility for the Bonneville Unit. Upper Stillwater Reservoir, located in the Uinta Mountains about 31 miles northwest of Duchesne, will serve as a regulating reservoir at the beginning of Strawberry Aqueduct. The reservoir will be kept full during the June to September recreation months. Fluctuations in the reservoir will occur during the winter months; this is determined by predicted runoff and storage levels in the downstream reservoirs. Docs Diversion structure on the South Fork of Rock Creek would divert water into Docs Feeder Pipeline for conveyance to Upper Stillwater Reservoir. The 8.1-mile-long Stillwater Tunnel, the upper tunnel of the Strawberry Aqueduct System, will head at Upper Stillwater Reservoir and pass through the drainage divide separating Rock Creek from the North Fork of the Duchesne River. The North Fork Siphon, to connect Stillwater Tunnel to Hades Tunnel, would cross under the North Fork of the Duchesne River about 4 miles upstream from the confluence of the West Fork and the North Fork of the Duchesne River. Hades Creek Diversion Dam, to be located about 0.9 mile upstream from the confluence of Hades Creek and the North Fork of the Duchesne River, would divert water to the Strawberry Aqueduct through a 2.75-mile-long, 2.5-foot-diameter buried feeder pipeline. The Win Diversion structure, located about 1,100 feet upstream from the confluence of Twin and Wolf Creeks, will divert Twin Creek water to the aqueduct. The Rhodes Diversion structure, located about 3.5 miles upstream from the confluence of Wolf Creek and the West Fork of the Duchesne River, will divert Wolf Creek water to the aqueduct. The West Fork Pipeline, beginning at the outlet portal of Rhodes Tunnel which extends almost a mile from Wolf Creek to the drainage basin of the West Fork of the Duchesne River, will carry Bonneville Unit water along the north side of the West Fork of the Duchesne River, running in a southwesterly direction, to the inlet portal of Vat Tunnel. Vat Diversion Dam, located about 7 miles west of the confluence of the West Fork and Wolf Creek, will divert flows of the West Fork of the Duchesne River. The 7.4-mile-long Vat Tunnel will carry this water through Red Creek Mountain to Currant Creek Reservoir.

Currant Creek Reservoir, an open water connection between Vat Tunnel and the Currant Creek pipeline portion of the Strawberry Aqueduct, will divert water from Currant Creek and five of its smaller tributary streams into the aqueduct. The reservoir will have a capacity of 15,500 acre-feet. The upper 1,000 acre-feet will fill and empty several times each year and the water surface elevation will fluctuate about 4 feet. Entirely within the Uinta National Forest, the reservoir site will be a choice recreation area with development around the reservoir for fishing, boating, and overnight camping.

Currant Creek Pipeline links the reservoir with Currant Tunnel, which extends 1.7 miles from Currant Creek to Layout Creek. Currant Tunnel, the 3.3-mile-long Layout Tunnel, and the 4.1-mile-long Water Hollow Tunnel will carry Currant Creek, Layout Creek, and Water Hollow Creek flows diverted by Currant Creek Dam, Layout Creek Diversion Dam, and Water Hollow Diversion structure to the enlarged Strawberry Reservoir. The enlarged reservoir created by Soldier Creek Dam will be four times larger and reach a water level approximately 45 feet higher than the existing reservoir behind Strawberry Dam which was built in the early 1900's as part of the Strawberry Valley Project. When the water level rises above the old Strawberry Dam, it will be dredged out and the resulting one large reservoir will have a capacity of 1,106,500 acre-feet covering 17,000 surface acres. The maximum capacity will occur during long periods of high runoff, and the minimum capacity will occur during long periods of low flows and high demands resulting in an annual elevation fluctuation of about 10 feet. Soldier Creek Dam, completed in 1974, is a zoned earthfill structure 251 feet high with a crest length of 1,290 feet.

A recreation master plan for the enlarged Strawberry Reservoir includes new facilities that changes the recreation administration of the reservoir. The plan calls for development of two major recreation sites complete with boat-launching and marina facilities, modern flush-type sewage systems, fish-cleaning stations, and day use and overnight camping facilities. Dispersed strategically along the shoreline will be access areas for fishing and parking developments. While planned primarily to retain the present unique recreation environment at Strawberry Reservoir, the plan will provide a wide spectrum of recreation opportunities including development for winter sports activities.

Upper Stillwater Dam and Reservoir

Diamond Fork Power System

Power development in the Bonneville Unit will be developed by the Diamond Fork Power System with its three powerplants and associated waterways, regulating reservoirs, switchyards, and transmission lines. Bonneville Unit water in Strawberry Reservoir and water from the Strawberry Valley Project will be transferred from Uinta Basin to Bonneville Basin through the Syar pressure tunnel which will replace the existing free-flow tunnel. Approximately 197,600 acre-feet of water will be released annually through the tunnel to descend about 2,000 feet through the Syar, Sixth Water, and Dyne Powerplants, in succession, to the valley floor. The majority of the water released will be used for irrigation and municipal and industrial purposes.

The irrigation water will be used primarily as a supplemental supply for about 213,000 acres of land throughout the 12-county Bonneville Unit area. About 29,000 acres, mostly in Utah and Juab Counties, will receive a full water supply. Strawberry Reservoir water released through the Diamond Fork Power System during the nonirrigation season will be stored in Utah Lake, the proposed Hayes and enlarged Mona Reservoirs, and the existing Sevier Bridge Reservoir for use during the irrigation season. Summer season releases through the power system will be used primarily for irrigation and a small amount will be available for municipal and industrial purposes.

The Syar, Sixth Water, and Dyne Powerplants will have a total generating capacity of about 133,500 kilowatts. Part of this power would be used for Bonneville Unit pumping and the remainder for commercial consumption.

Syar Power Unit

The Syar Power Unit, composed of Syar Tunnel, penstock, and Powerplant, and Syar Dam and Reservoir, would be located in the southeast part of the Wasatch Mountains on a broad saddle separating Fifth Water and Sixth Water tributaries of Diamond Fork. Transbasin diversion of Bonneville Unit water would be accomplished through the pressurized Syar Tunnel which would extend from Strawberry Reservoir to the Syar penstock. The penstock would receive the water from the downstream portal of Syar Tunnel and deliver the water to Syar Powerplant. The powerplant, to be situated on the northeast bank of Syar Reservoir, would develop a potential head differential of about 350 feet between the Strawberry and Syar Reservoirs. Syar Reservoir would be formed by the 80-foot-high Syar Dam, and a lower dike would serve as an afterbay. The powerplant would be connected to the Sixth Water switchyard by a 138-kV line and operated by remote control from the Sixth Water Powerplant.

Sixth Water Power Unit

This unit, located in the southeast part of the Wasatch Mountains on the Sixth Water tributary of Diamond Fork, would include Corona Aqueduct and Sixth Water penstock, Powerplant, and Reservoir. Water from Syar Reservoir would be delivered by Corona Aqueduct to the Sixth Water Powerplant penstock and after passing through the powerplant would be regulated in Sixth Water Reservoir. The powerplant would be connected to an adjacent switchyard and would be attended and operated manually.

Dyne Power Unit

Dyne Aqueduct, penstock, and Powerplant constitute the Dyne Power Unit. The aqueduct would convey the water from the outlet works of Sixth Water Dam to Dyne penstock and then through the penstock to Wasatch Aqueduct which would extend southwest from the powerplant to York Ridge, a divide between Utah and Juab Counties. Diamond Fork River, Spanish Fork River, Wasatch

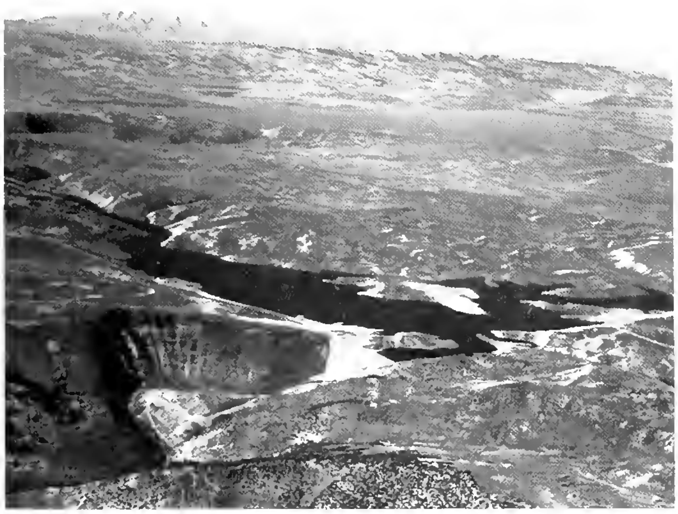
Currant Creek Dam

Aqueduct, Mona-Nephi Canal, Nephi-Sevier Canal, and the Sevier River will convey water from the powerplants and reservoirs to lands in Utah, Juab, and Millard Counties and by exchange to Sanpete and Sevier Counties.

Irrigation and Drainage System

Hayes Reservoir, to be formed by construction of a rolled earthfill dam on Diamond Fork River about 2,600 feet upstream from its junction with the Spanish Fork River, would fill and draw down to a minimum pool every year in order to attain the most efficient use of the water for power production.

Wasatch Aqueduct, to extend from Dyne Powerplant to the Mona-Nephi Canal at York Ridge, would consist of a series of conduits, siphons, tunnels, and canals. The water conveyed would be used primarily for irrigation land in the Bonneville Basin area. Mona-Nephi Canal, to consist of open sections with several short siphons and conduits, would extend from the terminus of Wasatch Aqueduct at York Ridge southward along the eastern side of Juab Valley to a point near Levan Ridge. The Mona Pumping Plant, to be located near the north end of Mona Reservoir opposite the damsite, would lift water from the reservoir into the Mona-Nephi Canal for irrigation use. Mona Reservoir, to be enlarged by constructing a new earth and rockfill dam on top of the existing dam, would fluctuate widely from year to year under Bonneville Unit operation, depending on available water supplies. The reservoir would fill during the nonirrigation season, becoming full in April or May each year, and be drawn down throughout the irrigation season. Bonneville Unit water would be conveyed from the enlarged Mona Reservoir by Elberta Canal to lands in the Elberta area in Utah County. The canal would begin at Elberta Diversion Dam and terminate near the small community of Elberta. Elberta Diversion Dam, planned to be a reinforced concrete structure consisting of a 20-foot-long overflow weir, would replace an existing structure located on Currant Creek about 1.5 miles downstream from Mona Dam. Elberta Diversion Dam would divert Bonneville Unit water flowing from Mona Reservoir into Elberta Canal. The Nephi Pumping Plant, to be located about 2 miles south of Nephi, would lift water from the Mona-Nephi Canal into Nephi-Sevier Canal for conveyance to the existing Sevier Bridge Reservoir. Bonneville Unit water to be added to Sevier Bridge Reservoir would total 29,500 acre-feet which would be delivered to downstream farmlands via the Sevier River and existing irrigation canals and laterals and to upstream farmlands by exchange through existing facilities.



Soldier Creek Dam

Provo Bay Irrigation Development

An irrigation development proposed for the Provo Bay area would include a low Provo Bay dike, drains to lower the water table, canals to deliver irrigation water, and the Hobble Creek Diversion Dam and Springville and Provo Bay Bypasses to carry Hobble Creek water around the dike. Pumping plants would be required to pump drain water into the lake and to pump water from the lake into Provo Bay Canal for irrigation use. The drainage system would include about 65 miles of closed-tile subsurface drains, about 22 miles of open lateral drains, and about 11 miles of open main outlet collector drains.

The Provo Bay Drains Pumping Plant, to be located southwest of Provo Bay Canal near the southwest corner of the Provo Bay area, would lift surface and subsurface drainage water from Provo Bay through Provo Bay Dike into Utah Lake. Hobble Creek Diversion Dam, to be located on Hobble Creek in Utah Valley west from the mouth of Hobble Creek Canyon, would divert a major part of the high runoff flows of Hobble Creek to Springville Bypass for conveyance around Springville to Provo Bay Bypass. The diversion structure would have a crest width of 20 feet, a crest length of about 2,200 feet, and a maximum height of about 12 feet. Springville Bypass would consist of an open concrete chute and a gravel-lined canal and would convey floodflows in excess of 600 cubic feet per second around Springville. Provo Bay Bypass would begin along Hobble Creek and serve as a new route for the waters of Hobble Creek to Utah Lake. The bypass would consist of a gravel-lined canal. It would convey some water at all times, but would reach capacity only when carrying floodwaters. The Provo Bay Irrigation Pumping Plant would pump water from an intake channel of Utah Lake into Provo Bay Canal. This canal would traverse the bay in a counterclockwise direction with laterals extending from the main canal on the north and south sides of the bay to serve lands in the higher areas. Two small pumping plants would pump water into the laterals. Beer Creek Dike, to be located about 7 miles west of Spanish Fork, would be constructed to prevent flooding of the lower area of Beer Creek by Utah Lake. The Beer Creek Pumping Plant, on Beer Creek about 12 miles west of Spanish Fork, would pump drainage water from the inland side through the dike into Utah Lake. The diversion dam and canal would divert and convey the natural flow of Beer Creek and its tributary, Spring Creek, around the west end of the dike and back into Beer Creek Channel and into Utah Lake.

Mosida Canal would be located in west-central Utah County along the northwest side of Goshen Valley and the southwest side of Utah Lake. Water would be lifted from Utah Lake into the canal through a 0.3-mile-long discharge line by Mosida Lower Pumping Plant. The Mosida Relift Pumping Plant would lift water from the canal to a higher section of the canal through a 0.3-mile-long discharge line for irrigation of lands in the southern portion of the Mosida area.

Corrective measures for subsurface drainage deficiencies are planned as a part of the Bonneville Unit development. Most of the drainage system would be designed after the Bonneville Unit irrigation system has been in operation and the exact location of drainage problems have become apparent.

Utah Lake Diking

Diking of Utah Lake by separating Provo and Goshen Bays from the main body of Utah Lake would reduce the surface area by about 35 percent and would result in a yearly net evaporation savings of 105,000 acre feet of water. This amount, together with return flows collected in the lake and spills that will be saved, would develop a new water supply of about 150,000 acre-feet annually.

Lower Stillwater Dam and Reservoir

Project operations would avoid extreme drawdowns of the lake. Water from Jordanelle or Strawberry Reservoirs could be released into the lake to help make up deficits and to maintain higher lake levels during low water years. Water collected in Utah Lake would consist of natural flows, water released from Strawberry Reservoir through the Diamond Fork Power System, and return flows from project water used for irrigation and municipal and industrial purposes. Part of the project water in Utah Lake would be used for irrigation of lands west of the lakeshore in the Mosida area and part would be exchanged upstream on the Provo River for water that presently flows into the lake. Additional water from evaporation savings would be stored in the proposed Jordanelle Reservoir, a feature of the Municipal and Industrial Water System.

Utah Lake

Bottle Hollow resort

The proposed Provo Bay Dike would be an earthfill structure 6.5 miles long with a maximum height of 24 feet above the bed of the lake. The dike would be 20 feet wide, with a crest elevation of 4499 feet and would contain about 3,420,000 cubic yards of embankment material. The dike would begin near the Provo River north of Provo Municipal Airport and would extend southward west of the airport and across the bay. The bay, at the eastern extremity of Utah Lake, covers about 7,000 acres and has a capacity of approximately 26,600 acre-feet. The bay area lands could be reclaimed by drainage and inclusion of drainage facilities.

Goshen Bay Dike would be a terraced earthfill structure and would extend 5.4 miles from Lincoln Point in a northwesterly direction across Utah Lake. The dike would have a maximum height above the lake bed of 31 feet and, at crest elevation 4499.0, would be 20 feet wide. It would require about 7,845,000 cubic yards of embankment material. The bay area, at the southern extremity of Utah Lake, covers about 27,000 acres and has a storage capacity of approximately 230,000 acre-feet. An emergency outlet capable of passing a flow of 1,000 cubic feet per second would be constructed in the dike to permit lake water to be spilled into the bay under flood conditions. Lands are not suitable for reclamation because of high salt content and a heavy texture, but are suitable for the State Wildlife Management Area planned for the perimeter of the bay. This wildlife area would replace losses of waterfowl hunting and habitat in the Bonneville Basin portion of the Bonneville Unit.

Municipal and Industrial Water System

The Municipal and Industrial Water System would include Jordanelle Reservoir on the Provo River, Jordan Aqueduct sections 1 through 4, Alpine Aqueduct, and Lampton Reservoir on the Jordan River. Municipal and industrial water developed by the system would total 99,000 acre-feet to be distributed to Salt Lake County, northern and southern Utah County, and Juab County. Part of the water saved by diking Utah Lake would be exchanged upstream in Jordanelle Reservoir for Provo River water that presently flows into Utah Lake. Stored water would be released to the Provo River and then diverted to Alpine or Jordan Aqueducts for municipal and industrial uses.

Jordanelle Dam and Reservoir

Jordanelle Dam and Reservoir, located on the Provo River about 6 miles north of Heber City, would provide water storage at an upstream site by exchange for Bonneville Unit water in Utah Lake and Strawberry Reservoir and for most of the water presently regulated in 15 small reservoirs on the headwaters of the Provo River. The reservoir would function as a long-term holdover reservoir and is expected to hold storage through a 6-year drought period. Plans are for a capacity of 320,000 acre-feet with a surface area of 3,068 acres. The municipal and industrial water stored in Jordanelle Reservoir will be delivered to Salt Lake County through the Provo River and the buried Jordan Aqueduct to northern Utah County through the Provo River and Alpine Aqueduct.

Jordan Aqueduct

The Jordan Aqueduct, on which construction started in 1971, will be completed about 1980. The 36-mile-long aqueduct will extend from near the mouth of Provo Canyon in a northwesterly direction to the Point-of-the-Mountain and the Jordan Water Purification Plant. From this point it will continue down the west side of

Irrigated land east of Spanish Fork, Utah

Salt Lake Valley and terminate near the Salt Lake City boundary at street coordinates 2100 south and 4000 west. About 70,000 acre-feet of water will be delivered to the Salt Lake Valley annually, on a long-term average, through the aqueduct from the Provo River, mountain streams, available ground water, and eventually Jordanelle Reservoir.

Alpine Aqueduct

The Alpine Aqueduct, located in Utah Valley extending from the mouth of Provo Canyon north to Lehi and south to Provo, will convey water from the Provo River to Utah Valley Purification Plant. It will also carry treated water to Orem and Provo, Utah, and communities in the northern end of Utah Valley.

Lampton Dam and Reservoir

Lampton Dam and Reservoir, to be located on the Jordan River south of Salt Lake City, would store and regulate return flows to the Jordan River from Provo River Project and Bonneville Unit irrigation water together with spills from Utah Lake. Flood control would be provided for the lower Jordan River area.

Bennion Pumping Plant and Diversion Structure

Bennion Pumping Plant and Diversion Structure would be located on the Jordan River between Bennion and Murray about 5 miles north of Lampton Dam. This plant would pump return flows that occur in the Jordan River downstream of Lampton Dam into the existing North Jordan Canal. Direct flows that are presently diverted into the North Jordan Canal would normally be stored in Lampton Reservoir and replaced downstream by return flows at the Bennion Pumping Plant.

Indian Commitments System

To compensate the Ute Indian Tribe for economic losses associated with stream fishing in Rock Creek within the Uintah and Ouray Indian Reservation, Bottle Hollow Reservoir was constructed and Lower Stillwater Reservoir is planned to provide fishing, wildlife, and recreation activities. These areas will provide 800 surface acres of fishing waters and a base from which recreation-oriented enterprises can be developed to provide additional employment and needed income for members of the Ute Indian Tribe. Development of wildlife management areas on Ute Tribal lands will be included throughout the Bonneville Unit.

Lower Stillwater Dam and Reservoir

Lower Stillwater Dam and Reservoir would be located approximately 26 miles north of Duchesne. Both features are currently in planning stages.

Bottle Hollow Dams and Reservoir

Bottle Hollow Reservoir, located at Bottle Hollow Resort on Indian land about 1 mile west of Fort Duchesne and about 6 miles east of Roosevelt, is an offstream reservoir on Bottle Hollow Draw. Water to fill the reservoir, used exclusively for fishing, wildlife, and recreation purposes, comes from the Uinta River diverted through the Indian-owned Bench Canal. Two dams and a dike created the 11,000-acre-foot Bottle Hollow Reservoir. The north dam is 500 feet long and 74 feet high, and the south dam is 680 feet long and 86 feet high. The 860-foot-long dike is about 9 feet high. The outlet works and spillway have capacities of 210 and 30 cubic feet per second, respectively; both are located in the south dam and have a combined outlet. A total of about 287,000 cubic yards of embankment material were required for the dams and dike.

Wildlife Management Areas on Ute Tribal Lands

As part of the Bonneville Unit commitment to the Indians, six waterfowl areas have been selected for development by Ute Tribal authorities. The waterfowl areas will occupy Indian lands along the Duchesne River between Ouray and Bridgeland. When developed, these areas would mitigate waterfowl losses attributable to the Bonneville Unit in the Uinta Basin and provide additional hunting benefits for waterfowl and pheasant.

PROJECT DATA

Land Areas (1977)

(See Central Utah Project.)

Facilities in Operation

Storage dams	4
Diversion dams	3

Climatic Conditions

(See Central Utah Project.)

ENGINEERING DATA

Storage Facilities

CURRANT CREEK DAM

Type: Rolled zoned earthfill
Location: On Currant Creek, about 14 mi northwest of Fruitland, Utah.
Construction period: 1974-75
Dimensions:

Structural height	130	ft
Crest width	30	ft
Maximum base width	800	ft
Crest length	1,600	ft
Crest elevation	7692.0	ft
Total volume	2,268,000	yd³
Reservoir, Currant Creek:		
Total capacity to El. 7678	16,000	acre-ft
Active capacity	1,000	acre-ft
Inactive storage	14,340	acre-ft
Dead storage	210	acre-ft
Surcharge storage	1,540	acre-ft
Surface area	300	acres

Spillway:

Crest width	20	ft
Crest elevation	7678.0	ft
Capacity at El. 7683.2	850	ft³/s

14-ft-diameter concrete-lined circular tunnel in right abutment

Outlet works capacity	5,540	ft³/s

Outlet capacity at maximum water surface controlled by two 24-in-square slide gates in right abutment.

Bottle Hollow Dams and Reservoir

Bottle Hollow Dike

Type: Zoned earthfill
Location: On small drainage offstream from Uinta River 1 mi west of Ft. Duchesne, Utah.
Construction period: 1969-70
Dimensions:

Structural height	9	ft
Top width	30	ft
Maximum base width	75	ft
Crest length	860	ft
Crest elevation	5114.0	ft
Total volume[1]		

North Bottle Hollow Dam

Type: Zoned earthfill
Location: On small drainage offstream from Uinta River, 1 mi west of Ft. Duchesne, Utah.
Construction period: 1969-70
Reservoir, Bottle Hollow:

Total capacity to El. 5106.5	11,000	acre-ft
Active capacity	11,000	acre-ft
Surface area	400	acres
Dimensions:		
Structural height	74	ft
Top width	30	ft
Maximum base width	350	ft
Crest length	500	ft
Crest elevation	5114.0	ft
Total volume	287,000	yd³

South Bottle Hollow Dam

Type: Zoned earthfill
Location: On small drainage offstream from Uinta River 1 mi west of Ft. Duchesne, Utah.
Construction period: 1969-70
Dimensions:

Structural height	80	ft
Top width	30	ft
Maximum base width	350	ft
Crest length	680	ft
Crest elevation	5114.0	ft
Total volume[1]		
Reservoir, Bottle Hollow:		
Total capacity to El. 5106.5	11,000	acre-ft
Active capacity	11,000	acre-ft
Surface area	400	acres
Spillway:		
Crest length[2]		
Crest elevation	5105.0	ft
Capacity at El. 5108.1	30	ft³/s
Outlet works:[2]		
Capacity	210	ft³/s

[1]Included in volume given for North Dam.
[2]Spillway is 4-ft-diameter, modified horseshoe conduit.

Hayes Dam

Type: Rolled earthfill
Location: 0.5 mi upstream from confluence of Diamond Fork and Spanish Fork Rivers.
Construction period: Proposed
Dimensions:

Structural height	200	ft
Crest elevation	5165.0	ft
Crest length	1,870	ft
Crest width	35	ft
Maximum base width	1,300	ft
Volume of fill	5,960,000	yd³
Outlet works:		
Capacity at maximum water surface El. 5158.8 ft	1,000	ft³/s

A 6-ft-diameter, 760-ft-long circular tunnel with a gate chamber housing one 5-ft-square, high-pressure emergency slide gate and a 10-ft-diameter, 560-ft-long horseshoe tunnel housing a 66-in-diameter steel pipe.

Spillway: Capacity at maximum water surface elevation	4,000	ft³/s

Morning-glory type located in left abutment, a 750-ft-long structure of 13.5-ft-diameter, concrete-lined circular tunnel.
Reservoir, Hayes:

Area at normal water surface El. 5150.2	680	acres
Total capacity	51,500	acre-ft
Active capacity	43,400	acre-ft
Inactive and dead capacity	8,100	acre-ft
Surcharge capacity	5,700	acre-ft

Jordanelle Dam

Type: Rolled earthfill
Location: 6 mi north of Heber, Utah.
Construction period: Proposed
Dimensions:

Height above streambed	296	ft
Crest elevation	6181.0	ft
Crest length	2,800	ft
Crest width	45	ft
Volume of fill	14,650,000	yd³
Outlet capacity at maximum water surface El. 6119.0 (in right abutment)	3,600	ft³/s
Spillway capacity at maximum water surface elevation (in right abutment)	6,600	ft³/s
Discharge capacity:		
Outlet works	3,600	ft³/s
Spillway	6,600	ft³/s
Reservoir, Jordanelle[3]:		
Area at top of active capacity, El. 6166	3068	acres
Total capacity	320,300	acre-ft
Active capacity	320,100	acre-ft
Inactive and dead storage	200	acre-ft
Surcharge storage	12,000	acre-ft

Lampton Dam

Location: On the Jordan River, south of Salt Lake City, Utah.
Construction period: Proposed

Lower Stillwater Dam

Location: About 26 mi north of Dechesne, Utah.
Construction period: Proposed

[3]Stores active capacity of 15 upstream lakes.

MONA DAM ENLARGEMENT

Type: Rolled earth-rock fill
Location: 12 mi north of Nephi, Utah, and 0.5 mi west of U.S. Highway 91.
Construction period: Proposed
Dimensions:

Height above streambed	50	ft
Crest elevation	4907.0	ft
Crest length	550	ft
Crest width	25	ft
Maximum base width	225	ft
Volume of fill	85,000	yd³
Outlet works: Capacity at maximum water surface El. 4901.0	290	ft³/s

Located in right abutment, 250 ft of 4-ft-square conduit with two 33-in-square pressure gates.

Spillway: Capacity at maximum water surface elevation	2,200	ft³/s

Morning-glory-type, 160-ft-long, 9.5-ft-diameter concrete-lined circular conduit in right abutment.
Reservoir, Mona:

Area at normal water surface El. 4896.8	3,000	acres
Increased height of normal water surface elevation	14.0	ft
Total capacity	47,000	acre-ft
Previous total capacity	19,200	acre-ft
Active capacity	39,500	acre-ft
Inactive and dead storage	7,500	acre-ft
Surcharge storage	15,000	acre-ft

SIXTH WATER DAM

Type: Rolled earth-rock fill
Location: 1.5 mi west of Syar damsite on Sixth Water Creek.
Construction period: Proposed
Dimensions:

Height above streambed	150	ft
Crest elevation	6406.0	ft
Crest length	590	ft
Crest width	30	ft
Maximum base width	1,650	ft
Volume of fill	510,000	yd³

Outlet works:

Capacity at maximum water surface El. 6399.4	950	ft³/s

In right abutment, a 6-ft-diameter, 420-ft-long circular tunnel with four 2.75-ft-square, high pressure gates. Also, a 370-ft-long flat bottom tunnel with an 8-ft-diameter arch

Spillway: Capacity at maximum water surface elevation	5,080	ft³/s

In right abutment, uncontrolled 640-ft open channel with weir crest.
Reservoir, Sixth Water:

Area at normal water surface, El. 6385.0	35.0	acres
Total capacity	1,020	acre-ft
Active capacity	500	acre-ft
Inactive and dead storage	520	acre-ft
Surcharge storage	470	acre-ft

SOLDIER CREEK DAM

Type: Zoned earthfill
Location: On Strawberry River, 34 mi southeast of Heber City, Utah.
Construction period: 1970-74
Dimensions:

Structural height	251	ft
Top width	30	ft
Maximum base width	1,430	ft
Crest length	1,290	ft
Crest elevation	7,612.0	ft
Total volume	3,422,000	yd³

Reservoir, Strawberry (enlarged):

Total capacity to El. 7602.4	1,106,500	acre-ft
Active capacity	951,000	acre-ft
Surface area	17,000	acres

Upper outlet works:

Elevation	7512.0	ft
Capacity	1,400	ft³/s

Lower outlet works:

Elevation	7383.0	ft
Capacity	1,500	ft³/s

Spillway: None

STARVATION DAM

Type: Zoned earthfill
Location: 3 mi northwest of Duchesne, Utah, on Strawberry River.
Construction period: 1967-70
Dimensions:

Structural height	200	ft
Top width	30	ft
Maximum base width	855	ft
Crest length	3,070	ft
Crest elevation	5725.0	ft
Total volume	1,836,000	yd³

Reservoir, Starvation:

Total capacity to El. 5712.0	167,000	acre-ft
Active capacity	152,000	acre-ft
Surface area	3,300	acres

Spillway:

Crest width	30	ft
Crest elevation	5712.0	ft
Capacity at El. 5718.3	16,000	ft³/s

Outlet works:

Capacity	2,310	ft³/s

SYAR DAM

Type: Rolled earth-rock fill
Location: 6.5 mi southwest of Strawberry Reservoir in Rays Valley between Fifth and Sixth Water Creeks.
Construction period: Proposed
Dimensions:

Structural height	88	ft
Crest elevation	7194.0	ft
Crest length	3,240	ft
Crest width	30	ft
Volume of fill	810,000	yd³

Outlet works:

Capacity[1]	1,600	ft³/s

Located near maximum section of Dam No. 1,215 ft of 12.5-ft-diameter circular conduit from inlet structure to gate chamber and 165 ft of 18.5-ft-diameter circular conduit from gate chamber to access house at downstream toe.
The spillway is a morning-glory-type inlet with 135 ft of 6-ft-diameter conduit. It is located between the dams in the southwest corner of the reservoir.
Reservoir, Syar:

Area at normal water surface elevation, El. 7185	32	acres
Total capacity	930	acre-ft
Active capacity	660	acre-ft
Inactive and dead storage	270	acre-ft
Surcharge storage (excl. flood control)	35	acre-ft

[1]Capacity is the same at maximum and minimum water surface elevations.

UPPER STILLWATER DAM

Type: Rolled earth-rock fill
Location: Rock Creek, about 31 mi northwest of Duchesne, Utah.
Construction period: Proposed
Dimensions:

Structural height	188	ft
Crest elevation	8167.0	ft
Crest length	2,920	ft
Crest width	30	ft
Maximum base width	1,115	ft
Volume of fill	5,195,000	yd³
Outlet works: Capacity at maximum water surface	820	ft³/s

650 ft of 8-ft-diameter circular tunnel and 600 ft of 8.5 ft-diameter modified horseshoe tunnel through the left of the abutment.

Spillway: Capacity at maximum water surface elevation	7,820	ft³/s

Uncontrolled morning-glory type with weir crest located in left abutment.
Reservoir, Upper Stillwater:

Area at normal water surface El. 8154.5	320	acres
Total capacity	29,500	acre-ft
Active capacity	26,600	acre-ft
Inactive and dead storage	2,900	acre-ft
Surcharge storage	2,090	acre-ft
Capacity of 7-ft-diameter outlet to Strawberry Aqueduct	283	ft³/s

BEER CREEK DIKE

Location: Across Beer Creek area, about 7 mi west of Spanish Fork.
Dimensions:

Structural height	12	ft
Average height above land	5	ft
Crest elevation	4499.0	ft
Crest length	7,200	ft
Crest width	20	ft

GOSHEN BAY DIKE

Type: Terraced earthfill
Location: Across southern end of Utah Lake from Lincoln Point northwest to west edge north of the Knolls.
Dimensions:

Structural height	30	ft
Crest elevation	4499.0	ft
Crest length	28,500	ft
Crest width	20	ft
Volume of fill	7,845,000	yd³

Outlet works: Gate controlled overflow con-weir capable of passing 1,000 ft³/s in either direction.

PROVO BAY DIKE

Type: Earthfill
Location: Across the west extremity of Provo Bay where it joins main body of Utah Lake, from vicinity of Provo River, south along airport dike, about 3.5 mi southwest of Provo, Utah.
Construction period: Proposed
Dimensions:

Structural height	24	ft
Height above lake bed	20	ft
Crest elevation	4499.0	ft
Crest length	34,500	ft
Crest width	20	ft
Volume of fill	3,420,000	yd³

Diversion Facilities

DOCS DIVERSION DAM

Type: Reinforced concrete
Location: South fork of Rock Creek, 1 mi southwest of Upper Stillwater Reservoir.

Height above streambed	5.5	ft
Length of concrete overflow weir section (spillway)	20	ft
Design flood capacity of spillway at crest El. 8197.5	240	ft³/s
Capacity of concrete headworks to Docs Feeder pipe	100	ft³/s

Sluiceway: 300 ft of 24-in-diameter concrete pressure pipe controlled by a 24-in-diameter slide gate.

ELBERTA DIVERSION DAM

Type: Reinforced concrete overflow weir
Location: On Currant Creek, terminating near Elberta, Utah.
Construction period: Proposed

HADES CREEK DIVERSION DAM

Type: Reinforced concrete overflow weir section and intake box
Location: On Hades Creek in the Strawberry Aqueduct System.
Construction period: Proposed
Dimensions:

Weir crest length	12	ft
Weir crest elevation	8000.0	ft

Sluiceway: 200-ft, 24-in-diameter concrete pressure pipe controlled by 24-in slide gate
Headworks: 36- by 30-in slide gate which regulates flows into Hades Creek Feeder pipe.

Diversion capacity	150	ft³/s

HOBBLE CREEK DIVERSION DAM

Location: On Hobble Creek in Utah Valley, west of the mouth of Hobble Creek Canyon.
Construction period: Proposed
Dimensions:

Crest width	20	ft
Crest length	2,200	ft
Structural height	12	ft

KNIGHT DIVERSION DAM

Type: Rolled earthfill
Location: Duchesne River, 5 mi upstream from Duchesne, Utah.
Construction period: 1967-68

Height	29	ft
Crest length	2,117	ft
Volume	49,000	yd³
Height of spillway crest above streambed	11	ft
Crest length of concrete overflow weir section (spillway)	100	ft
Design flood capacity of spillway at crest El. 5736.5 ft	6,000	ft³/s
Capacity at concrete headworks to Starvation Feeder Conduit	300	ft³/s

LAYOUT CREEK DIVERSION DAM

Type: Reinforced concrete with overflow weir section and intake box
Location: On Layout Creek south of Currant Creek Reservoir in the Strawberry Aqueduct System.
Construction period: 1970-75
Dimensions:

Weir crest length	10	ft
Weir crest elevation	7903.0	ft

Sluiceway: 180-ft, 24-in-diameter concrete pressure pipe controlled by a 24-in-diameter slide gate.
Headworks: 18- by 18-in slide gate.

Diversion capacity	100	ft³/s

RHODES DIVERSION DAM

Type: Reinforced concrete overflow weir section and intake box
Location: On Wolf Creek in the Strawberry Aqueduct System.
Construction period: Proposed
Dimensions:

Weir crest length	12	ft
Weir crest elevation	7899.0	ft

Sluiceway: 250 ft of 24-in-diameter concrete pressure pipe with a 24-in-diameter slide gate.
Headworks: 24-in-square slide gate

Diversion capacity	260	ft³/s

VAT DIVERSION DAM

Type: Reinforced concrete overflow, spillway on right side of dam
Location: On West Fork of Duchesne River in Strawberry Aqueduct System.
Construction period: Under construction
Dimensions:

Weir crest length	50	ft
Weir crest elevation	7882.0	ft

Sluiceway: 5-ft-square reinforced concrete box about 110 ft long connected to a baffled outlet box. Flow controlled by 5-ft slide gates in series.
Headworks: Reinforced concrete direct intake structure with trashrack and operating deck on upstream face of dam. Flows controlled by two 7-ft-square slide gates in series for a 6-ft-diameter intake pipe and two 2-ft-square slide gates in series for a 1.5-ft-diameter intake pipe.

Diversion capacity	2,100	ft³/s

WATER HOLLOW DIVERSION DAM

Type: Reinforced concrete structure with an overflow weir section, sluice and bypass channel, and an outlet works
Location: On Water Hollow Creek east of Strawberry Reservoir in the Strawberry Reservoir System.
Construction period: Completed 1971
Dimensions:

Structural height	10	ft
Weir crest length	12	ft
Total crest length	210	ft
Weir crest elevation	7615.0	ft
Volume	12,000	yd³

Sluiceway: 50 ft long controlled by a 48- by 36-in slide gate.
Headworks: Controlled by a 18- by 24-in slide gate.

Diversion capacity	20	ft³/s

General: Protective dikes extend on both sides of the dam, 80 ft to the left and 30 ft to the right.

WIN DIVERSION DAM

Type: Reinforced concrete overflow weir section and intake box
Location: In Wolf Creek section of Strawberry Aqueduct System.
Construction period: Proposed
Dimensions:

Weir crest length	7	ft
Weir crest elevation	7985.0	ft

Sluiceway: 120 ft of 18-in-diameter concrete pressure pipe with an 18-in-diameter slide gate
Headworks: 18-in slide gate

Diversion capacity	50	ft³/s

Carriage Facilities

ALPINE AQUEDUCT

Type: Steel, coated with mortar
Location: At mouth of Provo Canyon, 5 mi north of Provo, Utah.
Construction period: Under construction
Length:

Section		
1	0.7	mi
2	3	mi
3	11.2	mi

Capacity:

Section		
1	450	ft³/s
2	30-115	ft³/s
3	10-90	ft³/s

Diameter:

Section		
1	90	in
2	27-60	in
3	18-48	in

BOTTLE HOLLOW INLET CHANNEL

Location: Bottle Hollow Complex on small drainage offstream from Uinta River, 1 mi west of Ft. Duchesne, Utah.
Construction period: 1969-70

Length	1,580	ft
Capacity	50	ft³/s

Typical maximum section, earth lined:

Bottom width	6	ft
Side slopes	2:1	
Water depth	2.6	ft

BEER CREEK CANAL

Location: Starts in lower Beer Creek lands about 2.5 mi northwest of Payson, Utah, and extends northwest to the Beer Creek Pumping Plant.

Capacity	200-100	ft³/s
Length	5.7	mi

CURRANT CREEK PIPELINE (SRAWBERRY AQUEDUCT)

Type: Precast concrete pressure pipe
Location: Along Currant Creek downstream from Currant Creek Dam, about 11 mi northwest of Fruitland, Utah.
Construction period: Under construction

Length	1,220	ft
Capacity	620	ft³/s
Diameter	132	in

CURRANT TUNNEL

Construction period: 1970-75

Length	8,900 ft
Capacity	620 ft³/s
Diameter:	
Drilled	13 ft
Lined	10.25 ft

DOCS FEEDER PIPE

Type: Concrete pressure pipe
Location: From Docs Diversion Dam into Upper Stillwater Reservoir.

Length	4,170 ft
Capacity	100 ft³/s
Diameter	42 in

ELBERTA CANAL

Location: Heads at Elberta Diversion Dam on Currant Creek about 1.5 mi downstream from Mona Dam and extends westerly to Elberta Subarea.

Capacity	115-25 ft³/s
Length	12.9 mi

HADES CREEK FEEDER PIPELINE

Type: Concrete pipe
Location: Extending generally southeast from Hades Creek Diversion Dam to North Fork Siphon in the Strawberry Aqueduct System.
Construction period: Proposed

Length	13,985 ft
Capacity	30 ft³/s
Diameter	30 in

JORDAN AQUEDUCT REACHES 1 AND 2

Type: Steel and concrete
Location: West side of Salt Lake County from Point-of-the-Mountain to street coordinates 5900 south and 4000 west.
Construction period: 1971-73

Length	14.9 mi
Capacity	270 ft³/s
Diameter	78 in

LAYOUT CREEK FEEDER PIPE

Type: Concrete pipe
Location: Extending east from Layout Creek Diversion Dam to Strawberry Aqueduct joining at a point near the outlet of Layout Tunnel.
Construction period: 1970-75

Length	4,570 ft
Capacity	8 ft³/s
Diameter	12 in

LAYOUT CREEK FEEDER PIPELINE

Type: Asbestos-cement
Location: On Layout Creek 2 mi above its confluence with Currant Creek.
Construction period: 1970-75

Length	8 mi
Capacity	20 ft³/s
Diameter	18-15 in

LAYOUT CREEK SIPHON

Type: Precast concrete pressure pipe
Location: On Layout Creek 2 mi upstream from its confluence with Currant Creek.
Construction period: 1970-74

Length	5,280 ft
Capacity	620 ft³/s
Diameter	132 in

LAYOUT TUNNEL

Construction period: 1970-75

Length	17,320 ft
Capacity	620 ft³/s
Diameter:	
Drilled	13 ft
Lined	10.25 ft

MONA-NEPHI CANAL

Location: Extends southward from terminus of Wasatch Aqueduct at York Ridge along the eastern side of Juab Valley to a point near Levan Ridge.

Capacity	175-190-150 ft³/s
Length	24.1 mi

MOSIDA CANAL

Location: In an area extending about 18 mi south from west abutment of Goshen Bay Dike to within 1 mi north of Elberta, Utah.

Capacity	200 ft³/s
Length	18.5 mi

NEPHI-SEVIER CANAL

Location: Extends southward from terminus of Mona-Nephi Canal near Levan Ridge to Sevier Bridge Reservoir on Sevier River, about 16 mi northwest of Gunnison, Utah.

Capacity	150 ft³/s
Length	27 mi

OPEN CHANNEL NO. 2 (STRAWBERRY AQUEDUCT)

Location: Between U.S. Highway No. 40 and Strawberry Reservoir, 27 mi southeast of Heber City, Utah.
Construction period: 1968-71

Length	5,260 ft
Capacity	620 ft³/s
Typical maximum section, earth lined:	
Bottom width	18 ft
Side slopes	1.5:1
Water depth	8.8 ft

PROVO BAY CANALS

Location: Extending about 4 mi east from Provo Bay Dike and about 1.5 mi south of Provo, Utah.

Capacity	200-10 ft³/s
Length	18.3 mi

RHODES FEEDER PIPE

Type: Concrete pipe
Location: Extending east-southeast from Rhodes Diversion Dam to Strawberry Aqueduct System.
Construction period: Proposed

Length	1,590 ft
Capacity	15 ft³/s
Diameter	18 in

STARVATION FEEDER CONDUIT

Location: From Knight Diversion Dam, 4 to 5 mi northwest of Duchesne, Utah, along the Duchesne River into Starvation River.

Construction period: 1967-68

Length:

Tunnel, 7-ft-diameter	1.0 mi
Pipeline, 84-in-diameter, precast concrete	0.75 mi
Outlet channel and baffled apron drop	0.25 mi
Total	2.0 mi
Capacity	300 ft³/s
Outlet channel - Typical maximum section, earth lined:	
Bottom width	14 ft
Side slopes	3:1
Water depth	5.1 ft

STRAWBERRY AQUEDUCT

Location: From Upper Stillwater Reservoir southwest 36.8 miles to the enlarged Strawberry Reservoir.
Capacity: From 285 ft³/s at Upper Stillwater Reservoir Inlet to 620 ft³/s at Strawberry Reservoir Outlet.

Aqueduct features	Length (ft)	Lined dia. (ft)	Capacity (ft³/s)	Type
Intake structures	260	7	285	Circular reinforced concrete-lined pressure tunnel
Stillwater Tunnel (under construction)	42,640	7	285	Concrete-lined horseshoe tunnel
North Fork Siphon (maximum head 730 ft)	5,790	6	305	Welded steel pipe
Hades Tunnel	17,990	7	305	Concrete-lined horseshoe tunnel
Wolf Creek Pipeline	5,110	7	305-325	Precast concrete pipe
Rhodes Tunnel	4,320	7	325	Concrete-lined horseshoe tunnel
West Fork Pipeline	22,200	7	325	Precast concrete pipe
Vat Tunnel	38,740	7.75	475	Concrete-lined horseshoe tunnel
Open Channel No. 1	60	—	475	
Currant Creek Pipeline	3,860	10.25	620	Precast concrete pipe
Currant Tunnel	8,900	10.25	620	Concrete-lined horseshoe tunnel
Layout Creek Pipeline (construction period 1970-75)	220	10.25	620	Precast concrete pipe
Layout Tunnel	17,320	10.25	620	Concrete-lined horseshoe tunnel
Water Hollow Pipeline	240	10.25	620	Precast concrete pipe
Water Hollow Tunnel	21,720	10.25	620	Concrete-lined horseshoe tunnel
Open Channel No. 2	5,260		620	
Total	194,630			

SYAR TUNNEL

Type: Concrete-lined circular pressure tunnel
Location: Extends through Great Basin Divide between enlarged Strawberry Reservoir and potential Syar Powerplant and Reservoir.

Length	6.5 mi
Elevation of inlet portal	7507.0 ft
Elevation of outlet portal	7387.4 ft
Head	119.6 ft
Capacity	400 ft³/s
Diameter	8 ft

VAT FEEDER PIPE

Type: Concrete pressure pipe
Location: Extends east from Vat Diversion Dam to Wolf Creek Pipeline joining near the pipeline outlet.
Construction period: Under construction

Length	4,300 ft
Capacity	300 ft³/s
Diameter	66 in

WASATCH AQUEDUCT

Location: Extends from tailrace of Dyne Powerplant on Diamond Fork about 10 mi upstream from its confluence with Spanish Fork River, southward to York Ridge near Utah-Juab County Line.

Capacity	200-175 ft³/s
Length:	
Conduit	15.2 mi
Tunnel	5.6 mi
Siphon	1.7 mi
Open canal	9.5 mi
Total	32.0 mi

WATER HOLLOW CREEK SIPHON

Type: Precast concrete pressure pipe
Location: On Water Hollow Creek 5 mi upstream from its confluence with Currant Creek.
Construction period: 1970-74

Length	5,280 ft
Capacity	620 ft³/s
Diameter	132 in

WATER HOLLOW FEEDER PIPE

Type: Concrete pressure pipe
Location: Extending southeast from Water Hollow Diversion Dam to Strawberry Aqueduct northeast of Strawberry Reservoir.
Construction period: 1970-75

Length	245 ft
Capacity	13 ft³/s
Diameter	15 in

WATER HOLLOW FEEDER PIPELINE

Type: Asbestos-cement pressure pipe
Location: On Water Hollow Creek 5 mi upstream from its confluence with Currant Creek.
Construction period: 1970-72

Length	5,280 ft
Capacity	20 ft³/s
Diameter	21 in

WATER HOLLOW TUNNEL

Location: Part of the Strawberry Aqueduct.
Construction period: 1968-71

Length	21,571	ft
Capacity	620	ft³/s
Diameter:		
Drilled	13	ft
Lined	10.25	ft

WIN FEEDER PIPE

Type: Concrete pressure pipe
Location: Extends south from Win Diversion Dam to Strawberry Aqueduct at a point on Wolf Creek Pipeline.
Construction period: Proposed

Length	750	ft
Capacity	5	ft³/s
Diameter	12	in

PUMPING PLANTS:

MOSIDA PUMPING PLANTS

Location: In an area extending about 10 mi south from west abutment of Goshen Bay Dike to within 10 mi north of Elberta, Utah.

Pumping plant:	Capacity (ft³/s)	Head (ft)
Mosida	200	115
Mosida Relift	100	80

PROVO BAY PUMPING PLANTS

Location: About 2 and 5 mi southwest of Provo, respectively.

Canal Pumping Plants	200 (combined)	16 (average)
Drains Pumping Plant	226	31

NEPHI PUMPING PLANT

Location: About 2 mi south of Nephi Utah.	150	154 (to lift water through 880-ft-long discharge line)

MONA PUMPING PLANT

Location: North end of enlarged Mona Reservoir, 7 mi north of Nephi, Utah.	125	235

BEER CREEK PUMPING PLANT

Location: About 12 mi west of Spanish Fork, Utah.	25	14

BENNION PUMPING PLANT

Location: On the Jordan River between Bennion and Murray, Utah, about 5 mi north of Lampton Dam.

Powerplants

DYNE POWERPLANT

Location: On Diamond Creek, southwest of Strawberry Reservoir. Part of the Diamond Fork Power System.
Construction period: Proposed

Capacity	33,000	kW
Design head	800	ft
Average annual production	132,400,000	kWh
Discharge through turbines	615	ft³/s

JORDANELLE POWERPLANT

Location: At Jordanelle Dam, 6 mi north of Heber, Utah, on the Provo River.
Construction period: Proposed

Capacity	10,400	kW
Design head	242	ft
Average annual production	39,086,000	kWh
Number of turbines	2	

SIXTH WATER POWERPLANT

Location: At Sixth Water Dam, 1.5 mi west of Syar damsite on Sixth Water Creek. Part of the Diamond Fork Power System.
Construction period: Proposed

Capacity	90,000	kW
Design head	770	ft
Average annual production	134,000,000	kWh
Discharge through turbines	1,600	ft³/s

SYAR POWERPLANT

Location: At Syar Dam, 6.5 mi southwest of Strawberry Reservoir in Rays Valley. Part of the Diamond Fork Power System.
Construction period: Proposed

Capacity	10,500	kW
Design head	332	ft
Average annual production	53,100,000	kWh
Discharge through turbines	450	ft³/s

Roadway Construction

HIGHWAY 40 RELOCATION

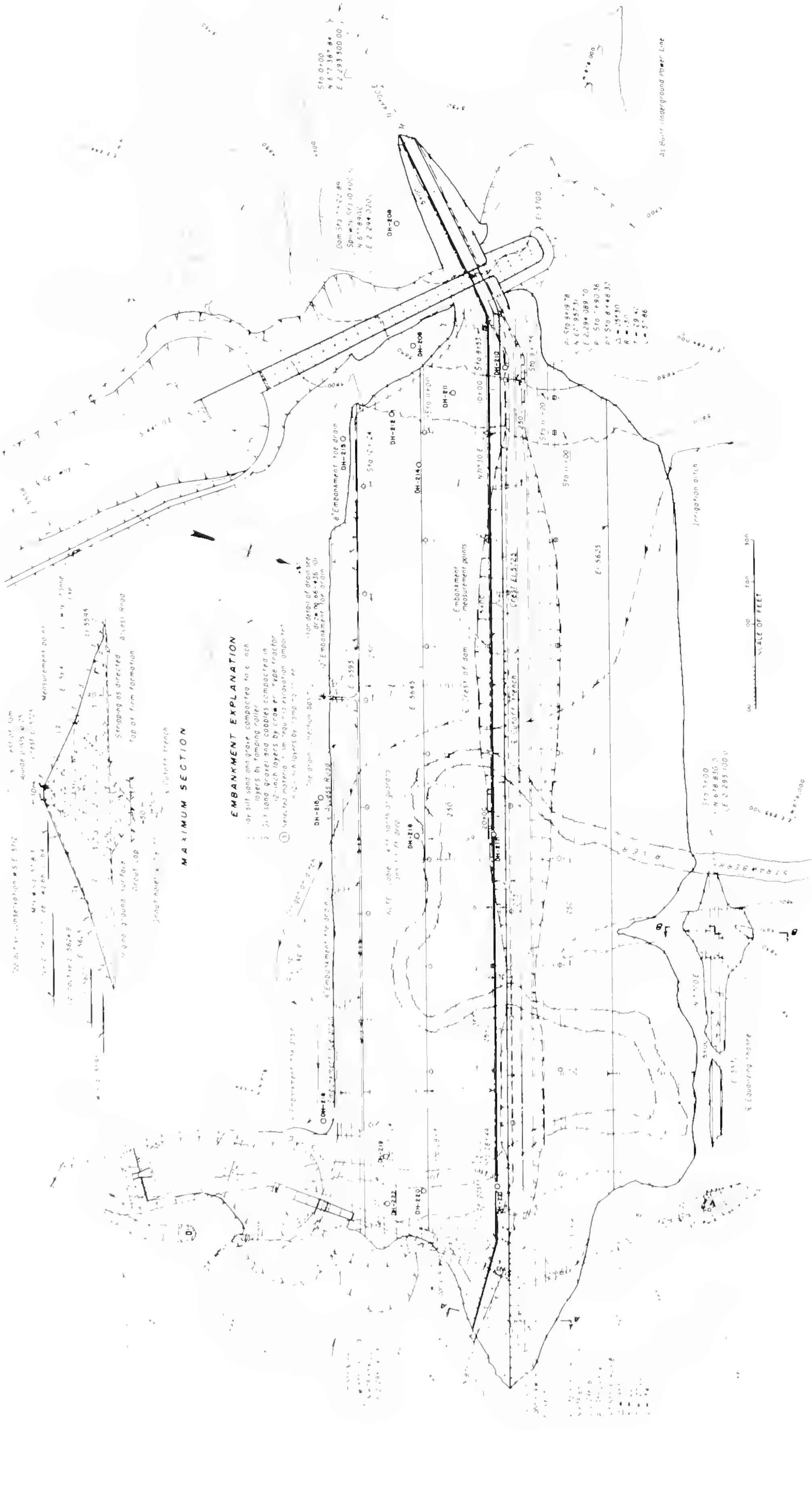
Location: Around and over Starvation Reservoir.
Construction period: 1968-69
Dimensions:

Roadway length	6.75	mi
Roadway width	24	ft
Starvation bridge length	1,634	ft
Starvation bridge height	100	ft

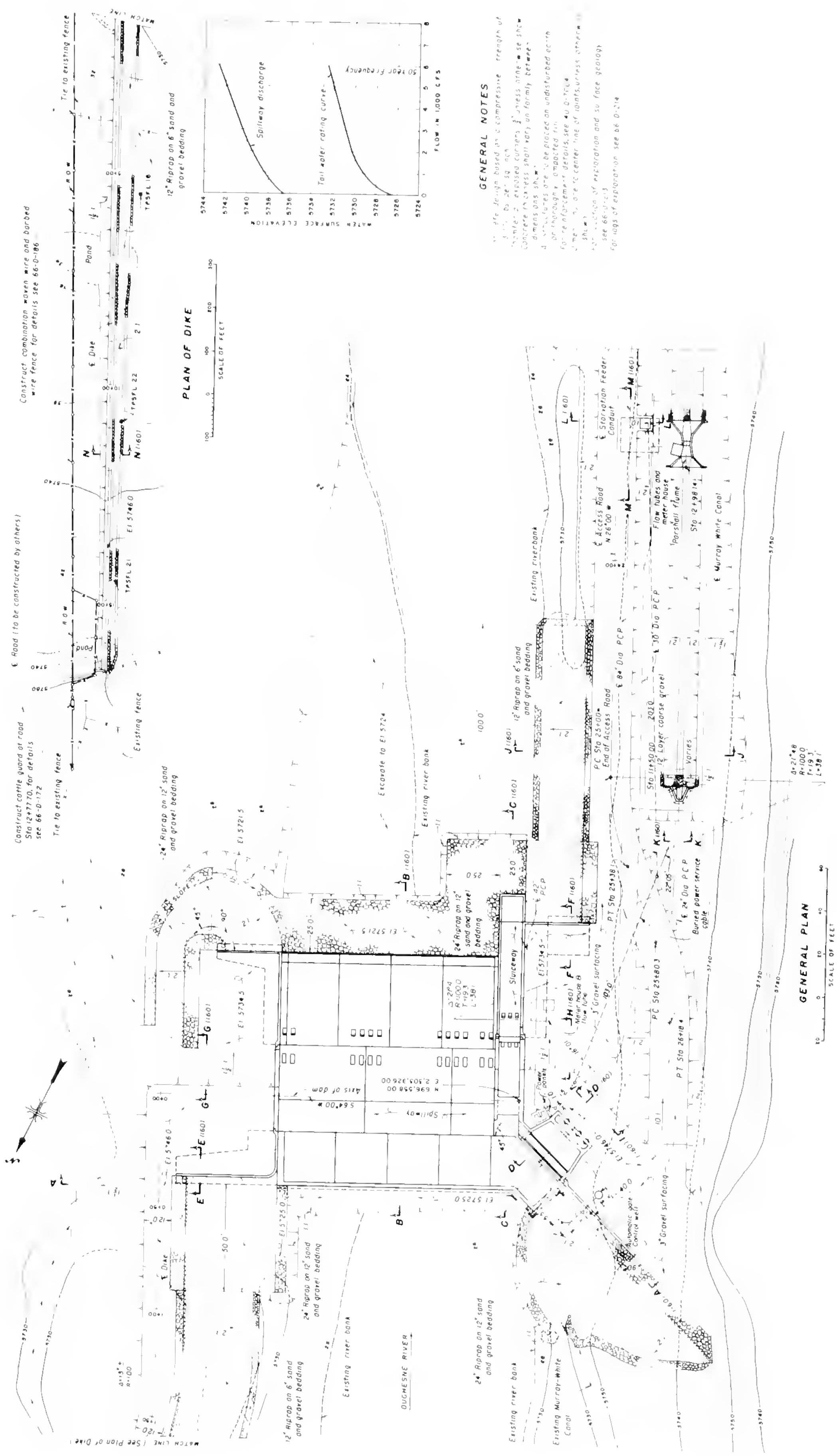
STILLWATER TUNNEL OUTLET PORTAL ACCESS ROAD

Location: From Rock Creek to North Fork of Duchesne River.
Construction period: 1971
Dimensions:

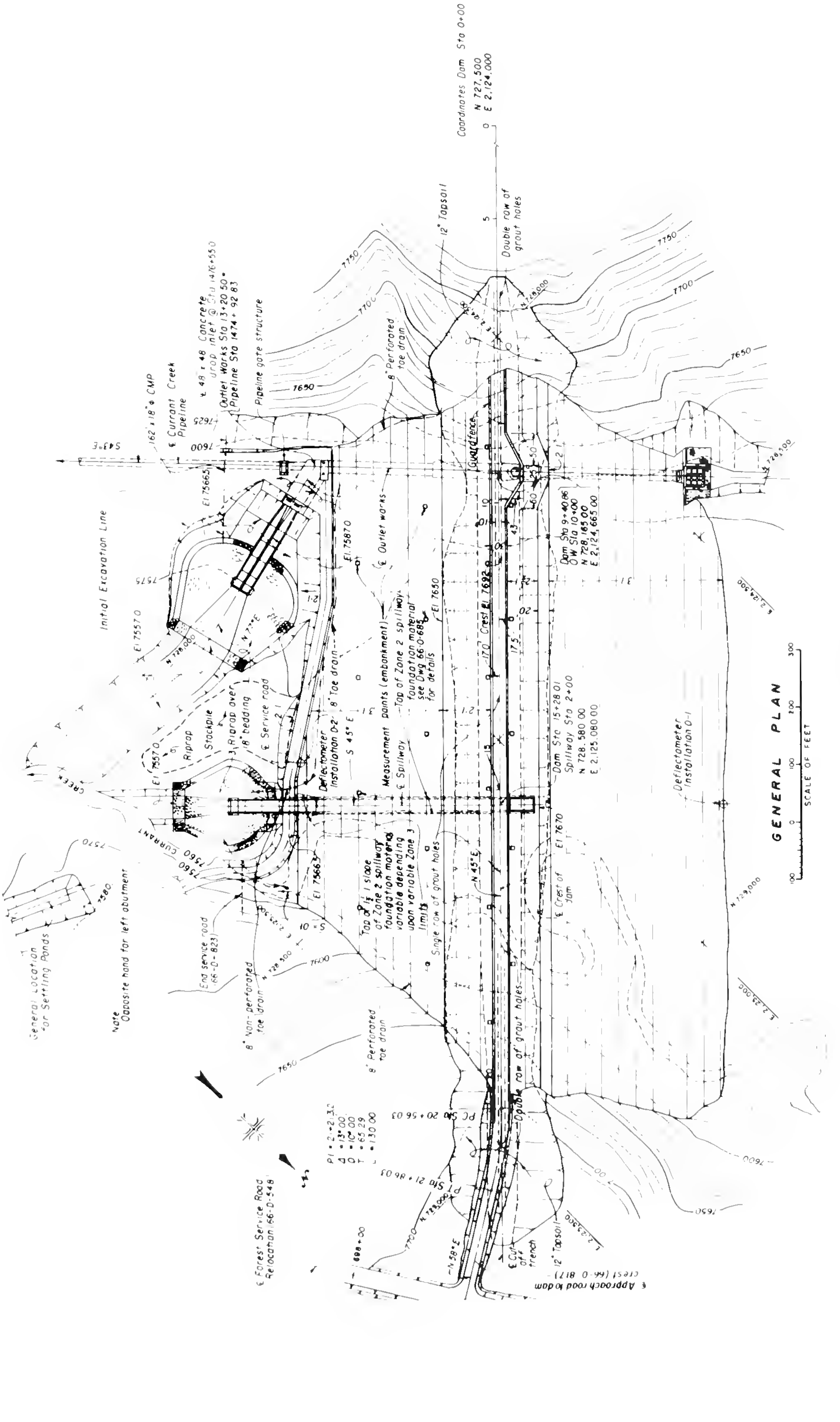
Length	2.6	mi
Width	24	ft



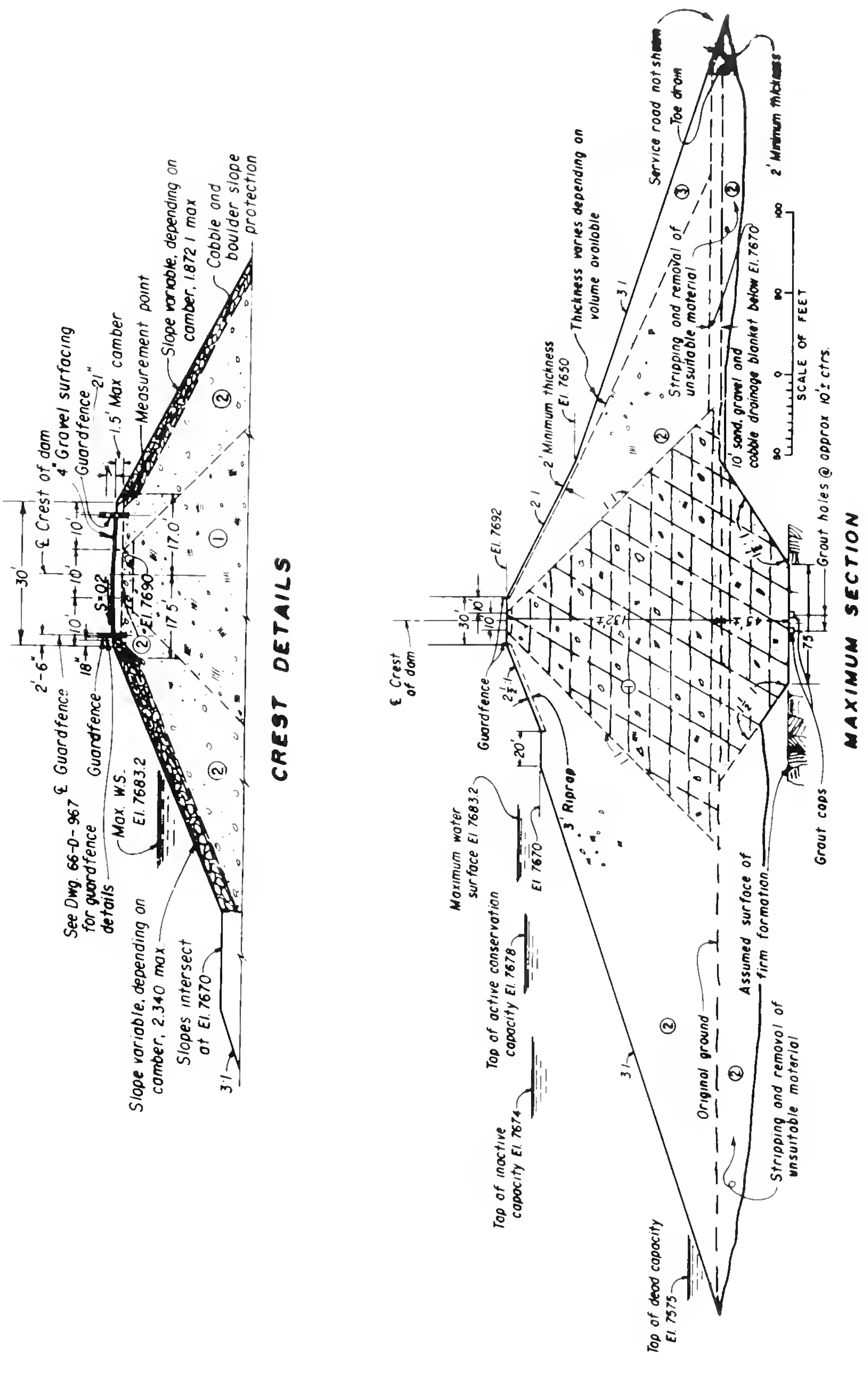
Starvation Dam, Plan and Section



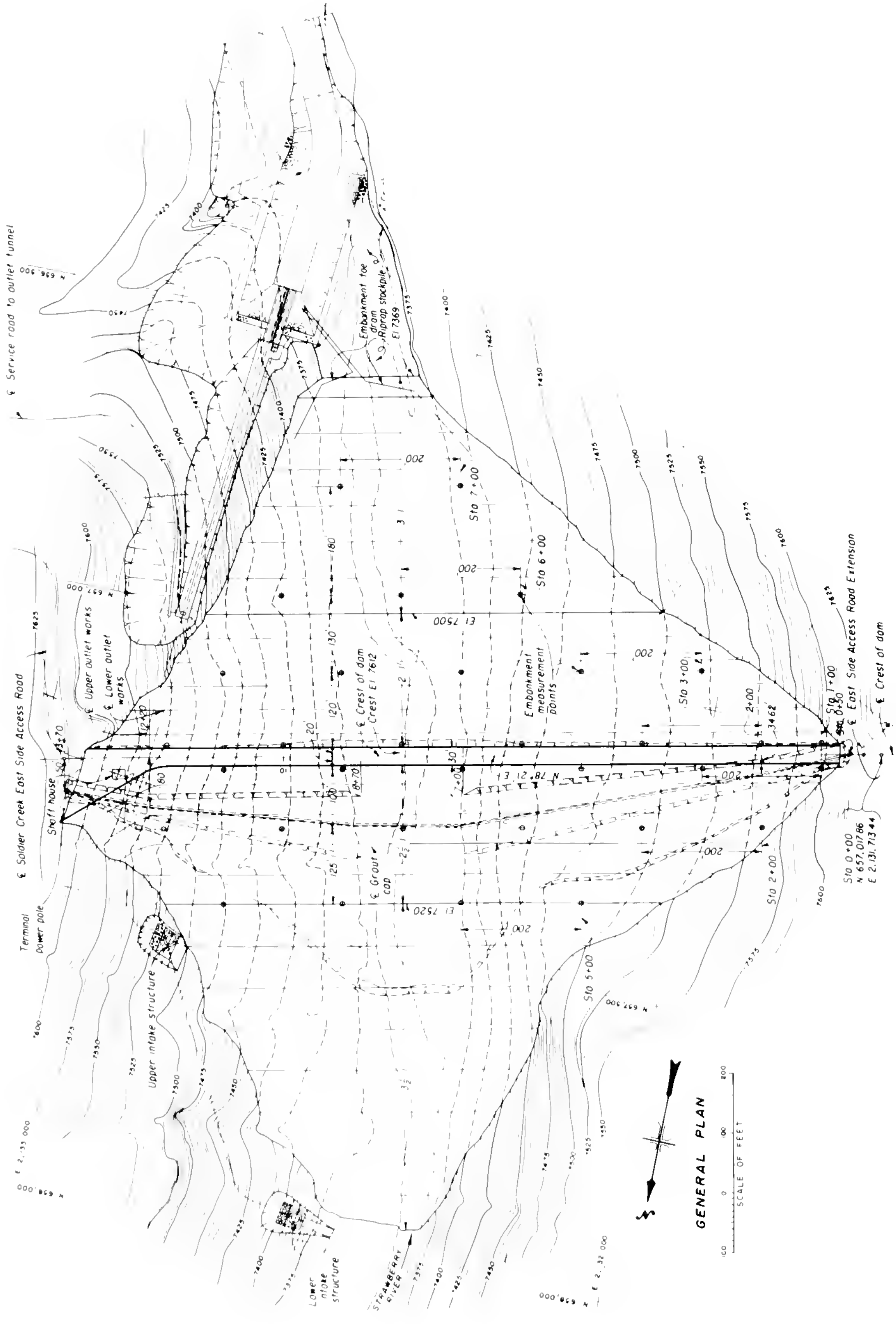
Knight Diversion Dam, Plan



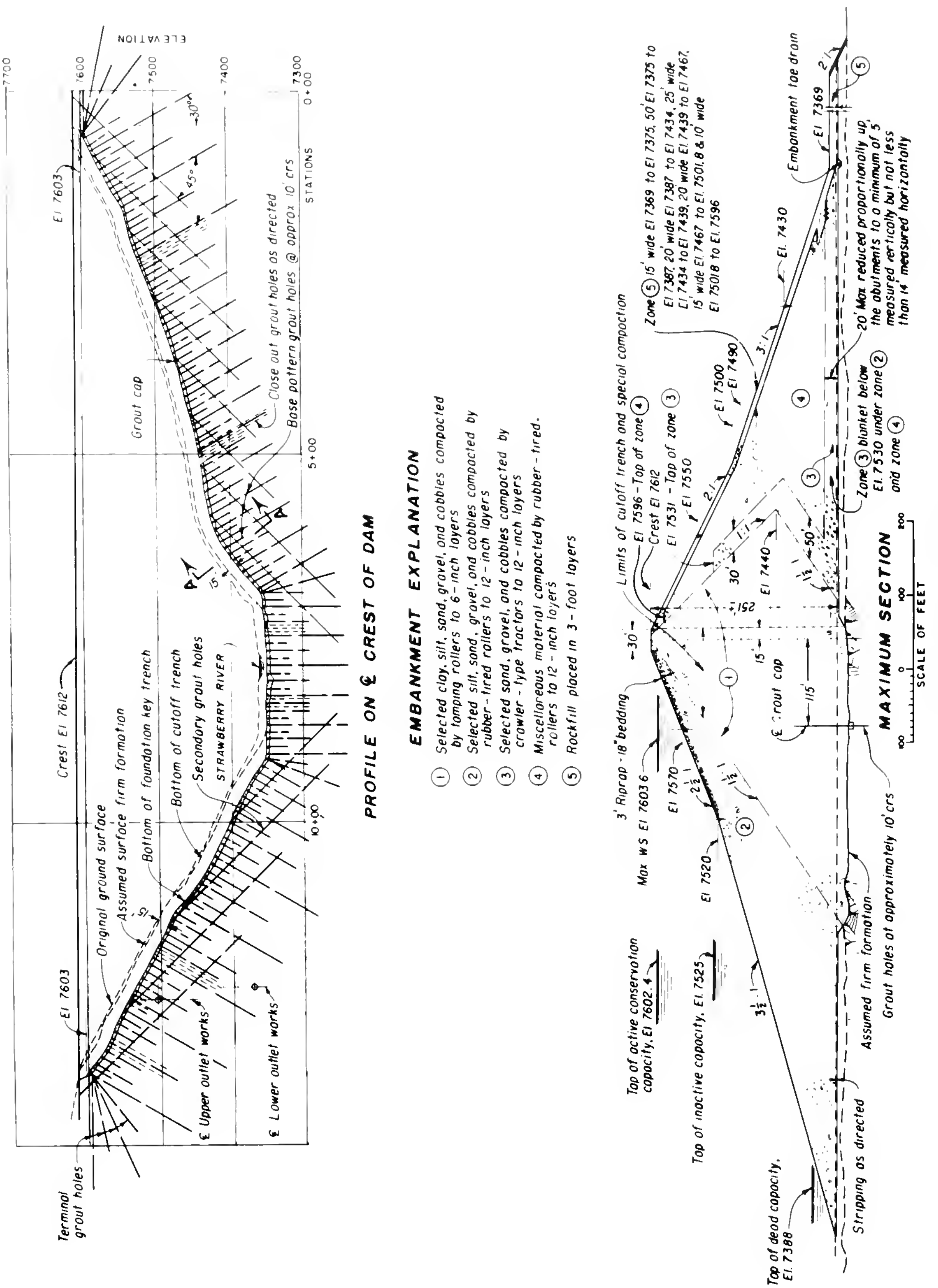
Currant Creek Dam, Plan



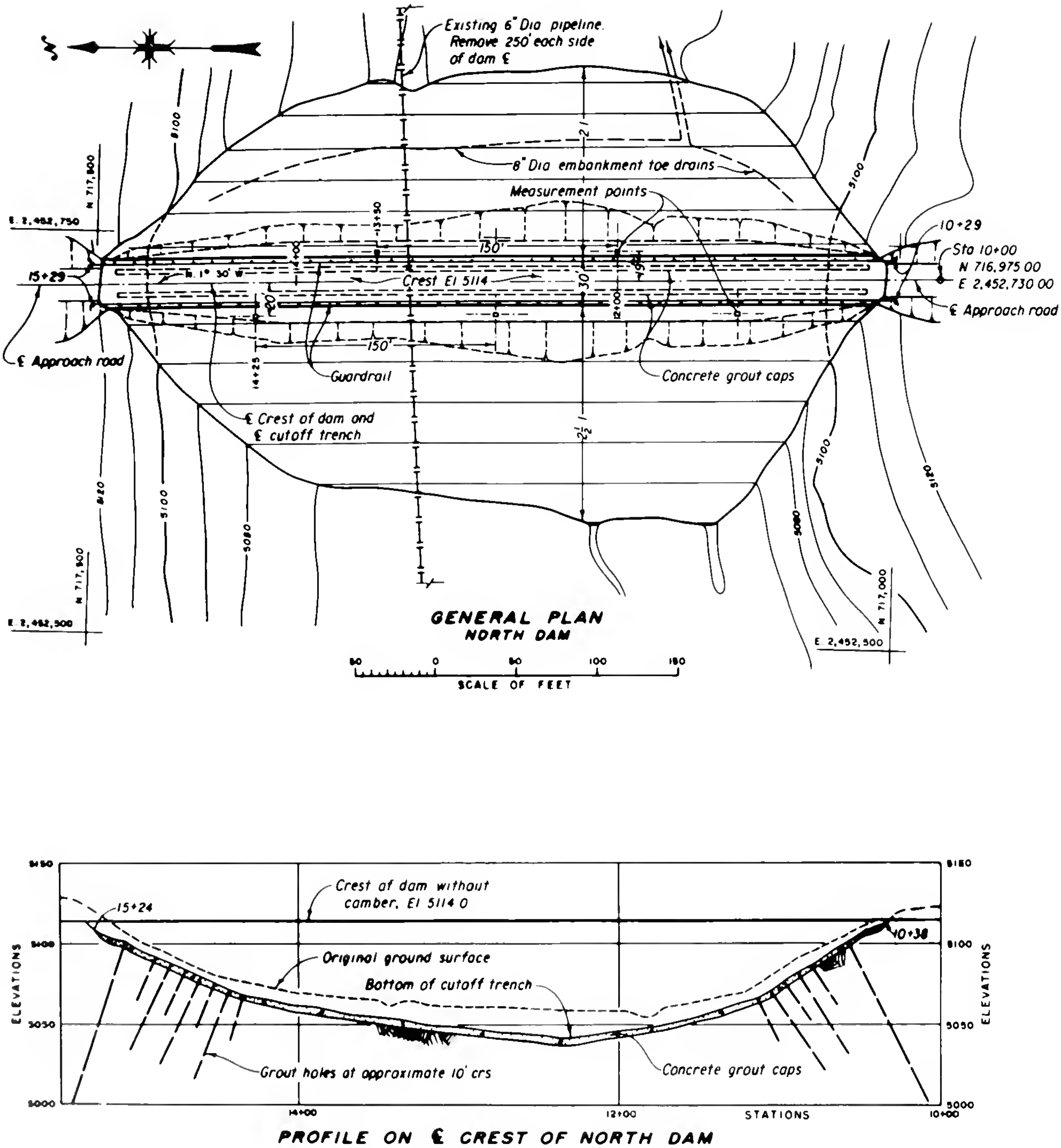
Currant Creek Dam, Sections



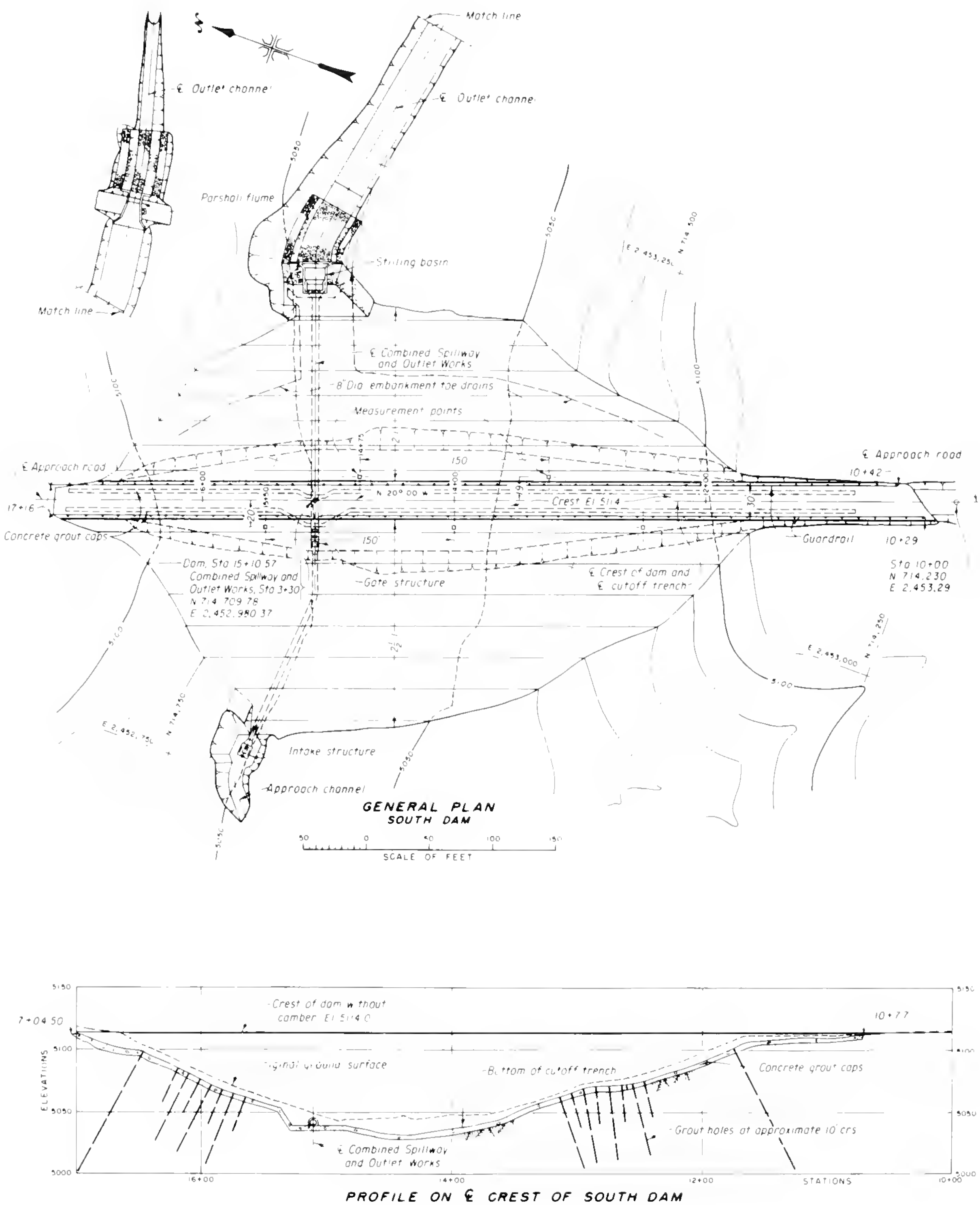
Soldier Creek Dam, Plan



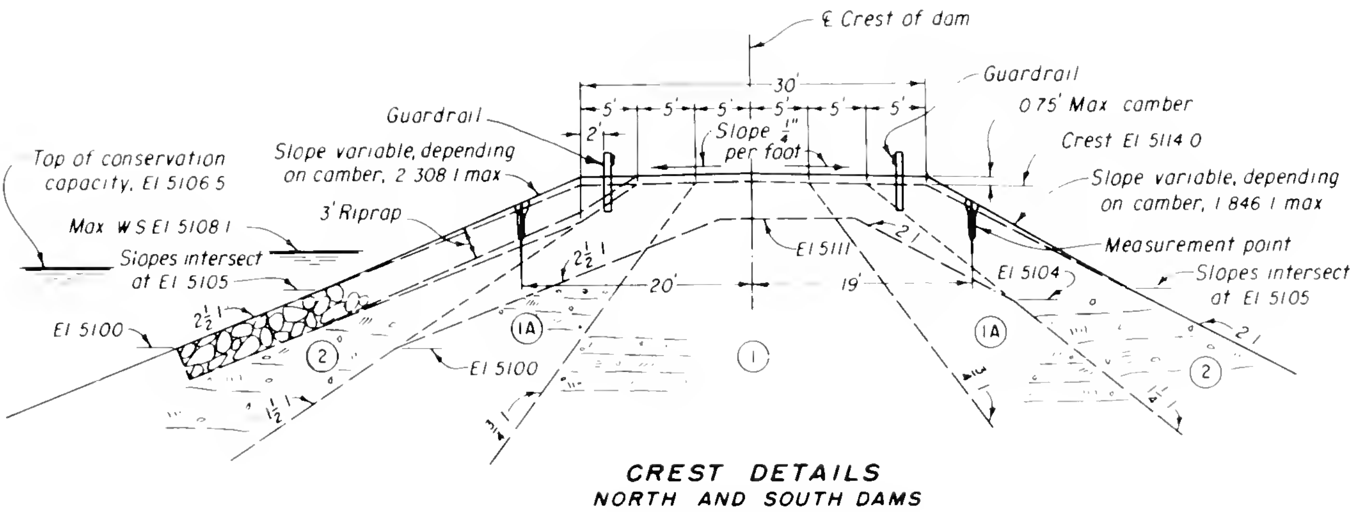
Soldier Creek Dam, Profile and Section

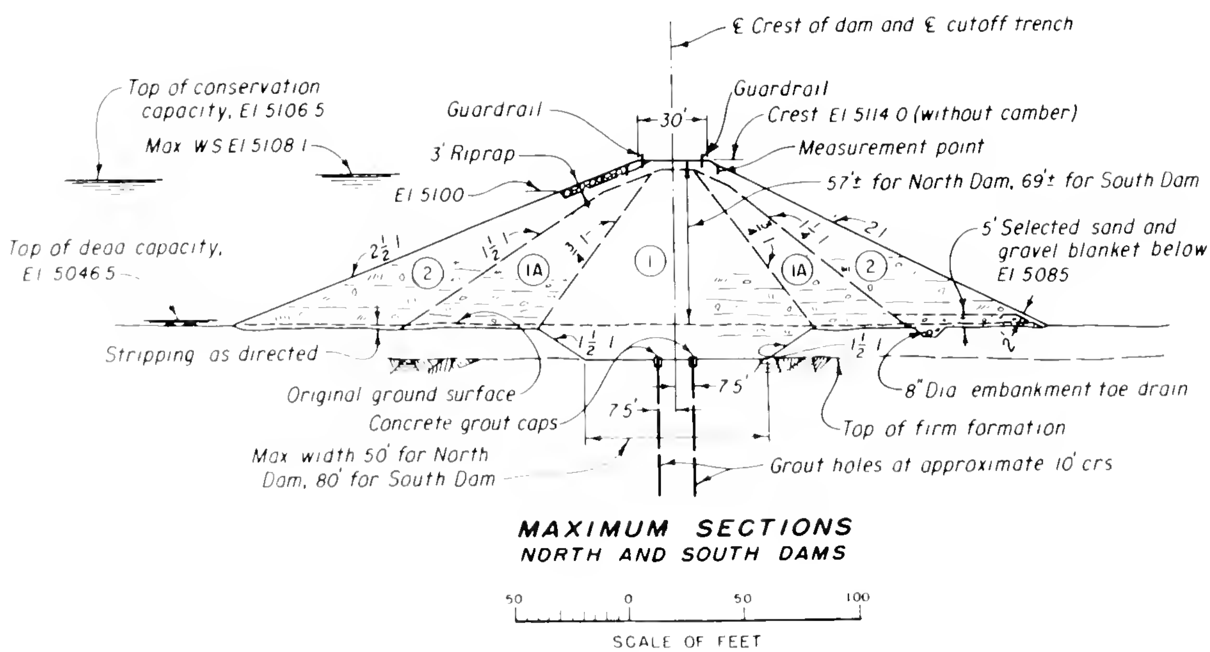


Bottle Hollow North Dam, Plan and Profile



Bottle Hollow South Dam, Plan and Profile



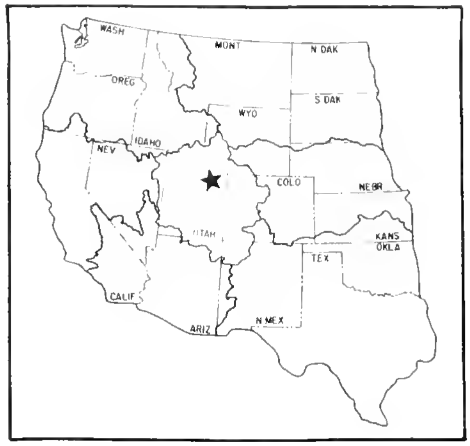


Bottle Hollow North & South Dams, Sections

Central Utah Project
Vernal Unit

Utah: Uintah County

Upper Colorado Region
Water and Power Resources Service



PLAN

The Vernal Unit of the Central Utah Project is approximately centered around the city of Vernal in the Ashley Valley of northeastern Utah. This area lies within the Green River Basin of the Upper Colorado River Basin. Principal constructed features of the unit are Fort Thornburgh Diversion Dam and Steinaker Feeder Canal through which surplus flows of Ashley Creek are conveyed to the offstream Steinaker Reservoir. Water stored in the reservoir is released into Steinaker Service Canal and delivered to preproject irrigation canals and ditches. A supplemental water supply is provided to about 14,700 acres. This water will partially replace Ashley Creek water, including releases from privately constructed upstream reservoirs. Some of the replaced water is used on lands upstream of Steinaker Service Canal and some is diverted from Ashley Springs on Ashley Creek into the municipal pipelines through which about 1,600 acre-feet of water is delivered annually to the communities of Vernal, Naples, and Maeser.

The Vernal Unit is the only one of the six units which comprise the Central Utah Project that is complete. It was completed in 1962.

Steinaker Dam and Reservoir

The unit features store and distribute excess spring flows of Ashley Creek. In years prior to the project, Ashley Creek flows dwindled to an inadequate water supply by late summer. Water stored in Steinaker Reservoir can now be released to provide supplemental water to approximately 14,700 acres of land. Municipal water is supplied to the communities of Vernal, Naples, and Maeser, Utah.

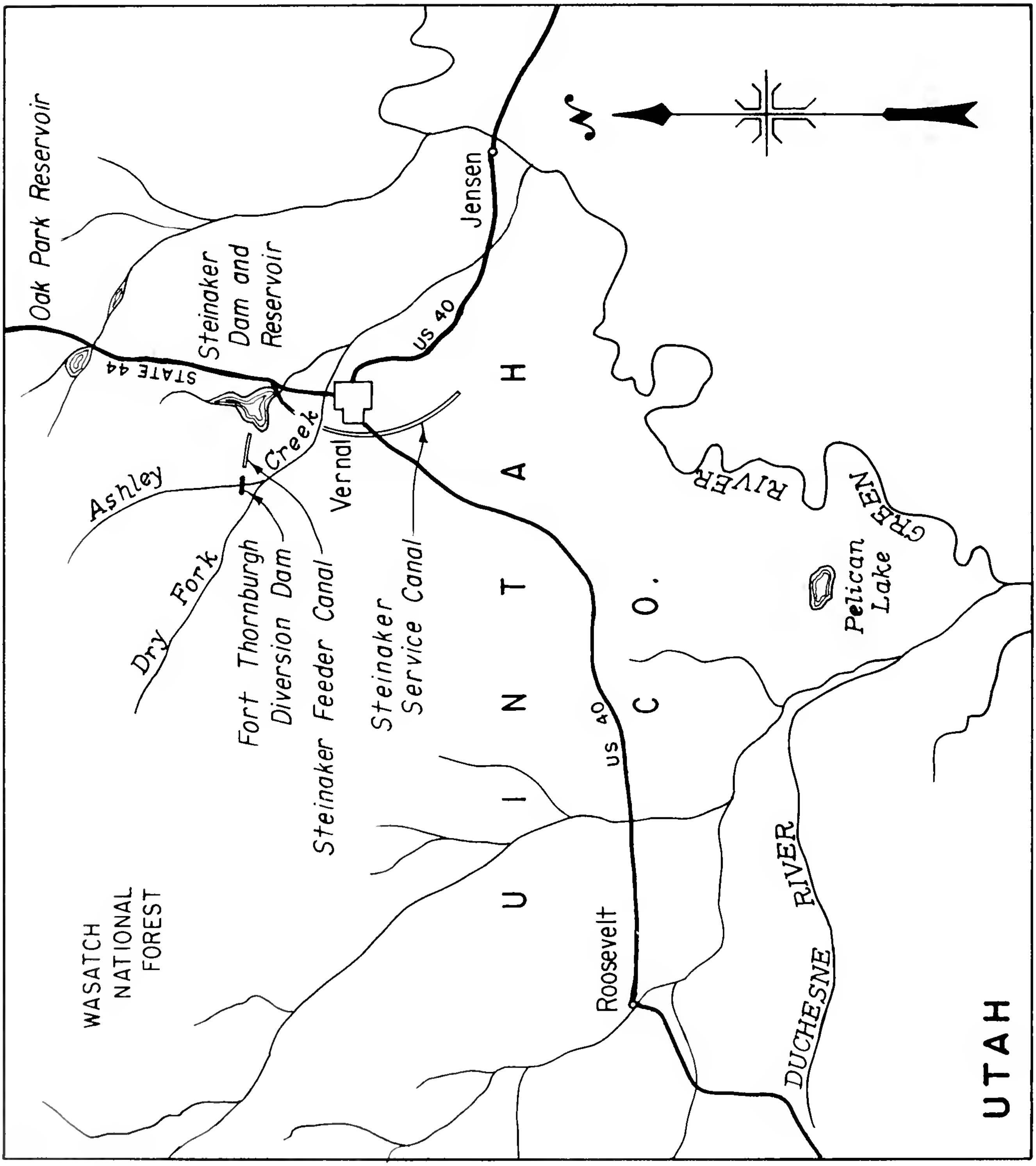
Steinaker Dam and Reservoir

Flows of Ashley Creek are regulated by Steinaker Dam, constructed offstream in Steinaker Draw about 3.5 miles north of Vernal. Steinaker Dam is a zoned earthfill structure with a height of 162 feet, crest length of 1,997 feet, and a volume of 1,892,000 cubic yards. Steinaker Reservoir has a total capacity of 38,173 acre-feet and a surface area of 820 acres.

Diversion and Carriage Facilities

Water from Ashley Creek is diverted by the Fort Thornburgh Diversion Dam on Ashley Creek, 4 miles northwest of Vernal. From the diversion dam, the water is conveyed eastward to the reservoir through the 2.8-mile-long Steinaker Feeder Canal. Reservoir water is released to the Steinaker Service Canal and conveyed south 11.6 miles to existing canals and ditches.

Part of the water in the Steinaker Service Canal is provided directly for unit lands downstream of the canal as a supplemental supply, and part is utilized as a replacement supply to these lands in exchange for natural streamflow and storage releases from existing reservoirs that are diverted upstream. Exchange water made available upstream is used for municipal purposes in Vernal, Maeser, and Naples, and for supplemental irrigation of unit lands upstream of the Steinaker Service Canal. The municipal water is diverted from Ashley Springs on Ashley Creek and is distributed through existing facilities.



Central Utah Project, Vernal Unit

DEVELOPMENT

Construction

The Vernal Unit repayment contract between the Uintah Water Conservancy District and the United States was executed June 15, 1958, and validated by the courts November 25, 1958. Construction of irrigation facilities was started May 14, 1959, and completed in 1962. Construction of drainage facilities was initiated in 1970 and were scheduled to be finished in 1977.

Project Funding

Repayment of project costs is scheduled as follows: $98,000 prepayment from the Colorado River Development Fund and contributions; $231,000 nonreimbursable fish and wildlife, recreation, and highway improvement credits; $8,020,050 from Upper Colorado River Basin Funds credited to the State of Utah; $606,000 from municipal and industrial water users; and $1,500,000 to be repaid by Uintah Water Conservancy District in 50 equal annual installments. The District commenced repayment of its obligation in 1966 and as of September 1978 has repaid $301,433.

Operating Agency

Project facilities were turned over to the Uintah Water Conservancy District for operation and maintenance on January 1, 1967.

BENEFITS

Irrigation

Principal crops grown on project lands are barley, corn, oats, alfalfa, corn silage, and irrigated pasture. In 1975, the total gross crop value amounted to $1,810,985 from 13,848 irrigated acres. The total estimated project cost is $10,402,000; of this amount, $9,602,000 has been allocated to irrigation, $569,000 to municipal and industrial water, and $231,000 to nonreimbursable fish and wildlife and other costs.

Recreation

Recreation facilities at Steinaker Reservoir are administered by the Utah Division of Parks and Recreation and consist of boating, waterskiing, and fishing. There were 131,179 visitors to the reservoir area during 1978.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental service	14,700	acres

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	2	
Canals, total length	15	mi
Drains	Incomplete	

ENGINEERING DATA

Storage Facilities

STEINAKER DAM

Type: Rolled earthfill
Location: Offstream in Steinaker Draw, about 3.5 miles north of Vernal, Utah.
Construction period: 1959-62

Reservoir, Steinaker:		
Total capacity	38,173	acre-ft
Active capacity	33,100	acre-ft
Inactive capacity	4,100	acre-ft
Surface area at El. 5518	820	acres
Dimensions:		
Structural height	162	ft
Hydraulic height	138	ft
Crest length	1,997	ft
Volume	1,892,000	ft³

Diversion Dams

FORT THORNBURGH DIVERSION DAM

Type: Rockfill overflow, embankment wings
Location: Ashley Creek, Utah - Uintah Conservation District.
Construction period: Completed 1961

Dimensions:		
Crest length	1,564	ft
Weir crest length	132	ft
Height	9	ft
Weir crest elevation	5608.5	ft
Volume	7,000	yd³
Diversion capacity	710	ft³/s
Flood capacity	3,400	ft³/s
Headworks capacity	400	ft³/s

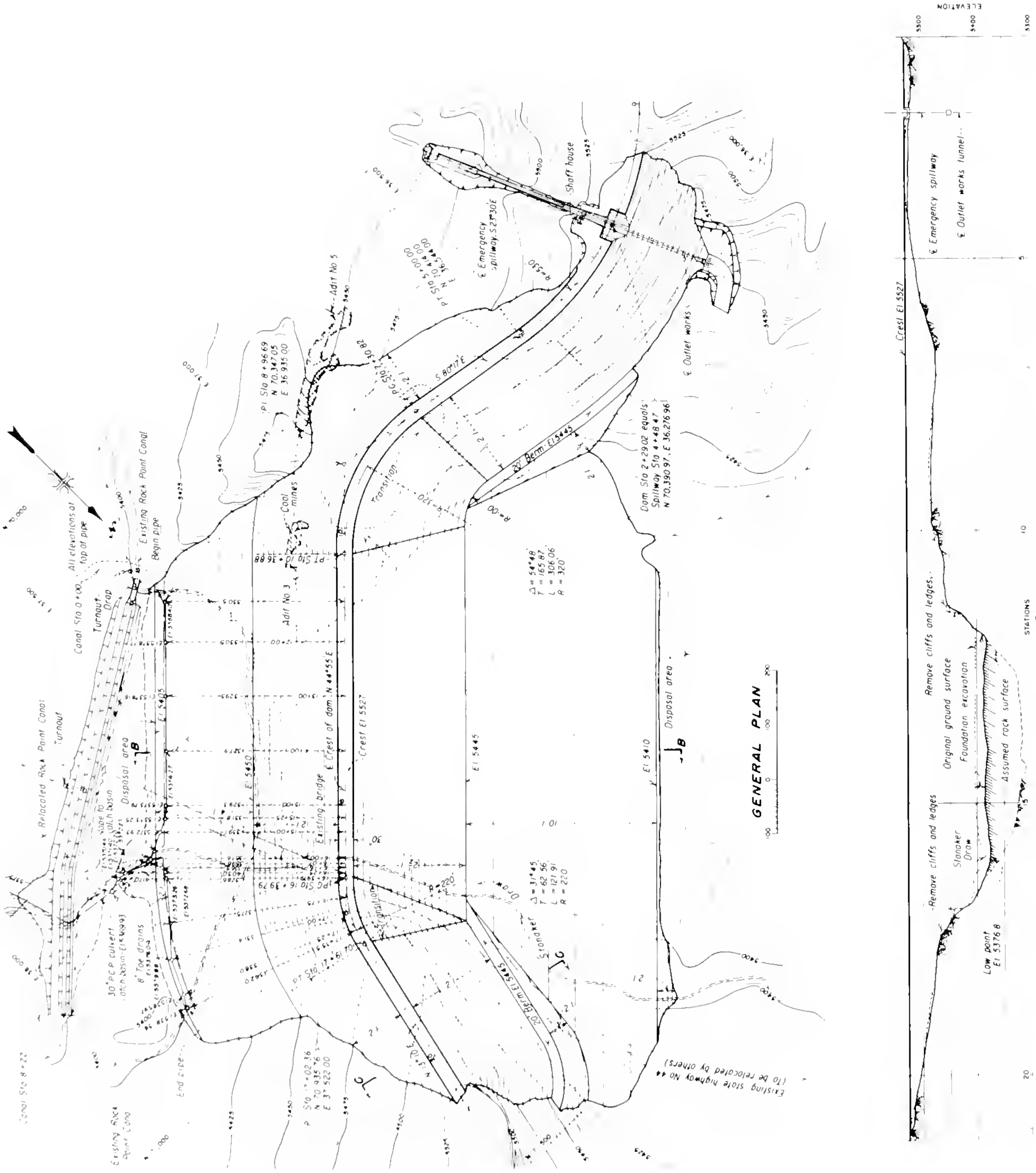
Carriage Facilities

STEINAKER FEEDER CANAL

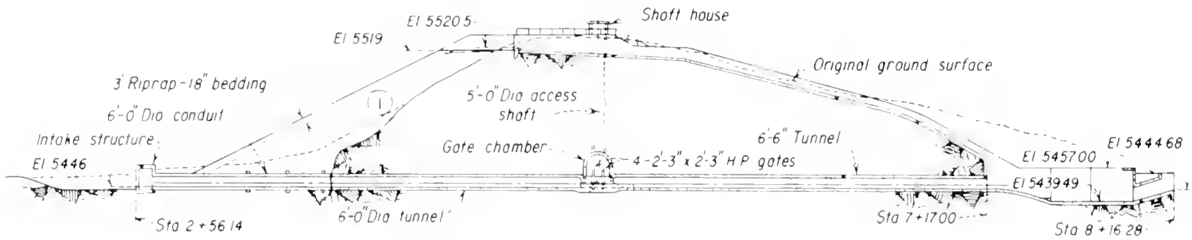
Capacity	400	ft³/s
Length	3	mi

STEINAKER SERVICE CANAL

Capacity	300	ft³/s
Length	12	mi

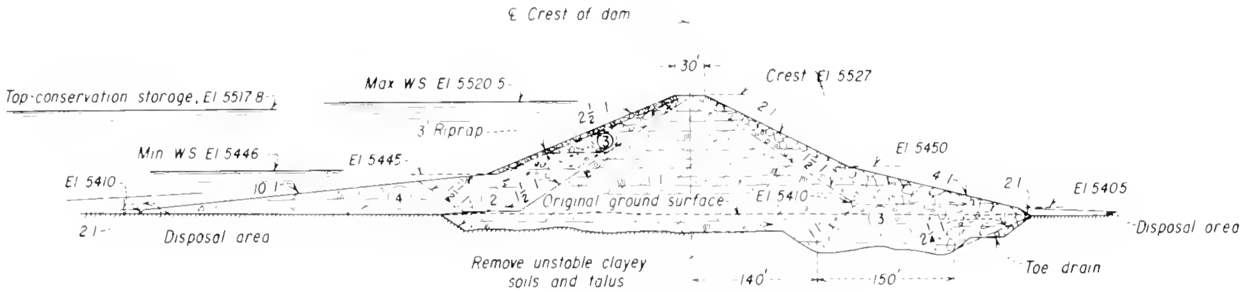


Steinaker Dam, Plan and Profile



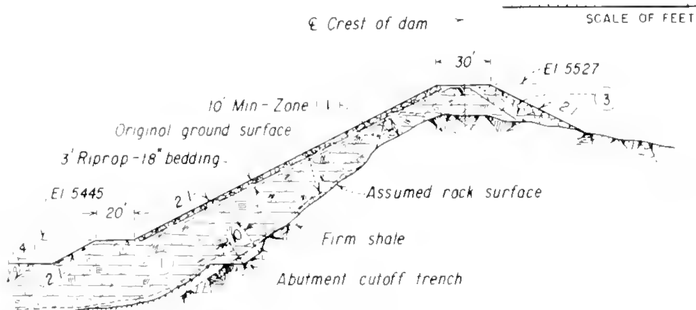
PROFILE ON ℄ OUTLET WORKS AND EMERGENCY SPILLWAY

50 0 50 100
SCALE OF FEET



TYPICAL SECTION B-B

100 0 100 200
SCALE OF FEET

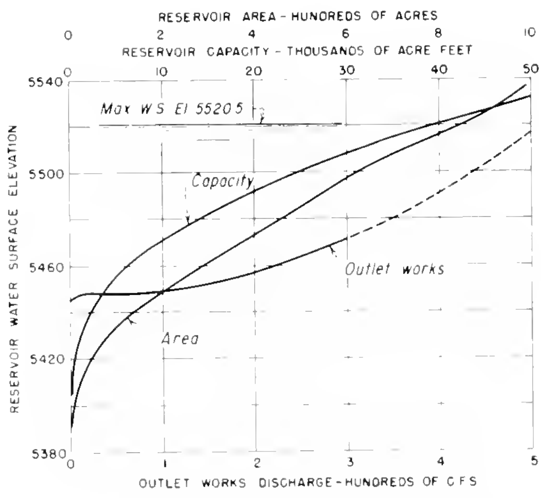


TYPICAL ABUTMENT SECTION C-C

50 0 50 100
SCALE OF FEET

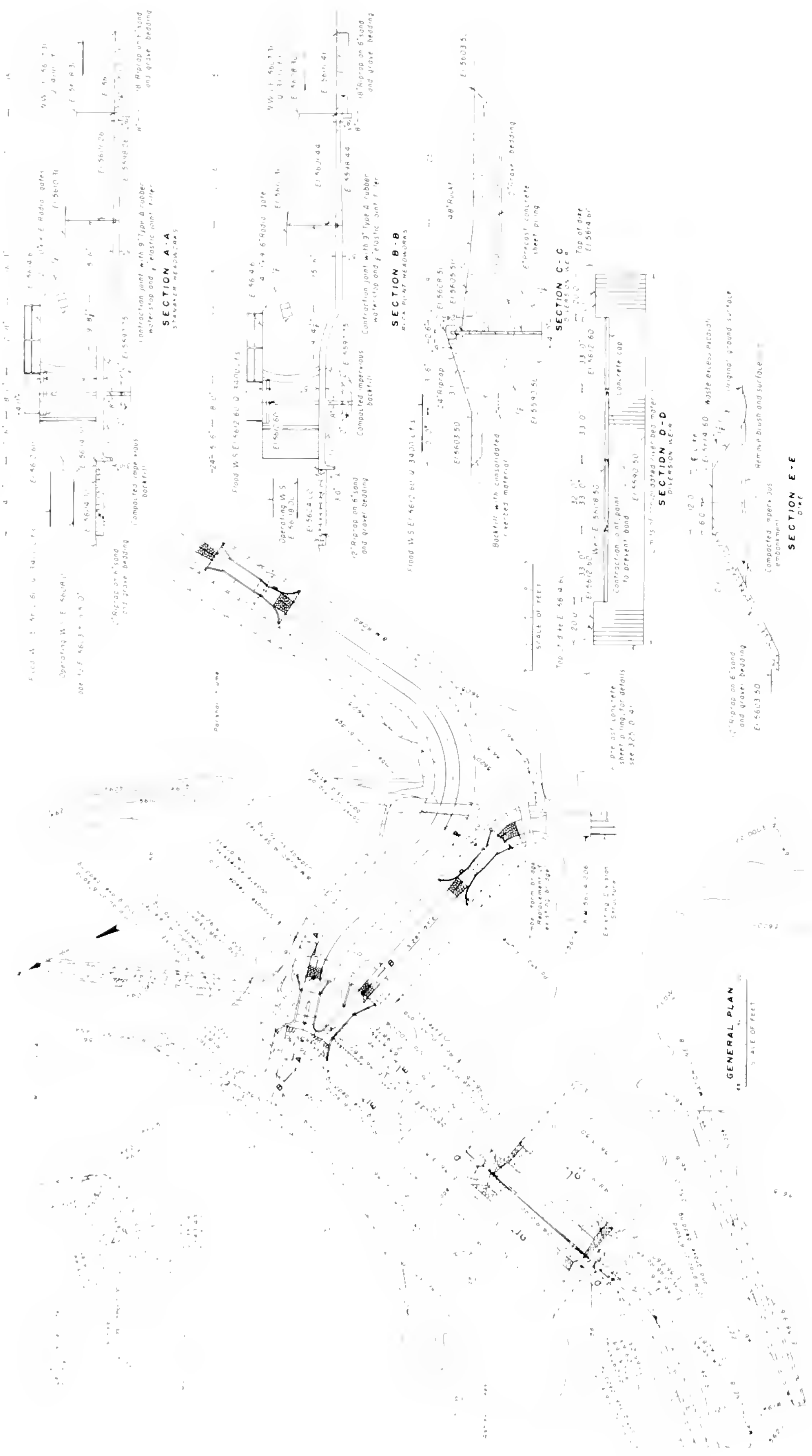
EMBANKMENT EXPLANATION

1. Selected clay, silt, and sand compacted by tamping rollers to 6-inch layers
2. Selected clay, silt, sand, gravel, and cobbles compacted by tamping rollers to 12-inch layers
3. Selected sand, gravel, cobbles, and boulders compacted by crawler-type tractors to 12-inch layers
4. Miscellaneous soil and rock fragments placed in 24-inch layers and compacted by travel of equipment



AREA-CAPACITY-DISCHARGE CURVES

Steinaker Dam, Sections

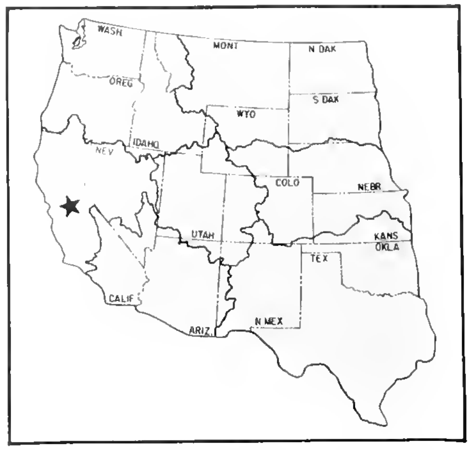


Fort Thornburgh Diversion Dam, Plan and Sections

Central Valley Project

California: 35 Counties[1]

Mid-Pacific Region
Water and Power Resources Service



California's Central Valley Basin includes two major watersheds—those of the Sacramento River on the north, and the San Joaquin River on the south—plus the Tulare Lake Basin. The combined watersheds extend nearly 500 miles in a northwest-southeast direction and range from about 60 to 100 miles in width. The basin is surrounded by mountains except for a gap in its western edge, at the Carquinez Straits. The valley floor occupies about one-third of the basin; the other two-thirds are mountainous. The Cascade Range and Sierra Nevada, on the north and the east, rise in elevation to about 14,000 feet and the Coast Ranges on the west to as high as 8,000 feet. The Sacramento River and its tributaries flow southward, draining the northern part of the basin. The San Joaquin River and its tributaries flow northward, draining the central southern portion. These two river systems join at the Sacramento-San Joaquin Delta, flow through Suisun Bay and Carquinez Straits into San Francisco Bay, and out the Golden Gate to the Pacific Ocean.

The Central Valley Project, one of the Nation's major water conservation developments, extends from the Cascade Range on the north to the semiarid but fertile plains along the Kern River on the south. Initial features of the project were built primarily to protect the Central Valley from crippling water shortages and menacing floods. New project units were built to provide water and power to match the continued growth of the State.

Irrigated rice field

Although developed primarily for irrigation, this multiple-purpose project also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water quality.

The Central Valley Project has been developed in segments. Information on major features of the various divisions and units is contained in separate sections that follow this project summary. The sections are:

- Allen Camp Unit of the Pit River Division
- Folsom and Sly Park Units of the American River Division
- Auburn-Folsom South Unit of the American River Division
- Delta Division
- Friant Division
- Sacramento Canals Unit of the Sacramento River Division
- San Felipe Division
- San Luis Unit of the West San Joaquin Division
- Shasta/Trinity River Divisions.

PLAN

Reservoirs of the Central Valley Project are coordinated in their operation to obtain maximum yields and deliver water into the main river channels and canals of the project in the most efficient and economical manner. Irrigation and municipal water is delivered from the main

[1] Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Kern, Kings, Lassen, Madera, Mariposa, Merced, Modoc, Monterey, Nevada, Placer, Plumas, Sacramento, San Benito, San Joaquin, Santa Clara, Santa Cruz, Shasta, Sierra, Siskiyou, Stanislaus, Tehama, Trinity, Tulare, Tuolumne, Yolo, and Yuba Counties.

Central Valley Project

canals in accordance with long-term contracts negotiated with irrigation districts and other local organizations. Distribution of water from the main canals to the individual users is the responsibility of the local districts.

Irrigation distribution systems consist of lateral canals and pipe systems to convey water from the main canals to individual farms. The Bureau of Reclamation has built several distribution systems and is constructing others for the water users. Public Law 84-130 also provides loans administered by the Bureau of Reclamation through which organized water users may build their own distribution systems.

Irrigating tomatoes

DEVELOPMENT

Early History

Agriculture in the Central Valley Basin has developed through three overlapping stages: the cattle ranching of the early days, followed by dry farming of small grains, and finally the specialized and intensified irrigation farming of today. Although there were earlier settlements in the Central Valley, the real development of the area began in 1849 after the discovery of gold, as people came to the mining regions of the Sierra Nevada. The demand for food and fiber occasioned by this influx gave impetus to the great agricultural development of the valley.

Cattle raising as a major activity was brought to a sudden end by the disastrous drought of 1863-64 which resulted in the loss of practically all the cattle in California. This factor, plus growth of population, increased cost of land, and development of the railroads after 1869 made grain production first in agricultural importance. Dry farming of wheat and barley continued to expand until the latter part of the century, then declined as other grain regions were developed. Meanwhile, irrigation farming developed to the dominant position it now occupies.

Investigations

The average annual rainfall ranges from 5 inches in the southern end to more than 30 inches in the northern end of the Central Valley, with more than three-fourths of the rainfall coming in a 5-month period from December through April. This condition produced seasonal floods and droughts with heavy winter and spring runoffs, leaving a shortage of water in the summer and autumn when it is most needed for irrigation. Because maturing crops needed water at a time of year when natural streamflow was lowest, many farmers resorted to irrigating by pumping from wells. As irrigated agriculture expanded, the water pumped from the ground greatly exceeded the natural recharge by rainfall and streamflows. Thus, hundreds of thousands of acres developed for irrigation in the southern part of the valley burdened a rapidly diminishing supply with an increasing demand for water. In addition, diverting streamflows to irrigation and lowering ground-water levels by pumping further reduced the low summer flows of the rivers. As a result, salt water from San Francisco Bay began encroaching upon croplands in the Sacramento-San Joaquin Delta, endangering another large producing area as well as inhibiting industrial development.

Investigation and development of irrigation in the Central Valley date back to the 1850's when private interests first constructed canals to serve local areas near the rivers. This was followed by irrigation projects under the auspices of communities, irrigation districts, public utilities, and municipalities. While these projects were subject to State and local laws, their planning was concerned with relatively small tracts of land and not with the valley as a unit. The resulting conflicts of rights and interests present an imposing problem in water development which will probably not be completely resolved for years.

Efforts at developing a comprehensive plan for the Central Valley date back to 1873 when the Army Engineers prepared a report on irrigation in the San Joaquin and Sacramento Valleys and Tulare Basin. Since then, many reports detailing and enlarging on the plan have been prepared by Federal and State agencies. The Bureau of Reclamation has participated in these studies and has published several reports.

In 1919, a plan was submitted to the Governor of California for coordinated development of the water resources of the Central Valley. This created State-wide interest, and in 1921 the legislature made the first of a series of appropriations for investigating plans for the conservation, control, storage, distribution, and application of all waters of the State. In 1931, the Division of Water Resources submitted to the legislature the State Water Plan, which included a comprehensive plan for utilizing the water resources of the Central Valley.

In 1933, the State legislature approved the Central Valley Project Act of 1933 which provided for the construction, operation, and maintenance of a system of works, designated as the Central Valley Project. The project included Shasta Dam (then Kennett Dam) and Shasta Lake, Contra Costa Canal, Delta Cross Channel, Delta-Mendota Canal, Friant Dam and Millerton Lake, Madera Canal, Friant-Kern Canal, Keswick Afterbay, Tracy Pumping Plant, facilities for generation and transmission of electric energy, and "such other units as may be from time to time added to the units herein above specifically enumerated." The voters approved the plan, but the depression of the 1930's made it impossible to sell the bonds needed to finance construction. California then appealed to the Federal Government for help.

Authorization

Funds for construction of the initial features of the Central Valley Project were provided by the Emergency Relief Appropriation Act of 1935 (49 Stat. 115). The project was authorized by a finding of feasibility by the Secretary of the Interior, and approved by the President on December 2, 1935, for construction by the Bureau of Reclamation. Additional authorizations were made by the Rivers and Harbors Act of August 26, 1937 (50 Stat. 844, 850), and October 17, 1940 (54 Stat. 1198, 1199). American River features were authorized under the act of October 14, 1949 (63 Stat. 852), and the Sacramento Valley Canals were authorized under the act of September 26, 1950 (64 Stat. 1036). Trinity River Division was authorized by Public Law 386, 84th Congress, 1st session, approved August 12, 1955. The San Luis Unit, West San Joaquin Division, was authorized as a part of the Central Valley Project on June 3, 1960, Public Law 86-488 (74 Stat. 156). On September 2, 1965, the Auburn-Folsom South Unit of the American River Division was authorized by Public Law 89-161 (79 Stat. 615). Authorization of the Tehama-Colusa Canal enlargement, under the Sacramento River Division, was given in Public Law 90-65 (81 Stat. 167), August 19, 1967. San Felipe Division features were authorized by Public Law 90-72 (81 Stat. 173), signed on August 27, 1967. The most recent addition to the Central Valley Project was the Allen Camp Unit, Pit River Division, authorized on September 28, 1976, by Public Law 94-423 (90 Stat. 1324).

Construction

Construction of the initial units of the Central Valley Project began in October 1937 with the Contra Costa

Central Valley Operations Control Center

Canal. The entire canal was completed in 1948. First delivery of water was made on August 16, 1940. A contract for the construction of Shasta Dam, keystone of the Central Valley Project, was awarded July 6, 1938; work was started in 1938 and was essentially complete in 1945. Storage of water began in January 1944, and the first power was delivered in June 1944. Construction details for each feature are included in this publication under the appropriate division or unit.

Operating Agencies

Except for the Contra Loma and Martinez Dams in the Delta Division, the John A. Franchi Diversion Dam in the Friant Division, the Sly Park Unit, and the San Luis Unit, the storage and conveyance facilities of the project are operated by the Bureau of Reclamation. Each irrigation district operates its own distribution system. Contra Loma and Martinez Dams are operated by the Contra Costa County Water District. The John A. Franchi Diversion Dam is operated by the Madera Irrigation District. The Sly Park Unit is operated by El Dorado Irrigation District. The State of California Departments of Water Resources and Parks and Recreation operate the San Luis Dam and Reservoir and the San Luis Canal, major Federal/State joint-use facilities. The Westlands Water District operates Reaches 1 and 2 of the Coalinga Canal.

BENEFITS

Irrigation

Each year, between 3 and 4 million acre-feet of water are delivered through the Central Valley Project for irrigation use on nearly 2 million acres of fertile land. This land produces more than $1 billion in crops annually. The

Irrigating corn for livestock

principal crops are cotton, barley, rice, alfalfa hay, grapes, citrus and other fruits, and nuts.

Municipal and Industrial Water

Approximately 320,000 acre-feet of the water produced by the project is furnished to communities for municipal and industrial use in a normal year. The largest share of this water is pumped into the Contra Costa Canal and carried to the cities of Martinez, Antioch, and Pittsburg. It also is used by the steel, oil, rubber, paper, and chemical industries of the area and supplements the supply of an existing private water utility. The cities of Redding, Roseville, Placerville, Sacramento, Fresno, and Coalinga receive a portion of their water needs from the Central Valley Project.

Hydroelectric Power

While the Central Valley Project is primarily an irrigation development, another important benefit is electric power. Project facilities generate in excess of 5.5 billion kilowatt-hours of hydroelectric power annually. This power is dedicated first to meeting the requirements of the project facilities, such as power for pumping project water and station service at pumping and generating plants, fish facilities, and project construction facilities. The remaining energy is marketed to various preference customers in northern California. These customers consist of 12 irrigation districts, 7 Federal agencies, 6 municipalities, 5 State agencies, 2 utility districts, and 1 rural electric cooperative.

Flood Control

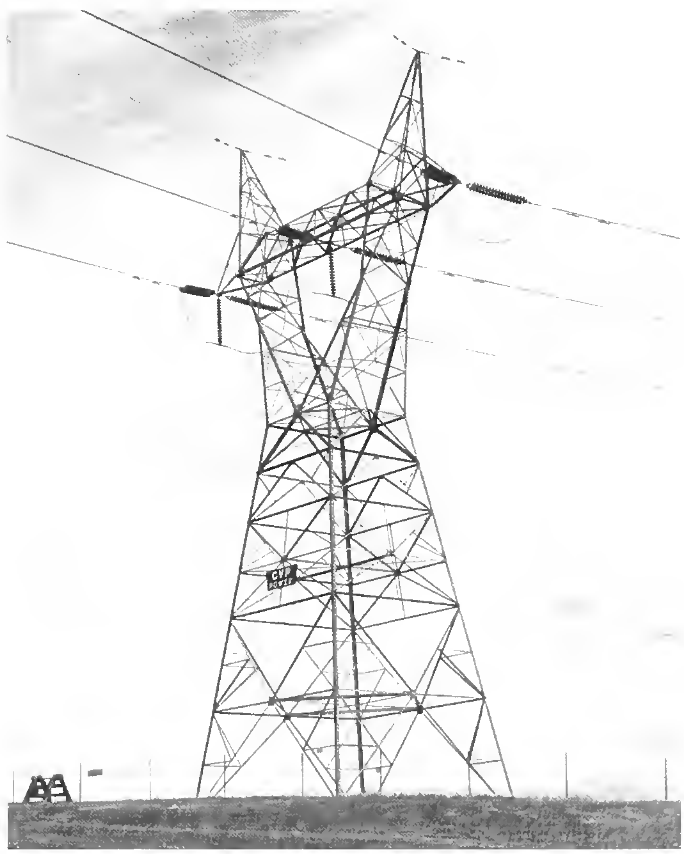
Shasta, Friant, and Folsom Reservoirs, as well as the smaller reservoirs, have reserves of storage space for flood control, and their operations have decreased flood dangers and damage. There are also flood control benefits from reservoirs and channel improvements on the Sacramento River and its tributaries, on the San Joaquin and its tributaries, and on Tulare Basin streams.

Water Quality

Of all the lands in the Central Valley, some of the most productive are those of the Delta where the Sacramento and San Joaquin Rivers converge east of San Francisco Bay. The danger of saltwater intrusion from the ocean through San Francisco Bay on these 360,000 acres is great. Through an annually renewed coordinated operating agreement with the State of California, in-basin uses for the Sacramento Valley and the Sacramento-San Joaquin Delta, including Delta outflows for water quality maintenance, are shared proportionately by the Central Valley Project and the California State Water Project.

Recreation and Fish and Wildlife

In addition to crop production and the energy produced by its powerplants, the project is paying substantial dividends to the State's commercial fisheries. Specific recreation facilities and fish and wildlife benefits are listed under the individual units or divisions in this publication.



Transmission tower and power lines

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	64,122	acres
Supplemental irrigation service	2,320,163	acres
Temporary irrigation service	385	acres
Total	2,384,970	acres
Number of irrigated farms	20,120	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,464,143	518,137,873
1969	1,530,243	542,223,371
1970	1,541,986	544,908,308
1971	1,624,159	582,221,872
1972	1,733,387	696,739,236
1973	1,933,917	1,249,151,085
1974	2,040,478	1,370,309,874
1975	1,932,718	1,362,343,246
1976	1,958,106	1,371,744,701
1977	1,814,074	1,447,326,539

Facilities in Operation

Storage dams	16	
Diversion dams	3	
Canals	593	mi
Pumping plants	39	
Drains	84	mi
Pipelines, conduits, and aqueducts	28.7	mi
Tunnels	16.3	mi
Pumping-generating plants	2	
Powerplants	7	
Transmission lines	18.1	mi
Substations	21	

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	101,064
Urban/suburban irrigation service	270,213
Municipal and other water service	486,317
Total	857,594

Power Generation (kilowatt hours)

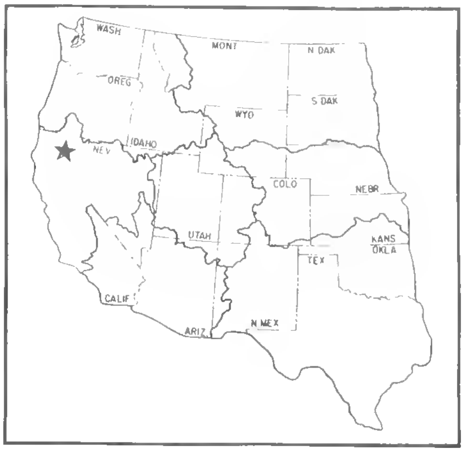
Fiscal Year		Shasta Powerplant	Keswick Powerplant	Trinity Powerplant	Judge Francis Carr Powerhouse	Spring Creek Powerplant	Folsom Powerplant	Nimbus Powerplant	O'Neill Pumping-Generating Plant	San Luis Pumping-Generating Plant[1]	TOTAL
1967	G[2]	2,402,402,600	564,183,100	501,210,400	621,632,000	802,005,000	780,796,000	75,630,900	--	--	5,747,860,000
	N[3]	2,397,407,699	562,603,900	499,400,290	619,952,210	800,602,070	778,945,820	75,138,840	--	--	5,734,050,829
1968	G	2,036,347,400	502,538,000	644,683,600	783,248,000	865,901,000	656,830,000	69,904,600	496,200	5,112,410	5,565,061,210
	N	2,031,243,620	500,803,800	642,798,910	781,556,330	864,612,950	655,098,300	69,321,200	456,000	5,112,410	5,551,003,520
1969	G	2,195,595,300	520,619,100	403,408,200	491,523,000	696,419,000	824,663,000	83,919,300	1,027,100	7,765,800	5,224,939,800
	N	2,190,187,940	518,942,300	401,593,270	490,055,430	695,144,120	822,772,980	83,317,790	1,000,800	7,765,800	5,210,780,430
1970	G	2,316,649,900	523,409,400	639,574,400	744,563,000	870,693,000	709,916,000	78,814,900	1,231,400	19,941,889	5,904,793,589
	N	2,310,956,260	521,831,500	637,572,350	742,931,460	868,904,190	708,126,170	78,194,270	1,139,000	19,941,889	5,889,597,089
1971	G	2,571,298,500	565,916,300	637,442,400	743,885,000	892,955,000	762,621,000	87,593,400	1,510,300	42,129,769	6,305,351,669
	N	2,564,897,670	563,919,500	635,298,390	742,182,880	891,422,390	760,792,330	86,929,850	1,332,000	42,129,769	6,288,904,779
1972	G	2,281,442,400	513,715,100	488,944,900	574,370,000	625,137,000	594,496,000	69,547,600	2,090,392	83,424,144	5,236,167,536
	N	2,277,722,890	511,607,900	487,030,990	572,666,530	623,630,450	592,732,020	68,769,490	2,090,392	83,424,144	5,219,674,806
1973	G	2,203,157,500	521,322,700	574,645,700	702,605,000	876,913,000	786,319,000	86,256,800	1,039,700	68,340,155	5,820,599,555
	N	2,196,938,170	519,263,500	572,497,970	700,647,770	875,467,010	784,418,060	85,661,760	433,000	68,340,155	5,803,667,395
1974	G	2,749,816,800	601,394,700	821,825,700	926,959,000	1,212,956,000	986,401,000	96,854,800	450,300	71,244,811	7,467,903,111
	N	2,744,335,430	599,879,500	819,630,870	925,418,310	1,211,450,880	984,743,100	96,233,130	--	71,244,811	7,452,936,031
1975	G	2,562,128,000	575,690,400	568,667,000	624,371,000	786,157,000	790,711,000	90,576,600	1,649,200	115,155,872	6,115,106,072
	N	2,557,491,750	574,016,800	566,591,260	622,878,360	784,766,330	789,161,890	89,971,370	1,293,000	115,155,872	6,101,326,632
1976	G	2,332,556,800	542,149,200	446,697,400	537,720,000	554,498,000	453,588,000	55,736,300	1,666,900	134,697,604	5,059,309,904
	N	2,328,326,670	540,150,000	444,756,300	536,143,370	553,311,090	452,110,910	55,097,140	1,367,000	134,697,604	5,046,260,084
TQ[4]	G	473,641,600	150,404,400	198,114,700	265,412,000	262,844,000	88,687,000	11,990,900	2,340,400	101,083,422	1,554,518,422
	N	472,806,640	150,087,600	197,770,880	265,058,020	262,590,910	88,383,710	11,864,070	2,167,688	101,083,422	1,551,812,940
1977	G	910,960,000	351,086,400	424,325,100	723,930,000	731,696,000	124,922,000	17,000,100	16,300,800	118,055,119	3,118,275,549
	N	906,585,450	349,704,000	422,534,930	722,575,820	730,262,270	123,572,810	16,382,370	15,677,000	118,055,119	3,105,349,799

[1] Federal Share.
[2] Gross
[3] Net
[4] Transitional quarter

Central Valley Project
Allen Camp Unit, Pit River Division (Proposed)

California: Lassen and Modoc Counties

Mid-Pacific Region
Water and Power Resources Service



The Allen Camp Unit, located about 100 miles northeast of Redding and 50 miles southwest of Alturas, Calif., is in the advance planning stage. Water will be stored on the Pit River at Allen Camp damsite for irrigation, flood control, fish and wildlife enhancement, and outdoor recreation. Irrigation water will be supplied to 15,800 acres of land, and supplemental water will be furnished to a proposed 11,000-acre national wildlife refuge.

PLAN

Water supplies will be obtained from Allen Camp Reservoir on the Pit River by direct diversion, by releases to the river, and by reuse of irrigation return flows. Flows of the Pit River will be controlled by operation of the reservoir, thus protecting Big Valley from floods. Adequate drainage is to be provided by a system of closed drains.

Allen Camp Dam and Reservoir

Allen Camp damsite is on the Pit River about 11 miles north of the Lassen-Modoc county line and some 20 miles southwest of the town of Canby. The dam will be an earth and rockfill structure with a height of about 100 feet above streambed and a crest length of 1,700 feet. The reservoir will have a capacity of about 90,000 acre-feet and a water surface area of 2,300 acres. Active conservation space will be used to provide water for irrigation, recreation, and fish and wildlife.

Hillside Canal

Hillside Canal, about 25 miles in length, will extend from Allen Camp Dam to about 2 miles southeast of Bieber. The concrete-lined canal will have an initial capacity of about 100 cubic feet per second.

Pilot Canal

Pilot Canal will be 3.5 miles in length, extending from Hillside Canal to southwest of Pilot Butte. The unlined canal will have a capacity of 15 cubic feet per second.

Distribution System

The distribution system will consist of unlined laterals with metered turnouts on the main canals and laterals, and other required structures. The capacity of this system will range from 6.5 to 25 cubic feet per second. Most of the irrigable lands in the service area will be served by gravity.

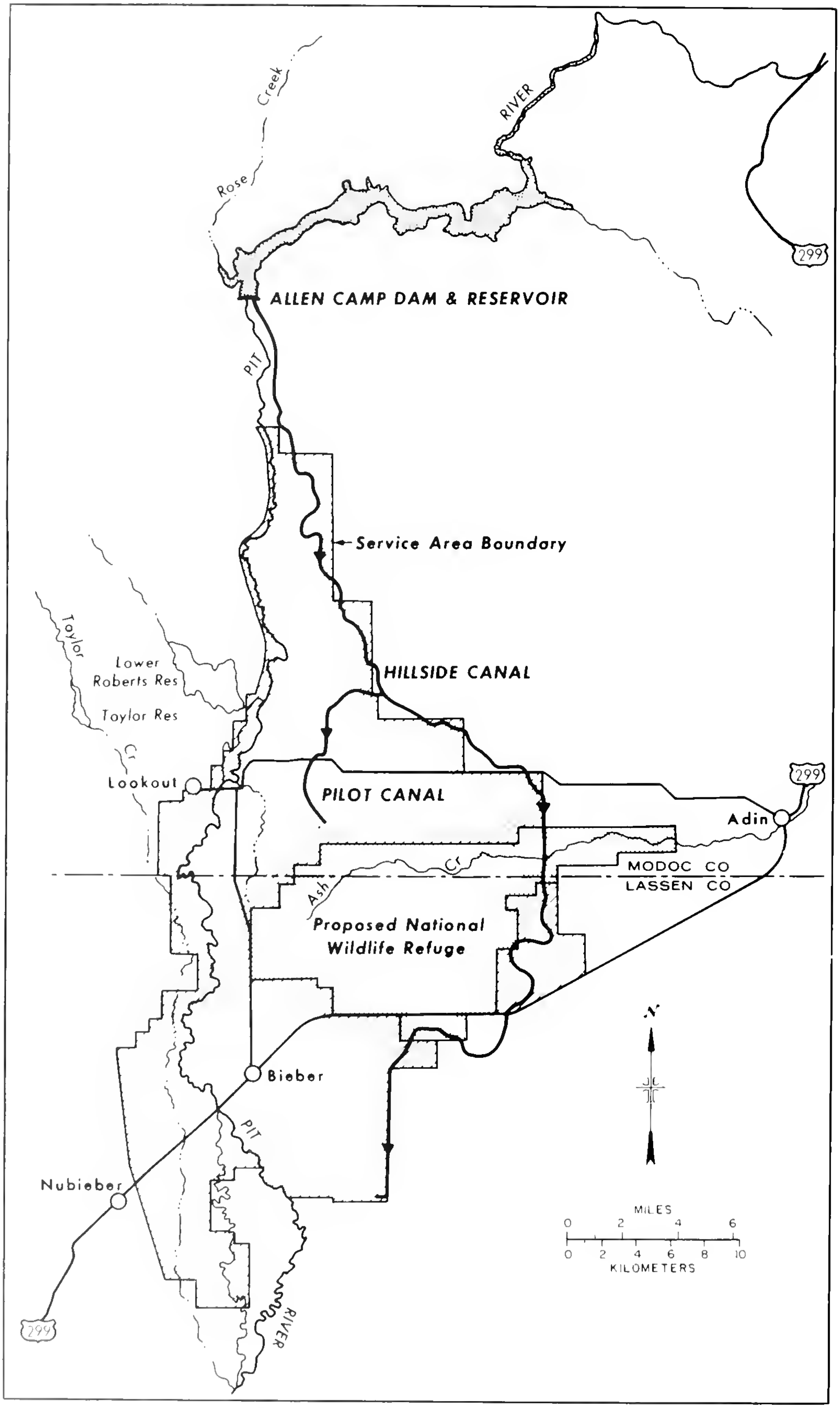
Pumping Plants

When the reservoir water supply is normal or below, return flows will be reclaimed by pumps spaced over the area. Pumping also will be required to irrigate areas above the main canal that cannot be served by gravity.

Drainage System

A system of closed drains will be an integral part of Allen Camp Unit.

Centralized Water and Power System Control Center



Central Valley Project, Allen Camp Unit

DEVELOPMENT

Early History

The first settlers entered the northeast area of California in the early 1870's. They found the climate and the native grasses of the valley meadows suitable for raising cattle. By 1900, many small diversion dams had been built to wild-flood the land by using flows of the Pit River and its tributaries. Farms were improved, and stock-watering ponds and several small storage projects were constructed.

A prosperous lumber industry flourished in the northeastern part of California for a time; however, the rapid depletion of existing mature timber supplies led to a decline of the industry. Presently, large areas of the forest are being replanted. While the lumber industry still forms a portion of the economy of Alturas and Susanville, the downward trend of logging activity is evidenced by the reduction in the population of Modoc and Lassen Counties while the population of the rest of California is growing rapidly.

The cattle industry is still the mainstay of the region's economy. The predominant type of agriculture is the production of fodder for livestock. National forest ranges and private timberlands of the surrounding mountains are used to graze cattle during the summer while the valley fields are producing hay for winter feed.

In December 1964, storms caused extensive flood damage to roads, fences, and crops, and produced widespread erosion. Rains during the last week of December were followed by a 2-day blizzard in January, a moderate 2-day rain, and then a hard freeze. Streams in the valley, including the Pit River, became ice-bound, backing water over lands seldom flooded. Sheet ice 4 to 6 inches thick formed over thousands of acres, the result of impeded drainage and freezing temperatures. All the winter wheat was lost under this ice.

There was a severe drought in Modoc and Lassen Counties during 1965-66 which threatened the livestock industry. Local farm advisors estimated that hay production dropped by about 50 percent in 1966.

Investigations

Since 1903, the area has been the subject of numerous studies and reports. The State of California investigated the area and issued its findings in Department of Resources Bulletin No. 86, dated September 1964.

In September 1966, the Allen Camp Unit was authorized for study by Public Law 89-561 (80 Stat. 710). A feasibility investigation was conducted by the Bureau of Reclamation, with the Big Valley Irrigation District and Modoc and Lassen Counties sharing some of the investigation costs. A feasibility report on a plan of development for the unit was completed in April 1967, modified by a reevaluation report dated June 1968, and adopted by the Secretary of the Interior as his proposed report on September 27, 1968.

Authorization

The Allen Camp Unit, Pit River Division, was authorized as an addition to the Central Valley Project on September 28, 1976, by Public Law 94-423 (90 Stat. 1324).

Construction

This unit, still in the advance planning stage, has not been scheduled for construction. An environmental statement and a definite plan report are scheduled for completion in 1980.

Fish and wildlife enhancement will be one of many project benefits.

BENEFITS

Measurable monetary benefits attributable to Allen Camp Unit will be derived principally from irrigation, flood control, recreation, fish and wildlife enhancement, national wildlife refuge, wetland development, and area redevelopment functions, with some incidental private power enhancement.

Many aspects of reclamation development cannot be evaluated in monetary terms, but are nevertheless significant. For example, flood protection will eliminate the general disruption of activities caused by past floods, thus enhancing the general welfare and security of the people. Unmeasured fish and wildlife benefits include the economic advantages to persons, other than sportsmen, as well as the aesthetic and ecological values of unharvested and nongame species.

PROJECT DATA

Climatic Conditions

Annual precipitation	12.86	in
Temperature:		
Maximum	107	°F
Minimum	−32	°F
Mean	47	°F
Growing season	165	days
Elevation of irrigable area	4150.0	ft

ENGINEERING DATA

Water Supply

PIT RIVER

Drainage area at Canby	1,431	mi²
Annual discharge at Canby:		
Maximum (1971)	468,900	acre-ft
Minimum (1934)	14,280	acre-ft
Average	181,000	acre-ft

Storage Facilities

ALLEN CAMP DAM (PROPOSED)

Type: Rolled earth and rockfill
Location: On the Pit River about 11 mi north of the Lassen-Modoc county line.

Reservoir, Allen Camp:		
Total capacity	90,000	acre-ft
Surface area	2,300	acres
Dimensions:		
Structural height	100	ft
Crest length	1,700	ft

Carriage Facilities

HILLSIDE CANAL (PROPOSED)

Location: From Allen Camp Dam easterly to about 2 mi southeast of Bieber.

Length	25	mi
Capacity	100	ft³/s

PILOT CANAL (PROPOSED)

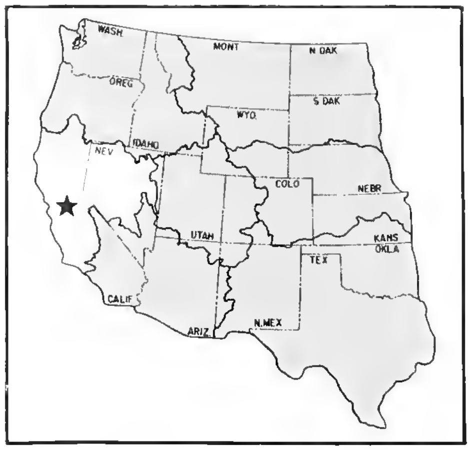
Location: From Hillside Canal southeasterly to southwest of Pilot Butte.

Length	3.5	mi
Capacity	15	ft³/s

Central Valley Project
Auburn-Folsom South Unit, American River Division

California: El Dorado, Placer, Sacramento, and San Joaquin Counties

Mid-Pacific Region
Water and Power Resources Service



The Auburn-Folsom South Unit of the Central Valley Project was designed to provide a new and supplemental water supply for irrigation, municipal and industrial needs, and to alleviate the badly depleted ground-water conditions in the Folsom South service area. The unit also will provide hydroelectric power, flood control, fish protection and enhancement, and new recreation facilities. Authorized in 1965, the unit consists of Auburn Dam, Reservoir, and Powerplant, Folsom South Canal, Sugar Pine Dam and Reservoir, County Line Dam and Reservoir, and appurtenant works.

PLAN

In conjunction with Folsom and Nimbus Dams and other facilities of the Central Valley Project, Auburn Reservoir will control the varying flows of the north and middle forks of the American River. Releases from the reservoir will operate Auburn Powerplant and supply the Folsom South Canal. Water from Sugar Pine Reservoir on North Shirttail Canyon will be piped to the Forest Hill Divide service area for irrigation, and for municipal and industrial use. County Line Reservoir on Deer Creek will operate in conjunction with pumping from Folsom Lake to provide water service in the Folsom-Malby area for municipal and industrial use.

Auburn Dam and Reservoir

Auburn Dam was designed as a concrete arch structure 700 feet in height with a crest length of 4,000 feet. The earthquake requirements for the damsite have required a reevaluation of the type of dam to be constructed. Alternatives being considered are rockfill and curved concrete gravity-type dams. Reservoir capacity behind such a structure would be 2,300,000 acre-feet. The damsite is on the North Fork of the American River adjacent to the city of Auburn, Calif.

Sugar Pine Dam and Reservoir

Sugar Pine Dam, located on North Shirttail Canyon approximately 7 miles north of Foresthill, Calif., will be an earth and rockfill structure 197 feet high with a crest length of 680 feet. Reservoir capacity will be 6,950 acre-feet.

County Line Dam and Reservoir

County Line Dam will be an earthfill structure 90 feet high and 585 feet long. The dam, to be located on Deer Creek about 10 miles south of Folsom Dam, will create a reservoir with a capacity of 40,000 acre-feet.

Folsom South Canal

The 68.8-mile-long Folsom South Canal originates at Nimbus Dam on the American River in Sacramento County and extends southward, paralleling and to the east of State Highway 99 through San Joaquin County; it will terminate about 20 miles southeast of the city of Stockton. This concrete-lined canal has a capacity of 3,500 cubic feet per second for the first two reaches, a total of 26.7 miles. A reduced capacity that varies from 2,000 to 125 cubic feet per second is now planned for the remaining three reaches, a total of 42.1 miles. The first two reaches were completed in 1973 to a point just south of State Highway 104. Construction of the three remaining reaches has been suspended pending completion and consideration of alternative studies.

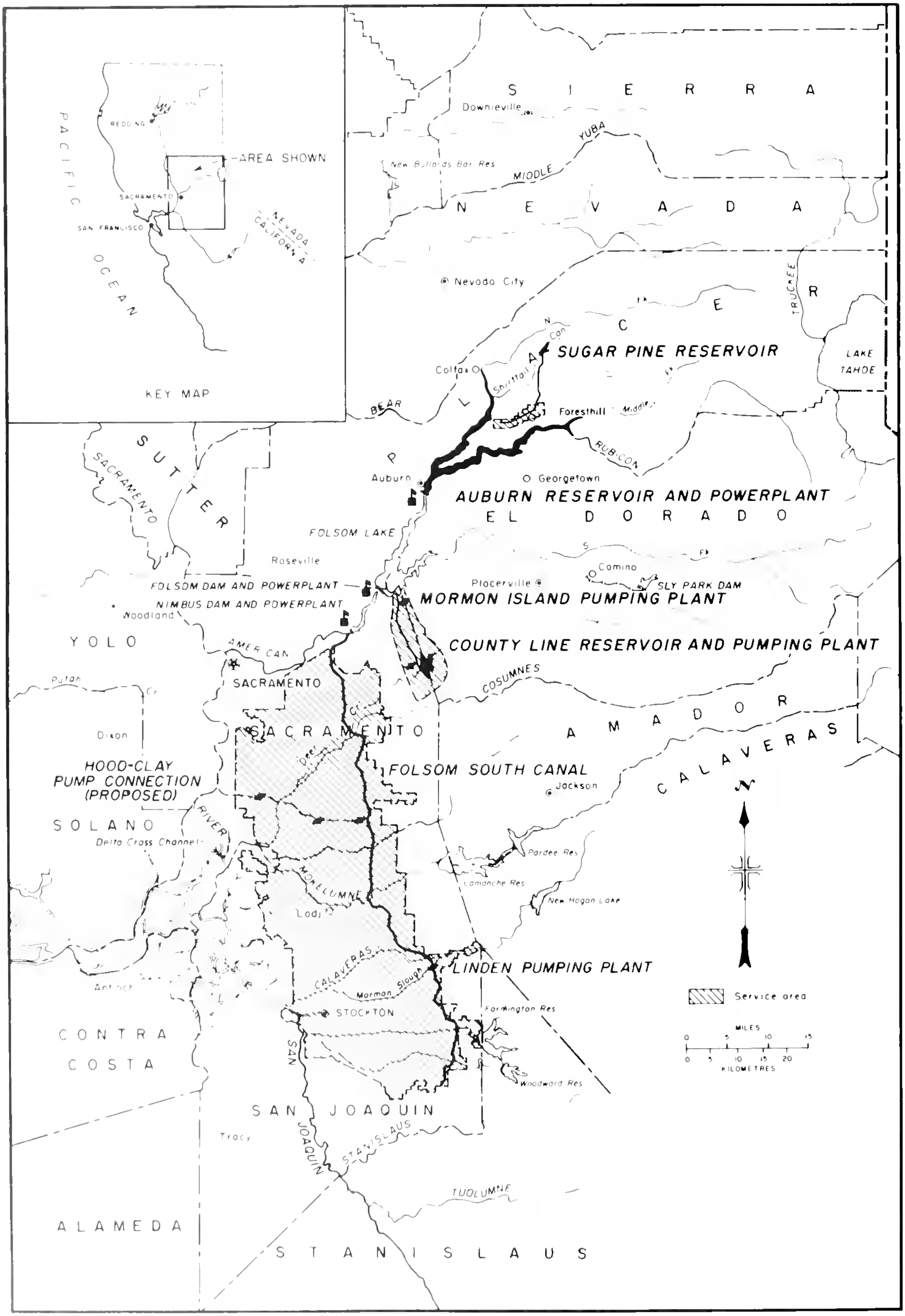
Auburn Powerplant

Auburn Powerplant was designed to be built at the downstream toe of Auburn Dam and to house five units, each with a capacity of 150,000 kilowatts.

DEVELOPMENT

Early History

Settlement of the basin began about 1844. In 1848, discovery of gold near the present site of Coloma precipitated a great influx of gold seekers from all parts of the country. At the height of the gold rush, the American



Central Valley Project, Auburn-Folsom South Unit

River foothill area was one of the most populous in the State. However, as the sources of gold were exhausted, many left the basin or turned to farming, lumbering, or service trades.

Early miners quickly recognized the potential of riverflows to help in dredging, panning, and sluicing for gold. Diversion dams began appearing on the river in the 1850's. As mining activities declined, two of the dams were used to divert water for use in suburban Sacramento areas and remained in use until the completion of Folsom Dam in 1955. In December 1964, the last of those early diversion dams was breached by floodwaters.

Investigations

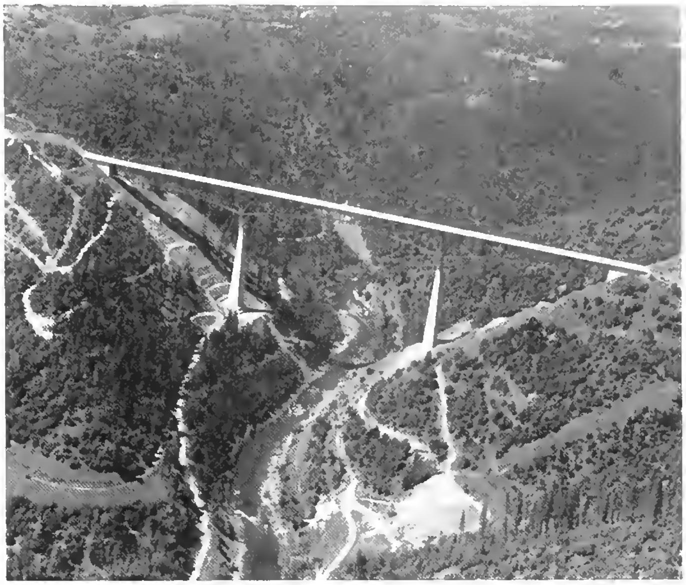
Recognition of the need for a dam to regulate the erratic flows and develop the waters of the American River dates back to the 1880's. The U.S. Army Corps of Engineers had included such a recommendation in a survey of western watersheds made under the direction of President Grant. The recommendation was received, but no action was taken.

During the first 20 years of this century various private power companies, municipalities, farm groups, and the State of California reviewed the Corps' old survey. The State envisioned a giant multipurpose water project and purchased a potential damsite on the Middle Fork just east of Auburn. However, the deepening depression forced a halt to further planning.

One of the first proposals to construct a dam near the present Auburn Dam site was presented in a report dated February 1928. In 1934, the Forest Service discussed some of the power and water potentials of the North Fork of the American River in a report. In May 1957, the State of California Department of Water Resources published the results of a State-wide water resources investigation. That report incorporated much of the material developed in previous investigations, and envisioned an Auburn Reservoir with a tunnel to a proposed Auburn Ravine Reservoir which would permit water deliveries to be made to the Placer service area below Wise Powerhouse.

Prior to 1940, the Bureau of Reclamation conducted studies of various possibilities in the American River Basin. Most of the earlier studies related to the lower portion of the basin and were made in connection with the comprehensive plan for the Central Valley Basin.

When Folsom Dam was authorized for construction as part of the Central Valley Project in 1949, the law directed the Secretary of the Interior to investigate possibilities for further projects in the American River Basin. Subsequent studies included those which led to construction of the Sly Park Unit of the Central Valley Project, and to the Auburn-Folsom South Unit.



Auburn-Foresthill Bridge

Following extensive investigations, a feasibility report on the Auburn Unit was issued by the Bureau of Reclamation on January 29, 1960. Primarily because of an acceleration of the already rapid population growth in the Central Valley area and the increased need for water, a supplemental evaluation of the Auburn-Folsom South Unit was completed and a report issued on March 22, 1963. This reevaluation included a recommendation for a significant increase in Auburn Reservoir's proposed capacity.

Authorization

Authorization to construct the Auburn-Folsom South Unit as an addition to the Central Valley Project was contained in Public Law 89-161, approved by the President on September 2, 1965 (79 Stat. 615).

Construction

Reaches 1 and 2 of the Folsom South Canal are complete and in operation, and the Auburn-Foresthill Bridge over the North Fork of the American River is open to traffic. Construction of the three remaining reaches of Folsom South Canal has been suspended pending completion and consideration of alternative studies relating to the Folsom South Canal—Lower American River.

The Auburn Dam diversion tunnel was completed in 1972; excavation and foundation treatment for Auburn Dam and Powerplant is nearing completion. Issuance of specifications and bid opening for the prime contract to construct the dam and powerplant are being held in abeyance pending seismic evaluation of the site and subsequent decision as to required design modifications.

Folsom South Canal

BENEFITS

The main purpose of the Auburn-Folsom South Unit is to provide a new and supplemental water supply to the Folsom South service area for irrigation and municipal and industrial needs. It also will alleviate the badly depleted ground-water conditions in the area. The unit will provide a supplemental irrigation supply of about 545,000 acre-feet and an estimated 305,000 acre-feet annually for municipal and industrial use.

The unit also will provide an initial capacity of 300,000 kilowatts for hydroelectric power; flood control; fish protection and enhancement; and recreation facilities, including campsites, picnic areas, boat launching ramps, and swimming areas.

PROJECT DATA

Facilities in Operation

Canals	26.7	mi

Climatic Conditions

Annual precipitation	27	in
Temperature:		
Maximum	74	°F
Minimum	48	°F
Mean	61	°F
Growing season	242	days
Elevation of irrigable area	85-1292.0	ft

ENGINEERING DATA

Water Supply

AMERICAN RIVER, NORTH FORK

Drainage area at Auburn damsite	973	mi²
Annual discharge:		
Maximum (1950)	2,834,000	acre-ft
Minimum (1924)	360,000	acre-ft
Average	1,588,000	acre-ft

NORTH SHIRTTAIL CANYON CREEK

Drainage area	9	mi²
Annual discharge:		
Maximum (1969)	26,490	acre-ft
Minimum (1959)	4,370	acre-ft
Average	15,000	acre-ft

Storage Facilities

AUBURN DAM[1]

Type: Concrete arch		
Location: On the North Fork of the American River adjacent to the city of Auburn, Calif.		
Reservoir, Auburn:		
Total capacity to El. 1131	2,326,000	acre-ft
Active capacity, El. 1131	1,966,000	acre-ft
Surface area	9,963	acres
Shoreline	140	mi
Dimensions:		
Structural height	695	ft
Hydraulic height	650	ft
Top width	40	ft
Maximum base width	196	ft
Crest length	4,150	ft
Crest elevation	1135.0	ft
Total volume	6,300,000	yd³
Spillway: Two chutes, 10 gated orifices per chute.		

SUGAR PINE DAM

Type: Earth and rockfill		
Location: On North Shirttail Canyon about 7 mi north of Foresthill, Calif.		
Reservoir, Sugar Pine:		
Total capacity	6,950	acre-ft
Active capacity	5,900	acre-ft
Surface area	142	acres
Dimensions:		
Structural height	197	ft
Hydraulic height	171	ft
Top width	39	ft
Maximum base width	984	ft
Crest length	689	ft
Crest elevation	3649.9	ft
Total volume	1,000,000	yd³
Spillway: Ungated chute		

[1]All statistics for Auburn Dam are as currently designed, the values shown are subject to change pending seismic evaluation of the site.

Carriage Facilities

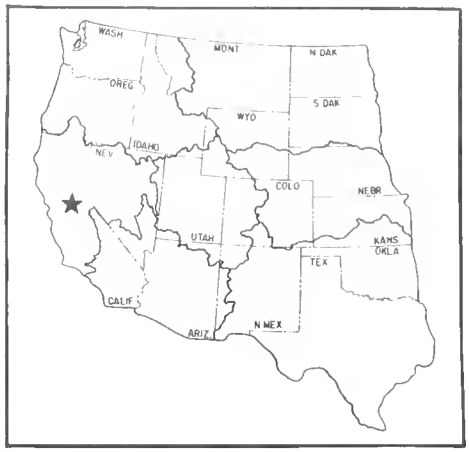
FOLSOM SOUTH CANAL

Location: From Nimbus Dam, near Sacramento, Calif., southward, paralleling and to the east of State Highway 99.		
Construction period: 1970- (Pending)		
Length (Constructed)	26.7	mi
(To be constructed)	42	mi
Capacity	3,500	ft³/s
Section (Initial reach):		
Bottom width	34	ft
Side slopes	1.5:1	
Water depth	17.8	ft

Central Valley Project
Delta Division

California: Alameda, Contra Costa, Fresno, Merced, Sacramento, and Stanislaus Counties

Mid-Pacific Region
Water and Power Resources Service



The Delta Division provides for transport of water through the central portion of the great Central Valley, including the Sacramento-San Joaquin Delta. The main features of the division are Delta Cross Channel, Contra Costa Canal, Tracy Pumping Plant, and Delta-Mendota Canal, constructed and operated by the Bureau of Reclamation.

Delta Cross Channel

The Delta Cross Channel is a controlled diversion channel between the Sacramento River and Snodgrass Slough. Water is diverted from the river through a short excavated channel near Walnut Grove into the slough. The water then flows through natural channels for about 50 miles to the vicinity of the Tracy Pumping Plant. The diversion provides an adequate supply of water to the intakes of the Contra Costa and the Delta-Mendota Canals, improves the irrigation supplies in the Sacramento-San Joaquin Delta, and helps repel ocean salinity. The earth-section channel is designed to divert approximately 3,500 cubic feet per second.

Contra Costa Canal

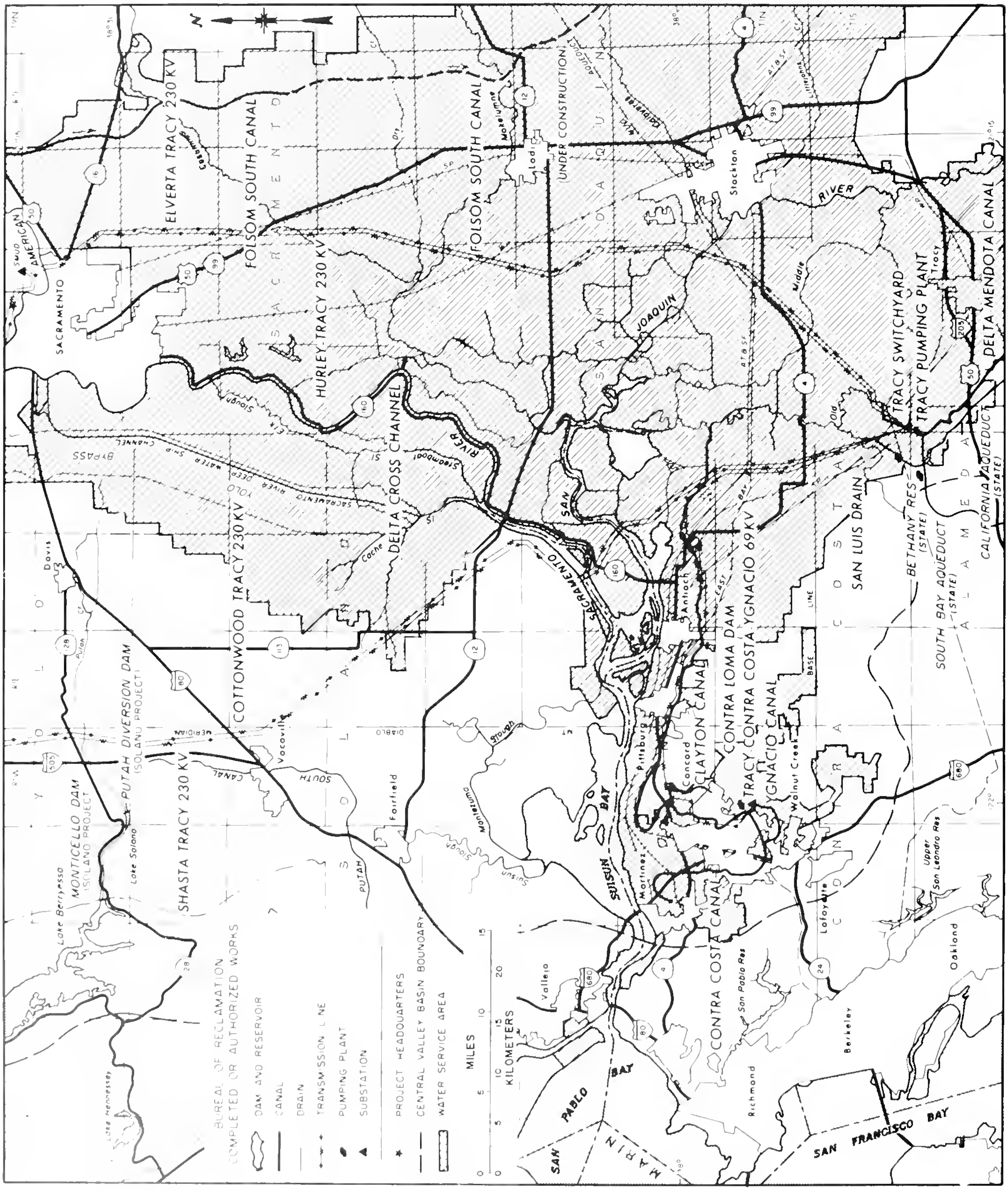
The Contra Costa Canal, completed in 1948, originates at Rock Slough about 4 miles southeast of Oakley, Calif., where it intercepts natural flow in the Sacramento-San Joaquin Delta. Water for irrigation and municipal and industrial use is lifted 127 feet by a series of four pumping plants. The 47.7-mile-long canal terminates in the Martinez Reservoir. The initial diversion capacity is 350 cubic feet per second, which gradually decreases to 22 cubic feet per second at the terminus. Two short canals, Clayton and Ygnacio, are integrated into the Contra Costa Canal system.

Tracy Pumping Plant

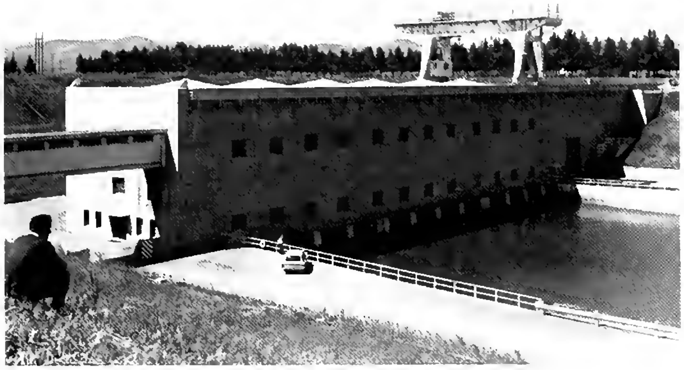
Tracy Pumping Plant, completed in 1951, consists of an inlet channel, pumping plant, and discharge pipes. Water in the delta being released from storage in Shasta, Clair Engle, and Folsom Lakes, or entering the Sacramento River system below those reservoirs, is lifted 197 feet into the Delta-Mendota Canal. Each of the six pumps at

Delta Cross Channel

Contra Costa Canal



Central Valley Project, Delta Division



Tracy Pumping Plant

Tracy is powered by a 22,500 horsepower motor and is capable of pumping 767 cubic feet per second. Power to run the huge pumps is supplied by Central Valley Project powerplants. The water is pumped through three 15-foot-diameter discharge pipes and carried about 1 mile up to the Delta-Mendota Canal. The intake canal includes the Tracy Fish Screen, which was built to intercept downstream migrant fish so they may be returned to the main channel to resume their journey to the ocean.

Delta-Mendota Canal

The Delta-Mendota Canal, completed in 1951, carries water southeasterly from the Tracy Pumping Plant along the west side of the San Joaquin Valley for irrigation supply, use in the San Luis Unit, and to replace San Joaquin River water stored at Friant Dam and used in the Friant-Kern and Madera systems. The canal is 115.7 miles long and terminates at the Mendota Pool about 30 miles west of Fresno. The initial diversion capacity is 4,600 cubic feet per second, which is gradually decreased to 3,211 cubic feet per second at the terminus. The earth-lined intake channel to the Tracy Pumping Plant is 2.5 miles long.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	47,550	acres
Supplemental irrigation service	186,412	acres
Temporary irrigation service	385	acres
Total	234,347	acres
Number of irrigated farms	1,780	

Facilities in Operation

Storage dams	2	
Canals	174.6	mi
Pipelines	5.2	mi
Tunnels	0.26	mi
Pumping plants	5	
Transmission lines	2.31	mi
Substations[1]	8	

[1]Includes Port Chicago Substation owned by U.S. Navy, operated by Bureau of Reclamation.

Climatic Conditions

Annual precipitation	18.7	in
Temperature:		
Maximum	114	°F
Minimum	14	°F
Mean	57	°F
Growing season	280	days
Elevation of irrigable area	20-300.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	4,672
Urban/suburban irrigation service	13,513
Municipal and other water service	190,023
Total	208,208

ENGINEERING DATA

Storage Facilities

CONTRA LOMA DAM[2]

Type: Zoned earthfill
Location: Offstream, in Contra Costa County near the southern city limits of Antioch, Calif.
Construction period: 1966-67

Reservoir, Contra Loma:		
Total capacity to El. 205	2,100	acre-ft
Active capacity, El. 169-205	1,780	acre-ft
Surface area at El. 205	81	acres
Shoreline	2	mi
Dimensions:		
Structural height	107	ft
Hydraulic height	82	ft
Top width	30	ft
Maximum base width	630	ft
Crest length	1,050	ft
Crest elevation	217.0	ft
Total volume	641,000	yd³
Spillway: Uncontrolled ogee crest to concrete chute and stilling basin.		
Crest elevation	211.0	ft
Capacity: (Emergency Only)		
Outlet works: Steel-lined concrete conduit and steel pipe in concrete-lined tunnel through right abutment.		
Capacity at El. 211	970	ft³/s

MARTINEZ DAM[2]

Type: Modified homogeneous
Location: Offstream, near Martinez, Calif.
Construction period: 1946-47

Reservoir, Martinez:		
Total capacity to El. 66	268	acre-ft
Active capacity, El. 35-66	260	acre-ft
Surface area at El. 66	14	acres
Dimensions:		
Structural height	62	ft
Hydraulic height	42	ft
Top width	20	ft

[2]Operated by Contra Costa County Water District.

Maximum base width	317 ft
Crest length	1,200 ft
Crest elevation	72.0 ft
Total volume	195,000 yd³

Spillway: Uncontrolled concrete lined chute in right abutment, box culvert type intake.

Crest elevation	66.0 ft
Capacity, El. 67.9	53 ft³/s

Outlet works: Concrete conduit through base of dam controlled by three 24-in-square slide gates in gate tower at inlet end.

Carriage Facilities

Contra Costa Canal

Location: Originates at Rock Slough near Oakley, Calif., extends in a westerly direction along the south side of Suisun Bay and terminates at Martinez Reservoir.
Construction period: 1937-48

Length	47.7 mi
Capacity	350 ft³/s
Section (initial reach):	
Bottom width	24 ft
Side slopes	3:1
Water depth	6.5 ft

Delta Cross Channel

Location: From the Sacramento River near Walnut Grove, Calif., to Snodgrass Slough.
Construction period: 1950-51

Length	1.2 mi
Capacity	3,500 ft³/s
Section (initial reach):	
Bottom width	210 ft
Side slopes	3:1
Water depth	26 ft

Delta-Mendota Canal

Location: From Tracy Pumping Plant southeast along the west side of the San Joaquin Valley to the Mendota Pool on the San Joaquin River about 30 mi west of Fresno, Calif.
Construction period: 1946-51

Length	115.7 mi
Capacity	4,600 ft³/s
Section (initial reach):	
Bottom width	100 ft
Side slopes	3:1
Water depth	11.3 ft

Clayton Canal

Location: From Contra Costa Canal generally southeast to its terminus in an agricultural area.
Construction period: 1947-48

Length	1.8 mi
Capacity	38 ft³/s
Section (initial reach):	
Bottom width	4 ft
Side slopes	1.25:1
Water depth	2.2 ft

Ygnacio Canal

Location: From Contra Costa Canal generally south to its terminus in an agricultural area.
Construction period: 1947-48

Length	5.2 mi
Capacity	30 ft³/s
Section (initial reach):	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	1.9 ft

Delta-Contra Costa Shortcut Pipeline

Construction period: 1971-72

Length	5.2 mi
Capacity	90 ft³/s
Cross section:	
Diameter	3.5-5 ft

Pretensioned concrete pipe, mortar coated and mortar lined steel pipe.

Tunnel No. 1, Contra Costa Canal

Construction period: 1938-39

Length	1,360 ft
Capacity	320 ft³/s
Cross section:	
Diameter	9.25 ft
Lining type: Horseshoe	
Lining thickness	5-7 in

Contra Costa Canal No. 1 Pumping Plant

Number of units	6
Total capacity	410 ft³/s
Total dynamic head	25-28 ft
Total horsepower	1,550

Contra Costa Canal No. 2 Pumping Plant

Number of units	6
Total capacity	410 ft³/s
Total dynamic head	25-26 ft
Total horsepower	1,550

Contra Costa Canal No. 3 Pumping Plant

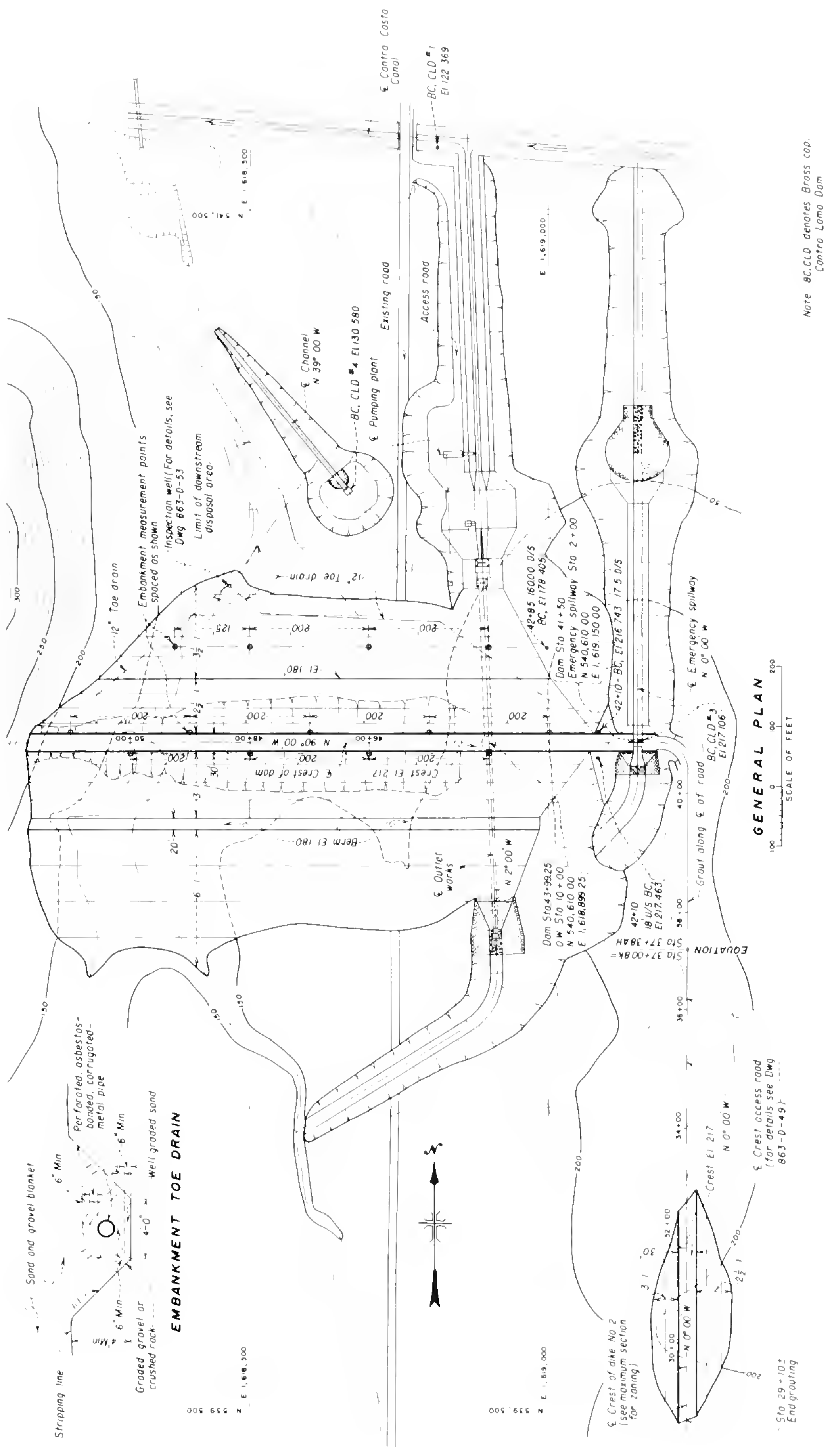
Number of units	6
Total capacity	410 ft³/s
Total dynamic head	31-35 ft
Total horsepower	1,900

Contra Costa Canal No. 4 Pumping Plant

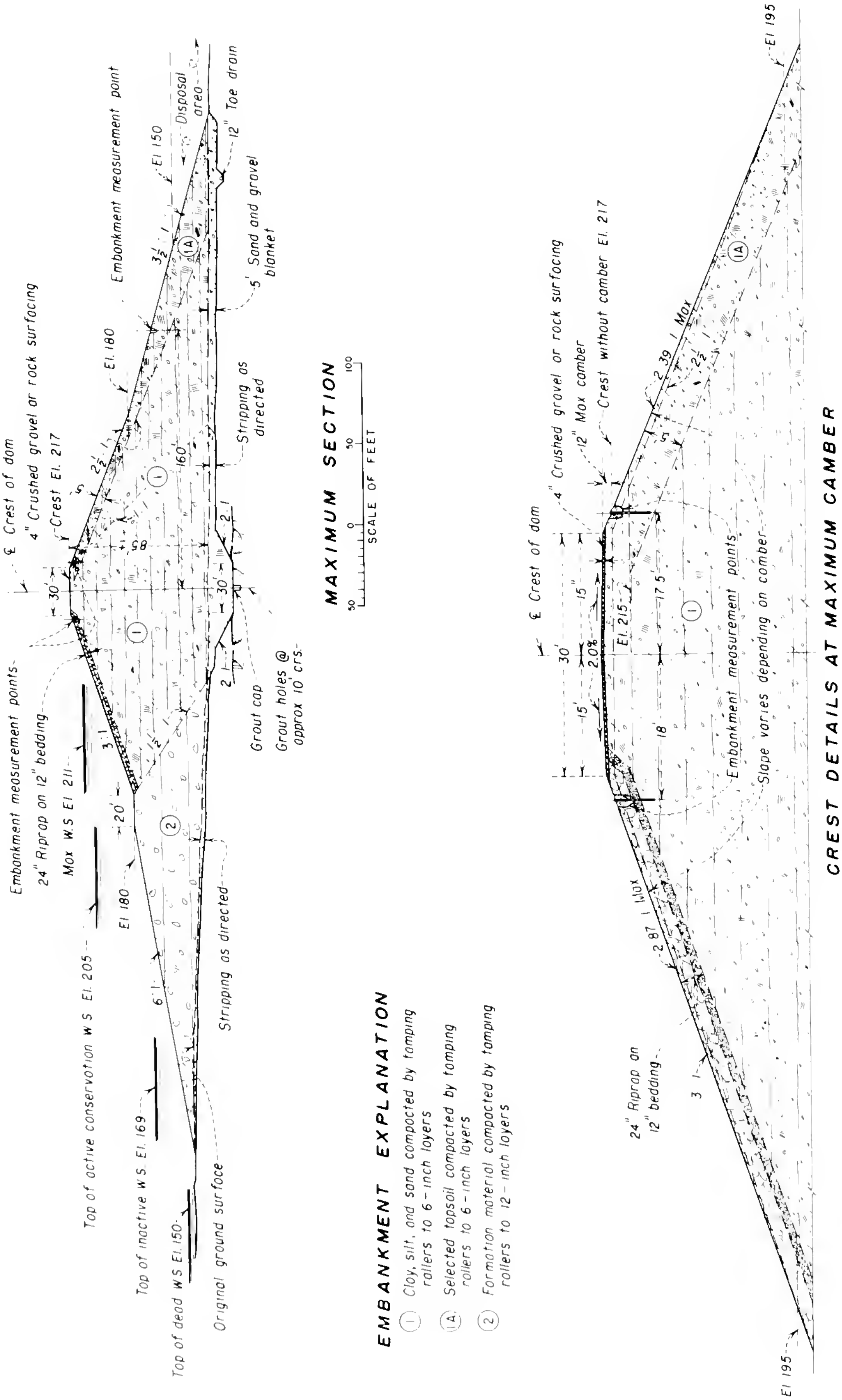
Number of units	6
Total capacity	394 ft³/s
Total dynamic head	51-53 ft
Total horsepower	3,000

Tracy Pumping Plant

Number of units	6
Total capacity	4,602 ft³/s
Total dynamic head	197 ft
Total horsepower	135,000



Contra Loma Dam. Plan



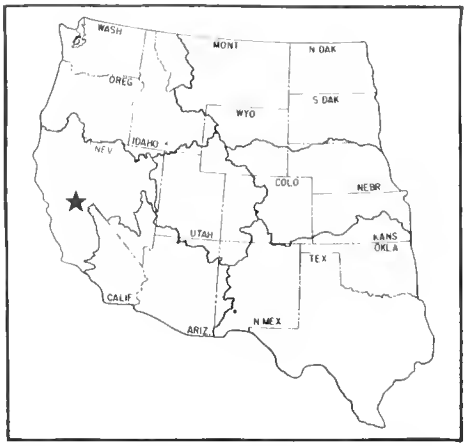
Contra Loma Dam, Sections

Central Valley Project

Folsom and Sly Park Units, American River Division

California: El Dorado, Placer, and Sacramento Counties

Mid-Pacific Region
Water and Power Resources Service



The American River Division, a part of the Central Valley Project, provides water for irrigation, municipal and industrial use, hydroelectric power, recreation, and flood control through a system of dams, canals, and powerplants. The division includes the Folsom and Sly Park Units, both authorized in 1949 and now in operation, and the Auburn-Folsom South Unit, authorized in 1965.

The Folsom Unit consists of Folsom Dam, Lake, and Powerplant, Nimbus Dam and Powerplant, and Lake Natoma on the American River. The Sly Park Unit includes Sly Park Dam and Jenkinson Lake on Sly Park Creek, Camp Creek Diversion Dam on Camp Creek, and the Camino Conduit.

Folsom Dam and Folsom Lake

Folsom Dam was constructed by the Corps of Engineers and upon completion was transferred to the Bureau of Reclamation for coordinated operation as an integral part of the Central Valley Project. Construction of the dam began in October 1948 and was completed in May 1956. The dam has a concrete main river section with a height of 340 feet and a crest length of 1,400 feet flanked by long earthfill wing dams extending from the ends of the concrete section on both abutments. The dam, plus the earthfill auxiliary, Mormon Island Saddle Dam, and eight other earthfill dikes, formed Folsom Lake which has a storage capacity of 1,010,000 acre-feet. The dam regulates flows of the American River for irrigation, power, flood control, municipal and industrial use, fish and wildlife, recreation, and other purposes.

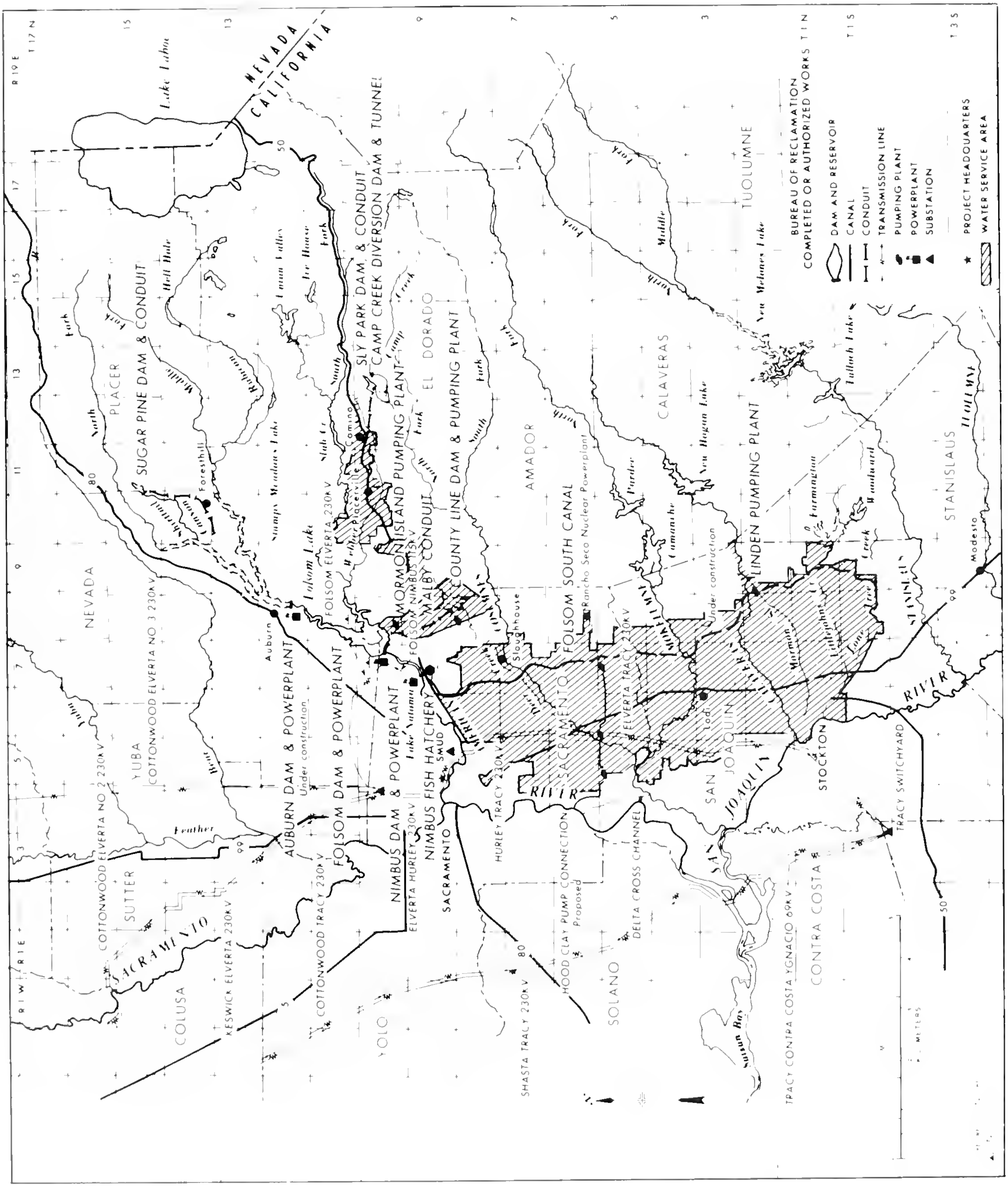
Folsom Lake is the most popular multiuse year-round unit in the California State Park System. Recreation facilities at the 18,000-acre park, which is administered by the California Department of Parks and Recreation, include 50 miles of trails for hiking and horseback riding, picnicking, fishing, swimming, boating, water skiing, and camping.

Folsom Powerplant

Folsom Powerplant, constructed and operated by the Bureau of Reclamation, is located at the foot of Folsom

Sly Park Dam

Nimbus Dam



Central Valley Project, Folsom and Sly Park Units

Dam on the north side of the river. Water from the dam is released through three 15-foot-diameter penstocks to three generating units. The plant has a total capacity of 198,720 kilowatts.

Nimbus Dam and Lake Natoma

Nimbus Dam, on the American River 7 miles below Folsom Dam, formed Lake Natoma to reregulate the releases for power made through Folsom Powerplant. The dam, completed in 1955, is a concrete gravity structure with a gated control overflow section. The structure is 87 feet high with a crest length of 1,093 feet. The dam was constructed and is operated by the Bureau of Reclamation.

Folsom Dam and Powerplant

A fish hatchery on the left bank of the river about 0.3 mile below the dam was built by the Bureau of Reclamation and is operated by the State of California with funds advanced each year by Reclamation. The hatchery was built to compensate for the spawning areas of salmon and steelhead that were inundated by construction of Nimbus Dam.

Lake Natoma forms an attractive recreation area. Facilities, administered by the California Department of Parks and Recreation, provide for boating, picnicking, swimming, fishing, and camping.

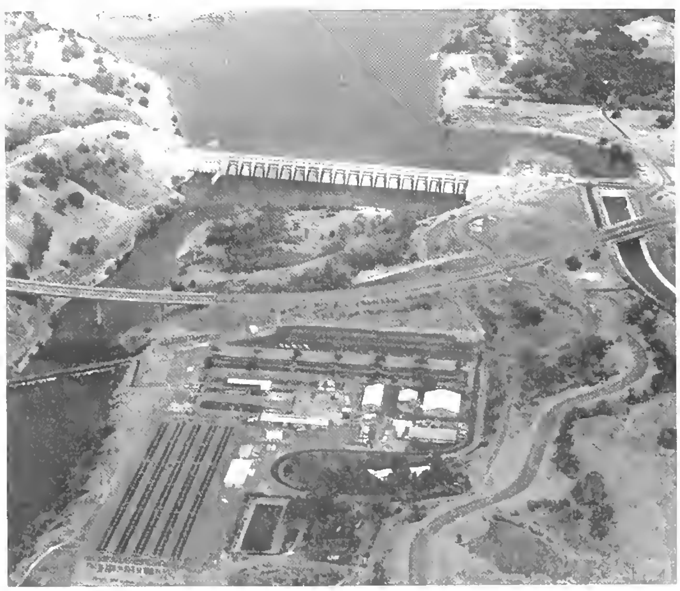
Nimbus Powerplant

Nimbus Powerplant

Nimbus Powerplant, constructed and operated by the Bureau of Reclamation, is located on the right abutment of Nimbus Dam on the north side of the river. Each of its two generators has a capacity of 7,763 kilowatts.

Sly Park Dam and Jenkinson Lake

Sly Park Dam on Sly Park Creek is an earthfill structure 190 feet high with a crest length of 760 feet, and has an auxiliary earthfill dam 130 feet high with a crest length of 600 feet. Jenkinson Lake has a storage capacity of 41,000 acre-feet. Municipal and industrial water is furnished to the city of Placerville and nearby small communities, and irrigation water to El Dorado Irrigation District. The Sly Park Unit, including Sly Park Dam



Nimbus Dam and Fish Hatchery

and Jenkinson Lake, Camp Creek Diversion Dam and the Camino Conduit, and Camino and Camp Creek Tunnels, was constructed by the Bureau of Reclamation. Upon completion in 1955 the facilities were transferred to El Dorado Irrigation District for operation.

The Sly Park Recreation Area, operated by El Dorado Irrigation District in cooperation with the Bureau of Reclamation, offers camping, boating, swimming, picnicking, and fishing.

Camp Creek Diversion Dam

Camp Creek Diversion Dam is a concrete structure 20 feet high and 119 feet in crest length. It diverts a portion of the flow of Camp Creek through the Camp Creek Tunnel into the upper part of Jenkinson Lake.

Camino Conduit

The Camino Conduit, with a capacity of 125 cubic feet per second, extends some 7 miles west from Sly Park Dam to the community of Camino, Calif., to deliver supplemental water to El Dorado Irrigation District for irrigation and municipal purposes.

Distribution System

Construction is nearing completion on water treatment facilities and a distribution system for irrigation and municipal purposes in western El Dorado County. These facilities are being built by the Bureau of Reclamation and will be operated and paid for by El Dorado Irrigation District.

Folsom Dam, Powerplant, and Lake

PROJECT DATA

Land Areas (1977)

Irrigable area:

Supplemental irrigation service	67,834	acres
Number of irrigated farms	1,077	

Facilities in Operation

Storage dams	3	
Diversion dams	1	
Tunnels	0.97	mi
Conduits	7.2	mi
Powerplants	2	
Transmission lines	2.15	mi
Substations	2	

Climatic Conditions

Annual precipitation	22.4	in
Temperature:		
Maximum	112	°F
Minimum	17	°F
Mean	61	°F
Growing season	200	days
Elevation of irrigable area	310.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	4,083
Urban/suburban irrigation service	49,078
Municipal and other water service	47,024
Total	100,185

ENGINEERING DATA

Water Supply

AMERICAN RIVER

Drainage area at Fair Oaks	1,888	mi²
Annual discharge at Fair Oaks:		
Maximum (1907)	5,620,000	acre-ft
Minimum (1924)	605,000	acre-ft
Average	2,742,000	acre-ft

SLY PARK AND CAMP CREEKS

Drainage area at Sly Park Dam	47	mi²
Annual discharge at Sly Park Dam (includes diversions from Camp Creek):		
Maximum (1952)	99,300	acre-ft
Minimum (1924)	7,560	acre-ft
Average	42,374	acre-ft

Storage Facilities

FOLSOM DAM

Type: Concrete gravity, earth wings
Location: On the American River about 20 mi northeast of Sacramento, Calif.
Construction period: 1948-56
Reservoir, Folsom:

Average annual inflow, 1905-70	2,731,100	acre-ft
Total capacity to El. 466	1,010,000	acre-ft
Active capacity, El. 327-466	920,000	acre-ft
Surface area at El. 466	11,450	acres
Shoreline	75	mi

Dimensions:

Structural height	340	ft
Hydraulic height	268	ft
Top width	36	ft
Maximum base width	270	ft
Crest length (includes earthwing dams and dikes)	26,670	ft
Crest elevation	480.5	ft
Total volume (includes embankment from wing dams and dikes)	13,970,000	yd³

Spillway: Gated central overflow; five 42- by 50-ft radial gates located through the overflow section of the dam, and three 42- by 53-ft auxiliary spillway gates.

Elevation top of gates	five at 468.0	ft
	three at 471.0	ft
Crest elevation	418.0	ft
Capacity, El. 475.4	567,000	ft³/s

Outlet works: Three 15.5-ft-diameter penstocks located through the right nonoverflow section of the dam. Also eight 5- by 9-ft outlet conduits controlled by two slide gates and one 84-in-diameter supply conduit to Folsom Pumping Plant.

Capacity at El. 466	30,960	ft³/s

NIMBUS DAM

Type: Concrete gravity
Location: On the American River 7 mi downstream from Folsom Dam.
Construction period: 1952-55
Reservoir, Lake Natoma:

Average annual inflow, 1955-70	2,699,900	acre-ft
Total capacity to El. 125	8,760	acre-ft
Active capacity, El. 118.5-125	2,800	acre-ft
Surface area at El. 125	540	acres
Shoreline	14	mi

Dimensions:

Structural height	87	ft
Hydraulic height	46	ft
Top width	28	ft
Maximum base width	135	ft
Crest length	1,093	ft
Crest elevation	132.0	ft
Total volume	121,100	yd³

Spillway: Gated control overflow section; eighteen 40- by 24-ft radial gates.

Elevation top of gates	126.0	ft
Crest elevation	102.4	ft
Capacity, El. 126.5	300,000	ft³/s

Outlet works: Six openings for two generating units at base of powerplant. Inlet channel for Folsom South Canal upstream from left abutment.
Foundation: Up to 20 ft of alluvium underlain by bedded deposits of compacted tuffs and clayey volcanic sandstones and conglomerates.
Special treatment: Timber and concrete cutoffs beneath upstream apron; impervious earth core extends into both abutments.
Mass concrete: Natural aggregate from American River channel plants.

Volume	121,000	yd³
Aggregate size (maximum)	6	in
Cement content	0.925	bbl/yd³

SLY PARK DAM

Type: Zoned earthfill
Location: On Sly Park Creek 12 mi east of Placerville, Calif.
Construction period: 1953-55

Reservoir, Jenkinson Lake:

Average annual inflow, 1922-70	43,000	acre-ft
Total capacity to El. 3471	41,000	acre-ft
Active capacity, El. 3350-3471	40,600	acre-ft
Surface area at El. 3471	650	acres
Shoreline	8	mi

Dimensions:

Structural height	190	ft
Hydraulic height	165	ft
Top width	35	ft
Maximum base width	890	ft
Crest length	760	ft
Crest elevation	3482.0	ft
Total volume	1,130,000	yd^3

Spillway: Uncontrolled concrete-lined chute at left abutment.

Crest elevation	3471.0	ft
Capacity, El. 3476	6,700	ft^3/s

Outlet works: Concrete conduit through base of dam controlled by two 2.25-ft-square high-pressure slide gates. Also, a 12-ft diversion and outlet channel.

Capacity to El. 3476	250	ft^3/s

Foundation: Steeply dipping, irregularly weathered quartzites, schists, and phyllites of the Calaveras formation.

Special treatment: Grout curtain beneath dam.

Diversion Facilities

Camp Creek Diversion Dam

Type: Concrete overflow weir

Location: On Camp Creek about 1.75 mi east of Sly Park, Calif.

Year completed: 1953

Dimensions:

Structural height	20	ft
Hydraulic height	11	ft
Crest length	119	ft
Crest elevation	3558.0	ft
Volume	2,000	yd^3
Diversion capacity	500	ft^3/s

Carriage Facilities

Camino Conduit

Location: From Sly Park Dam generally west to Camino, Calif.

Construction period: 1953-55

Length	38,016	ft
Capacity	125	ft^3/s

Cross section:

Diameter	4-3	ft

Description: Precast concrete and welded plate steel

Camino Tunnel

Location: At County Road No. 90 about 1.5 mi east of Sly Park Dam.

Construction period: 1954-55

Length	2,289	ft
Capacity	125	ft^3/s

Cross section:

Diameter	7	ft

Lining type: Horseshoe

Lining thickness	3.5-7	in

Description: Steel reinforced, concrete lined

Camp Creek Tunnel

Location: From Camp Creek Diversion Dam generally northwest to Sly Park Reservoir.

Construction period: 1952-53

Length	2,845	ft
Capacity	500	ft^3/s

Cross section:

Diameter	7	ft

Lining type: Horseshoe

Lining thickness	3.5-7	in

Description: Steel reinforced, concrete lined

Power Facilities

Folsom Powerplant

Location: Folsom Dam

Year of initial operation: 1955

Year last generator placed in operation: 1955

Nameplate capacity	198,720	kW
Number and capacity of generators (3)	76,176	kW
Rated head	300	ft

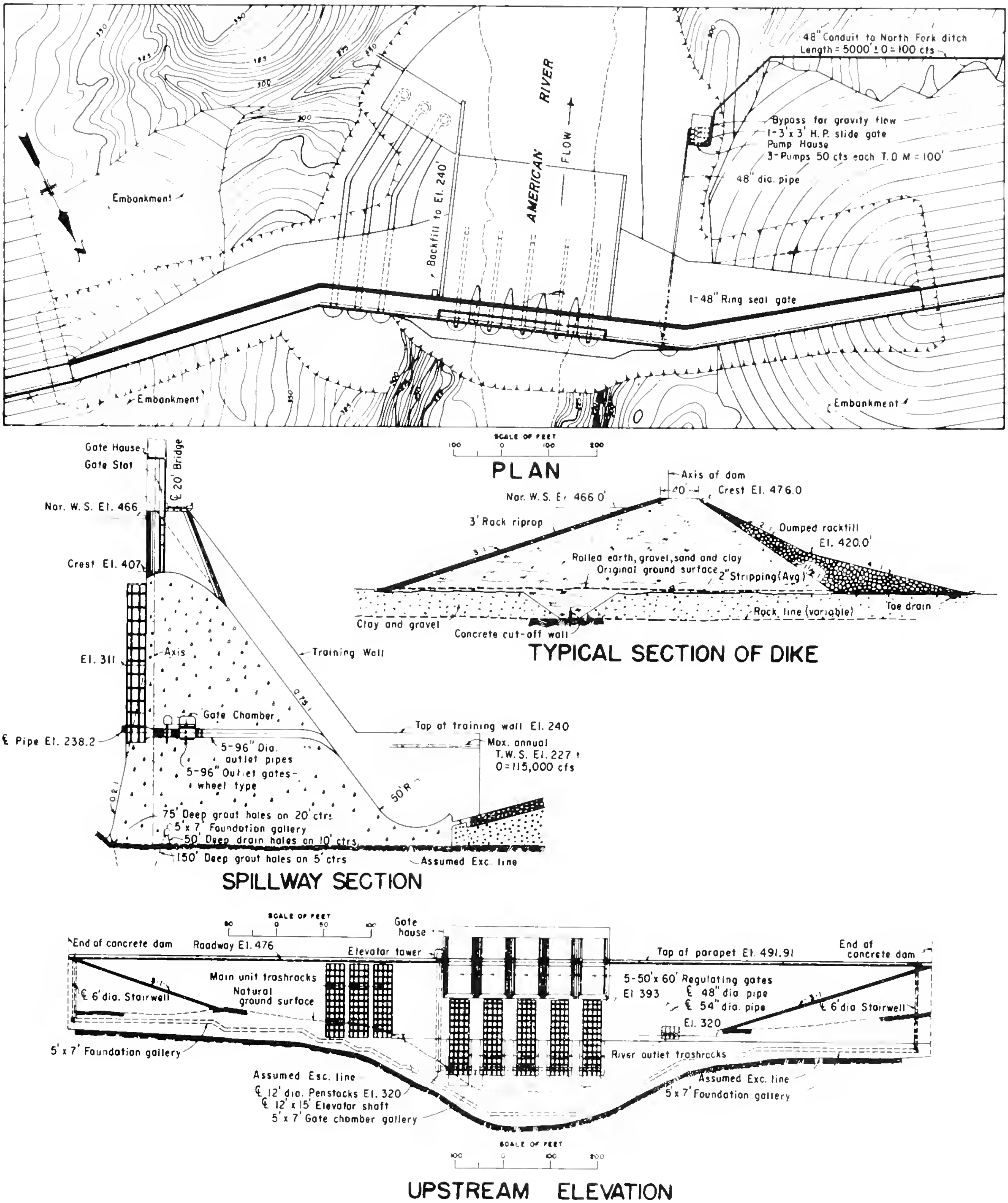
Nimbus Powerplant

Location: Nimbus Dam

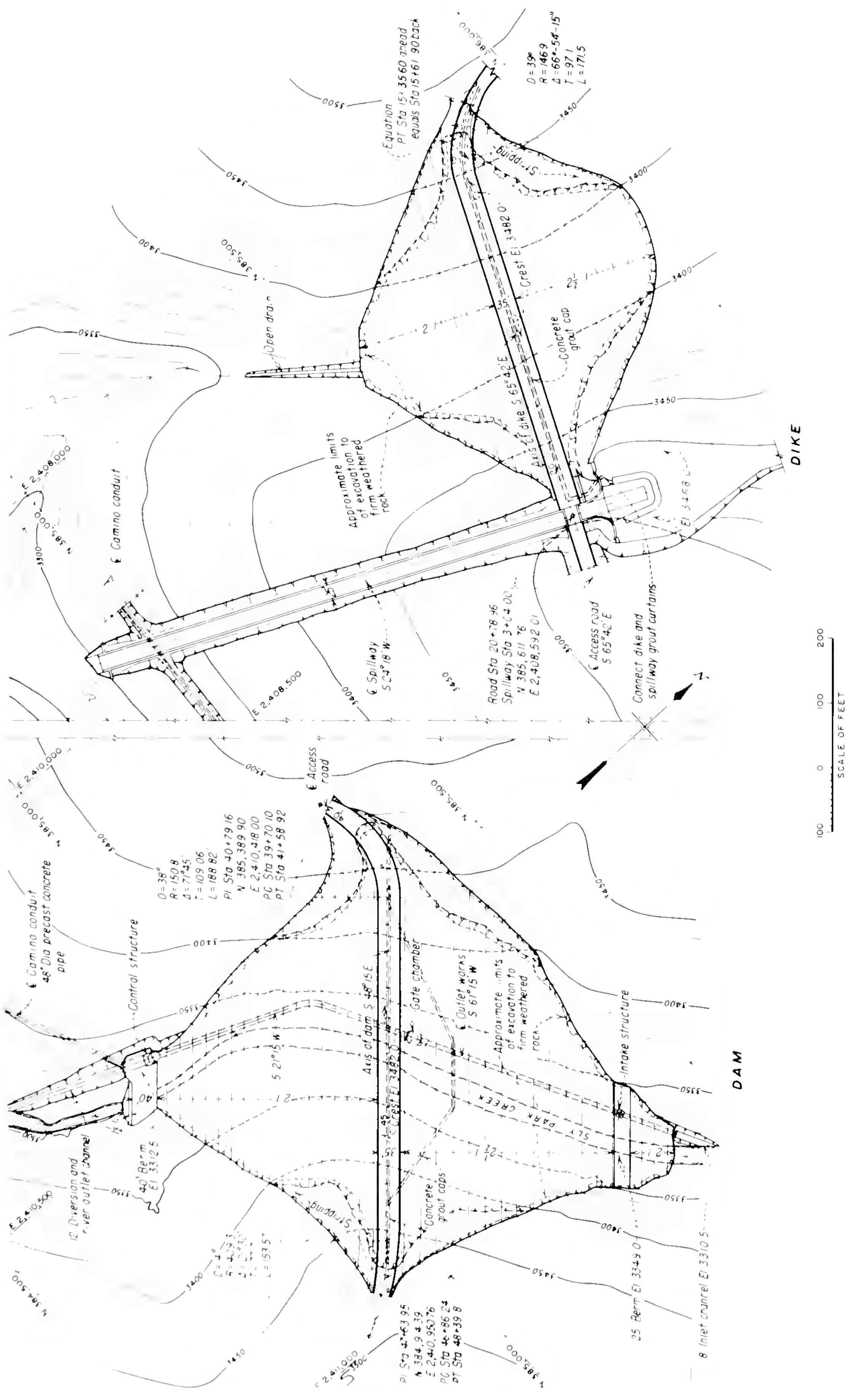
Year of initial operation: 1955

Year last generator placed in operation: 1955

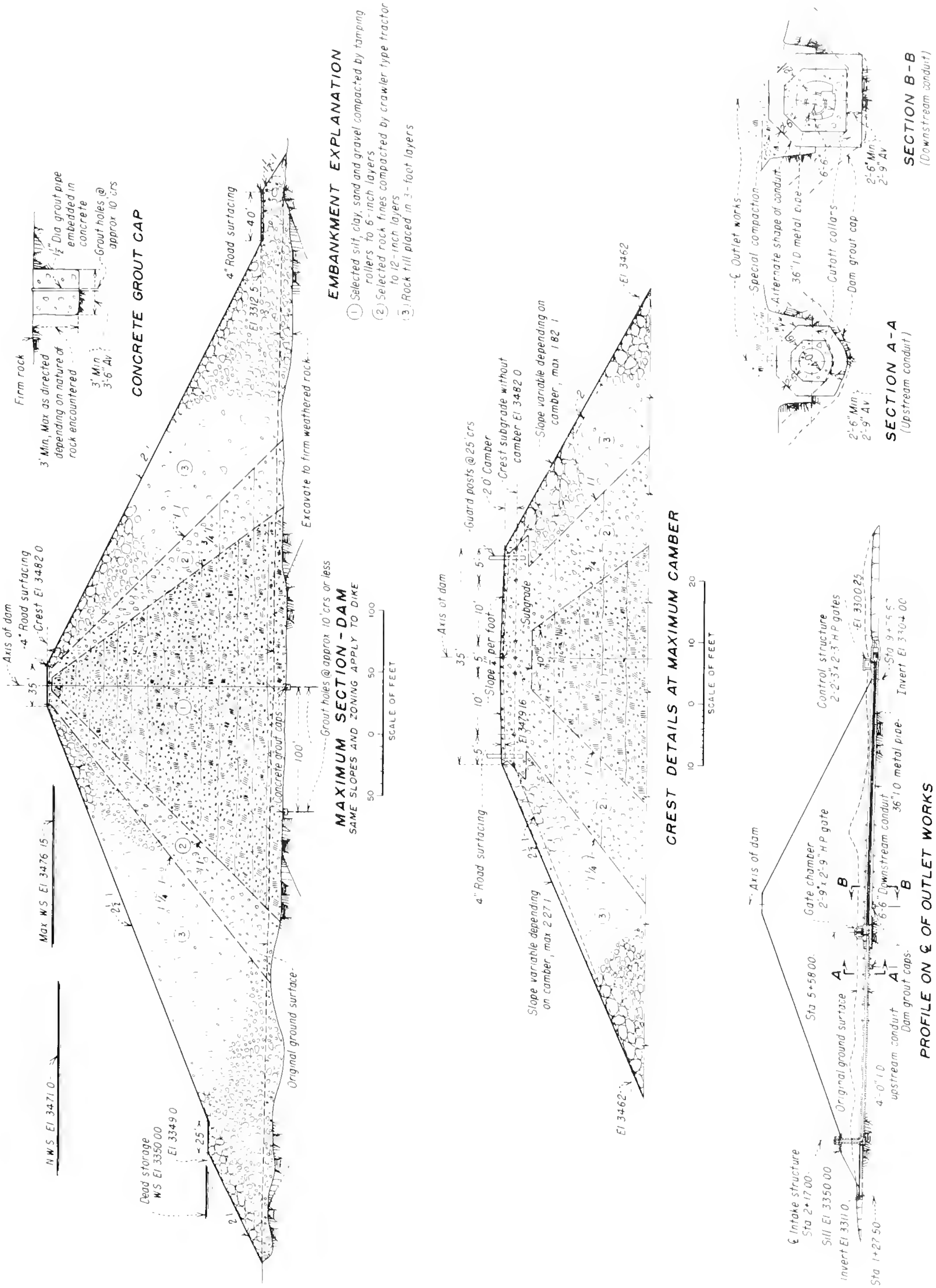
Nameplate capacity	13,500	kW
Number and capacity of generators (2)	7,763	kW
Rated head	41.5	ft



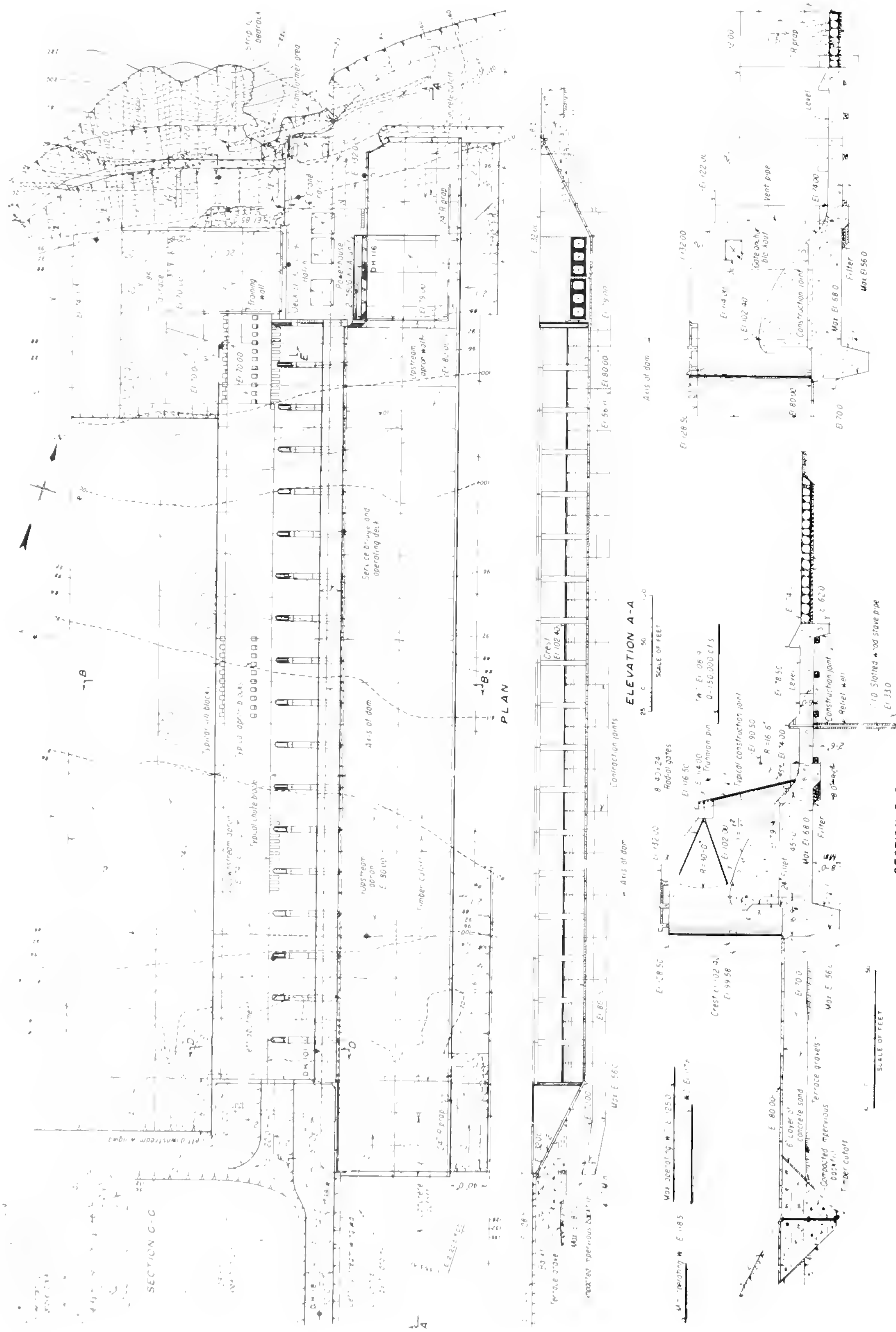
Folsom Dam, Plan and Sections



Sly Park Dam, Plan



Sly Park Dam, Sections

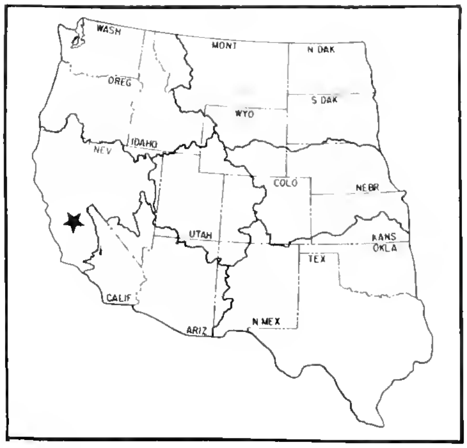


Nimbus Dam, Plan and Sections

Central Valley Project
Friant Division

California: Fresno, Kern, Madera, and Tulare Counties

Mid-Pacific Region
Water and Power Resources Service



The Friant Division provides for the transport of surplus northern California water through the southern part of the semiarid Central Valley. The main features of this division are Friant Dam, Friant-Kern Canal, and Madera Canal, all constructed and operated by the Bureau of Reclamation.

Friant Dam and Millerton Lake

Friant Dam is located on the San Joaquin River 25 miles northeast of Fresno, Calif. Completed in 1942, the dam is a concrete gravity structure 319 feet high with a crest length of 3,488 feet. It controls the San Joaquin River flows, provides downstream releases to meet requirements above Mendota Pool, and provides flood control, conservation storage, and diversion into Madera and Friant-Kern Canals. The reservoir, Millerton Lake, has a capacity of 520,500 acre-feet. The reservoir also serves as a recreation area, providing boating, fishing, picnicking, and swimming.

Friant Dam

Friant-Kern Canal

Friant-Kern Canal carries water from Millerton Lake southerly for supplemental and new irrigation supplies in Fresno, Tulare, and Kern Counties. Construction of the canal began in 1945 and was completed in 1951. The canal is 151.2 miles long and has an initial capacity of 4,000 cubic feet per second that gradually decreases to 2,000 cubic feet per second at its terminus in the Kern River about 4 miles west of Bakersfield.

Madera Canal

The 35.9-mile-long Madera Canal carries water northerly from Millerton Lake to furnish lands in Madera County with a supplemental and a new irrigation supply. The canal, completed in 1945, has an initial capacity of 1,000 cubic feet per second, decreasing to a capacity of 625 cubic feet per second at the Chowchilla River.

PROJECT DATA

Land Areas (1977)

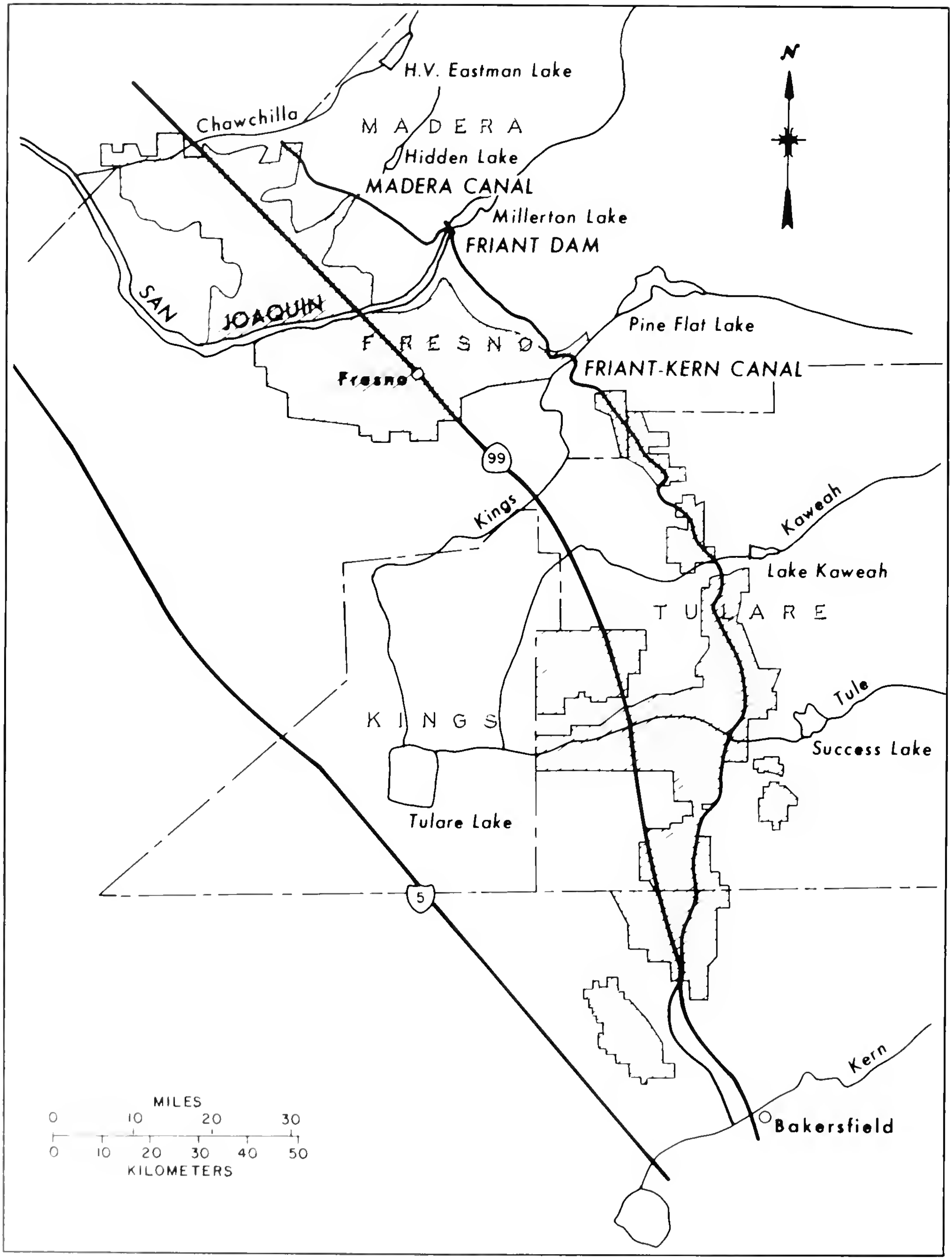
Irrigable area:		
Supplemental irrigation service	1,021,724	acres
Number of irrigated farms	12,860	

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	187.1	mi
Pumping plants	2	
Transmission lines	1.65	mi
Substations	1	

Climatic Conditions

Annual precipitation	8.9	in
Temperature:		
Maximum	116	°F
Minimum	17	°F
Mean	64	°F
Growing season	260	days
Elevation of irrigable area	361.5	ft



Central Valley Project, Friant Division

Settlement

Number of persons served with project water (1977):

Farm irrigation service	68,057
Urban/suburban irrigation service	190,695
Municipal and other water service	191,074
Total	449,826

ENGINEERING DATA

Water Supply

San Joaquin River

Drainage area at Friant Dam	1,675	mi²
Annual discharge at Friant Dam:		
Maximum (1938)	3,591,500	acre-ft
Minimum (1971)	47,830	acre-ft
Average	1,700,000	acre-ft

Storage Facilities

Friant Dam

Type: Concrete gravity
Location: On the San Joaquin River 20 mi northeast of Fresno, Calif.
Construction period: 1939-42
Reservoir, Millerton Lake:

Average annual inflow, 1907-70	1,729,900	acre-fet
Total capacity to El. 578	520,500	acre-ft
Active capacity, El. 442-578	433,800	acre-ft
Surface area at El. 578	4,900	acres
Shoreline	47	mi
Dimensions:		
Structural height	319	ft
Hydraulic height	293	ft
Top width	20	ft
Maximum base width	267	ft
Crest length	3,488	ft
Crest elevation	581.3	ft
Total volume	2,135,000	yd³

Spillway: Overflow section at center of dam controlled by three 18- by 100-ft drum gates.

Elevation top of gates	578.0	ft
Crest elevation	560.0	ft
Capacity, El. 578	83,000	ft³/s

Outlet works: River outlets—Four 110-in-diameter steel pipes through the dam controlled by four 96-in hollow-jet valves at downstream end, and two 18-in needle valves branched from two of the 110-in valves. Friant-Kern Canal Outlet—Four 110-in-diameter steel pipes through dam controlled by four 96-in hollow-jet valves. Madera Canal Outlet—Two 91-in-diameter steel pipes through dam controlled by two 86-in valves.

Capacity at El. 578	16,400	ft³/s

Foundation: Moderately hard, compact, quartz-biotite schist impregnated with varying amounts of granite material cut by small igneous dikes. Major fault zone 150-ft wide in left abutment, other minor faults in both abutments, springs in major fault zone.

Special treatment: Cement grout curtain under upstream toe. Faults excavated and backfilled and major fault extensively grouted.

Mass concrete: Natural aggregate from pits 3 mi downstream, oversized crushed; 17 percent low-heat, 59 percent low-heat low alkali, and 24 percent modified cement blended with 20 to 25 percent pumicite except in spillway face; temperature controlled by circulating river water through embedded pipe system.

Volume	2,030,736	yd³
Aggregate size (maximum)	8	in

Diversion Facilities

John A. Franchi Diversion Dam[1]

Type: Earth, steel sheet piling
Location: On the Fresno River.
Year completed: 1964
Dimensions:

Structural height	15	ft
Hydraulic height	15	ft
Crest length	263	ft
Volume	13,000	yd³

[1] Formerly Madera Diversion Dam. Operated by Madera Irrigation District.

Carriage Facilities

Friant-Kern Canal

Location: From Friant Dam near Friant, Calif., generally south to the vicinity of Bakersfield, Calif.
Construction period: 1945-51

Length	151.2	mi
Capacity	4,000	ft³/s
Section (initial reach):		
Bottom width	36	ft
Side slopes	1.5:1	
Water depth	15.5	ft

Madera Canal

Location: From Friant Dam near Friant, Calif., generally northwest.
Construction period: 1940-45

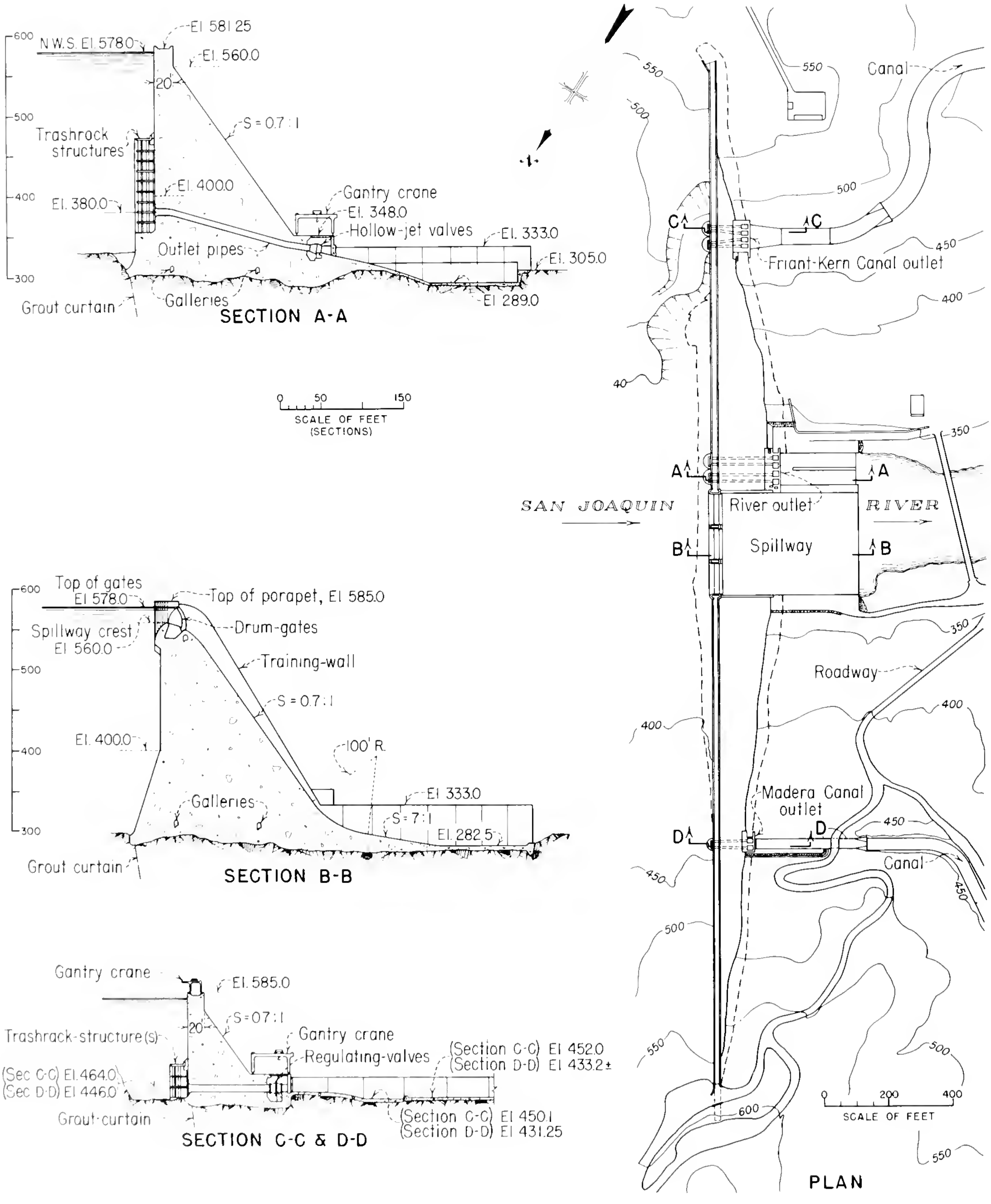
Length	35.9	mi
Capacity	1,000	ft³/s
Section (initial reach):		
Bottom width	20	ft
Side slopes	1.5:1	
Water depth	9.2	ft

Delano-Earlimart I.D. Pumping Plant No. D-3

Number of units	11	
Total capacity	136.4	ft³/s
Total dynamic head	31-49	ft
Total horsepower	1,090	

Lindsay-Strathmore I.D. Trauger Pumping Plant

Number of units	9	
Total capacity	142.5	ft³/s
Total dynamic head	107-187	ft
Total horsepower	3,900	



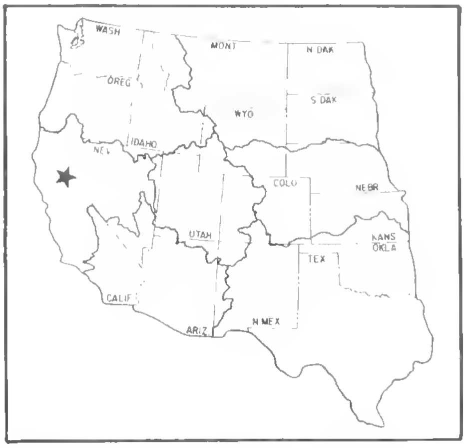
Friant Dam, Plan and Sections

Central Valley Project

Sacramento Canals Unit, Sacramento River Division

California: Colusa, Glenn, and Tehama Counties

Mid-Pacific Region
Water and Power Resources Service



The Sacramento Canals Unit of the Central Valley Project was designed to provide irrigation water in the Sacramento Valley, principally in Tehama, Glenn, and Colusa Counties. Authorized in 1950, the unit consists of the Red Bluff Diversion Dam, Corning Pumping Plant, Tehama-Colusa Canal, Corning Canal, and Stony Canal. The Stony Canal has been authorized but is not yet under construction. The remaining facilities were constructed and are operated by the Bureau of Reclamation. Included at the upper end of the Tehama-Colusa Canal are the Tehama-Colusa fish facilities which were constructed by Reclamation and are operated by the Fish and Wildlife Service.

Red Bluff Diversion Dam

The Red Bluff Diversion Dam, on the Sacramento River about 2 miles southeast of Red Bluff, Calif., diverts water from the Sacramento River to the Corning Canal and the Tehama-Colusa Canal service areas. Completed in 1964, the dam is a concrete gated weir structure 52 feet high and 5,985 feet long, including earth wings. Fish ladders at each abutment permit king salmon and steelhead to pass around the dam in their migration to spawning areas.

Corning Canal

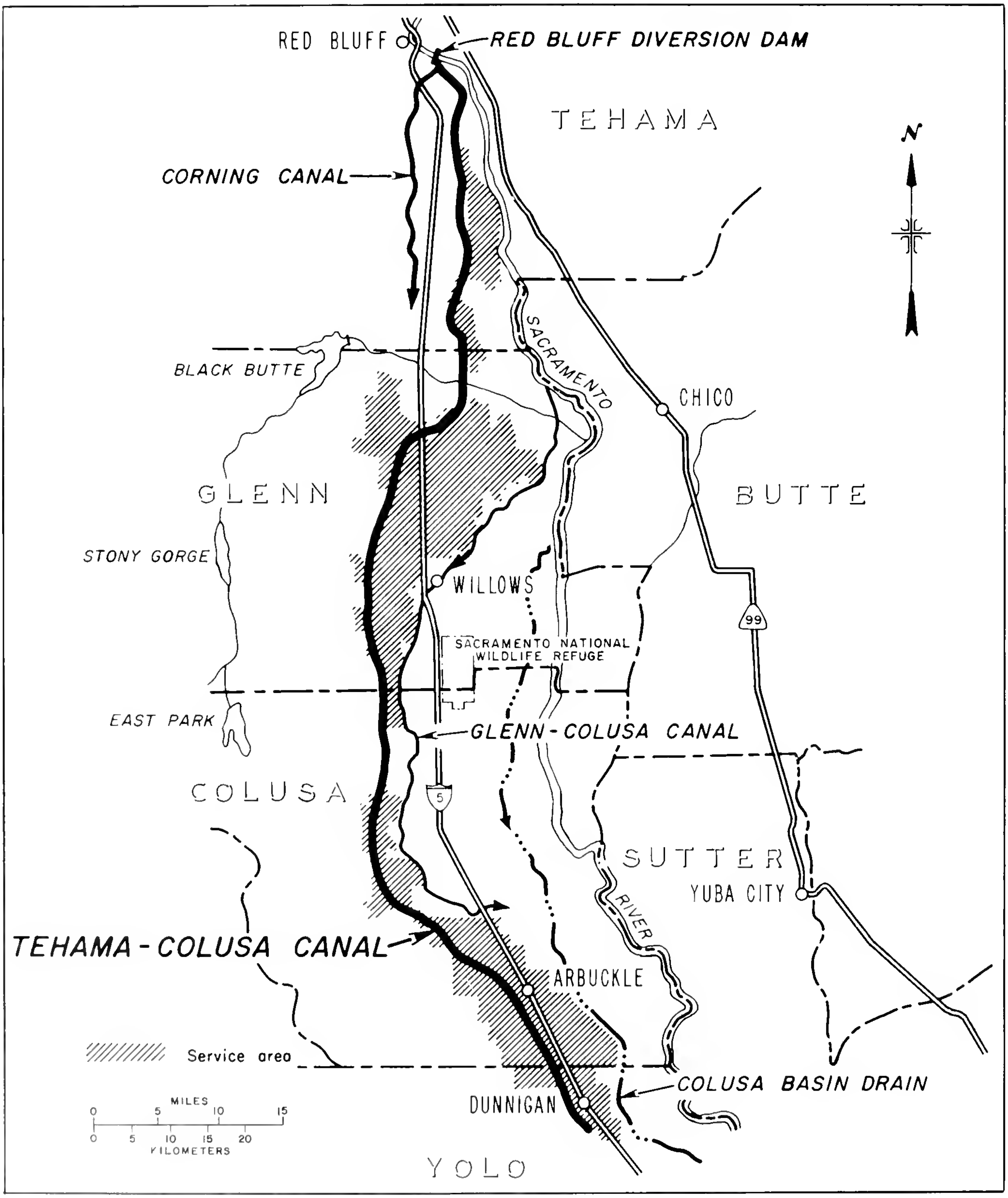
The Corning Canal diverts water from the Tehama-Colusa Canal about 0.5 mile downstream from the Red Bluff Diversion Dam. The water is lifted 56 feet at the Corning Pumping Plant and delivered to lands in Tehama County that have elevations too high to be served from Tehama-Colusa Canal. The canal was completed in 1959. It is 21 miles long, terminating about 4 miles southwest of Corning, Calif. The initial diversion capacity is 500 cubic feet per second, gradually decreasing to 88 cubic feet per second at the terminus.

Tehama-Colusa Canal

The Tehama-Colusa Canal is partially completed. Reaches 1 through 5 are complete; reaches 6 and 7 are under construction with completion scheduled in 1979. Invitation for bids to construct Reach 8 is scheduled for issuance. As now planned, the canal will be 113.4 miles

Red Bluff Diversion Dam

Corning Pumping Plant



Central Valley Project, Sacramento Canals Unit long; will extend from Red Bluff Diversion Dam through Glenn and Colusa Counties; and will terminate in Yolo County south of Dunnigan, Calif. The initial capacity is to be 2,530 cubic feet per second, diminishing to 1,700 cubic feet per second at the terminus.

The first reach of the canal has a multipurpose function: At the upper end of the canal are the Tehama-Colusa fish facilities which provide 1.6 million square feet of special gravel-bottomed portions of the canal as a spawning area for salmon. These facilities are the largest of their kind in the world.

Tehama-Colusa Canal

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	16,872	acres
Supplemental irrigation service	36,989	acres
Total	53,861	acres
Number of irrigated farms	507	

Facilities in Operation

Diversion dams	1	
Canals	89.6	mi
Pumping plants	5	
Substations	1	

Climatic Conditions

Annual precipitation	18	in
Temperature:		
Maximum	116	°F
Minimum	15	°F
Mean	64	°F
Growing season	260	days
Elevation of irrigable area	35-400.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,565

ENGINEERING DATA

Water Supply

SACRAMENTO RIVER

Drainage area above Bend Bridge, near Red Bluff	8,900	mi²
Annual discharge:		
Maximum (1909)	15,300,000	acre-ft
Minimum (1924)	3,320,000	acre-ft
Average	9,718,707	acre-ft

Diversion Facilities

RED BLUFF DIVERSION DAM

Type: Concrete ogee-gated weir, embankment wings
Location: On the Sacramento River about 2 mi southeast of Red Bluff, Calif.
Year completed: 1964
Dimensions:

Structural height	52	ft
Hydraulic height	24	ft
Crest length, including earth wings	5,985	ft
Crest elevation	267.0	ft
Volume	201,300	yd³
Diversion capacity	3,030	ft³/s

Carriage Facilities

CORNING CANAL

Location: From the Corning Canal Pumping Plant near Red Bluff, Calif., south to the vicinity of Corning, Calif.
Construction period: 1954-59

Length	21	mi
Capacity	500	ft³/s
Section (initial reach):		
Bottom width	22	ft
Side slopes	2:1	
Water depth	7.2	ft

TEHAMA-COLUSA CANAL

Location: From Red Bluff Diversion Dam south, paralleling Interstate 5.
Construction period: 1965-(Under construction)

Length:		
Constructed	65.7	mi
Under construction	29.9	mi
Capacity	2,530	ft³/s
Section (initial reach):		
Bottom width	24	ft
Side slopes	1.5:1	
Water depth	15.8	ft

CORNING CANAL PUMPING PLANT INTAKE CHANNEL

Location: At the Red Bluff Diversion Dam on the Sacramento River.
Construction period: 1959-60

Length	0.5	mi
Capacity	500	ft³/s
Section:		
Bottom width	30	ft
Side slopes	3:1	
Water depth	5.5	ft

Colusa County Water District Pumping Plant No. 2A

Number of units	7	
Total capacity	84	ft³/s
Total dynamic head	111	ft
Total horsepower	1,500	

Colusa County Water District Pumping Plant No. 2A1

Number of units	6	
Total capacity	83	ft³/s
Total dynamic head	111	ft
Total horsepower	1,450	

Colusa County Water District Pumping Plant No. 2B

Number of units	6	
Total capacity	83	ft³/s
Total dynamic head	101	ft
Total horsepower	1,300	

Colusa County Water District Pumping Plant No. 2C

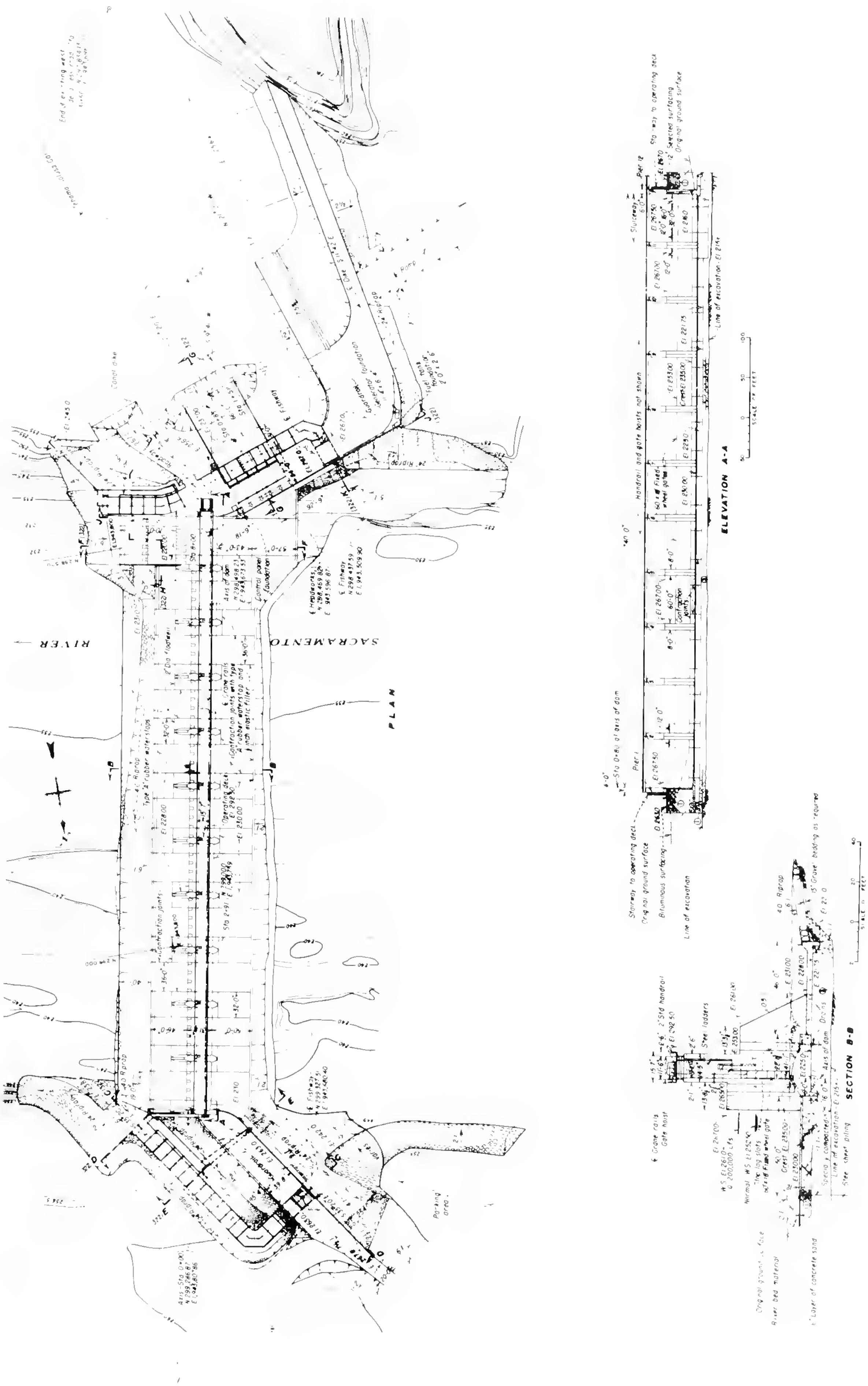
Number of units	6	
Total capacity	85	ft³/s
Total dynamic head	103	ft
Total horsepower	1,025	

Colusa County Water District Pumping Plant No. 2D

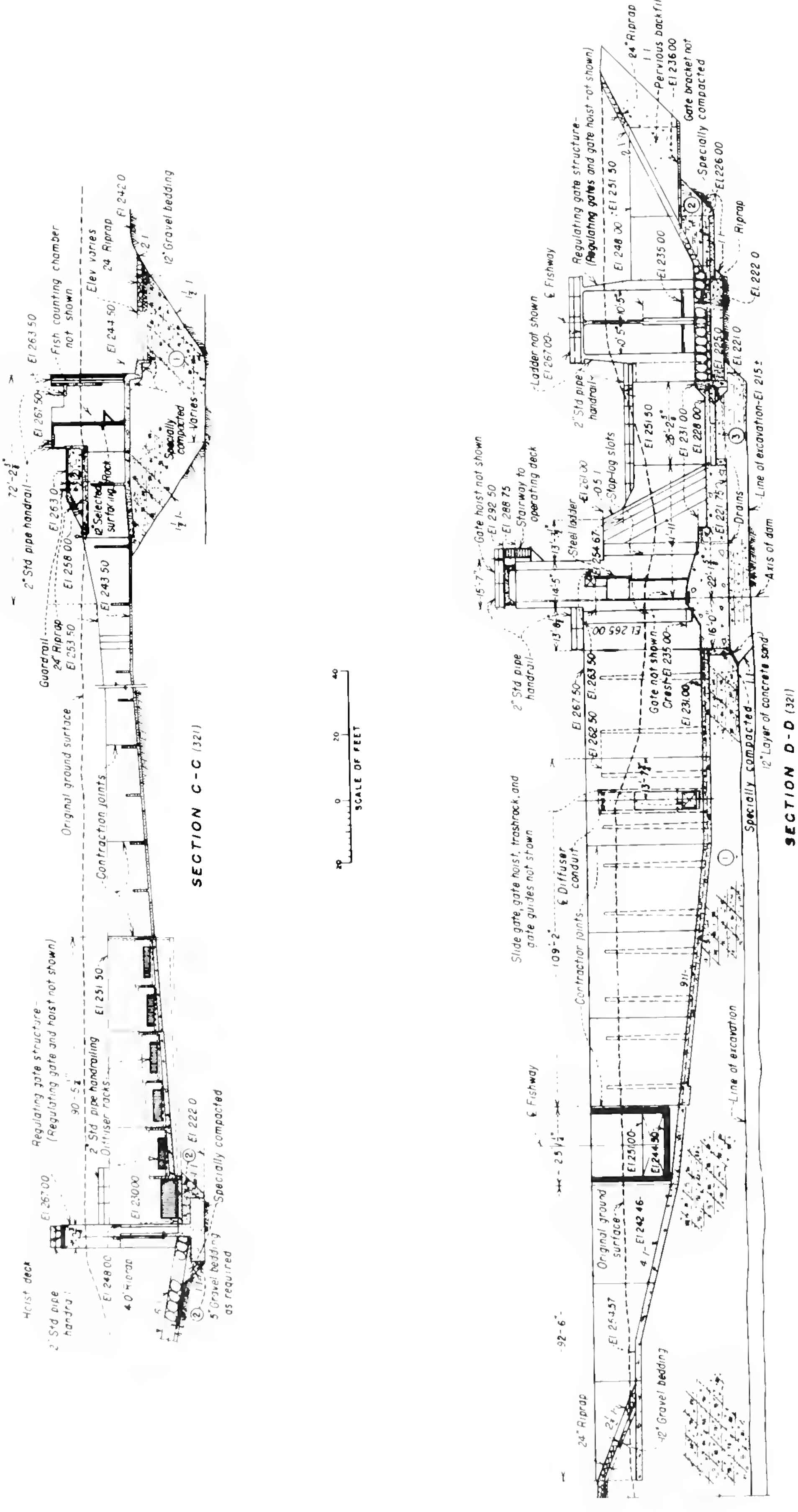
Number of units	5	
Total capacity	21.6	ft³/s
Total dynamic head	103	ft
Total horsepower	405	

Corning Canal Pumping Plant

Number of units	6	
Total capacity	477	ft³/s
Total dynamic head	59-71	ft
Total horsepower	4,050	



Red Bluff Diversion Dam, Plan and Sections

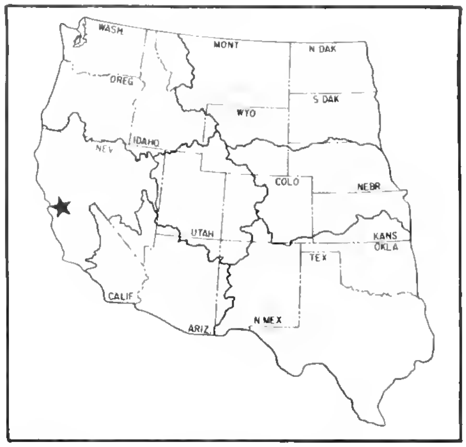


Red Bluff Diversion Dam. Sections

Central Valley Project
San Felipe Division

California: Monterey, San Benito, Santa Clara, and Santa Cruz Counties

Mid-Pacific Region
Water and Power Resources Service



The San Felipe Division of the Central Valley Project, in the central coastal area of California, embraces the Santa Clara Valley in Santa Clara County, the north portion of San Benito County, the south portion of Santa Cruz County, and the northern edge of Monterey County. Authorized in 1967, the division will provide supplemental water to 38,700 acres of land in addition to 132,400 acre-feet of water annually for municipal and industrial use. Water from San Luis Reservoir will be transported to the service area through Pacheco Tunnel and other project features which include 43.5 miles of closed conduits, two pumping plants, and two small reservoirs.

PLAN

Water will be conveyed from the delta of the San Joaquin and Sacramento Rivers through the Delta-Mendota Canal to O'Neill Forebay. The water will then be pumped into San Luis Reservoir and diverted through the existing 1.8 miles of Pacheco Tunnel to the Pacheco Pumping Plant. At the pumping plant, the water will be lifted to the 5.3-mile-long high-level section of Pacheco Tunnel. The water will flow through the tunnel and, without additional pumping, through the Pacheco Conduit to the bifurcation of the Santa Clara and Hollister Conduits; the water supply then will be conveyed throughout the service areas for irrigation and municipal uses.

Alinement of Pacheco Tunnel

Coyote Afterbay Dam and Reservoir

Located on Coyote Creek north of Gilroy, the Coyote Afterbay Dam will be an earth and rockfill structure 46 feet high with a crest length of 880 feet. Reservoir capacity will be 62 acre-feet.

San Justo Dam and Reservoir

San Justo Dam, located about 3 miles southwest of Hollister, will be an earthfill structure 141 feet high with a crest length of 722 feet. A dike structure 66 feet high with a crest length of 918 feet will be required. These features will form a reservoir with a 9,906 acre-foot capacity.

Hollister Conduit

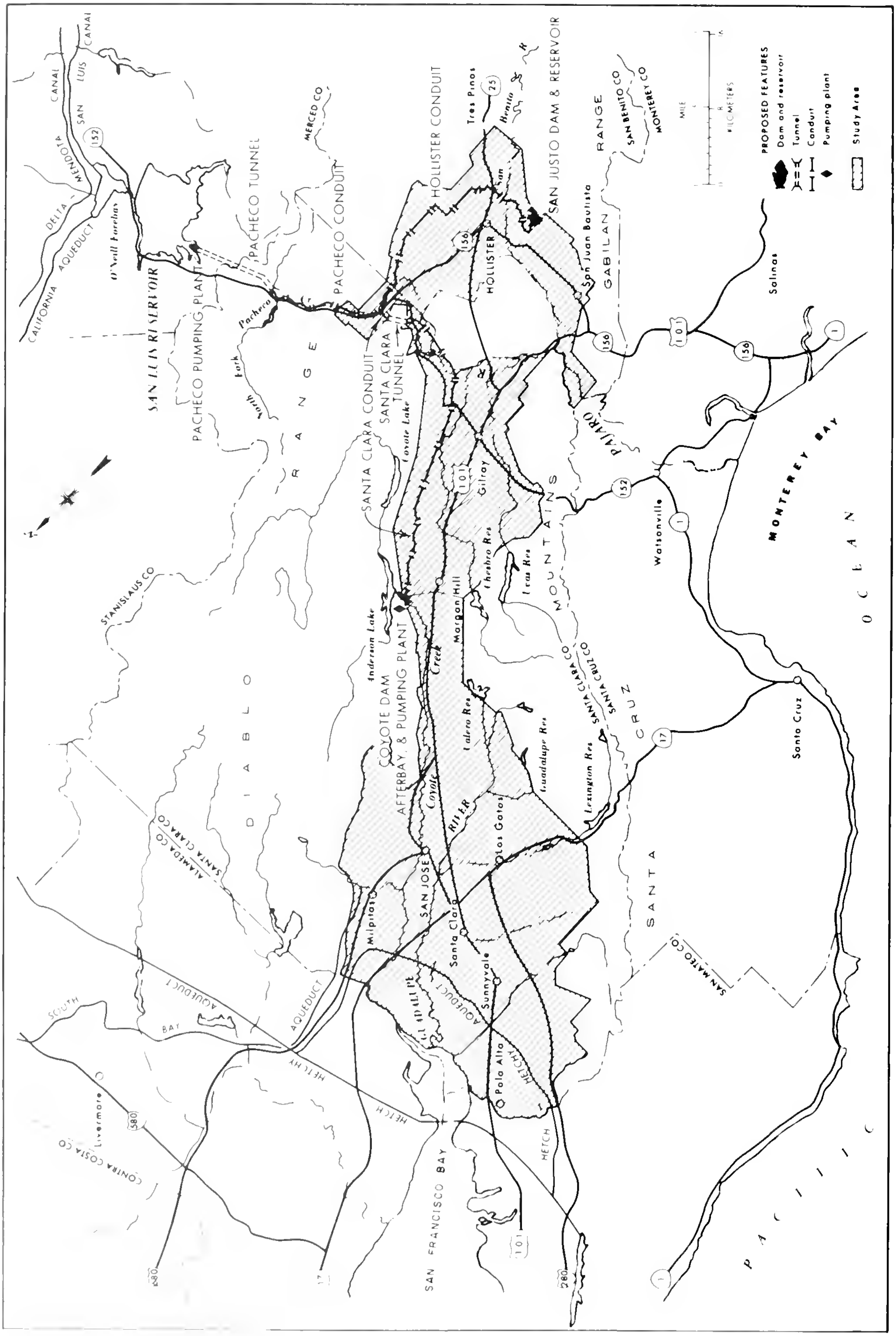
The 14.3-mile-long Hollister Conduit will have a capacity of 83 cubic feet per second, and will extend from Pacheco Conduit to San Justo Reservoir.

Pacheco Conduit

The 7.8-mile-long Pacheco Conduit, with a capacity of 413 to 480 cubic feet per second, will extend from the Pacheco Tunnel outlet to the bifurcation of the Santa Clara and Hollister Conduits.

Santa Clara Tunnel and Conduit

Santa Clara Tunnel and Conduit will be 22.4 miles long, with a capacity of 330 cubic feet per second. It will convey water from the Pacheco Conduit to the Coyote Afterbay Reservoir.



Central Valley Project, San Felipe Division

Pacheco Tunnel

The 7.1-mile-long Pacheco Tunnel will be 9.5 feet in diameter, with a capacity of 480 cubic feet per second. It will bring water through the Diablo Mountain Range from the San Luis Reservoir.

Pumping Plants, Switchyards, and Transmission Lines

Project facilities will include two pumping plants, two switchyards, and 41 miles of transmission line.

DEVELOPMENT

Early History

The first significant development of the Santa Clara Valley was the establishment of Spanish missions. Mission Santa Clara, from which the valley derived its name, was founded in 1777 at the northern edge of the present city of Santa Clara. Other Spanish settlements were the Pueblo de San Jose de Guadalupe at the site of the present city of San Jose, and the Mission San Juan Bautista. Although early farm activities consisted of growing fruit trees and nonirrigated crops, and breeding livestock, some irrigation was started at an early date at the Mission San Juan Bautista. However, cattle ranching was the predominant industry on the large Mexican land grants.

The lower Pajaro River Basin was first settled for farming around 1851. Construction of the Southern Pacific Railroad through Pajaro Gap in 1870 stimulated agriculture, and by 1880, commercial fruit growing became important. In 1886, a sugar beet factory was built in Watsonville.

Irrigated agriculture developed rapidly after World War I with the improvement of pump design and the availability of electric power. Ground water was readily available in most of the area, and farmers made extensive use of the supply.

Northern Santa Clara County experienced a large influx of military personnel and civilians during and after World War II. Industrial development was greatly accelerated in the vicinities of San Jose, Sunnyvale, Mountain View, and Milpitas. Tremendous urban expansion took place and continued at a rapid pace. Demands on the ground water far exceeded the supply, and local resources were inadequate.

Investigations

The initial investigation that eventually led to the San Felipe Division was the Pajaro River Basin investigation authorized by the Congress in 1948. The resulting reconnaissance report pointed out the ground-water overdraft in the area and recommended that an organization be formed to consider importation of water.

Alinement of Santa Clara Tunnel

Also in 1948, the State of California initiated investigations of the Santa Clara Valley under joint sponsorship of the State, the Santa Clara County Board of Supervisors, and the city of San Jose.

On July 29, 1955, California sent the Secretary of the Interior a joint resolution requesting that the Congress take action to initiate feasibility studies. Congressional action came in August 1958 when House Joint Resolution 585 directed the Secretary of the Interior to investigate the possibility of providing service from the Central Valley Project to Santa Clara, San Benito, Santa Cruz, and Monterey Counties.

On June 22, 1959, a cooperative investigation contract between the United States and the Santa Clara-Alameda-San Benito Water Authority was signed. This investigation culminated in the Bureau of Reclamation's proposed feasibility report on the San Felipe Division dated May 1963. After review by all interested Federal, State, and local agencies, the report was revised and submitted to the Commissioner of Reclamation on March 31, 1964. This report was the basis for the Commissioner's proposed report to the Secretary of the Interior, who submitted the final report to the Speaker of the House of Representatives on September 26, 1966. The report was subsequently printed as House Document No. 500, 89th Congress, 2d session.

Authorization

The San Felipe Division, Central Valley Project, was authorized for construction by Public Law 90-72, dated August 27, 1967 (81 Stat. 173).

Construction

Under authority contained in the San Luis Unit authorization act (Public Law 86-488), the intake and first 1.8 miles of the Pacheco Tunnel were constructed prior to completion of San Luis Reservoir in 1968. Invitation for bids to construct the remaining 5.3 miles through the Diablo Range near Pacheco Pass has been issued.

BENEFITS

Irrigation

The San Felipe Division was designed to provide a supplemental irrigation water supply to 38,700 acres, and 132,400 acre-feet of water annually for municipal and industrial use.

PROJECT DATA

Climatic Conditions

Annual precipitation	12.9	in
Temperature:		
Maximum	112	°F
Minimum	15	°F
Mean	58	°F
Growing season	345	days
Elevation of irrigable area	234.0	ft

ENGINEERING DATA

Storage Facilities

COYOTE AFTERBAY DAM

Type: Earth and rockfill
Location: On Coyote Creek north of Gilroy.
Construction period: Proposed
Reservoir (Afterbay):

Total capacity	62	acre-ft
Active capacity	45	acre-ft
Dimensions:		
Structural height	46	ft
Hydraulic height	30	ft
Top width	20	ft
Maximum base width	160	ft
Crest length	880	ft
Crest elevation	429.0	ft
Total volume	63,000	yd³
Spillway: Morning-glory		
Crest elevation	421.0	ft
Capacity, El. 423	250	ft³/s
Outlet works:		
Capacity at El. 421	230	ft³/s

(This capacity is in addition to 80 ft³/s in pipe.)

SAN JUSTO DAM

Type: Earthfill
Location: About 3 mi southwest of Hollister.
Construction period: Proposed
Reservoir, San Justo:

Total capacity to El. 497	9,906	acre-ft
Active capacity	8,800	acre-ft
Surface area	33	acres
Dimensions:		
Structural height:		
Dam	141	ft
Dike	66	ft
Top width (dam and dike)	49	ft
Crest length:		
Dam	722	ft
Dike	918	ft
Total volume:		
Dam	922,900	yd³
Dike	380,400	yd³

Carriage Facilities

HOLLISTER CONDUIT

Location: From the Pacheco Conduit to the San Justo Reservoir.
Construction period: Proposed

Length	14.3	mi
Capacity	83	ft³/s

PACHECO CONDUIT

Location: From Pacheco Tunnel outlet to bifurcation of Santa Clara and Hollister Conduits.
Construction period: Proposed

Length	7.8	mi
Capacity	480	ft³/s

PACHECO TUNNEL

Location: From San Luis Reservoir through the Diablo Mountain Range.
Construction period: First 1.8 mi completed in 1968, remaining 5.3 mi pending.

Length	7.1	mi
Capacity	480	ft³/s
Cross section:		
Diameter	9.5	ft
Lining type: Circular		
Lining thickness	8-18	in

SANTA CLARA TUNNEL AND CONDUIT

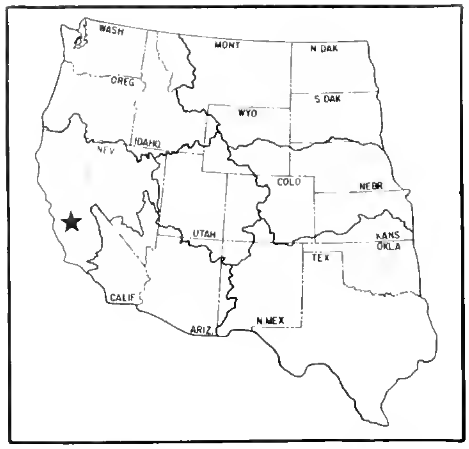
Location: From Pacheco Conduit to Coyote Afterbay Reservoir.
Construction period: Proposed

Length	22.4	mi
Capacity	330	ft³/s

Central Valley Project
San Luis Unit, West San Joaquin Division

California: Fresno, Kings, and Merced Counties

Mid-Pacific Region
Water and Power Resources Service



The San Luis Unit, a part of the Central Valley Project and also the State of California Water Plan, was authorized in 1960 to be constructed and operated jointly with the State of California. Some features are "joint-use facilities" of the Federal Government and the State. The principal purpose of the Federal portion of the facilities is to furnish approximately 1.25 million acre-feet of water as a supplemental irrigation supply to some 600,000 acres located in the western portion of Fresno, Kings, and Merced Counties.

The major portion of the San Luis Unit is a combined effort of the Federal and State governments; 55 percent of the total cost is contributed by the State of California and the remaining 45 percent by the United States. The joint-use facilities are O'Neill Dam and Forebay, San Luis Dam and Reservoir, San Luis Pumping-Generating Plant, Dos Amigos Pumping Plant, Los Banos and Little Panoche Reservoirs, and San Luis Canal from O'Neill Forebay to Kettleman City, together with the necessary switchyard facilities.

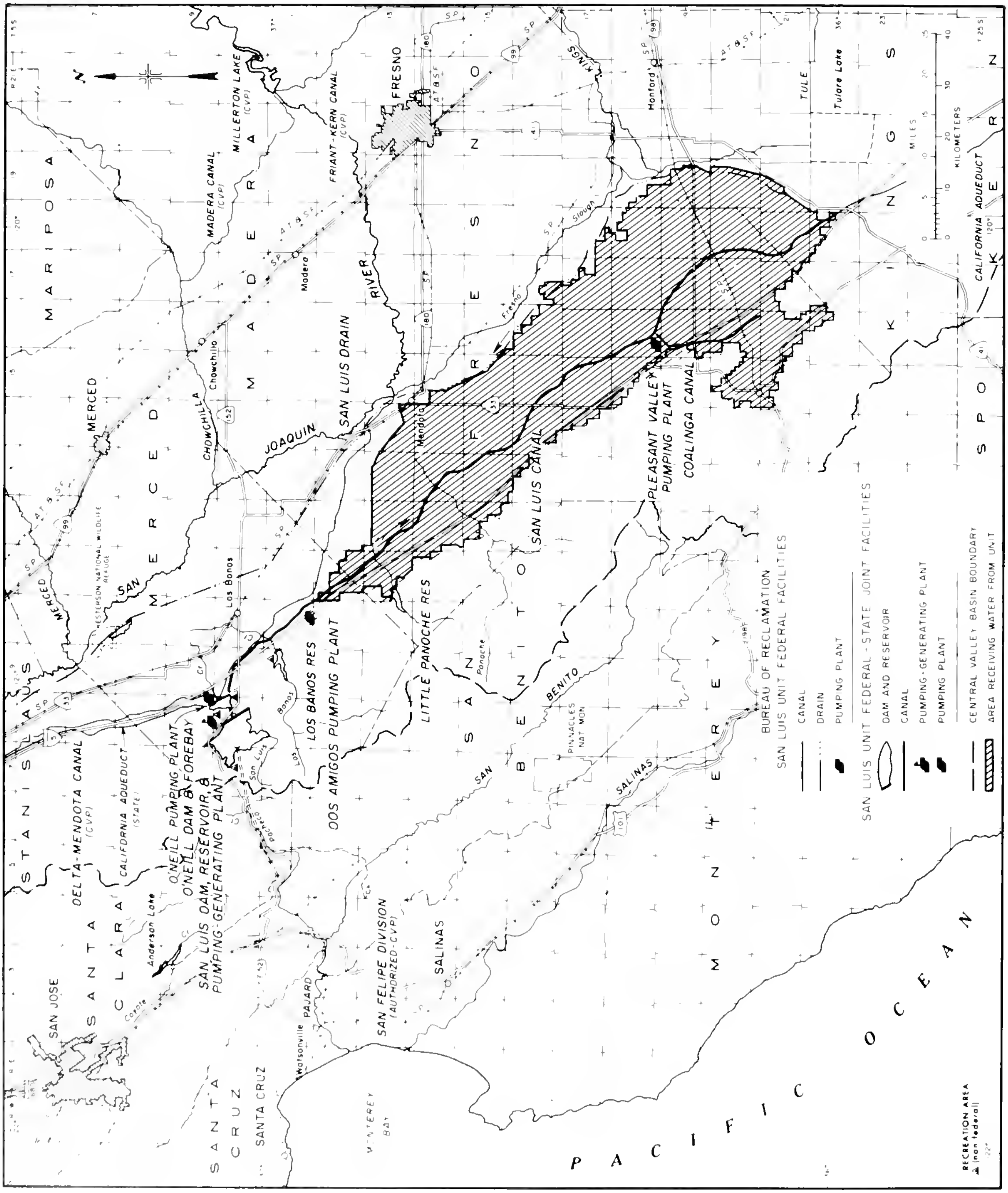
San Luis Dam and Reservoir

The Federal-only portion of the San Luis Unit includes the O'Neill Pumping Plant and Intake Canal, Coalinga Canal, Pleasant Valley Pumping Plant, and the San Luis Drain.

The San Luis Reservoir serves as the major storage and O'Neill Forebay acts as an equalizing basin for the upper stage dual-purpose pumping-generating plant. Pumps located at the base of O'Neill Dam take water from the Delta-Mendota Canal through an intake channel (a Federal feature) and discharge it into the O'Neill Forebay. The California Aqueduct (a State feature) flows directly into the O'Neill Forebay. The pumping-generating units lift the water from the O'Neill Forebay and discharge it into the main reservoir. When not pumping, these units generate electric power by reversing flow through the turbines. Water for irrigation is released into the San Luis Canal and flows by gravity to Dos Amigos Pumping Plant where it is lifted more than 100 feet to permit gravity flow to its terminus at Kettleman City. A State canal system continues to southern coastal areas. During irrigation months, water from the California Aqueduct flows through the O'Neill Forebay into the San Luis Canal without first being pumped into the San Luis Reservoir. Cross drainage along the San Luis Canal is achieved by two detention reservoirs, Los Banos and Little Panoche. The reservoirs provide recreation benefits in addition to flood control.

San Luis Dam and Reservoir

These joint Federal-State facilities are located on San Luis Creek near Los Banos, Calif. Completed in 1967, San Luis Dam is a zoned earthfill structure 382 feet high with a crest length of 18,600 feet. The reservoir has a



Central Valley Project, San Luis Unit

O'Neill Forebay Pumping Plant

capacity of 2,041,000 acre-feet, and is used to store surplus water of the Sacramento-San Joaquin Delta. Releases are made through the San Luis Pumping-Generating Plant, using its power generating capacity. The reservoir offers recreation facilities for fishing, boating, water skiing, and camping.

O'Neill Dam and Forebay

These joint Federal-State facilities are located on San Luis Creek 2.5 miles downstream from San Luis Dam. O'Neill Dam is a zoned earthfill structure with a height of 87 feet and a crest length of 14,300 feet. The forebay, with a capacity of 56,400 acre-feet, is utilized as a hydraulic junction point for Federal and State waters. The top 20,000 acre-feet act as reregulator storage necessary to permit offpeak pumping and onpeak generation by the main San Luis Pumping-Generating Plant.

Dos Amigos Pumping Plant and Switchyard

Recreation facilities are included at the forebay for picnicking, camping, swimming, boating, water skiing, and fishing.

O'Neill Pumping Plant

This Federal facility consists of an intake channel leading off the Delta-Mendota Canal, 70 miles from the Tracy Pumping Plant, and six pumping-generating units. Normally these units operate as pumps to lift water from 45 to 53 feet into the O'Neill Forebay. When water is occasionally released from the forebay to the Delta-Mendota Canal, these units will operate as generators. When operating as pumps and motors, each unit can discharge 700 cubic feet per second and has a rating of 6,000 horsepower. When operating as turbines and generators, each unit has a generating capacity of about 4,200 kilowatts.

San Luis Pumping-Generating Plant

San Luis Pumping-Generating Plant

This joint Federal-State facility, located at San Luis Dam, lifts water by pump-turbines from the O'Neill Forebay into San Luis Reservoir. During the irrigation season, water is released from San Luis Reservoir back through the pump-turbines to the forebay and energy is reclaimed. Each of the eight pumping-generating units has a capacity of 63,000 horsepower as a motor and 53,000 kilowatts as a generator. As a pumping station to fill San Luis Reservoir, each unit lifts 1,375 cubic feet per second at 290 feet total head. As a generating plant, each unit passes 1,640 cubic feet per second at the same head.

San Luis Canal

This joint Federal-State facility is a concrete-lined canal 101.3 miles long with a capacity ranging from 8,350 to

Delta-Mendota Canal and California Aqueduct

13,100 cubic feet per second. Access sites for public fishing are provided.

Dos Amigos Pumping Plant

This joint Federal-State facility, 17 miles south of the Forebay, is a relift plant in the San Luis Canal. The plant contains six pumping units, each capable of delivering 2,200 cubic feet per second at 125 feet of head.

Pleasant Valley Pumping Plant

This Federal facility lifts water 180 feet from an intake channel leading from San Luis Canal at mile 74. Three 7,000-, three 3,500-, and three 1,250-horsepower units are used to deliver 1,135 cubic feet per second into the Coalinga Canal and 50 cubic feet per second to a distribution lateral serving adjacent lands north of the pumping plant.

Coalinga Canal

This Federal facility, formerly called Pleasant Valley Canal, carries water from the turnout structure on the San Luis Canal to the Coalinga area in Fresno County. The system includes a 1.6-mile intake channel to the Pleasant Valley Pumping Plant and 11.6 miles of canal. The initial capacity of the canal is 1,100 cubic feet per second, decreasing to 425 cubic feet per second at the terminus. Reaches 1 and 2 of the canal are operated by the Westlands Water District.

Los Banos and Little Panoche Detention Dams and Reservoirs

These joint Federal-State facilities are required to protect the San Luis Canal by controlling flows of streams crossing the canal. The Los Banos Reservoir also protects the city of Los Banos and adjacent areas from damaging floods and provides recreation facilities for picnicking, camping, swimming, fishing, and boating.

San Luis Drain

The San Luis Drain, a Federal facility, is designed to convey and dispose of subsurface irrigation return flows from the San Luis service area. A feature of the drain is the Kesterson Reservoir where water is ponded, regulated, and allowed to evaporate pending approval and construction of an outlet for the San Luis Drain. The reservoir serves in the conservation and management of wildlife and recreation, and is designated as a national wildlife refuge. Eighty-seven miles of the planned 188-mile-long drain have been completed.

Distribution System

A system of laterals and relift pumping facilities to take water from the San Luis Canal and convey it to over 583,000 irrigable acres is being constructed by the Bureau of Reclamation.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	531,376	acres
Number of irrigated farms	364	

Facilities in Operation

Storage dams	4	
Canals	115	mi
Tunnels	1.8	mi
Pumping plants	26	
Drains	84	mi
Pumping-generating plants	2	
Substations[1]	3	

[1]Includes Dos Amigos and San Luis Substations, operated by the State of California.

Climatic Conditions

Annual precipitation	14.5	in
Temperature:		
Maximum	115	°F
Minimum	19	°F
Mean	59	°F
Growing season	280	days
Elevation of irrigable area	310.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	8,733
Municipal and other water service	21,471
Total	30,204

ENGINEERING DATA

Water Supply

SAN LUIS CREEK

Drainage area	84.6	mi^2
Annual discharge:		
Maximum (1952)	17,030	acre-ft
Minimum (1961)	58	acre-ft
Average	4,260	acre-ft

Storage Facilities

SAN LUIS DAM[2]

Type: Zoned earthfill
Location: On the San Luis Creek 12 mi west of Los Banos, Calif.
Construction period: 1963-67
Reservoir, San Luis:

Total capacity to El. 544	2,041,000	acre-ft
Active capacity, El. 326-544	1,961,000	acre-ft
Surface area at El. 544	13,000	acres
Shoreline	65	mi
Dimensions:		
Structural height	382	ft
Hydraulic height	303	ft
Top width	30	ft
Maximum base width	2,420	ft
Crest length	18,600	ft
Crest elevation	554.0	ft
Total volume	77,670,000	yd^3
Spillway: Concrete morning-glory inlet, concrete conduit, concrete chute, concrete stilling basin, and outlet channel.		
Crest elevation	544.0	ft
Capacity, El. 545.8	875	ft^3/s
Outlet works: Four concrete conduits controlled by roller-mounted gates and bulkhead gate in the trashrack structure; connected to four dual-purpose pump-generators.		
Capacity at El. 544	13,120	ft^3/s

O'NEILL FOREBAY DAM

Type: Zoned earthfill
Location: On San Luis Creek 12 mi west of Los Banos, Calif.
Construction period: 1963-67
Reservoir, O'Neill Forebay:

Total capacity to El. 225	56,400	acre-ft
Active capacity, El. 217-225	20,800	acre-ft
Surface area at El. 225	2,250	acres
Shoreline	14	mi
Dimensions:		
Structural height	87	ft
Hydraulic height	61	ft
Top width	30	ft
Maximum base width	382	ft
Crest length	14,300	ft
Crest elevation	233.0	ft
Total volume	2,880,000	yd^3
Spillway: Concrete morning-glory inlet, concrete conduit, concrete chute, stilling basin, and outlet channel.		
Crest elevation	225.0	ft
Capacity, El. 228	3,300	ft^3/s

LITTLE PANOCHE DETENTION DAM[2]

Type: Zoned earthfill
Location: On Little Panoche Creek.
Construction period: 1965-66
Reservoir, Little Panoche:

Total capacity to El. 641.5	5,580	acre-ft
Active capacity, El. 590-641.5	5,270	acre-ft
Surface area at El. 641.5	188	acres
Shoreline	10	mi
Dimensions:		
Structural height	151	ft
Hydraulic height	86	ft
Top width	30	ft
Maximum base width	660	ft
Crest length	1,440	ft
Crest elevation	676.0	ft
Total volume	1,160,000	yd^3
Spillway: Morning-glory inlet with concrete conduit leading to concrete stilling basin equipped with flipbucket and baffled apron.		
Crest elevation	641.5	ft
Capacity, El. 670.4	3,220	ft^3/s
Outlet works: Concrete intake structure leading to concrete conduit, terminating together with the spillway into the stilling basin.		
Capacity at El. 670.4	1,040	ft^3/s

LOS BANOS DETENTION DAM[2]

Type: Zoned earthfill
Location: On Los Banos Creek above the San Luis Canal.
Construction period: 1964-65
Reservoir, Los Banos:

Total capacity to El. 353.5	34,600	acre-ft
Active capacity, El. 296-353.5	26,300	acre-ft
Surface area at El. 327.8	470	acres
Shoreline	12	mi
Dimensions:		
Structural height	167	ft
Hydraulic height	126	ft
Top width	30	ft
Maximum base width	830	ft
Crest length	1,370	ft
Crest elevation	384.0	ft
Total volume	2,110,000	yd^3
Spillway: Approach channel, concrete crest structure, and concrete chute leading to concrete stilling basin.		
Crest elevation	353.5	ft
Capacity, El. 378.2	8,600	ft^3/s
Outlet works: Concrete intake structure connecting to a concrete conduit, then to concrete-lined tunnel. Flow empties into concrete chute and stilling basin. Flow controlled by two 3.5-ft-square high pressure gates.		
Capacity at El. 378.2	1,255	ft^3/s

Foundation special treatment: Single grout curtain with grout cap placed on bottom of cutoff trench. Also, grout curtain through spillway crest structure cutoff.

[2]Operated by California Department of Water Resources.

Carriage Facilities

San Luis Canal

Location: From O'Neill Forebay south to Kettleman City, Calif.
Construction period: 1963-68

Length	101.3	mi
Capacity	13,100	ft³/s
Section (initial reach):		
Bottom width	110	ft
Side slopes	2:1	
Water depth	32.8	ft

Coalinga Canal

Location: From above the Pleasant Valley Pumping Plant, extends southwest and somewhat parallel to the San Luis Canal.
Construction period: 1968-73

Length	11.6	mi
Capacity	1,100	ft³/s
Section (initial reach):		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	11.3	ft

O'Neill Forebay Inlet Channel

Construction period: 1965-66

Length	0.5	mi
Capacity	4,200	ft³/s
Section:		
Bottom width	80	ft
Side slopes	1.5:1	

Pleasant Valley Intake Channel

Construction period: 1968-69

Length	1.6	mi
Capacity	1,110	ft³/s
Section:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	11.8	ft

Pacheco Tunnel (Reach 1)

Location: From inlet in San Luis Reservoir west under the reservoir.
Construction period: 1964-68

Length	9,592	ft
Capacity	670	ft³/s
Cross section:		
Diameter	13	ft
Lining type: Circular		
Lining thickness	8-18	in

O'Neill Pumping-Generating Plant

Number of units	6	
Total capacity	4,200	ft³/s
Total dynamic head	44-56	ft
Total horsepower	36,000	

San Luis Pumping-Generating Plant

Number of units	8	
Total capacity	11,000	ft³/s
Total dynamic head	290	ft
Total horsepower	504,000	

Dos Amigos Pumping Plant

Number of units	6	
Total capacity	13,200	ft³/s
Total dynamic head	107-125	ft
Total horsepower	240,000	

Pleasant Valley Pumping Plant

Number of units	9	
Total capacity	1,185	ft³/s
Total dynamic head	197	ft
Total horsepower	35,250	

San Luis Water District Pumping Plants

Number of pumping plants	7	
Number of units in each plant	4-6	
Total capacity of each plant	31-103	ft³/s
Total dynamic head of each plant	162-264	ft
Total horsepower of each plant	1,100-3,000	

Westlands Water District Pumping Plants

Number of pumping plants	15	
Number of units in each plant	4-6	
Total capacity of each plant	23-96	ft³/s
Total dynamic head of each plant	87-277	ft
Total horsepower of each plant	1,100-2,400	

Power Facilities

San Luis Pumping-Generating Plant

Location: At San Luis Dam, 12 mi west of Los Banos, Calif.
Year of initial operation: 1968
Year last generator placed in operation: 1968

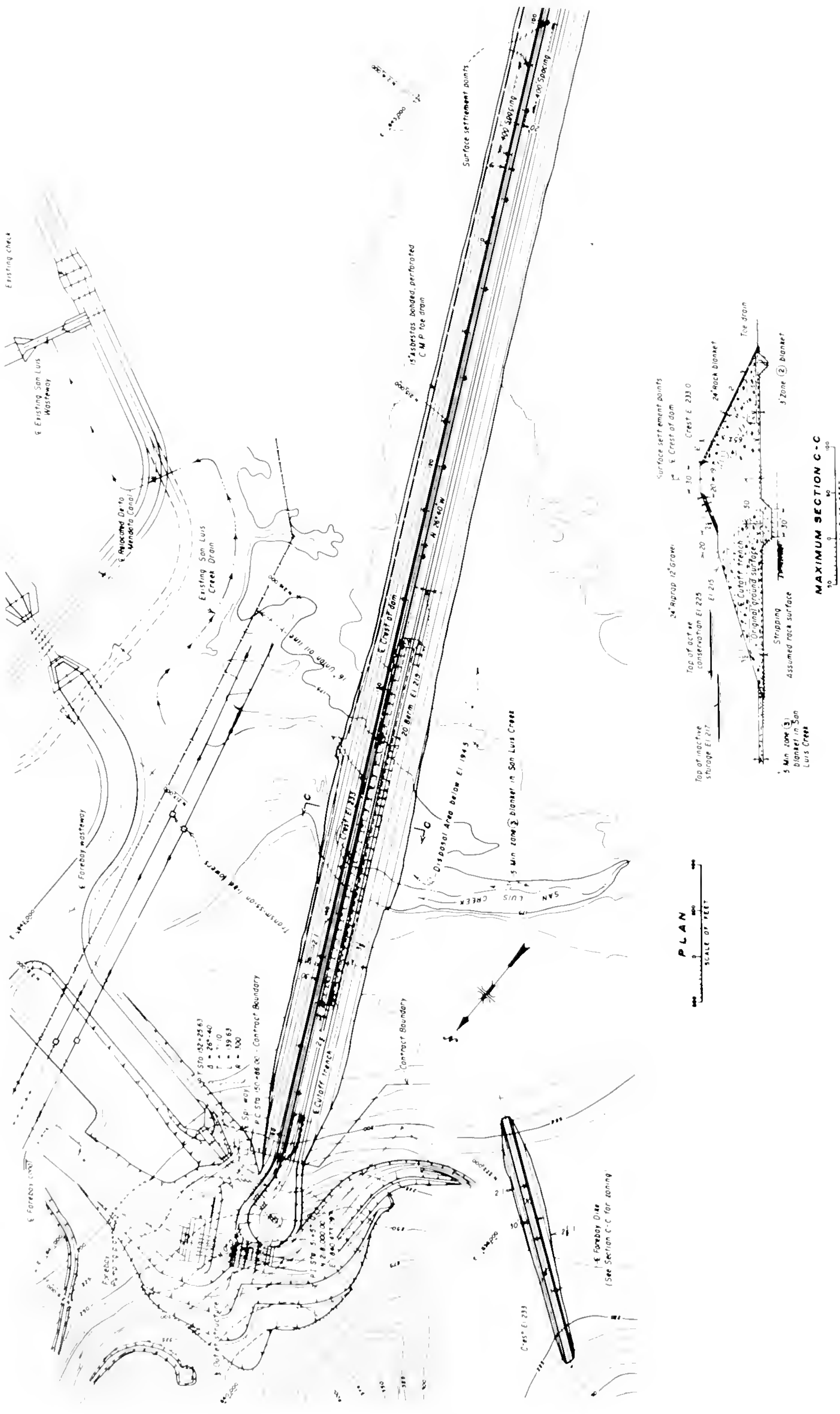
Nameplate capacity	424,000	kW
Number and capacity of generators	(8) 53,000	kW
Maximum head	323	ft

O'Neill Pumping-Generating Plant

Location: At O'Neill Forebay Dam, 12 mi west of Los Banos, Calif.
Year of initial operation: 1967
Year last generator placed in operation: 1968

Nameplate capacity	25,200	kW
Number and capacity of generators	(6) 4,200	kW
Maximum head	56	ft

San Luis Dam, Plan and Sections

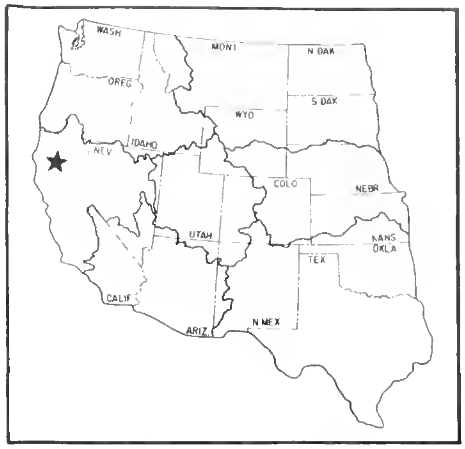


O'Neill Forebay Dam, Plan and Sections

Central Valley Project
Shasta/Trinity River Divisions

California: Shasta, Trinity, and Tehama Counties

Mid-Pacific Region
Water and Power Resources Service



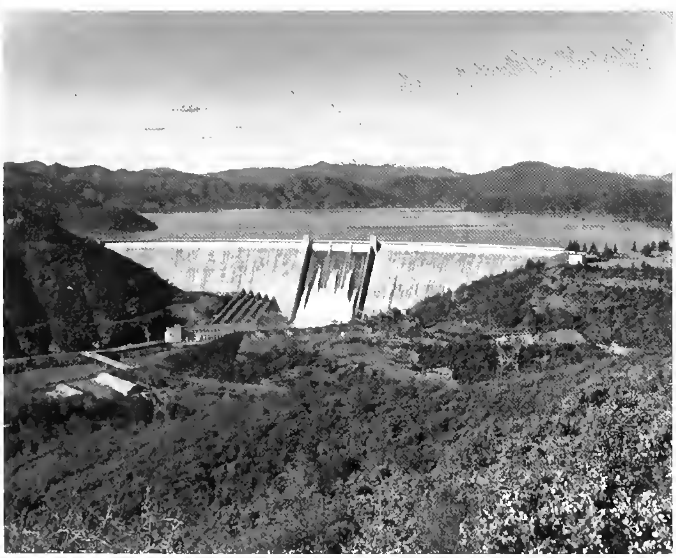
The Shasta and Trinity River Divisions catch and channel southward the headwaters of the network of Central Valley Project waterways. Shasta Dam, the main feature of the Shasta Division, was one of the initial structures of the project which was authorized in 1935. The Trinity River Division was authorized by the Congress in 1955 and completed in 1964. Surplus water from the Trinity River Basin is stored, regulated, and diverted through a system of dams, reservoirs, tunnels, and powerplants into the Sacramento River for use in water-deficient areas of the Central Valley Basin.

The Shasta Division consists of Shasta Dam and Shasta Lake, Shasta Powerplant, and Keswick Dam and Powerplant. The Trinity River Division consists of Trinity Dam and Clair Engle Lake, Trinity Powerplant, Lewiston Dam and Lake, Lewiston Powerplant, Clear Creek Tunnel, Judge Francis Carr Powerhouse, Whiskeytown Dam and Lake, Spring Creek Tunnel and Powerplant, Spring Creek Debris Dam and Reservoir, and related pumping and distribution facilities. These facilities were built and are operated by the Bureau of Reclamation. Transmission lines were constructed and operated by the Bureau of Reclamation until October 1, 1977, when they were transferred to the Western Area Power Administration, Department of Energy.

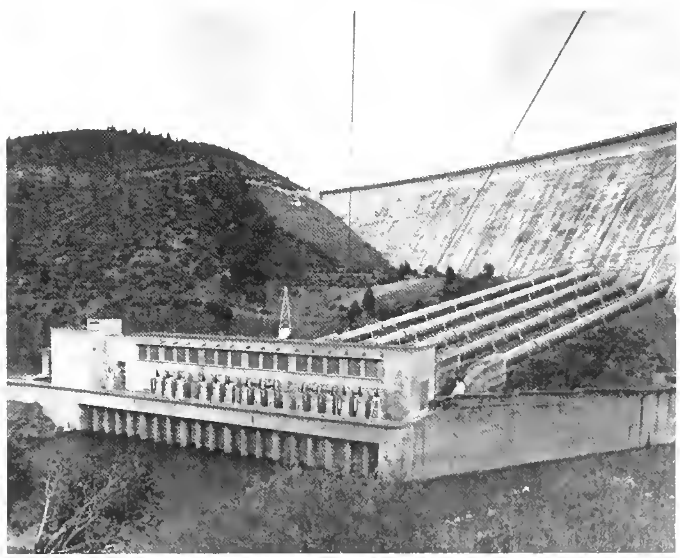
Reservoirs of both divisions provide boating, fishing, swimming, water skiing, camping, hunting, and sightseeing which are enjoyed by nearly a million tourists annually. The Whiskeytown-Shasta-Trinity National Recreation Area is administered by the Forest Service.

Shasta Dam and Shasta Lake

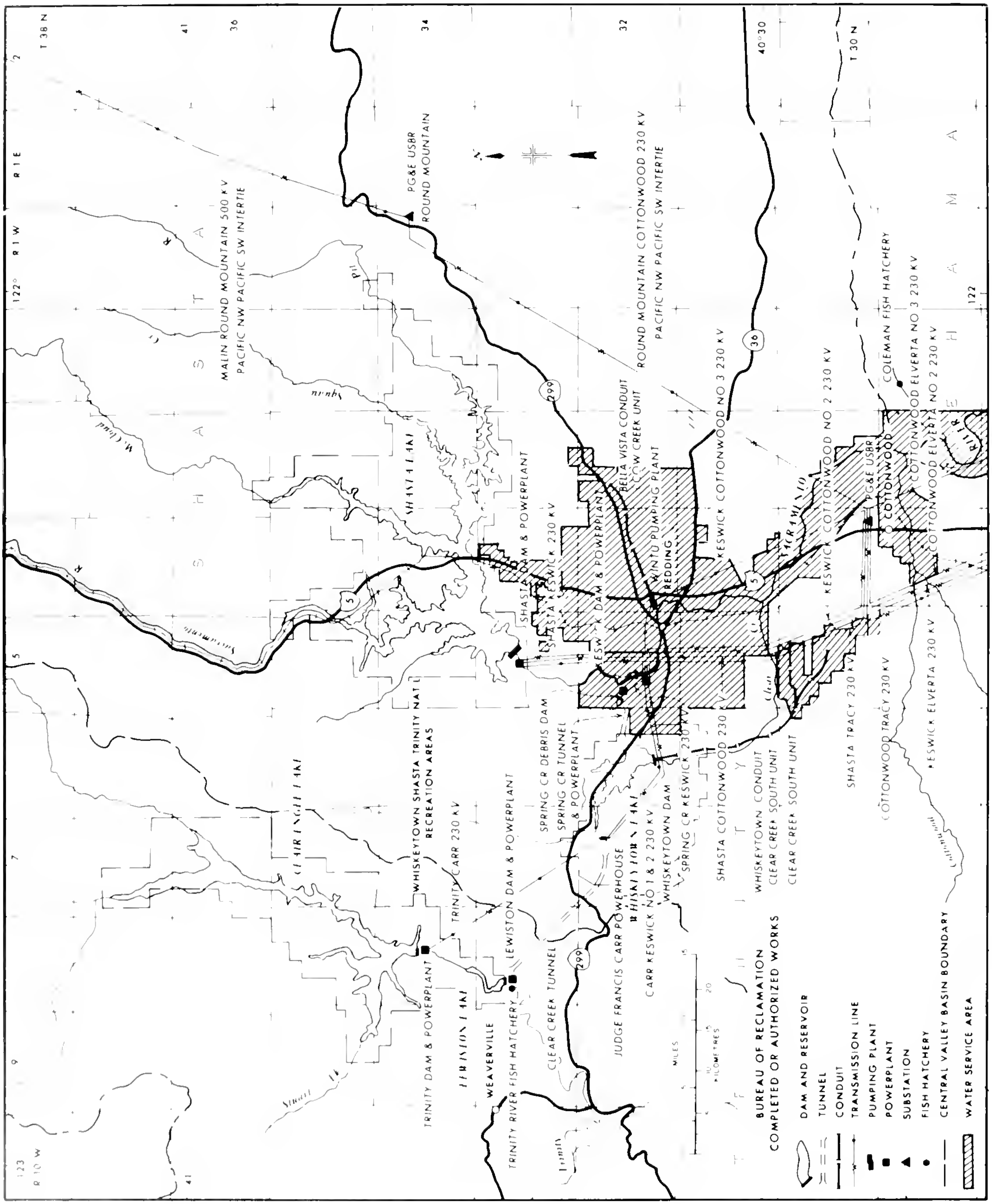
Shasta Dam, on the Sacramento River near Redding, Calif., serves to control floodwater and store surplus winter runoff for irrigation use in the Sacramento and San Joaquin Valleys, and to provide maintenance of navigation flows and conservation of fish in the Sacramento River, protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water, water for municipal and industrial use, and generation of hydroelectric energy. Completed in 1945, the dam is a curved concrete gravity structure 602 feet high with a crest length of 3,460 feet. Shasta Lake, with a capacity of



Shasta Dam and Lake



Shasta Powerplant



Central Valley Project, Shasta/Trinity River Divisions

Trinity Dam and Lake Clair Engle

4,552,000 acre-feet, provides abundant recreation, including boating, fishing, swimming, water skiing, camping, hunting, and houseboating. Many summer homesites have been developed along the shore, some accessible only by boat. Many resorts cater to the needs of the visitors to the Shasta Lake Recreation Area.

Shasta Powerplant

Shasta Powerplant is located just below Shasta Dam. Water from the dam is released through five 15-foot penstocks leading to the five main generating units and two station service units. Total capacity of these units is 539,000 kilowatts.

Keswick Dam and Reservoir

Keswick Dam is located on the Sacramento River 9 miles downstream from Shasta Dam. It is a concrete gravity structure 157 feet high with a crest length of 1,046 feet. The dam creates a 23,800 acre-foot afterbay for Shasta Lake and the Trinity River Division, and stabilizes the uneven water releases from the powerplants. The dam also has migratory fish trapping facilities that operate in conjunction with the Coleman Fish Hatchery 25 miles downstream on Battle Creek. Salmon and other migratory fish are trapped as they reach the dam, and are then taken to the hatchery operated by the Fish and Wildlife Service.

Keswick Powerplant

Keswick Powerplant, located at Keswick Dam, has three generating units with a total capacity of 75,000 kilowatts.

Trinity Dam and Clair Engle Lake

On the Trinity River, Trinity Dam regulates flows and stores surplus water for irrigation. Completed in 1962, it is an earthfill structure 538 feet high with a crest length of 2,450 feet. The dam forms Clair Engle Lake with a storage capacity of 2,448,000 acre-feet. The lake offers recreation facilities for camping, boating, water skiing, swimming, fishing, and hunting.

Trinity Powerplant

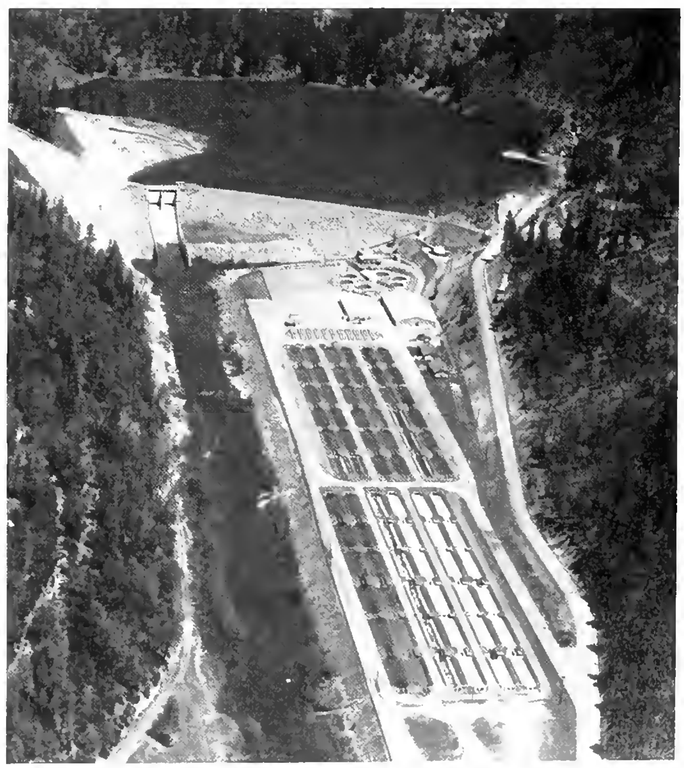
Trinity Powerplant at Trinity Dam has two generators with a total capacity of 105,556 kilowatts.

Lewiston Dam and Lake

Lewiston Dam, about 7 miles downstream from Trinity Dam, creates an afterbay to Trinity Powerplant and diverts water by means of Clear Creek Tunnel to Whiskeytown Lake. Lewiston Dam is an earthfill structure 91 feet high and 745 feet long, forming a reservoir with a capacity of 14,660 acre-feet.

Lewiston Powerplant

Lewiston Powerplant, using releases for the support of fish life and other downstream purposes in the Trinity River, has one station service unit with a capacity of 350 kilowatts.



Lewiston Dam and Reservoir

Trinity River Fish Hatchery

The Trinity River Fish Hatchery, operated by the California Department of Fish and Game, has a capacity of about 40 million eggs. It is immediately downstream from Lewiston Dam and compensates for the upstream spawning area that has been rendered inaccessible and unusable by the dams.

Clear Creek Tunnel

Clear Creek Tunnel, 17.4 feet in diameter and 10.7 miles long, conveys water from Lewiston Lake to Judge Francis Carr Powerhouse and Whiskeytown Lake. A bypass is provided into Crystal Creek.

Judge Francis Carr Powerhouse

The Judge Francis Carr Powerhouse on Clear Creek has two generators with a total capacity of 141,444 kilowatts.

Whiskeytown Dam and Lake

Located on Clear Creek, Whiskeytown Dam provides regulation for Trinity River flows discharged from Judge Francis Carr Powerhouse and regulates the runoff from the Clear Creek drainage area. The dam is an earthfill structure 282 feet high with a crest length of 4,000 feet. The reservoir, Whiskeytown Lake, has a capacity of 241,100 acre-feet and provides recreation facilities for picnicking, camping, swimming, boating, water skiing, fishing, and hunting.

Judge Francis Carr Powerhouse

Whiskeytown Dam and Lake

Spring Creek Tunnel

The Spring Creek Tunnel diverts water from Whiskeytown Lake on Clear Creek, a tributary of the Sacramento River, to the Spring Creek Powerplant. The tunnel is 18.4 feet in diameter and about 2.4 miles in length, including the 0.6-mile-long, 17-foot-diameter Rock Creek Siphon.

Spring Creek Powerplant

Spring Creek Powerplant is located on an arm of Spring Creek at Keswick Reservoir. It has two generators with a total capacity of 150,000 kilowatts.

Spring Creek Debris Dam and Reservoir

Spring Creek Debris Dam, located on Spring Creek above the Spring Creek Powerplant tailrace, is an earthfill structure 196 feet high with a crest length of 1,110 feet. Spring Creek Reservoir, with a capacity of 5,870 acre-feet, controls debris which would otherwise enter the powerplant tailrace, and provides important fishery benefits by controlling contaminated runoff resulting from old mine tailings on Spring Creek.

Distribution System

The Cow Creek Unit and the Clear Creek South Unit were authorized as a part of the Trinity River Division. They consist of pumping plants and conveyance systems to transport irrigation water to some 6,800 acres of irrigable land east of Redding, and 4,600 acres of irrigable land west of Anderson, respectively.

Keswick Dam and Powerplant

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	475,828	acres
Number of irrigated farms	3,532	

Facilities in Operation

Storage dams	6	
Conduits and aqueducts	16.3	mi
Tunnels	13.3	mi
Pumping plants	1	
Powerplants	5	
Transmission lines	11.99	mi
Substations	6	

Climatic Conditions

Annual precipitation:		
Trinity River Hatchery	35.7	in
Shasta Dam	60.1	in
Temperature:		
Maximum	116	°F
Minimum	−7	°F
Mean	53	°F
Growing season	150	days
Elevation of irrigable area	550.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	13,954
Urban/suburban irrigation service	16,927
Municipal and other water service	36,725
Total	67,606

ENGINEERING DATA

Water Supply

Sacramento River

Drainage area at Shasta Dam	6,665	mi²
Annual discharge:		
Maximum (1958)	9,121,000	acre-ft
Minimum (1924)	2,654,000	acre-ft
Average	5,575,000	acre-ft

Trinity River

Drainage at Lewiston	719	mi²
Annual discharge:		
Maximum (1941)	2,672,000	acre-ft
Minimum (1968)	126,300	acre-ft
Average	1,245,000	acre-ft

Clear Creek

Drainage area at Igo	228	mi²
Annual discharge:		
Maximum (1941)	747,800	acre-ft
Minimum (1972)	58,620	acre-ft
Average	333,300	acre-ft

Storage Facilities

Shasta Dam

Type: Concrete curved gravity, embankment wing
Location: On the Sacramento River 9 mi northwest of Redding, Calif.
Construction period: 1938-45

Reservoir, Shasta Lake:

Average annual inflow, 1922-70	5,439,600 acre-ft
Total capacity to El. 1067	4,552,000 acre-ft
Active capacity, El. 840 to 1067	3,965,000 acre-ft
Surface area at El. 1067	29,740 acres
Length	35 mi
Shoreline	365 mi

Dimensions:

Structural height	602 ft
Hydraulic height	525 ft
Top width	30 ft
Maximum base width	883 ft
Crest length	3,460 ft
Crest elevation	1077.5 ft
Total volume	8,430,000 yd³

Spillway: Overflow section near center of dam controlled by three 110- by 28-ft drum gates.

Elevation top of gates	1069.5 ft
Crest elevation	1037.0 ft
Capacity, El. 1065[1]	186,000 ft³/s

Outlet works: Eighteen 102-in-diameter conduits through dam in three tiers (6-in upper, 8-in middle, 4-in lower) controlled by fourteen 96-in wheel-type gates (upper and middle) and four 102-in tube valves. Five 183-in-diameter steel pipes through dam, controlled by five 15- by 19-ft coaster gates, deliver water to the powerplant.

Capacity	81,800 ft³/s

Foundation: Hard, tough, durable greenstone; usually hard and sound beneath streambed. In abutments, decay of the geologically ancient formation penetrates deeply along many joints and occasional small crush zones.

Special treatment: Cement grout curtain with adjacent drainage holes placed beneath foundation drainage gallery; crush zones cleaned out to sound rock and backfilled with concrete; mud seams, joints, and crevices pressure-grouted.

Mass concrete: Natural aggregate from pits near Redding, Calif. Oversize crushed; low heat cement; temperature control with river water and refrigerated water in extreme heat; aggregate and mixing water cooled in summer, heated in winter.

Volume:

Earth	2,160,000 yd³
Concrete	6,270,000 yd³

Keswick Dam

Type: Concrete gravity, embankment wings

Location: On the Sacramento River about 4 mi northwest of Redding, Calif.

Construction period: 1941-50

Reservoir, Keswick:

Average annual inflow 1943-70	6,091,300 acre-ft
Total capacity to El. 587	23,800 acre-ft
Active capacity, El. 574 to 587	7,470 acre-ft
Surface area at El. 587	640 acres
Length	9 mi
Shoreline	25.5 mi

Dimensions:

Structural height	157 ft
Hydraulic height	118 ft
Top width	20 ft
Maximum base width	110.6 ft
Crest length	1,046 ft
Crest elevation	595.5 ft
Total volume	197,000 yd³

[1]Capacity does not include 2-ft flashboards.

Spillway: Overflow section at left side of dam controlled by four 50-ft-square slide gates.

Elevation top of gates	587 ft
Crest elevation	537.0 ft
Capacity, El. 589.8	271,000 ft³/s

Outlet works: Power — nine penstock openings in powerhouse section controlled by nine 23- by 17-ft fixed-wheel gates. Fish trap — concrete conduit through dam controlled by one 5-ft-square slide gate.

Capacity of power outlet works	248,000 ft³/s

Foundation: Badly weathered quartz-biotite schist cut by calcite veins, quartz veins, clay seams, and mud seams. Large fault marked by a crush zone 10 to 12 ft wide strikes up and downstream and crosses the damsite under the old stream channel.

Special treatment: Grout blanket over entire foundation area; grout curtain along upstream toe.

Volume	197,000 yd³

Trinity Dam

Type: Zoned earthfill

Location: On the Trinity River about 9 mi upstream from Lewiston, Calif.

Construction period: 1957-62

Reservoir, Clair Engle Lake:

Average annual inflow 1912-70	1,168,500 acre-ft
Total capacity to El. 2370	2,448,000 acre-ft
Active capacity, El. 2145-2370	2,135,000 acre-ft
Surface area at El. 2370	16,535 acres
Shoreline	145 mi

Dimensions:

Structural height	538 ft
Hydraulic height	440 ft
Top width	40 ft
Maximum base width	2,680 ft
Crest length	2,450 ft
Crest elevation	2395.0 ft
Total volume	29,410,000 yd³

Spillway: Tunnel on left abutment; uncontrolled morning-glory concrete crest structure 54 ft in diameter.

Crest elevation	2370.0 ft
Capacity, El. 2387	24,000 ft³/s

Outlet works: Tunnel 28 ft in diameter through left abutment with one penstock bifurcating into two just upstream from powerhouse, with bypass outlet facilities adjacent to the powerplant.

Lewiston Dam (Storage and Diversion)

Type: Zoned earthfill

Location: On the Trinity River about 7 mi downstream from Trinity Dam.

Construction period: 1960-63

Reservoir, Lewiston Lake:

Total capacity to El. 1902	14,660 acre-ft
Active capacity, El. 1898-1902	2,890 acre-ft
Surface area at El. 1902	750 acres
Shoreline	15 mi

Dimensions:

Structural height	91 ft
Hydraulic height	73 ft
Top width	25 ft
Maximum base width	380 ft
Crest length	745 ft
Crest elevation	1910.0 ft
Total volume	265,000 yd³

Spillway: Gated chute with two 30- by 27.5-ft radial gates.	
Elevation, top of gates	1902.0 ft
Crest elevation	1874.5 ft
Capacity, El. 1902	30,000 ft³/s

WHISKEYTOWN DAM

Type: Zoned earthfill	
Location: On Clear Creek about 9 mi west of Redding, Calif.	
Construction period: 1960-63	
Reservoir, Whiskeytown Lake:	
Total capacity to El. 1210	241,100 acre-ft
Active capacity, El. 1100-1210	213,550 acre-ft
Surface area at El. 1210	3,220 acres
Shoreline	36 mi
Dimensions:	
Structural height	282 ft
Hydraulic height	252 ft
Top width	30 ft
Maximum base width	1,450 ft
Crest length	4,000 ft
Crest elevation	1228.0 ft
Total volume	4,535,000 yd³
Spillway: Morning-glory type, 24.5 ft in diameter, leading to a 21-ft-diameter concrete lined tunnel with a flip bucket and outlet channel.	
Crest elevation	1210.0 ft
Capacity, El. 1220.5	28,650 ft³/s
Outlet works: Consists of a 19-ft-diameter conduit and concrete lined tunnel, and an upper level system consisting of a concrete intake structure and shaft with a 6-ft-diameter concrete lined tunnel. Flow into the control house controlled by 2.75- by 3.75-ft gates.	
Capacity at El. 1220.5	12,500 ft³/s
Foundation special treatment: A double cap and grout curtain was placed at the bottom of the cutoff trench along with an upstream grout curtain. Grouting also performed in rock surrounding the spillway and outlet works shafts and tunnels.	

SPRING CREEK DEBRIS DAM

Type: Earthfill	
Location: On Spring Creek upstream from the Spring Creek Powerplant tailrace channel.	
Construction period: 1961-63	
Reservoir, Spring Creek:	
Total capacity to El. 795	5,870 acre-ft
Active capacity, El. 679-795	5,650 acre-ft
Surface area at El. 795	87 acres
Shoreline	2.5 mi
Dimensions:	
Structural height	196 ft
Hydraulic height	169 ft
Top width	30 ft
Maximum base width	1,040 ft
Crest length	1,110 ft
Crest elevation	816.0 ft
Total volume	1,891,000 yd³
Spillway: Ungated chute	
Crest elevation	795.0 ft
Capacity, El. 809.5	5,260 ft³/s
Outlet works: A 6-ft-diameter concrete lined tunnel with two 2.25-ft-square gates to a 6.5-ft flat bottom concrete conduit.	
Capacity at El. 809.5	660 ft³/s

Carriage Facilities

CLEAR CREEK SOUTH MAIN AQUEDUCT

Construction period: 1965-67	
Length	8.5 mi
Capacity	73 ft³/s
Cross section:	
Diameter	2.8-2.6 ft
Lining type: Steel and concrete	

COW CREEK MAIN AQUEDUCT

Construction period: 1965-66	
Length	7.8 mi
Capacity	92 ft³/s
Cross section:	
Diameter	3.4 ft
Lining type: Pretensioned reinforced concrete	

SPRING CREEK TUNNEL

Location: From the east side of Whiskeytown Lake easterly through the Rock Creek Siphon, then to the Spring Creek Powerplant.	
Construction period: 1960-63	
Length	12,707 ft
Capacity	3,800 ft³/s
Cross section:	
Diameter	18.4 ft
Lining type: Circular	
Lining thickness	9-37 in

CLEAR CREEK TUNNEL

Location: From Lewiston Reservoir near Lewiston Dam southeasterly to the Judge Francis Carr Powerhouse and Whiskeytown Lake.	
Construction period: 1957-62	
Length	56,668 ft
Capacity	3,200 ft³/s
Cross section:	
Diameter	17.4 ft
Lining type: Circular	
Lining thickness	9-37 in

SPRING CREEK POWERPLANT TAILRACE TUNNEL

Construction period: 1960-62	
Length	567 ft
Capacity	3,600 ft³/s
Cross section:	
Diameter	21 ft
Lining type: Horseshoe	

JUDGE FRANCIS CARR POWERHOUSE BYPASS

Construction period: 1969-70	
Length	270 ft
Capacity	1,600 ft³/s
Cross section:	
Diameter	6 ft
Lining type: Circular	
Lining thickness	9 in

WINTU PUMPING PLANT

Number of units	4
Total capacity	100 ft³/s
Total dynamic head	295 ft
Total horsepower	4,000

Power Facilities

Shasta Powerplant

Location: Shasta Dam
Year of initial operation: 1944
Year last generator placed in operation: 1949

Nameplate capacity		539,000 kW
Number and capacity of generators	(2)	143,750 kW
	(3)	109,250 kW
	(2)	2,300 kW
Maximum head		487 ft

Keswick Powerplant

Location: Keswick Dam
Year of initial operation: 1949
Year last generator placed in operation: 1950

Nameplate capacity		75,000 kW
Number and capacity of generators	(3)	28,750 kW
Maximum head		101 ft

Trinity Powerplant (Includes Lewiston Powerplant)

Location: Trinity Powerplant - At Trinity Dam
Lewiston Powerplant - At Lewiston Dam.
Year of initial operation: 1964
Year last generator placed in operation: 1964

Nameplate capacity		105,906 kW
Number and capacity of generators	(2)	60,695 kW
	(1)	403 kW
Maximum head		470 ft

Judge Francis Carr Powerhouse

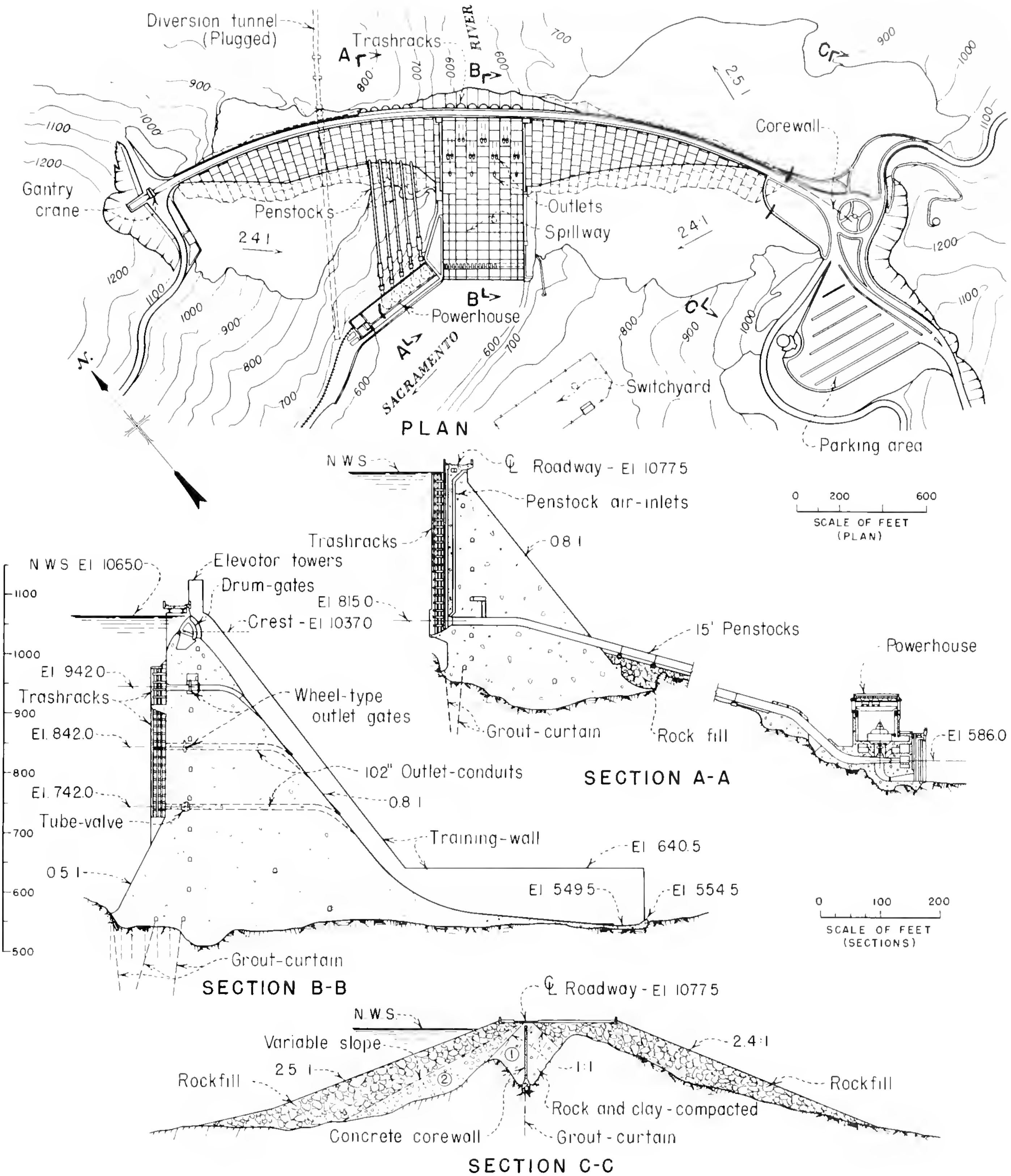
Location: At the outlet of Clear Creek Tunnel on the northwestern extremity of Whiskeytown Lake.
Year of initial operation: 1963
Year last generator placed in operation: 1963

Nameplate capacity		141,444 kW
Number and capacity of generators	(2)	81,330 kW
Maximum head		712 ft

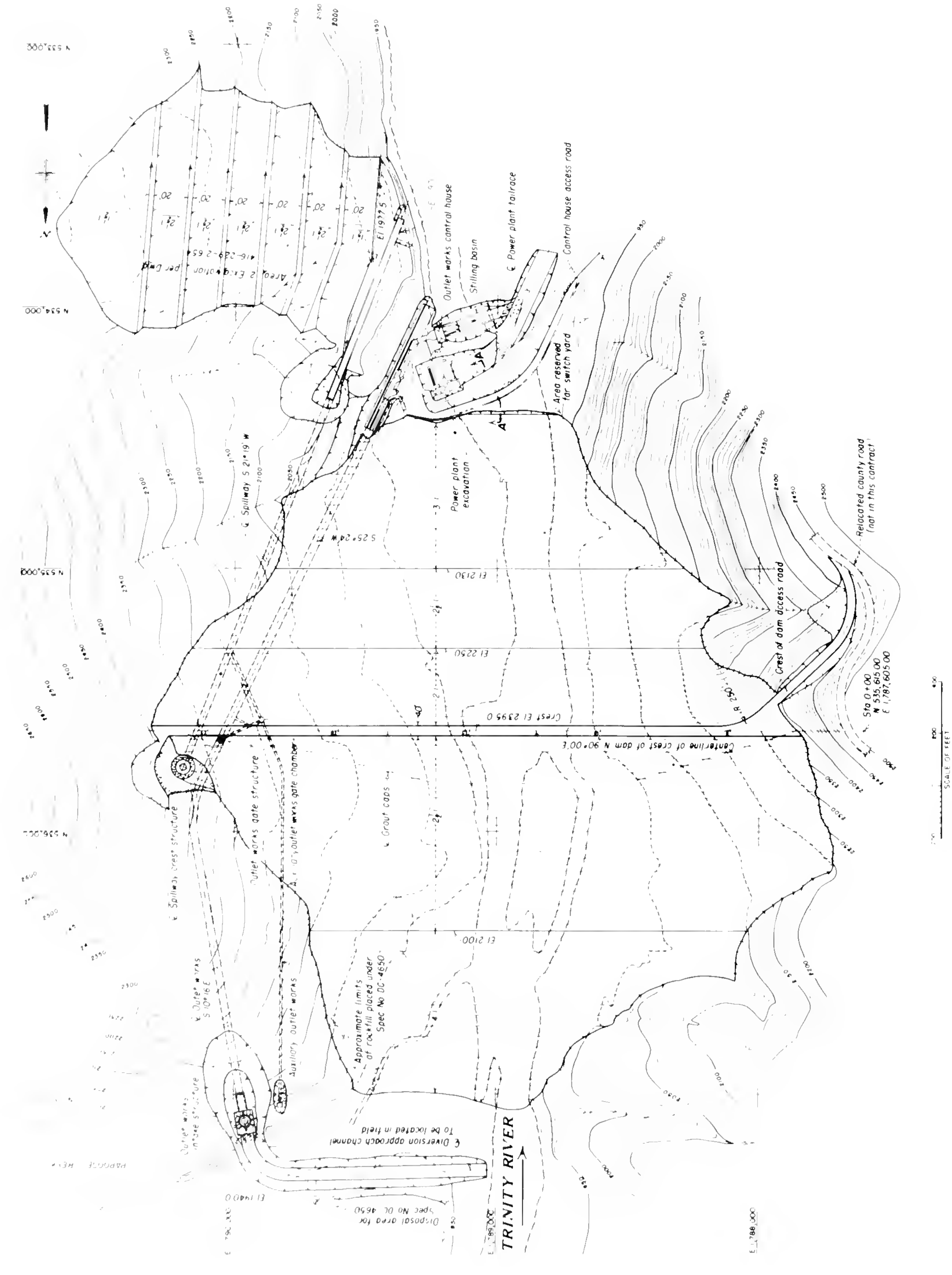
Spring Creek Powerplant

Location: On the Spring Creek arm of Keswick Reservoir.
Year of initial operation: 1964
Year last generator placed in operation: 1964

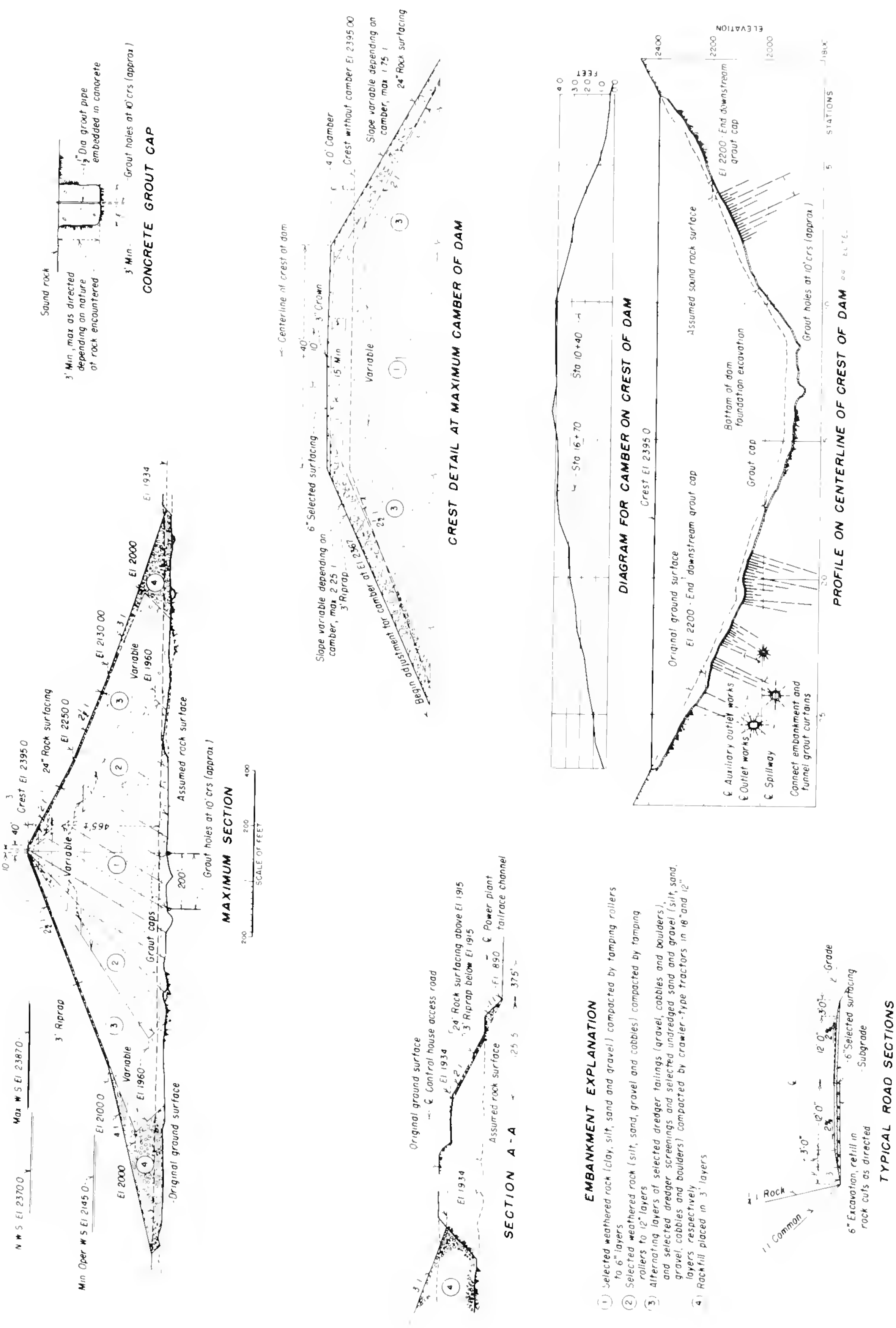
Nameplate capacity		150,000 kW
Number and capacity of generators	(2)	86,250 kW
Maximum head		636 ft



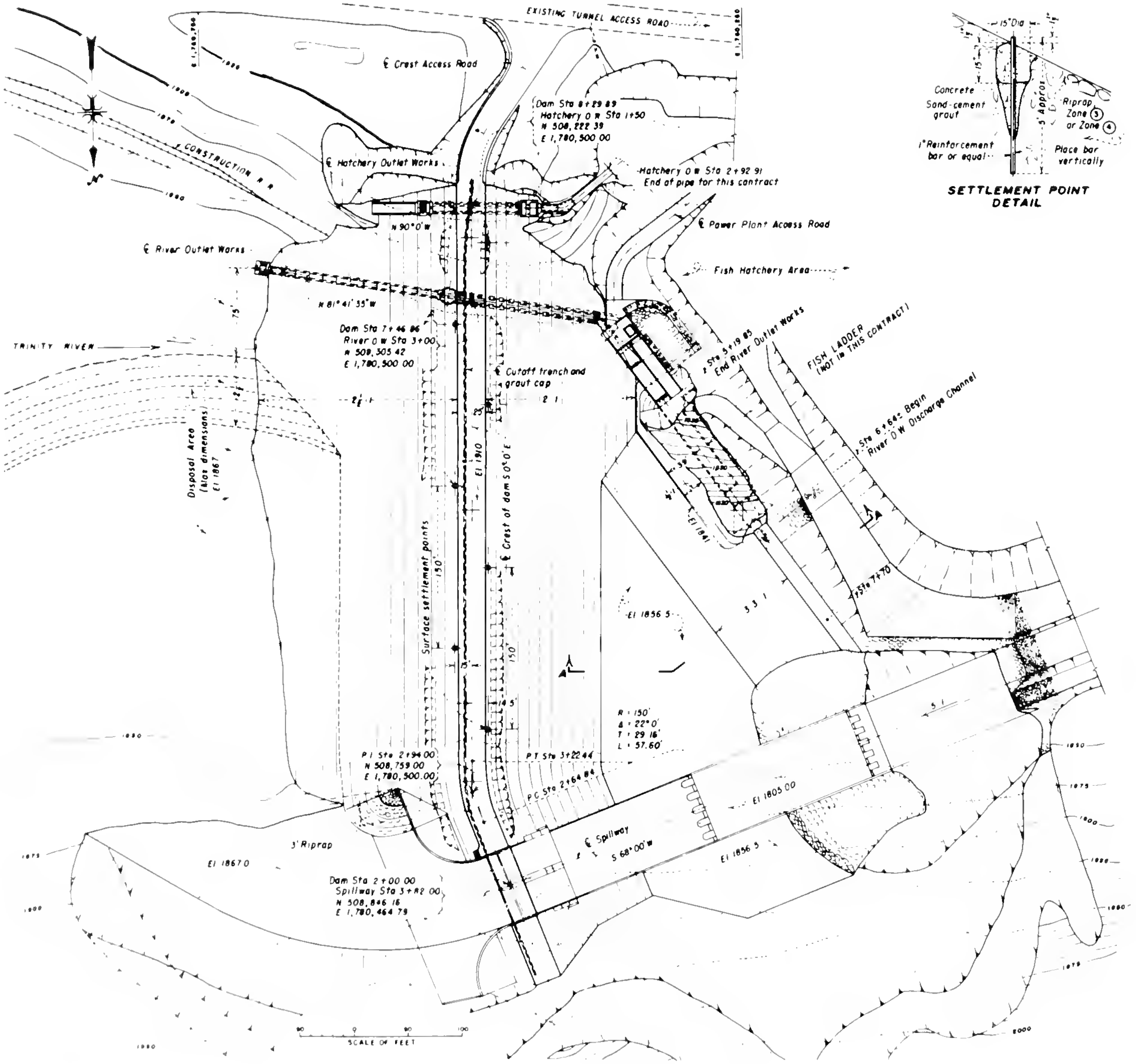
Shasta Dam, Plan and Sections



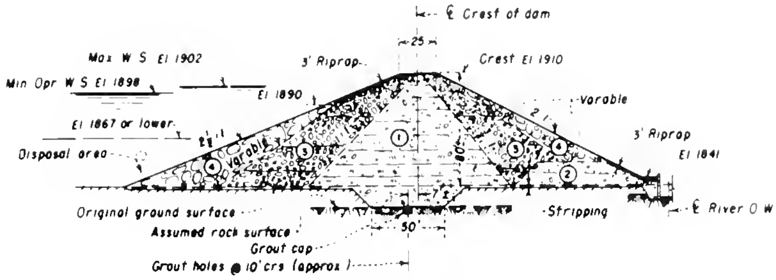
Trinity Dam, Plan



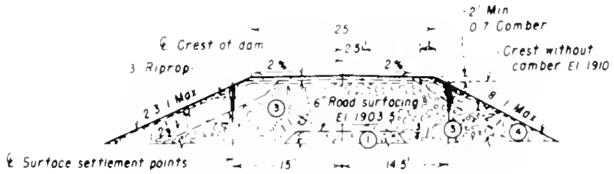
Trinity Dam, Sections



Lewiston Dam, Plan



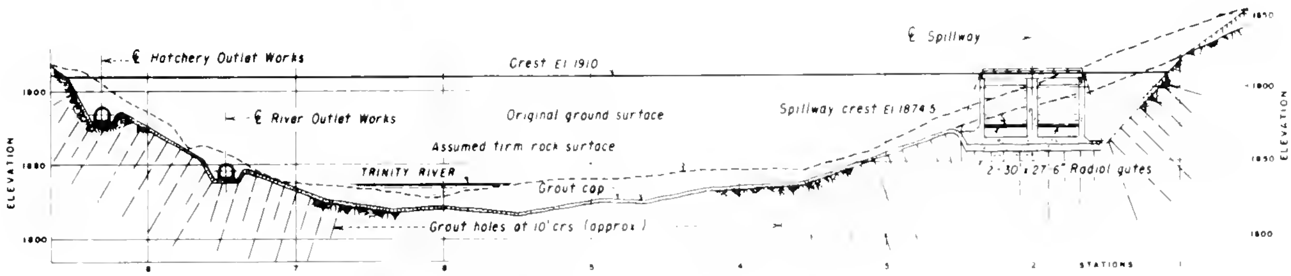
MAXIMUM SECTION



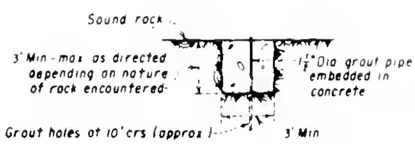
CRES T DETAIL AT MAXIMUM CAMBER

EMBANKMENT EXPLANATION

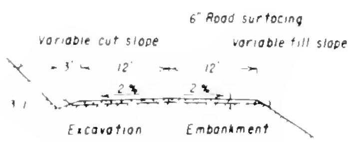
1. Selected weathered rock (clay, silt, sand and gravel sizes) compacted by tamping rollers to 6-inch layers
2. Selected sand, gravel, and cobbles compacted by crawler-type tractor to 12-inch layers
3. Selected weathered rock and fresh rock fragments to 12-inch max size compacted by tamping rollers in 12"-inch layers
4. Rock fill placed in 3-foot layers



PROFILE ON ℄ OF CREST OF DAM



CONCRETE GROUT CAP

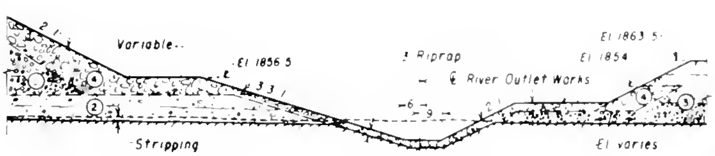


TYPICAL CREST ROAD SECTION

RESERVOIR STORAGE ALLOCATIONS

PURPOSE	ELEVATIONS	STORAGE ACRE-FEET
Power	1898 to 1902	2,000
Inactive	Streambed to 1898	12,000
Total storage capacity		14,000

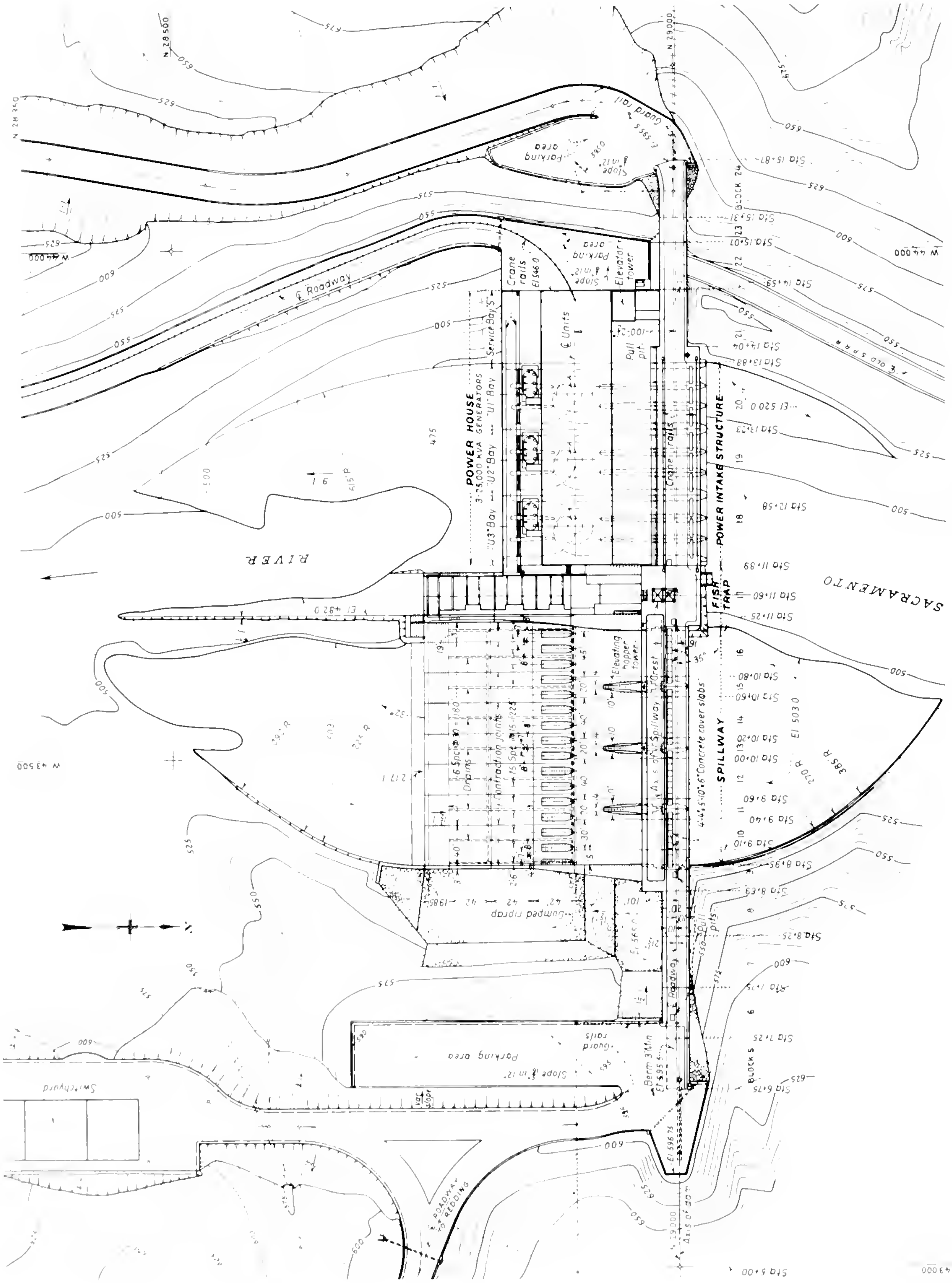
A spillway capacity of 30,000 c.f.s at Max W S El 1902 is provided to pass the maximum Trinity Dam flood release



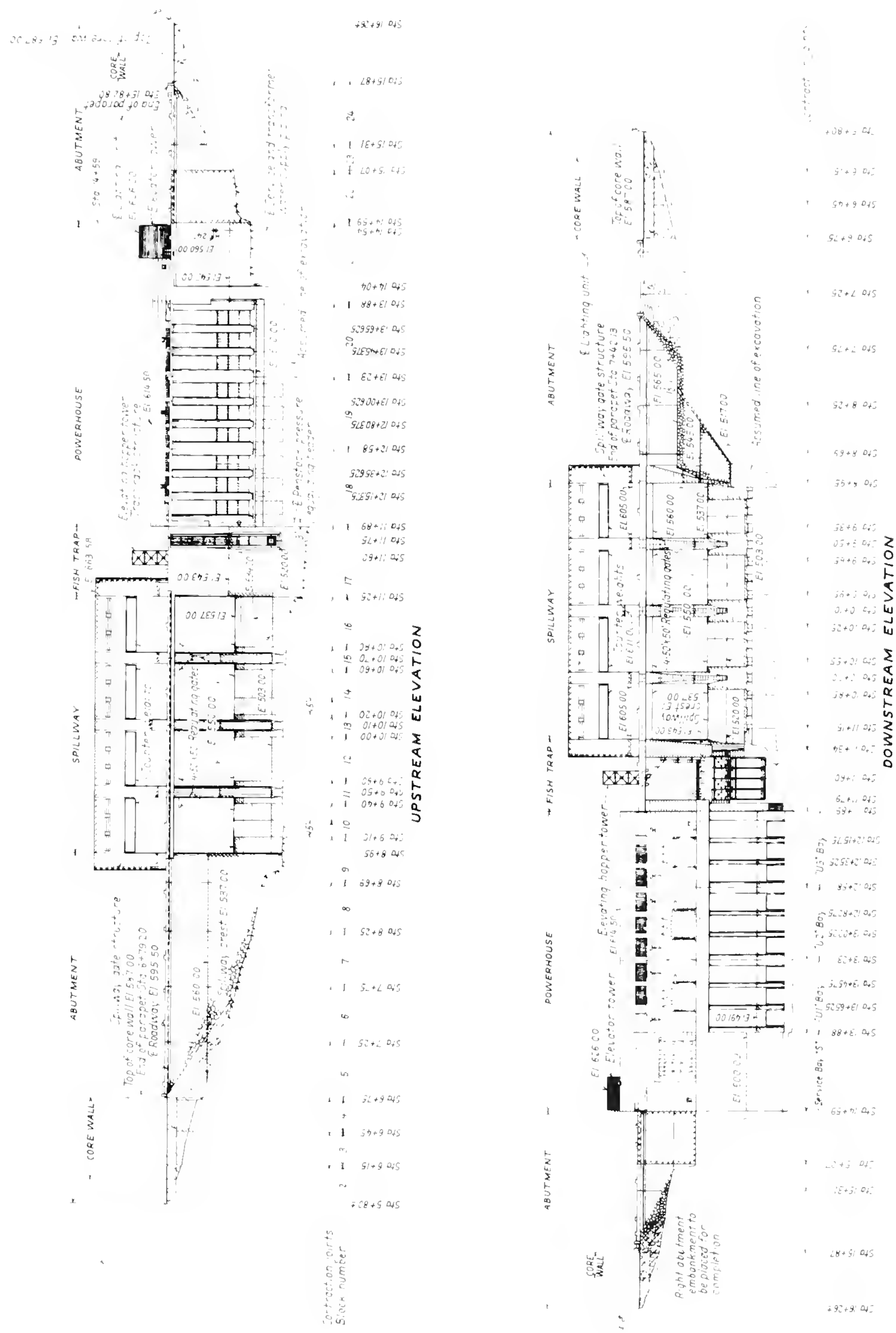
SECTION A-A

10 0 50
SCALE OF FEET

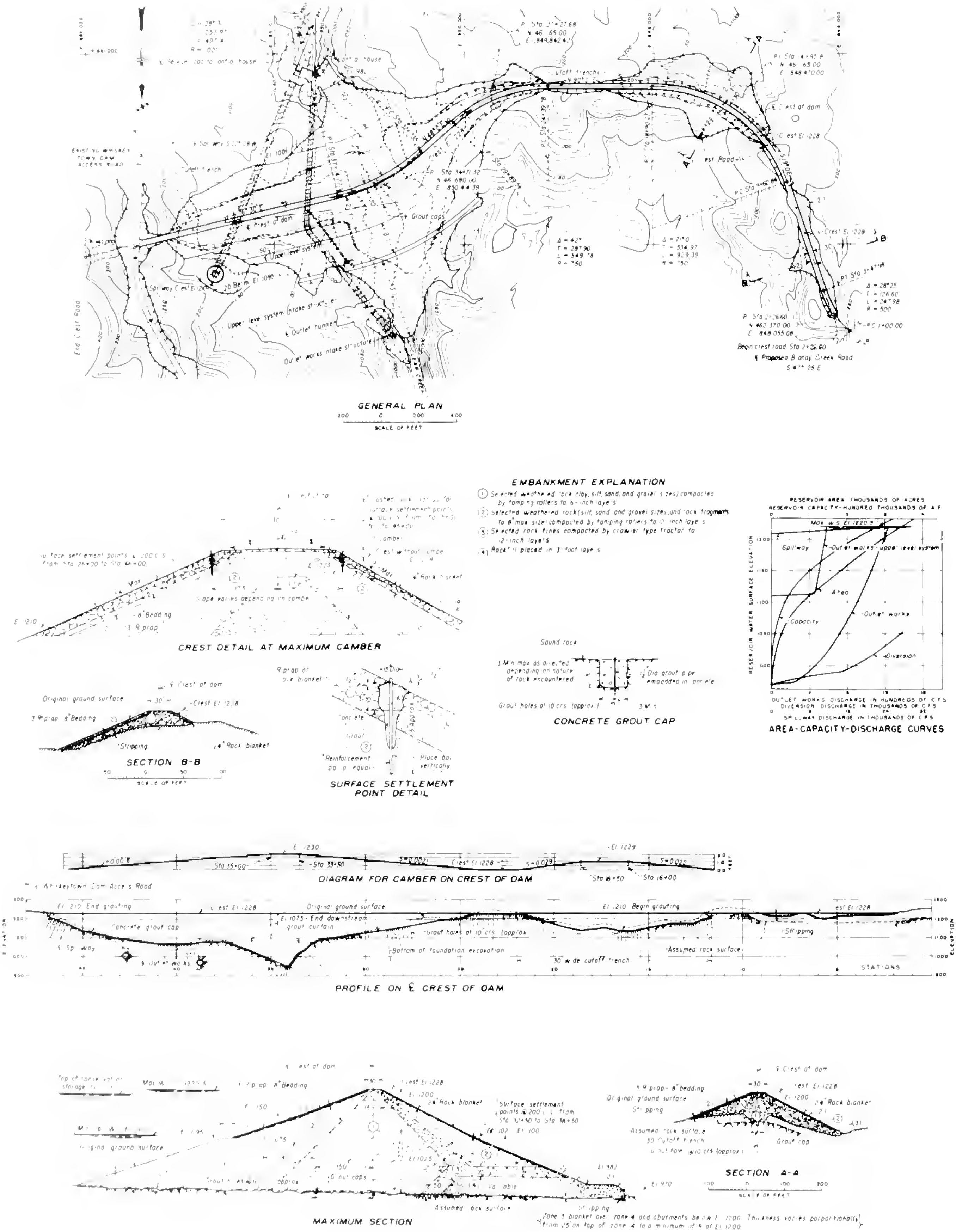
Lewiston Dam, Sections



Keswick Dam and Powerplant, Plan



Keswick Dam and Powerplant, Profiles

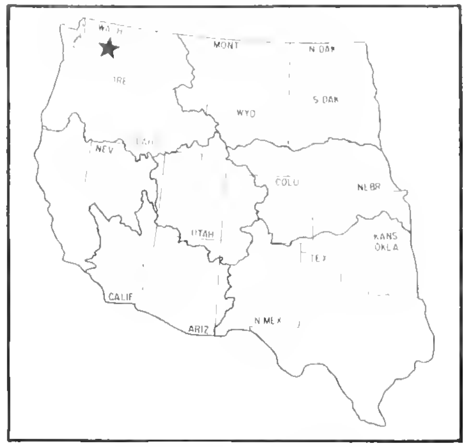


Whiskeytown Dam, Plan and Sections

Chief Joseph Dam Project

Washington: Chelan, Douglas, and Okanogan Counties

Pacific Northwest Region
Water and Power Resources Service



Chief Joseph Dam, constructed by the Corps of Engineers, is on the Columbia River in north-central Washington and is a key structure in the comprehensive development of the Columbia River Basin. Storage water from the reservoir, and power revenues to assist in paying for irrigation features, are necessary for present and future irrigation development of the area.

Four divisions of the Chief Joseph Dam Project have been authorized: Foster Creek, Greater Wenatchee, Okanogan-Similkameen, and Chelan.

Lands of the Foster Creek Division are along the Columbia River near its confluence with the Okanogan River. The division includes the Bridgeport Bar and Brewster Flat Units, which have been constructed and are in operation. A third unit, Bluebottle Flat, has been authorized but construction has been deferred.

Four of the original seven units of the Greater Wenatchee Division have been authorized. Three of these units have been constructed—Brays Landing, East Wenatchee, and Howard Flat. Moses Coulee Unit has been authorized, but construction deferred.

The Oroville-Tonasket and Whitestone Coulee Units of the Okanogan-Similkameen Division have been constructed and are in operation. The third unit, Oroville-Tonasket Unit Extension, has been authorized and construction is expected to start soon.

The Chelan Division, Manson Unit, has been authorized and constructed. The unit is located in Chelan County, bordering the north shore of the lower end of Lake Chelan, about 40 miles up the Columbia River from Wenatchee.

PLAN

Foster Creek Division

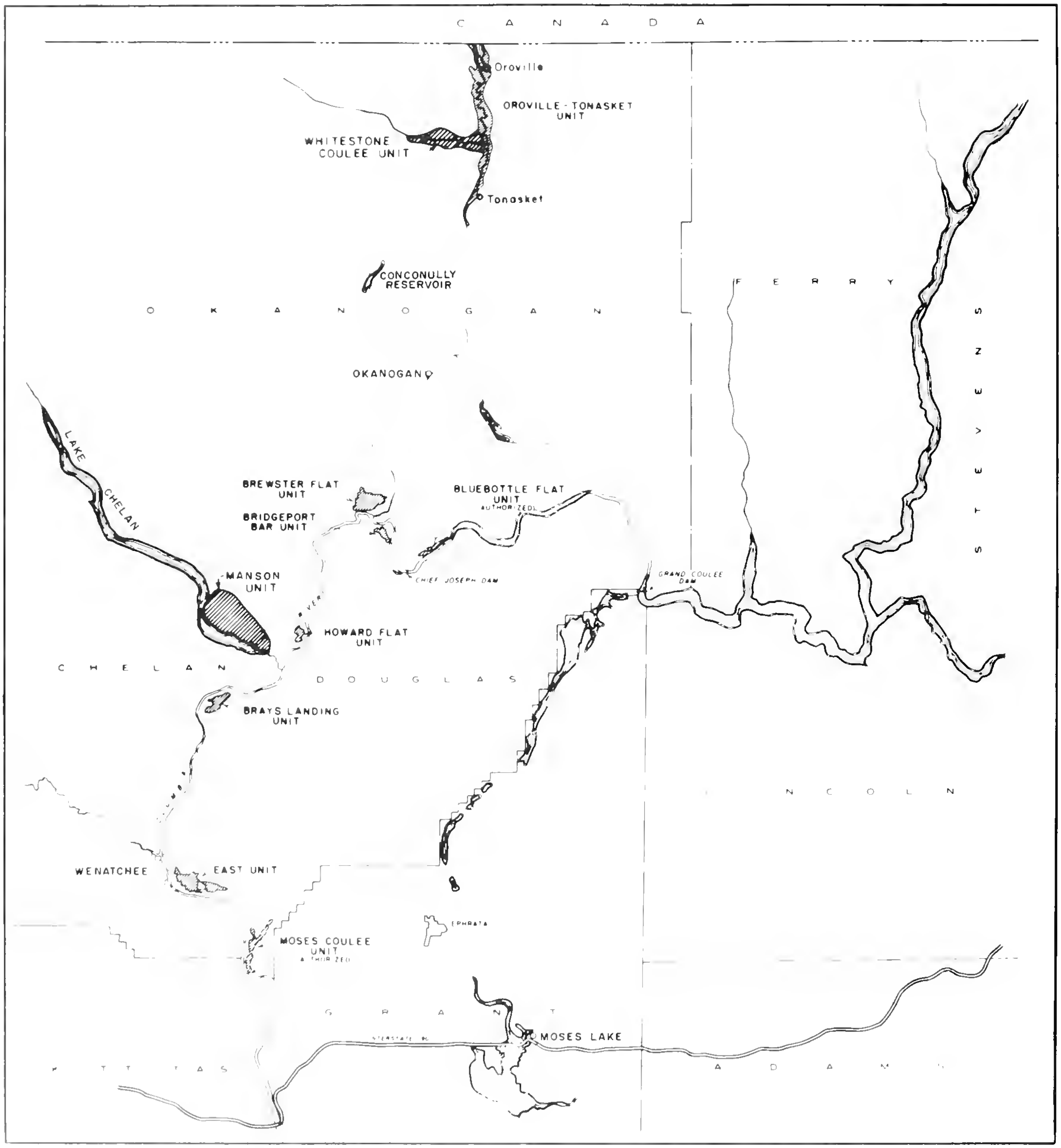
The Foster Creek Division provides a full water supply to 2,907 acres of irrigable land.

Brewster Flat Unit.—This unit required the construction of a main pumping plant, a booster pumping plant, a relift pumping plant, two steel reservoirs, and a closed-pipe distribution system to serve 2,432 acres of irrigable land. The main plant is on the right bank of the Columbia River and has four 11.7-cubic-foot-per-second, 190-foot head, vertical turbine deep well pumps. The booster plant is located in a building a short distance from the river. The building houses four 11.5-cubic-foot-per-second, 350-foot head, horizontal centrifugal pumping units.

A relift pumping plant at the 66,840-cubic-foot (0.5-Mgal) equalizing reservoir has three 13-cubic-foot-per-second, 150-foot head, horizontal centrifugal pumping units.

Two steel tanks, constructed on the discharge lines, serve as equalizing reservoirs for the distribution system. The lower tank has a capacity of 66,840 cubic feet and 40,100 cubic feet (0.3 Mgal) in the upper tank.

Bridgeport Bar Unit.—This unit includes two entirely separate and independent systems and areas. The plan selected for the Townsite area (301 acres) will involve construction of a gravity supply canal from the left abutment of Chief Joseph Dam to the existing facilities serving part of the area. Development of this area has been deferred. A small pumping plant has been constructed to serve the remaining area, primarily the new land. The plan for the Bar area (475 acres) required a complete new system to serve the area, only a fraction of which was previously irrigated through individual systems. Major features include a pumping plant on the Columbia River, an equalizing reservoir, a steel discharge line, and a steel and asbestos-cement pipe distribution system. The pumping plant consists of two vertical turbine pumps, each capable of delivering 4.45 cubic feet per second at a dynamic head of 200 feet. The equalizing reservoir is a 13,368-cubic-foot (0.1-Mgal) steel tank.



Chief Joseph Dam Project

Lake Chelan Pumping Plant

Greater Wenatchee Division

A total of 7,104 acres of irrigable land is being served by closed-pipe distribution systems of the East, Brays Landing, and Howard Flat Units of the Great Wenatchee Division. The three units are separate land areas requiring independent irrigation systems.

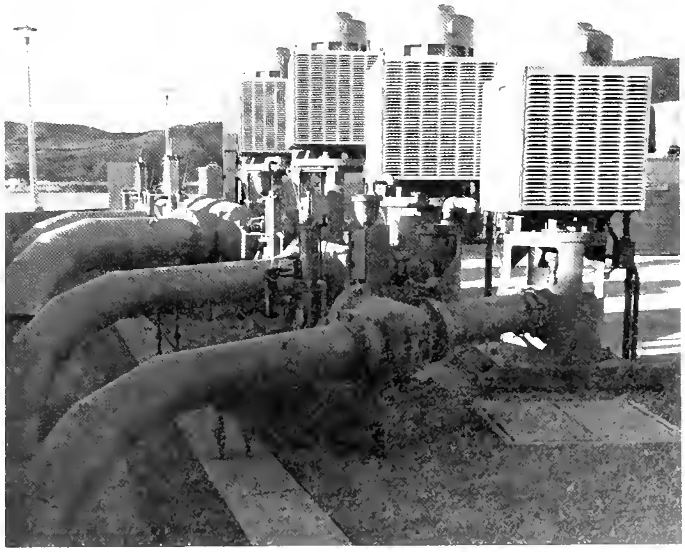
East Unit.—This unit provides a supply of irrigation water for 4,526 acres of land. Water is pumped from the Columbia River, lifted 677 feet to an equalizing reservoir, conveyed to the lands through a closed-pipe system, and delivered at sprinkler pressure.

Major features include a main pumping plant on the Columbia River, a booster (high lift) pumping plant, and two relift pumping plants. The river plant is on the left bank of the Columbia River and has a maximum capacity of 76 cubic feet per second at a dynamic head of 81 feet. The four vertical turbine pumps discharge directly into two-stage horizontal centrifugal pumps in the booster plant, which has a capacity of 76 cubic feet per second with a dynamic head of 652 feet. Both plants have multiple pumping units of two sizes to give flexibility in meeting pumping requirements. The discharge line from the Booster Pumping Plant to the regulating reservoir is 12,575 feet long and ranges from 48 to 36 inches in diameter. Operation of the pumping facilities is controlled automatically by floats connected to the 267,360-cubic-foot (2-Mgal) concrete-lined regulating reservoir.

A North Relift Pumping Plant (Lateral 9), adjacent to the main reservoir, serves 317 acres of land above the main body of the project lands along Lateral 9. The plant has a capacity of 5.65 cubic feet per second at a dynamic head of 108 feet. A 10,026-cubic-foot (75,000-gal) concrete-lined regulating reservoir is provided for the area. Float-controlled switches regulate the operation of the relift plant.

The East Relift Pumping Plant (Lateral 10) irrigates about 1,460 acres above the main body of project lands at the east end of the unit. The plant has a capacity of 26 cubic feet per second at a dynamic head of 108 feet. A 20,052-cubic-foot (0.15-Mgal) concrete-lined regulating reservoir is located on high ground north of the plant.

Brays Landing Unit.—Water for the Brays Landing Unit serves 1,667 irrigable acres, comprised of a series of high terraces with irregular topography, that require sprinkler irrigation. Major facilities include a main pumping plant,



Four units at Lake Chelan Pumping Plant

discharge line, main regulating reservoir, closed-pipe lateral system, and four small pumping plants and reservoirs.

The Main Pumping Plant on the Columbia River 25 miles north of Wenatchee, Wash., consists of five well pumping units with a combined capacity of 32.25 cubic feet per second at a dynamic head of 135 feet. Water also is delivered to a reservoir at Pumping Plant No. 1 (booster plant) and then to a pressure pipeline and three pumping plants (A, B, and C), each with its own regulating reservoir. The pressure lateral system covers 16 miles.

Howard Flat Unit.—There are 911 acres of irrigable land in the Howard Flat Unit, which is in Chelan County on a large, relatively flat terrace about 5 miles northeast of Chelan, Wash.

A pumping plant complex near the Columbia River consists of a three-unit river (well pump) plant, with a total capacity of 16.7 cubic feet per second at heads of 110 and 112 feet, and a river booster plant. The booster plant consists of three units with a total capacity of 16.7 cubic feet per second at a head of 490 feet.

Water from the river complex is delivered to the Reservoir Relift Pumping Plant, a five-unit plant with a capacity of 16.8 cubic feet per second and a dynamic head of 178 feet.

Two smaller pumping plants are located on opposite ends of the lateral system. The North Booster Pumping Plant consists of three units with a total capacity of 5.54 cubic feet per second at a total dynamic head of 84 feet. The two-unit South Booster Pumping Plant has a capacity of 1.34 cubic feet per second at a total dynamic head of 54 feet.

Okanogan-Similkameen Division

Facilities have been completed for two units of the Okanogan-Similkameen Division and a third unit has been authorized but not yet constructed. The Oroville-Tonasket Unit is along the Similkameen and Okanogan Rivers in north-central Washington near the Canadian border. Oroville-Tonasket Unit Extension covers the same area as the original unit with an addition of approximately 600 acres. The extension has been authorized, and is primarily for the purpose of rehabilitating the distribution system; however, work has not yet started. Whitestone Coulee Unit has been completed and is contained in a narrow strip of land running west from the Okanogan River.

Oroville-Tonasket Unit.—This unit provides irrigation service to 9,493 acres; 8,052 were previously irrigated, and 1,441 were irrigable dry lands. In addition, 187 acres of water-right lands will continue to receive water but will not be entitled to a firm water supply.

Aerial view, Brays Landing Unit

Water supply for the Oroville-Tonasket Unit is by diversion from the Similkameen River and by pumping from the Okanogan River. Project works include a headworks structure on the Similkameen River with a 0.5 mile connecting reach of main canal, three auxiliary pumping plants on the Okanogan River, rehabilitation of a section of the main canal, and replacement of the Upper Okanogan Siphon. The headworks is a concrete structure with control gates, located about 0.5 mile above the existing main canal headworks, requiring construction of a 190-cubic-foot-per-second, unlined connecting canal. Fish screens are in the main canal 1.5 miles below the headworks. Main canal rehabilitation required interspersed sections consisting of 4,695 feet of concrete bench flume, 759 feet of concrete elevated flume, 3,357 feet of concrete-lined canal, and 256 feet of 84-inch-diameter concrete siphon. The Upper Okanogan Siphon, crossing the Okanogan River just above the town of Oroville, is 8,304 feet long, and consists primarily of 33-inch-diameter pretensioned concrete-cylinder pipe with a capacity of 36 cubic feet per second.

Auxiliary Pumping Plants No. 1, 2, and 3 are located respectively about 2, 13, and 11 miles south of Oroville. Plants 1 and 3 are located on the east bank of the Okanogan River and Plant No. 2 is on the west bank of the river. The plants are outdoor type, reinforced concrete flat-slab structures supported by precast prestressed concrete piles, with two units at each plant. All three plants are equipped with vertical turbine units. Plant 1 has a total capacity of 11.5 cubic feet per second at a total dynamic head of 145 feet, and each pump is powered with a 125-horsepower motor. Plant 2 has a total capacity of 8.7 cubic feet per second, at a total dynamic head of 127 feet, and each pump is powered by a 100-horsepower motor. Plant 3, the smallest, has a total capacity of 5.5 cubic feet per second, at a total dynamic head of 125 feet, and each pump is powered by a 60-horsepower motor.

Aerial view of orchards, Chelan Division

Flooding of the Okanogan River in the spring of 1972 destroyed the Ellisford Siphon that carried water across the Okanogan River from the South Branch Canal to the Tonasket Line Canal. Using funds provided by the Office of Emergency Preparedness, the siphon was replaced by the Midway Pumping Plant, located about 8 miles south of Oroville, that pumps water directly from the Okanogan River into the Tonasket Line Canal. This plant is equipped with three vertical turbine units, powered by one 600-horsepower motor and two 300-horsepower motors, that have a total capacity of 56 cubic feet per second at a total dynamic head of 110 feet.

Oroville-Tonasket Unit Extension.—The primary purpose of the Oroville-Tonasket Unit Extension is to replace the badly deteriorated irrigation distribution system of the Oroville-Tonasket Irrigation District. Water losses are running about 40 percent in the present system. About 10,000 acres will be provided a full water supply through a pipe distribution system operating with project-supplied pressure for sprinkler irrigation. Approximately 600 acres now supplied from private sources will be added.

Existing facilities will be removed except for the Upper Okanogan Siphon, two short reaches of canal which will be incorporated into the new distribution system, and the initial 2.5 miles of the main canal which has future potential for fish rearing.

Six pumping plants, one on Osoyoos Lake and five on the Okanogan River, will lift irrigation water into eight adjacent closed pipe distribution systems. Fifteen relift pumping plants will provide sprinkler pressure on the higher lands.

Whitestone Coulee Unit.—Facilities of the Whitestone Coulee Unit provide an irrigation water supply to 2,490 acres of land; 1,865 were previously irrigated, and 625 were irrigable dry lands. In addition, 103 acres of water-right lands will continue to receive water but will not be entitled to a firm water supply. Water source is Toats Coulee Creek at a point some 15 miles northwest of Tonasket. Toats Coulee Diversion Dam is a concrete structure with an ogee overflow section, and headworks for the main supply canal. This supply canal across Sinlahekin Creek is a 6-mile-long buried concrete pipe, 45- to 18-inches in diameter, and has a maximum capacity of 70 cubic feet per second. At the terminal of the main supply canal, a wye structure containing a sleeve valve diverts water to an outlet structure and then into Spectacle Lake Reservoir and/or the 2.78-mile-long North Branch Canal. The active storage capacity at Spectacle Lake has been increased from 3,800 to 6,250 acre-feet by construction of a 24-foot-high homogenous earthfill dike across the low point in the rim of Spectacle Lake. This also required a concrete gated outlet structure to divert water into the Spectacle Lake Canal. A small two-unit pumping plant on Spectacle Lake Canal delivers 3.6 cubic feet per second to a 20-foot-diameter regulating tank that serves about 120 acres of land. Two larger pumping plants are located on Spectacle Lake. The North Branch Pumping Plant, a two-unit installation with a dynamic head of 230 feet and total capacity of 13 cubic feet per second, delivers water through an 18-inch-diameter pipeline into the North Branch Canal. The Whitestone Flats Plant, three units with a dynamic head of 187 feet and total capacity of 17 cubic feet per second, conveys water through a 27-inch-diameter pipe into Whitestone Flats Canal.

Distribution is made through about 27 miles of lined and unlined laterals. Most lands are sprinkler irrigated, with each farm providing the pressure required.

Fish screens are included at Spectacle Lake Outlet Works and at the two larger pumping plants.

Chelan Division

Manson Unit.—This unit provides full irrigation service to 6,055 acres of land; 4,003 were previously irrigated, and 2,052 were irrigable dry lands. In addition, about 200 acres of water-right lands will continue to receive water but will not be entitled to a firm water supply.

Constructed facilities have replaced most of the irrigation facilities built by the Lake Chelan Reclamation District. Antilon Reservoir is the only portion of the original system remaining and the reservoir spillway has been modified to provide a constant water surface elevation of 2,318 feet.

Major new works include Lake Chelan Pumping Plant, 8 relift pumping plants, 4 booster pumping plants, 13 regulating tanks, and a pressure pipeline distribution system. The irrigation water is pumped from Lake Chelan and distributed through the pipeline system for sprinkler irrigation. Limited drainage facilities were constructed at scattered locations throughout the unit.

Lake Chelan Pumping Plant is outdoor-type, constructed of reinforced concrete. There are eight pumping units, each consisting of a vertical turbine pump directly connected to a vertical solid-shaft motor. Total rated capacity is 106.7 cubic feet per second at a rated head of 267 feet. A traveling water screen is provided to protect the pumps from moss and debris and to serve as a fish screen.

The eight Relift Pumping Plants, A through H, are outdoor-type, reinforced concrete, flat-slab structures. There are 42 pumps in these plants, all of the motor-driven, horizontal, centrifugal variety with hydraulic cylinder-operated discharge valves and valve operating systems.

The booster pumping plants are of the closed-system type and provide additional head to small acreages. Each plant is equipped with two pumping units which draw water from a 6-inch bypass, which in turn draws water from an adjacent lateral.

The 13 regulating tanks are provided as afterbays for the primary and relift pumping plants. The tanks are used to control pump operation and supply water from the related pumping plant discharge lines to downstream laterals according to demand.

Water pumped from Lake Chelan is delivered to the farm units through a system of pressure pipelines. The system consists of about 71 miles of buried noncorrosive pipe ranging in diameter from 6 to 48 inches. The Lake Chelan discharge line is steel, mortar-lined and coated pipe, about 4,000 feet long. The A and B pumping plant discharge lines and 12,000 feet of laterals total about 2.8 miles, and are reinforced plastic mortar (RPM) pipe. The remainder of the pipe is asbestos-cement. The pipe distribution system provides a peak farm delivery of 0.015 cubic feet per second (6.9 gal/min) for each acre at a minimum pressure of 35 pounds per square inch to the sprinkler nozzle at the high point of each tract.

A buried pipe drain system consists of 8.8 miles of pipe and two small pumps to lift water out of the low areas.

DEVELOPMENT

Early History

Settlement of the north-central Washington region began soon after 1811 when agents of John Jacob Astor established a fur trading post and fort at the junction of the Columbia and Okanogan Rivers. The fort was abandoned after the treaty of 1846 established the United States-Canadian boundary at the 49th parallel.

Cattle raising was the first agricultural enterprise, beginning as early as 1826 in the Okanogan Valley and reaching a peak during the 1870's after being extended to the Big Bend area, now occupied in part by the Columbia Basin Project. However, settlement was slow until after 1900, when large-scale irrigation developments were started. Settlers came to Wenatchee Valley and planted orchards after the Highline Canal provided water for 20,000 acres. Settlement and development of the Foster Creek area have been related to the resources and growth of the vast north-central Washington region.

Irrigation development in the Whitestone Coulee area began in 1918 to serve 10,000 acres but because of adversities, including a critical water shortage, facilities were not completed until 10 years later and served only about 2,000 acres.

In the Manson area, the original district was formed in 1908 to irrigate some lowlands with water from Wapato Lake; however, real progress did not begin until 1911.

Investigations

The investigations of the Foster Creek Division were initiated with a general Bureau of Reclamation reconnaissance of irrigation possibilities in the Okanogan River Basin, and were completed in 1950. Included in the study were some lands along the Columbia River, both upstream and downstream from the mouth of the Okanogan. These lands are not geographically part of the Okanogan Basin but were included in the study because of the interrelated water supply problems associated with diversions from Rufus Woods Lake. On the basis of information developed in the reconnaissance study, detailed investigation of the Foster Creek area was given first priority. A feasibility-type investigation of Foster Creek development was started early in 1951 and culminated in

Relift Pumping Plant D, Manson Unit

a report by the Bureau of Reclamation in October 1952. Meanwhile, the act of July 17, 1952 (Public Law 577), was enacted, providing a basis for authorization of irrigation works in connection with Chief Joseph Dam and for financial assistance to such developments from power revenues. In a final report dated December 21, 1953, the Commissioner of Reclamation modified the plan. This report was the basis for authorization of the project.

The Bureau of Reclamation made a reconnaissance study of the Greater Wenatchee area in 1945. A development investigation was begun in 1946, and a project planning report was published in 1950. Engineering investigations were made in 1952 and 1953, and economic and feasibility studies of the area were made in 1955. The final plan was prepared in 1959 and revised in 1962.

In 1950, a reconnaissance investigation was undertaken to establish a basic plan for irrigation of lands in the Okanogan Basin and lands along the Columbia River in the vicinity of Chief Joseph Dam and the mouth of the Okanogan River. This report was published in 1951. Feasibility investigations of the Okanogan-Similkameen Division were started in the fall of 1955, and a detailed land classification study was started in early 1956. The final plan was reported in September 1964.

Further investigations of the Oroville-Tonasket Unit have resulted in a feasibility report completed in 1975 recommending replacement of most of the existing facilities of that unit.

Original development of the Manson Unit of the Chelan Division was a private venture. However, by passage of Public Law 577 in 1952, and at the request of local water users through their congressional representatives, feasibility investigations were begun in 1956 and completed in early 1960.

Orchard, East Unit

Authorization

Foster Creek Division, comprising three units, was authorized July 27, 1954, by Public Law 540, 83d Congress, 2d session (68 Stat. 568). This was the first authorization under the provisions of the act of July 17, 1952, which provides the basis for favorable pumping and power rates and financial assistance to irrigation development from Chief Joseph Dam Project power revenues.

Construction of four units of the Greater Wenatchee Division was authorized by Public Law 85-393, approved May 5, 1958 (72 Stat. 104).

The Oroville-Tonasket Unit of the Okanogan-Similkameen Division was authorized by Public Law 87-762, approved October 9, 1962 (76 Stat. 761).

The Oroville-Tonasket Unit Extension of the Okanogan-Similkameen Division was authorized by Public Law 94-423, approved September 28, 1976 (90 Stat. 1325).

Construction of the Whitestone Coulee Unit of the Okanogan-Similkameen Division was authorized by Public Law 88-599, approved September 18, 1964 (78 Stat. 955).

The Manson Unit of the Chelan Division was authorized by Public Law 89-557, approved September 7, 1966 (80 Stat. 704).

Construction

Construction of the Bridgeport Bar and the Brewster Flat Units of the Foster Creek Division began in 1956 and was completed in 1958. Construction of the Bluebottle Flat Unit has been deferred.

Brays Landing, East Wenatchee, and Howard Flat Units of the Greater Wenatchee Division were placed under construction in 1960 and completed in 1964.

The Oroville-Tonasket Unit of the Okanogan-Similkameen Division was placed under construction in 1965 and completed in 1969.

Construction of the Whitestone Coulee Unit of the Okanogan-Similkameen Division began in 1968 and was completed in 1975.

The Manson Unit of the Chelan Division was placed under construction in 1971 and completed in 1976.

BENEFITS

Irrigation

Apples, pears, cherries, and alfalfa hay are the chief crops produced in the project area. The apples are world famous for their high quality.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Division	Full service, acres	Supplemental service, acres	Total, acres
Foster Creek	2,907	--	2,907
Greater Wenatchee	7,104	--	7,104
Okanogan-Similkameen	9,493	2,490	11,983
Chelan	6,055	--	6,055
Total	25,559	2,490	28,049

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	15,810	12,262,597
1969	15,831	15,941,826
1970	16,136	12,299,397
1971	16,296	11,794,094
1972	16,705	11,141,755
1973	17,046	16,353,746
1974	16,867	18,161,704
1975	19,899	14,963,266
1976	24,938	26,187,479
1977	25,064	33,194,179

Facilities in Operation

Canals	26	mi
Laterals	233	mi
Drains	12	mi
Regulating reservoirs	26	
Irrigation wells	8	
Pumping plants	38	

Climatic Conditions

Annual precipitation	8.1	in
Temperature:		
Maximum	105	°F
Minimum	−21	°F
Mean	51	°F
Growing season	232	days
Elevation of irrigable area	878-1450.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	4,824
Other water service[1]	5,384
Total	10,208

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Carriage Facilities

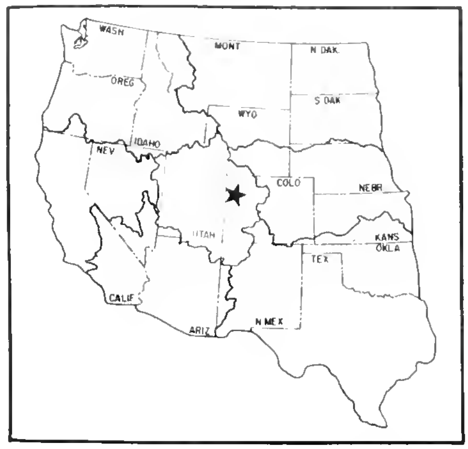
PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Dynamic head, ft	Total horsepower
Foster Creek Division				
Bridgeport Bar Unit				
Bar Area, Main	2	8.9	200	300
Brewster Flat Unit				
Main	4	46.0	190	1,200
Booster	4	46.8	350	2,400
Relift	3	39.0	150	900
Greater Wenatchee Division				
East Unit				
River	4	76.0	81	900
Booster	4	76.0	652	7,500
North Relift (Lateral 9)	3	5.65	108	100
East Relift (Lateral 10)	4	26.00	108	420
Brays Landing Unit				
Main (well pump)	5	32.25	135	750
No. 1	5	31.20	241	1,100
A	5	31.20	317	1,500
B	5	19.01	161	495
C	3	9.08	130	200
Howard Flat Unit				
River (well pump)	3	16.7	110-112	275
River Booster	3	16.7	490	1,200
Reservoir Relift	5	16.8	178	495
North Booster	3	5.54	84	80
South Booster	2	1.34	54	15
Okanogan-Similkameen Division				
Oroville-Tonasket Unit				
No. 1	2	11.5	145	250
No. 2	2	8.7	127	200
No. 3	2	5.5	125	120
Midway	3	56.0	110	1,050
Whitestone Coulee Unit				
North Branch	2	13.0	230	400
Whitestone Flats	3	17.0	187	375
Spectacle Lake Canal	2	3.6	119	80
Chelan Division				
Manson Unit				
Lake Chelan	8	106.70	267	4,250
Relift A	9	94.80	277	3,800
Relift B	7	47.40	193	1,450
Relift C	7	29.65	270	1,300
Relift D	5	10.66	314	775
Relift E	4	4.52	304	400
Relift F	4	6.80	347	600
Relift G	4	3.00	184	120
Relift H	2	1.90	583	250
Booster A-a	2	0.40	35-65	7
Booster C-a	2	0.60	238	40
Booster F-a	2	0.46	132	20
Booster H-a	2	0.44	238	40

Collbran Project

Colorado: Mesa County

Upper Colorado Region
Water and Power Resources Service



The Collbran Project, in west-central Colorado, has developed, for multiple purposes, a major part of the unused water in Plateau Creek and its principal tributaries. Supplemental irrigation water can be furnished to 19,710 acres and full irrigation service can be supplied to 2,500 acres of land. Electrical energy is generated for use in west-central Colorado. Major project works include Vega Dam and Reservoir, two powerplants, two major diversion dams, about 37 miles of canal, and about 18 miles of pipeline and penstock. East Fork Diversion Dam and Feeder Canal, along with the Bonham-Cottonwood Collection System, carry water into the 1,000-acre-foot capacity Bonham Reservoir, which in turn supplies the major portion of the water to operate the Molina powerplants. The project also has rehabilitated and modified the operation of 17 small privately owned storage reservoirs on the Grand Mesa situated in the Cottonwood Creek and Big Creek watersheds. Fifteen of the 17 reservoirs provide water for power generation through the exchange of storage water on Grand Mesa for irrigation water from Vega Reservoir. The other reservoirs also are reserved for irrigation exchanges.

PLAN

Vega Dam was constructed across the channel of Plateau Creek, forming a reservoir with a total capacity of 33,800 acre-feet and an active capacity of 32,980 acre-feet. The reservoir stores surplus flows of Plateau, Leon, and Park Creeks. The Leon and Park Creek flows are brought to the reservoir through the 2.7-mile-long Leon-Park Feeder Canal. The Southside Canal extends west from Vega Reservoir 32.8 miles to a terminal drop structure on Mesa Creek about 3.25 miles south of the town of Mesa, Colo. The canal crosses several north-flowing tributaries of Plateau Creek to which releases are made but does not intercept their flow. Most project water from Plateau, Leon, and Park Creeks, including both storage and direct flow, is released from Vega Reservoir and delivered by the Southside Canal. Some water is released at Vega Reservoir into Plateau Creek for diversion by downstream ditches.

Water used for the generation of power is collected from the Big and Cottonwood Creek drainage areas at elevations of more than 9800 feet above sea level. These waters are stored by the 17 previously existing reservoirs on Grand Mesa or collected by the Bonham-Cottonwood pipeline and piped down the mesa slopes through two hydroelectric powerplants and released into Plateau Creek. The two powerplants have a combined capacity of 13,500 kilowatts.

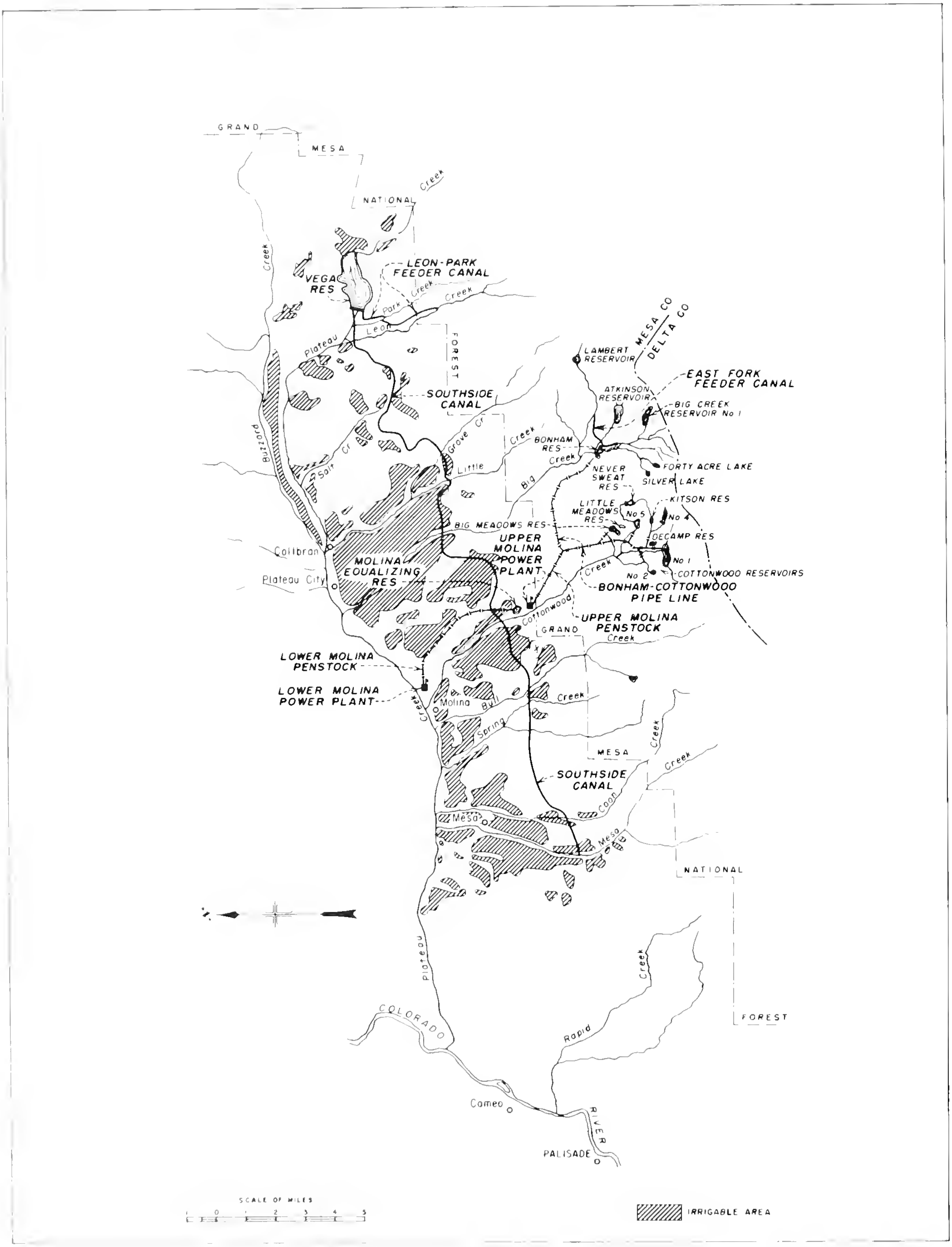
Vega Dam and Reservoir

Vega Dam is near the Grand Mesa in western Colorado, about 10 miles east of the town of Collbran. The dam is a zoned, rolled earth and rockfill structure with a maximum height above foundation of 162 feet, a crest length of 2,100 feet, and a volume of 981,825 cubic yards of material. The outlet works is near the left abutment and consists of an intake structure, 5-foot-diameter concrete pressure conduit, concrete gate chamber for a 3.5-foot-square high-pressure emergency gate, 8-foot-diameter concrete horseshoe conduit containing a 51-inch-diameter steel pipe, control house containing two 2.25-foot-square high-pressure control gates, concrete stilling basin, and an outlet channel which discharges into the Southside Canal.

Vega Reservoir has a surface area of about 900 acres, with a capacity of 33,800 acre-feet, and a shoreline of approximately 7 miles.

Leon-Park Feeder Canal

The Leon-Park Feeder Canal conveys water from Leon and Park Creeks to Vega Reservoir. The 350-cubic-foot-per-second-capacity canal begins at the Leon Creek Diversion Dam on Leon Creek and extends about 2 miles to a siphon under Park Creek. Water diverted from Park Creek by the Park Creek Diversion Dam, about 1,000 feet above the siphon outlet, then combines with the Leon Creek diversions, and flows about 0.7 mile to Vega Reservoir.



Collbran Project

Vega Dam and Reservoir

Southside Canal

Southside Canal heads at the outlet works of Vega Reservoir and conveys irrigation water westward from the reservoir to project lands. The 32.8-mile-long canal has an initial capacity of 240 cubic feet per second and a terminal capacity of 50 cubic feet per second at Mesa Creek. Thirteen siphons carry the canal across major streams of the area, and seven concrete chutes are used to drop the canal in elevation. A 2,389-foot-long, 6.25-foot-diameter horseshoe tunnel carries the canal water through a ridge on the divide between Salt and Tea Creeks, eliminating canal construction through a badly eroded area.

Bonham Dam and Reservoir

Bonham Dam is located on Grand Mesa, 12 miles south of Collbran. The dam consists of two embankments separated by an intervening knoll. Reclamation rehabilitation in 1962 added earth and rockfill material to the crest and downstream face, raising the crest 2 feet. This allows a 4-foot freeboard above the normal reservoir water surface. The completed structure is 1,500 feet in length, has a 25-foot-wide crest, and is 38 feet high. The spillway was rehabilitated and now has a capacity of 1,830 cubic feet per second.

Bonham Reservoir has a total capacity of 1,222 acre-feet. It has been in operation for more than 50 years. The Bonham power water outlet works consists of a 750-foot inlet channel, intake structure to a 36-inch-inside-diameter, steel-lined conduit, and a gate structure with a 36-inch cast-iron slide gate. The 36-inch steel-lined conduit is reduced to a 33-inch-inside-diameter, steel-lined pipe where it becomes the Bonham pipeline at a manhole structure about 100 feet downstream from the gate structure.

East Fork Diversion Dam and Feeder Canal

The East Fork Diversion Dam and Feeder Canal divert the natural flow of the East Fork of Big Creek and releases from Atkinson and Lambert Reservoirs to Bonham Reservoir. The East Fork Diversion Dam is a concrete ogee, gravity-type structure with overflow section and wingwalls of concrete and embankments of compacted earth at each end of the dam. The concrete headworks are controlled by one 3-foot-square slide gate, feeding the canal. The sluiceway is controlled by a 6-foot-square radial gate.

The East Fork Feeder Canal, with a capacity of 30 cubic feet per second, has a length of 1.3 miles. The first mile conveys water from East Fork to Atkinson Creek; the

Collbran Project farmlands

water is then carried by the stream channel for approximately 600 feet, where it is redirected into the feeder canal. The water is then carried by the feeder canal to its terminal drop structure, located at the east end of Bonham Dam, for storage in Bonham Reservoir.

Bonham-Cottonwood Pipeline

The Bonham-Cottonwood pipeline collects water from small streams and reservoirs in the watersheds of Big and Cottonwood Creeks and delivers it to the Upper Molina penstock. The pipeline, consisting of two main branches and several smaller feeder lines, delivers a maximum of 50 cubic feet per second to the Upper Molina penstock.

The Bonham section, about 5.4 miles long, extends from Bonham Reservoir to the Upper Molina penstock. It consists of a 33-inch pretensioned concrete pipe with a maximum capacity of 50 cubic feet per second. A feeder line delivers water into this section from an unnamed stream inlet west of Bonham Reservoir.

Extending about 3.7 miles from Cottonwood Reservoir No. 1 to the Upper Molina penstock is the Cottonwood section of the pipeline. It receives water directly from Cottonwood No. 1, DeCamp, and Big Meadows Reservoirs, as well as from three uncontrolled stream inlets which also take releases from six other reservoirs. This section has a maximum capacity of 28.3 cubic feet per second. The pipe ranges from a minimum of 18-inch inside diameter to a 36-inch maximum.

Upper Molina Penstock and Powerplant

The Upper Molina penstock extends from the junction of the Bonham and Cottonwood pipelines, then continues approximately 2.4 miles down the north slope of Grand Mesa, and terminates at the Upper Molina Powerplant. The penstock consists of welded steel pipe with a capacity of 50 cubic feet per second, ranging in diameter from 36 inches at the junction with the Bonham-Cottonwood collection system to 33 inches at the lower section.

Bonham Reservoir acts as a forebay for the Upper Molina Powerplant, which controls releases up to a maximum capacity of 50 cubic feet per second from the reservoir. Upper Molina Powerplant consists of a single 8,640-kilowatt generating unit constructed on the east bank of Cottonwood Creek, operating at a design head of 2,490 feet with power tailwater discharges up to 50 cubic feet per second into the Molina Equalizing Reservoir.

Lower Molina Penstock and Powerplant

The Lower Molina penstock extends 4.7 miles from the Molina Equalizing Reservoir to the Lower Molina Powerplant. The penstock consists of steel pipe ranging in diameter from 36 inches at its upper end to 30 inches at the lower section. It has a maximum capacity of 50 cubic feet per second.

The single-unit Lower Molina Powerplant is located on the south bank of Plateau Creek near Molina, Colo. It has an installed capacity of 4,860 kilowatts at a design head of 1,400 feet and a maximum water discharge of 50 cubic feet per second. Both plants are operated in conjunction with Colorado River Storage Project power operations.

Substations and Transmission Lines

Power generated at the powerplants is transformed to a transmission voltage of 115 kilovolts at two substations constructed adjacent to the plants. A 5.5-mile transmission line leads from the substation at the Upper Molina Powerplant, delivers energy produced at the plant to the substation at Lower Molina Powerplant, and then connects to the Colorado-Ute Electrical Association system for distribution.

DEVELOPMENT

Early History

Numerous small private reservoirs were constructed on Grand Mesa to regulate the runoff of Big, Cottonwood, Mesa, and Bull Creeks. These reservoirs are filled with water during the spring runoff, and the stored water is released on demand of the irrigators in Plateau Valley to supplement the low natural streamflows of late summer. Individual water users or small cooperative associations built most of the reservoirs in basins formed by glacial action.

Privately constructed canals and ditches are also operated intermittently throughout the winter months to supply the communities of Collbran and Mesa and the rural area with domestic and stock water.

Investigations

Investigations were initiated in 1937 to study the needs of the area for proper development of its abundant resources. Included in the plans for developing the necessary supplemental irrigation water for arable lands was the plan to generate additional power for industrial and domestic use.

Authorization

Authorized July 3, 1952, by act of Congress (Public Law 445, 82nd Congress, 2nd session).

Construction

The contract for construction of Vega Dam was awarded in 1957 and the dam was completed in 1960. Other construction and rehabilitation contracts were awarded beginning in 1959. All work was completed in 1962.

Operating Agencies

The Bureau of Reclamation operates the 17 small Grand Mesa reservoirs, Bonham-Cottonwood pipeline, and the Molina Powerplants and penstocks. Since January 1, 1963, the Collbran Conservancy District has operated Vega Dam and Reservoir, the Leon-Park Diversion Dams and Feeder Canal, and the Southside Canal.

BENEFITS

Irrigation

Vega Dam and Southside Canal provide water for the irrigation of 22,210 acres of full and supplemental service project lands. Principal crops are alfalfa, hay, small grains, and pasture. These crops are used primarily to support beef cattle and sheep production.

Vega Reservoir recreation

Hydroelectric Power

Two hydroelectric powerplants are in operation, with a combined installed capacity of 13,500 kilowatts.

Recreation and Fish and Wildlife

Construction and operation of the reservoirs have improved lake fisheries and wildlife values. Some minor damage to stream fisheries and wildlife values resulted from the reduction of flows downstream from storage or diversion structures and from inundation of some stream habitat in the Vega reservoir area. However, the net effect is an increase in fish and wildlife. The Vega recreation areas are administered by the Colorado Division of Parks and Outdoor Recreation. Fishing, camping, boating, picnicking, and sightseeing are the principal activities. In 1977, visitation totaled 62,871.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	2,500	acres
Supplemental irrigation service	19,710	acres
Total	22,210	acres

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	19,542	982,967
1969	19,888	1,105,788
1970	19,397	1,119,246
1971	19,878	1,356,611
1972	19,880	1,322,321
1973	20,063	1,700,052
1974	20,110	1,749,042
1975	19,769	1,884,004
1976	19,909	1,684,799
1977	19,843	[1]684,877

[1]Colorado River runoff in 1977 was the lowest in 61 years of record. In most areas of Colorado, precipitation for the year was considerably below average resulting in lower yields because of the extreme drought.

Facilities in Operation

Storage dams (main storage and rehabilitation)	18	
Diversion dams	3	
Canals	37	mi
Powerplants	2	
Pipelines and penstocks	18	mi

Climatic Conditions

Annual precipitation	15.5	in
Temperature:		
Maximum	100	°F
Minimum	−30	°F
Mean	46	°F
Growing season	155	days
Elevation of irrigable area	5500-7000.0	ft

ENGINEERING DATA

Water Supply

Plateau Creek

Drainage area near Collbran, Colo.	88	mi²
Annual discharge:		
Maximum (1922)	118,500	acre-ft
Minimum (1934)	21,300	acre-ft
Average	68,400	acre-ft

Big Creek

Drainage area at Upper Station near Collbran, Colo.	20	mi²
Annual discharge:		
Maximum (1952)	27,000	acre-ft
Minimum (1951)	13,700	acre-ft
Average	20,200	acre-ft

Cottonwood Creek

Drainage area at Upper Station near Collbran, Colo.	20	mi²
Annual discharge:		
Maximum (1929)	20,900	acre-ft
Minimum (1934)	6,800	acre-ft
Average	13,200	acre-ft

Storage Facilities

Vega Dam

Type: Zoned, rolled earth and rockfill
Location: On Plateau Creek, about 10 mi east of Collbran, Colo.
Construction period: 1957-59
Reservoir, Vega:

Total capacity to El. 7984	33,800	acre-ft
Active capacity	32,980	acre-ft
Surface area, El. 7984	897.5	acres
Dimensions:		
Structural height	162	ft
Top width	30	ft
Maximum base width (approx.)	880	ft
Crest length	2,100	ft
Crest elevation	7997.0	ft
Volume	981,825	yd³

Spillway: Uncontrolled ogee crest, concrete lined chute and stilling basin on the right abutment.
Outlet works: Concrete pressure conduit from the intake structure to the gate emergency chamber, then an 8-ft horseshoe conduit, containing a 51-in steel pipe through the dam, where the discharge to Southgate Canal is controlled by two 2.5-ft-square, high-pressure gates.

Bonham Dam

Type: Earthfill
Location: On Big Creek, about 12 mi south of Collbran, Colo.
Construction period: Rehabilitation 1962
Reservoir, Bonham:

Total capacity to El. 9796	1,124	acre-ft
Active capacity	1,000	acre-ft
Surface area, El. 9796	88	acres

Dimensions:

Structural height	38 ft
Top width	25 ft
Maximum base width	180 ft
Crest length	1,500 ft
Crest elevation	9800.7 ft
Volume	15,000 yd³

Spillway: Open crest with a concrete sill 250 ft wide, 1,830 ft³/s capacity.

Power outlet works: 30-in welded steel conduit encased in concrete and 30-in cast-iron slide gates with a capacity of 50 ft³/s.

Diversion Facilities

East Fork Diversion Dam

Type: Concrete weir, embankment wings
Location: East Fork of Big Creek.
Year completed: 1962
Dimensions:

Height above streambed	8 ft
Weir crest length	29 ft
Total crest length	120 ft
Weir crest elevation	9863.2 ft
Volume (concrete)	144 yd³
Volume (total)	1,000 yd³

Sluiceway: 6-ft-square radial gate.
Headworks: 3-ft-square slide gate.

Diversion capacity	30 ft³/s

Leon Creek Diversion Dam

Type: Concrete ogee
Location: Leon Creek about 8 mi east of Collbran, Colo.
Year completed: 1960
Dimensions:

Height above streambed	10 ft
Weir crest length	51 ft
Crest length	230 ft
Crest elevation	8026.0 ft
Volume	2,000 yd³
Overflow weir capacity	2,000 ft³/s

Headworks: Concrete with three 5-ft-square control gates.

Diversion capacity	350 ft³/s

Park Creek Diversion Dam

Type: Concrete ogee
Location: Park Creek, about 8 mi east of Collbran, Colo.
Year completed: 1960
Dimensions:

Height above streambed	8 ft
Weir crest length	16 ft
Crest length	140 ft
Crest elevation	8020.2 ft
Volume	1,000 yd³
Overflow weir capacity	700 ft³/s

Headworks: Concrete with three 4-ft-square control gates.

Diversion capacity	150 ft³/s

Carriage Facilities

Leon-Park Feeder Canal

Location: From Leon Creek Diversion Dam to Park Creek and from Park Creek Diversion Dam to Vega Reservoir.
Construction period: 1960-61

Length	2.7 mi
Final capacity	350 ft³/s
Typical maximum section (unlined):	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	5.8 ft

Southside Canal

Location: From Vega Dam westerly to a point on Mesa Creek 3.25 mi south of Mesa, Colo.
Construction period: 1959-60

Length	32.8 mi
Initial capacity	240 ft³/s
Typical maximum section (unlined):	
Bottom width	16 ft
Side slopes	1.5:1
Water depth	4.4 ft

Southside Tunnel

Location: In divide between Salt and Tea Creeks on alinement of Southside Canal.
Construction period: 1958-60

Length	2,389 ft
Capacity	240 ft³/s
Cross section: Horseshoe	
Height	6.25 ft
Width	6.25 ft
Lining: Concrete, thickness	3.5-7 in

East Fork Feeder Canal

Location: From East Fork westerly to Bonham Reservoir.
Construction period: 1961-62

Length	1.3 mi
Final capacity	35 ft³/s
Typical maximum section (unlined)	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2.4 ft

Bonham-Cottonwood Pipeline

Type: Pretensioned reinforced concrete pressure pipe
Location: From Bonham Reservoir northwest and from Cottonwood Reservoirs No. 1, 2, 4, and 5, and DeCamp, Kitson, Little Meadows, and Big Meadows Reservoirs north to a junction with Upper Molina penstock.
Construction period: 1959-62

Diversion capacity (max.)	50 ft³/s
Bonham section:	
Maximum capacity	50 ft³/s
Length	5.4 mi
Diameter:	
(Min. inside)	31 in
(Max. inside)	33 in
Cottonwood section:	
Maximum capacity	28.3 ft³/s
Length	4.2 mi
Diameter:	
(Min.)	18 in
(Max.)	30 in

UPPER MOLINA PENSTOCK

Location: From Bonham-Cottonwood pipeline northwest to Upper Molina Powerplant (southwest of Collbran, Colo.).
Type: Steel plate
Construction period: 1959-61

Diameter (outside)	36 in
Length	2.4 mi
Capacity	50 ft^3/s

LOWER MOLINA PENSTOCK

Location: From Upper Molina Powerplant to Lower Molina Powerplant (southwest of Collbran, Colo.).
Type: Steel plate
Construction period: 1959-61

Diameter (outside)	36 in
Length	4.7 mi
Capacity	50 ft^3/s

Power Facilities

UPPER MOLINA POWERPLANT

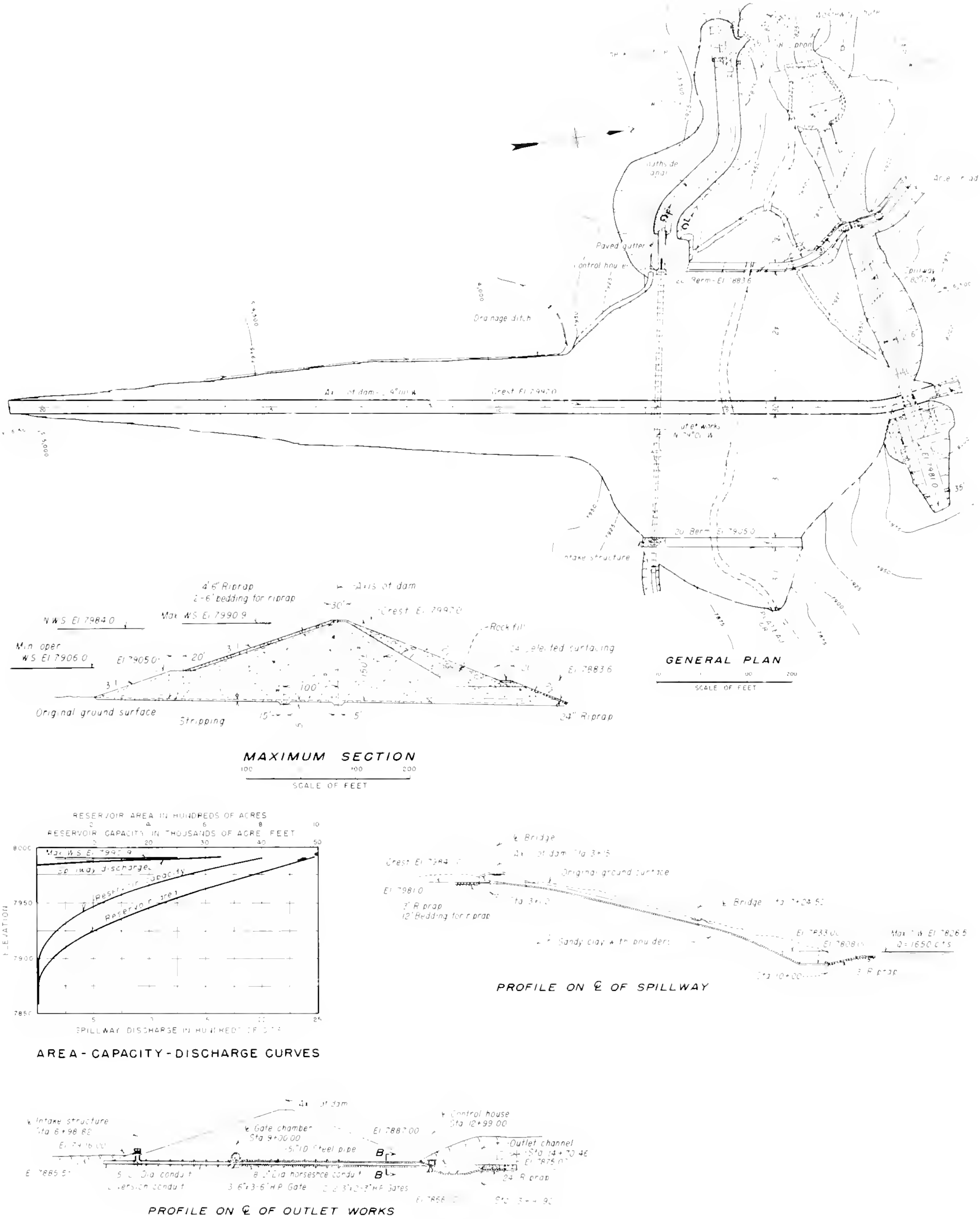
Location: East bank of Cottonwood Creek about 7 mi southeast of Molina, Colo., and about 23 mi northeast of Palisade, Colo.
Year of initial operation: 1962

Nameplate capacity	8,640 kW
Number and capacity of generators (1)	8,640 kW
Maximum static head	2,688 ft

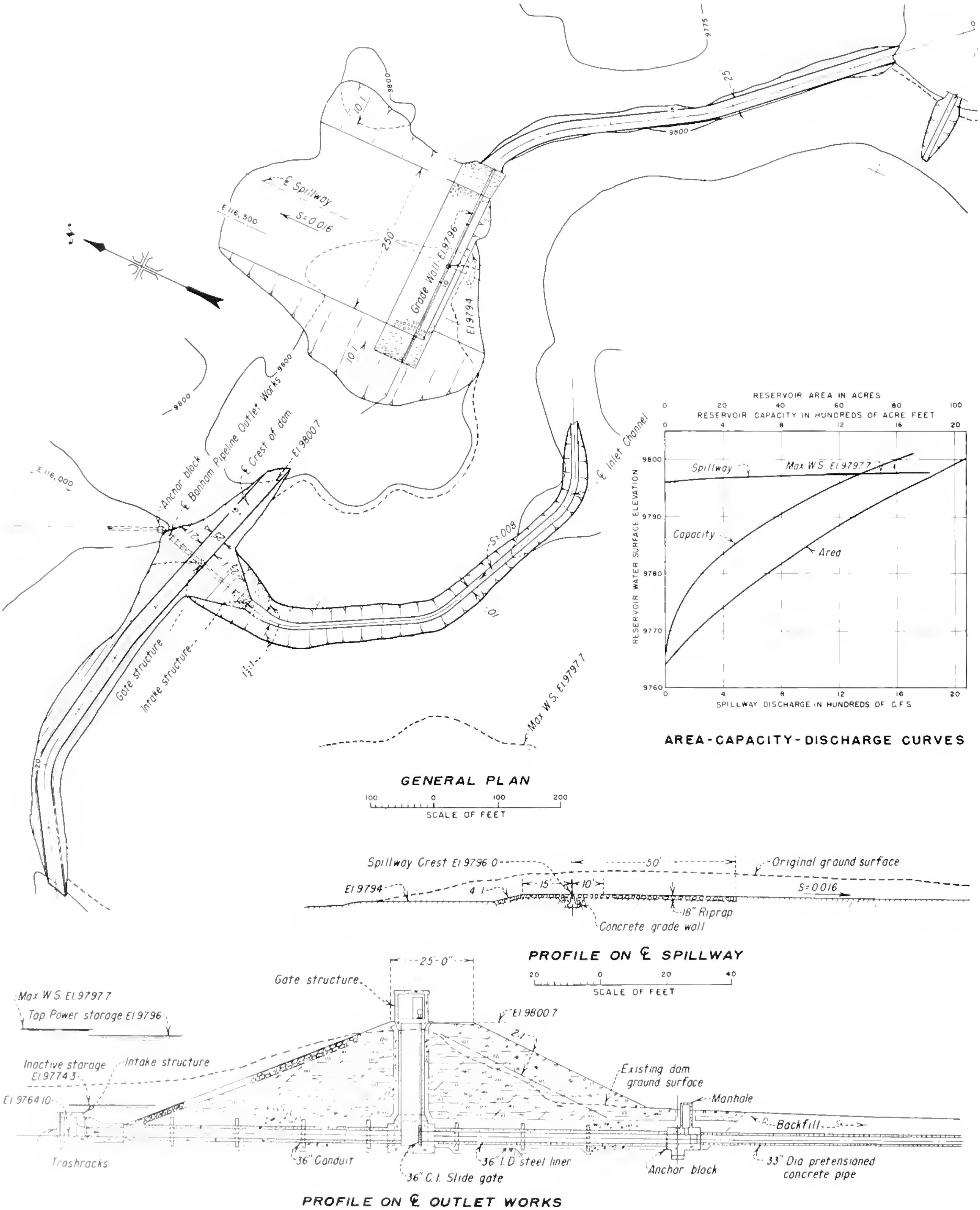
LOWER MOLINA POWERPLANT

Location: On the south bank of Plateau Creek, near Molina, Colo.
Year of initial operation: 1962

Nameplate capacity	4,860 kW
Number and capacity of generators (1)	4,860 kW
Maximum static head	1,614 ft



Vega Dam, Plan and Sections

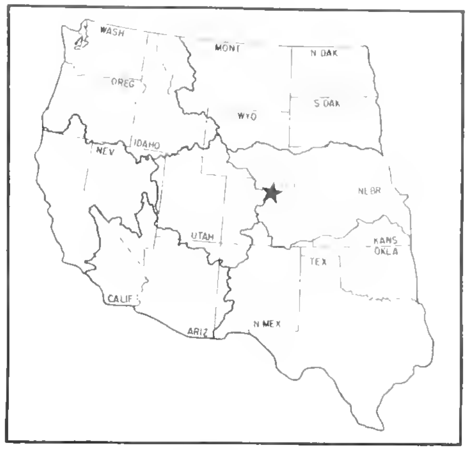


Bonham Dam, Plan and Sections

Colorado-Big Thompson Project

Colorado: Boulder, Grand, Larimer, Logan, Morgan, Sedgwick, Summit, Washington, and Weld Counties

Lower Missouri Region
Water and Power Resources Service



The Colorado-Big Thompson Project is one of the largest and most complex natural resource developments undertaken by the Bureau of Reclamation. It consists of over 100 structures integrated into a transmountain water diversion system through which multiple benefits are provided to the people.

The project spreads over approximately 250 miles in the State of Colorado. It stores, regulates, and diverts water from the Colorado River on the western slope of the Continental Divide to the eastern slope of the Rocky Mountains. It provides supplemental water for irrigation of about 720,000 acres of land, municipal and industrial use, hydroelectric power, and water-oriented recreation opportunities.

Major features of the project include dams, dikes, reservoirs, powerplants, pumping plants, pipelines, tunnels, transmission lines, substations, and other associated structures.

PLAN

The project diverts approximately 260,000 acre-feet of water annually (310,000 acre-feet maximum) from the Colorado River headwaters on the western slope to the Big Thompson River, a South Platte River tributary on the eastern slope, for distribution to project lands and communities. The Northern Colorado Water Conservancy District apportions the water used for irrigation to more than 120 ditches and 60 reservoirs. Eleven communities receive municipal and industrial water from the project. Electric power produced by six powerplants is marketed by the Western Division of the Pick-Sloan Missouri Basin Program.

The western slope collection system traps runoff from the high mountains and stores, regulates, and conveys the water to the Alva B. Adams Tunnel for diversion under the Continental Divide.

To assure irrigation and power generation under prior rights on the Colorado River, Green Mountain Reservoir was constructed on the Blue River. Spring runoff is stored in this reservoir and later released to meet the requirements of the Colorado River, and to allow diversion of water by the project throughout the year.

Irrigation systems on the Colorado River, above the Blue River confluence, were improved to enable continued use of existing rights. Releases are made from Lake Granby to maintain the Colorado River as a live fishing stream.

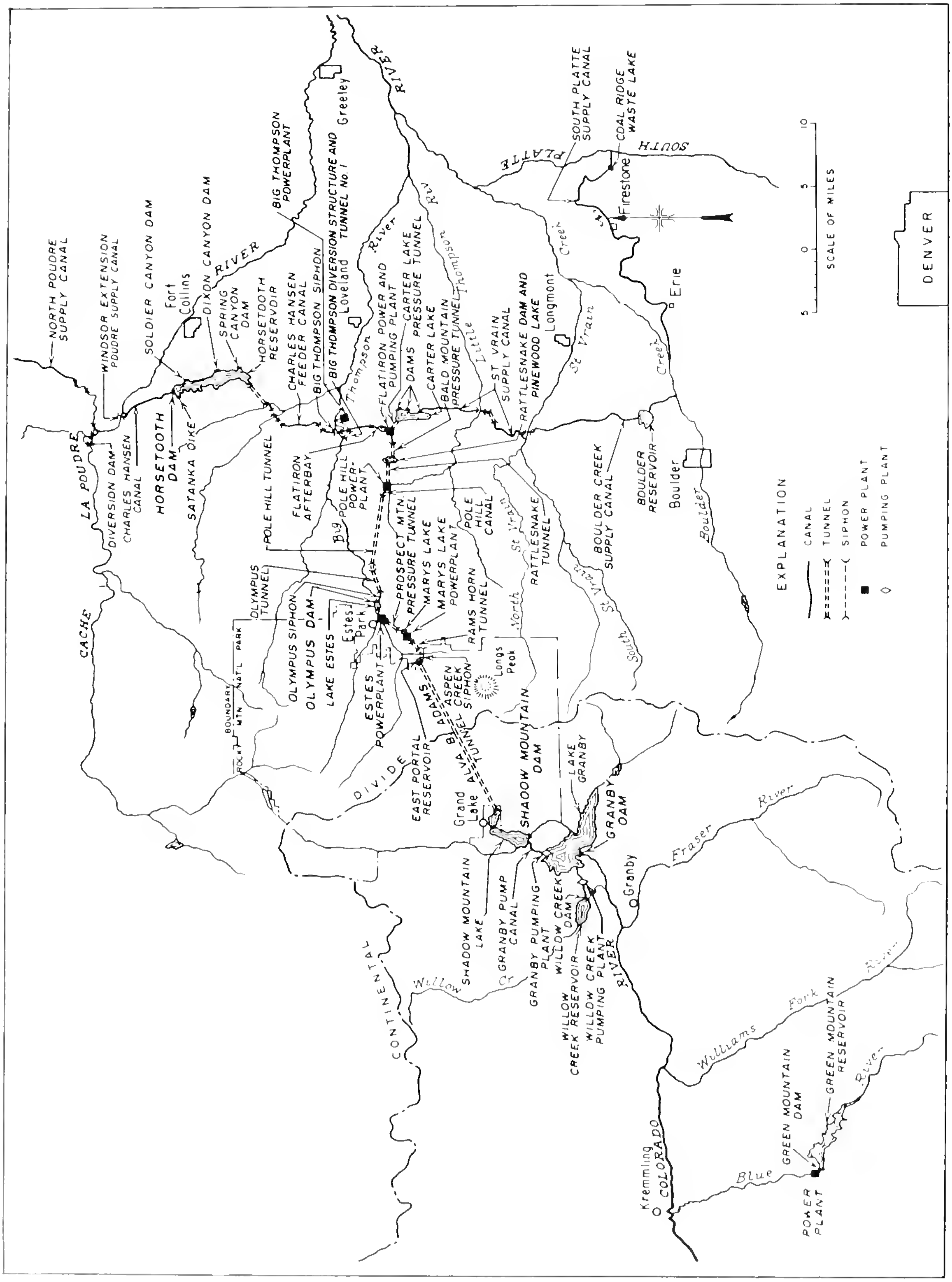
The principal storage features are Lake Granby and Granby Dam, located on the Colorado River near Granby. Willow Creek, a tributary below Lake Granby, is diverted by Willow Creek Dam and Canal. Willow Creek Pumping Plant lifts the water 175 feet; it then flows by gravity to Lake Granby.

Granby Pumping Plant lifts the water 125 feet from Lake Granby to Granby Pump Canal. The canal conveys the water 1.8 miles to Shadow Mountain Lake, which also intercepts North Fork flows of the Colorado River. Shadow Mountain Lake connects with Grand Lake to make a single body of water from which diversions flow to the Alva B. Adams Tunnel to begin the journey to the eastern slope.

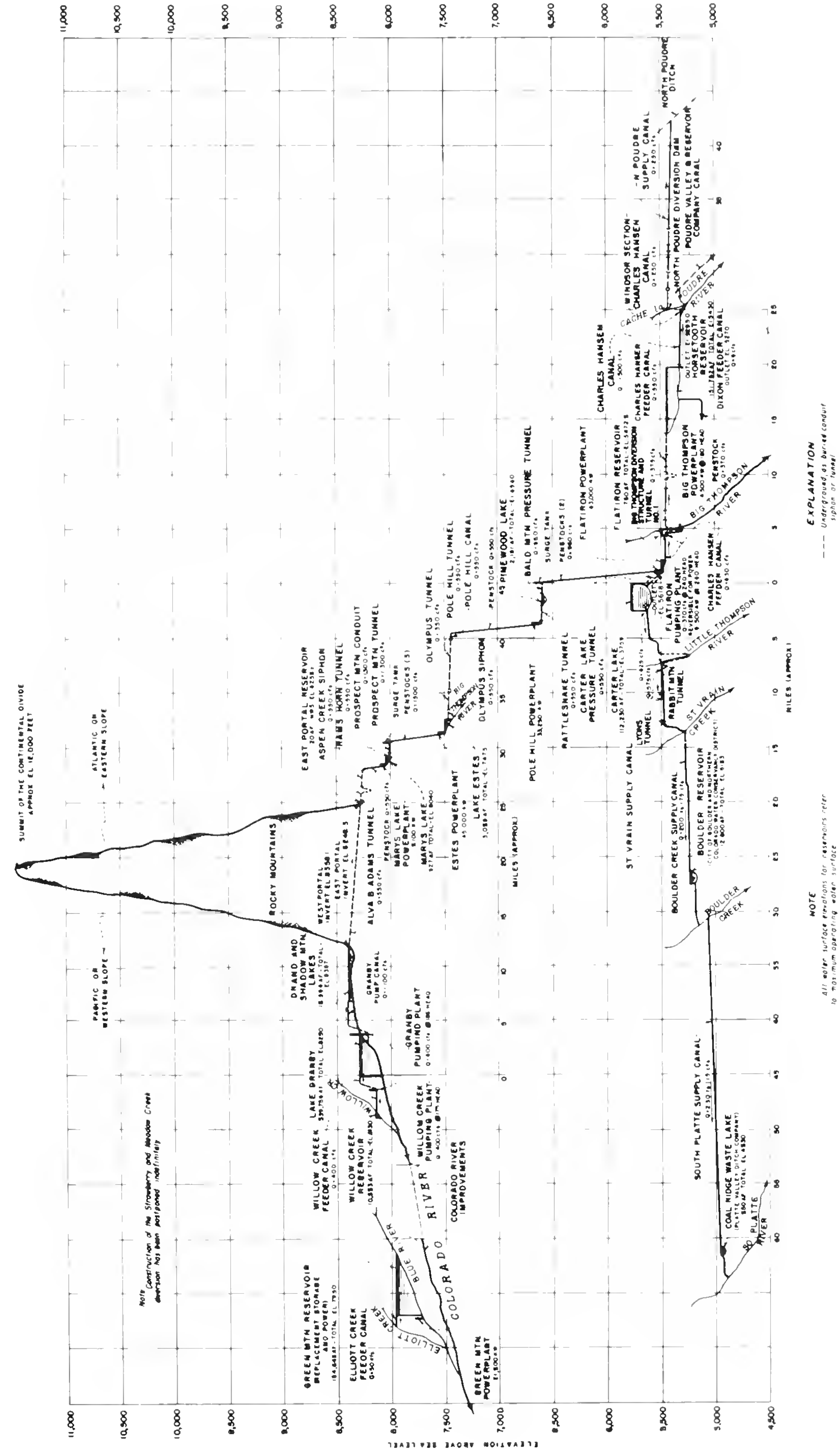
Emerging from Alva B. Adams Tunnel into the East Portal Reservoir, the water flows across Aspen Creek Valley in a siphon and then under Rams Horn Mountain through a tunnel. At this point, it enters a steel penstock and falls 205 feet to Marys Lake Powerplant. This powerplant is located on the west shore of Marys Lake, which provides afterbay and forebay capacity for re-regulating the flow. Between Marys Lake and Estes Powerplant, on the shore of Lake Estes, the water is conveyed by Prospect Mountain Conduit and Prospect Mountain Tunnel.

Lake Estes, below Estes Powerplant, is formed by Olympus Dam constructed across the Big Thompson River. The afterbay storage in Lake Estes and the forebay storage in Marys Lake enable the Estes Powerplant to meet daily variations in energy demand.

Water from Lake Estes and some Big Thompson River floodwaters are conveyed by Olympus Siphon and Tunnel



Colorado-Big Thompson Project



Colorado-Big Thompson Project, Profile

Granby Dam and Reservoir

and Pole Hill Tunnel and Canal to a penstock through which the water drops 815 feet to Pole Hill Powerplant. It is then routed through Pole Hill Powerplant Afterbay, Rattlesnake Tunnel, Pinewood Lake, and Bald Mountain Pressure Tunnel, and dropped 1,055 feet through two penstocks to Flatiron Powerplant. This powerplant discharges into Flatiron Reservoir, which regulates the water for release to the foothills storage and distribution system. The afterbay storage in Flatiron Reservoir and the forebay storage in Pinewood Lake enable Flatiron Powerplant to meet daily power loads.

Southward, the Flatiron reversible pump lifts water from Flatiron Reservoir, a maximum of 297 feet, and delivers it through Carter Lake Pressure Conduit and Tunnel to Carter Lake. When the flow is reversed, the unit acts as a turbine-generator and produces electric energy.

The St. Vrain Supply Canal delivers water from Carter Lake to the Little Thompson River, St. Vrain Creek, and Boulder Creek Supply Canal. The latter delivers water to Boulder Creek and Boulder Reservoir. The South Platte Supply Canal, diverting from Boulder Creek, delivers water to the South Platte River.

Northward, the Charles Hansen Feeder Canal transports water from Flatiron Reservoir to the Big Thompson River and Horsetooth Reservoir. The canal crosses the Big Thompson River in a siphon above the river and highway. Water from the Big Thompson River can be diverted into the canal by Tunnel No. 1, Horsetooth Supply Conduit.

Project water deliveries and Big Thompson River water to be returned to the river are dropped through a chute from the feeder canal ahead of the siphon crossing, or are passed through the Big Thompson Powerplant to convert the available head to electric energy.

Horsetooth Reservoir is west of Fort Collins between two hogback ridges, where Horsetooth Dam closes the gap at one end. Soldier, Dixon, and Spring Canyon Dams and Satanka Dike close the remaining gaps.

An outlet at Soldier Canyon Dam supplies water to Fort Collins, rural water districts, Colorado State University, and the Dixon Feeder Canal for the irrigated area cut off from its water supply by the reservoir.

The principal outlet from Horsetooth Reservoir is through Horsetooth Dam into the Charles Hansen Canal. This canal delivers water to a chute discharging into the Cache la Poudre River and to a siphon crossing the river to supply the Poudre Valley and Reservoir Company Canal. A turnout supplies the Greeley municipal water works. Water is delivered to the river to replace, by exchange, that water diverted upstream of the North Poudre Supply Canal, which conveys it to the North Poudre Ditch.

Green Mountain Dam, Reservoir, and Powerplant

Green Mountain Dam is on the western slope 13 miles southeast of Kremmling on the Blue River, a tributary of the Colorado. This dam provides replacement storage for water diverted by the project to the eastern slope. The dam is an earthfill structure, 309 feet high, with a crest length of 1,150 feet and a volume of 4,360,000 cubic yards. The reservoir has a total capacity of 154,600 acre-feet. The powerplant has two units with a total installed generating capacity of 21,600 kilowatts.

East Portal, Alva B. Adams Tunnel

Granby Dam and Lake Granby

Granby Dam is located on the Colorado River about 5.5 miles northeast of Granby. It collects and stores most of the project water supply, including the flow of the Colorado River and water pumped from Willow Creek. The dam is constructed of compacted earthfill, 298 feet high, with a crest length of 861 feet. There are 6,424 feet of auxiliary dikes. The reservoir has a capacity of 539,800 acre-feet. Total volume of the dam is 2,974,000 cubic yards. The dikes have a total volume of 1,739,000 cubic yards.

Willow Creek Dam, Reservoir, and Pumping Plant

Willow Creek Dam is 127 feet high, 1,100 feet long, and constructed of earthfill. There are 3.4 miles of canals with a capacity of 400 cubic feet per second and a pumping plant with two 200-cubic-foot-per-second pumps that lift water 175 feet into Lake Granby. The dam diverts an average of 40,000 acre-feet of water each year from Willow Creek into Lake Granby. The reservoir capacity is 10,600 acre-feet.

Granby Pumping Plant and Pump Canal

Water is pumped from Lake Granby into Shadow Mountain Lake by Granby Pumping Plant and Canal. The pumping plant contains three centrifugal pumps with a total capacity of 600 cubic feet per second at 186-foot head. The pumping lift ranges from 85 to 186 feet according to the water surface elevation in Lake Granby. The water is discharged into a canal which has a capacity of 1,100 cubic feet per second, and conveyed 1.8 miles to Shadow Mountain Lake.

Shadow Mountain Dam and Reservoir

Shadow Mountain Dam, located on the Colorado River below its confluence with the Grand Lake outlet, is an earthfill structure 63 feet high and 3,077 feet long. The reservoir formed by the dam has a total capacity of 18,400 acre-feet and is linked to Grand Lake through a connecting channel. Shadow Mountain Lake receives the water pumped from Lake Granby and also intercepts North Fork flows of the Colorado River. Project water is released from Grand Lake directly into the Alva B. Adams Tunnel, through which it flows to the eastern slope of the Continental Divide.

Alva B. Adams Tunnel

This 9.75-foot-diameter, 13.1-mile-long tunnel extends from Grand Lake through the Continental Divide to a point 4.5 miles southwest of Estes Park. It has a capacity of 550 cubic feet per second.

East Slope Power System-Upper

The structures of this system convey water 4.3 miles from the east portal of Alva B. Adams Tunnel to the Big Thompson River.

Emerging from the tunnel into the East Portal Reservoir, the water flows across Aspen Creek Valley in a siphon and then under Rams Horn Mountain in a tunnel. At this point, the water enters a steel penstock and falls 205 feet to Marys Lake Powerplant, which has an installed capacity of 8,100 kilowatts. This plant is located on the west shore of Marys Lake, which has been enlarged by diking the small natural basin to provide afterbay and forebay capacity for reregulating the flow. From Marys Lake to Estes Powerplant, the water is dropped 482 feet in a pressure system consisting of Prospect Mountain Conduit and Prospect Mountain Tunnel.

Estes Powerplant contains three generating units served by three 78-inch-diameter penstocks about 0.75 mile long. The installed plant capacity is 45,000 kilowatts when operating under an average net head of 482 feet.

Olympus Dam, a zoned earthfill structure with a concrete overflow spillway, is 70 feet high and has a crest length of 1,951 feet. It impounds Lake Estes on the Big Thompson River and provides regulating capacity for energy purposes. The lake has a total capacity of 3,100 acre-feet and controls the discharges from Estes Powerplant, river inflow and outflow, and releases of project water to the Lower East Slope Power System.

East Slope Power System-Lower

This system conveys project water from Lake Estes in a southeasterly direction to the Foothills storage and supply system. Project water released from Lake Estes flows through Olympus Siphon and Tunnel and Pole Hill Tunnel and Canal into Pole Hill Penstock and Powerplant. Water also can be released from Lake Estes to the Big Thompson River. Leaving Pole Hill Powerplant Afterbay, the water enters Rattlesnake Tunnel and flows into Pinewood Lake formed by Rattlesnake Dam. Bald Mountain Tunnel carries the water into the Flatiron Penstocks and Powerplant which discharges into Flatiron Reservoir, where it is stored for irrigation use. Pole Hill Powerplant operates under an average net head of 815 feet with a generating capacity of 33,250 kilowatts.

The Flatiron Powerplant operates under an average net head of 1,055 feet, with a generating capacity of 71,500 kilowatts. The powerplant contains two main power units and a reversible 13,000-horsepower pump-turbine unit which lifts water southward from Flatiron Reservoir to Carter Lake. This unit is capable of discharging a maximum of 370 cubic feet per second into Carter Lake and normally operates on surplus or off-peak power generated by other power units of the project system.

The pumping unit at Flatiron Powerplant pumps from Flatiron Reservoir to Carter Lake through a 1.4-mile-long connecting pressure tunnel. The pumping lift through this tunnel ranges from 200 to 300 feet, depending on the water surface elevation in Carter Lake. During peak load demands on the project system, water can be released from Carter Lake to flow back into Flatiron Reservoir, and at such times the pump-turbine operates in reverse to generate 8,500 kilowatts of power.

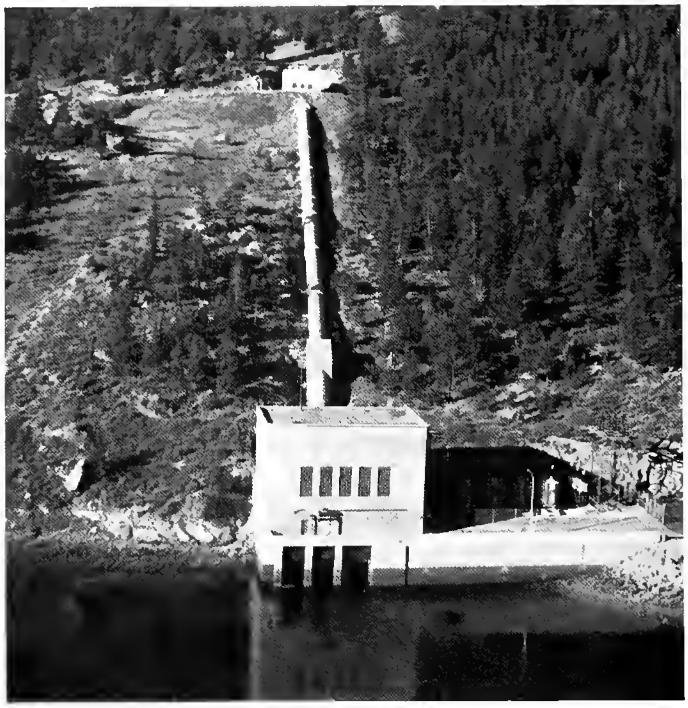
Flatiron Dam provides afterbay storage for water discharged from the powerplant. The water then flows by gravity northward through the Charles Hansen Feeder Canal, to and across the Big Thompson River, and on to Horsetooth Reservoir for delivery to the Poudre River, Poudre Valley Canal, and, by exchange, to the North Poudre Supply Canal.

Water pumped southward into Carter Lake is stored for irrigation deliveries to the Little Thompson River, St. Vrain Creek, Boulder Creek, and the South Platte River.

Carter Lake Dam and Reservoir

Carter Lake is one of the two main project storage reservoirs in the East Slope distribution system. Water is stored in this reservoir for delivery to the Little Thompson River, St. Vrain Creek, Boulder Creek, and the South Platte River, for return to Flatiron Reservoir for use in the Big Thompson or Cache la Poudre Valleys, or for power generation.

Carter Lake Reservoir is formed in a natural basin in the foothills by a 214-foot-high earthfill dam and two smaller dams across low saddles in the surrounding hills. The reservoir has a total capacity of 112,200 acre-feet.



Marys Lake Powerplant

St. Vrain Supply Canal

Leading from the Carter Lake outlet, the St. Vrain Supply Canal extends southward 9.8 miles to St. Vrain Creek near Lyons. It consists of an open canal, siphons, tunnels, drops, and flumes designed to convey 625 cubic feet per second of water to the Little Thompson River turnout and 575 cubic feet per second from the turnout to St. Vrain Creek.

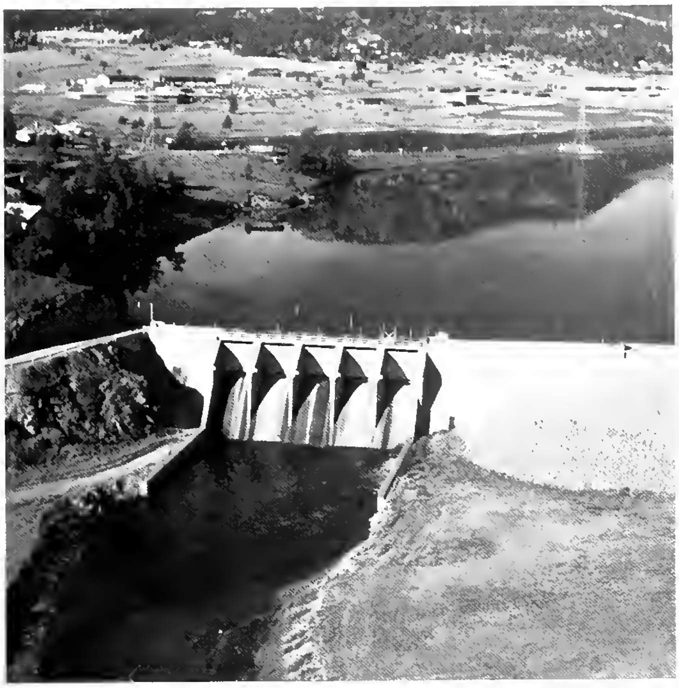
Boulder Creek Supply Canal

Boulder Creek Supply Canal begins at the turnout near the end of the St. Vrain Supply Canal, crosses St. Vrain Creek by a siphon, and extends southeasterly 15.7 miles. It discharges into Boulder Creek about 6 miles east of Boulder. The canal has a carrying capacity of 200 cubic feet per second.

Near the lower end of the canal, the city of Boulder constructed Boulder Reservoir to be used for storage and regulation of the city's water for replacement water carried in the canal. This reservoir was built under an agreement between the city and the Northern Colorado Water Conservancy District. Under the agreement, the reservoir provides 175 cubic feet per second of flow for the South Platte Supply Canal.

South Platte Supply Canal

This canal extends from Boulder Creek generally northeast to the South Platte River, a distance of about 32.2 miles. The capacity of the canal is 230 cubic feet per



Olympus Dam

second at the start and progressively decreases. Near the lower end of the canal, the Platte Valley Irrigation Co. constructed Coal Ridge Waste Lake for storage. This reservoir was built under an agreement with the Northern Colorado Water Conservancy District. Under the agreement, the lake provides 100 cubic feet per second of South Platte Supply Canal flows.

Charles Hansen Feeder Canal

Beginning at the outlet of Flatiron Reservoir, the Charles Hansen Feeder Canal extends northward to Horsetooth

Estes Powerplant

Reservoir. The canal has a capacity of 930 cubic feet per second to the Big Thompson River and 550 cubic feet per second to the reservoir. The canal crosses the Big Thompson River and U.S. Highway 34 in a 9-foot-diameter steel siphon. A control structure ahead of the Big Thompson River Siphon provides a means to release irrigation water to the Big Thompson River to bypass surplus water, and to release water to the Big Thompson Powerplant. The Horsetooth Supply Conduit, an important feature of the canal, diverts water from the Big Thompson River about 1 mile upstream from the control structure and delivers it via a tunnel to the Charles Hansen Feeder Canal above the control structure. Diverted water is used for power generation at the Big Thompson Powerplant, or water surplus to the needs of the Big Thompson Valley can be stored in Horsetooth Reservoir. North of the Big Thompson River, the canal passes through four concrete-lined tunnels; the outlet of the last tunnel discharges the water into the Horsetooth Reservoir.

Big Thompson Powerplant

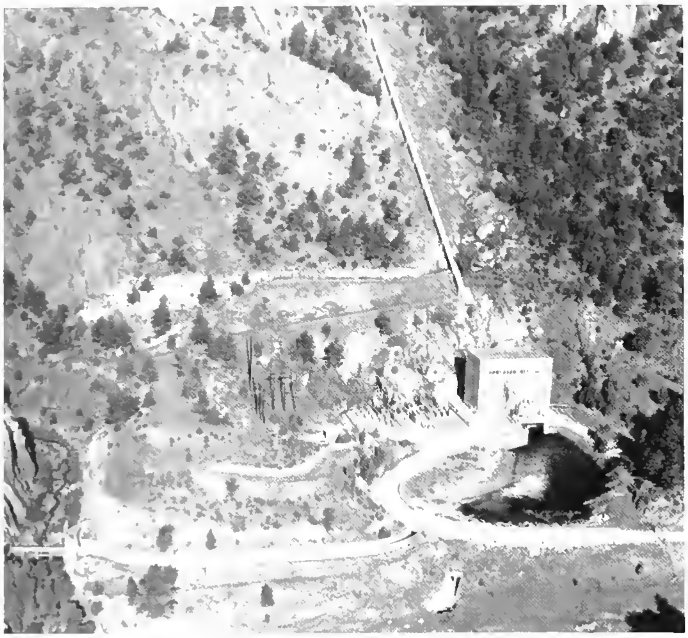
The Big Thompson Powerplant is on the Big Thompson River about 9 miles west of Loveland and just downstream from the river crossing of the Charles Hansen Feeder Canal. The plant operates under an effective head of 180 feet and has a generating capacity of 4,500 kilowatts.

Horsetooth Reservoir

Horsetooth Reservoir, with a total capacity of about 151,800 acre-feet, furnishes the main supply for the Poudre Valley, where 50 percent of the project water is used. The reservoir is 6.5 miles long, and is formed by four large earthfill dams. Horsetooth Dam closes the northern end of the valley, and Soldier Canyon, Dixon Canyon, and Spring Canyon Dams close natural outlets eroded through the hogback ridge. These dams have heights of 155, 226, 240, and 220 feet, respectively. The dams contain more than 10 million cubic yards of earthfill.

Charles Hansen and North Poudre Supply Canals

Outlets at Horsetooth Dam discharge into the Charles Hansen Canal, which is designed to carry a maximum of 1,500 cubic feet per second northward 5.1 miles to the Cache la Poudre River. Project water released into the river at this point is used to supplement the water supply of irrigation systems stemming from the river. It also serves as replenishment for the water taken from the river a few miles upstream by the North Poudre Supply Canal, a 12.5-mile-long canal which carries supplemental water to the North Poudre Ditch. The 0.5-mile, 250-cubic-foot-per-second Windsor Extension Canal takes



Pole Hill Powerplant

part of the Poudre supply across the river to the Poudre Valley Canal, an older waterway that serves a portion of the conservancy district.

The Soldier Canyon Dam outlet supplies water to Colorado State University, to the small Dixon Feeder Canal for the irrigated area cut off from its water supply by Horsetooth Reservoir, to Fort Collins, and to rural water districts.

The Cache la Poudre, Big Thompson, and Little Thompson Rivers, and St. Vrain and Boulder Creeks are tributaries of the South Platte River, through which water imported from the western slope is supplied to the South Platte River Basin system. This supplemental water is used to alleviate the critical shortages that have hampered and restricted the cultivation of fertile lands in the South Platte River Valley.

Flatiron Powerplant

Power Distribution System

Power transmission facilities include nearly 677 miles of transmission lines, 35 permanent substations, 2 mobile substations, 1 mobile transformer, 22 metering stations, and 6 permanent service shops. With the exception of 3 miles of steel tower construction and 13.1 miles of submarine-type conduit, the transmission circuits are of wood pole H-frame construction. The submarine-type conduit is the connection between eastern and western slope circuits and is in a nitrogen gas-filled pipe suspended from the top of the Alva B. Adams Tunnel. Project power facilities are interconnected with plants of the North Platte, Kendrick, Riverton, and Shoshone Projects, and are tied into the lines of the Public Service Company of Colorado at five points in Colorado.

Flatiron Dispatching Office

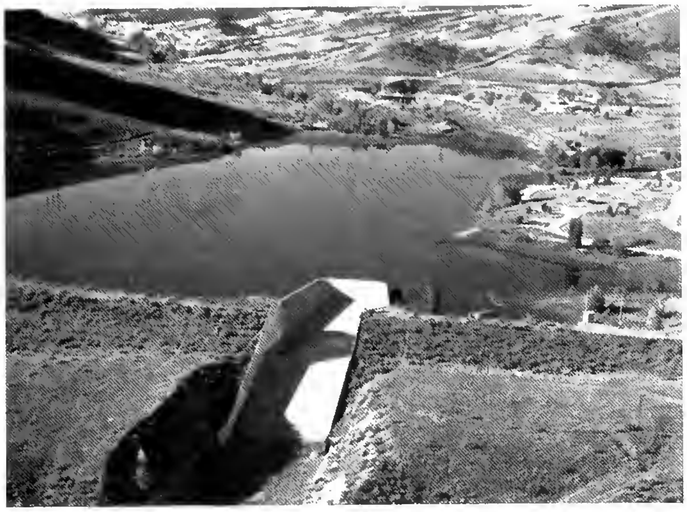
DEVELOPMENT

Early History

In 1870, before statehood was achieved by the Colorado Territory, the Union Colony of 2,000 people was established at Greeley. This marked the inception of cooperative irrigation in the South Platte River Valley and the beginning of an era in which irrigation became important in the economic development of northeastern Colorado.

The Union Colony started with construction of ditches to supply direct flow from the river to 12,000 acres. The venture was so successful that by 1900 the streams were overappropriated and attention was given to development of plains reservoirs to store the spring floods. By 1910, most of the better reservoir sites were used and few other possibilities were apparent, except costly transmountain diversion.

During these years, the increasing demand for agricultural products for a growing population, and the tendency to prepare as large an irrigation system as possible



Flatiron Dam and Reservoir

Pinewood Lake and Rattlesnake Dam

to spread the cost of the works, resulted in over-expansion, especially in years of high and adequate runoff. Subnormal or even normal runoff years were critical for much of the area so developed. Water shortages continually plagued the irrigators.

Investigations

The idea of transmountain water diversions had been in existence since 1889, when the Colorado legislature appropriated money to investigate such a proposal. Progressive steps in legislation finally led, in 1922, to the signing of the Colorado River Compact, which apportioned the Colorado River water between the upper and lower basin States. Later, the Boulder Canyon Act provided funds for determining the amount of lands that

Flatiron Penstocks

were or could be irrigated in the Colorado River Basin. A plan was developed whereby Colorado River water could be diverted into watersheds in northeastern Colorado where there was a surplus of irrigable lands and a shortage of water. The upper basin States successfully developed a compact in 1948 prorating the upper basin's share based on the 1922 compact.

Engineering investigations of the Colorado-Big Thompson Project began in 1933, when a preliminary survey to determine the feasibility of a project was undertaken. A favorable report was presented in 1934. In January 1935, the Bureau of Reclamation was allotted funds by the Public Works Administration to make a new study.

Project construction was contingent upon the formation of a conservancy district to contract with the United States Government. Accordingly, the Colorado Water Conservancy Law was passed by the Colorado legislature in 1937. The law contains several unique features. One provides that a conservancy district may be organized by any district court upon petition of a stipulated number of property owners; another recognizes that all who benefit as a result of project development should contribute to its cost and operation in proportion to those benefits.

The Northern Colorado Water Conservancy District was organized in 1937 with boundaries which include large areas of Larimer, Boulder, and Weld Counties, and portions of Morgan, Washington, Logan, and Sedgwick Counties.

Authorization

First construction funds were provided in the Interior Department Appropriation Act of August 9, 1937 (50 Stat. 595). The Secretary's finding of feasibility was approved by the President on December 21, 1937.

Horsetooth Dam and Reservoir

Construction

Construction of the project began at Green Mountain Dam during November 1938. The first power was generated at the Green Mountain Powerplant in May 1943; all construction of the dam and powerplant was completed in October 1943. Construction of Granby Dam started in 1941, and of Alva B. Adams Tunnel in the summer of 1940. Work was curtailed during World War II, but not entirely stopped. At the end of the war, the tempo of construction was speeded up. During 1956, all major features were essentially completed except the Big Thompson Powerplant, which was completed in 1959.

Operating Agencies

The Bureau of Reclamation operates all project features on the western slope, including power, storage, and carriage, and all similar works on the eastern slope above the supply canals leading from Carter Lake and Horsetooth Reservoirs. All project works below these two reservoirs are operated and maintained by the Northern Colorado Water Conservancy District.

BENEFITS

Irrigation

The Colorado-Big Thompson Project helps stabilize the agricultural and industrial economy of northeastern Colorado. It is particularly effective each year during late summer months of the irrigation season, and has a tremendous impact throughout the season in drought years.

Principal crops include sugar beets, potatoes, beans, corn, small grains, fruits, alfalfa, vegetables, dairy products, poultry, and eggs. In addition, lambs, hogs, and cattle are fattened from the byproducts of the sugar beets.

Municipal and Industrial Water

Municipal supplies have been an important aspect in the distribution of project water. Originally, nine communities had allotments totaling 44,950 acre-feet. Eleven communities now receive full or supplemental supplies. Each year, as urban population increases, irrigation allotments are transferred to domestic purposes. The dependable availability of water continues to attract a variety of industries.

Hydroelectric Power

From the eastern portal of the Alva B. Adams Tunnel, water descends about 2,800 feet to the foothills. Nearly every foot of the head is used for hydroelectric power generation. Gross generation averages 760 million kilowatt-hours, of which 70 million kilowatt-hours are used by project pumps and 690 million kilowatt-hours (36 percent of the total power marketed by the Western Division of the Pick-Sloan Missouri Basin Program) are marketed to customers in northern Colorado, eastern Wyoming, and western Nebraska.

The water and power control center for Reclamation's reservoirs, powerplants, and transmission lines in Wyoming, Colorado, and western Nebraska is at the project headquarters in Loveland, Colo. This Western Division of the Missouri River Basin is an interconnected system of 15 Reclamation powerplants and 391,750 kilowatts of installed capacity. The Reclamation system has 13 interconnections with other utilities with which power exchanges may be made.

Big Thompson Siphon

Recreation

About two million people visit the manmade lakes annually to enjoy fishing, motor- and sailboating, water skiing, swimming, camping, hiking, and picnicking. Trout, kokanee, bass, walleye, and perch are the principal fish caught in the clear, cool waters. Ice fishing and snowmobiling have become favorite winter sports.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	720,000	acres
Number of irrigated farms	3,650	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	720,000	98,712,837
1969	720,000	96,422,132
1970	720,000	102,472,357
1971	720,000	117,977,554
1972	676,274	140,890,357
1973	661,418	169,123,755
1974	658,720	269,312,087
1975	658,720	280,483,739
1976	658,720	225,890,031
1977	645,058	236,163,983

Facilities in Operation

Storage dams	14	
Diversion dams	7	
Canals	99.1	mi
Pumping plants	3	
Powerplants	6	
Transmission lines	676.7	mi
Substations	35	

Climatic Conditions

Annual precipitation	15	in
Temperature:		
Maximum	102	°F
Minimum	−41	°F
Mean	48	°F
Growing season	120-150	days
Elevation of irrigable area	3500-5400.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	14,780
Municipal and other water service[1]	382,287
Total	397,067

[1]Urban and suburban, residential, commercial, municipal and industrial lands.

Power Generation

Fiscal Year	Big Thompson Powerplant, kWh	Estes Powerplant, kWh	Flatiron Powerplant, kWh	Green Mountain Powerplant, kWh	Marys Lake Powerplant, kWh	Pole Hill Powerplant, kWh	Total kWh
1949				65,690,800			65,690,800
1950				79,813,200			79,813,200
1951		16,549,000		72,688,800	1,710,000		90,947,800
1952		19,139,700		96,205,300	7,574,000		122,919,000
1953		55,350,300		82,979,200	21,480,500		159,810,000
1954		130,229,700	126,585,800	56,694,000	49,197,100	103,692,000	466,398,600
1955		134,749,600	284,038,000	36,533,000	49,471,300	221,097,000	725,888,900
1956		102,732,200	252,454,000	71,189,400	39,196,800	196,763,000	662,335,400
1957		100,749,000	253,612,000	66,937,600	38,646,800	197,108,000	657,053,400
1958		70,499,000	222,570,000	97,011,700	27,233,200	172,014,000	589,327,900
1959	15,130,500	126,231,000	288,537,000	58,063,500	48,315,000	224,145,000	750,422,000
1960	13,461,500	112,037,500	270,083,000	68,960,000	42,977,000	211,642,000	719,161,000
1961	13,717,000	112,005,000	271,096,000	52,600,500	42,958,000	215,040,000	707,416,500
1962	15,565,000	74,357,000	197,485,000	79,331,200	28,239,000	154,036,000	549,013,200
1963	14,936,000	138,569,500	300,514,000	52,034,500	52,680,000	236,396,000	795,130,000
1964	13,649,000	138,840,000	301,771,000	21,224,500	53,102,000	242,128,000	770,714,500
1965	13,111,000	121,427,000	283,723,000	32,636,000	46,670,000	225,394,000	711,961,000
1966	11,029,000	82,472,000	215,394,000	57,988,500	32,166,000	169,170,000	568,219,500
1967	12,734,000	135,633,000	300,883,000	40,568,000	52,503,000	237,700,000	780,021,000
1968	12,897,000	91,005,000	218,123,000	42,528,000	34,328,000	173,028,000	571,909,000
1969	13,194,000	78,474,000	205,442,000	52,454,000	29,477,000	163,394,000	542,435,000
1970	15,785,000	98,289,000	252,113,000	83,789,000	37,184,000	199,100,000	686,260,000
1971	16,781,000	74,210,000	204,011,000	72,916,000	28,072,000	162,744,000	558,734,000
1972	15,355,000	116,250,000	263,196,000	72,349,000	45,037,000	207,820,000	720,007,000
1973	16,091,000	103,415,000	246,628,000	56,932,000	38,564,000	195,354,000	656,984,000
1974	16,312,000	92,585,000	216,412,000	78,748,000	33,704,000	170,070,000	607,831,000
1975	15,648,000	123,971,000	282,426,000	52,639,000	46,415,000	224,676,000	745,775,000
1976	16,398,000	107,031,000	263,472,000	58,815,000	41,365,000	208,384,000	695,465,000
1977	12,013,600	134,697,500	299,541,400	40,798,900	51,908,300	241,345,000	780,304,700

ENGINEERING DATA

Water Supply

COLORADO RIVER

Drainage area above Shadow Mountain Dam	187	mi²
Annual discharge at Shadow Mountain Lake:		
Maximum (1921)	231,800	acre-ft
Minimum (1934)	63,000	acre-ft
Average	139,800	acre-ft
Drainage area between Granby Dam and Shadow Mountain Dam	124	mi²
Annual discharge at Lake Granby:		
Maximum (1957)	369,400	acre-ft
Minimum (1954)	132,000	acre-ft
Average	230,300	acre-ft

WILLOW CREEK

Drainage area above Willow Creek Dam	127	mi²
Annual discharge at Willow Creek Reservoir:		
Maximum (1962)	102,000	acre-ft
Minimum (1954)	25,300	acre-ft
Average	55,000	acre-ft
Estimated average annual diversions (all sources)	257,700	acre-ft

BLUE RIVER

Drainage area above Green Mountain Dam	599	mi²
Annual discharge at Green Mountain Reservoir:		
Maximum (1957)	517,900	acre-ft
Minimum (1964)	171,900	acre-ft
Average	345,100	acre-ft

Storage Facilities

GREEN MOUNTAIN DAM

Type: Zoned earthfill
Location: On the Blue River, 13 mi southeast of Kremmling, Colo.
Construction period: 1938-43
Date of closure (first storage): November 16, 1942
Reservoir, Green Mountain:

Average annual inflow, 1937-76	345,100	acre-ft
Total capacity to El. 7950	154,600	acre-ft
Active capacity, El. 7800-7950	146,900	acre-ft
Surface area	2,130	acres
Dimensions:		
Structural height	309	ft
Hydraulic height	264	ft
Top width	40	ft
Maximum base width	1,688	ft
Crest length	1,150	ft
Crest elevation	7960.0	ft
Total volume	4,360,000	yd³

Spillway: Concrete-lined open channel in left abutment controlled by three 25- by 22-ft radial gates.

Elevation top of gates	7950.0	ft
Crest elevation	7928.0	ft
Capacity at El. 7950	25,000	ft³/s

Outlet works: Concrete-lined tunnel through right abutment enclosing two 8.5-ft-diameter steel penstocks leading to powerhouse. An outlet pipe branches from each penstock near the downstream end. Each outlet is controlled by a 44-inch needle valve.

Capacity at El. 7950	1,530	ft³/s

Foundation: Thin-bedded limey shale overlying moderately hard and firm trachyte porphyry sill. Joints, slips, and faults are combined with a high water table on both abutments.
Special treatment: Cement grout curtain beneath five cutoff walls, supplemental grouting of abutments; exposed shale painted with asphalt emulsion.

GRANBY DAM AND DIKES

Type: Zoned earthfill
Location: On the Colorado River, 5.5 mi northeast of Granby, Colo. Dikes No. 1, 2, and 4 are continuous and close low areas west of Granby Dam. No. 3 closes a saddle about 1 mi southeast of Granby Dam.
Construction period: 1941-50
Date of closure (first storage): September 14, 1949
Reservoir, Lake Granby:

Average annual inflow, 1937-76	230,300	acre-ft
Total capacity to El. 8280	539,800	acre-ft
Active capacity, El. 8186.9-8280	463,300	acre-ft
Surface area	7,260	acres

Dimensions:	*Dam*	*Dikes No. 1, 2, and 4*	*Dike No. 3*
Structural height	298 ft	20-98 ft	60 ft
Hydraulic height	223 ft	Offstream	Offstream
Top width	40 ft	30 ft	30 ft
Maximum base width	1,515 ft	120-400 ft	649 ft
Crest length	861 ft	4,430 ft	1,994 ft
Total volume	2,974,000 yd³	995,000 yd³	744,000 yd³

Spillway: Concrete-lined open channel at left abutment controlled by two 21- by 20-ft radial gates.

Elevation top of gates	8280.0	ft
Crest elevation	8260.0	ft
Capacity at El. 8280	11,500	ft³/s

Outlet works: Concrete-lined tunnel through left abutment controlled by one 12-in needle valve and one 30-in hollow-jet valve.

Capacity at El. 8280	435	ft³/s

Foundation: Granite, schist, and gneiss bedrock with many minor faults.
Special treatment: Cutoff trench and two concrete cutoff walls.

WILLOW CREEK DAM

Type: Zoned earthfill
Location: On Willow Creek, 4 mi north of Granby, Colo.
Construction period: 1951-53
Date of closure (first storage): April 2, 1953
Reservoir, Willow Creek:

Average annual inflow, 1937-76	55,000	acre-ft
Total capacity to El. 8130	10,600	acre-ft
Active capacity, El. 8077-8130	9,100	acre-ft
Surface area	303	acres
Dimensions:		
Structural height	127	ft
Hydraulic height	95	ft
Top width	30	ft
Maximum base width	715	ft
Crest length	1,100	ft
Crest elevation	8140.0	ft
Total volume	392,000	yd³

Spillway: Uncontrolled concrete-lined overflow weir and chute at left abutment.

Crest length	354	ft
Crest elevation	8130.0	ft
Capacity at El. 8132	3,200	ft³/s

Outlet works:
Diversion: Willow Creek Feeder Canal headworks at left abutment, controlled by two 8- by 7-ft radial gates.

Capacity (maximum)	400 ft³/s

Outlet: Concrete-lined tunnel through right abutment, controlled by two 3- by 6.5-ft high-pressure slide gates.

Capacity at El. 8132	2,050 ft³/s

Foundation: Fine-grained siltstones with a series of lava flows.
Special treatment: Cutoff trench and concrete cutoff wall.

Shadow Mountain Dam and Dikes

Type: Zoned earthfill
Location: On Colorado River below its confluence with the Grand Lake outlet. Series of low dikes extend from right abutment of dam.
Construction period: 1944-46
Date of closure (first storage): 1946
Reservoir, Shadow Mountain and Grand Lake:

Average annual inflow, 1920-47	139,800 acre-ft
Total capacity to El. 8367	18,400 acre-ft
Active capacity, El. 8366-8367[2]	1,800 acre-ft
Surface area	1,852 acres
Dimensions:	
Structural height	63 ft
Hydraulic height	37 ft
Top width	30 ft
Maximum base width	430 ft
Crest length (including dikes)	3,077 ft
Crest elevation	8375.0 ft
Total volume (including dikes)	167,000 yd³

Spillway: Concrete-lined open channel at right abutment, controlled by two 18- by 20-ft radial gates.

Elevation top of gates	8367.0 ft
Crest elevation	8348.0 ft
Capacity at El. 8367	10,000 ft³/s

Outlet works: Sluicing outlet only below spillway floor, controlled by 2.5-ft-square slide gate at inlet end.

Capacity (maximum)	50 ft³/s

Marys Lake Dikes

Type: Homogeneous earthfill
Location: Two dikes on shoreline of Marys Lake 2 mi from Estes Park, Colo.
Construction period: 1947-49
Date of closure (first storage): August 1950
Reservoir, Marys Lake:

Total capacity to El. 8040	900 acre-ft	
Active capacity, El. 8025-8040	500 acre-ft	
Surface area	42 acres	
Dimensions:	*Dike No. 1*	*Dike No. 2*
Structural height	29 ft	35 ft
Hydraulic height	20 ft	25 ft
Top width	30 ft	30 ft
Maximum base width	170 ft	185 ft
Crest length	820 ft	950 ft
Crest elevation	8050.0 ft	8050.0 ft
Total volume (both dikes)	90,000 yd³	

Spillway: None
Outlet works: Concrete intake structure to Prospect Mountain Conduit through base of Dike No. 1, controlled by one 12.5-ft-square fixed-wheel gate.

Capacity (controlled by capacity of conduit)	1,300 ft³/s

[2]One-foot operating range in accordance with Senate Document No. 80.

Olympus Dam

Type: Zoned earthfill, concrete overflow section
Location: On the Big Thompson River, 1.5 miles east of Estes Park, Colo.
Construction period: 1947-49
Date of closure (first storage): November 1948
Reservoir, Lake Estes:

Average annual inflow, 1937-76	90,300 acre-ft
Total capacity to El. 7475	3,100 acre-ft
Active capacity, El. 7450.25-7475	2,600 acre-ft
Surface area	185 acres
Dimensions:	
Structural height	70 ft
Hydraulic height	45 ft
Top width	30 ft
Maximum base width	288 ft
Crest length	1,951 ft
Crest elevation	7481.0 ft
Total volume	311,600 yd³

Spillway: Concrete overflow section at south abutment, controlled by five 20- by 17-ft radial gates.

Elevation top of gates	7475.0 ft
Crest elevation	7460.0 ft
Capacity at El. 7475	21,200 ft³/s

Outlet works:
Outlet: Two 18-in pipes through gravity section, each controlled by a 2.5-ft-square slide gate.
Diversion: Intake to Olympus Siphon at right of overflow section controlled by two 6.25- by 8.0-ft fixed-wheel gates.

Capacity (controlled by capacity of siphon)	550 ft³/s

Foundation: Sand, gravel, and cobbles up to 15 ft deep lying over decomposed, fractured and broken granite.
Special treatment: Grout curtain beneath concrete section.

Rattlesnake Dam

Type: Zoned earthfill
Location: On Rattlesnake Creek, 12 mi east of Estes Park, Colo.
Construction period: 1951-52
Date of closure (first storage): January 4, 1954
Reservoir, Pinewood:

Total capacity to El. 6580	2,180 acre-ft
Active capacity, El. 6550-6580	1,570 acre-ft
Surface area	97 acres
Dimensions:	
Structural height	130 ft
Hydraulic height	100 ft
Top width	30 ft
Maximum base width	615 ft
Crest length	1,100 ft
Crest elevation	6595.0 ft
Total volume	432,000 yd³

Spillway: Uncontrolled concrete weir and concrete-lined chute at right abutment.

Crest length	102 ft
Crest elevation	6580.0 ft
Capacity at El. 6589	10,400 ft³/s

Outlet works:
River outlet: Cement-lined, cast-iron pipe through base of dam controlled by one 16-in gate valve.

Capacity at El. 6589	23 ft³/s

Diversion outlet: Intake to Bald Mountain Pressure Tunnel.
Foundation: Generally soft, jointed, decomposed or broken schist lying over gneiss.
Special treatment: Grout curtain beneath cutoff wall.

Flatiron Dam

Type: Zoned earthfill
Location: On Chimney Hollow Creek 8 mi southwest of Loveland, Colo.
Construction period: 1951-53
Date of closure (first storage): January 1954
Reservoir, Flatiron:

Total capacity to El. 5472.8	760 acre-ft
Active capacity, El. 5462-5472.8	440 acre-ft
Surface area	47 acres
Dimensions:	
Structural height	86 ft
Hydraulic height	55 ft
Top width	30 ft
Maximum base width	455 ft
Crest length	1,725 ft
Crest elevation	5486.0 ft
Total volume	382,000 yd³

Spillway: Uncontrolled concrete crest and concrete-lined channel at left abutment.

Crest elevation	5472.8 ft
Capacity at El. 5480	23,600 ft³/s

Outlet works: Twin-barrel concrete conduit through base of dam near left abutment controlled by two 6.75- by 9.0-ft radial gates.

Capacity at El. 5464.8	930 ft³/s

Carter Lake Dams

Type: Zoned earthfill
Location: Carter Lake No. 1, the southernmost dam, is at a natural outlet from Carter Lake Basin, 7 mi northwest of Berthoud, Colo. Carter Lake No. 2 is in a saddle on east shoreline of the reservoir. No. 3 is in a saddle on the north shoreline.
Construction period: 1950-52
Reservoir, Carter Lake:

Total capacity to El. 5759	112,200 acre-ft
Active capacity, El. 5618-5759	108,900 acre-ft
Surface area	1,140

Dimensions:	*No. 1*	*No. 2*	*No. 3*
Structural height	214 ft	75 ft	55 ft
Hydraulic height	190 ft	55 ft	40 ft
Top width	40 ft	30 ft	40 ft
Maximum base width	1,320 ft	368 ft	270 ft
Crest length	1,235 ft	1,150 ft	1,425 ft
Crest elevation	5769.0 ft	5769.0 ft	5769.0 ft
Total volume	2,547,000 yd³	321,000 yd³	212,000 yd³

Spillway: None
Outlet works: Concrete conduit through base of Dam. No. 1, controlled by two 3-ft-square slide gates.

Capacity at El. 5763	1,260 ft³/s

Foundation: Sandstones, limestones, siltstones, and shales in alternating layers, generally broken and fractured.
Special treatment: Foundations grouted.

Horsetooth Dam and Satanka Dike

Type: Zoned earthfill
Location: North end of Horsetooth Reservoir.
4 mi northwest of Fort Collins, Colo. Satanka Dike closes saddle on north shoreline, about 800 ft northwest of the dam.
Construction period: 1946-49
Date of closure (first storage): January 10, 1951
Reservoir, Horsetooth:

Total capacity to El. 5430	151,800 acre-ft
Active capacity, El. 5270-5430	143,500 acre-ft
Surface area	1,873 acres

Dimensions:	*Dam*	*Dike*
Structural height	155 ft	30 ft
Hydraulic height	Offstream	Offstream
Top width	35 ft	25 ft
Maximum base width	785 ft	120 ft
Crest length	1,840 ft	348 ft
Crest elevation	5440.0 ft	5440.0 ft
Total volume (dam and dike)	1,871,000 yd³	

Spillway: None
Outlet works: Concrete conduit through base of dam, controlled by two 72-in hollow-jet valves.

Capacity at El. 5430	2,500 ft³/s

Foundation: Limey shales and sandstones overlain with silty, sandy clay.
Special treatment: Cutoff trench and concrete cutoff wall.

Soldier Canyon Dam

Type: Zoned earthfill
Location: East shore of Horsetooth Reservoir, 3.5 mi west of Fort Collins, Colo.
Construction period: 1946-49
Dimensions:

Structural height	226 ft
Hydraulic height	203 ft
Top width	40 ft
Maximum base width	1,365 ft
Crest length	1,438 ft
Crest elevation	5440.0 ft
Total volume	3,212,000 yd³

Spillway: None
Outlet works: Concrete-lined, tunnel through right abutment housing 30-in steel pipe, controlled by one 18-in pivot (butterfly) valve.

Capacity at El. 5430	90 ft³/s

Foundation: Sandstone and shale
Special treatment: Cutoff trench and concrete cutoff wall.

Dixon Canyon Dam

Type: Zoned earthfill
Location: East shore of Horsetooth Reservoir, 3 mi southeast of Fort Collins, Colo.
Construction period: 1946-49
Dimensions:

Structural height	240 ft
Hydraulic height	215 ft
Top width	40 ft
Maximum base width	1,500 ft
Crest length	1,265 ft
Crest elevation	5440.0 ft
Total volume	2,961,000 yd³

Spillway: None
Outlet works: None
Foundation: Sandstone and shale
Special treatment: Cutoff trench and concrete cutoff wall.

Spring Canyon Dam

Type: Zoned earthfill
Location: East shore of Horsetooth Reservoir, 4.5 mi southwest of Fort Collins, Colo.
Construction period: 1946-49
Dimensions:

Structural height	220 ft
Hydraulic height	198 ft
Top width	40 ft
Maximum base width	1,350 ft
Crest length	1,120 ft

Crest elevation: 5440.0 ft
Total volume: 2,095,000 yd^3
Spillway: None
Outlet works: None
Foundation: Sandstone and shale
Special treatment: Cutoff trench and concrete cutoff wall.

Diversion Facilities

Willow Creek Forebay Dam

Type: Earth and rockfill
Location: On Willow Creek Feeder Canal, 1 mi west of Granby Reservoir.
Year completed: 1953
Dimensions:
Structural height: 24 ft
Hydraulic height: 11 ft
Crest length: 580 ft
Crest elevation: 8120.0 ft
Total volume: 15,000 yd^3
Spillway:
Capacity: 450 ft^3/s
Diversion outlet: Forebay connects to pumping plants through 1,500-ft-long channel.
Capacity: 400 ft^3/s

East Portal Dam

Type: Rockfill with concrete corewall
Location: On the Wind River at East Portal of Alva B. Adams Tunnel, 4.5 mi southwest of Estes Park, Colo.
Year completed: 1947
Dimensions:
Structural height: 76 ft
Hydraulic height: 10 ft
Crest length: 245 ft
Crest elevation: 8265.0 ft
Spillway:
Capacity: 550 ft^3/s
Crest elevation: 8258.3 ft
Diversion outlet: To Parshall flume section ahead of Aspen Creek Siphon.
Capacity: 550 ft^3/s

Little Hell Creek Diversion Dam

Type: Earth and rockfill
Location: On Little Hell Creek above Pole Hill switchyard.
Year completed: 1952
Dimensions:
Structural height: 43 ft
Hydraulic height: 33 ft
Crest length: 220 ft
Crest elevation: 6640.0 ft
Volume: 10,000 yd^3
Spillway: None
Diversion capacity: 550 ft^3/s

South Platte Supply Canal Diversion Dam

Type: Diversion embankment and concrete overflow structure connected by 885-ft channel
Location: On Boulder Creek about 8 mi east of Boulder, Colo.
Year completed: 1956
Dimensions:
Structural height (embankment): 10.6 ft
Hydraulic height (embankment): 5 ft
Crest length (embankment): 64 ft
Crest length (concrete section): 34 ft
Crest elevation (embankment): 5052.2 ft
Spillway: Concrete overflow type
Capacity: 230 ft^3/s

Pole Hill Afterbay Dam

Type: Earth and rockfill
Location: Below Pole Hill Powerplant, 10.5 mi east of Estes Park, Colo.
Year completed: 1953
Dimensions:
Structural height: 32 ft
Hydraulic height: 21 ft
Crest length: 220 ft
Crest elevation: 6597.0 ft
Volume: 6,000 yd^3
Siphon spillway:
Capacity: 550 ft^3/s
Crest elevation: 6593.0 ft
Diversion capacity: 550 ft^3/s

Big Thompson Diversion Dam

Type: Concrete box, combined overflow and grated inlet
Location: On the Big Thompson River, at west portal of Horsetooth Supply Conduit, 8.5 mi west of Loveland, Colo.
Year completed: 1950
Dimensions:
Structural height: 35 ft
Hydraulic height: 8 ft
Crest length: 90 ft
Crest elevation: 5500.0 ft
Weir crest length: 50 ft
Weir crest elevation: 5486.5 ft
Volume: 1,300 yd^3
Spillway: Overflow
Diversion capacity: 600 ft^3/s

North Poudre Diversion Dam

Type: Concrete ogee weir
Location: On the Cache la Poudre River about 11 mi northwest of Fort Collins, Colo.
Year completed: 1952
Dimensions:
Structural height: 24 ft
Hydraulic height: 6 ft
Crest length: 200 ft
Crest elevation: 5439.0 ft
Weir crest length: 130 ft
Weir crest elevation: 5428.0 ft
Volume: 1,300 yd^3
Spillway: Overflow
Diversion capacity: 250 ft^3/s

Carriage Facilities

Elliot Creek Feeder Canal

Location: From Elliot Creek into Green Mountain Reservoir, just above dam.
Construction period: 1943
Length: 1.1 mi
Capacity: 90 ft^3/s
Typical maximum section in earth:
Bottom width: 4 ft
Side slopes:
In fill: 1.5:1
In cut: 2:1
Water depth: 2 ft
Typical flume section:
Bottom width: 9.5 ft
Water depth: 2 ft
Lining thickness: 6 in

WILLOW CREEK FEEDER CANAL

Location: From Willow Creek Dam generally east to Willow Creek Pumping Plant, then to Granby Reservoir.
Construction period: 1951-53

Length	3.4 mi
Capacity	400 ft³/s
Typical maximum section in earth:	
Bottom width	14 ft
Side slopes	1.5:1
Water depth	6.9 ft
Typical maximum section, concrete lined:	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	5.2 ft
Lining thickness	4 in

GRANBY PUMP CANAL

Location: From Granby Pumping Plant to Shadow Mountain Lake.
Construction period: 1949-50

Length	1.8 mi
Capacity	1,100 ft³/s
Typical maximum section in earth:	
Bottom width	20 ft
Side slopes	2:1
Water depth	10.5 ft
Typical maximum section, gravel lined:	
Bottom width	20 ft
Side slopes	2:1
Water depth	10.5 ft
Lining thickness	3-4.5 ft

ALVA B. ADAMS TUNNEL

Location: From Grand Lake east to a point on Wind River about 4.5 mi southwest of Estes Park, Colo.
Construction period: 1940-47

Length	13.4 mi
Capacity	550 ft³/s
Cross section: Circular	
Diameter	9.75 ft
Lining: Concrete	

ASPEN CREEK SIPHON

Location: From Parshall flume section at East Portal Reservoir to Rams Horn Tunnel.
Construction period: 1947-48

Length	1.3 mi
Capacity	550 ft³/s
Diameter	10.75 ft

RAMS HORN TUNNEL

Location: End of cut-and-cover flume section from Aspen Creek Siphon northeast to penstock gate structure for Marys Lake Powerplant.
Construction period: 1946-47

Length	1.3 mi
Capacity	550 ft³/s
Cross section: Horseshoe	
Diameter	10 ft
Lining: Concrete	

PROSPECT MOUNTAIN CONDUIT

Location: From outlet in Marys Lake Dike No. 1 eastward to Prospect Mountain Tunnel.
Description: Reinforced-concrete pressure conduit (covered)
Construction period: 1947-49

Length	0.6 mi
Capacity	1,300 ft³/s
Diameter	12.5 ft

PROSPECT MOUNTAIN PRESSURE TUNNEL

Location: From Prospect Mountain Conduit northeast to surge tank and Estes Powerplant penstock gate structure.
Construction period: 1946-48

Length	1.1 mi
Capacity	1,300 ft³/s
Cross section: Circular	
Diameter	12.5 ft
Lining: Concrete	

OLYMPUS SIPHON

Location: From Olympus Dam to Olympus Tunnel.
Construction period: 1950
Type: Monolithic concrete pipe

Length	0.8 mi
Capacity	550 ft³/s
Diameter	10.75 ft

OLYMPUS AND POLE HILL TUNNELS

Location: From Olympus Siphon east to Pole Hill Canal. The tunnels are connected by a short length of covered conduit.
Construction period: 1949-52

Length (Olympus, 1.8; Pole Hill, 5.4)	7.2 mi
Capacity	550 ft³/s
Cross section: Horseshoe	
Diameter	9.75 ft
Lining: Concrete	

POLE HILL CANAL

Location: From end of Pole Hill Tunnel to Pole Hill Powerplant penstock gate structure.
Construction period: 1952

Length	0.5 mi
Capacity	550 ft³/s
Typical maximum section, concrete lined:	
Bottom width	7 ft
Side slopes	1.25:1
Water depth	7.4 ft
Lining thickness	4 in
Typical maximum section, bench flume:	
Bottom width	16.3 ft
Water depth	7.4 ft
Lining thickness	8 in

RATTLESNAKE SIPHON AND TUNNEL

Location: From Pole Hill Powerplant Afterbay east to Pinewood Reservoir.
Construction period: 1950-52

Length	1.7 mi
(Outlet through dam, 9.75-ft-diameter concrete siphon, 274 ft long, crosses creek bed).	
Capacity	550 ft³/s
Cross section (tunnel): Horseshoe	
Diameter	9.75 ft
Lining: Concrete	

BALD MOUNTAIN PRESSURE TUNNEL

Location: From Pinewood Reservoir east to surge tank, Flatiron Powerplant penstock gate structure.

Construction period: 1950-52
Length ... 1.3 mi
Capacity ... 960 ft³/s
Cross section: Circular
Diameter ... 10.5 ft
Lining: Concrete

CARTER LAKE PRESSURE CONDUIT AND TUNNEL

Location: From Flatiron Powerplant southeast to Carter Lake Reservoir.
Construction period: 1950-52
Length (conduit, 0.2 mi; tunnel, 1.2 mi) ... 1.4 mi
Capacity ... 550 ft³/s
Cross section: Circular
Diameter ... 8 ft
Lining: Concrete

FLATIRON CANAL

Location: Connection between Flatiron Power and Pumping Plant afterbay pool and the Flatiron Reservoir.
Construction period: 1951-53
Length ... 0.3 mi
Capacity ... 960 ft³/s
Typical maximum section:
Bottom width ... 20 ft
Side slopes ... 1.5:1
Water depth ... 18.8 ft

ST. VRAIN SUPPLY CANAL

Location: From Carter Lake Reservoir at Dam No. 1 south to St. Vrain Creek near Lyons, Colo.
Construction period: 1952-54
Length ... 9.8 mi
Capacity ... 625 ft³/s
Typical maximum, concrete lined:
Bottom width ... 7 ft
Side slopes ... 1.25:1
Water depth ... 6 ft
Lining thickness ... 4 in
Typical maximum section in earth:
Bottom width ... 20 ft
Side slopes ... 1.5:1
Water depth ... 7.4 ft

BOULDER CREEK SUPPLY CANAL

Location: From turnout near end of St. Vrain Supply Canal generally south to Boulder Creek about 6 mi east of Boulder, Colo. Boulder (municipal) Reservoir on canal line used as carrier.
Construction period: 1953-55
Length ... 15.7 mi
Capacity ... 200 ft³/s
Typical maximum section in earth:
Bottom width ... 12 ft
Side slopes ... 1.5:1
Water depth ... 4.6 ft
Typical maximum section in rock:
Bottom width ... 12 ft
Side slopes ... 0.5:1
Water depth ... 4.3 ft
Typical maximum section, compacted earth lined:
Bottom width ... 12 ft
Side slopes ... 1.5:1
Water depth ... 4.6 ft
Lining thickness:
Sides ... 3 ft
Bottom ... 1.5 ft

SOUTH PLATTE SUPPLY CANAL

Location: From Boulder Creek about 8 mi east of Boulder, Colo., generally northeast to vicinity of Fort Lupton, Colo. Coal Ridge Waste Lake on canal line and used as carrier.
Construction period: 1954-56
Length ... 32.2 mi
Capacity ... 230 ft³/s
Typical maximum section in earth:
Bottom width ... 20 ft
Side slopes ... 2:1
Water depth ... 3.2 ft

CHARLES HANSEN FEEDER CANAL

Location: From Flatiron Reservoir generally north to Horsetooth Reservoir—Flatiron section to Big Thompson turnout; Horsetooth section to reservoir.
Construction period: 1949-53
Length:
Flatiron section ... 3.8 mi
Horsetooth section ... 9.4 mi
Typical maximum section, concrete lined:

	Flatiron	*Horsetooth*
Capacity	930 ft³/s	550 ft³/s
Bottom width	13 ft	7 ft
Side slopes	1.25:1	1.25:1
Water depth	8.8 ft	8.2 ft
Lining thickness	4 in	4 in

Typical maximum section in rock:
Bottom width ... 15 ft
Side slopes ... 1:1
Water depth ... 8.1 ft

DIXON FEEDER CANAL

Location: From Soldier Canyon Dam to College Lake and Dixon Canyon Reservoir.
Construction period: 1950
Length ... 3 mi
Capacity ... 8 ft³/s
Typical maximum section in earth:
Bottom width ... 3 ft
Side slopes ... 1.5:1
Water depth ... 1 ft

CHARLES HANSEN CANAL

Location: From Horsetooth Dam generally north to Cache la Poudre River.
Construction period: 1950-52
Length ... 5.1 mi
Capacity ... 1,500 ft³/s
Typical maximum section in earth:
Bottom width ... 32 ft
Side slopes ... 1.5:1
Water depth ... 7.2 ft
Typical maximum section, concrete lined:
Bottom width ... 12 ft
Side slopes ... 1.25:1
Water depth ... 7.2 ft
Lining thickness ... 4 in
Length ... 2.8 mi

WINDSOR EXTENSION CANAL

Location: From Charles Hansen Canal near the Cache la Poudre River to existing Poudre Valley Canal.
Construction period: 1952
Length ... 0.5 mi
Capacity ... 250 ft³/s

Typical maximum section, concrete bench flume:	
Width	8 ft
Water depth	5 ft
Wall thickness	8 in
Typical maximum section, concrete lined:	
Bottom width	7 ft
Side slopes	1.25:1
Water depth	5.6 ft
Lining thickness	4 in

NORTH POUDRE SUPPLY CANAL

Location: From North Poudre Diversion Dam on the Cache la Poudre River about 11 mi northwest of Fort Collins, generally northeast.

Construction period: 1951-53

Length	12.5 mi
Capacity	250 ft³/s
Typical maximum section in earth:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	5.6 ft
Typical maximum section in rock:	
Bottom width	14 ft
Side slopes	0.5:1
Water depth	5.6 ft
Typical maximum section, concrete lined:	
Bottom width	6 ft
Side slopes	1.25:1
Water depth	5.6 ft
Lining thickness	4 in

PUMPING PLANTS[3]

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Granby	3	600	186	18,000
Willow Creek	2	400	175	10,000
Flatiron	1[4]	370	240	13,000

[3]There are 12 small pumping units installed on the project in the Kremmling area. They have capacities of 2 to 12 ft³/s, with a total capacity of 91 ft³/s. Total dynamic heads range from 7.5 to 17 ft, and the installed horsepower ranges from 7.5 to 20.

[4]The unit may be operated in reverse as a generating unit (8,500-kW capacity) to utilize water released back to Flatiron Reservoir from Carter Lake for redistribution via Charles Hansen Canal, or for power purposes only.

Power Facilities

GREEN MOUNTAIN POWERPLANT

Location: At right side, toe of Green Mountain Dam.

Year of initial operation: 1943

Year last generator placed in operation: 1943

Nameplace capacity	21,600 kW
Number and capacity of generators (2)	10,800 kW
Maximum head	261 ft

MARYS LAKE POWERPLANT

Location: At western shore of Marys Lake, 2.5 mi southwest of Estes Park, Colo.

Year of initial operation: 1951

Nameplate capacity	8,100 kW
Number of generators	1
Maximum head	210 ft

ESTES POWERPLANT

Location: At the upper end of Lake Estes near Estes Park, Colo.

Year of initial operation: 1950

Year last generator placed in operation: 1950

Nameplate capacity	45,000 kW
Number and capacity of generators (3)	15,000 kW
Maximum head	572 ft

POLE HILL POWERPLANT

Location: In Little Hell Canyon, 10 mi east of Estes Park, Colo.

Year of initial operation: 1954

Nameplate capacity	33,250 kW
Number of generators	1
Maximum head	840 ft

FLATIRON POWERPLANT

Location: In Chimney Hollow, 10 mi west of Loveland, Colo.

Year of initial operation: 1954

Year last generator placed in operation: 1954

Nameplate capacity	71,500 kW
Number and capacity of generators (2)	31,500 kW
(1)	8,500 kW
Maximum head	1,118 ft

BIG THOMPSON POWERPLANT

Location: On the Big Thompson River 9 mi west of Loveland, Colo.

Year of initial operation: 1959

Ultimate nameplate capacity	4,500 kW
Maximum head	183.5 ft

SUBSTATIONS AND SWITCHYARDS

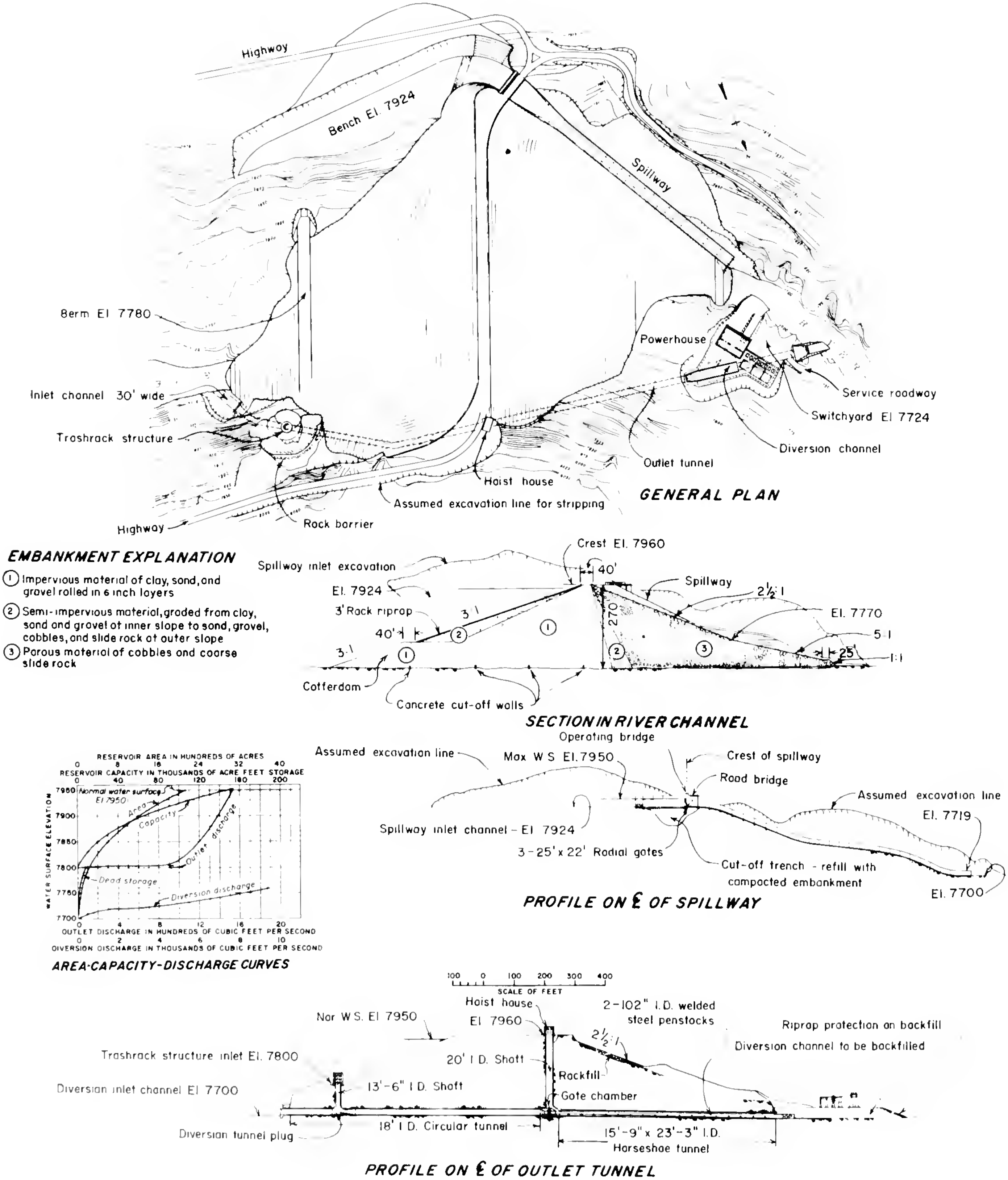
Substations and switchyards	35
Project also operates two mobile substations and one mobile transformer	
Total capacity of transformers	683,628 kVA

TRANSMISSION LINES

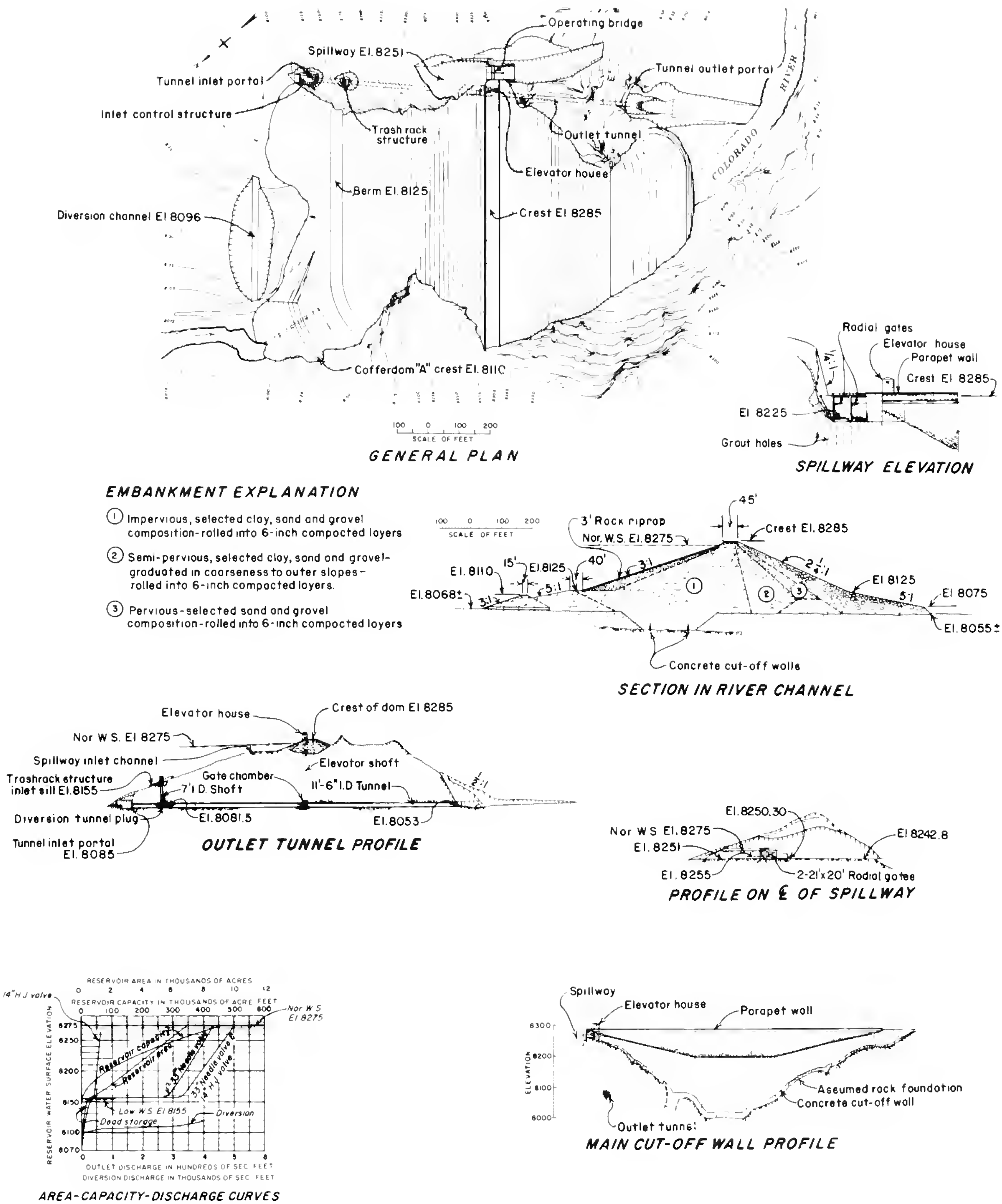
Total number of lines	37
Total circuit miles	676.72

Designation	Capacity kV	Circuit miles	Year placed in service
Beaver Creek—Limon			
Beaver Creek—Woodrow	115	18.46	1951
Woodrow-Morgan Co. REA So. Woodrow Tap	115	9.36	1951
Morgan Co. REA So. Woodrow Tap—Last Chance	115	8.08	1951
YWEA Last Chance—Big Sandy	115	30.27	1951
Big Sandy—Limon	115	3.92	1951&1975
Beaver Creek—Wray			
Beaver Creek—Akron	115	22.18	1950
Akron—YWEA Otis Tap	115	17.12	1950
YWEA Otis Tap—Yuma Tap (Colo.)	115	8.19	1950
Yuma Tap—Eckley Tap	115	10.07	1951
Eckley Tap—Tri-State's Wray Tap	115	13.97	1951
Tri-State's Wray Tap—Wray	115	2.14	1951
Yuma Tap—Yuma (Colo.)	115	0.84	1953
Cheyenne-Flatiron			
Tap near Ault—PV REA Black Hollow Tap	115	5.13	1952
PV REA Black Hollow Tap—Timnath Tap	115	4.53	1952
Timnath Tap—Poudre	115	3.94	1952
Poudre—Station 400	115	4.06	1952
Station 400—P.S. Co. Ft. Collins	115	1.00	1952
P.S. Co. Ft. Collins—Drake Road Tap	115	1.10	1952
Drake Road Tap—T.S. Horseshoe Tap	115	3.80	1952
T.S. Horsetooth Tap—Flatiron	115	11.87	1952

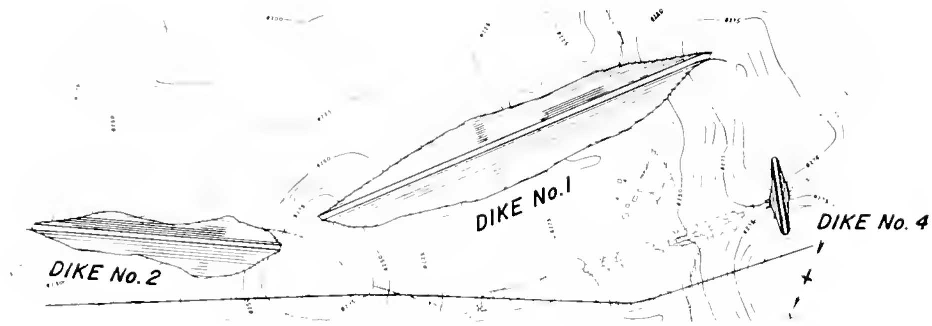
Designation	Capacity kV	Circuit miles	Year placed in service
Erie—Beaver Creek			
Erie—Brighton	115	6.10	1950
Brighton—Hoyt	115	40.42	1952
Hoyt—Morgan Co. REA Adena Tap	115	14.95	1952
Morgan Co. REA Adena Tap—Beaver Creek	115	17.01	1952
Hoyt—Wiggins	115	13.10	1950
Estes—Flatiron	115	16.28	1939
Estes—Marys Lake	115	3.11	1951
Estes—Pole Hill	115	10.29	1953
Flatiron—Kodak			
Flatiron—PV REA Carter Lake Tap	115	2.00	1950
PV REA Carter Lake Tap—Loveland West Tap	115	4.04	1950
Loveland West Tap—Loveland Tap	115	1.49	1950
Loveland Tap—Derby Hill	115	0.83	1950
Derby Hill—Boyd	115	2.27	1950
Boyd—PV REA Kodak West Tap	115	10.17	1950
PV REA Kodak West Tap—Kodak	115	2.80	1971
Loveland Tap—Loveland	115	0.89	1950
PV REA Kodak West Tap—Windsor	115	0.13	1950
Flatiron—Pole Hill	115	4.83	1950
Flatiron—PV REA Lyons Tap	115	10.83	1950
Greeley—Rosedale	115	4.61	1940
Green Mountain—Summit			
Green Mountain—Henderson Temporary Tap	115	12.41	1938
Henderson Temp. Tap—Summit	115	15.81	1938
Kodak-Weld			
Kodak—PV REA Kodak East Tap	115	2.59	1971
PV REA Kodak East Tap—Weld	115	2.82	1950
Windsor—PV REA Kodak East Tap	115	0.57	1950
Longmont Northwest—Erie			
Longmont Northwest—Longmont Tap	115	3.30	1950
Longmont Tap—Erie	115	14.10	1950
Longmont Tap—Longmont	115	0.23	1951
PV REA Lyons Tap—Longmont Northwest			
PV REA Lyons Tap—Hygiene	115	0.08	1950
Hygiene—Longmont Northwest	115	3.19	1950
Sidney—Beaver Creek			
Sterling—MC REA Messex Tap	115	21.38	1948
MC REA Messex Tap—Beaver Creek	115	14.40	1948
Weld—Beaver Creek			
Weld—Point near Rosedale	115	14.19	1940
Point near Rosedale—PV REA Kersey Tap	115	7.43	1940
PV REA Kersey Tap—Prospect Valley Tap	115	7.86	1940
Prospect Valley Tap—MC REA Orchard Tap	115	16.66	1940
MC REA Orchard Tap—Wiggins Tap	115	0.99	1940
Wiggins Tap—Bijou Tap	115	8.68	1940
Bijou Tap—Ft. Morgan Tap	115	7.70	1940
Ft. Morgan Tap—Ft. Morgan East Sub. Tap	115	1.03	1940
Ft. Morgan East Sub. Tap—Brush Tap	115	9.92	1940
Brush Tap—Beaver Creek	115	0.77	1940
Prospect Valley Tap—Morgan Co. Lost Creek Tap	115	7.31	1944
Morgan Co. Lost Creek Tap—Prospect Valley	115	8.12	1944
Wiggins Tap—Wiggins	115	5.97	1940
Ft. Morgan Tap—Ft. Morgan	115	0.02	1940
Brush Tap—Brush	115	0.01	1940
Estes—Granby PP			
Estes—East Portal	69	5.99	1951
West Portal—Grand Lake Tap	69	2.84	1939
Grand Lake Tap—Shadow Mt. Tap	69	2.69	1939
Shadow Mt. Tap—Granby PP	69	3.42	1939
Shadow Mt. Tap—Shadow Mt.	69	0.89	1939
Green Mountain—Granby Pumping Plant			
Green Mtn—Kremmling Tap	69	10.13	1939
Kremmling Tap—Troublesome Tap	69	4.45	1939
Troublesome Tap—Wm Fork Tap (Denver)	69	5.81	1939
Wm Fork Tap (Denver)—Windy Gap Tap	69	11.78	1939
Windy Gap Tap—Granby	69	5.53	1939
Granby—Granby PP	69	6.18	1939
Kremmling Tap—Muddy Pass	69	29.71	1951
Granby—Willow Creek Pumping Plant	69	0.70	1953
Sterling—Holyoke			
Sterling—Fleming	69	19.40	1948
Fleming—Crook Tap	69	2.06	1948
Crook Tap—Haxtun	69	9.44	1948
Haxtun—Holyoke	69	17.35	1948
Granby—Granby Dam (Station Service)	24.9	1.60	1946
Flatiron—Big Thompson	13.8	4.32	1957
Flatiron—Pole Hill	13.8	4.87	1950
Troublesome—Colo. River Improvement	12.5	10.00	1947
Estes—Marys Lake	6.9	3.42	1951



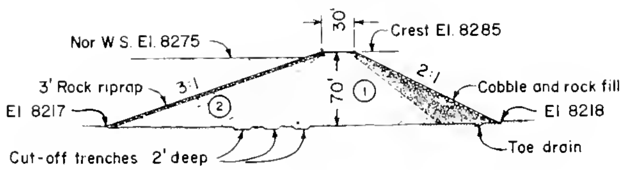
Green Mountain Dam, Plan and Sections



Granby Dam, Plan and Sections



PLAN

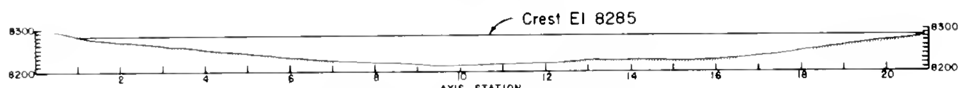


DIKE No. 1 MAXIMUM SECTION

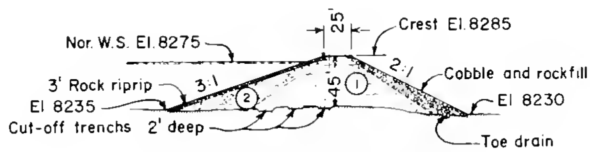
EMBANKMENT EXPLANATION

(1) Impervious material of clay, sand and gravel rolled in 6-inch layers

(2) Semi-pervious material, graded from clay, sand and gravel at inner slope - to sand, gravel, cobbles and rock at outer slope

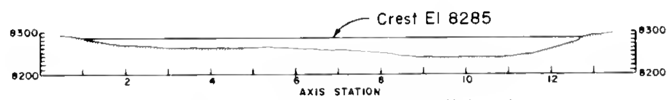


PROFILE ON AXIS OF DIKE No. 1

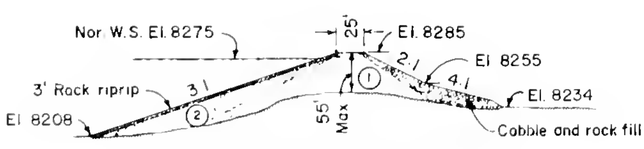


DIKE No. 2 MAXIMUM SECTION

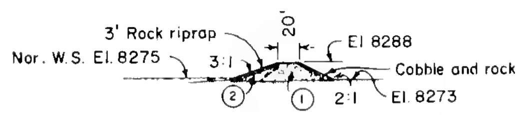
DIKE No. 3 PLAN



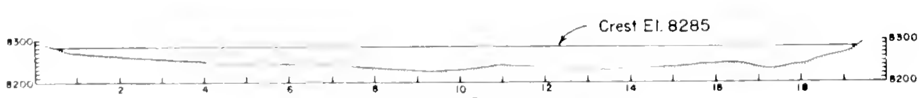
PROFILE ON AXIS OF DIKE No. 2



DIKE No. 3 MAXIMUM SECTION

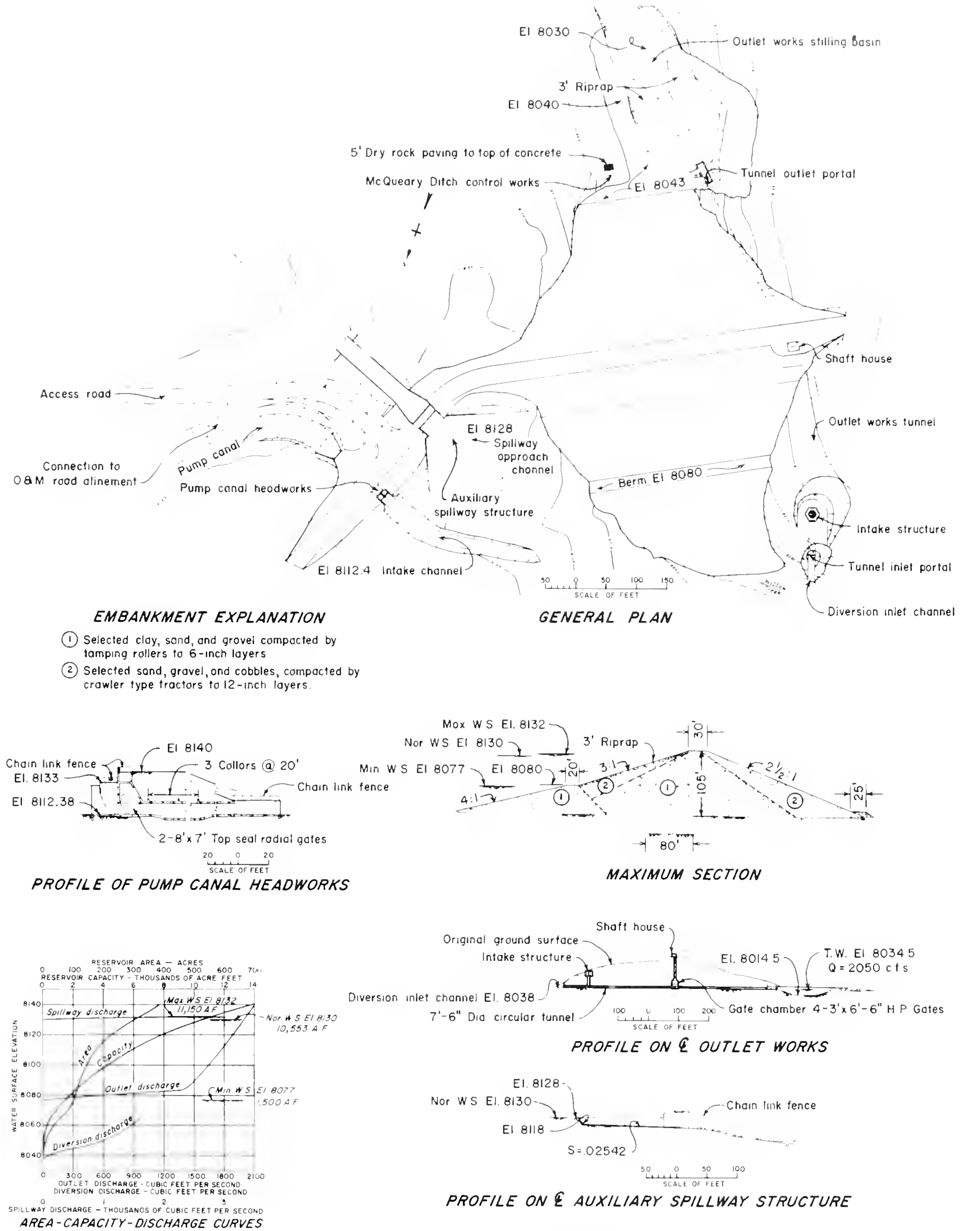


DIKE No. 4 MAXIMUM SECTION

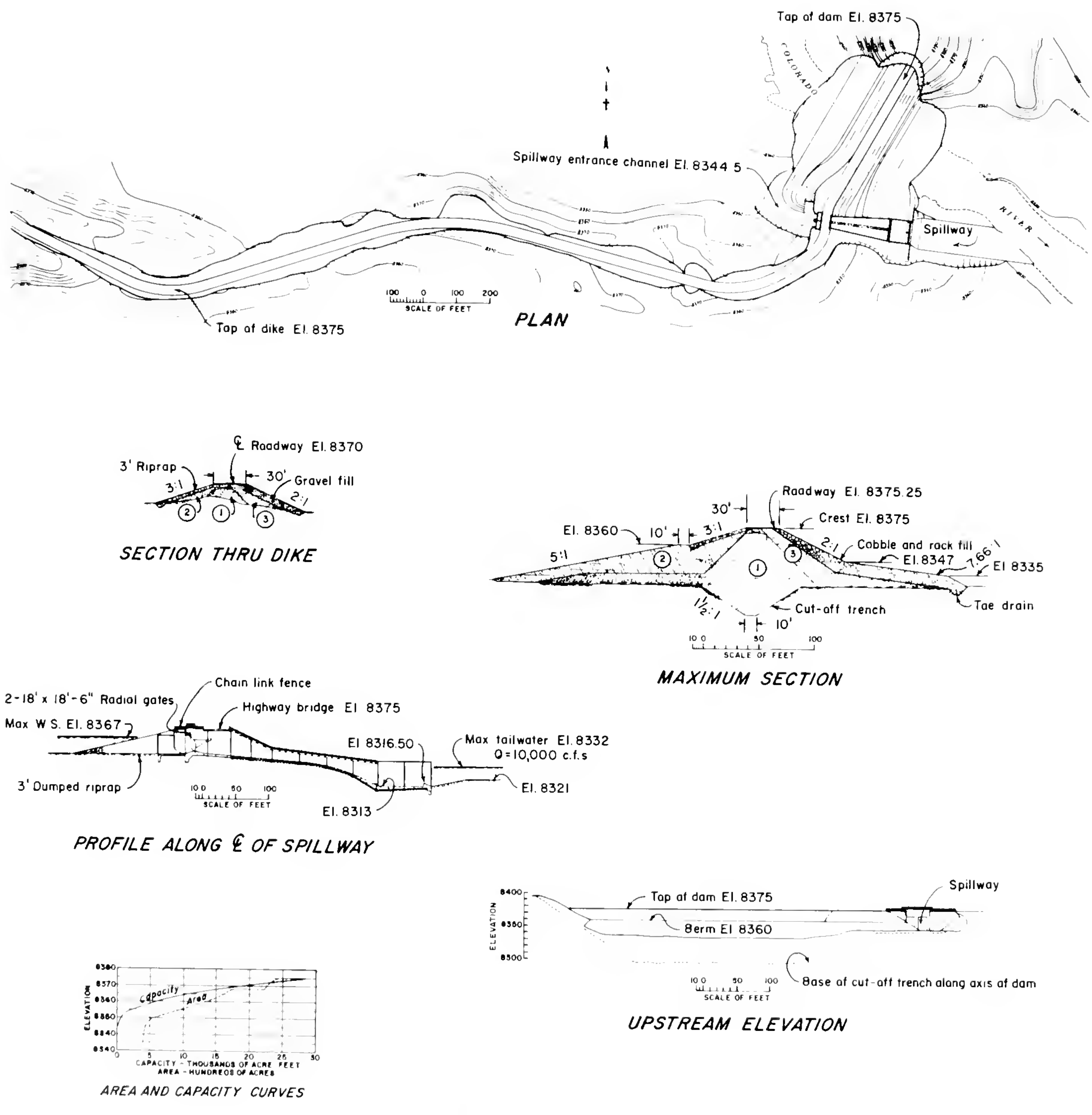


PROFILE ON AXIS OF DIKE No. 3

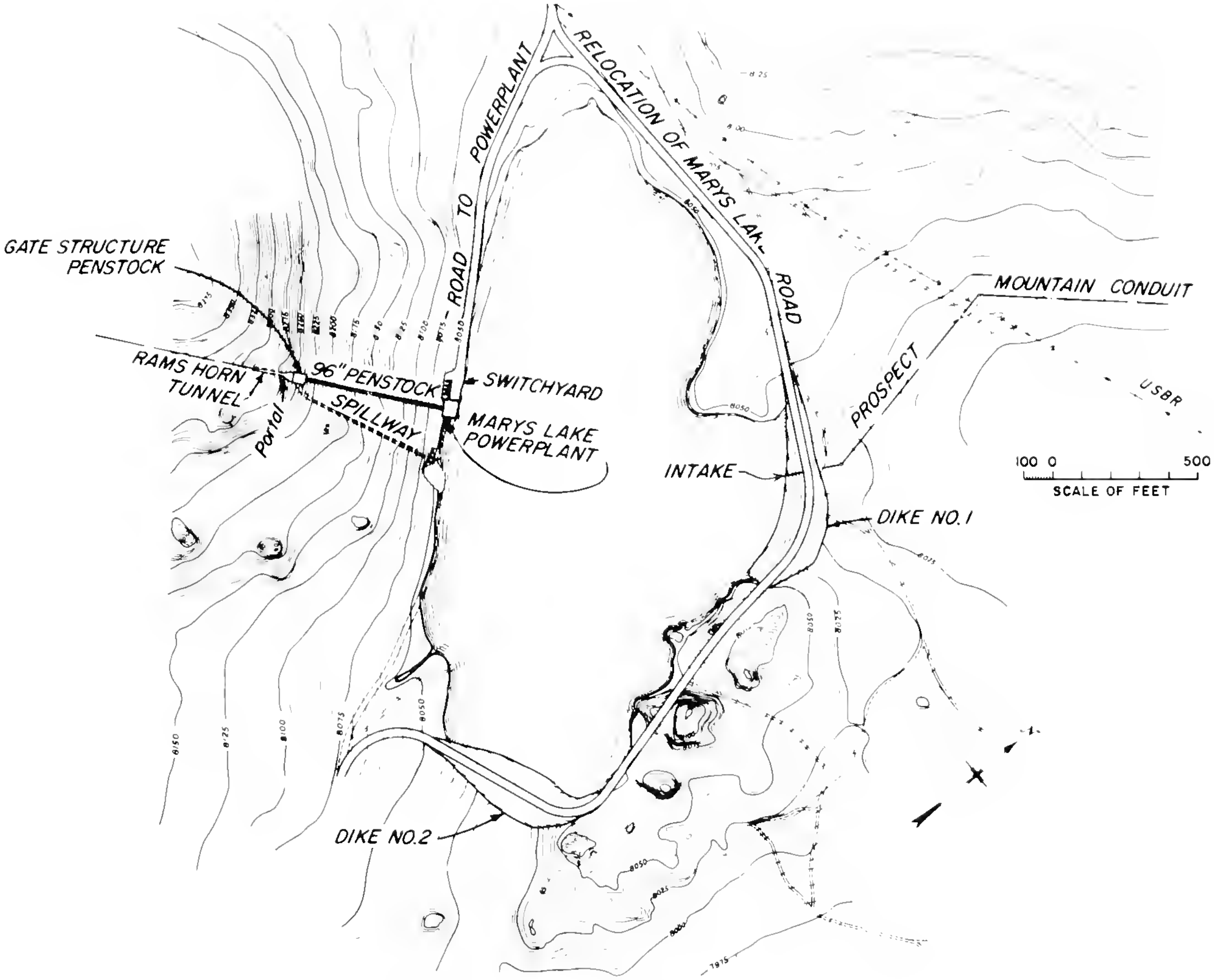
Granby Dikes, Plan and Sections



Willow Creek Dam, Plan and Sections



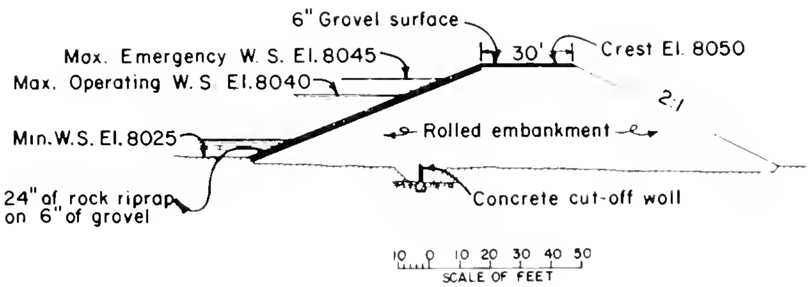
Shadow Mountain Dam, Plan and Sections



PLAN

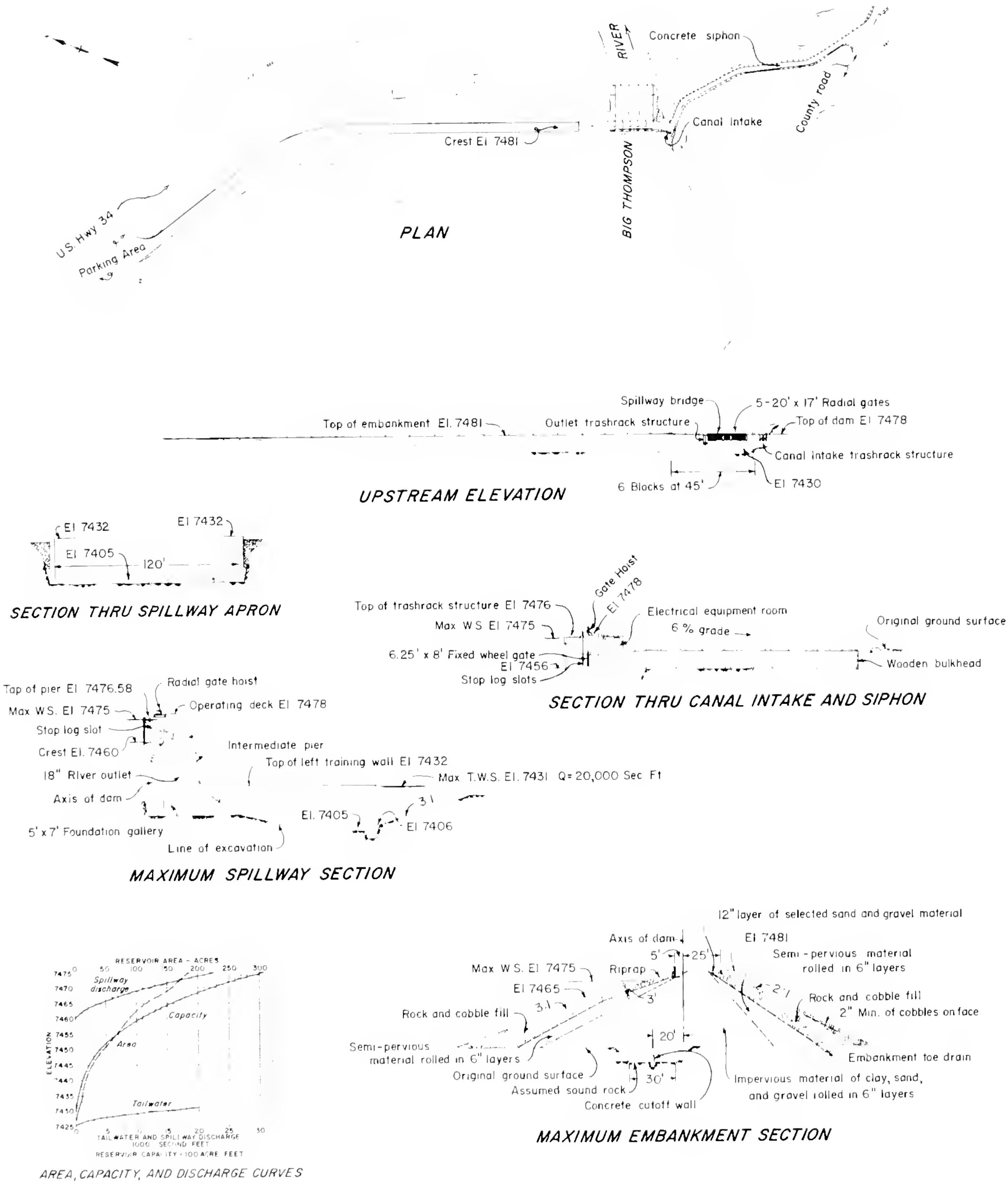
RESERVOIR CAPACITY

ELEVATION	AREA (ACRES)	CAPACITY (ACRE-FT)
8025	29.35	0
8030	34.57	160
8035	39.21	344
8040	42.49	548
8045	46.03	769
8050	49.91	1009

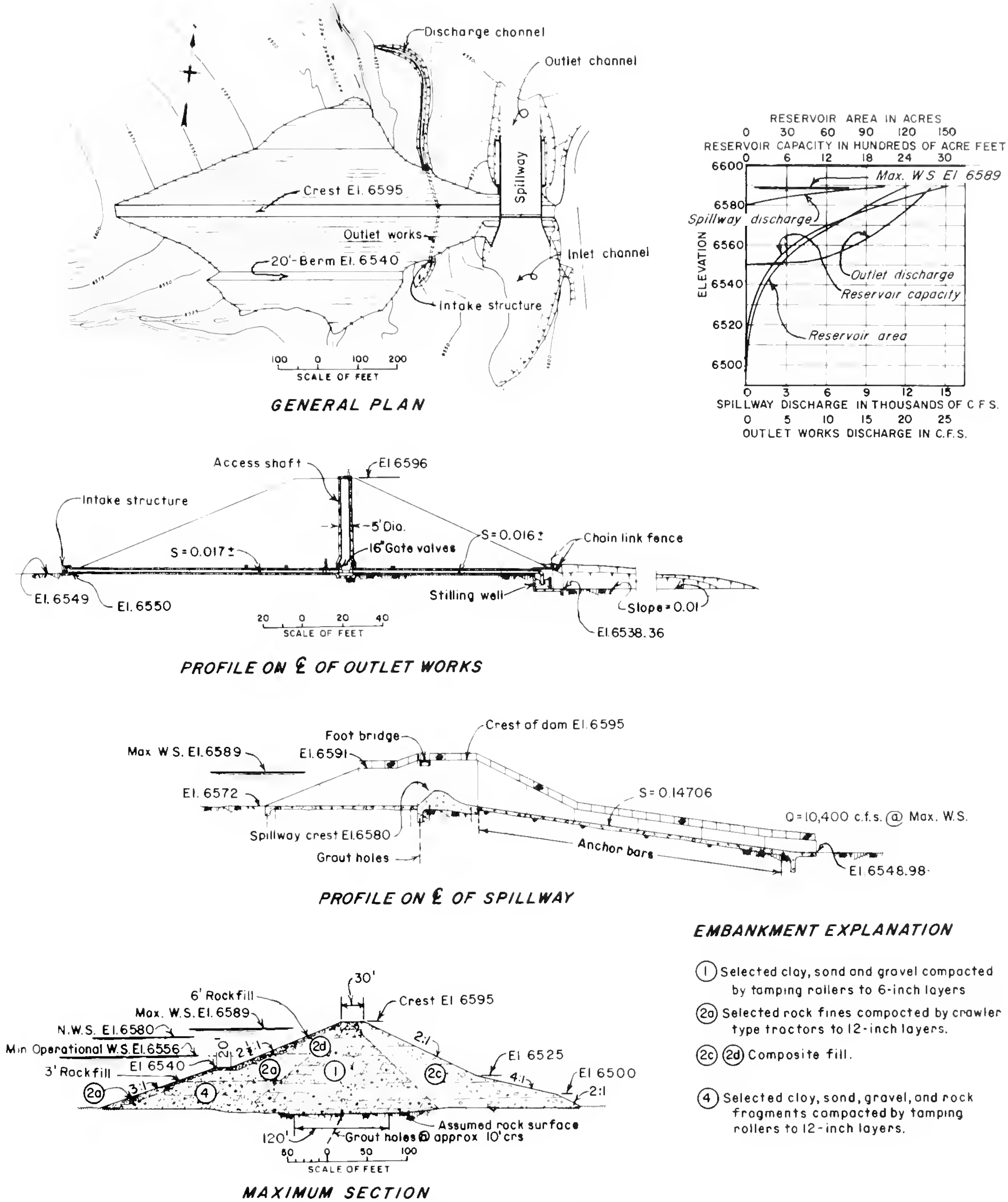


MAXIMUM SECTION OF DIKES

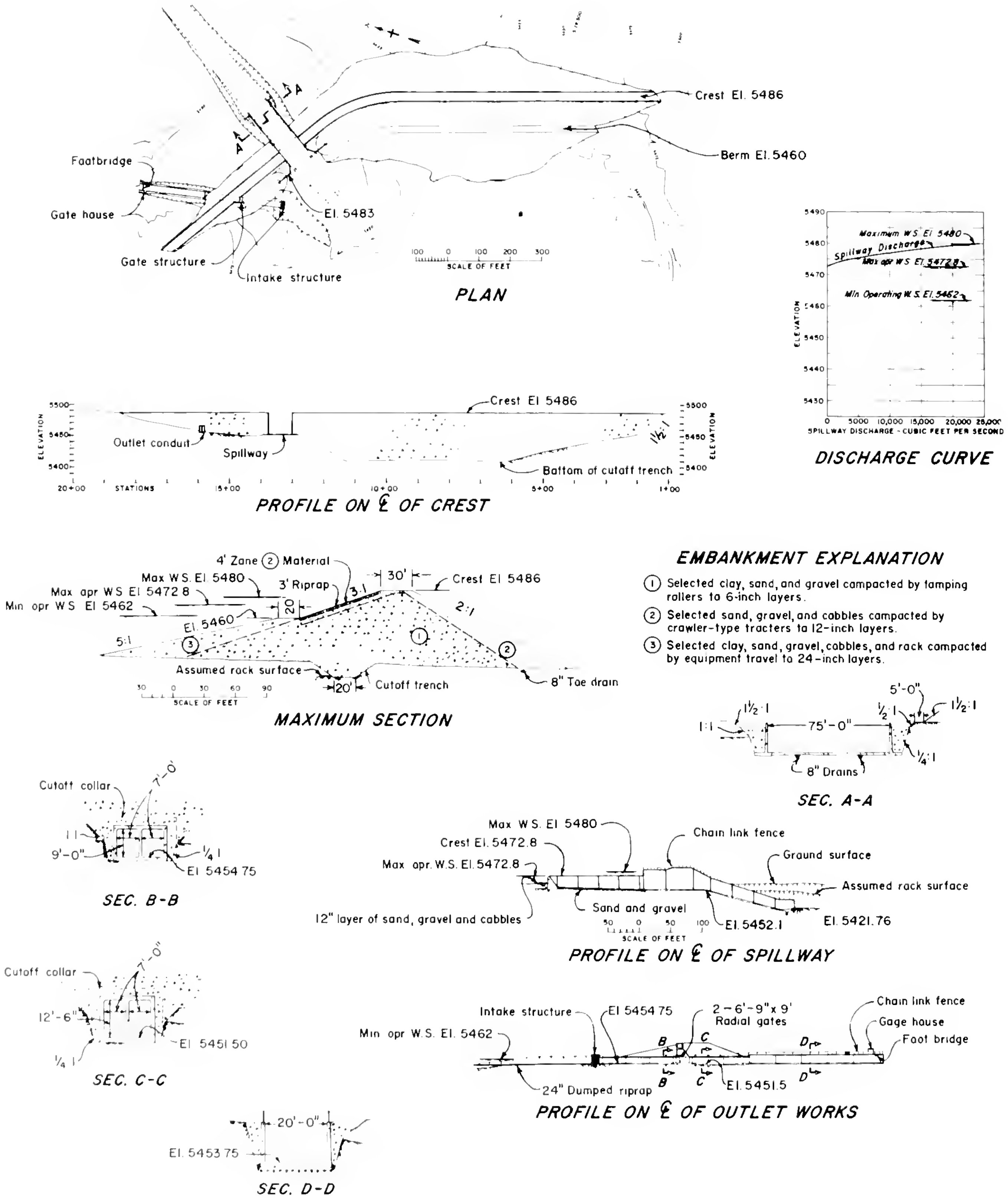
Marys Lake, Plan and Section of Dikes



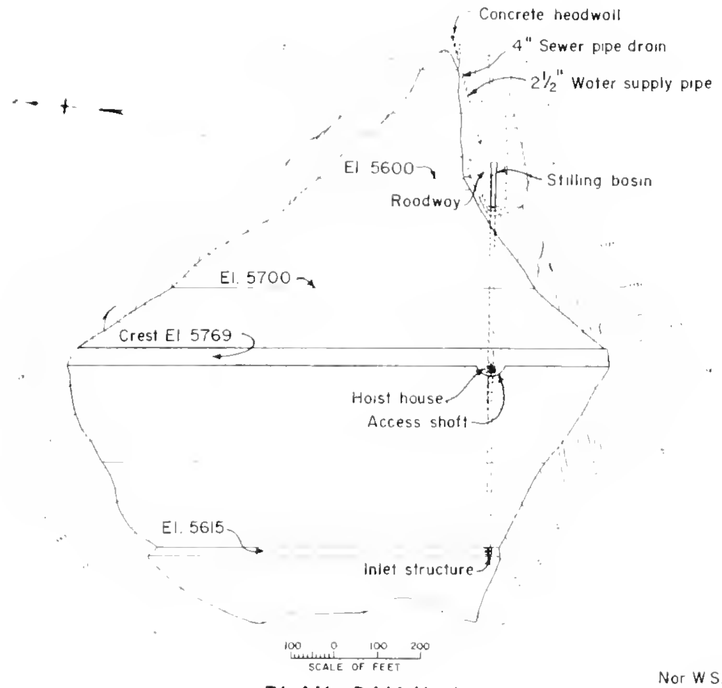
Olympus Dam, Plan and Sections



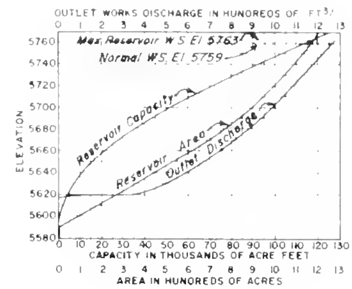
Rattlesnake Dam, Plan and Sections



Flatiron Dam, Plan and Sections



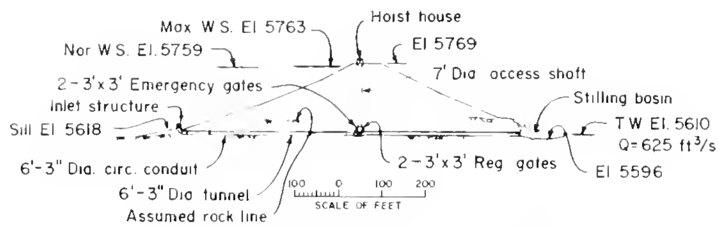
PLAN DAM No. 1



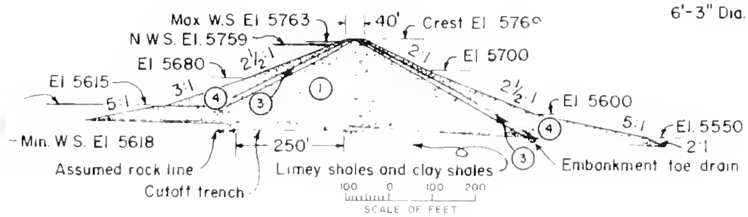
AREA, CAPACITY, AND DISCHARGE CURVES

EMBANKMENT EXPLANATION

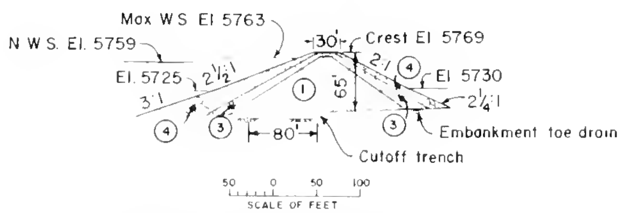
- (1) Impervious material of clay, sand and gravel compacted by rollers to 6" layers.
- (3) Rock fines compacted to 12" layers by crawler type tractors
- (4) Rock fill increasing in coarseness toward outer slope.



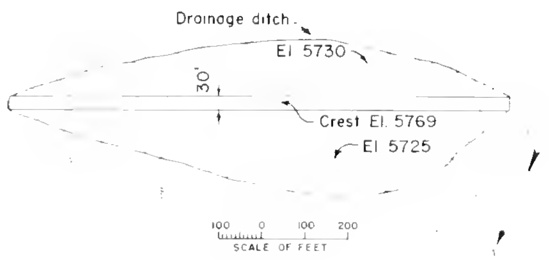
PROFILE ALONG ℄ OUTLET WORKS



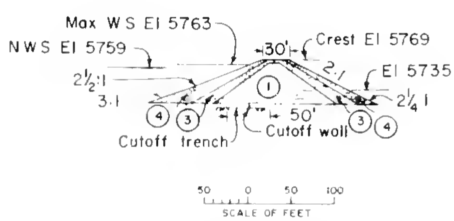
MAXIMUM SECTION DAM No. 1



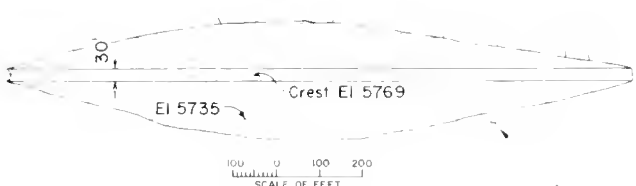
MAXIMUM SECTION - DAM No. 2



PLAN DAM No. 2

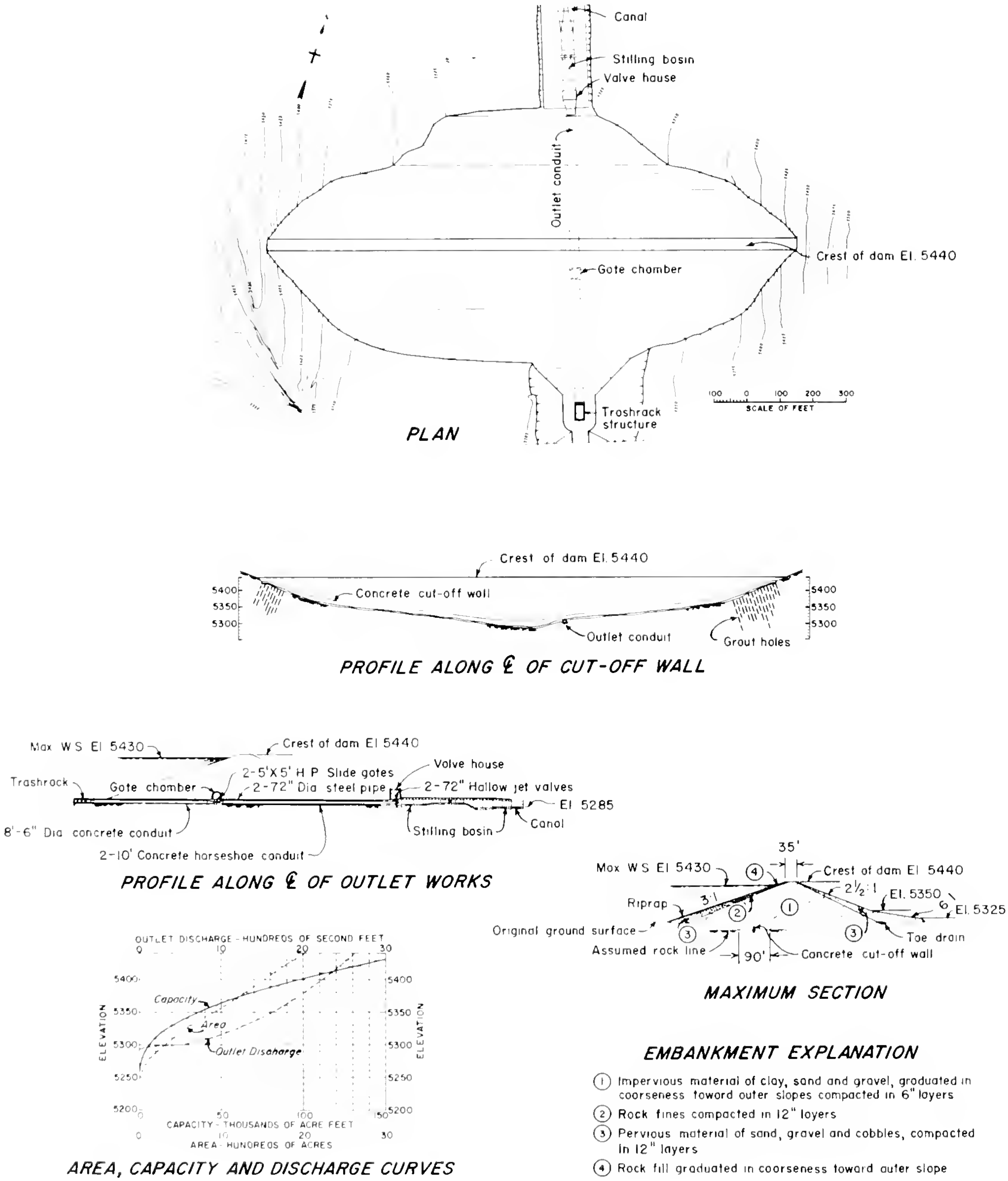


MAXIMUM SECTION DAM No. 3

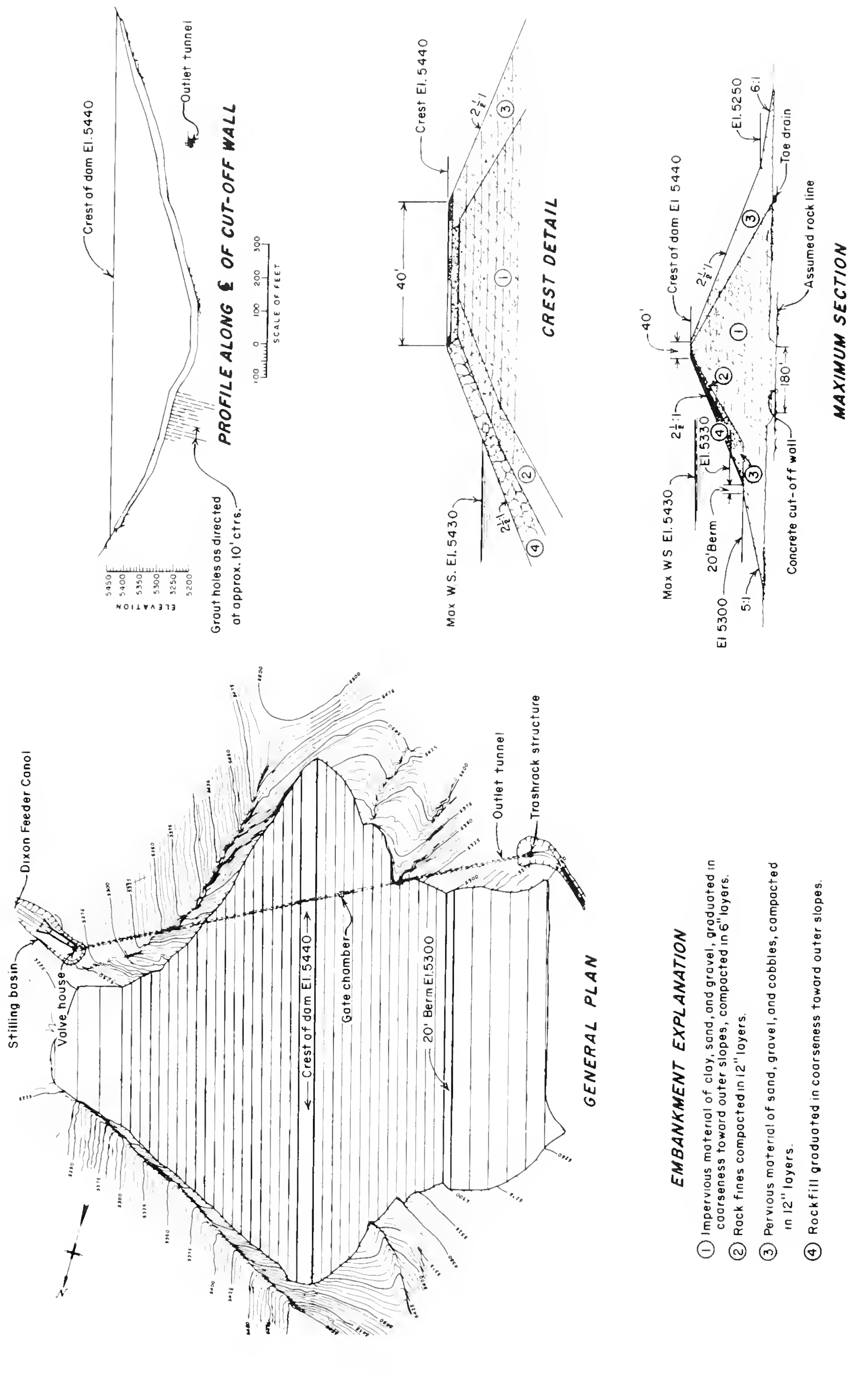


PLAN DAM No. 3

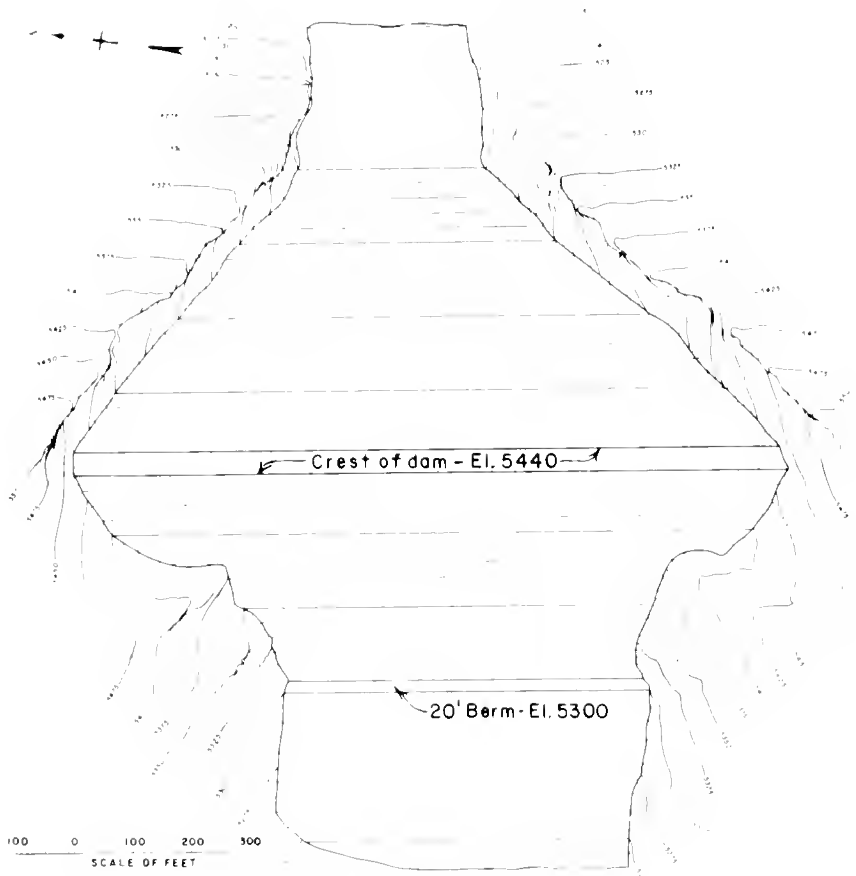
Carter Lake Dams, Plan and Sections



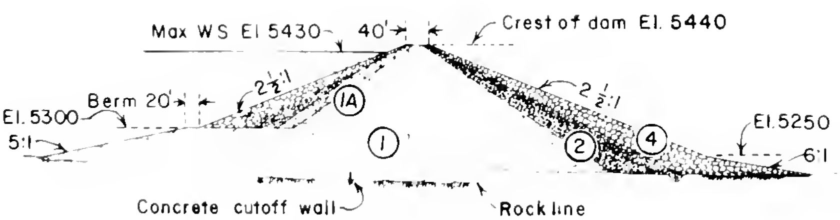
Horsetooth Dam, Plan and Sections



Soldier Canyon Dam, Plan and Sections



PLAN



MAXIMUM SECTION

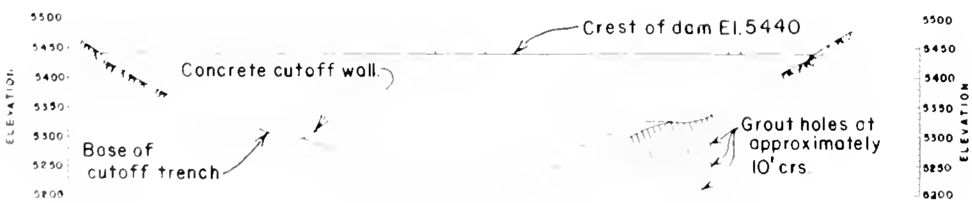
EMBANKMENT EXPLANATION

(1) Impervious material of clay, sand and gravel, graduated in coarseness toward outer slopes, compacted in 6" layers

(1A) Semipervious sand and gravel compacted in 12" layers.

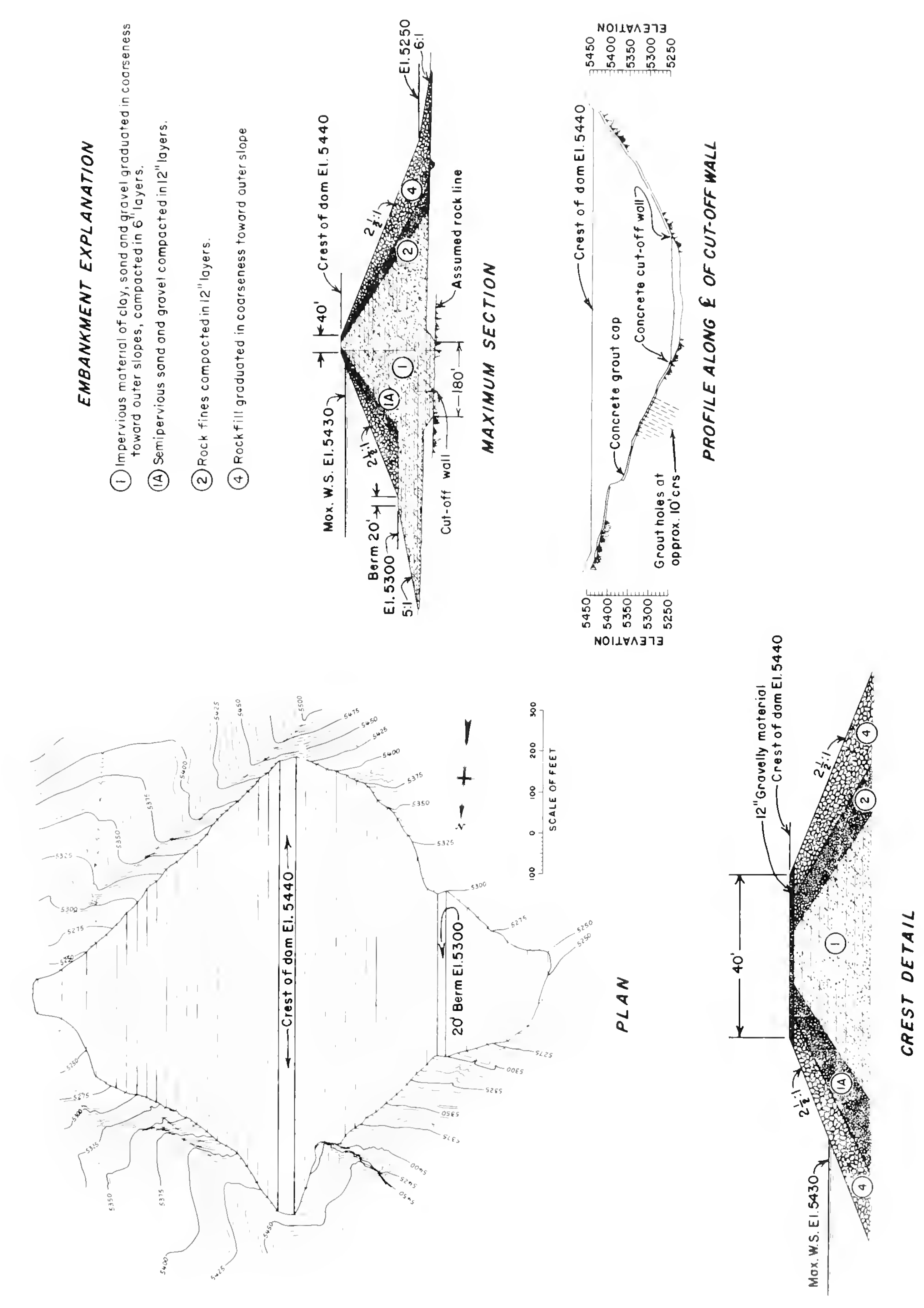
(2) Rock fines compacted in 12" layers.

(4) Rockfill graduated in coarseness toward outer slope.

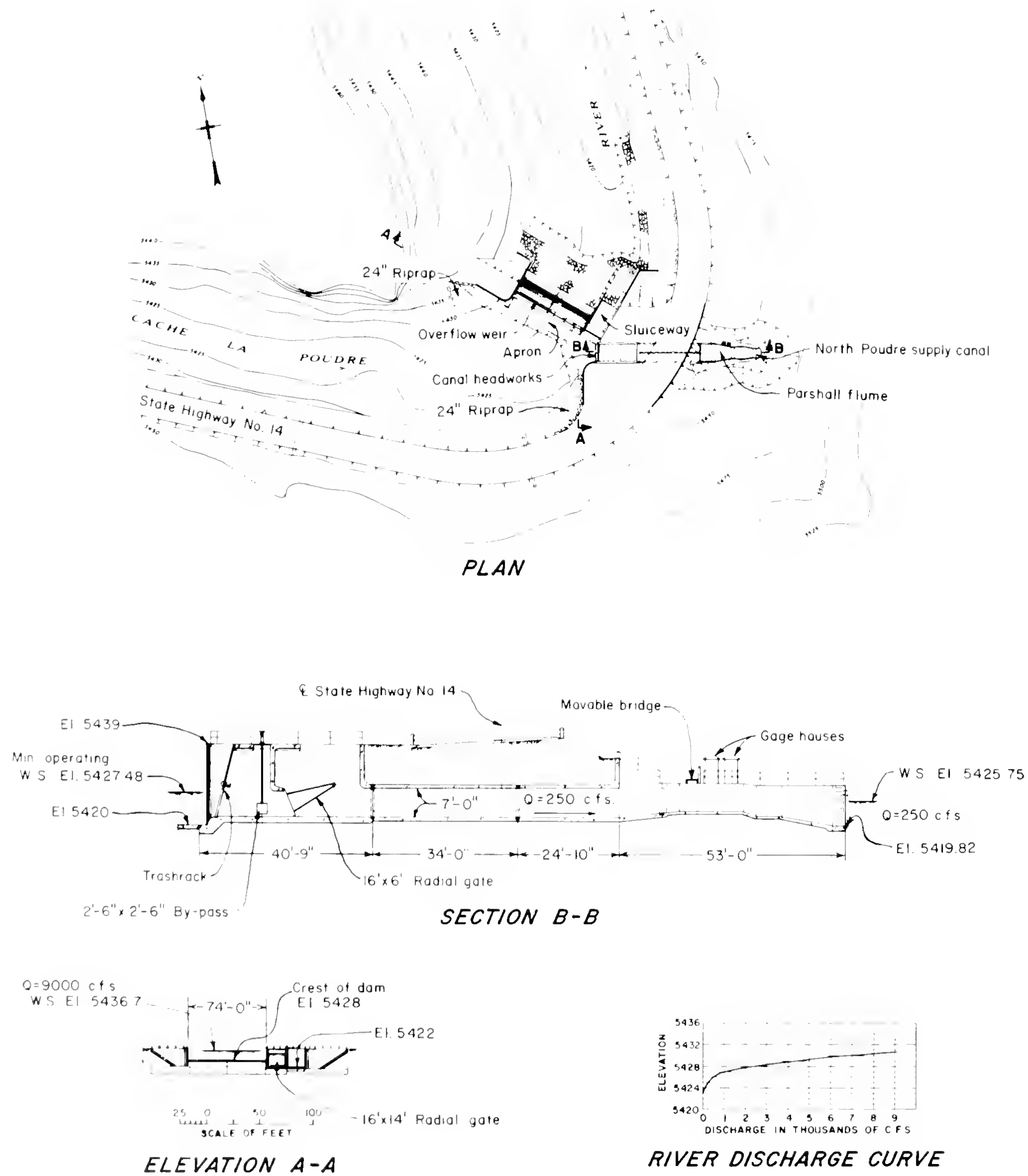


PROFILE ALONG ℄ OF CUTOFF WALL

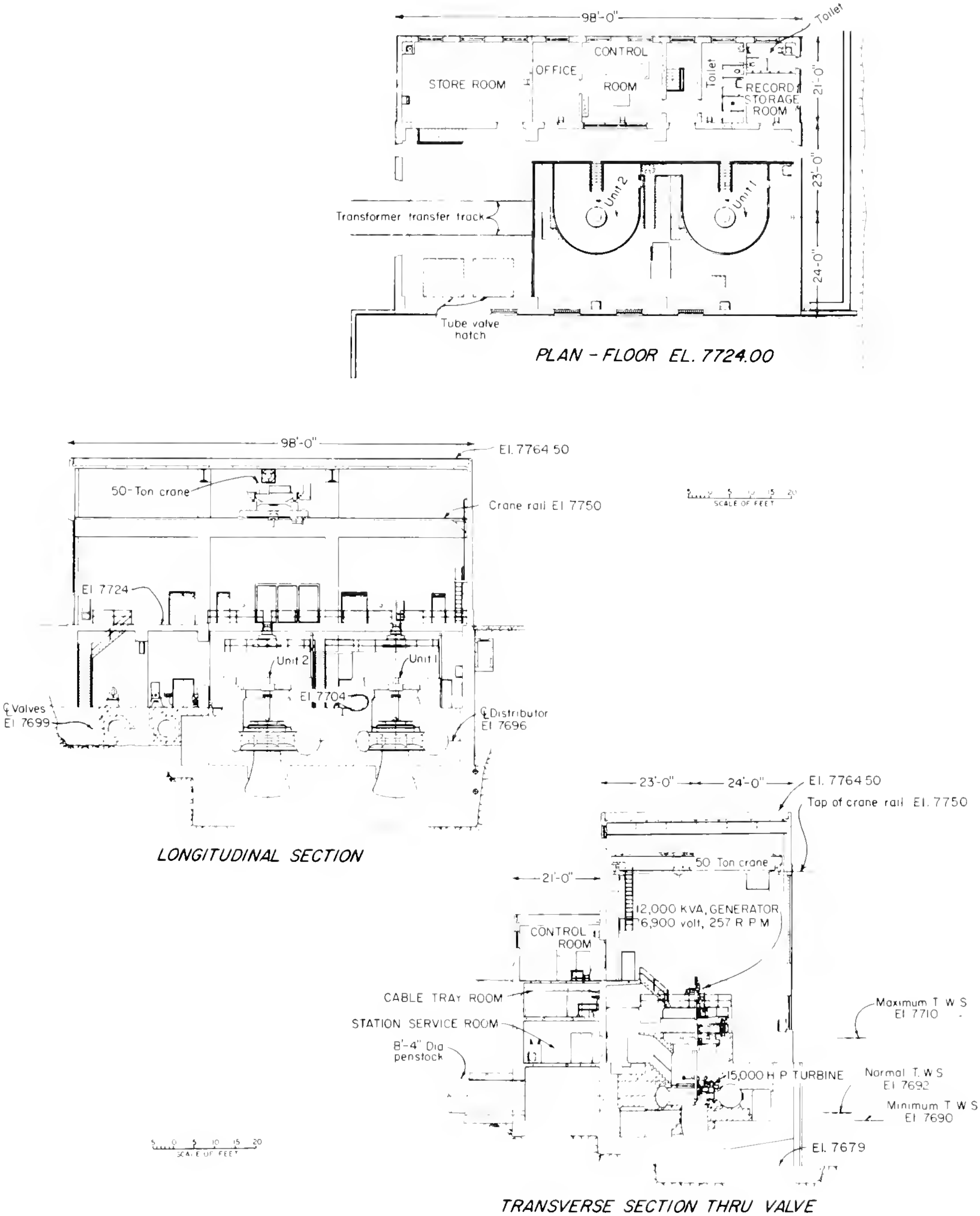
Dixon Canyon Dam, Plan and Sections



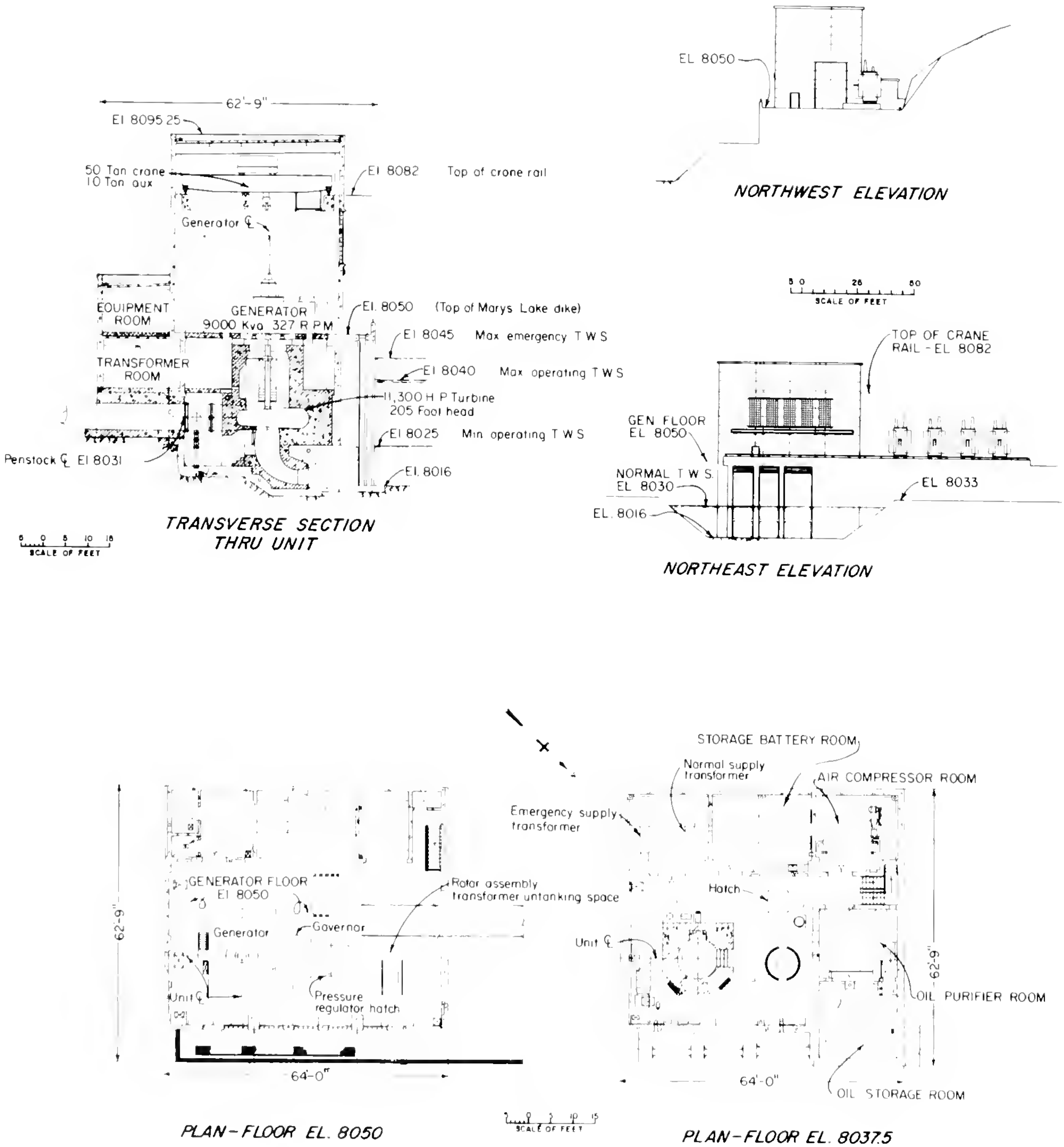
Spring Canyon Dam, Plan and Sections



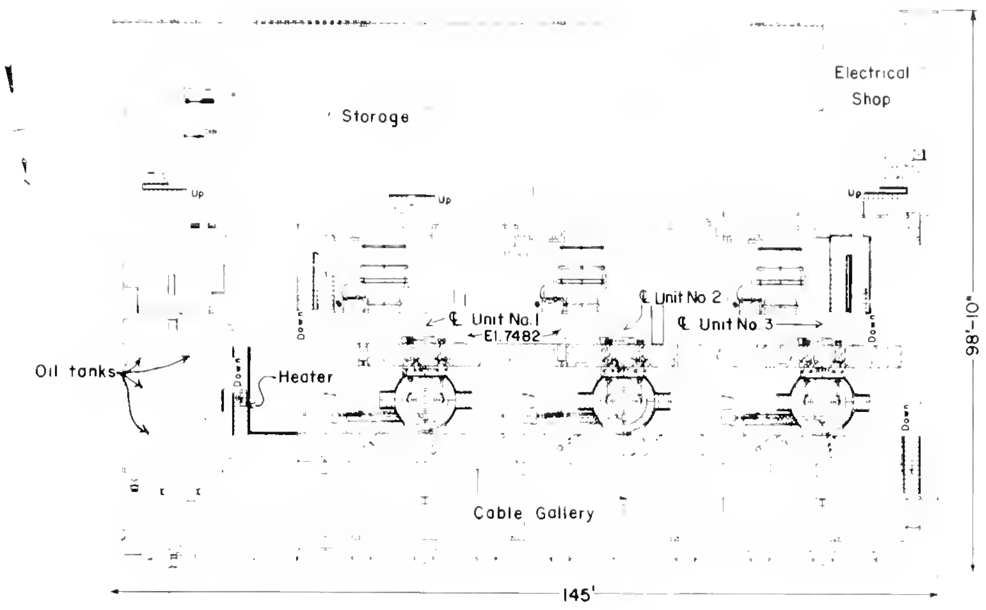
North Poudre Diversion Dam, Plan and Sections



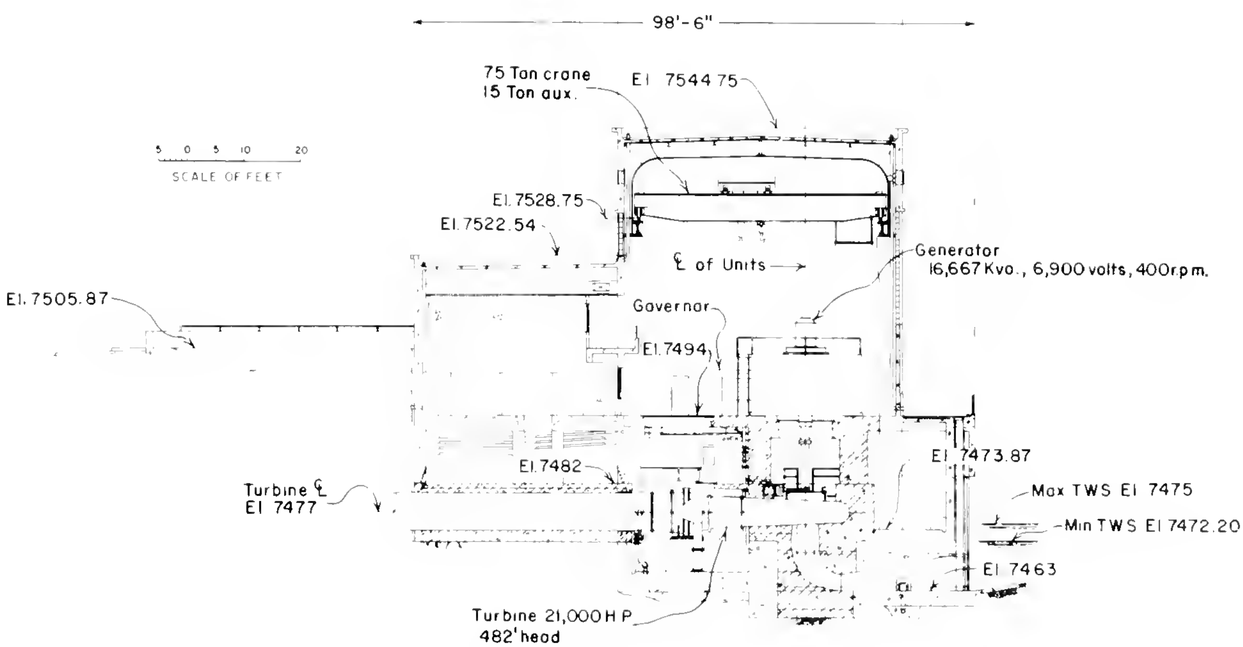
Green Mountain Powerplant, Plan and Sections



Marys Lake Powerplant, Plan and Sections

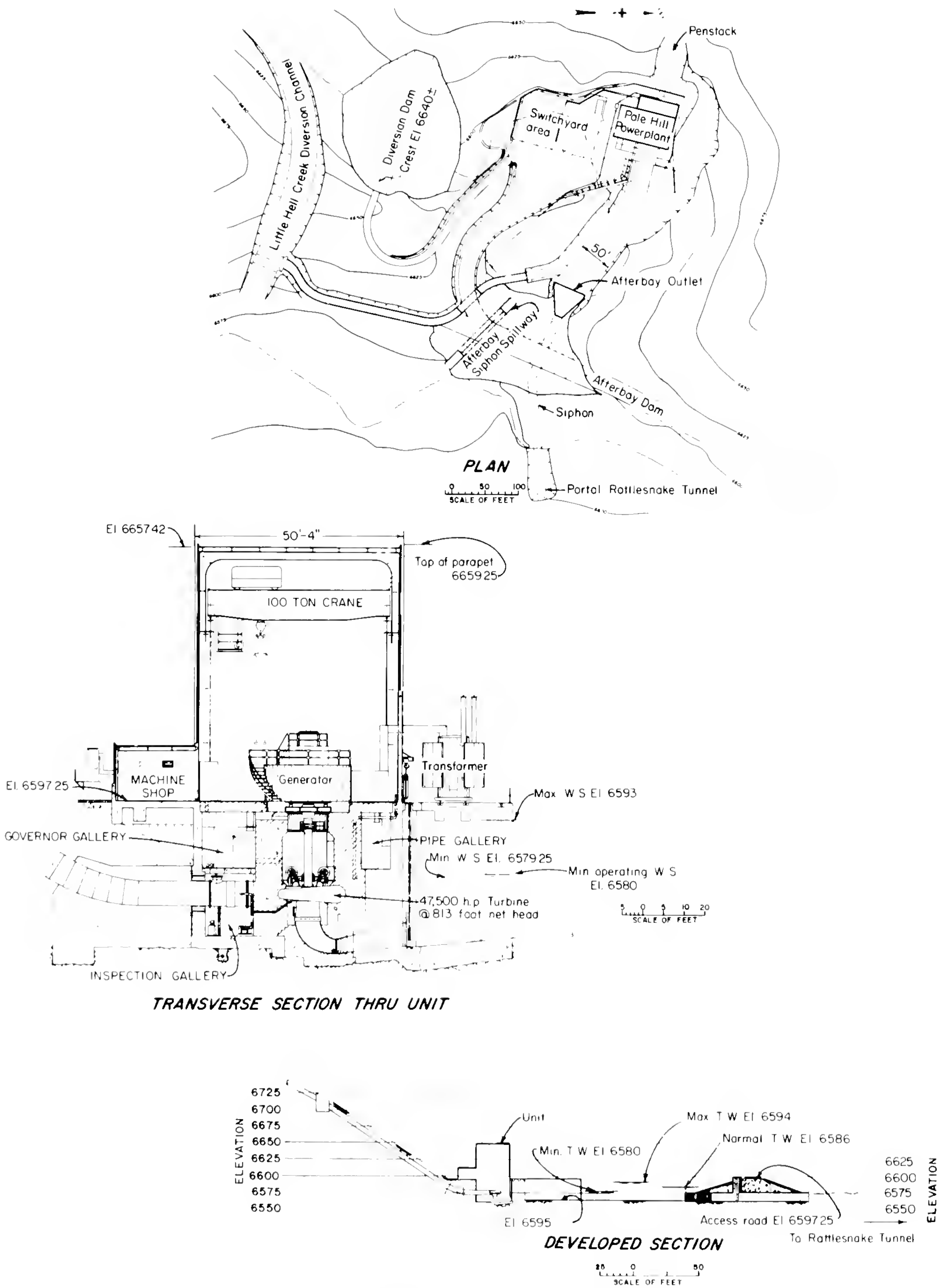


PLAN-FLOOR EL.7482

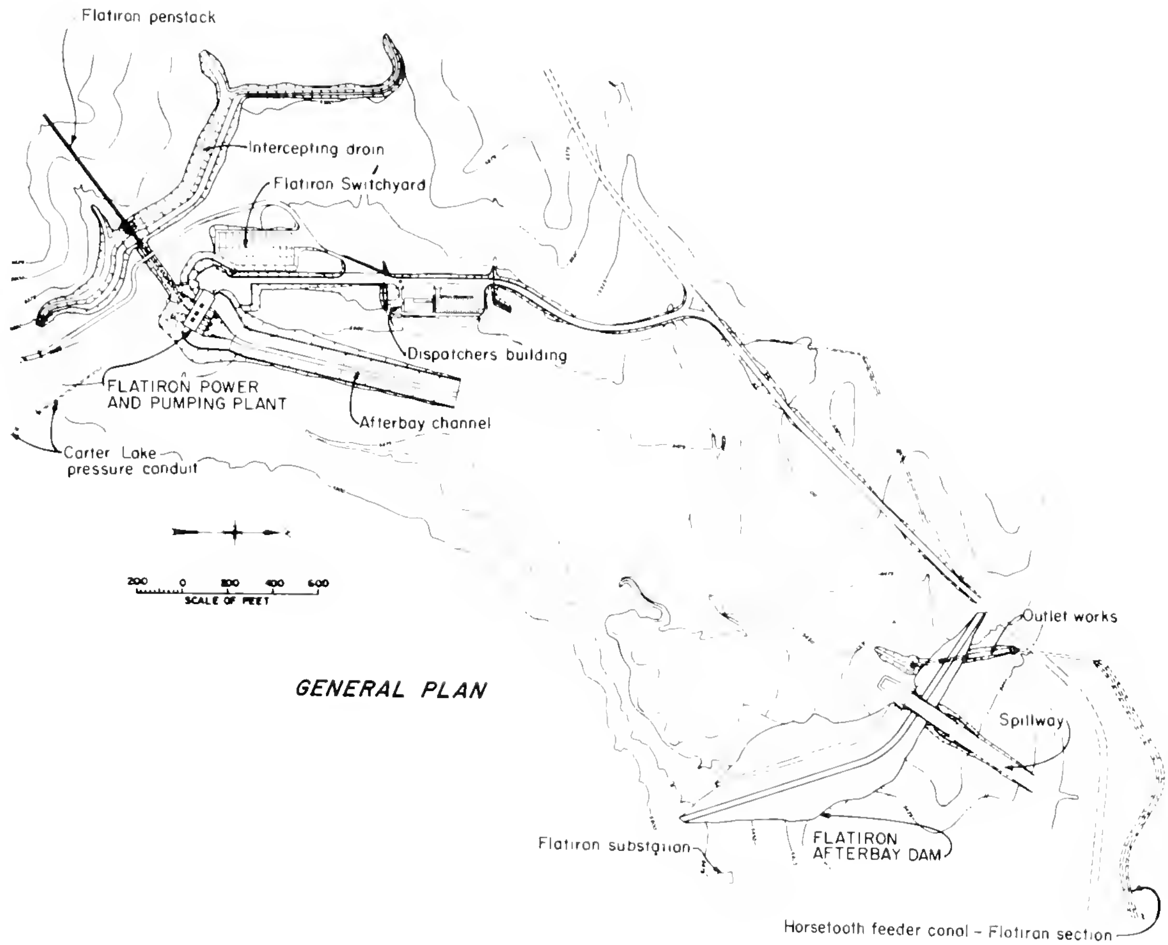


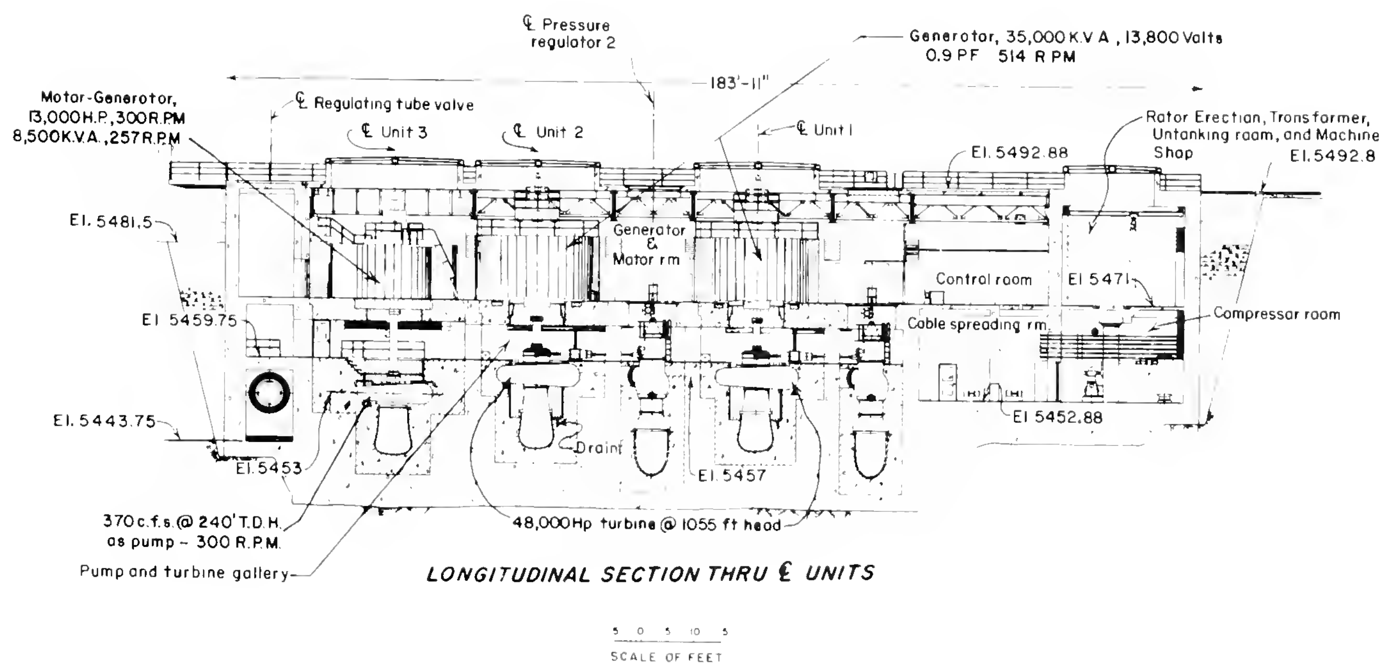
TRANSVERSE SECTION THRU UNIT

Estes Powerplant, Plan and Section

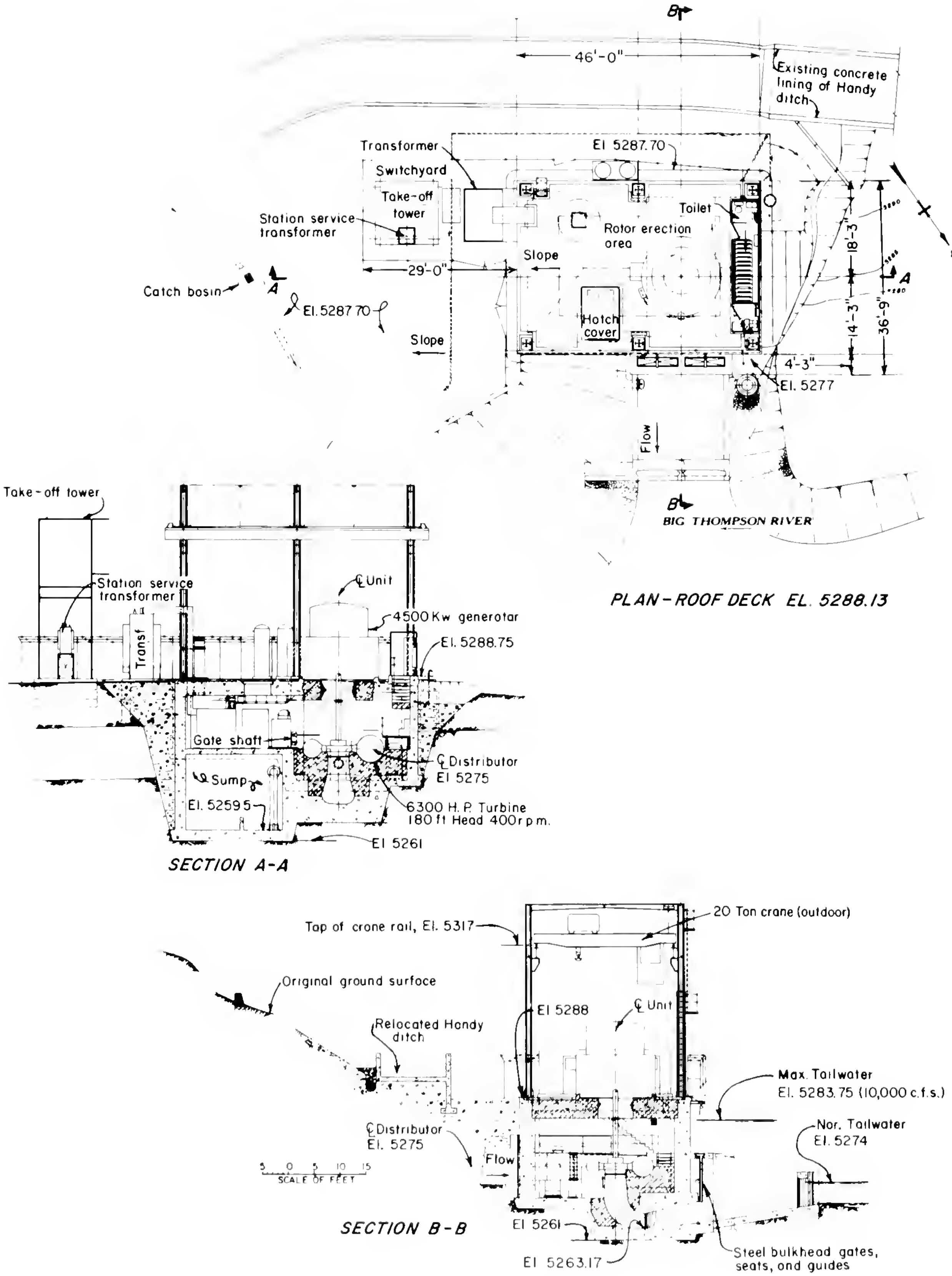


Pole Hill Powerplant, Plan and Sections

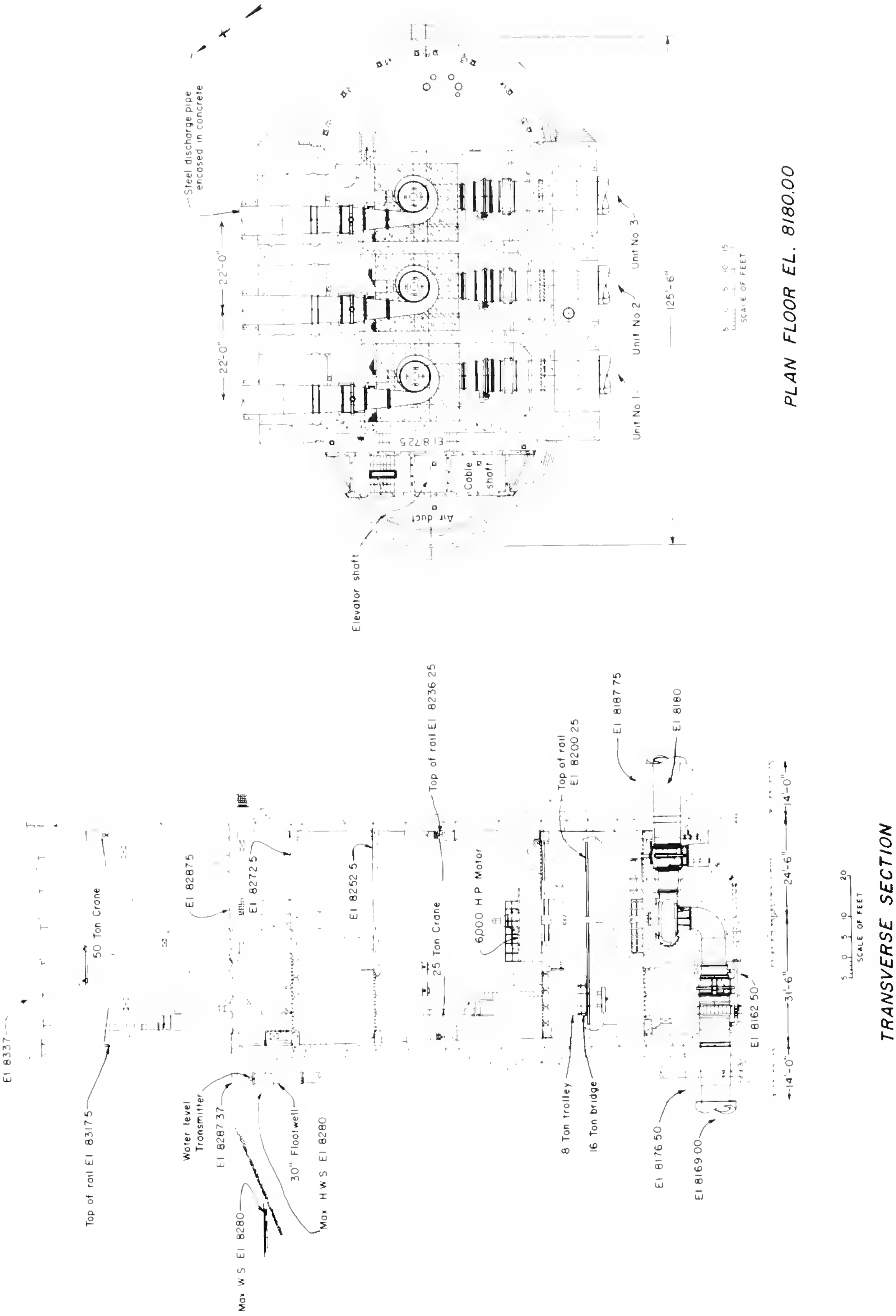




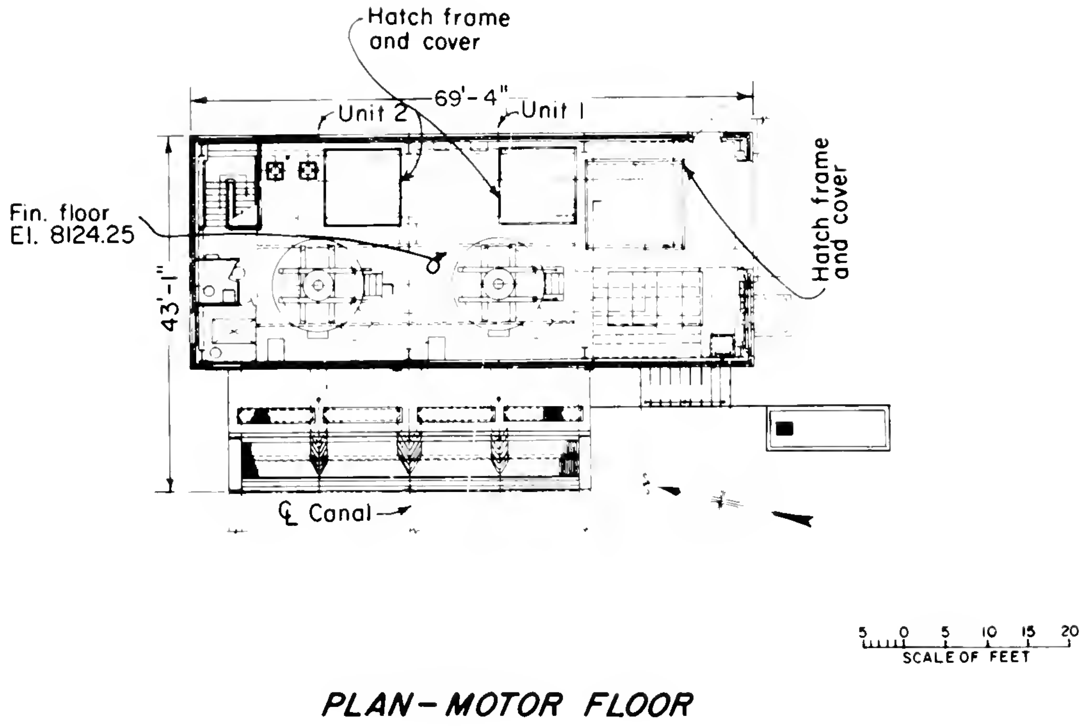
Flatiron Power and Pumping Plant, Plan and Section

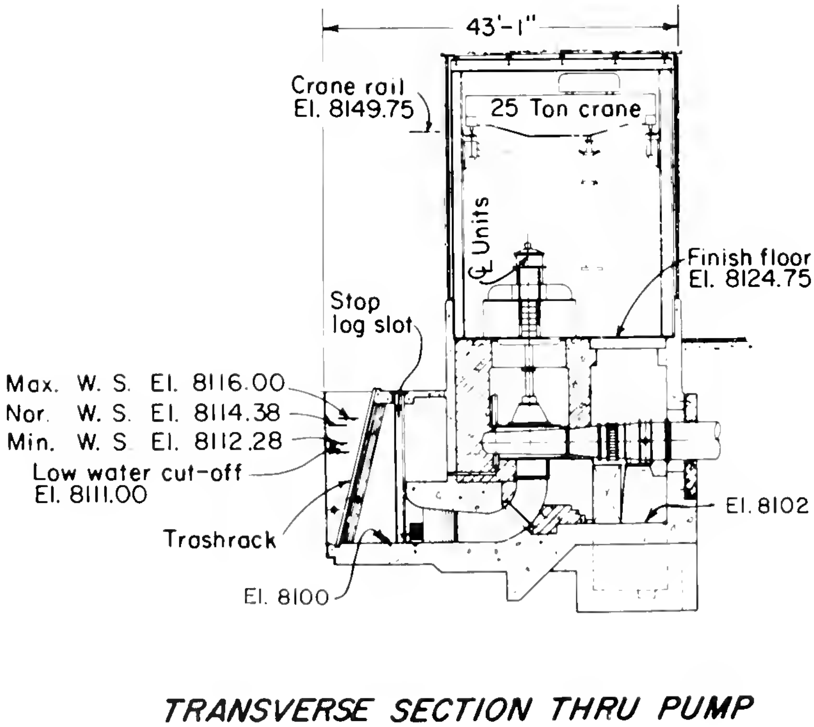


Big Thompson Powerplant, Plan and Sections



Granby Pumping Plant. Plan and Section



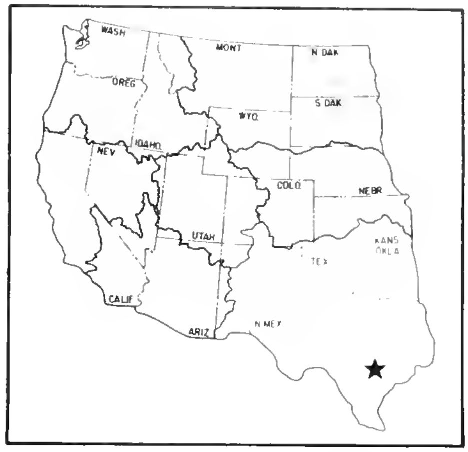


Willow Creek Pumping Plant, Plan and Section

Colorado River Project

Texas: Burnet and Travis Counties

Southwest Region
Water and Power Resources Service



The Colorado River Project of Texas consists of Marshall Ford (Mansfield) Dam, on the Colorado River 13 miles northwest of Austin, Tex. It does not include the powerplant, which was constructed and is being operated and maintained by the Lower Colorado River Authority, a public agency of the State of Texas. Primarily a flood-control project, the Marshall Ford Dam and its reservoir, Lake Travis, serve also to improve navigation, regulate streamflow, and provide storage for irrigation uses and power generation.

PLAN

The reservoir, created by Marshall Ford Dam, stores water for controlling floods, for irrigation, for power development, and for improving navigation through regulating the streamflow.

Marshall Ford Dam

Marshall Ford Dam, completed in May 1942, has a concrete gravity section across the river, flanked on both ends by earth embankments. The structural height of the concrete section is 278 feet and the length is 2,423 feet. It contains 1,870,000 cubic yards of concrete. The earth sections have a combined length of 2,670 feet, and contain 1,695,000 cubic yards of earth, rock, and gravel fill. The spillway has an ogee section with an effective length of 700 feet in the river channel. The outlet works has a total capacity of 125,000 cubic feet per second at normal water surface elevation.

DEVELOPMENT

Early History

The earliest attempt made by settlers in the Colorado River Basin of Texas to conserve the high runoff of the Colorado River was the construction of the Austin Dam and Powerplant. Completed by the city of Austin in 1893, the dam provided storage water for irrigation, hydroelectric power development, and flood control. After 7 years of operation, the dam was destroyed by flood. It was rebuilt and suffered similar damage in 1915, and again in 1935. The Lower Colorado River Authority completed rehabilitation of the Austin Dam on April 6, 1940.

Investigations

On November 13, 1934, the Texas State Legislature authorized the organization of the Lower Colorado River Authority for the purpose of completing Hamilton Dam and constructing additional dams along the river to provide irrigation, flood control, and power benefits. The Authority applied to the Federal Government for funds. Under the terms of the Emergency Relief Appropriations Act of 1935, the President approved an allotment of $15 million to the Federal Emergency Administration of Public Works for power and irrigation purposes. At the same time, he approved the allocation of $5 million to the Bureau of Reclamation for constructing the flood-control features of the project.

Investigation of the project was made by the Bureau of Reclamation and reported February 12, 1935. A detailed report by the Board of Engineers was submitted October 29, 1935.

Authorization

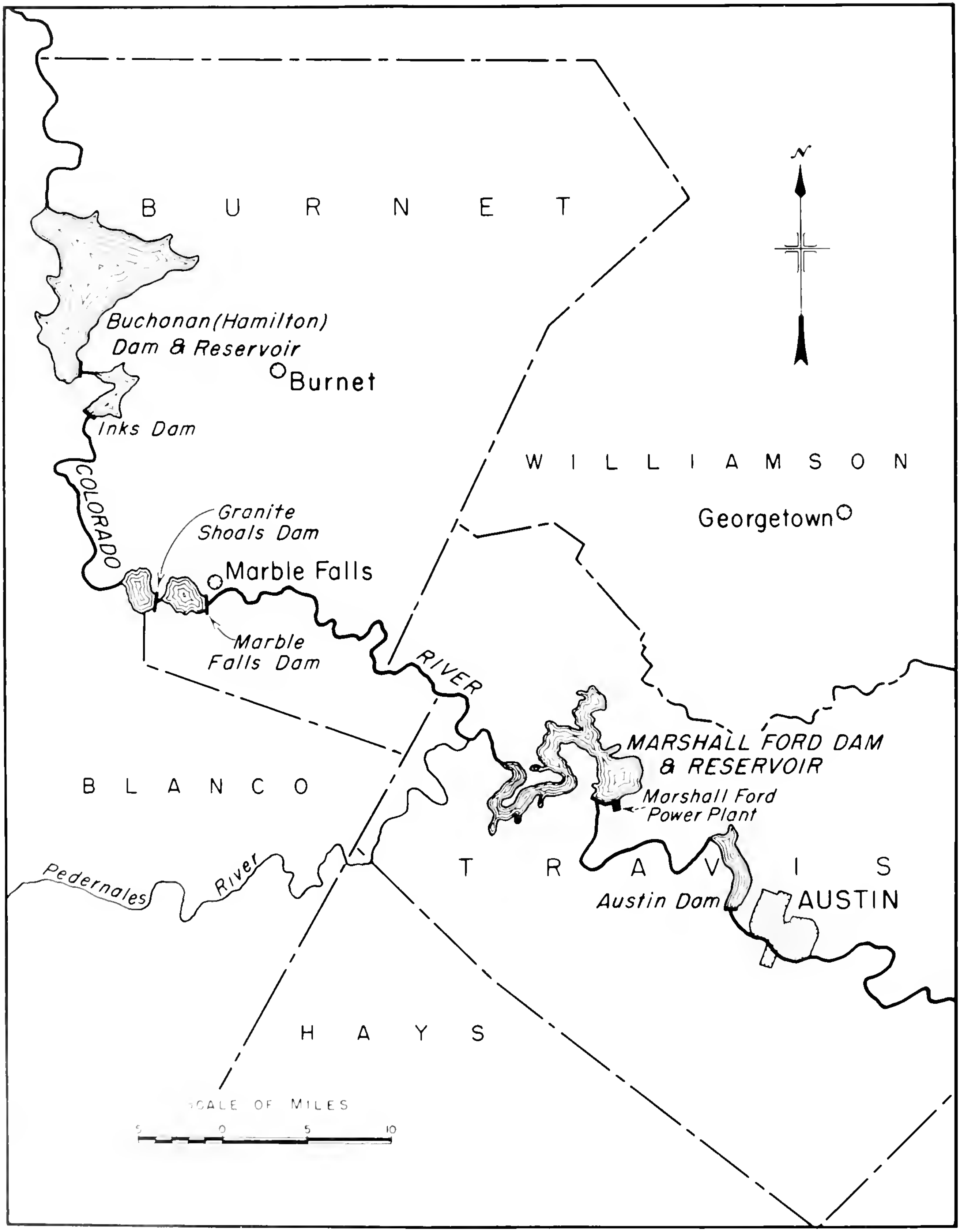
The construction of Marshall Ford Dam was authorized by section 3 of the Rivers and Harbors Act of August 26, 1937 (50 Stat. 850).

Construction

Construction of the dam began on February 19, 1937, and was completed in May 1942.

Operating Agency

The project is operated and maintained by the Lower Colorado River Authority of Texas. The dam has been renamed Mansfield Dam by the Authority.



Colorado River Project

Marshall Ford (Mansfield) Dam

BENEFITS

The benefits result from the construction of a series of dams on the Colorado River, the key structure being the Marshall Ford Dam.

Irrigation

The project enables stored water to be released as needed for irrigation in the coastal plains below Austin. Releases during the growing season are scheduled to coincide with peak electric energy requirements.

Flood Control

The facilities will reduce to a minimum a flood equal in size to any of record occurring above Marshall Ford (Mansfield) Dam.

ENGINEERING DATA

Water Supply

COLORADO RIVER, TEXAS

Drainage area above Marshall Ford Dam[1] ...	37,900	mi²
Annual discharge below Marshall Ford Dam since closure, Sept. 1940.		
Maximum (1957)	4,067,000	acre-ft
Minimum (1964)	468,000	acre-ft
Average discharge	1,164,600	acre-ft

[1]Of the area cited, about 11,900 mi² are noncontributing.

Storage Facilities

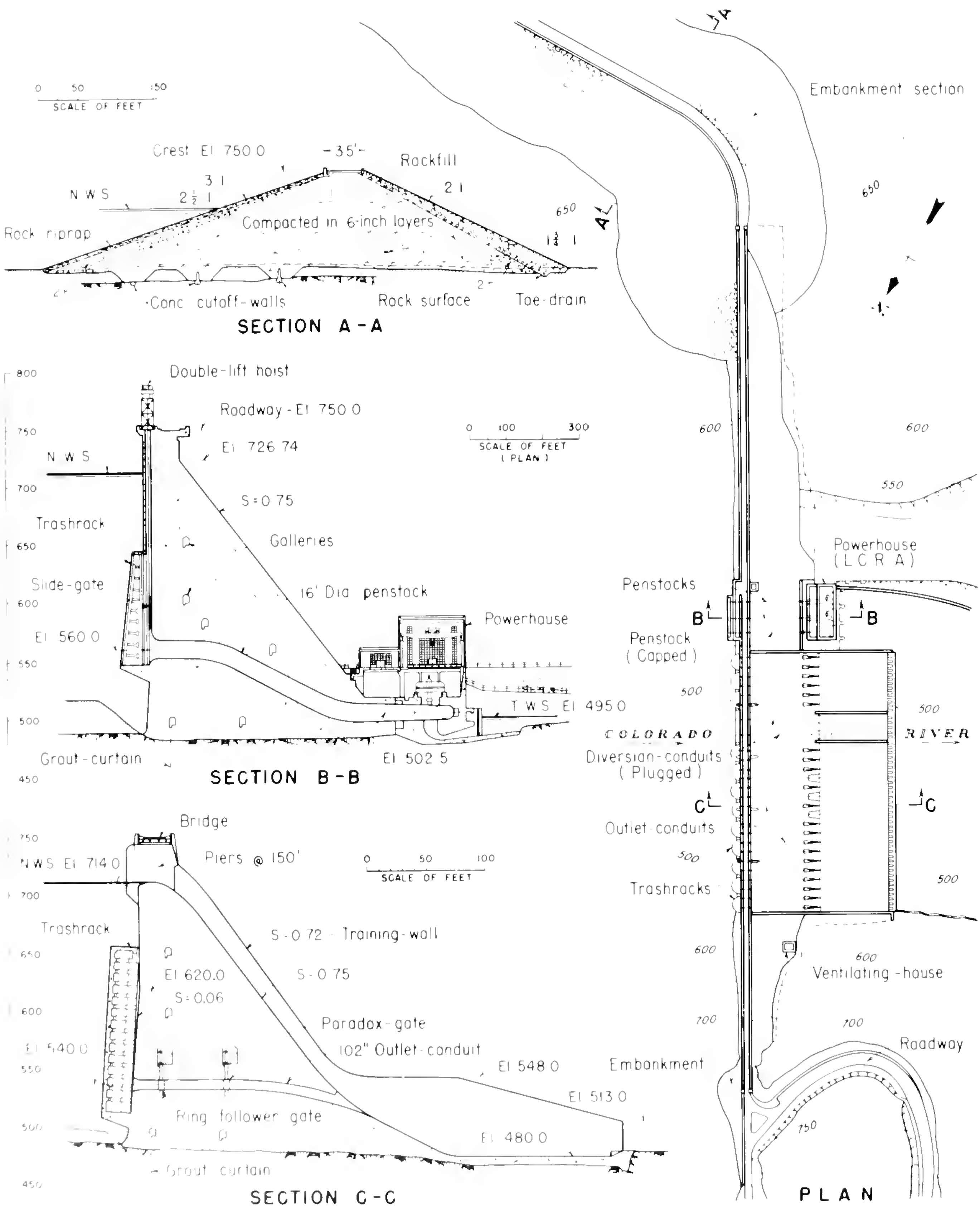
MARSHALL FORD DAM[2]

Type: Concrete straight gravity with earth embankment wings		
Location: On the Colorado River 13 mi northwest of Austin, Tex.		
Construction period: 1937-42		
Date of closure (first storage): Sept. 10, 1940		
Reservoir, Marshall Ford:		
Total capacity to El. 714	1,953,900	acre-ft
Active capacity, El. 618 to 714	1,590,800	acre-ft
Exclusive flood control capacity, El. 691 to 714	580,800	acre-ft
Joint use capacity, El. 681 to 691	202,300	acre-ft
Conservation storage capacity	807,600	acre-ft
Surface area El. 681	18,900	acres
Dimensions:		
Structural height	278	ft
Hydraulic height	225	ft
Top width	20	ft
Maximum base width	286	ft
Crest length	5,093	ft
Crest elevation	750.0	ft
Total volume	3,565,000	yd³
Spillway: Uncontrolled overflow section in central portion of dam.		
Crest length	700	ft
Crest elevation	714.0	ft
Capacity at El. 746	508,000	ft³/s
Outlet works:		
River: 24 conduits through dam, each controlled by one 102-in paradox gate.		
Capacity of the 24 river outlet gates at El. 714	125,000	ft³/s
Power: Three steel pipes through dam, each controlled by a 16.67- by 22.11-ft slide gate, capacity of three power outlets at El. 714	5,100	ft³/s
Foundation: Horizontal series of thin alternating hard and soft beds of limestone, marl, and clay with some porous strata. Well developed block pattern or joint cracks in riverbed.		
Special treatment: Entire foundation cement-grouted, high-pressure grout curtain beneath grouting and drainage galleries.		
Mass concrete: Natural aggregate from pits near dam (oversize crushed), and broken and crushed rock from Sudduth area, 75 mi from dam; low-heat portland cement; temperature control natural and using river water and refrigerated water through embedded pipe system, in different stages.		
Volume	1,870,000	yd³
Maximum size aggregate	6	in
Water-cement ratio by weight	0.58	
Cement content	0.985-1.07	bbl/yd³
Contraction joints: Transverse, 30 to 53 ft; horizontal, entire length of dam. Joints grouted through embedded pipe system after cooling of concrete.		

[2]The Lower Colorado River Authority Designates the Structure as Mansfield Dam and the reservoir as Lake Travis.

Power Facilities

The powerplant at Marshall Ford Dam was constructed and is operated by the Lower Colorado River Authority. The powerhouse has three units and a total design rating generating capacity of 67,500 kW. The Authority also has powerplants at Buchanan, Inks, Granite Shoals, Marble Falls, and Austin Dam.

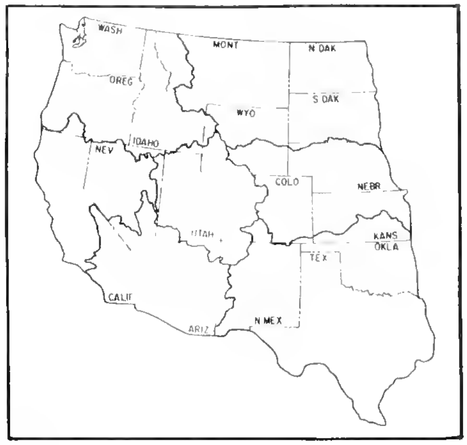


Marshall Ford Dam, Plan and Sections

Colorado River Basin Project

Lower Colorado River Basin
States of Arizona, California, Nevada, and New Mexico

Upper and Lower Colorado Regions
Water and Power Resources Service



The Colorado River Basin Project provides a program for further comprehensive development of the water resources of the Colorado River Basin and the provision of additional and adequate water supplies for use in the upper and lower Colorado River Basins. The project was authorized for regulating flows of the Colorado River; controlling floods; improving navigation; providing for storage and delivery of the waters of the Colorado River for reclamation of lands, including supplemental water supplies, and municipal, industrial, and other beneficial purposes; improving water quality; providing for outdoor recreation facilities; improving fish and wildlife conditions; and generation and sale of electric power. It will also provide a program for development of a regional water plan; for the satisfaction of the requirements of the Mexican Water Treaty; and long-range augmentation studies of the Colorado River. However, a 10-year moratorium was declared, from the date of the act (September 30, 1968), against making any studies or plans for the importation of water into the Colorado River Basin from any river drainage basin lying outside the natural drainage basin of the Colorado River.

Central Arizona Project, Arizona

The Central Arizona Project is a multipurpose water resource development and management project which will coordinate the use of Colorado River water and the local water resources of the Gila River Basin. The project will provide supplemental water for Indian and non-Indian agricultural areas in Maricopa, Pinal, and Pima Counties in Arizona; western New Mexico; and municipal and industrial water for the Phoenix and Tucson metropolitan areas. Additional purposes include flood control, recreation, fish and wildlife conservation, sediment retention, salinity control, power generation, and area redevelopment.

The Central Arizona Project is subdivided into the Granite Reef, Regulatory Storage, Salt-Gila, Gila River, Tucson, Indian Distribution, and Colorado River Divisions, the Navajo Project participation agreement, the transmission facilities, and the drainage system.

Dixie Project, Utah

The Dixie Project, proposed for Washington County, Utah, was reauthorized under the Colorado River Basin Project which provided for its financial integration and participation in the Lower Colorado River Basin development fund.

The purpose of the project was to utilize the waters from the Virgin and Santa Clara Rivers. It would have provided supplemental irrigation water to about 8,900 acres of developed land and a full supply to about 4,600 acres of new land. Municipal and industrial water would have been provided to the city of St. George, Utah. However, the project was dropped from further consideration when an agreement could not be reached with the Washington County Water Conservancy District for repayment of construction costs.

Upper Basin Projects

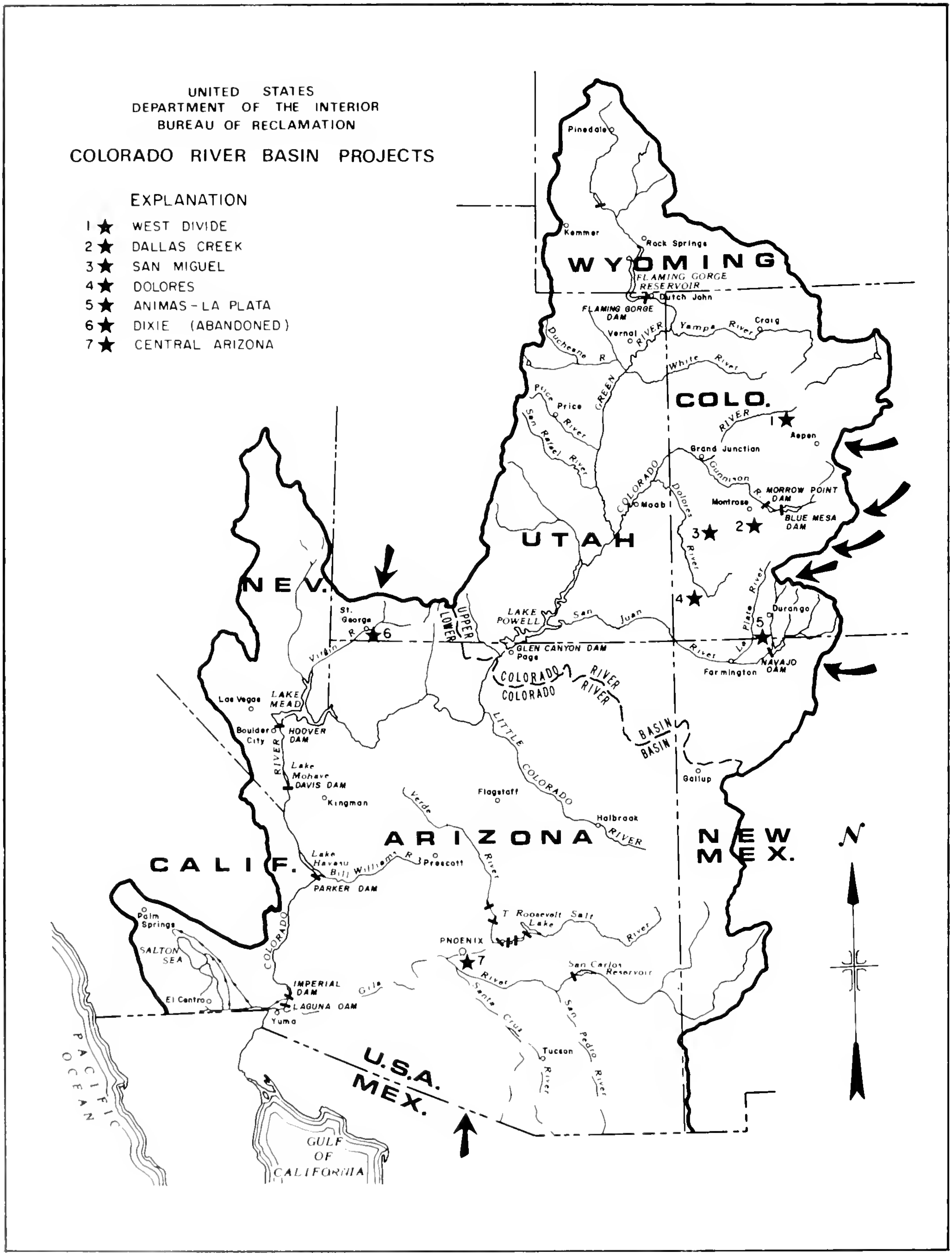
The Colorado River Basin Project provides for reimbursement of the Upper Colorado River Basin fund for expenditures made from that fund to meet deficiencies in the generation at Hoover Dam during the filling of Lake Powell.

The construction of five projects in the Upper Colorado River Basin also was provided for in the Colorado River Basin Act. These projects are to be constructed concurrently with the Central Arizona Project and are listed under "Authorization." Each project is described separately in this publication.

DEVELOPMENT

Early History

There is archeological evidence that some 2,000 years ago irrigation canals were built and maintained by the ancient Hohokam Tribe (Hohokam is a Pima Indian word which, loosely translated, means "the people who have gone away") in the Salt River Valley of the Colo-


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN PROJECTS
EXPLANATION
1 ★ WEST DIVIDE
2 ★ DALLAS CREEK
3 ★ SAN MIGUEL
4 ★ DOLORES
5 ★ ANIMAS - LA PLATA
6 ★ DIXIE (ABANDONED)
7 ★ CENTRAL ARIZONA
WYOMING
COLO.
UTAH
NEV.
ARIZONA
CALIF.
NEW MEX.
U.S.A.
MEX.
Pinedale
Kemmer
Rock Springs
FLAMING GORGE RESERVOIR
Dutch John
FLAMING GORGE DAM
Vernal
Craig
Yampa River
White River
Duchesne R
GREEN RIVER
Price
Price River
San Rafael River
Aspen
Grand Junction
Gunnison R
MORROW POINT DAM
BLUE MESA DAM
Montrose
Moab
COLORADO RIVER
Dolores River
Durango
La Plata River
NAVAJO DAM
Farmington
San Juan River
LAKE POWELL
GLEN CANYON DAM
Page
UPPER
LOWER
St. George
Virgin R
COLORADO RIVER BASIN
LITTLE COLORADO RIVER
Gallup
Holbrook
Flagstaff
Las Vegas
LAKE MEAD
Boulder City
HOOVER DAM
Lake Mohave
DAVIS DAM
Kingman
Verde River
Lake Havasu
Bill Williams R
Prescott
PARKER DAM
T Roosevelt Lake
Salt River
PHOENIX
San Carlos Reservoir
Gila River
Santa Cruz River
San Pedro River
Tucson
Palm Springs
SALTON SEA
El Centro
IMPERIAL DAM
LAGUNA DAM
Yuma
PACIFIC OCEAN
GULF OF CALIFORNIA
N

rado River Basin near present-day Phoenix, Ariz. The Hohokams probably began settlement of the valley as early as 300 B.C. and abandoned it about 1400 A.D., possibly because irrigaton raised the water table, which induced water logging and alkali problems. This would have rendered much of the land unfit for cultivation. Other Indians practiced irrigation in the vicinity before and during the period of exploration of this region of the southwest by white men.

The next irrigators of the Colorado River Basin were Jesuits who established themselves at the old missions of Cuevavi and San Xavier in Arizona in 1732. In the period of 1768-1822, considerable irrigation was practiced along the Santa Cruz River near the missions and the Spanish presidios of Tubac and Tucson.

After the Gadsden Purchase in 1854, a number of settlers began to develop irrigation in Arizona. The Federal Government first attempted to reclaim arid land on the Colorado River Indian Reservation in Arizona and California in 1867. In 1883, the Grand Valley Canal, a private development, was started to irrigate large areas in Grand Valley on the western slope of the Rocky Mountains in Colorado.

The possibility of exporting water from the Colorado River to Imperial Valley in California was considered before the Civil War. After passage of the Reclamation act by the Congress in 1902, the Reclamation Service (Bureau of Reclamation since 1923) began investigations to determine the feasibility of constructing large irrigation works in the Colorado River Basin.

In the early 1900's, men of vision realized the growth potential of the Pacific Southwest. They understood the underlying importance of the waters of the Colorado River Basin to its growth. To ensure that this great resource potential did not become dedicated to the benefit of any one area or State, they instituted a series of actions which led to interstate compacts and international treaties, State and congressional legislation, and Supreme Court decisions, which today in aggregate constitutes the "Law of the River."

The first action comprising the Law of the River began in 1922 with approval of the Colorado River Compact by representatives of the Colorado River Basin States. The compact appropriated the waters of the Colorado River System between the upper and lower basins but did not divide the water among the States. The Boulder Canyon Project Act of 1928 approved the compact and authorized the construction of Hoover Dam and the All-American Canal System.

This act and the Boulder Canyon Project Adjustment Act of 1940 gave certain key responsibilities to the Secretary of the Interior relative to the comprehensive and coordinated development of the Colorado River. The Mexican Treaty of 1944 obligated the United States to deliver 1,500,000 acre-feet of Colorado River water annually to Mexico. The Upper Colorado River Compact of 1948 divided the Upper Basin Colorado River Compact apportionments of the Colorado River for beneficial consumptive use among the Upper Basin States. This, in turn, led to the Colorado River Storage Project Act of 1956 which established an Upper Basin Development Fund and authorized the initial phase of the comprehensive Upper Basin plan of development.

In January 1963, the Secretary of the Interior started studies to develop a regional Colorado River plan. The Secretary's report on the Pacific Southwest Water Plan was submitted January 21, 1964, and on March 9, 1964, the Senate Subcommittee on Irrigation and Reclamation began hearings on the plan, including the Central Arizona Project. On September 30, 1968, the Congress passed Public Law 90-537 authorizing the Colorado River Basin Project and established the Lower Colorado River Basin Development Fund.

Investigations

Comprehensive investigations of development of the water and land resources of the Colorado River Basin were authorized by the Boulder Canyon Project Act and the Boulder Canyon Project Adjustment Acts. The Secretary of the Department of the Interior submitted his report and the individual project supplemental informational reports of the *Western United States Water Plan* in January 1964. Presented in the report is a regional water plan to relieve the acute water problem of the Pacific Southwest. The supplemental reports present additional information on proposed projects.

The Lower Colorado Region State-Federal Interagency Group for the Pacific-Southwest Interagency Committee of the Water Resources Council prepared a report and appendixes of the *Lower Colorado River Comprehensive Framework Studies*. The report was issued in June 1971 and presents a framework program for the development and management of the waters and related land resources of the Lower Colorado Region. The Colorado River Basin Project Act of 1968 directed the Secretary of the Interior to conduct reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the 17 Western States lying wholly or in part west of the Continental Divide. *The Westwide Study Report of the Critical Water Problems Facing the Eleven Western States* was issued in April 1975.

Authorization

The Colorado River Basin Project was authorized by the act of September 30, 1968 (Public Law 90-537, 82 Stat.

885). Authorized developments are:

LOWER COLORADO RIVER BASIN

Central Arizona Project, Arizona, and New Mexico;
Dixie Project, Utah[1].

UPPER COLORADO RIVER BASIN

Animas-La Plata, San Juan River, Colorado and New Mexico;
Dolores Project on the Dolores River in Colorado;
Dallas Creek Project on the Uncompahgre River and its tributaries in west-central Colorado;
West Divide on a series of Colorado River tributaries in Colorado;
San Miguel on the San Miguel River in southwestern Colorado.

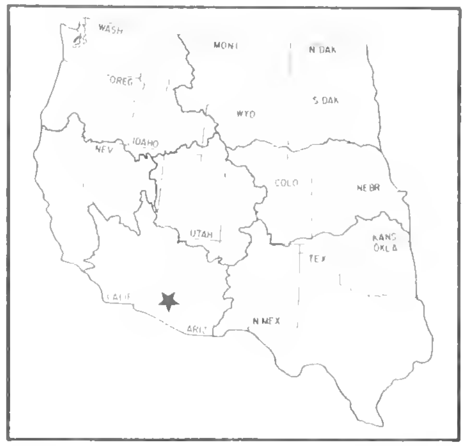
Guidelines were established in the authorizing legislation for the investigations of augmentation of the Colorado River, protection for areas of potential export, the Mexican Water Treaty obligations, the Lower Basin shortage formula, and the criteria for the coordinated operation of Lake Powell and Lake Mead.

[1]Repayment contract was not signed and the project was dropped from the plan.

Colorado River Basin Project
Central Arizona Project

Arizona: Maricopa, Pinal, and Pima Counties
New Mexico: Catron, Hidalgo, and Grant Counties

Lower Colorado Region
Water and Power Resources Service



The Central Arizona Project is a multipurpose water resource development and management project which will provide supplemental Colorado River water, either directly or by exchange, to nearly 1 million acres of Indian and non-Indian irrigated agricultural land areas in Maricopa, Pinal, and Pima Counties, Arizona; and Catron, Hidalgo, and Grant Counties, New Mexico. In addition, the project ultimately will provide 500,000 acre-feet of municipal and industrial water for the Phoenix and Tucson metropolitan areas and substantial benefits from power generation, flood control, outdoor recreation, fish and wildlife conservation, and sediment control. The project was subdivided, for administration and construction purposes, into the following seven divisions: Granite Reef, Regulatory Storage (formerly Orme Division), Salt-Gila, Gila River, Tucson, Indian Distribution, and Colorado River.

The Colorado River Basin Project Act, under which the Central Arizona Project was authorized, provided for the Secretary of the Interior to enter into an agreement with non-Federal interests, whereby the Federal Government acquired the right to 24.3 percent of the power produced at the non-Federal Navajo Generating Station, Navajo Project. The agreement also includes the delivery of power and energy over the transmission facilities to delivery points within the Central Arizona Project area.

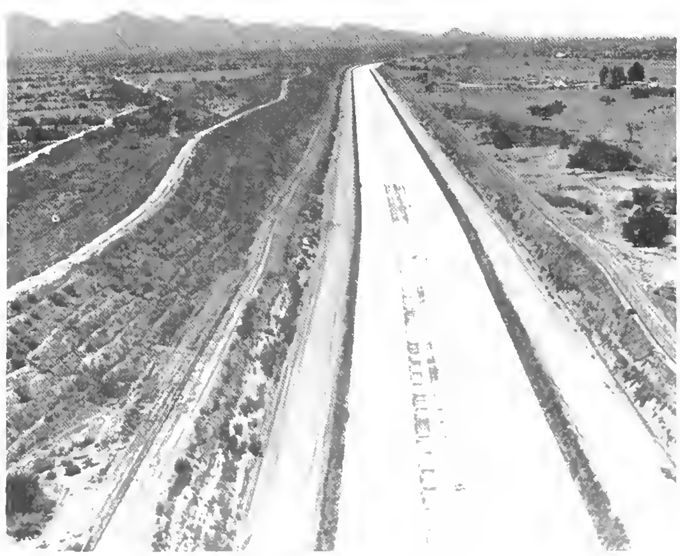
Construction was started on the project in 1973 with the award of a contract for the construction of the Havasu Intake Channel Dike and excavation for the pumping plant, features of the Granite Reef Division. Construction of the other divisions of the Central Arizona Project will follow in an orderly fashion.

PLAN

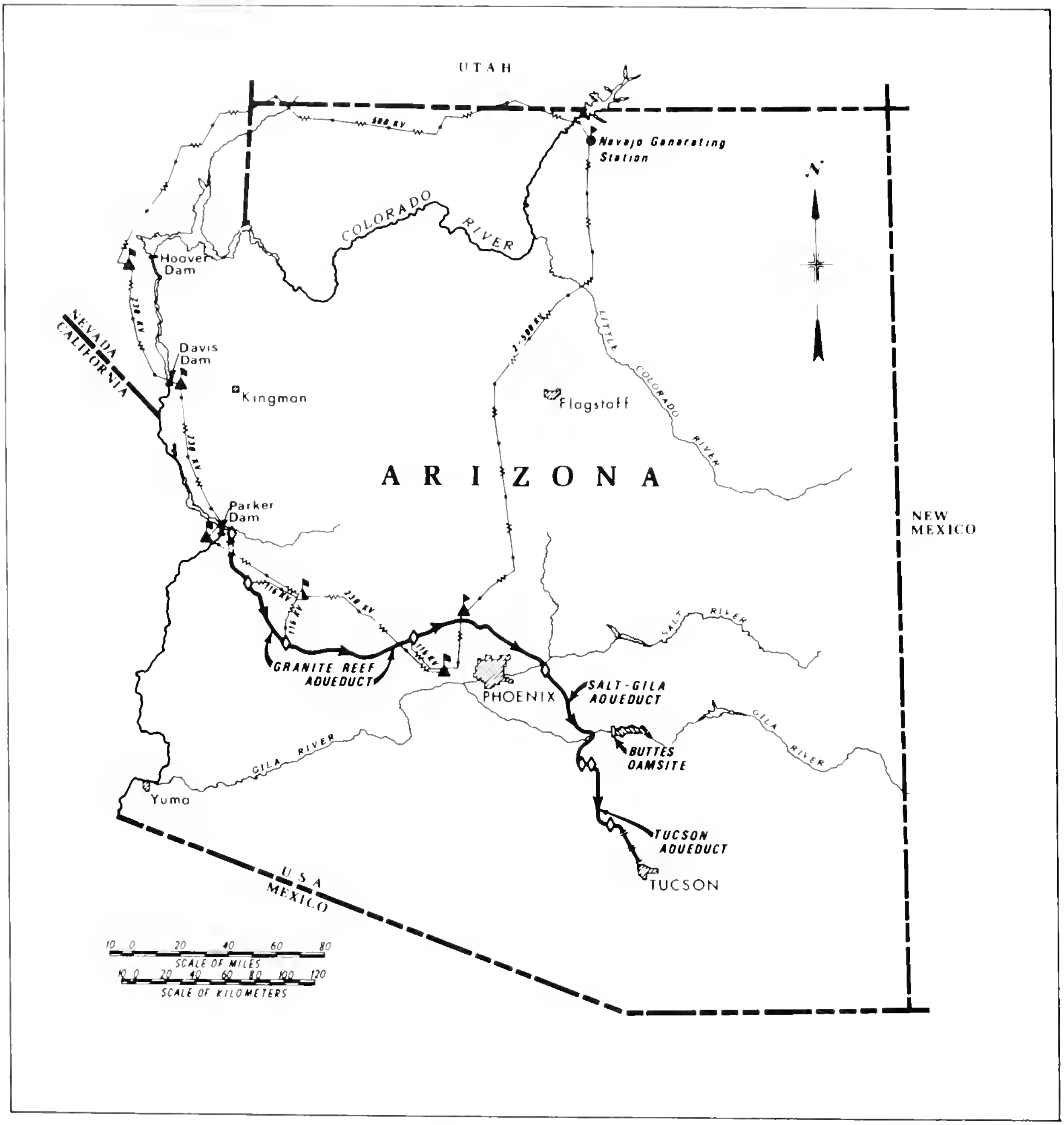
The plan calls for construction of a system of pumping plants and aqueducts which will convey Colorado River water from the Bill Williams River arm of Lake Havasu to the project service area. Also, the plan as presently conceived includes the construction of a dam and reservoir on the Gila River to provide conservation storage, flood and sediment control, and recreation opportunities. Federal participation in the Navajo Generating Station will provide pumping power for the project.

Havasu Diversion and Granite Reef Aqueduct—Granite Reef Division

An intake channel and high-lift pumping plant, located on the south side of the Bill Williams River arm of Lake Havasu, will be used to divert and lift Colorado River water over 800 feet from the lake to the inlet portal of the 6.8-mile-long Buckskin Mountains Tunnel. The water will be discharged at the outlet portal of the tunnel into the open channel of the Granite Reef Aqueduct. It will then be conveyed through 173.9 miles of concrete-lined open channel, 7.4 miles through six siphons, 1.3 miles through two tunnels, and 0.6 mile through three pumping plants for a total distance of about 190 miles to the Phoenix metropolitan area. The aqueduct will have a maximum capacity of 3,000 cubic feet per second. Relift pumping stations will be located at Bouse Hills, Little Harquahala Mountains, and near the Hassayampa



Granite Reef Aqueduct



Colorado River Basin Project, Central Arizona Project

River. To deliver water from the Colorado River to the Phoenix service area will require a total pump lift of about 1,200 feet.

Salt-Gila Aqueduct—Salt-Gila Division

The Salt-Gila Aqueduct, which will begin at the terminus of the Granite Reef Aqueduct just south of the Salt River Siphon, will consist of about 58 miles of open, concrete-lined channel and a series of siphons with a proposed initial capacity of 2,750 cubic feet per second. A pumping plant will lift the project water from Granite Reef to the Salt-Gila Aqueduct.

Tucson Aqueduct—Tucson Division

The Tucson Aqueduct will begin at the terminus of the Salt-Gila Aqueduct and will convey water about 60 miles to Tucson, Ariz. A series of pumping plants will be required to relift the water to Tucson for municipal and industrial use. Deliveries of project water from the Salt-Gila and Tucson Aqueducts for irrigation use in Maricopa and Pinal Counties are planned.

Indian Distribution System Division

The distribution system will deliver project water to the central Arizona Indian tribes which have been allocated project water by the Secretary of the Interior for irrigation purposes. The current plan is to deliver to the tribes a fixed supply of 257,000 acre-feet annually for the first 20 years of project operation, through the year 2005. After the first 20 years, the tribes will receive at least 10 percent of the CAP water supply, or 20 percent of all irrigation water, whichever is greater. Through the year 2005, the individual entitlements amount to 4,300 acre-feet for the Fort McDowell Reservation, 13,300 acre-feet for the Salt River Reservation, 173,100 acre-feet for the Gila River Reservation, 58,300 acre-feet for the Ak-Chin Reservation, and 8,000 acre-feet for the Papago Reservation.

Buttes Dam and Reservoir—Gila River Division

Buttes Dam will be constructed on the Gila River within Pinal County about 4 miles upstream from the existing Ashurst-Hayden Diversion Dam. Capacity will be provided in the multipurpose storage reservoir for conservation, flood, and sediment control. Outdoor recreation and fish and wildlife benefits also will be afforded by development of these facilities.

Power Sources

Provisions of the Colorado River Basin Project Act allowed the Federal Government to participate in the non-Federal Navajo Project. The Navajo Generating Station, near Page, Ariz., will provide pumping power for the Central Arizona Project. The Southern and Western Transmission Systems, feaures of the Navajo Project, will transmit this power to Westwing Substation near Phoenix and McCullough Substation near Boulder City, Nev.

The Navajo Generating Station was constructed by the Salt River Project Agricultural Improvement and Power District of Arizona. The Southern Transmission System, completed in 1974 by the Arizona Public Service Co., consists of two 500-kV transmission lines to the Phoenix area. The Western Transmission System consists of one 500-kV transmission line to the McCullough Switchyard near Boulder City, Nev. This line was constructed by the Department of Water and Power of the City of Los Angeles, Calif., and was completed and placed in service on October 27, 1974. Other participants in the Navajo Project are the Nevada Power Co., the Tucson Gas and Electric Co., and the Bureau of Reclamation. The Bureau's share is 24.3 percent, or 546,750 kilowatts.

Construction of the Navajo Generating Station began in April 1970. The third, and last, generating unit was completed and placed in operation on April 30, 1976. Until energy is required for the Central Arizona Project or other purposes authorized by Public Law 90-537, Reclamation's share of the interim energy produced is being sold to other participants in the station and to the Southern California Edison Co.

Transmission System

The transmission system to supply power to the pumping plants and check structures along the Granite Reef Aqueduct is under construction. It will have a total length of about 309 miles, of which 250 miles comprise the 230-kV line interconnecting the delivery portion of the transmission system. The radial transmission lines to the pumping plants consist of about 51 miles of 115-kV lines and 8 miles of 230-kV lines.

The route of the 230-kV transmission line begins at the McCullough Switching Station in Clark County, Nevada, and interconnects the Davis Switchyard, the Parker Switchyard, and the Liberty Substation in Arizona. A new substation, called Harcuvar, will be constructed in Yuma County, Arizona, and a new tap station, called Hassayampa Tap, will be constructed in Maricopa County, Arizona. Approximately 59 circuit miles of radial transmission lines will be constructed to supply power to Havasu, Bouse Hills, Little Harquahala, and Hassayampa Pumping Plants.

Delivery of power to the proposed Salt-Gila Aqueduct will utilize both existing transmission lines and the transmission lines to be constructed for the Granite Reef Aqueduct. A new tap station will be constructed in Maricopa County, Arizona, on the existing Mesa-Coolidge 230-kV line, and about 6 miles of 69-kV line will be constructed to feed the Salt-Gila Pumping Plant. Delivery of power to the proposed Tucson Aqueduct also will require the existing and constructed transmission lines for the Granite Reef Aqueduct. About 40 miles of existing transmission lines will be reconstructed and additional capacity added to the Coolidge Substation to supply the Tucson Aqueduct Pumping Plants. About 25 miles of new 115-kV transmission lines will be constructed to supply power to pumping plants near Picacho Mountain. Additions to existing substations, the new tap substations, and new transmission lines will be required to supply power to pumping plants which are in the advance planning stage.

DEVELOPMENT

Early History

Since prehistoric times, communities have irrigated the lands along the Gila and Salt Rivers by diversion of streamflow into systems of ditches, with temporary brush and rock dams. In the late 1800's, the Pima Indians farmed possibly as much as 35,000 acres along the Gila River within the present Gila River Indian Reservation. In the 1860's, settlers began to redevelop and extend

Havasu Pumping Plant

abandoned farmland along the Salt River in the vicinity of Phoenix. These early enterprises were severely handicapped by raging spring floods and low waterflows during the later stages of the growing season.

The Salt River was almost totally controlled by a series of dams constructed between 1911 and 1946 on the Salt and Verde Rivers. The Bureau of Indian Affairs completed Coolidge Dam on the Gila River in 1928. Due to the increased control and regulated supply of available water, agriculture expanded and prospered along the desert plains adjoining the streams.

In the Salt River Valley, application of irrigation water led to a rise in the water table and eventually to drainage problems. By 1918, waterlogging threatened the productivity of the irrigated area. A system of shallow wells was established to draw down the water level, and the pumpage was used for new agricultural expansion. Conditions were ideal for ground-water development because of the highly permeable alluvial aquifers, a shallow water table, and good quality water. Pumping soon exceeded recharge and eventually led to a decline in water levels below the original levels.

The 1930's through 1950's brought low cost hydropower, improved well drilling equipment, and high capacity pumps. As a consequence, the pumping rate was further increased, and ground-water irrigation spread from the vicinity of the rivers throughout the central Arizona desert basins. The rate of pumping eventually far exceeded the rate of recharge, water levels dropped rapidly, and in some areas, increased pump lifts, poor water quality, and farm crop controls forced farmland out of production.

The mild winters of central and southern Arizona, the development of efficient air-conditioning, and the growth of air transportation have been factors in a tremendous expansion of urban population, particularly in the Phoenix and Tucson metropolitan areas.

As agricultural lands have been taken over by urban growth, the surface and ground-water supplies have shifted to municipal and industrial users at approximately the same delivery requirement per acre. In areas where urban projects have expanded onto raw desert areas, municipal and industrial uses have contributed to the increasing overdraft of ground-water supplies.

Investigations

Formal investigations for the Central Arizona Project were started in 1944 by the Phoenix Development Office. The Central Arizona Project report was published as House Document No. 136, 81st Congress, 1st session, and was recommended for authorization in 1949.

During the 1950's, the Central Arizona Project was tabled while the Supreme Court heard the issue of Lower Colorado River water rights in the case of Arizona v. California. In 1961, when it appeared that a Supreme Court decision favorable to Arizona might be imminent, the Phoenix Development Office reopened investigations, using funds provided by the States of Arizona and New Mexico.

The resulting report, dated January 1962, documented the major changes that had taken place since the initial report. Continuous investigations through authorization provided data for reports on this project in 1964, 1967, and 1968.

Authorization

The Central Arizona Project was authorized for construction under the Colorado River Basin Project Act, Public Law 90-537 (82 Stat. 885), approved September 30, 1968. In March 1977, a Presidential Review of water projects was initiated. A statement on the water projects was released April 18, 1977, recommending modification of the Central Arizona Project by the elimination of Orme, Hooker, and Charleston Dams and making Federal funding contingent upon further study of ground-water supplies and institution of ground-water regulation and management by the State of Arizona. Since Public Law 90-537 qualified the authorizing language for Orme and Hooker Dams with the phrase "or suitable alternatives," other plans will be formulated in an effort to determine suitable alternatives for those features.

Construction

Initial construction of the Central Arizona Project began in 1973, and completion of the aqueduct is scheduled for the mid-1980's; other project features are scheduled for completion by the early 1990's.

BENEFITS

Irrigation

Project water will provide irrigation benefits to non-Indian farmers with a past history of irrigation, and to Indian farmers to irrigate all of their presently developed acreage.

Municipal and Industrial Water

Project works will provide water for municipal and industrial use in the Phoenix and Tucson metropolitan areas.

Flood Control

Although central Arizona usually suffers from water shortages, periodical and destructive floods do occur. Extensive flood control benefits are included in the project.

Recreation

The Central Arizona Project will create recreation potential with the development of water-oriented activities, equestrian paths, and other activities.

Fish and Wildlife

Considerable fish and wildlife benefits will be realized with completion of the project.

Reduction of Ground-water Overdraft

Substituting most of Arizona's remaining entitlement in the Colorado River for a portion of the current ground-water overdraft would reduce the overdraft and land subsidence, which has become a major problem.

PROJECT DATA

Climatic Conditions

Annual precipitation	7.7	in
Temperature:		
Maximum	116	°F
Minimum	27	°F
Mean	71	°F
Growing season	304	days

ENGINEERING DATA

Water Supply

COLORADO RIVER
(See Boulder Canyon Project.)

Diversion Facilities—Granite Reef Division

LAKE HAVASU
(See Parker-Davis Project for details.)

HAVASU INTAKE CHANNEL DIKE

Type: Earthfill land form embankment
Location: In Yuma County, about 20 mi north of Parker, Ariz.
Construction period: 1973-74
Dimensions:

Structural height	36	ft
Top width	30	ft
Crest length	2,481	ft
Crest elevation	456.0	ft
Slope: Natural angle of repose		
Volume	739,491	yd³

Carriage Facilities—Granite Reef Division

BUCKSKIN MOUNTAINS TUNNEL

Location: From Lake Havasu 6.8 mi through the Buckskin Mountains, discharging into open section of Granite Reef Aqueduct.
Construction period: 1975-(Under construction)

Length	6.8	mi
Capacity	3,000	ft³/s
Cross section: Circular		
Diameter	22	ft
Depth of water	15.6	ft
Lining: Concrete	20	in

GRANITE REEF AQUEDUCT

Location: From the Havasu diversion facilities at Lake Havasu on the Colorado River to the Phoenix metropolitan area.
Construction period: 1973-(Under construction)

Length: 173.9 mi open channel and 16.1 mi closed	190	mi
Initial capacity	3,000	ft³/s
Typical maximum section:		
Bottom width	24	ft
Side slope	1.5:1	
Water depth	16.4	ft
Lining: Concrete	3.5	in

BURNT MOUNTAIN TUNNEL

Location: In Maricopa County, about 30 mi southeast of Salome and about 60 mi west of Phoenix, Ariz.
Construction period: 1978-(Under construction)

Length	0.6	mi
Capacity	3,000	ft³/s
Cross section: Horseshoe		
Diameter	19.5	ft
Depth of water	15.17	ft
Lining: Concrete	20	in

AGUA FRIA TUNNEL

Location: In Maricopa County, about 27 mi northwest of Phoenix, Ariz.
Construction period: 1978-(Under construction)

Length	0.7	mi
Capacity	3,000	ft³/s
Cross section: Horseshoe		
Diameter	19.5	ft
Depth of water	15.17	ft
Lining: Concrete	20	in

Siphons

CUNNINGHAM WASH SIPHON

Location: In Reach 2 of the Granite Reef Aqueduct, about 6 mi north of Bouze, Ariz.
Construction period: 1978-(Under construction)
Description: Monolithic concrete pipe

Length	0.7	mi
Diameter	21	ft
Capacity	3,000	ft³/s

CENTENNIAL WASH

Location: In Reach 4 of the Granite Reef Aqueduct, about 19 mi southeast of Salome, Ariz.
Construction period: 1978-(Under construction)
Description: Prestressed concrete pipe

Length	1.1	mi
Diameter	21	ft
Capacity	3,000	ft³/s

JACKRABBIT WASH

Location: In Reach 7 of the Granite Reef Aqueduct, about 25 mi northwest of Buckeye, Ariz.
Construction period: 1978-(Under construction)
Description: Prestressed concrete pipe

Length	0.3	mi
Diameter	21	ft
Capacity	3,000	ft³/s

HASSAYAMPA RIVER

Location: In Reach 7 of the Granite Reef Aqueduct, about 22 mi north of Buckeye, Ariz.
Construction period: 1978-(Under construction)
Description: Prestressed concrete pipe

Length	0.7	mi
Diameter	21	ft
Capacity	3,000	ft³/s

AGUA FRIA RIVER

Location: In Reach 9 of the Granite Reef Aqueduct, about 27 mi northwest of Phoenix, Ariz.
Construction period: 1975-78
Description: Prestressed concrete pipe

Length	1.9	mi
Diameter	21	ft
Capacity	3,000	ft³/s

NEW RIVER

Location: In Reach 9 of the Granite Reef Aqueduct, about 27 mi northwest of Phoenix, Ariz.
Construction period: 1975-78
Description: Prestressed concrete pipe

Length	1.1	mi
Diameter	21	ft
Capacity	3,000	ft³/s

SALT RIVER

Location: In Reach 12 of the Granite Reef Aqueduct, about 24 mi northeast of Phoenix, Ariz.
Construction period: 1975-78
Description: Prestressed concrete pipe

Length	1.6	mi
Diameter	21	ft
Capacity	3,000	ft³/s

DIKES—GRANITE REEF DIVISION—
PARADISE VALLEY FLOOD DETENTION DIKE

Type: Earthfill
Location: In Reach 11 of the Granite Reef Aqueduct, about 14 mi north of Phoenix.
Construction period: 1974-76
Dimensions:

Maximum structural height	47	ft
Top width	14	ft
Crest length	16	mi
Crest elevation	1542, 1547, 1553.0	ft
Slope	1.5:1 to 4:1	
Volume	8,129,600	yd³

PUMPING PLANTS—GRANITE REEF DIVISION

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Havasu		Data on pumping plants pending final design		
Bouse Hills				
Little Harquahala				
Hassayampa				
		Data on pumping plant requirements for other divisions pending final designs.		

Power Facilities

Navajo Project Participation Agreement. Federal entitlement to 24.3 percent of the output (nameplate capacity is 2,250,000 kW) from the Navajo Generating Station located at Page, Ariz.

SUBSTATIONS AND SWITCHYARDS—GRANITE REEF DIVISION

Switchyard additions	2
Switchyards (new)	4
Substations (new)	2
Substation additions	2

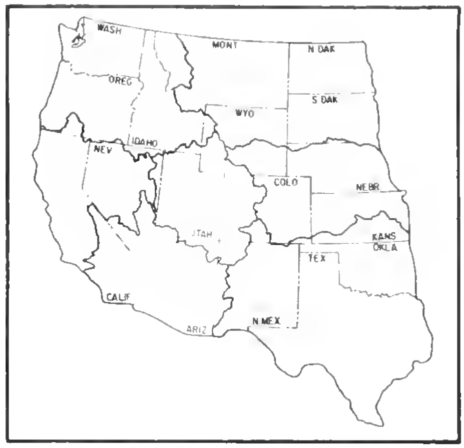
TRANSMISSION LINES—GRANITE REEF DIVISION

Total number of lines	7
Total circuit miles	309

Designation	Capacity, kV	Circuit miles	Year placed in service
Davis-Parker No. 2	230	69	
Liberty-Parker	230	119	
McCullough-Davis	230	62	
Havasu-Parker	230	2	
Hassayampa Tap Line	230	6	
Harcuvar-Bouse Hills	115	24	
Harcuvar-Little Harquahalla	115	27	
Navajo-Westwing (twin circuits)[1]	500	258	1974
Navajo-McCullough[1]	500	276	1974

[1]The Federal entitlement in the Navajo Project includes use of capacity in the Western and Southern Transmission Systems.

Colorado River Basin Salinity Control Project



Colorado River Basin States: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

Lower Colorado and Upper Colorado Regions Water and Power Resources Service

The Colorado River Basin Salinity Control Act, Public Law 93-320, authorized the construction, operation, and maintenance of works in the Colorado River Basin to control the salinity of the water delivered to Mexico. Title I of the act (programs downstream from Imperial Dam) authorized construction of the Desalting Complex, the Coachella Canal, and the Protective and Regulatory Pumping Units. These are primarily water recovery measures and were being designed or under construction in 1978. Title II of the act (programs upstream from Imperial Dam) authorized construction of the Paradox Valley Unit, Colorado; Grand Valley Unit, Colorado; Crystal Geyser Unit, Utah; and the Las Vegas Wash Unit, Nevada. In 1978, advance planning studies or construction activities were underway on these four units.

Also authorized under Title II is the acceleration of 12 feasibility investigations of salinity control measures being conducted under the Colorado River Water Quality Improvement Program. These investigations are classified in three categories: irrigation source control, point source control, and diffused source control.

In providing for programs downstream from Imperial Dam, Title I of the act permits implementation of the provisions of Minute No. 242. This minute, formally approved by the United States and Mexico on August 30, 1973, is an agreement by the two governments which provides that the United States shall adopt measures to ensure that 1,360,000 acre-feet of water delivered annually to Mexico upstream of Morelos Dam shall have an average salinity of no more than 115 parts per million, plus or minus 30 parts per million, over the annual average salinity of Colorado River water arriving at Imperial Dam. It further provides for the United States to deliver to Mexico across the land boundary at San Luis, Ariz., and in the Limitrophe Section of the Colorado River downstream from Morelos Dam, approximately 140,000 acre-feet of water annually with salinity substantially the same as that of water customarily delivered there. The minute provided that the concrete-lined Main Outlet Drain Extension (MODE) be extended from Morelos Dam to the Santa Clara Slough in Mexico at United States expense.

Included in the Desalting Complex Unit, Title I of the project, are structural measures consisting of: (1) a membrane-process desalting plant, a pretreatment plant, and the necessary appurtenant works to treat drainage water from the Wellton-Mohawk Division, Gila Project; (2) extension of the concrete-lined bypass drain from Morelos Dam to the Santa Clara Slough in Mexico; and (3) replacement of an existing metal flume in the MODE with a concrete siphon. Nonstructural measures consist of: (1) an irrigation efficiency improvement program in the Wellton-Mohawk Division; (2) an irrigable acreage reduction program in the Wellton-Mohawk Division; and (3) acquisition of land, if needed, in the Corps of Engineers' Painted Rock Reservoir.

In connection with the desalting plant, but to be investigated independently, Section 101c of the act authorized the Reject Stream Replacement Study to identify feasible measures which could adequately replace the water lost through reject from the Yuma Desalting Plant and any Wellton-Mohawk drainage water bypassed to the Santa Clara Slough. The source of any such replacement water was limited by the act to the States of Arizona, Colorado, California, New Mexico, and those portions of Nevada, Utah, and Wyoming which are within the natural drainage basin of the Colorado River. The act also specified a study completion date no later than June 30, 1980.

In addition to these two criteria set forth in the act, a third factor, the maximum quantity of replacement water necessary, needed to be established as a basis for the identification of possible replacement sources. Early computer modeling studies identified 42,000 acre-feet per year as a maximum amount of reject that could be expected from the plant during the years of maximum production. It is necessary, therefore, to identify replacement sources which could provide 42,000 acre-feet of water in any given year. This amount may vary somewhat since it is dependent on final sizing studies on the desalting plant. In 1978, a status report was prepared on the Reject Stream Replacement Study.

The Coachella Canal Unit, Title I Division, involves replacing the first 49 miles of the existing unlined Coachella Canal with a new concrete-lined canal. This action will save most of the water that is being lost through seepage in the unlined reach of the canal.

The United States is entitled to temporary use of the saved water during an interim period, for the purpose of meeting the salinity control objectives of Minute No. 242. The interim period commences on completion of construction of the new canal and will end the first year that the Secretary of the Interior delivers mainstream Colorado River water to California in an amount less than the sum of the quantities requested by (1) the California agencies under contracts made pursuant to Section 5 of the Boulder Canyon Project Act, and (2) Federal establishments to meet water rights acquired in California in accordance with the Supreme Court decree in Arizona v. California.

In connection with the reconstruction of the Coachella Canal, the act also provides, as a nonstructural measure, for acquisition of land on the Imperial East Mesa, California, which receives or has been granted the right to receive water from Imperial Irrigation District's capacity in the Coachella Canal. Approximately 4,200 acres of land are involved.

The Protective and Regulatory Pumping Unit authorized by the act provides for construction of a well field located on a 5-mile-wide strip of land along the Southerly International Boundary between Arizona and Sonora, Mexico. Minute No. 242 limits the quantity of water pumped from the combination of private wells and the unit well field to 160,000 acre-feet annually. A significant amount of the water pumped by the unit will be delivered to the Southerly International Boundary near San Luis, Ariz. This water, when combined with the drainage and regulatory waste flows from the Valley Division of the Yuma Project, will make up the 140,000 acre-feet per year of water delivered to Mexico at the Southerly International Boundary. This 140,000 acre-feet of water, with the 1,360,000 acre-feet of water delivered at the Northerly International Boundary, will make up the 1,500,000 acre-feet of Mexican Treaty entitlement to Colorado River water.

A smaller part of the water pumped will be available for use in Arizona for agricultural and other purposes. As a nonstructural measure, the act authorized acquisition of about 23,500 acres of land, or interest therein, within 5 miles of the Mexican Border for the well field on Yuma Mesa.

In 1978, construction was underway on all units of the Title I Division, and investigations on the replacement of the reject stream from the Yuma Desalting Plant were continuing.

Power will be supplied to the Desalting Complex Unit by the Department of Energy's Parker-Davis Project Transmission System, which connects the Yuma area with the system of the utilities operating in the power supply area. The initial source of electrical energy, through 1985, will be the Navajo Generating Station of the Navajo Project, a private development located near Page, Ariz., in which the Bureau of Reclamation is a participant. This source was developed to supply the power requirements of the Central Arizona Project and augment the Lower Colorado River Basin Fund. The power will be utilized from the inservice date of the Yuma Desalting Plant through such time as it may be required by the Central Arizona Project. Other sources are under study to provide a permanent power supply. Energy for operating the well field of the Protective and Regulatory Pumping Unit eventually will be served from the same source as that of the Yuma Desalting Plant. Because of the earlier inservice date associated with the well field, it is proposed to use, on an interim basis, power supplied from the Colorado River Storage Project. The energy will be transmitted through the Parker-Davis Transmission System. The source of power for those units to be constructed under Title II are under study.

In 1978, intensified feasibility investigations were underway on divisions or units of the Colorado River Water Quality Improvement Program, accelerated studies of which were authorized by Title II of the Colorado River Basin Salinity Control Act. These investigations will develop information for construction of additional units to help control those areas that are contributing to the salinity of the Colorado River. Nonstructural studies are being made under this investigation program which, if found feasible, would reduce the salinity contributed to the river through improved irrigation management practices and an irrigation system improvement program.

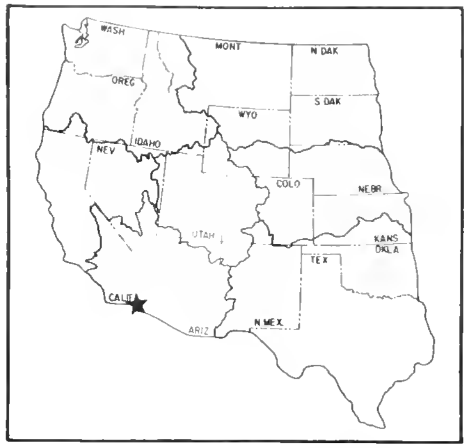
Significant modification may be found in the project plan during the definite planning stage of investigations or during the preparation of final designs of project features.

Colorado River Basin Salinity Control Project

Coachella Canal Unit, Title I Division
(Under Construction)

California: Imperial and Riverside Counties

Lower Colorado Region
Water and Power Resources Service



The existing 123-mile Coachella Canal is a feature of the Coachella Division of the All-American Canal System (see Boulder Canyon Project, All-American Canal System). The Coachella Canal conveys Colorado River water from the All-American Canal to irrigate 78,530 acres in the Coachella Valley. The first 86 miles of the waterway are unlined. The remaining 37 miles are concrete lined. The Coachella Canal also has six turnouts to serve about 6,500 acres of non-Federal land on Imperial East Mesa, of which about 500 acres have been developed. Its capacity is 2,500 cubic feet per second at the turnout from the All-American Canal and decreases through successive reaches to 1,300 cubic feet per second at the beginning of the existing lined section.

After the canal's completion in 1948, seepage losses developed along the 86-mile unlined section. The initial 49 miles traverse the coarse, sandy soils of Imperial East Mesa where the most severe seepage occurs. At the Coachella Canal turnout, the average annual diversions are 497,800 acre-feet. Of this amount, an estimated average of 168,470 acre-feet per year has been lost because of canal seepage.

Coachella Canal Diversion

The primary purpose of the unit is to reduce the water losses in the Coachella Canal by constructing a new concrete-lined canal to replace the initial 49 miles of the existing canal. It will extend from the turnout on the All-American Canal to mile post 49, where it will rejoin the existing canal just upstream from siphon No. 7. The water saved by this action will temporarily be used to replace the water lost to the Colorado River by bypassing saline water to the Santa Clara Slough.

PLAN

The principal feature of the unit will be a new 49-mile concrete-lined canal. Water measurements of flow quantities will be made at two Parshall flumes, one at each end of the new canal. Water quantities will also be measured at each turnout and at all wildlife watering devices. Other features will consist of five new check drop structures, eight siphons, three irrigation turnouts, and operating roads. The existing Coachella Canal turnout, railroad bridges, siphon No. 7, and flood protective works will be retained without modification. All other existing structures on the first 49 miles of the canal will be abandoned, including the unlined section of the canal.

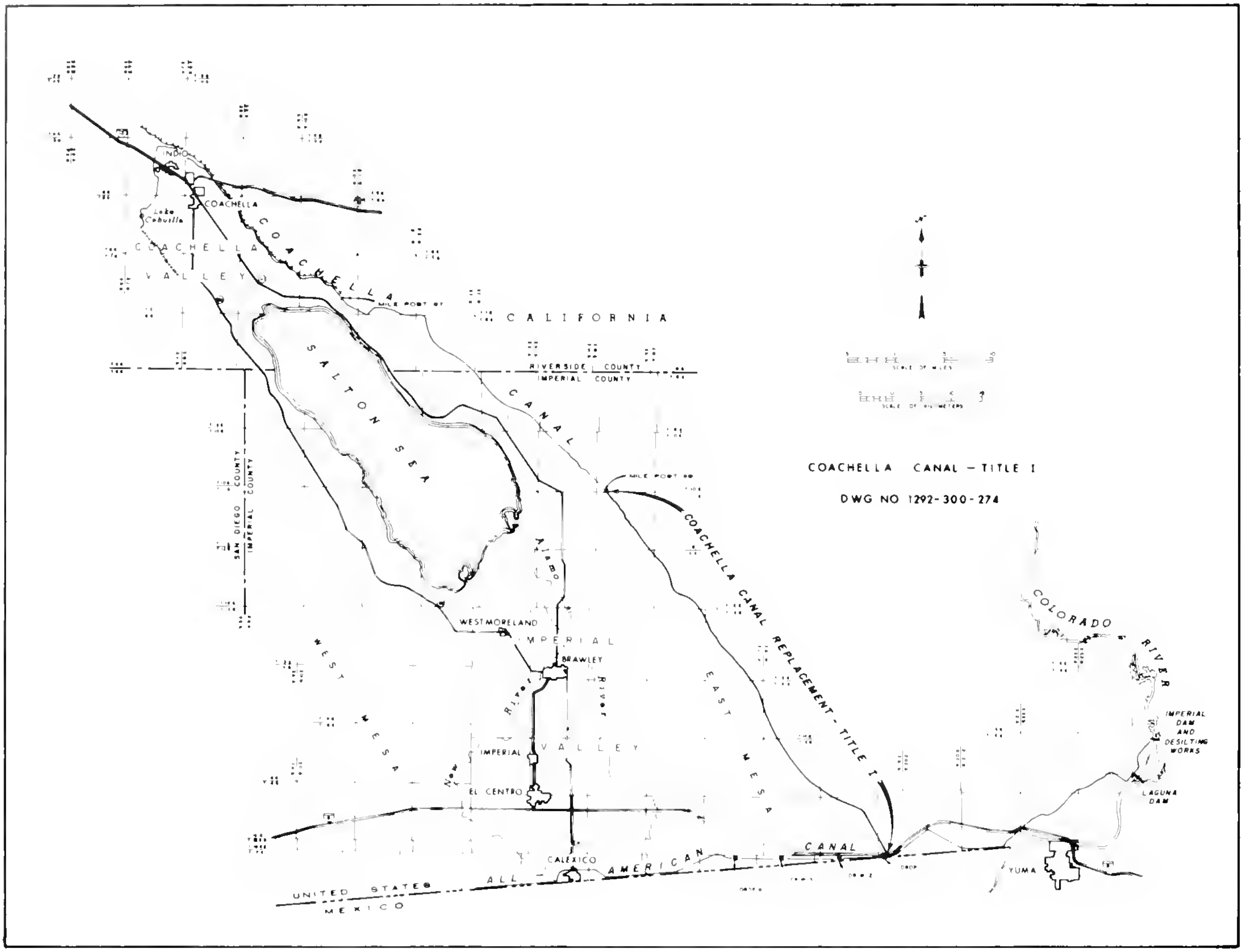
The new canal is designed to accommodate a flow of 1,550 cubic feet per second, a decrease from the capacity of 2,500 cubic feet per second in the existing waterway.

Reduction of Seepage Losses

The estimated average seepage of the existing unlined canal is 141,000 acre-feet per year. It is projected that this loss would be reduced to 9,000 acre-feet per year after lining, representing an annual savings of 132,000 acre-feet of water.

Acreage Reduction

The initial 49 miles of the Coachella Canal are presently managed and controlled by the Imperial Irrigation



Coachella Canal Unit

District, which provides irrigation water for California's Imperial Valley from the All-American Canal. The district also serves a few farms on the Imperial East Mesa, primarily with water from the Coachella Canal.

In 1948, when the Coachella Canal was first placed into service, it was estimated that the irrigation potential on the Imperial East Mesa would be approximately 6,500 acres. Only 500 acres of this land have been developed, with another 500 acres under partial cultivation.

The Congress made a provision in the law authorizing the Colorado River Basin Salinity Control Project approving purchase of private lands on Imperial East Mesa adjacent to the Coachella Canal. The acquisition of these lands by the Federal Government will be on a nonreimbursable basis and they will be returned to public domain. By this action, the Imperial Irrigation District was relieved of responsibility to provide these lands with irrigation services. When the purchase of lands for acreage retirement is complete, the commitment to agriculture adjacent to the Coachella Canal will not exceed 2,000 acres.

Fish and Wildlife

The reduction in the greenbelt areas and seepage ponds, that will occur as a result of the construction, will cause a loss of habitat units. Five measures have been recommended for mitigation which will replace 68.5 percent of the losses.

One feature will be to construct 25 watering devices which will consist of drilling wells, windmills, and water storage tanks. Each windmill would be capable of producing a maximum of 300 gallons of water per hour when operating under optimum conditions.

The California Department of Fish and Game plans to restore Finney Lake. About 363 acres of land adjacent to the Salton Sea National Wildlife Refuge will be developed through the construction of dikes, ponds, and marshes. The existing tile drainage system will be rehabilitated.

Heavy vegetation growth along unlined section of canal

Several isolated parcels of land, totaling 2,120 acres, with high wildlife value will be dedicated to public ownership and maintained in their present condition. The 160-acre Wister Habitat area will be developed by constructing perimeter roads, levees, ponds, and supply ditches to provide marsh habitat suitable for wildlife.

Attendant Facilities

Power transmission lines will be constructed from existing powerlines. They will provide energy to electric motors used to operate gates and sensory devices located at control points.

The entire length of the relocated canal will be flanked by two operating roads. A 20-foot-wide gravel surface operation and maintenance road will be constructed along the southwest bank of the new canal and a 16-foot unsurfaced service road will be graded along the northeast bank. Abutments will be provided on each side of the canal, about 2,000 feet downstream from the turnout, for a future vehicle bridge to provide access to a proposed recreation area being planned by the Bureau of Land Management.

Checks in the canal will be provided with motorized controls having an interface matching the sensory gate opening equipment. This equipment will be furnished and installed by the Coachella Valley County Water District. Monitoring equipment will be installed at all check structures and remote control sensory equipment will measure the rate of flow through each of the two Parshall flumes located at the inlet and outlet transition of the 49-mile lined portion of the canal.

DEVELOPMENT

History

(See the Desalting Complex for the history of development.)

Investigations

In the 30 years that the Coachella Canal has been in use, numerous tests, studies, and surveys have been conducted to determine the effectiveness of the waterway and the approximate amount of water lost by seepage along its 123-mile length. Several official studies and reports have been published.

Authorization

This unit was authorized by the Colorado River Basin Salinity Control Act, Title I, of Public Law 93-320, 93rd Congress H.R. 12165, dated June 24, 1974 (88 Stat. 266). An amendment to the act is proposed which would provide funds for mitigation of fish and wildlife losses associated with replacement of the initial 49 miles of the Coachella Canal.

Construction

Construction of the relocated portion of the Coachella Canal, including advance planning and preconstruction activities, will require about 4 years. Construction started in 1978 and is scheduled to be completed in 1981.

Operating Agencies

The Imperial Irrigation District operates the first 49 miles of the existing canal and the Coachella Valley County Water District operates and maintains the remaining 74 miles. Upon completion of the lining of the canal, the operation and maintenance of the entire 123-mile length will be assumed by the Coachella Valley County Water District. Fish and wildlife mitigation measures will be operated by the fish and wildlife agencies on a nonreimbursable basis.

BENEFITS

Irrigation

The lining of the first 49 miles of the Coachella Canal will result in direct irrigation benefits through the saving of 132,000 acre-feet of water and a reduction in operation and maintenance costs.

PROJECT DATA

Land Areas (1977)

(See Coachella Division, All-American Canal System, Boulder Canyon Project Rehabilitation and Betterment Program.)

Facilities in Operation

Diversion Dam[1]	1	
Canals:		
All-American Canal to Coachella Turnout[1]	36.2	mi
Coachella Canal	123	mi

[1]See Boulder Canyon Project, All-American Canal System.

Climatic Conditions

Annual precipitation	3	in
Temperature:		
Maximum	120	°F
Minimum	20	°F
Mean	73	°F
Growing season	365	days
Elevation of irrigable area	75-230.0	ft

ENGINEERING DATA

Water Supply

(See All-American Canal System.)

Storage Facilities

(See All-American Canal System.)

Carriage Facilities

(See All-American Canal System.)

COACHELLA CANAL

Location: The first 48.3 mi of the new concrete-lined canal from Drop No. 1 on the All-American Canal to milepost 49 near Siphon No. 7 on the existing Coachella Canal.

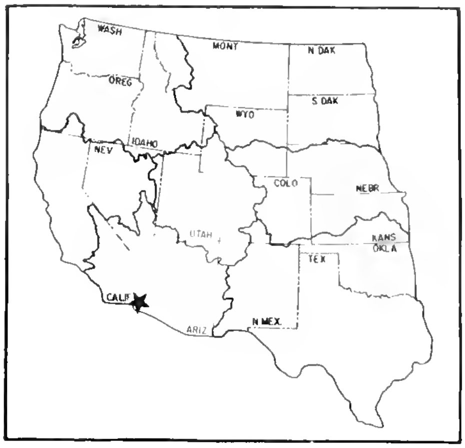
Construction period: 1978- (Under construction)

Length of new canal (open channel 47.8 mi, closed siphons 0.5 mi)	48.3	mi
Capacity	1,550	ft^3/s
Typical maximum section, concrete lined:		
Bottom width	16	ft
Side slopes	1.5:1	
Water depth:		
From Station 9+31 to 861+20 (16.1 mi)	10.42	ft
From Station 861+20 to siphon No. 7, end of lining (32.9 mi)	12	ft
Lining thickness	3	in

Colorado River Basin Salinity Control Project
Desalting Complex Unit, Title I Division
(Under Construction)

Arizona: Yuma County

Lower Colorado Region
Water and Power Resources Service



The Desalting Complex Unit is one of three components authorized under Title I of the Colorado River Basin Salinity Control Act. The other two components are the Coachella Canal Unit and the Protective and Regulatory Pumping Unit.

The objectives of the Desalting Complex Unit are to reduce the quantity and improve the quality of irrigation drainage pumped from the shallow aquifer beneath the farmlands of the Wellton-Mohawk Division of the Gila Project. The purpose of improving the quality of the drainage water is to make it usable as part of the deliveries to Mexico in accordance with the treaty of February 3, 1944, and the International Boundary and Water Commission's Minute No. 242 of August 30, 1973.

Pumped drainage from the Wellton-Mohawk development is currently transported to the Santa Clara Slough in Mexico without credit toward treaty deliveries. The primary objective of Minute No. 242 is to limit the average annual salinity of the approximately 1,360,000 acre-feet of water delivered to Mexico upstream of Morelos Dam to no more than 115 parts per million plus or minus 30 parts per million over the annual average salinity of Colorado River water which arrives at Imperial Dam. In 1978, the salinity at Morelos Dam averaged 926 parts per million.

The Desalting Complex Unit consists of both structural and nonstructural measures to be implemented in the lower Gila and Colorado River Valleys of southwestern Arizona and northwestern Sonora, Mexico. Structural features include the installation, about 4 miles west of Yuma, of what will be the world's largest membrane desalting plant, capable of producing 148 cubic feet per second (95.7 Mgal/d) of product water. Also included are a 50.7-mile-long concrete-lined bypass drain to carry plant reject to the Santa Clara Slough in Mexico; the replacement of a steel flume section of the Main Outlet Drain Extension (MODE) with a buried reinforced concrete pipe siphon; attendant works such as access roads, bridges, and electric power transmission lines; and works to mitigate impacts on fish and wildlife habitat.

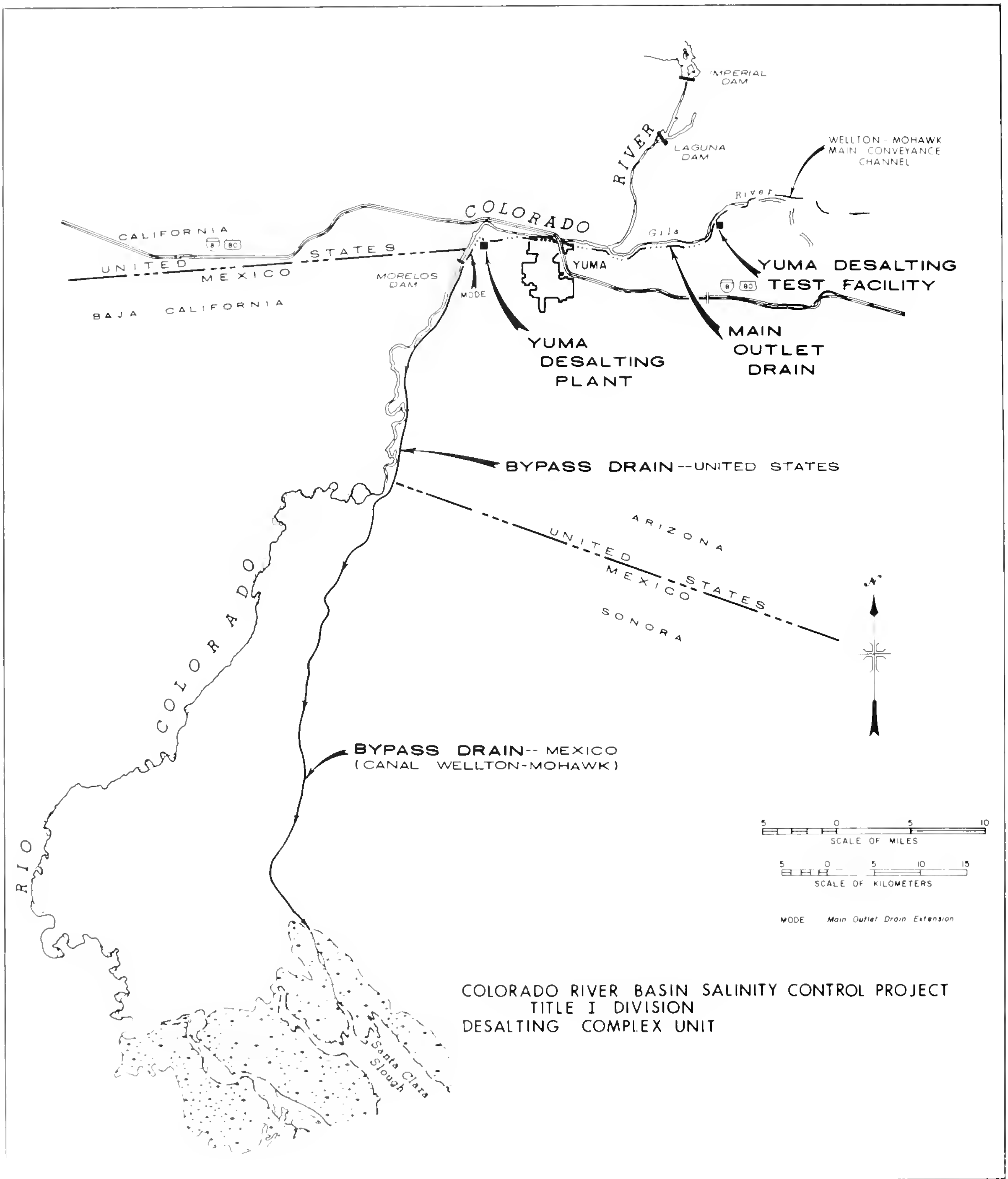
Nonstructural measures include the Irrigation Efficiency Improvement Program in conjunction with an acreage reduction program to reduce drainage flows in the Wellton-Mohawk Division of the Gila Project from 214,000 to 167,000 acre-feet by 1981, and ultimately to 136,000 acre-feet.

A proposal is under consideration to modify the operation of the existing Corps of Engineers' Painted Rock Dam, located on the Gila River about 20 miles northwest of Gila Bend, Ariz. The dam provides protection from floods to agricultural lands along the lower Gila and the lower Colorado Rivers in Arizona and California. Since the Gila River traverses the entire length of the Wellton-Mohawk Division, floodflows in the river can infiltrate the aquifer and significantly aggravate drainage conditions; such conditions require additional water to be pumped from the aquifer.

The Corps of Engineers is making studies to determine the optimum release schedule to reduce infiltration of floodwater to the Wellton-Mohawk aquifer. The schedules being studied include the approved schedule designed to empty the reservoir in a short time, and a schedule that would store water in the reservoir for longer periods during and following a flood. The schedule, if modified, would reduce infiltration to the aquifer beneath the Wellton-Mohawk Division, and would reduce pumping requirements.

PLAN

In executing the plan to reduce the quantity and improve the quality of Wellton-Mohawk Division drainage so the majority of it can be credited toward treaty deliveries, seven measures are being implemented: (1) construction of the Yuma Desalting Plant; (2) construction of the bypass drain in the United States and Mexico (completed in 1977); (3) implementation of the Wellton-Mohawk Irrigation Efficiency Improvement Program; (4) Wellton-Mohawk acreage reduction; (5) Painted Rock Reservoir land acquisition and operation schedule modification; (6)



Yuma Desalting Complex Unit

construction of the MODE siphon (completed in 1976); and (7) fish and wildlife mitigation measures.

Yuma Desalting Plant

The major feature of the Desalting Complex Unit is a membrane desalting plant that will reduce the salinity of Wellton-Mohawk Irrigation and Drainage District pumped drainage water before it is returned to the Colorado River. The plant site is about 4 miles west of Yuma, near the Arizona Public Service Yucca Powerplant, and is known as the Yucca site.

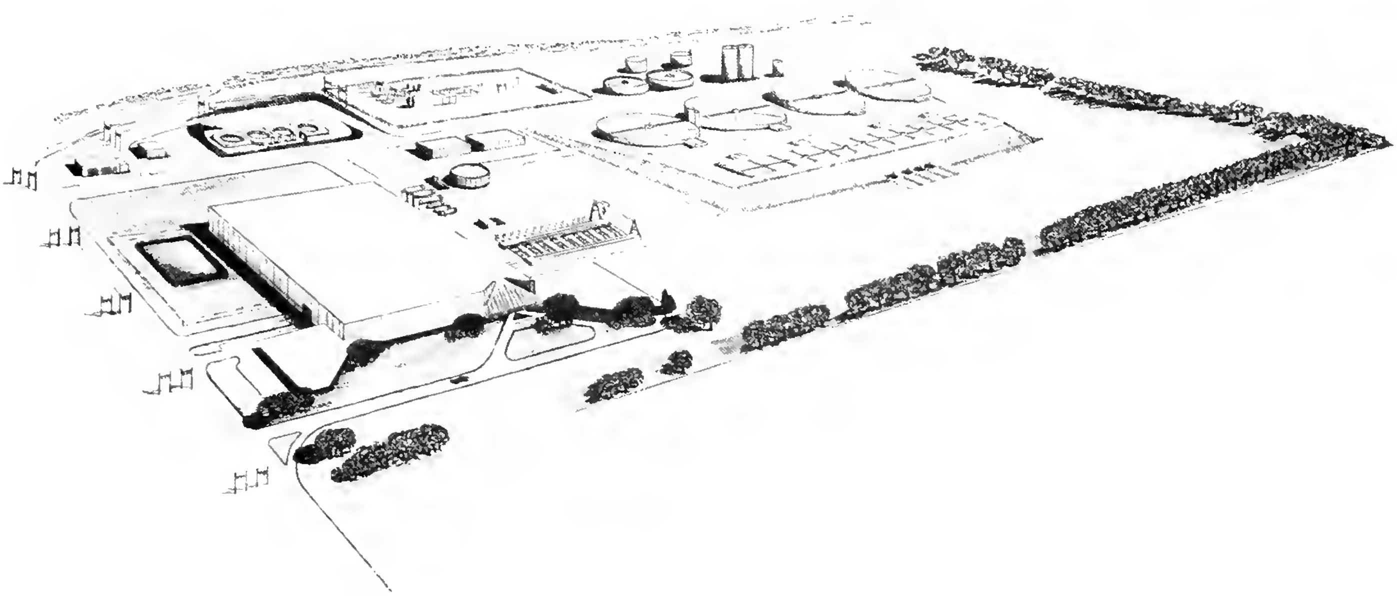
The membrane desalting plant will have the capacity to treat 129,400 acre-feet of pretreated feed water at 2,904 parts per million. The result will be 90,570 acre-feet of product water at 283 parts per million and 46,640 acre-feet of reject and other bypass flows at 7,749 parts per million.

Wellton-Mohawk drainage is expected to total 167,000 acre-feet annually when the plant becomes operational in 1981. Approximately 29,790 acre-feet of MODE water which will not be desalted will be blended with the product water to produce 120,360 acre-feet of total blended water for return to the Colorado River. This flow, combined with other flows to the river below Imperial Dam, will result in 1,360,000 acre-feet of water at 980 parts per million for delivery to Mexico at the Northerly International Boundary. Consequently, the salinity of water arriving at the boundary will annually average 115 parts per million, plus or minus 30 parts per million, more than the salinity of water arriving at Imperial Dam, in accordance with the provisions of Minute No. 242.

Bypass Drain

The bypass drain extends from the end of the MODE at Morelos Dam, through Arizona and Sonora, to the upper end of the Santa Clara Slough, 30 miles from the Gulf of California. The drain is 50.7 miles long with a capacity equal to that of the MODE, 353 cubic feet per second, and is concrete lined. The normal flow will be the desalting plant reject plus some bypass; this will be a maximum of about 66.5 cubic feet per second.

Reject will be carried in the existing MODE for 2 miles from the desalting plant to Morelos Dam where it will enter the bypass drain. The drain begins at the terminus of the MODE at Morelos Dam and is adjacent to the Yuma Valley Levee on the east side of the river channel most of the 16 miles to the Southerly International Boundary. The boundary crossing is near the Colorado River west of San Luis, Mexico. The remaining 34.7 miles of the bypass drain, from the Southerly International Boundary to the upper end of the Santa Clara Slough, was constructed by Mexico at United States expense.



Artist's conception of Yuma Desalting Plant

MODE Siphon

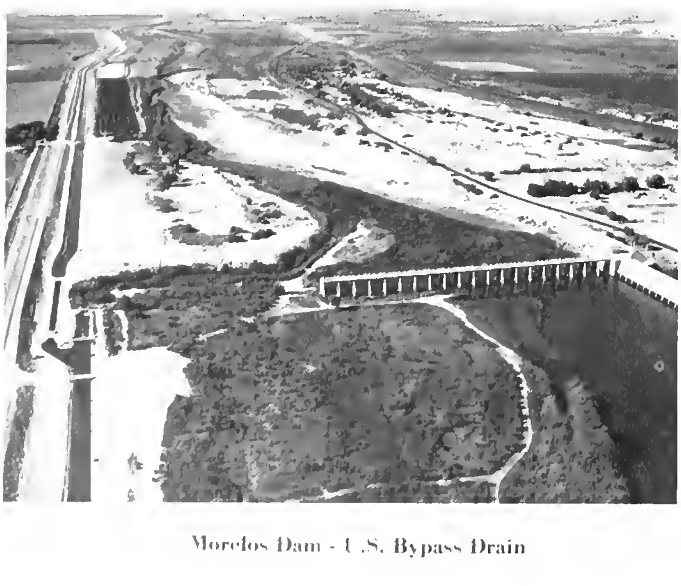
A 12.5-foot-diameter semicircular metal flume section of the MODE has been replaced with a buried circular concrete siphon. The flume was adjacent to the Colorado River in Yuma at the foot of Prison Hill. The siphon is 0.66 mile long and 10 feet in diameter. It was completed in June 1976.

Wellton-Mohawk Irrigation Efficiency Improvement Program

An irrigation efficiency improvement program is in progress in the Wellton-Mohawk Division to reduce drainage flows from irrigation. All drainage is pumped from the aquifer beneath irrigated lands to maintain a desired minimum water table depth of 8 feet. The program is a combination of several subprograms — Irrigation Management Services, onfarm improvements, research and demonstrations, accelerated education, and the work of the Technical Field Committee. These, in conjunction with the acreage reduction program, function to improve the average irrigation efficiency in the division from 56 to 64 percent by the time the desalting plant comes on line, and ultimately to a level of 72 percent. This will result in a reduction of drainage flows from 214,000 to 167,000 acre-feet annually by 1981, and ultimately to 136,000 acre-feet annually.

Wellton-Mohawk Acreage Reduction

The irrigable land of the division was reduced from the 75,000 acres authorized for development to approximately 65,000 acres. This was to reduce existing marginal operations of developed land, and prevent further development of undeveloped land. Part of the land was in Federal ownership and the balance was acquired from State and private owners. The objective was to reduce drainage return flows from land with low irrigation efficiency.



Morelos Dam - U.S. Bypass Drain

Painted Rock Dam and Reservoir

Painted Rock Reservoir Land Acquisition and Operation Schedule Modification

The Corps of Engineers has studied a number of release schedules for Painted Rock Dam and has identified six viable plans for the discharge of floodwater stored in the reservoir. The Corps' preliminary recommended plan would schedule releases ranging from 250 to 22,500 cubic feet per second, depending on the reservoir stage.

Public Law 93-320, in Section 101.(j), authorizes the acquisition of additional land in Painted Rock Reservoir that would be required for temporary storage capacity due to operation schedule modifications. The law does not, however, authorize the expenditure of funds until it has been determined by a Federal Court that the Corps of Engineers lacks legal authority to use such lands for this purpose.

Fish and Wildlife Mitigation

The development of the Desalting Complex Unit (including the Protective and Regulatory Pumping Unit) will result in the loss of fish and wildlife habitat units. Mitigation measures will replace 65.6 percent of these losses.

The mitigation measures were not originally authorized, but are included in the proposed amendatory legislative package of September 1978.

Yuma Desalting Test Facility

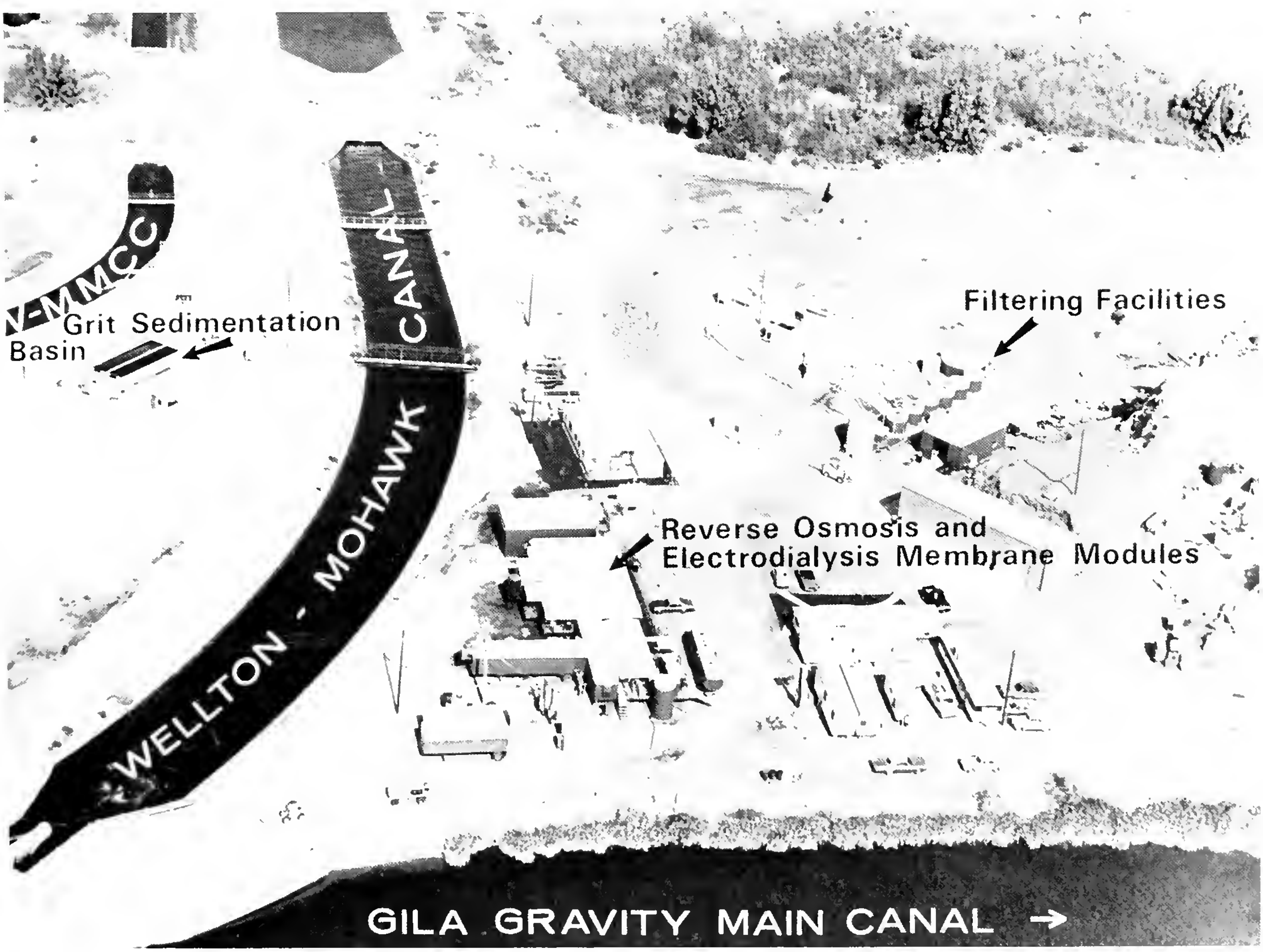
The purpose of the Yuma Desalting Test Facility is to test pretreatment processes and membrane desalting equipment, using the Wellton-Mohawk drainage as feed water. The data obtained from the tests were utilized to determine the type of equipment needed for the Yuma Desalting Plant. A mobile test facility was located at its present site in 1971. This facility was expanded in 1973 through the installation of a larger intake and pretreatment system.

Following this expansion, desalting membrane manufacturers brought test units to the facility for experimental purposes. The testing of the desalting membrane units was at the manufacturer's expense. The Federal Government supplied the pretreated drain water.

Seven companies installed test units in 1973 and early 1974. Two additional units were put on line in late 1975. The test facility grew from its original processing of 0.22 to over 2.2 cubic feet per second (100 to 1,000 gal/min) and from six membrane test units with a total capacity of about 0.09 cubic foot per second (60,000 gal/d) to 10 units, the largest of which produced 0.27 cubic foot per second (175,000 gal/d). Nearly all units tested were membrane elements of commercial size and configuration and generally representative of the size and type that were purchased for the Yuma Desalting Plant.

The pretreatment system has been similarly designed to be representative of the system planned for the Yuma Desalting Plant. Several processes utilizing diatomaceous earth, potassium permanganate, manganese zeolite, alum flocculation, and partial lime softening have been tested since 1974. A partial lime softening process has consistently provided the best and most reliable results.

Testing at the facility is scheduled to continue until June 1980.



Yuma Desalting Test Facility

Attendant Facilities

A switchyard will be constructed at the desalting plant site. Incoming power will be at 161 kilovolts. A 161/13.8-kilovolt transformer will be installed in the switchyard. The transmission line as proposed will be constructed from the Department of Energy's Knob Substation to the Yuma Desalting Plant Switchyard (3.8 miles).

A potable water supply for domestic use will be furnished, with appropriate treatment from the desalting membrane product line when the plant is in operation. Two 1,000-cubic-foot (7,500-gal) storage tanks will be constructed and used to control pressure. During periods when the plant is down, the water supply will be pumped from an onsite 800-foot-deep well.

A 0.012-cubic-foot-per-second (7,500-gal/d) sewage treatment plant will be constructed to treat the sewage effluent from the desalting building, visitor center, laboratory, and other buildings.

An energy recovery system to recapture energy from the high-pressure reject stream will comprise two impulse turbines directly connected to the generating shaft, one at each end of the induction-type generator. The energy recovery equipment will be contained in a 1.5-kilovolt NEMA III non-walk-in-type indoor unit. One cable will go to the switchyard and the other to the intake pumping plant. The cable going to the intake pumping plant will provide an alternate path to supply power to the area if the main power line feeding the intake area is opened.

Chlorine equipment for bacteria and algae control will be housed in the building containing the energy recovery equipment.

Sludge Disposal Facilities[1]

The Pilot Knob waste disposal site is located in Imperial County, California. It is on Federal land under reclamation withdrawal about 2.5 miles west of the Colorado River and about 0.5 to 1 mile north of the Northerly International Boundary between California and Baja, California.

This feature controls earthfill disposal of excess calcium carbonate wastes generated in the pretreatment process of the feed water at the Yuma Desalting Plant.

Initial facilities for 50 years of operation include three contiguous blocks of land with raised berms around the perimeters. Each block is about 1,800 by 4,350 feet and is capable of containing 144 cells. Filled and earth covered cells will be slightly larger than 1 acre. The individual blocks will be developed at 15-year intervals and the cells within each block will be developed successively in sufficient number for 5 years of operation. All the cells will be lined to prevent water in the waste from percolating into the ground water.

The calcium carbonate wastes, at a concentration of about 60 percent solids, will be pumped by positive displacement pumps located at the desalting plant through a high-pressure steel pipeline to the disposal site. The pipeline will be about 4.5 to 6.5 miles long, depending on the block being filled.

Other facilities at the disposal site will include a 2,400-square-foot administration building, a potable water well, fuel storage with pump, chain link fencing around each block, an access road, transmission and communication lines, and a visual and sound buffer of planted native trees along the north boundary of the site.

[1]Studies of the sludge disposal facilities are in the advance planning stage. Project data for these facilities are dependent on final design.

DEVELOPMENT

History

The United States and Mexico signed a treaty in 1944 which guaranteed Mexico 1,500,000 acre-feet of Colorado River water annually. Of the total, approximately 1,360,000 acre-feet annually are delivered to Mexico upstream from Morelos Dam. The remaining 140,000 acre-feet annually are delivered at the Southerly International Boundary. The treaty contains no specific provisions regarding the quality of the water to be delivered. In 1961, the salinity of Colorado River water increased sharply. Two concurrent and principal factors led to this increase in salinity. The pumping of saline waters (initially averaging 6,000 parts per million) was begun by the Wellton-Mohawk Irrigation and Drainage District to lower ground-water levels below the crop root zone in the aquifer that underlies the Wellton-Mohawk Division of the Gila Project. This drainage was discharged to the Gila River, a tributary of the Colorado River, and consequently delivered to Mexico at the Northerly International Boundary. Also, excess Colorado River flows, which Mexico had received prior to 1961, were significantly decreased due to low runoff in the Upper Colorado River Basin.

In November 1961, as a result of the change in salinity, Mexico formally protested to the United States that the delivery of water that was harmful for the purposes stated in the treaty constituted a violation of the treaty. In response to this protest, the United States, in 1963 and 1964, began to modify Wellton-Mohawk drainage pumping and its river operations. In March 1965, a 5-year agreement, referred to as Minute No. 218, was reached by the two Governments. The minute, under which each country reserved its legal rights, became effective on November 16, 1965, and provided for practical measures to further reduce the salinity of waters reaching Mexico. These measures consisted of the construction and operation of the 12-mile-long MODE from the end of the Wellton-Mohawk Main Conveyance Channel to Morelos Dam to enable the United States to discharge all or part of the Wellton-Mohawk drainage water to the Colorado River either above or below Morelos Dam (as requested by Mexico). When scheduled deliveries to Mexico were the treaty minimum, the United States discharged all Wellton-Mohawk drainage below Morelos Dam without being charged to the treaty and the difference was made up by other water, largely from above Imperial Dam. This amounted to about 50,000 acre-feet per year. In 1971, Mexico requested the United States to bypass an additional 40,000 to 75,000 acre-feet of Wellton-Mohawk drainage flows annually to further reduce the average salinity of water diverted by Mexico at Morelos Dam.

In 1972, Mexico requested a prompt, permanent settlement of the salinity problem and the two Governments, in order to effect an immediate improvement in the quality of water delivered to Mexico above Morelos Dam, approved a new minute, No. 241, which was signed July 14, 1972. It provided for the bypass of 118,000 acre-feet of Wellton-Mohawk drainage water annually without charge against the treaty (more than twice the rate of the United States bypass under Minute No. 218), and its replacement by other water primarily from above Imperial Dam, but also from wells on the Yuma Mesa. Mexico again requested the United States to bypass additional Wellton-Mohawk drainage without replacement. All of the drainage water from the division was consequently bypassed to the Colorado River below Morelos Dam.

On August 30, 1973, joint recommendations were formally approved by the two Governments, and incorporated into Minute No. 242 of the International Boundary and Water Commission (terminating Minute No. 241).

Minute No. 242 provides that the approximately 1,360,000 acre-feet of treaty water, annually delivered to Mexico upstream of Morelos Dam, have an annual average salinity of no more than 115 ± 30 parts per million over the annual average salinity of Colorado River water arriving at Imperial Dam. It further provides approximately 140,000 acre-feet of water annually for delivery to Mexico on the land boundary at San Luis and in the Limitrophe Section of the Colorado River downstream from Morelos Dam, with a salinity substantially the same as that of waters customarily delivered there. The minute also provided for the construction of the concrete-lined bypass drain from Morelos Dam to the Santa Clara Slough in Mexico.

Those provisions of the minute which were dependent for their implementation on construction of works or on other measures which required expenditure of funds by the United States became effective upon authorization by the Congress and notification by the United States to Mexico of such authorization. This authorization was encompassed in Public Law 93-320, the Colorado River Basin Salinity Control Act of June 24, 1974.

The interim measures adopted by the United States to effect the requirements of Minute No. 242 pending completion and operation of the desalting plant consist of discharging all Wellton-Mohawk drainage waters to the Colorado River below Morelos Dam through MODE No. 3 bypass channel until June 23, 1977. Thereafter, these waters are to be conveyed by means of the bypass drain to the Santa Clara Slough; such waters are replaced by an equal volume of other waters, consisting principally of waters from above Imperial Dam and water pumped on the Yuma Mesa.

Pursuant to point 4 of Minute No. 242, providing for an extension of the concrete-lined Wellton-Mohawk bypass drain in Mexico at the expense of the United States, and pursuant to Minute No. 248, adopted by the commission on June 10, 1975, Mexico completed the 35 miles of drain in its territory in March 1977. The Bureau of Reclamation completed the part of the bypass drain in the United States in June 1977. This extension was placed in operation on June 23, 1977, providing a drain having a capacity of 353 cubic feet per second from the previous terminus of the Main Outlet Drain Extension at Morelos Dam to the Santa Clara Slough, on the Gulf of California.

Investigations

Investigations concerning the salinity problem on the Colorado River below Imperial Dam and a definitive solution to the international problems of the Colorado River waters delivered to Mexico under the terms of the 1944 treaty led to the preparation of a special report in September 1973 on the Colorado River International Salinity Control Project and the authorization of the Colorado River Basin Salinity Control Project. The final environmental statement on the project was issued June 18, 1975. The Interim Sizing Study, Yuma Desalting Plant, Special Report, was published June 1977. In 1971, research and development studies were undertaken and the Yuma Desalting Test Facility was established, with the installation of a mobile test facility originally constructed and operated by the Office of Saline Water. This facility was expanded in 1974 and has been operated for the Bureau of Reclamation by a contractor. A status report, prepared in April 1977, presents the findings of advance planning studies and project activities through June 1976.

The Reject Stream Replacement Study was authorized by the Colorado River Basin Salinity Control Act of 1974. This is a study to identify a feasible measure, or measures, which could replace the water lost through reject from the Yuma Desalting Plant. The study was initiated in 1975 and will continue until June 1980. A status report was prepared in January 1978.

Development testing of pretreatment processes and membrane desalting equipment will continue at the Yuma Desalting Test Facility through module proof testing and high recovery pretreatment and module testing in 1979-80.

Authorization

The unit was authorized for construction by the act of June 24, 1974 (88 Stat. 266), Public Law 93-320, Title I (specifically, section 101).

Construction

The first major construction on the Desalting Complex Unit began in Sepember 1975, by award of a contract for the construction of the Main Outlet Drain Extension concrete siphon and the relocation of the Yuma standby pumping plant. Installation of these structures and construction of the bypass drain were completed in 1977. Construction of the Yuma Desalting Plant and other features of the unit is scheduled to start in 1980.

BENEFITS

Social and political benefits accrue that are outside the normal realm of economic quantification; however, in addition to meeting the salinity provisions of Minute No. 242, the unit will have the capacity to annually reclaim about 120,360 acre-feet of water that is presently being bypassed and, therefore, lost for further use.

PROJECT DATA

Facilities Under Construction (1977)

Yuma Desalting Plant	1	
Bypass drain	50.7	mi
MODE siphon	0.66	mi

Climatic Conditions

Annual precipitation	3.5	in
Temperature:		
Maximum	120	°F
Minimum	22	°F
Mean	74	°F

ENGINEERING DATA

Water Supply

Wellton-Mohawk drainage water	167,000	acre-ft

Desalting Facilities

Yuma Desalting Plant

Type: Membrane
Location: The plant will be located about 4 mi west of Yuma, Ariz., near the Arizona Public Service Co.'s Yucca Powerplant.
Construction period: 1978-(Under construction)

Capacity	148	ft³/s
Wellton-Mohawk drainage influent	167,000	acre-ft
Plant product water effluent	90,570	acre-ft
Reject stream and bypass	46,640	acre-ft
Salinity concentration:		
Wellton-Mohawk drainage influent	3,200	p/m
Product water	283	p/m
Reject stream	7,749	p/m
Blended to the Colorado River (90,570 acre-ft product water and 29,790 acre-ft MODE water)	120,360	acre-ft

Carriage Facilities

Bypass Drain

Location: The bypass drain extends from the terminus of the existing MODE at Morelos Dam in Arizona to the upper end of the Santa Clara Slough, about 30 mi north of the Gulf of California, in Mexico.
Construction period: 1975-77

Length (16 mi in the U.S. and 34.7 mi in Mexico)	50.7	mi
Maximum capacity (reject stream 62.3 ft³/s—emergency conditions to carry entire MODE flow of 290.7 ft³/s)	353	ft³/s
Typical maximum section in United States, concrete lined:		
Bottom width	12	ft
Side slopes	1.5:1	
Lining: Concrete	3	in
Water depth, weighted average	6.8	ft
Typical maximum section in Mexico, concrete lined:		
Bottom width	10.17	ft
Side slopes	2:1	
Water depth	5.09	ft
Lining	3.94	in
Freeboard	1.64	ft

Main Outlet Drain Extension Siphon

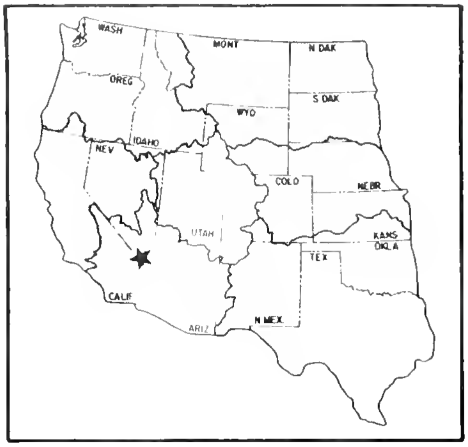
Location: Adjacent to the base of Prison Hill, extends under the railroad bridge and U.S. Highway 80 Alternate bridge, continues downstream along the south bank of the Colorado River.
Construction period: 1975-76
Description: Reinforced concrete pressure pipe with monolithic concrete transitions

Length	0.66	mi
Diameter	10	ft
Capacity	353	ft³/s

Colorado River Basin Salinity Control Project
Las Vegas Wash Unit, Title II Division
(Under Construction)

Nevada: Clark County

Lower Colorado Region
Water and Power Resources Service



The Las Vegas Wash Unit of the Colorado River Basin Salinity Control Project, Title II, is about 12 miles southeast of Las Vegas, Nev., and 3.5 miles west of Lake Mead. The unit is part of a comprehensive plan to check the steadily increasing salinity levels of the Colorado River. As proposed, the unit would be developed in stages. The first stage would be capable of reducing the annual salt load contributed by Las Vegas Wash to the Colorado River system by 41,000 tons and reduce the salt concentration at Imperial Dam by 4 parts per million. Operation of both stages of the unit would annually remove 83,000 tons of salt from the Colorado River system and improve the quality of the water at Imperial Dam by about 9 parts per million.

PLAN

First stage facilities would include a bypass pipeline to divert treated municipal wastewater around the project facilities and a monitoring system to establish an accurate record of conditions prior to project operation. Also included would be a subsurface barrier, an intake pumping plant, a brine reject pipeline, and evaporation ponds. The second stage would consist primarily of the addition of a desalting plant.

Clark County, Nevada, initiated construction of its Advance Wastewater Treatment Plant (AWT) in 1976, which will provide additional treatment for the effluent from the existing city of Las Vegas and Clark County Sanitation District secondary wastewater treatment plants. The quality of the effluent from the AWT plant will meet the adopted standards for water discharged into Las Vegas Wash and Lake Mead.

To operate the Las Vegas Wash Unit, it would be necessary to bypass the outflow from the AWT plant to a point downstream of the unit's facilities rather than allow the wastewater to flow down the upper Las Vegas Wash and become a part of the collected flows.

Monitoring System

This system would be composed of several surface flow gaging stations that would also function as water quantity and quality stations. A network of new and existing observation wells and piezometers would be maintained as a part of the system.

The monitoring system would provide the data needed to analyze trends for determining the time of need and ultimate size of first and second stage facilities. In addition, the data would assist in determining the effectiveness of the unit and aid in future salinity control planning activities in the Colorado River Basin.

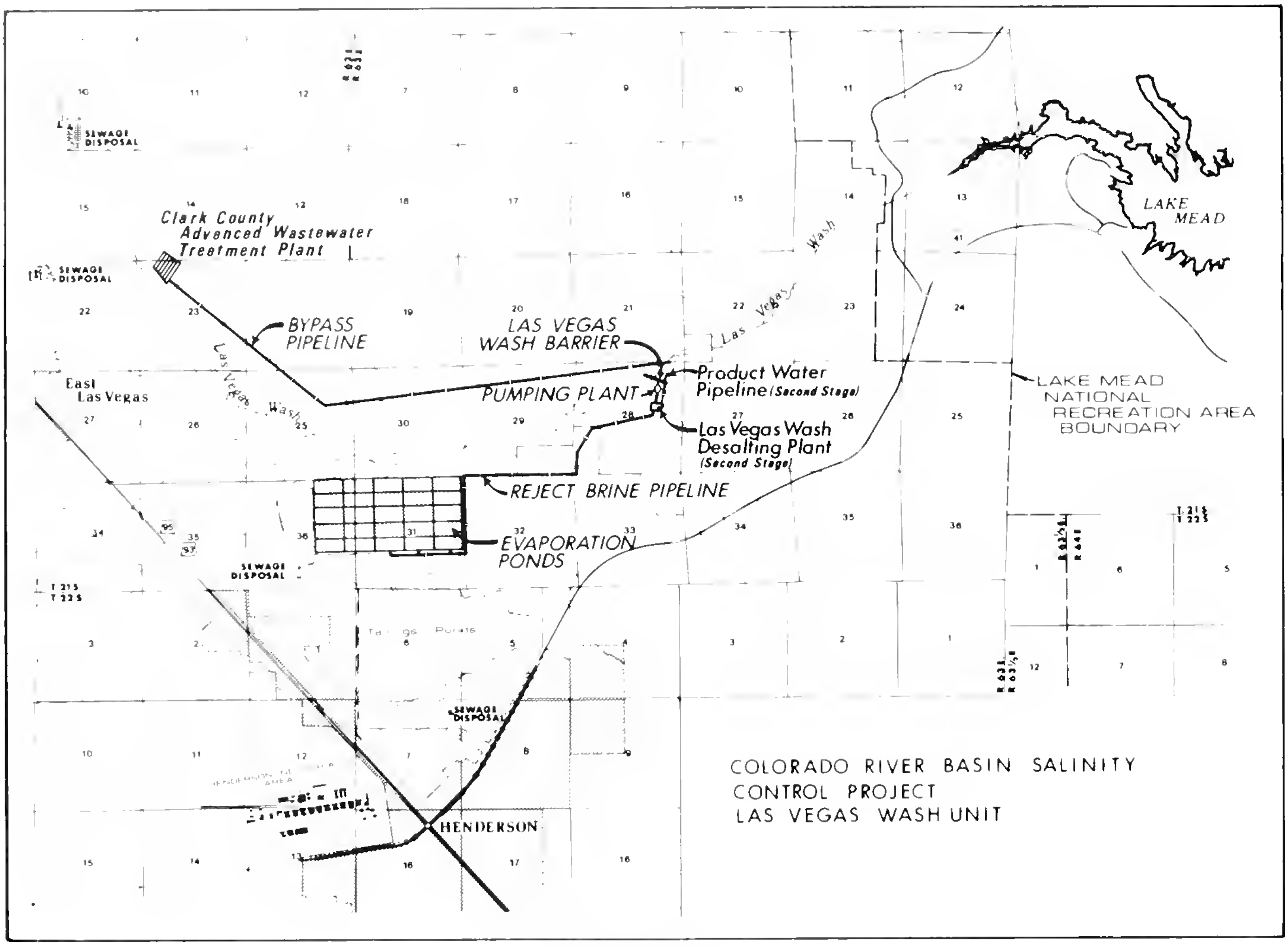
Las Vegas Wash Interception System

This system would consist of a subsurface barrier located about 12 miles southeast of Las Vegas, Nev. The barrier is designed as a compacted impervious clay-fill structure rising 25 feet above bedrock with a crest length of 1,300 feet. The barrier would intercept the flows of Las Vegas Wash, which then would be pumped to solar evaporation ponds during first stage operations, or to a desalting plant during second stage operations. A floodway channel would be constructed through the barrier near the center of the structure.

Collection System

This system would consist of a weir and gate structure for collecting streamflows and an intake conduit. The intake conduit would convey water to the intake pumping plant sump, which would be located near the right abutment.

The weir and gate structure would consist of a collection box 30 feet long in the upstream side of the barrier. A gated sluice conduit would be used periodically to clean out sediment from the collection box. The intake conduit would also be gated to prevent siltation from floodflows.



Las Vegas Wash Unit

Delivery System

As designed, this system would consist of an intake pumping plant designed to lift and convey collected flows through a supply pipeline to a steel receiving-regulating tank. From the tank, collected flows would be pumped through a brine reject pipeline to solar evaporation ponds.

The intake pumping plant would be an outdoor plant located near the right abutment of the barrier. It would consist of a reinforced concrete structure with a deck elevation of 1448.0 feet, a sump floor elevation of 1443.5 feet, and a sump roof elevation of 1458.0 feet. Maximum water surface would be at elevation 1456.09 feet and minimum water surface at 1447.3 feet.

Water would enter and pass through the intake conduit by gravity flow and empty into the sump of the pumping plant. A 36-inch-square slide gate would be mounted at the inlet to the intake conduit. Closing the slide gate insulates the sump from the collection box so the sump can be dewatered. Maximum water depth in the sump would be 12.5 feet. The minimum water depth would be about 3.8 feet.

The first stage design capacity of the intake pumping plant is 10.5 cubic feet per second at a head of 105 feet. The plant would have one 5.25-cubic-foot-per-second vertical turbine pump with a 100-horsepower, 460-volt induction motor and two 2.63-cubic-foot-per-second vertical turbine pumps with 50-horsepower, 460-volt induction motors. The plant design would accommodate installation of two more 5.25-cubic-foot-per-second units for the future second stage. Each of the pumping units would connect to a discharge line with a sleeve-type coupling. Each discharge line would be equipped with a butterfly valve and a check valve. The pumping discharge lines would be manifolded to a 24-inch line, which is transitionary to a 27-inch-diameter supply line.

The 27-inch supply pipeline would be about 0.27 mile long and capable of conveying up to 20 cubic feet per second of water from the intake pumping plant to a regulating tank at the proposed desalting plant site. The regulating tank would be of steel construction, 50 feet in diameter and 30 feet high, and used to supply water to the reject pumping plant under the first stage or to the desalting plant under the second stage.

The reject pumping plant would be an outdoor plant near the regulating tank. It is designed for a first stage capacity of 10 cubic feet per second at 199 feet of head. The plant would have one 5.5-cubic-foot-per-second horizontal shaft, split-case pump with a 100-horsepower, 460-volt induction motor and two 2.63-cubic-foot-per-second horizontal shaft, split-case pumps with 50-horsepower, 460-volt induction motors.

For the second stage, the plant's capacity would be increased to 20 cubic feet per second and its function would be that of a booster pumping plant for the pretreatment process. Under second stage operation, residual pressures from the desalting plant would be sufficient for delivering desalting plant reject brine to the evaporation ponds.

The 18-inch reject brine pipeline would be about 3.5 miles in length and deliver up to 10 cubic feet per second of water from the booster pumping plant to the evaporation ponds.

Treatment System

The treatment system for the first stage would consist of solar evaporation of all collected flows. The evaporation ponds, located near existing disposal ponds in Henderson, Nev., would be lined and consist of a series of individual 25-acre ponds connected by regulating structures. The ponds would require about 625 acres of land and range in depth from 8 to 22 feet. They would accommodate over 100 years of salt accumulations.

Any seepage from the ponds would be tributary to Las Vegas Wash upstream of the unit's interception facilities and would thus be collected and recycled through the unit's treatment facilities without adversely affecting any environmental regimen or influencing the overall quality of Las Vegas Wash discharges to Lake Mead. To ensure the safety of both the public and wildlife, and maintain the integrity of the ponds, the entire evaporation pond area would be enclosed within a security fence.

Attendant Facilities

Attendant facilities for the first stage include about 1.25 miles of access road, 2.5 miles of transmission line, and a transformer to convert the 12-kilovolt source to 480 volts.

Las Vegas Wash Unit project site

Second Stage (Proposed)

The proposed second stage consists of adding a desalting plant to the first stage. Some modification of the first stage facilities would be required.

It is anticipated that treatment for the second stage would consist of processing collected flows through a pretreatment and desalting plant with the product water being returned to the Las Vegas Wash below the interception facility. The rejected brine would be conveyed through the existing first stage reject pipeline by residual pressure from the desalting process for disposal in the first stage evaporation ponds.

In addition to first stage attendant facilities, the second stage would require an additional substation or switchyard to properly distribute electric energy to areas of need. Parking areas and accommodations for visitors also would be required.

DEVELOPMENT

Early History

Early explorers moved up Las Vegas Wash toward an oasis of spring-fed meadows at the present site of Las Vegas. After settlement by the Mormons in the 1850's, cattle ranches occupied much of the valley and artesian springs were used to cultivate crops of hay. Rapid population growth and increased ground-water use since the 1930's have resulted in a rapid and continuing decline in ground-water levels. Few springs in Las Vegas Valley are now active, and Las Vegas Creek nearly dried up in the late 1940's. However, rapid municipal growth has also resulted in a continuous increase in wastewater processed through sewage treatment plants and discharged to the lower portions of Las Vegas Wash. Increased urban and industrial development along the east side of the valley has resulted in increased ground-water return flows.

Rising local concern over the pollution of Lake Mead began in the early 1960's, and the first steps toward control were implemented by Clark County and various political subdivisions in 1964. This effort was centered around the development of a plan to reuse effluent water for irrigation and other nondrinking purposes.

In 1966, a water pollution control board was formed for the Clark County area, and in 1968, a local interagency water pollution task force was organized to function as a technical committee on water pollution control for the Clark County Regional Planning Council. On the recommendation of this task force, two consulting firms were hired by Clark County to develop a long-range water resource management program for optimization of the beneficial uses of the total water resources in the valley and the protection of the quality of these resources for future generations. Discussed in the consultants' report are four programs for controlling the salinity and pollution problems affecting Las Vegas Wash and Lake Mead.

During the 1971 State legislative session, the Las Vegas Valley Water District was delegated the responsibility for developing a plan to control the Las Vegas Wash pollution. The district was given until December 1972 to complete its studies and have a report ready for the 1973 legislative session. In accomplishing its assigned task, the district awarded several contracts for special studies that have contributed significantly to the development of a solution to the Las Vegas Wash salinity problem. The Nevada legislature enacted the County Sewage and Wastewater Law (chapter 790, statutes of Nevada, 1973) which empowered Clark County as the master agency for the collection, disposal, and treatment of sewage and wastewater. As master agency, the county became responsible for the pollution abatement problem in the Las Vegas Wash-Lake Mead area.

On August 9, 1973, the Colorado River Commission of Nevada issued resolution 73-5 which urged the Department of the Interior, through the Bureau of Reclamation, to immediately initiate reviews and studies and to produce an early report leading to construction of a Federal salinity control project for Las Vegas Wash flows. On August 31, 1973, the Clark County Board of County Commissioners approved a similar resolution in support of a Federal salinity control project. Federal funds were budgeted in October 1973 to initiate studies on the Las Vegas Wash Unit.

Investigations

Early studies showed that a significant portion of the highly saline flows in Las Vegas Wash occurred from surfacing ground-water returns, which qualified it as a point source of salinity under the Bureau of Reclamation studies on the Colorado River Water Quality Improvement Program. In January 1974, Reclamation issued a special report, "Las Vegas Wash Unit, Point Source Division, Colorado River Water Quality Improvement Program." The environmental statement was prepared as an authorized unit under Title II of the Colorado River Basin Salinity Control Act of 1974 and published as a part of the environmental statement on the Colorado River Water Quality Improvement Program of May 19, 1977.

Advance planning studies were initiated in 1976. Hydrologic studies on the surface and ground water in the project area are continuing.

Authorization

Construction of the unit was authorized under the Colorado River Basin Salinity Control Act of 1974, Title II (Public 93-320).

Construction

Construction of the first stage was initiated in 1977 on the Las Vegas Wash Collection System and construction of the access road to the site was completed in 1977. Construction was deferred in 1978 pending the results of additional hydrologic studies of the ground-water and surface-water conditions of the Las Vegas Wash area.

BENEFITS

Salinity Control

The first stage and total development of the unit would reduce the salinity of the Colorado River at Imperial Dam by about 4 and 9 parts per million, respectively, and annually remove about 41,000 tons of salt by first stage development. Full development would remove about 83,000 tons of salt from the river annually.

PROJECT DATA

Facilities Authorized for Construction—First Stage

Barrier	1	
Intake pumping plant	1	
Reject pumping plant	1	
Evaporation ponds	25	
Bypass pipeline	5	mi

Climatic Conditions

Annual precipitation	3.8	in
Temperature:		
Maximum	115	°F
Minimum	23	°F
Mean	68	°F
Growing season	241	days

ENGINEERING DATA

Water Supply

LAS VEGAS WASH[1]

Drainage area	2,200	mi²
Unit area-Las Vegas to Lake Mead	1,800	acres
Average annual runoff	62,700	acre-ft
Wastewater surface flows	85	ft³/s
Ground water	1	ft³/s
Maximum flood discharge July 4, 1975	1,400	ft³/s
Design flood for dams (100-year frequency)	15,000	ft³/s
Average annual flows	43,500	acre-ft
Average salt load of flows	200,000	tons

First Stage

Average rate of regulated flows collected	5	ft³/s
Average salinity of collected flows	8,400	p/m
Average salt load removed from stream	41,000	tons
Stream depletion	3,600	acre-ft

Second Stage

Maximum rate of flows to be collected	20	ft³/s
Average calculated salinity of collected flows	4,200	p/m
Average calculated total salt load removed from stream in combination with the first stage	83,000	tons
Stream depletion	1,450	acre-ft

Unit Stage	Annual Salt Removal	Salinity Reductions at Imperial Dam
First stage	41,000 tons	4 p/m
First and second stages	83,000 tons	9 p/m

INTERCEPTION AND COLLECTION SYSTEM—consisting of a barrier dam, intake conduit, and floodway channel (first and second stages).

INTERCEPTION SYSTEM

Barrier (authorized)
Description: Impervious earthfill structure
Location: About 12 mi southeast of Las Vegas, Nev., and about 3.5 mi west of Lake Mead.
Construction period: (Construction delayed)
First stage: 1978-80
Dimensions:

Structural height	25	ft
Top width (varies with depth)	185	ft
Base width	20	ft
Crest length	1,300	ft
Slope	1.5:1	

Floodway channel (constructed as a part of the barrier)
Description: Trapezoidal
Location: Extending downstream from the barrier. The flood channel contains four erosion control structures in addition to the barrier.
Construction period: (Construction delayed)

Length (downstream)	1,000	ft
Capacity	15,000	ft³/s
Typical maximum section		
Bottom width	200	ft
Side slopes	10:1	

[1]The water supply for Las Vegas Wash is derived from municipal and industrial wastewater, infrequent precipitation, and surfacing ground water.

Roadway across floodway channel
Location: Along centerline of barrier.
Description: Concrete slab

Length	100	ft
Width	20	ft
Thickness	12	in
Erosion control structures	4	
H piles for each structure	8 x 36 x 40	ft
Spacing of H piles	5	ft

COLLECTION SYSTEM — consisting of a collecting box for collecting streamflows, an intake conduit for conveying the collected flows to the Intake Pumping Plant sump.

Intake conduit
Location: Upstream and parallel to the barrier dam axis.
Description: Concrete conduit
Construction period: 1979- (Construction delayed)

Length	800	ft
Capacity	20	ft³/s
Conduit	36	in

Evaporation ponds
Location: Near existing disposal ponds in Henderson, Nev.
Construction period: (Construction delayed)

Ponds[2]	25	
Land area	625	acres
Dimensions:		
Length	1,470	ft
Width	750	ft
Depth	8-22	ft

Lining: Membrane or suitable alternative.

[2]Ponds will be separated by dikes and connected by regulating structures.

Carriage Facilities

SUPPLY PIPELINE

Description: Precast concrete pipe
Location: From the Intake Pumping Plant to a regulating tank at the desalting plant site.
Construction period: Construction delayed

Length	0.27	mi
Diameter	27	in
Capacity	20	ft³/s

REJECT BRINE PIPELINE[3]

Location: From the reject pumping plant to the evaporation ponds.
Description: Precast concrete pipe
Construction period: Construction delayed

Length	3.5	mi
Diameter	18	in
Capacity	10	ft³/s

BYPASS PIPELINE (FIRST AND SECOND STAGES)

Location: From Clark County's Advance Wastewater Treatment Plant along the north side of Las Vegas Wash; terminates downstream of the Barrier.
Construction period: Scheduled 1978-80

Length	5	mi
Diameter	66-78	in
Capacity	240	ft³/s

[3]Sized to accommodate both First and Second Stages.

Regulating Tank

Location: Desalting plant site.
Description: Steel
Construction period: Construction delayed

Height	30 ft
Diameter	50 ft

Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft
First stage intake	3	10.5	105
Reject	3	10.5	199
Second stage intake (additions)[1]	2	10.5	105

[1]Second stage facilities (essentially an addition of a desalting plant to the first stage, some modification to first stage facilities will be required).

Las Vegas Wash Membrane Desalting Plant

Location: On the south side of Las Vegas Wash about 1,400 ft upstream from the intake pumping plant near the barrier.
Construction period: Not yet scheduled
Description: Reverse osmosis

Quality input	4,200 p/m
Quality output	700 p/m
Quantity	20 ft³/s
Plant site:	
Length	676 ft
Width	355 ft
Plant capacity	13 Mgal/d

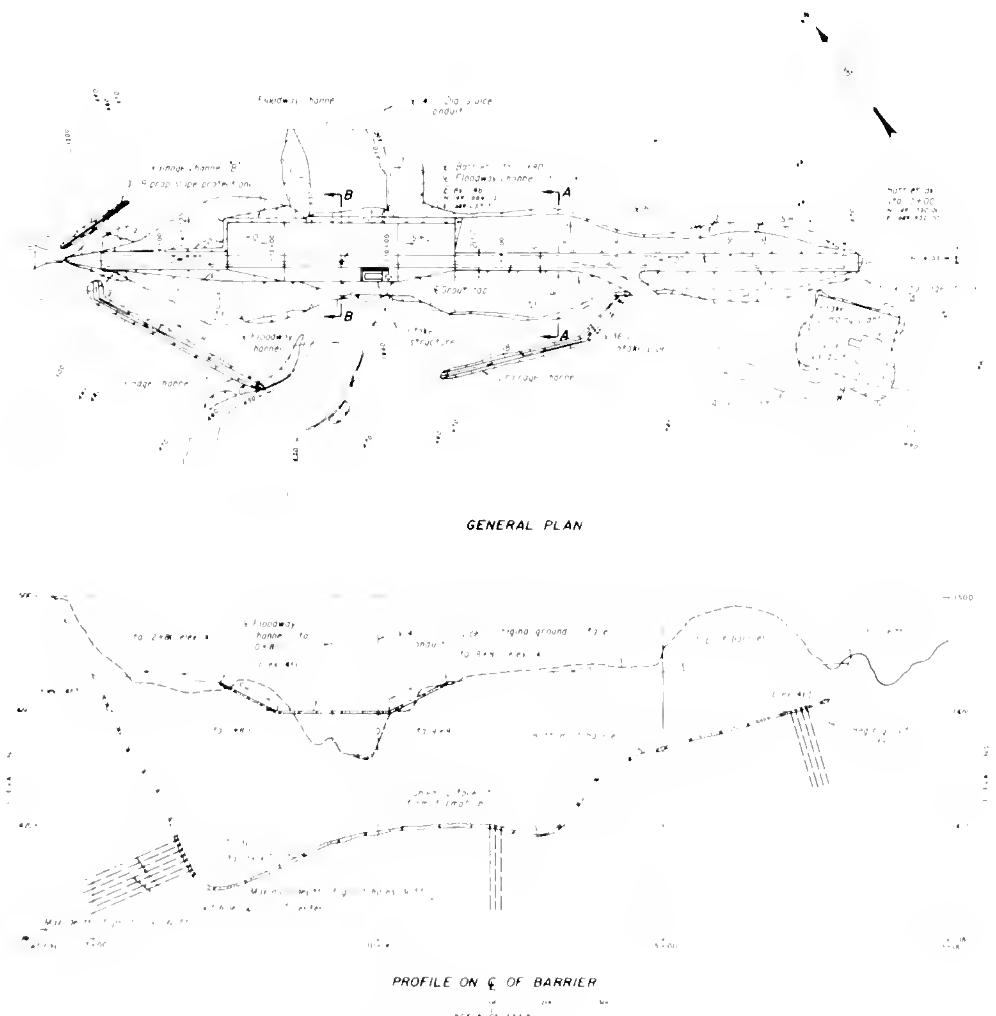
Product Water Pipeline

Location: From the desalting plant to a settling pool in Las Vegas Wash immediately below the barrier dam.
Construction period: Not yet scheduled

Length	0.28 mi
Diameter	18 in
Capacity	18 ft³/s

Power Supply — First and Second Stages

Power for the facilities will be provided by the Nevada Power Co. It is expected the company will extend an existing 12-kV line 8,900 ft to the intake pumping plant and desalting plant sites. Control meters located at each load area will provide final adjustment for utilization voltages.

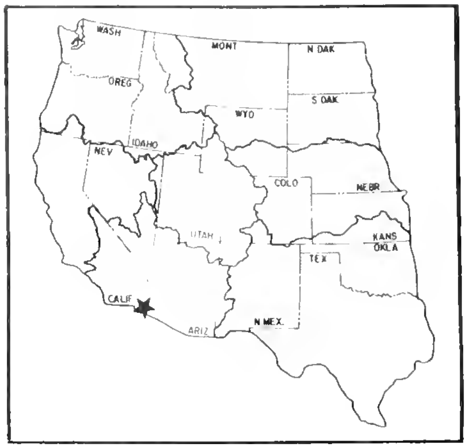


Las Vegas Wash Barrier, Plan and Profile

Colorado River Basin Salinity Control Project
Protective and Regulatory Pumping Unit, Title I Division (Under Construction)

Arizona: Yuma County

Lower Colorado Region
Water and Power Resources Service



The Protective and Regulatory Pumping Unit of the Colorado River Basin Salinity Control Project is adjacent to the United States-Mexico border in southwestern Arizona. It is on a 5-mile-wide strip of land which extends about 13 miles eastward from the vicinity of San Luis.

The objectives of the unit are to manage and conserve United States ground-water resources for the benefit of the United States, and to provide obligated water deliveries to Mexico.

This unit will be developed by constructing a well field to intercept part of the ground-water underflow that is moving southward into Mexico from Yuma Mesa in the United States. This underflow is being increased by ground-water withdrawals in the Sonora Mesa Well Field immediately south of the International Boundary. The development of the Protective and Regulatory Pumping Unit in the United States will also return the ground-water underflow to Mexico in near historic amounts.

The ground water recovered by the unit will be collected in a conveyance system and delivered as a portion of the Treaty obligation to Mexico in accordance with Minute No. 242.

Major features of the unit will consist of the well field, the Two-Forty-Two Lateral, a 34.5-kilovolt (kV) transmission line, and attendant facilities.

PLAN

There are no natural or constructed surface drains to carry irrigation drainage water from Yuma Mesa. Therefore, the Colorado River water applied for irrigating the agricultural lands on the Mesa is considered to be contributed to the underlying aquifers in the United States. Since much of this water is being lost to Mexico without being accredited to the United States as Treaty deliveries, interception of the ground-water flows will permit the recovery of this valuable water resource.

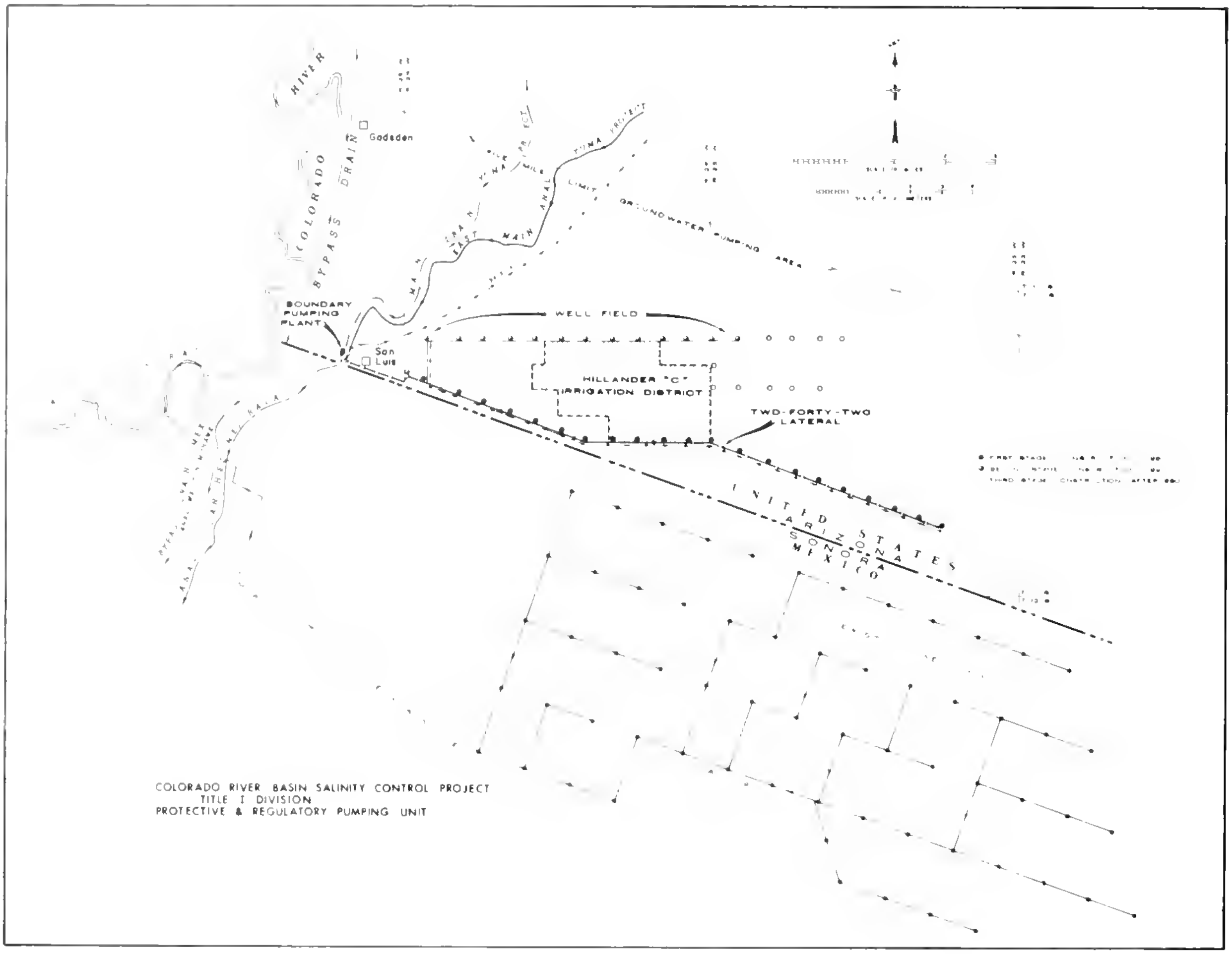
In accordance with the agreement made in Minute No. 242, each country will be limited to pumping no more than 160,000 acre-feet per year from its respective well field.

The water pumped from the 63 wells of the Sonora Mesa Well Field is collected in a canal and conveyed to agricultural lands in Mexico.

In the United States, the well field ultimately will consist of 35 wells, which will have a maximum total pumping capacity of 125,000 acre-feet per year. This will permit the United States to deliver at the Southerly International Boundary, in combination with drainage and regulatory flows from the Valley Division of the Yuma Project, about 140,000 acre-feet of water per year. Thus, the Protective and Regulatory Pumping Unit will become a major regulation facility for delivery of water to Mexico. A portion of the pumped water will be available for agricultural and other uses in Arizona. An additional 35,000 acre-feet are or will be pumped by private water users within the zone, part of which may be supplied by 10 additional wells.

Protective and Regulatory Pumping Well Field and Two-Forty-Two Lateral

This field of 35 wells will be constructed in the southern portion of Yuma Mesa, adjacent to the International Boundary. Plans for accomplishing the well field development program involve completing 21 wells by 1980, scheduling construction of approximately 14 wells between 1980 and 1990, and completing the program with approximately 10 additional wells after 1990, if they are required to maintain withdrawals of 160,000 acre-feet. The rate of installation of wells will be determined by the rate of decrease in drain flows, the rate of change in the ground-water table, and the rate at which domestic irrigation and municipal users are able to withdraw ground water with private systems. Maximum ground-water development within the 5-mile zone will be limited to 160,000 acre-feet per year.



CRBSCP - Protective and Regulatory Pumping Unit

The development through 1990 would ensure capability to meet the 140,000 acre-foot obligation at the Southerly International Boundary. Water from the wells would also have interim water supply potential for irrigation and municipal and industrial water contracts.

Hillander "C" Irrigation District, a private development which is near the well field, has expressed interest in entering into a water contract for 31,000 acre-feet of water based on a reasonable cost per acre-foot, taking into account the approximately 3,400 acres (2,300 acres are currently under irrigation) which are scheduled for irrigation development by 1981. The planned well field, along with pumping in Mexico, would have a significant impact on the existing wells by lowering the ground-water levels.

Other domestic users in the 5-mile zone are pumping approximately 4,000 acre-feet of water annually for municipal and irrigation uses. The planned well field would have a minimum effect on these users in the San Luis area.

The wells are drilled to a depth of about 600 feet. The lower 300 feet are screened. Each well is designed to pump 7.5 cubic feet per second and will be connected to the Two-Forty-Two Lateral. The lateral will carry the water westerly to the afterbay of the existing Boundary Pumping Plant, Yuma Project.

The design capacity of the lateral increases from 7.5 cubic feet per second at its beginning, near well No. 22, to about 220 cubic feet per second at its terminus.

The lateral is designed as an open and closed system; it will consist of a pipeline on each end and an open channel through the center. The reinforced concrete pipe ranges from 27 to 72 inches in diameter and the design capacity increases by 7.5 cubic feet per second in capacity at each well. The concrete-lined channel has a thickness of 2.5 inches and a base width that ranges from 4 to 6 feet. Water depth ranges from 2.8 to 5.8 feet with a velocity of 3.6 to 4.8 feet per second.

Two settling basins have been constructed to provide storage capacity for the accumulation of sediment, mostly windblown sand. A stand box has been provided at each well site along the pipeline to reduce the effect of water hammer. The terminal discharge pipeline is a 72-inch reinforced concrete pipe designed to carry 220 cubic feet per second.

Attendant Facilities

A 12-mile access road was constructed which closely parallels the collector and conveyance conduit and the well sites. This road will serve for the construction, operation, and maintenance of the unit facilities.

A 34.5-kV powerline was constructed adjacent to the access road and conveyance system to supply power to operate the wells that are in service. This transmission line will be extended to other wells as they are constructed.

Surveillance and control of the Protective and Regulatory Pumping Well Field for management of water deliveries to Mexico via the Southerly International Boundary will be made from the same point as for deliveries to the Northerly International Boundary. This will provide another degree of flexibility in preventing overdeliveries to Mexico.

Fish and Wildlife

(See the Desalting Complex Unit, Colorado River Basin Salinity Control Project.)

DEVELOPMENT

History

During the negotiations between the United States and Mexico to resolve the salinity problems of Colorado River water delivered to Mexico (Minute No. 242), the United States brought to the attention of the Mexican Government that the ground water underlying the United States was being withdrawn by Mexican pumping. This was due to operations of a ground-water well field that Mexico had installed immediately south of the International Boundary. It was recognized by the United States that this withdrawal of ground water would significantly affect the United States in several areas, particularly as Mexico expressed the intention to continue pumping from the well field at the rate of 160,000 acre-feet per year for use in irrigating Mexican agricultural lands.

Mexican use of these waters, by means of pumping, results in depletion of the ground water in the United States at no charge to the Colorado River Water Treaty allocations.

Yuma Valley agricultural drainage and irrigation wasteway flows delivered to Mexico at the Southerly International Boundary near San Luis, Sonora, Mexico, have been credited toward the 1,500,000 acre-feet per year delivery requirement of Colorado River water to Mexico. Historically, these flows have been about 125,000 acre-feet of drain flow and 15,000 acre-feet of wasteway flow annually. Pumping by Mexico and the United States has lowered ground-water elevations and is significantly reducing the amount of drainage flows from Yuma Valley. The annual combined flow is about 140,000 acre-feet at the Southerly International Boundary and will gradually be reduced to about 15,000 acre-feet of canal wasteway flow and no drainage flow. To maintain the Treaty flows to Mexico, any reduction in the deliveries at the Southerly International Boundary have to be made up by increased deliveries at the Northerly International Boundary with water from other sources. Under present conditions, this can be done only by releasing additional river storage waters not now committed to Mexico.

Among other things, Minute No. 242, which was approved on August 30, 1973, stipulates that the United States and Mexico will, pending a comprehensive agreement on ground water in the border areas, limit ground-water pumping within each country to 160,000 acre-feet annually within 5 miles of the Arizona-Sonora boundary.

Investigations

In 1962, the Congress appropriated funds for initiation of a plan for ground-water recovery and drainage relief in the Yuma Project, Valley Division, that would assist in regulating flows from the Colorado River. The ground-water recovery plan was enlarged in scope to include generally the entire Yuma area ground-water basin and increase the river regulation aspect. A study was completed and a plan developed by July 1964. Construction of the first phase, Valley Division, Conduit No. 1, was initiated in 1965. Mexico objected to the ground-water recovery plan and stated that it would increase the salinity of the water delivered to Mexico under the 1944 Treaty and replace the Colorado River water entitlement to Mexico with pumped ground water.

As a result of the conference with Mexico on October 12, 1965, the Bureau of Reclamation agreed to revise its ground-water recovery plan in the Yuma Valley.

In investigating the feasibility of carrying out the recovery program with minimum impact upon Mexico, alternative well locations were studied. Funds were made available to the Bureau of Reclamation to determine the feasibility of relocating the well field on Yuma Mesa near its western edge. Twelve (of the originally planned 13) drainage wells were constructed along the toe of the Mesa to relieve the drainage problem in the Valley Division of the Yuma Project. Water from these wells is delivered to Mexico as part of its entitlement under the 1944 Treaty.

In June 1966, a memorandum report comparing a Yuma Mesa well field and conduit plan with the Valley Division, Conduit Plan No. 1, Ground Water and River Regulation, was prepared. This report led to the construction of the Yuma Mesa well field and conduit.

In compliance with Minute No. 242 and Section 103(a) of the Colorado River Basin Salinity Control Act of 1974, a memorandum report was prepared on protective and regulatory ground-water pumping in November 1974. Presented in this report were alternative plans for a protective and regulatory ground-water pumping field, which set the framework for development of the Protective and Regulatory Pumping Unit.

Authorization

The unit was authorized by the Colorado River Basin Salinity Control Act, Title I, of June 24, 1974 (88 Stat. 266), Public Law 93-320. Sec. 103(a) of the act authorized the Secretary of the Department of the Interior to construct, operate, and maintain, consistent with Minute No. 242, well fields capable of furnishing approximately 160,000 acre-feet of water per year for use in the United States and for delivery to Mexico in satisfaction of the 1944 Mexican Water Treaty, and establish a 5-mile protective pumping zone along the Southerly International Boundary.

Construction

Construction of the unit features began in 1977. Installation of the access road and the Two-Forty-Two Lateral and construction of 13 wells and associated features was completed in 1978. Twenty-one wells are scheduled for completion by 1980. The remaining 14 wells are scheduled for completion after 1983.

Operating Agency

All unit works will be operated and maintained by the Bureau of Reclamation.

BENEFITS

Social and political benefits accrue that are outside the normal realm of economic quantification; however, the installation of this unit will use the United States ground-water resource in the Yuma area for the benefit of the United States and provide water deliveries to Mexico, thereby conserving upstream Colorado River water.

PROJECT DATA

Facilities Under Construction

Wells	21	
Two-Forty-Two Lateral	12.4	mi
Access road	12	mi
Transmission line, 34.5 kV	11.7	mi

Climatic Conditions

Annual precipitation	3	in
Temperature:		
Maximum (1969)	109	°F
Minimum (1968)	32	°F
Mean	71	°F

ENGINEERING DATA

Water Supply

Ground water is supplied from wells. On the Yuma Mesa, there is no surface drainage. The portion of the Colorado River water supply that is not used consumptively percolates into the ground-water reservoir.

Sediment Retention Facilities

Two settling basins provide storage for the accumulation of sediment.

Carriage Facilities

TWO-FORTY-TWO LATERAL

Location: Starts near well No. 22 and extends 12.4 mi west along the Southerly International Boundary to the afterbay of the existing Yuma Project's Boundary Pumping Plant near San Luis, Ariz.

Construction period: 1977-78

Length	12.4	mi
Open channel	6	mi
Pipeline	6.4	mi
Capacity[1]	7.5 - 220	ft³/s
Typical section (open channel):		
Bottom width (varies)	4 - 6	ft
Side slopes	1.5:1	
Water depth (varies)	2.8 - 5.8	ft
Lining, concrete	2.5	in
Typical section (pipeline):		
Type: Reinforced concrete		
Length	6.4	mi
Size:		
Maximum	72	in
Minimum	27	in

WELL FIELD

Location: On South Yuma Mesa, north of the Southerly International Boundary.

Construction period: 1977- (Under construction)

Number of wells	35	
Depth	600	ft
Diameter of well at surface	40	in
Total annual production	125,000	acre-ft

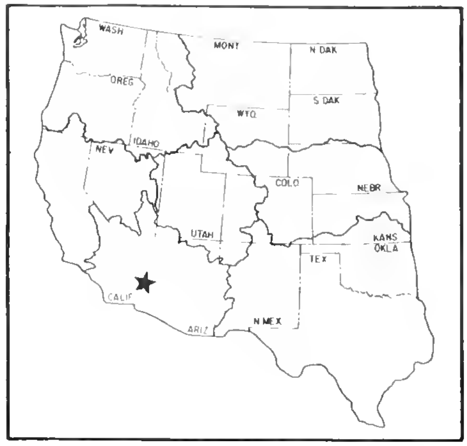
PUMPING UNITS

Designation	Number of units[2]	Total capacity	Dynamic head	Total horsepower
Well pump units	35	Data pending final design		

[1]Starting at well No. 22, the Two-Forty-Two Lateral increases in capacity by increments of 7.5 ft³/s as it adds the output from each of the wells along the course.

[2]Ten additional wells may be added if peaking conditions require more water or commitments are changed.

Colorado River Front Work and Levee System



Arizona: Coconino, Mohave, and Yuma Counties
California: Imperial, Riverside, and San Bernardino Counties
Nevada: Clark County

Lower Colorado Region
Water and Power Resources Service

The Colorado River Front Work and Levee System extends from Lee Ferry, Arizona (the division point between the Upper and Lower Colorado River Basins), to the Southerly International Boundary between the United States and Mexico, a distance of about 700 river miles. Its purpose is to control floods, improve navigation, and regulate the flows of the Colorado River. The work consists of constructing, operating, and maintaining the Colorado River Front Work and Levee System in Arizona, California, and Nevada; it includes controlling the river, improving, modifying, straightening, and rectifying the river channel, and conducting investigations.

The lower Colorado River extends about 280 river miles from Davis Dam to the boundary, and traverses three wildlife refuges, five Indian Reservations, and six irrigation districts. For administrative purposes, this reach of the river has been divided into 10 operational divisions. These divisions, starting at Davis Dam and proceeding in order downstream, are: Mohave Valley, Topock Gorge, Havasu, Parker, Palo Verde, Cibola, Imperial, Laguna, Yuma, and Limitrophe.

Mohave Valley Division

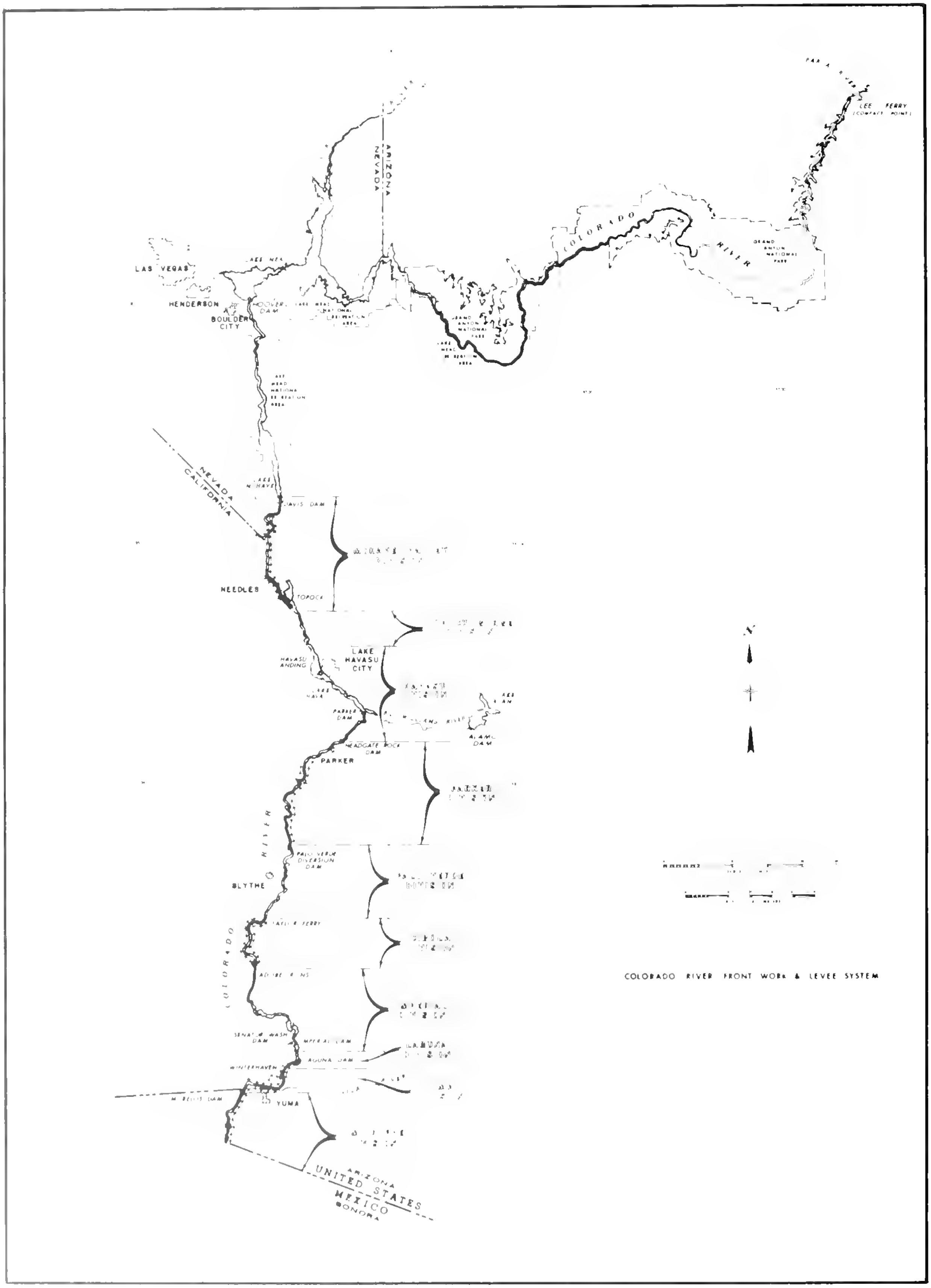
Major project facilities include the offstream Senator Wash Dam and Reservoir, a pumping-generating plant, access roads, water crossing facilities, and flood control levees. Regulation of river channel meandering by use of bankline structures with riprap protection, or a riprap-protected dredge channel, has been provided for the Mohave Valley, Upper Parker, Palo Verde, Cibola, and Yuma Divisions. Settling basins for trapping sediment have been built upstream from Topock Bridge and Laguna Dam. Salinity control features include the Main Outlet Drain (MOD) and the Main Outlet Drain Extension (MODE). These features convey the drainage flows from the Wellton-Mohawk Main Conveyance Channel (Drain) to the Bypass Drain below Morelos Dam. The Gila River Pilot channel was constructed to convey return flows from the irrigated lands in the Lower Gila River Valley to the Colorado River.

Water salvage activities along the Lower Colorado River include controlling the size of open water areas, selective clearing of phreatophytes, draining the river valley, and establishing deeper backwater areas. Major ground-water recovery programs have been undertaken by development of well fields and conveyance systems in the South Gila and Yuma Valleys, and on the Yuma Mesa.

Fish and wildlife features have been enhanced and wildlife losses have been mitigated by the development of Topock Marsh, Deer Island and other backwater improvements, Cibola Lake, and Mittry Lake. Park Moabi, McIntyre Park, Walters Camp, Laguna South recreation area, and several marinas have been developed for recreation purposes.

PLAN

This multiple-purpose program includes control of sediment movement, protection of communities and transportation facilities, maintenance of agricultural land by controlling the bed and banks of the river, and preservation



Colorado River Front Work and Levee System and enhancement of the fish, wildlife, and recreation resources of the area. Channel alinement rectification, control structures, levees, revetment, and flood control levees are used to confine the river to the designed channel during variations of discharge.

Mohave Valley Division

The Mohave Valley Division is located on the reach of the Colorado River from Davis Dam to Topock, Ariz. The area through which the river flows is an alluvial valley from 2 to 5 miles wide. It traverses the Fort Mohave Indian Reservation and that portion of the Havasu National Wildlife Refuge that lies upstream from Topock. Prior to the channelization program, there was a wide meandering of the river accompanied by general aggradation of the valley floor. The definable channel in the lower part of the valley was almost lost and the river flowed through a series of swamps and sloughs. Stabilization was initiated in 1949 by dredging to improve a channel between Needles and Topock. This work was completed January 5, 1953, and, along with associated levee construction, minimized the immediate flooding threat to Needles, Calif.

In January 1953, channel dredging, levee construction, and associated work were initiated on the reach of the river from Needles upstream to the Big Bend, 10 miles below Davis Dam.

Riverflows in the Mohave Division average 15,000 cubic feet per second in the summer and 7,000 cubic feet per second in the winter. The average depth of the channel during dredging was about 18 feet below the water surface at a flow of 15,000 cubic feet per second. Maximum depth dredged was about 25 feet. The average design width is about 450 feet.

The total dredge excavation in the Mohave Valley Division was 52,531,728 cubic yards. The total borrow for riverbanks, structures, and levees was 26,602,055 cubic yards. The design floods for levee construction in this reach of the river are: 50,000 cubic feet per second downstream of Davis Dam to Piute Wash, and 70,000 cubic feet per second downstream of Piute Wash.

Topock Marsh Water Control Facilities—Mohave Division

Topock Marsh is located on the Arizona side of the Colorado River midway between Davis Dam and Parker Dam. The northern portion of the marsh lies opposite Needles, while the southern extremity connects with the Colorado River at Topock. The marsh is almost entirely in the Havasu National Wildlife Refuge, which was established in 1941. Topock Marsh was created by backwaters resulting from the construction of Parker Dam.

Topock Gorge Division

Features constructed by the Bureau of Reclamation in Topock Marsh consist of inlet and outlet structures, a canal, and dikes. These structures make possible the maintenance of optimum water surface elevations in the marsh and permit diversion of water to the marsh from the Colorado River.

The Topock Marsh Dike was constructed with a crown elevation of 460.0 feet. It impounds a water surface area of 4,000 acres. The materials to construct the dike were excavated by dredge from the bottom of the marsh. The highest portion of the fill rises 14 feet above the bottom of the marsh. A section of the fill northwest of the outlet structure was constructed to elevation 459.0. The purpose of this special section is to localize and control damage which would result from floods on the local drainage area or on the river itself.

Topock Gorge Division

The Topock Gorge Division starts at Topock, Ariz., and extends downstream to Lake Havasu, a distance of about 12 miles. After the closure of Parker Dam in 1938, the rise in water surface elevation (adjusted to a standard flow of 15,000 cubic feet per second) was accelerated and increased from 443 feet to nearly 452 feet by 1948. During correction of the high water conditions which existed at Needles prior to 1951, it was recognized that sediment deposits in the Topock Gorge were an important factor leading to the high water levels that existed from Topock north beyond Needles.

The Bureau of Reclamation and the Fish and Wildlife Service are monitoring the effects of sediment action in this reach of the river. Future corrective measures undertaken in this division will be dependent upon the results of the monitoring program.

Havasu Division

The Havasu Division covers all of Lake Havasu and the river between Parker and Headgate Rock Dams.

A navigational hazard of submerged trees existed in Lake Havasu because the reservoir area was not cleared prior to closure of Parker Dam in 1938. In recent years, developments along the Colorado River have attracted thousands of visitors to Lake Havasu, with boating and water skiing replacing fishing as the dominant recreational activity. A number of accidental deaths have occurred on the lake. In several instances, the snags were a factor in the accident.

Snag removal operation, begun in 1965 with underwater cutting, clearing, and disposition of tree snags from boating areas on Lake Havasu, was accomplished under three separate contracts. The final contract was completed in 1971.

The design flood downstream of Parker Dam for this division is 50,000 cubic feet per second.

Lake Moovalya, Havasu Division

Parker Division

The Parker Division begins at Headgate Rock Dam and extends downriver about 33 miles to the Palo Verde Diversion Dam.

The channel throughout this reach has been subjected to scouring action by clear water releases from Parker Dam. Headgate Rock Dam, constructed for the Bureau of Indian Affairs by the Bureau of Reclamation in 1942, stabilized the channel below the dam. The area is protected from floods by the levee system built in conjunction with the construction of the Palo Verde Diversion Dam.

The plan of development divided Parker Division into two sections. Section I lies within the Colorado River Indian Reservation and extends about 16 miles downstream from Headgate Rock Dam to Alligator Bend. Section II embraces the river from Alligator Bend to Palo Verde Diversion Dam, a distance of 28.3 miles. The Arizona side and the northern part of this section that is in California lie within the Colorado River Indian Reservation.

Stabilization of the river in section I was accomplished by confining reaches of the river between training structures or stabilized bank lines. The basic channel improvement work was completed in 1967.

In 1969, a comprehensive plan for channel stabilization in section II was approved by the Department of the Interior. However, the work was deferred pending the location of the western boundary of the Colorado River Indian Reservation. In 1971, a task force appointed to review the River Management Program recommended that additional plans for the Parker Division below Alligator Bend be considered to reduce the environmental impact of the work. Several alternative plans involving a reduced program were evaluated but none have been adopted.

The design flood for this area is 50,000 cubic feet per second.

Palo Verde Division

The Palo Verde Division includes about 28 miles of river channel between Palo Verde Diversion Dam and Taylor's Ferry. Channelization by land-based equipment began in May 1962 and, except for routine maintenance and repair of constructed features, the channel stabilization was completed in September 1968. The work consisted primarily of earthfill training structures and bank protective riprap designed to prevent future meandering of the river. Many of the backwater areas created by the training structures were improved to benefit fish and wildlife.

The Bureau of Reclamation also participated in the development of the Blythe Marina and McIntyre Park. Both are administered by Riverside County, California. Dredging of the Blythe Marina began in June 1966 and was completed in February 1966. A 10-inch dredge was moved to McIntyre Park in July 1972 where it was used to deepen the backwater for recreation purposes. This work was completed in December 1972.

In addition to providing channel stability and 10,000 acre-feet of annual water salvage, the completed river stabilization work resulted in a reduction of the sediment load originating in the Palo Verde Division, thereby reducing the amount of material carried downstream.

The design flood for this section of the river is 75,000 cubic feet per second.

Cibola Division

The Cibola Division adjoins the Palo Verde Division at Taylor's Ferry and extends downstream about 24 miles to the Adobe Ruin gage at the lower end of Cibola Valley.

Prior to any Reclamation activities in the area, the channel through this division was characterized by a transition from degradation at the upper end to aggradation at the lower end, resulting from the adjustments that had taken place since construction of the storage dams upstream. The river had acquired a sizable sediment load in passing through the Parker and Palo Verde Divisions and the erosive force of the flow was reduced greatly by the time it arrived at the upstream end of this division. Immediately following the closure of Parker Dam, a balance point formed near the mouth of the Palo Verde Drain, with degradation above and aggradation below. The aggradation conditions caused a rise in the water surface in the Palo Verde Drain, thus raising the groundwater table through the lower third of the Palo Verde Valley.

The Bureau of Reclamation provided some relief to this situation in 1947 by moving the confluence of the river and the drain downstream about 2 miles. This was accomplished by constructing a pilot cut across a bend in the river and letting the drain use the old channel down to the new channel. This cutoff was successful in dropping the water surface at the drain gage by about 1.5 feet. However, the pilot cut could not lower the water-surface elevations in the drain enough to completely solve the problem.

Through much of the Cibola Division, the natural channel was shallow due to sediment deposition. A program to correct channel deficiencies by dredging and constructing levees was initiated in 1964 and completed in 1970. The dredged channel begins 2.2 miles downstream from Taylor's Ferry and ends at the lower end of Cibola Lake near Adobe. Major features constructed to preserve fish and wildlife in the area include the backwater improvement of the Palo Verde Oxbow Lake south of Palo Verde. Another area improved for fish and wildlife is Cibola Lake, in the Cibola National Wildlife Refuge that was established in August 1964.

The work in the Cibola Division provides an estimated 36,000 acre-feet of water salvage yearly, and has substantially reduced the sediment passing into the Imperial Division.

The design flood for this division is 80,000 cubic feet per second.

Imperial Division

The Imperial Division extends from the Adobe Ruin gaging station at the lower end of Cibola Valley to Imperial Dam. The channel length, including Imperial Reservoir, is about 36 miles.

This division consists of the diversion pool and associated backwater areas above Imperial Dam. It is the recipient of the sediment generated in the Parker, Palo Verde, and Cibola Divisions. The sediment load arriving in Imperial Division is deposited in areas outside the main channel. About 50 percent is deposited on sandbars or in backwater lakes. The remainder is diverted at Imperial Dam. Most of the diverted sediment is removed from the water by the desilting works in the All-American Canal, returned to the river below Imperial Dam, and dredged to permanent dry land storage areas near the Laguna Settling Basin just above Laguna Dam.

Since closure of Imperial Dam, sedimentation has filled a number of the backwater areas, particularly in the upper end of the division. Others have been isolated from the river by natural, river-formed dikes. This condition is causing serious deterioration of the water quality and fish and wildlife values in these isolated backwater areas. Generally, the remaining deeper backwater areas are located in the lower one-third of the division where the water was initially deeper and sediment deposition is less advanced. However, a short reach of the diversion pool immediately upstream from the dam is full of sediment

Cibola Division

and it occasionally has been difficult to divert water into the headworks of the Gila Gravity Main Canal. Some maintenance dredging has been accomplished immediately upstream from Imperial Dam to improve these diversions temporarily.

The design flood for this reach of the river is 80,000 cubic feet per second.

Senator Wash Dam, Reservoir, and Pumping-Generating Facility—Imperial Division

Senator Wash Dam and Reservoir, an offstream pumping-generating facility, is located about 18 miles northeast of Yuma, Ariz., on the California side of the Colorado River 2 miles upstream from Imperial Dam and at the river-end of Senator Wash. The purpose of this strategic offstream retention reservoir is to improve water scheduling of the Colorado River, with resulting salvage. This is accomplished by storing part of the riverflow upstream of Imperial Dam when it is not needed and releasing it to the river for downstream use when needed since 3 days are required for water released at Parker Dam to reach Imperial Dam.

The principal features are an earth dam, three dikes, a spillway, an outlet works, a pumping-generating plant, a switchyard, and access and service roads. A 69-kilovolt (kV) transmission line, approximately 18 miles long, constructed separately by the Parker-Davis Project, is now operated and maintained by the Western Area Power Administration (WAPA) of the Department of Energy.

Senator Wash Dam is a three-zone rolled earth embankment structure 2,342 feet long, with a maximum structural height of 93.6 feet. Squaw Lake Dike is a three-zone rolled earth embankment structure 3,795 feet long, with a maximum structural height of 95.3 feet. North Dike is a two-zone rolled earth embankment structure

Imperial Division

613 feet long, with a maximum structural height of 67.2 feet. A small single-zone rolled earth embankment structure was constructed in a small saddle on the right abutment of Senator Wash Dam and is included in the dimensions for the dam. A 3-foot layer of riprap was placed on the upstream slope of all the earth embankments. A 24-inch-thick impervious blanket, extending from the upstream toe of the dam, was constructed on the floor and slopes of the reservoir to elevation 210.0, the top of inactive storage.

An equalization channel uses the storage capacity of a small isolated basin behind North Dike.

The outlet works consist of an intake structure, a 10-foot-inside-diameter concrete conduit, a 6.5- by 10-foot-high pressure gate in a gate chamber, a 10-foot-inside-diameter steel pipe installed inside a 15-foot-inside-diameter concrete conduit, an access house, a concrete-encased steel manifold, and six 54-inch steel branchlines leading to the pump turbines.

The Senator Wash Pumping-Generating Plant is of the indoor type with a reinforced concrete substructure and steel framed superstructure. Six (including one spare) vertical-shaft, single-suction, centrifugal, Francis-type pump-turbines with fixed-vane diffuser-type casings are installed in the plant. Each pump-turbine is directly connected to a vertical shaft, 360-revolution-per-minute, synchronous motor-generator designed to operate either as a motor or as a generator. A 20-ton, floor-operated overhead traveling crane is provided for installing and maintaining the unit.

When operating as a pumping plant, each 1,750-horsepower pump is designed to operate from 31 feet of head to shut-off head and will deliver not less than 100 cubic feet per second at a total head of 74 feet while operating at 360 revolutions per minute. Under normal operations, each unit pumps about 200 cubic feet per second. When operating as a powerplant, each 4,000-volt generating unit has a rating of 1,200 kilovolt-amperes (kVA) at unity power factor. When operating as a turbine, each unit will discharge not less than 200 cubic feet per second under an effective head of 65 feet at 360 revolutions per minute. The normal release rate for each unit is about 150 cubic feet per second; however, on low reservoir operation, the release rate is about 100 cubic feet per second.

Normal starting and stopping of the unit is controlled from the remote control panel at Imperial Dam, which includes all the electrical control equipment (switching, alarm, and indicating) required for remote operation of the pumping-generating plant.

A 17.7-mile, 69-kV transmission line between WAPA's Gila Substation and Senator Wash Substation brings power for pumping to Senator Wash (about 10,000 kVA when all six pumps and all station loads are in operation) and carries generated power back to Gila Substation for integration into the WAPA power system (maximum of 7,200 kVA when all six generators are running). Since 1967, the average annual generation has been 1,400 megawatt-hours.

Laguna Settling Basin, All-American Canal Desilting Basin, and All-American Canal

Laguna Division

The Laguna Division was designated to facilitate the construction and operation of the Laguna Settling Basin and the appurtenant channels leading to and from the basin. It includes the 4.7-mile reach of river between Imperial and Laguna Dams.

The settling basin operation in the Laguna Division was originally adopted as a result of a general complaint lodged by Mexico that the United States was reintroducing sediment into the river in amounts that represented higher concentrations than were present in the river as it entered the Imperial Dam Reservoir area. At the same time, it was apparent that water was not available for sluicing operations of the size and type conducted in the past. Mechanical removal of the sediment by dredging rectified this situation.

Dredging of Laguna Settling Basin began in 1963 and was completed in 1965. About 1.2 million cubic yards of material were excavated.

The settling basin operation has been satisfactory and its two primary objectives, removing the sediment and not wasting deliveries of water to Mexico during sluicing flows, have been achieved. Dredging operation in the settling basin will be required on a continuing basis and new areas eventually will be needed to store sediment taken from the basin.

Operation of the dredge in Mittry Lake for the development of a fish and wildlife management area in the Laguna Division was hindered by extremely heavy tule (bulrush) growth in the area. Herbicide sprays and burning were used in an effort to prevent the accumulation of extensive floating mats of the growth; however, mechanical removal was required.

Dredging of the Gila Sluiceway began in 1970 and was completed in 1973. The purpose of this sluiceway is to carry sediment flushed from the Gila Main Canal Desilting Basin to the Laguna Settling Basin.

Yuma Division

The Yuma Division of the Colorado River Front Work and Levee System includes 21 miles of river channel between Laguna and Morelos Dams. The city of Yuma is on the south bank of the river, approximately in the center of the division. The channel in the Yuma Division reflects changes resulting from construction of storage dams and diversion of water for irrigation purposes upstream. It consists of a small active channel situated within a larger, older riverbed which is entrenched below the historic level of the unregulated river.

The flow into the upper end of the Yuma Division is regulated primarily by Laguna Dam. It normally consists of water used to flush sediment from the desilting works into the Laguna Settling Basin and from sluice-gate leakage and intermittent sluicing flows below Imperial Dam. Laguna Dam is used to reregulate the flows originating at Imperial Dam.

About 9 miles downstream from Laguna Dam, the Gila River enters the Colorado River from the east. The flow from the Gila River is the result of returns from canal wasteways, drainage from irrigation areas, and occasional floodflows. Since 1977, flows from the Wellton-Mohawk drainage wells, which were frequently discharged into the Colorado River downstream of Morelos Dam, are now carried to the Santa Clara Slough in Mexico by the bypass drain.

Yuma Division

The California Wasteway of the Yuma Main Canal is about 4 miles downstream from the mouth of the Gila River, across the river from Yuma. This wasteway returns to the river the water which is used to fulfill the United States Water Treaty obligation to Mexico. Under normal operating procedures, the return through this wasteway varies from about 20 cubic feet per second gate leakage to about 1,000 cubic feet per second. If flows greater than 1,000 cubic feet per second are required for release into the river, the water is transferred for discharge at the Imperial Irrigation District's Pilot Knob Powerplant.

Rockwood Heading, an old intake structure on the Alamo Canal, is about 2 miles upstream from Morelos Dam. It is no longer used for an intake structure but is used as a point of return for the Pilot Knob Powerplant and Wasteway from the All-American Canal. The powerplant is operated on a minimum flow of 1,000 cubic feet per second; the maximum capacity is 8,000 cubic feet per second. The return to the river at Rockwood Heading may vary between these minimum and maximum values. About 5 months of the year, there is no release made at this point because the 1,000-cubic-foot-per-second minimum flow required by the Mexican Treaty is in excess of Mexico's water order.

Prior to the completion of the Laguna Settling Basin in 1965, a comparatively heavy load of sediment was carried by the river into the upper end of the Yuma Division. The load was caused by the operation of the All-American Canal Desilting Works and periodic sluicing of Imperial Reservoir. The Laguna Settling Basin now intercepts the sediment below Imperial Dam and the trapped sediment is dredged out of the basin and pumped onto adjacent land. As a result, the water entering the Yuma Division is relatively sediment-free.

The early history of the Yuma Division shows that lateral movement of the river occurred infrequently. A major channel change occurred in 1920 and created what is commonly known as Yuma Island. Located about 3 miles northeast of Yuma, the island is a flood plain partially encircled by the pre-1920 river channel. This channel is filled with sediment except for the two small depressions which constitute Haughtelin and Bard Lakes.

The completion of Imperial Dam had an immediate effect upon the river in the Yuma Division. The reservoir behind the dam was comparatively small; however, it retained much of the sediment picked up downstream from Parker Dam and relatively clear water flowed through Laguna Dam into the upper reach of the Yuma Division.

This caused severe scouring action and degradation downstream from Laguna Dam. The degradation was most severe immediately following the closure of Imperial Dam but diminished as the reservoir silted up and the sediment concentration in the water passing Imperial Dam increased. By 1945, the sediment concentration in the flow diverted at Imperial Dam for irrigation purposes had increased to an objectionable level, and the desilting works for the All-American Canal were placed in operation. The sediment returning to the river from the desilting works increased the sediment concentration in the water below Imperial Dam to such proportions that degradation ceased, except for occasional scour. By 1947, the channel below Laguna Dam had degraded from 3 to 6 feet down to Yuma, and 5 to 8 feet downstream from Yuma. From 1947 to 1953, the channel remained relatively stable; with the generally lower flows since 1953, the channel has been slowly aggrading.

Sediment samples have been taken by the International Boundary and Water Commission at the Northerly International Boundary since 1956. Since the completion of the Laguna Settling Basin in 1965, the average sediment load arriving at this station has been 284,000 tons annually.

Protection from flooding in the low-lying valley lands has been provided throughout most of this division by an arrangement of levees which were constructed during the early activities of the Colorado River Front Work and Levee System and rehabilitated in 1951 and 1952 under international agreement subsequent to the Mexican Water Treaty of 1944.

During the rehabilitation of the Yuma levee system, the Upper Reservation Levee was relocated parallel to the river channel as it existed. This change reestablished the levee closer to the active channel of the river and left a fairly large area of land between the 1905 alinement of the levee and the relocated levee.

Studies conducted in 1948 by the International Boundary and Water Commission, the Corps of Engineers, and the Bureau of Reclamation established a design flood for use in the lower river. The flows accepted were 103,500 cubic feet per second from Imperial Dam to the mouth of the Gila River and 140,000 cubic feet per second below the mouth of the Gila River. Additional studies were made by the International Boundary and Water Commission concerning the effect of Morelos Dam on upstream water stages as related to levee design in the Yuma Division. The existing levee system in the Yuma Division was designed using the data from these studies.

The effectiveness of the present levee system is influenced by sediment disposal below Morelos Dam. The dredged spoil excavated from the Alamo Canal and deposited in the flood plain below Morelos Dam has constricted the channel to the extent that it, rather than the dam, has often controlled upstream water stages. Normal channel flows have been affected only temporarily, as there have been either occasional periods when normal flow below Morelos Dam was adequate to reopen the channel or the channel was reopened by a special flushing flow. However, these flows have removed sediment principally from the active channel and, except for the use of bulldozers to move sediment deposits into the river during the special flushing in 1960, they have not removed an appreciable amount of spoil from overbank areas. As a result, the spoil has continued to accumulate in the overbank areas between the flood levees.

Flood protection is provided for the division by the Reservation and Yuma Valley Levees. The Reservation Levee protects the lands to the west of the river from Laguna to the high lands below Yuma. The Yuma Valley south of Yuma is protected by a levee on the south and east side of the river from Prison Hill to the Southerly International Boundary.

The South Gila Levee provides protection to the lands to the south of the river from the mouth of the Gila River to Prison Hill, and an extension east along the south side of the Gila to the siphon of the Gila Gravity Main Canal, where it joins the Gila Levee System of the Corps of Engineers, gives full flood protection to lands in the South Gila Valley. The design floods used to establish

Colorado River near Morelos Dam

the required levee heights are for a discharge of 103,500 cubic feet per second from Imperial Dam to the mouth of the Gila River and 140,000 cubic feet per second downstream of the mouth of the Gila River.

The need for an improvement of the drainage of both Indian and non-Indian lands in the Reservation Division has long been recognized. Representatives of both the Quechan Tribal Council and the Bureau of Indian Affairs have indicated that such improvement work would be practicable as the result of the channel improvements currently proposed. The water table in much of the Bard and Reservation areas is too high for maximum productivity and efficient utilization of the agricultural lands. There are many washes in the area which contribute large quantities of runoff after rains during certain periods of the year.

The primary outlet for the subsurface drainage water and storm runoff water from lands in the Bard and Reservation areas is the Reservation Main Drain. This drain crosses under the Southern Pacific Railroad, the old highway, and the Yuma Main Canal through culvert structures which control the drain outlet flows. The outlet flows have been limited by the invert grades and size of the culverts. Consequently, under normal conditions the Main Drain has operated marginally. Significant storm runoff water from the washes in the area has formed a large lake above the outlet culverts, and some local flood damage has occurred. The backwater effect has further aggravated the drainage problems in the upper portions of the area served by the Main Drain.

Yuma Area Ground-Water Recovery and River Regulation Program—Yuma Division

In 1962, the Congress appropriated funds for initial investigation of a plan for ground-water recovery and drainage relief in the Yuma Valley that would also assist, to a small degree, in regulating flows in the Colorado River.

The ground-water recovery plan was enlarged in scope to include the entire Yuma area ground-water basin and to increase the river regulation aspects. A study was completed and a plan developed in July 1964. Construction of the first phase, Valley Division, Conduit No. 1, was initiated in 1965. Mexico objected to the ground-water program in Yuma Valley on the grounds that it would increase the salinity of waters delivered to Mexico and replace Colorado River water entitlement to Mexico with pumped ground water.

As a result of a conference with Mexico on October 12, 1965, the Bureau of Reclamation revised its ground-water recovery plan in Yuma Valley. The wells were relocated along the east side of the valley near the toe of the Yuma Mesa, thereby minimizing interference by ground-water pumping with the underflow to Mexico. The plan, as revised, provided for the conveyance of part of the water north to the Colorado River, and the remainder by Yuma Valley drains to Mexico at the Southerly International Boundary. Under all conditions, the plan provided for drainage improvement and substantial ground-water recovery and river regulation benefits.

To conduct the recovery program with minimum impact upon Mexico, alternative well locations were studied to determine the feasibility of relocating the well field on the Yuma Mesa near its western edge. Because additional drainage in Yuma Valley was badly needed, six drainage wells were constructed by the Bureau of Reclamation in addition to the seven wells developed by the Yuma County Water Users' Association along the eastern toe of the Mesa. The discharge from these wells is conveyed through a conduit system to the Yuma Valley Division of the Yuma Project drainage system at the Southerly International Boundary as part of Mexico's entitlement to Colorado River water.

South Gila Valley Well Field and Conduit System—Yuma Division

Another segment of the Yuma area ground-water and river regulating program is the Drain Pump Outlet Channel (DPOC) drainage system in the South Gila Valley. It consists of 24 drainage wells. The production of the wells ranges from 3 to 9 cubic feet per second. The eastern three conveyance conduits, DPOC Nos. 1, 2, and 3, discharge into the Gila River Pilot Channel, constructed by the Colorado River Front Work and Levee System in 1961. The western conduit, DPOC No. 4, discharges the pumped drainage water into the Colorado River.

The purpose of the DPOC drainage well field is to provide adequate drainage for the agricultural lands of the South Gila Valley and return it to the Colorado River to become a part of Treaty water delivered to Mexico above Morelos Dam. The drainage requirement has been 55,000 to 65,000 acre-feet per year.

Yuma Mesa Well Field and Conduit—Yuma Mesa Division

The Yuma Mesa Well Field is located along the western edge of Yuma Mesa. It is a segment of the overall ground-water recovery and river regulation program for the Yuma area.

The ground water recovered from the Yuma Mesa Well Field is collected in a conduit system and conveyed to a point in the Colorado River near Yuma.

Integrated into the Yuma Mesa Well Field system are six wells which were installed in Yuma Valley in 1965. These wells are located along the western toe of Yuma Mesa

Parker Division

and their discharge is conveyed through concrete pressure pipelines to the Valley Division drainage system.

The principal functions of the ground-water recovery program are to recover from the ground-water basin return flows from irrigation developments in the United States to assist in meeting requirements for delivery of water to Mexico, to provide some drainage relief for the Valley Division of the Yuma Project, and to assist in Colorado River operations by reducing overdeliveries to Mexico.

The Yuma Mesa Well Field consists of 12 wells, spaced about 0.5 to 1 mile apart, which have a total capacity of about 100 cubic feet per second. Each well is gravel-packed and contains a 16-inch stainless steel screen. The depth of the wells ranges from 189 to 286 feet. The conduit consists of 14.7 miles of reinforced concrete pressure pipe, the diameter of which ranges from 18 inches for the collector conduits to 66 inches for the main conduit. The average velocity in the conduit is about 4 feet per second. A baffled outlet structure was installed at the Colorado River end of the conduit. Transmission facilities consist of one substation, 2 miles of 34.5-kV line, and 12.3 miles of 12.47-kV line.

The Yuma Mesa Well Field is operated by remote control from Imperial Dam by the use of radio signals to actuate the individual pumping units and monitor the operation through electronic interrogation. The well field is operated on a 24-hour basis throughout the year. It is capable of pumping about 40,000 acre-feet of ground water annually and, in addition, about 9,000 acre-feet of water are pumped annually from the six Bureau of Reclamation drainage wells developed in Yuma Valley.

Limitrophe Division

The Colorado River at and downstream of Morelos Dam forms the boundary between the United States and Mexico. Proceeding downstream for a distance of 20 miles, the left bank of the river is in the United States and the right bank is in Mexico. The river has levees on both sides; the levee on the Mexican side is about 4 feet higher than the levee on the United States side.

The river conditions prevailing from Morelos Dam to the Southerly International Boundary are not typical of ordinary river conditions in that no degradation exists downstream from the dam. In fact, the gated portion of the structure does not always form the water surface control that would normally be the case. A downstream plug of sediment introduced in the channel below the dam sometimes controls the water surface elevation through the gated structure.

This sediment plug is a result of the operation of the Mexican dredge in the settlement basin at the head of the Alamo Canal and the method of disposal of sediment employed by Mexico at Morelos Dam. The Alamo Canal desilting basin is an overwidth and overdepth section of the canal that runs generally parallel to the river. For several years following the completion of Morelos Dam, the method used to dispose of the sediment was simply to pump it out of the desilting basin onto the ground between the basin and the river. Over a period of years, the disposal ground was built up by the deposition of dredge spoil until finally the sediment could be pumped no higher and some other means of disposal had to be found.

At this point, Mexico began pumping the sediment into the river and along the bank between the Mexican levee and the river. On occasion, the sediment deposit has deflected the current of the river against and has severely eroded the United States bank. After these periods of bank erosion, Mexico has brought its disposal line across the river on pontoons to deposit spoil on the United States side and thus return the river to the center of the channel. This type of operation has held the river away from the United States levee, but has built up the bed of the river with a sediment plug consisting of several million cubic yards of material.

Imperial Dam and Reservoir

The remainder of the river channel from Morelos Dam to the Southerly International Boundary is choked by sediment carried downstream from the sediment plug and is in generally poor condition. Because Mexico customarily diverts as much of the flow of the Colorado River as is feasible to put into the Alamo Canal, the flow below Morelos is greatly depleted and the channel has become overgrown with vegetation. In effect, this has seriously reduced the flood capacity of the channel and presents a direct threat to the safety of the Valley Division of the Yuma Project.

The river in the Limitrophe Division is no longer important as a channel for irrigation water. The inadequacies that have developed in its capacity to convey floodflows are being corrected by work presently underway. Because this division of the river is an International Boundary, all work activity, planning, or construction is coordinated with the International Boundary and Water Commission.

DEVELOPMENT

Early History

In its natural state before the upriver dams were built, the Colorado River experienced serious seasonal floods during part of the year, intense shortage of water the remainder of the year, a heavy silt load, and a flow too erratic to support year-round navigation. Full control of the river required regulation of the annual discharge by reservoir storage, plus supplemental downstream works at critical locations to solve localized problems.

Subsequent to the construction of the various dams on the river, the channel between dams was subjected to severe degradation downstream and aggradation upstream from a dam. In the wide river bottoms of Mohave and Cibola Valleys, the river surface was raised by continued aggradation until the banks were overtopped and swamps of considerable magnitude were created.

Palo Verde Division

Because of the immediate hazard to the city of Needles, emergency work was undertaken in 1944 to enlarge the existing inadequate levees along the Colorado River. The initial channelization work, Needles to Topock, was aimed at alleviating the flood and high-water hazard to the city of Needles and the facilities of the Atchison, Topeka, and Santa Fe Railway Company in Mohave Valley.

At Palo Verde Irrigation District's intake, 65 miles downstream from Parker Dam, degradation had lowered the riverbed to the point that diversions could not be made satisfactorily. Rock placement as the initial step in constructing the Palo Verde temporary weir commenced on January 12, 1945. On June 24, 1945, the first water was delivered through the district's new headworks upstream from the weir. Completion of the weir permitted full gravity diversion to be resumed through the canal system. However, continuing difficulty made construction of a new diversion facility necessary.

Investigations

Investigations by the Bureau of Reclamation revealed the need for a concerted, continuing project for an indefinite period to control the operation of the river efficiently.

Authorization

The Colorado River Front Work and Levee System was authorized by the acts of March 3, 1925 (43 Stat. 1186, 1198), January 21, 1927 (44 Stat. 1010, 1021), July 1, 1940 (54 Stat. 708), and the act of June 28, 1946 (60 Stat. 338), Public Law 79-469, as amended by the act of May 1, 1958 (72 Stat. 101).

Construction and Dredging

Mohave Division

Enlarging the existing levees along the Colorado River commenced in 1944. The initial channel stabilization, levee construction, and associated work, Needles to Topock, commenced in 1949 and was completed in 1953. Channelization and levee construction by dredging, Needles to Topock, started in 1953 and was completed in 1960. The Topock Settling Basin was constructed by dredging between December 1955 and November 1956. Dredging of Park Moabi started in 1964 and was completed in 1965. Work on the main dike of Topock Marsh was initiated in 1965 and completed in 1966 with the installation of the marsh's inlet and outlet facilities. Improvement of the Needles Marina was started in 1967 and completed in 1968. The Big Bend training structure was constructed between January and June 1969. Improvement of Park Moabi by dredging was accomplished during December 1971 and January 1972. Fish and wildlife habitat improvement of Topock Marsh started in January 1974 and should be completed in 1980.

Topock Gorge Division

Dredging of the Upper Topock Gorge began in 1967. However, the dredging was suspended in 1968 because of the Fish and Wildlife Services' objections.

Havasu Division

Snag removal in Lake Havasu was accomplished intermittently between December 1965 and June 1971.

Parker Division

Construction of bankline structures for the Parker Division, Section I, with land-based equipment, began in January 1966 and was completed in June 1968. Improvement of Deer Island by dredging began November 1968 and was completed in May 1969.

Cibola Division

Dredging of the channel and levee construction of the river between Taylor Ferry to Adobe Ruin started in June 1964 and was completed in December 1969. Construction of the lower Cibola Bridge was initiated in June 1969 and was completed February 1970. The Cibola dry cut was opened March 10, 1970. The Palo Verde Oxbow was dredged in 1970 and supplemental bankline work was completed by contract during May 20, 1971, to November 17, 1971. In 1974, dredging the mouth of the old river channel near Walter's Camp in the lower Cibola Valley was accomplished and the river bankline structure was extended to narrow the old river channel and provide boating access to the improved Walter's Camp recreation area. The Cibola Lake inlet and outlet structures were built in 1974.

Imperial Division

Starting in 1969, silt removal activities have been carried on intermittently above Imperial Dam to relieve the flow into the Gila Canal. Construction of Senator Wash Dam, Reservoir, and Pumping-Generating facility was accomplished during 1964-66.

Laguna Division

Construction of the Laguna Settling Basin, by dredge, commenced in July 1963. The dredging of the settling basin was accomplished in April 1965. Construction of a freshwater inlet channel to Mittry Lake, dredging Mittry Lake, and the Gila Sluiceway started in 1970 and was completed in 1973.

Yuma Division

Raising of Yuma Levees and construction of the Reservation Levee began in May 1951 and were completed in September 1952; dredging of the channel relocation was completed in 1954. Construction was started on the Main Outlet Drain and the Gila and South Gila Levees in 1960 and completed in 1962. Construction of the Valley Division Conduit No. 1 and drainage well field was started in 1965. This drainage well field was limited to six wells and a collector conduit and was installed in 1965. The Yuma Mesa Well Field and conduit were constructed during 1968-71, and the South Gila Valley drainage wells and drainage pump outlet channels were constructed in 1964. The Main Outlet Drain Extension was constructed in 1965. Dredging the river channel below Laguna Dam was accomplished in 1969.

Operating Agency

The Colorado River Front Work and Levee System is maintained and operated by the Bureau of Reclamation.

BENEFITS

The project has increased irrigation water supplies through reduction of water loss from evaporation; improved transportation; enhanced the fish and wildlife and recreation values of the area; improved navigation and control of diversions; reduced the silt load in the river; assisted in the control of floods and salinity; and has provided needed technical information for future efficient river operation.

Mohave Valley Division

PROJECT DATA

Facilities in Operation

Storage dam	1	
River channel stabilization	106.5	mi
Levees	150.9	mi
Drainage well fields	3	
Pumping-generating plant	1	
Transmission lines[1]	17.7	mi
Switchyard	1	

[1]Transmission lines are operated and maintained by the Western Area Power Administration.

Climatic Conditions

Division	Annual precipitation, in	Temperature Max.	Min.	Mean	Elevation Upper End - Lower End
Mohave Valley (Sta. Davis Dam No. 2)	4.3	121	28	72	655 - 510
Topock Gorge (Sta. Needles FAA AP)	4.1	121	23	73	510 - 482
Havasu (Sta. Parker Reservoir)	4.4	122	27	74	482 - 455
Parker (Sta. Parker)	3.8	121	17	72	286 - 277
Palo Verde (Sta. Blythe)	3.2	122	22	71	277 - 227
Cibola (Sta. Blythe)	3.2	122	22	71	227 - 206
Imperial (Sta. Yuma Proving Ground)	3.1	117	23	73	206 - 181
Laguna (Sta. Yuma Proving Ground)	3.4	117	23	73	181 - 151
Yuma (Sta. Yuma WB AP)	2.7	116	24	71	151 - 141
Limitrophe (Sta. Yuma WB AP)	2.7	116	24	71	141 - 99

Power Generation

Fiscal year	Senator Wash Pumping-Generating Plant, kWh	Fiscal year	Senator Wash Pumping-Generating Plant, kWh
1968	930,000	1973	1,616,000
1969	958,000	1974	1,378,000
1970	1,291,000	1975	1,331,000
1971	1,387,000	1976	[1]1,831,000
1972	1,025,000	1977	2,080,000

[1]Includes 510,000 kWh for the transition quarter.

ENGINEERING DATA

Water Supply

COLORADO RIVER (See Boulder Canyon Project.)

Storage Facilities

HOOVER DAM (See Boulder Canyon Project.)
DAVIS DAM (See Parker-Davis Project.)
PARKER DAM (See Parker-Davis Project.)
SENATOR WASH DAM

Diversion Facilities

PALO VERDE DIVERSION DAM (See Palo Verde Diversion Project.)
IMPERIAL DAM (See All-American Canal System.)
MORELOS DAM (Mexico's diversion dam)

Carriage Facilities

Mohave Valley Division

CHANNEL STABILIZATION

Location: Colorado River from Davis Dam, Arizona-Nevada, to Topock, Ariz., about 32 mi.
Construction period: 1949-53

Channel dredging and rectification	31	mi
Typical channel section:		
Average width of cut	450	ft
Average depth of cut	20	ft
Average depth of water at maximum flow of 15,000 ft³/s	18	ft
Maximum depth of water	25	ft
Stabilizing eroding riverbanks	12	mi
Volume of rock riprap	288,082	yd³
Training and jetty fill structures (est.)	16	mi
Volume of dredge spoil	52,531,728	yd³

LEVEES

Length	17	mi
Average height	13	ft
Design flood:		
Davis Dam to Piute Wash	50,000	ft³/s
Piute Wash to Lake Havasu	70,000	ft³/s
Volume (est.)	29,000,000	yd³
Access and service roads	106	mi
Average channel slope upstream of Needles Bridge	0.00024	
Average channel gradient, Needles Bridge to Topock	0.00016	

TOPOCK MARSH INTAKE STRUCTURE

Location: Arizona side of Colorado River near bridge at Needles, to upper end of Topock Marsh.
Construction period: 1965-66
Description: Three 42-in asbestos-bonded, corrugated-metal pipes with concrete headwalls and concrete inlet and outlet transitions. Diversion is from Colorado River.

Length of each pipe	204	ft
Diameter of each pipe	42	in
Diversion capacity	100	ft³/s

Gates: Three 42-in-diameter control gates and three 18- by 42-in rectangular gates for adjustment of flow measuring orifices.

TOPOCK MARSH INLET CANAL

Location: Extends eastward from intake structure below bridge at Needles to upper end of Topock Marsh.
Construction period: 1965-66

Length	4 mi
Bottom width	14 ft
Depth of water	4 ft
Capacity	100 ft³/s
Side slope	2:1
Gradient	0.00009
Annual diversion capacity	41,839 acre-ft
Surface area of marsh	4,000 acres

TOPOCK MARSH OUTLET STRUCTURE

Location: In Topock Dike near lower end of Topock Marsh.
Construction period: 1965-66
Description: A reinforced concrete structure with four 5-ft stop-log bays for water control and a 3-ft fish ladder and battery of flapgates to minimize reverse flows due to river floods.

TOPOCK SETTLING BASIN

Location: On the Colorado River, 6 mi south of Needles, Calif. It consists of a 4-mi-long reach extending upstream from Topock Bridge.
Construction period: 1955-56
Method of construction: Channel dredging

Length[2]	4.57 mi
Typical section:	
Average depth of the settling basin, when cleaned	18 ft
Maximum depth	25 ft
Average width	575 ft
Average summer flow	15,000 ft³/s
Average winter flow	7,000 ft³/s
Volume of material removed during construction	4,400,000 yd³
Sediment trap efficiency	90%
Annual sediment retention	900,000 yd³
Total capacity of the basin	2,000,000 yd³

TOPOCK MARSH DIKE

Location: The dike spurs from the Mohave Valley Division Levee about 5 mi northwest of Topock Bridge, runs in southeasterly direction for about 4 mi, ends on high ground north of Sacramento Wash.
Type: Earthfill
Construction period: 1965-66

Length	4 mi
Typical maximum section:	
Structural height	14 ft
Top width	24 ft
Crest elevation	460.0 ft
Slope: Natural angle of repose	10:1
Volume	1,016,377 yd³
Roadway on top of dike:	
Length	4 mi
Width	20 ft
Surfacing	0.5 ft

Outlet structure: Located in dike near lower end of marsh. It is a reinforced concrete structure with four 5-ft-long log bays and a 3-ft fish ladder.

[2]Length of the basin was increased from 4 to 4.57 mi in 1976 at the request of the Fish and Wildlife Service.

BIG BEND TRAINING DIKES

Location: About 10 mi downstream from Davis Dam.
Type: Earthfill structures
Construction period: 1959-60

Length	1 mi
Typical maximum section:	
Average structural height	9 ft
Top width	12-20 ft
Crest length — four structures	5,820 ft
Crest elevation	504.0 ft
Slope	2:1
Volume (rock)	21,000 yd³
Volume (gravel)	26,000 yd³

WATER CONTROL STRUCTURE, PARK MOABI

Location: About 8 mi south of Needles, Calif.
Construction period: 1965
Description: Three 42-in asbestos bonded, asphalt dipped corrugated metal pipe with 42-in-diameter slide gates and 16-ft frames and timber piling.

Length of each pipe	120 ft
Diameter of each pipe	42 in
Diversion capacity	100 ft³/s

Gates: Three 42-in-diameter control gates.

Topock Gorge Division

CHANNEL STABILIZATION

Location: On Colorado River from Topock, Ariz., to Lake Havasu, about 12 mi.
Construction period: 1967-68

Channel dredging and rectification[3]	1.7 mi
Typical channel section:	
Average width of cut	450 ft
Average depth of cut	20 ft

[3]Dredging was suspended June 1968 due to lack of agreement among the agencies involved.

Havasu Division

SNAG REMOVAL

Location: Lake Havasu and the river between Parker and Headgate Rock Dams.
Construction period: 1965, 1967, and 1969-71
Method of removing and disposing: The snags were removed by mechanical and physical methods, including explosives. The snags were disposed of by sinking waterlogged wood parts. All other parts were removed from the lake to disposal areas to dry and burn.

Total number of snags removed	7,510
Maximum cut of elevation below the normal operating level of the lake	435 ft
Normal operation level of the lake during removal	445-450 ft

Parker Division

CHANNEL STABILIZATION

Location: Headgate Rock Dam to Palo Verde Diversion Dam, 33 mi.

Palo Verde Diversion Dam and Levees
(See Palo Verde Diversion Project.)

CHANNEL STABILIZATION—SECTION I

Location: Within the Colorado River Indian Reservation and about 16 mi downstream from Headgate Rock Dam to Alligator Bend.
Construction period: 1966-68

Stabilizing eroding riverbanks	11	mi
Volume of rock riprap	235,000	yd³
Training and jetty fill structures	7.5	mi
Volume of fill structures	525,000	yd³
Bridge across river	1	
Access and service road construction	34	mi
Width of river channel	500	ft

CHANNEL STABILIZATION—SECTION II (PROPOSED)

Location: From Alligator Bend to Palo Verde Diversion Dam.
Construction period: Proposed

Channel dredging and rectification	21.4	mi
Volume of excavation by land-based equipment	5,800,000	yd³
Volume of dredged spoil	11,600,000	yd³
Volume of rock riprap	516,000	yd³
Access and service road construction	53	mi
Bridges across canals (new)	2	
Bridges across canals (reinforced)	2	
Width of river channel	500	ft
Side slopes	1.5:1	

FISH AND WILDLIFE AND RECREATION—SECTION I

DEER ISLAND BACKWATER IMPROVEMENT

Location: On Arizona side of Colorado River about 5 mi downstream from Headgate Rock Dam and across from Big River.
Construction period: 1968-69

Deepening of backwater areas by dredging	781,836	yd³
Outlet structure	1	
Parking unit	1	
Road construction	2.5	mi

FISH AND WILDLIFE AND RECREATION—SECTION II

Type of development: Deepening of backwater areas by dredging and installation of inlet and outlet structures for fresh water flows.
Construction period: Proposed

Deepening of backwater areas by dredging	4,660,000	yd³
Inlet and outlet structures for circulatory flows to backwaters	20	
Parking and sanitary units	5	
Road construction	24	mi

Palo Verde Division

CHANNEL STABILIZATION AND TRAINING STRUCTURES

Location: Palo Verde Diversion Dam to Taylor Ferry, 28 mi.
Type of development: Stabilized banklines and training structures, constructed with land-based equipment.
Construction period: 1962-68

Stabilizing eroding riverbanks	19.5	mi
Volume of rock riprap	466,000	yd
Access and service roads	23.6	mi

BACKWATER IMPROVEMENTS

Location: Includes areas A-7, A-10, C-5, and C-10.
Type of development: Deepening of backwater areas to enhance fish and wildlife habitat by dredging and constructing inlet and outlet structures to provide fresh water circulation to backwater areas.
Construction period: 1969-70

Deepening backwater areas by dredging	2,012,861	yd³
Inlet and outlet structures for circulatory flow	12	
Capacity of inlet and outlet structures (each)	30	ft³/s

DEVELOPMENT OF BLYTHE MARINA

Location: North of Interstate I-10 Bridge, Riverside County, Calif.
Type of development: Backwater area excavated by land-based equipment and 8-in dredge to develop boat marina.
Construction period: 1966

DEVELOPMENT OF MCINTYRE PARK

Location: 7 mi south of Blythe, Calif., on 26th Ave. and Colorado River.
Type of development: Training structure and backwater dredging.
Construction period: 1972

Cibola Division

CHANNEL STABILIZATION AND LEVEE

Location: From 2.2 mi below Taylor's Ferry to Adobe Ruin, 24 mi.
Type of development: Channel excavation and levee construction by dredging.
Construction period: 1964-70

Channel dredging and rectification	16	mi
Typical channel section:		
Average width of cut	450	ft
Average depth of cut	20	ft
Average depth of water at minimum flow of 10,000 ft³/s	7.6	ft
Average depth of water at maximum flow of 20,000 ft³/s	11.5	ft
Volume dredge excavation and levee construction	10,343,000	yd³
Volume of rehandled dredge and levee material	981,700	yd³
Riprap	254,400	yd³

LEVEES

Length	32.2	mi
Typical section:		
Average height	15	ft
Design flood	80,000	ft³/s
Width between levees—varies	750-1,000	ft
Volume	6,309,230	yd³
Levee roads	32.2	mi
Total access and service roads	51.8	mi
Average channel gradient	0.00042	

DREDGING CIBOLA LAKE

Location: Lower end of Cibola Valley on the Arizona side near Adobe Ruin.
Construction period: 1970

Volume of material excavated by dredging	2,238,300	yd³

BACKWATER IMPROVEMENT PALO VERDE DRAIN

Location: Abandoned river channel from outfall of the Palo Verde Drain to Adobe Ruin.

Construction period: 1970
Description: Extension of Palo Verde Drain to carry drainage water, originating in Palo Verde Irrigation District, to a new outfall into the relocated river channel near Adobe Ruin.

Length of abandoned channel	12	mi
Width of abandoned channel	150	ft
Elevation of outfall near Adobe Ruin with a riverflow of 10,000 ft³/s	210	ft
Average flow of drain (approx.)	500	ft³/s
Minimum flow	282	ft³/s
Maximum flow	577	ft³/s

DREDGING NEAR WALTER'S CAMP

Location: Imperial County, Calif.
Construction period: 1974

Imperial Division

SILT REMOVAL ABOVE IMPERIAL DAM

Location: Diversion pool immediately upstream from Imperial Dam near the headworks of the Gila Gravity Canal.
Construction period: Intermittent dredging since 1969

Storage Facilities

SENATOR WASH DAM

Type: Three-zoned earthfill, except for a low dike at the right abutment, which is single-zoned
Location: Offstream, pumped-storage feature 2 mi upstream from Imperial Dam and at the river end of Senator Wash.
Construction period: 1964-66
Date of closure (first storage): January 30, 1966
Reservoir, Senator Wash: Offchannel regulating reservoir. Water pumped from the Colorado River.

Total capacity	13,836	acre-ft
Active capacity	12,259	acre-ft
Surface area	470	acres
Elevation: Top of active conservation	251.0	ft
Dimensions:		
Structural height	93.6	ft
Height above bed of wash	84	ft
Crest width	30	ft
Maximum base width	619	ft
Crest length	2,342	ft
Crest elevation	265.0	ft
Total volume including riprap and bedding	1,248,000	yd³
Thickness of protective riprap	3	
Slope:		
Upstream from crest to El. 210	3:1	
From El. 210 to foundation	4:1	
Downstream from crest to El. 240	2:1	
From El. 240 to foundation	4:1	

Spillway:
Type: Uncontrolled concrete overflow with flip buckets

Width	20	ft
Crest length	208.22	ft
Crest elevation	251.0	ft
Capacity at El. 251	1,780	ft³/s

Inlet channel:
Type: Trapezoidal

Length	170	ft
Bottom width	20	ft
Sideslopes:		
Below El. 259	2:1	
Above El. 259	1:1	
Floor elevation	248.0	ft

Crest Structure and Bridge:
Type: Monolithic concrete section
Dimensions:

Length	73	ft
Width of monolithic section	20	ft
Floor thickness varies	12-5.5	in

Spillway bridge: 17-ft-wide, single-lane provides access to the dam.
Outlet works:
Type: Reinforced concrete conduit discharging directly into the manifold of pumping-generating plant.
Location: Center of Squaw Lake Dike; consists of an approach channel, intake structure, pressure conduit, gate chamber and shaft, downstream conduit, and access house.

Approach channel and intake structure:

Length of channel	250	ft
Bottom width	60	ft
Bottom elevation	189.5	ft
Sideslopes with riprap protection	2:1	

Intake structure: Upstream toe of the dam with a sill elevation of 190 ft. It consists of a solid top slab supported by six vertical columns, which support five vertical trashracks, a transition section for stop logs, and a heavy concrete base.

Height of structure	27.8	ft
Width of structure	41	ft

Pressure conduit: A reinforced concrete conduit extending through dike from intake structure to gate structure.

Length	187	ft
Inside diameter	120	in

Three concrete cutoff collars 18 ft apart.
Downstream pressure conduit: A 15-ft-inside-diameter reinforced concrete conduit section extending from gate chamber to access house.

Length	161	ft
Inside diameter of steel outlet pipe	120	in

Gated chamber and shaft: These facilities are upstream from the axis of dike, with a circular reinforced concrete shaft-type structure extending from conduits to top of dike. The gated chamber houses one 6.5- by 10-foot-high pressure gate. The inside diameter of the circular shaft is 8.5 feet.
Foundation: The abutments of Senator Wash Dam are andesite. The rock is generally highly fractured and has no regular breakage pattern. The fractures are almost always tight and secondary mineralization is well developed.
Special treatment: Pressure grouting required for rock formations under the earth embankment, the outlet works, gate chambers, and spillway crest.
Dike:
Type: Single-zoned earthfill
Location: At right abutment of Senator Wash Dam.
Construction period: 1966
Dimensions:

Maximum height	11	ft
Crest width	20	ft
Crest length	100	ft
Crest elevation	265.0	ft
Maximum base width	85	ft
Slope, upstream	3:1	

Slope, downstream	2:1
Protective rock riprap	3 ft

SQUAW LAKE DIKE

Type: Three-zoned earthfill
Location: In a saddle between Senator Wash and Squaw Lake.
Dimensions:

Maximum height	95.3 ft
Crest width	30 ft
Crest length	3,795 ft
Crest elevation	265.0 ft
Maximum base width	455 ft
Total embankment volume	950,000 yd³
Upstream slope	3:1
Downstream slope:	
From crest to El. 230	2:1
From El. 230 to foundation	4:1
Thickness of protective riprap	3 ft

Foundation: From left abutment for 21 ft, the foundation for Squaw Lake Dike is a lithic tuff. The rock is intensely fractured with an absence of secondary mineralization. Bearing capability is good and loads are minimal in this interval. The tuff is in fault contact with andesite. In the next 154 ft, the rock is andesite, although some talus and recent slope wash comprise part of the foundation on either side of the grout cap. The andesite is fractured and brecciated. Fractures are tight or healed with secondary minerals. For the next 308 ft, the Squaw Lake fault zone comprises the foundation and the south bank of the cutoff trench for 28 ft. In the next 102 ft, the rock is primarily a granite gneiss with a fault breccia structure. Fanglomerate is in fault contact with the brecciated tuff, which lies unconformably on trachyte near the outlet works in the dike. It underlies alluvium in the Squaw Lake for 220 ft. The fanglomerate is a dense rock with very low permeability. The short section (77 ft) in the outlet works trench is brecciated trachyte. The foundation is in silicic tuff for 228 ft. For the remaining 1,796 ft, the foundation is Pleistocene alluvium except for short sections of trachyte.

Special treatment: Pressure grouting required for rock formations under the embankment.

NORTH DIKE

Type: Two-zoned earthfill
Location: In a saddle northwest of Senator Wash Dam.
Dimensions:

Crest height	67.2 ft
Crest width	25 ft
Crest length	613 ft
Crest elevation	265.0 ft
Maximum base width	230 ft
Total embankment volume	79,000 yd³
Upstream slope	2.5:1
Downstream slope	2:1
Thickness of protective riprap	3 ft

Foundation: The full length of cutoff trench at North Dike was excavated to andesite bedrock. The dike foundation is andesite except a short section where sand and gravel of recent channel fill is present on either side of the cutoff trench.

Special treatment: Pressure grouting was required for rock formation under embankment and a grout cap was required under the cutoff trench.

Power Facilities

PUMPING GENERATING PLANT

Location: At discharge end of outlet works downstream from Squaw Lake Dike.
Year of initial operation: 1966
Year last generator placed in operation: 1966

Nameplate capacity	7,200 kW
Number of synchronous motor-generating units (including one spare)	6
Characteristics when operated as a pumping plant:	
Motor rating	1,750 hp
Maximum pump rating	1,575 hp
Rotational velocity	360 r/min
Rated head-pump	74 ft
Rated capacity of each pump	100 ft³/s
Installed capacity of each pump at rated head	160 ft³/s
Direction of unit: Clockwise (when looking down on unit)	
Characteristics when operating as a generating plant:	
Number of synchronous motor generators (including one spare)	6
Generator rating	1,200 kVA
Generator rating	4 kV
Maximum turbine rating	1,135 hp
Effective rated head of the centrifugal-type pump-turbines	65 ft
Rated capacity-turbine	200 ft³/s
Speed	360 r/min
Direction of rotation: Counterclockwise (when looking down on unit).	

Switchyards

Number in operation	1
Capacity of transformers	7,500-9,375 kVA
Transmission lines:	
Total number of lines	1
Total circuit miles	17.7 mi

Laguna Division

LAGUNA SETTLING BASIN

Location: On the 4.7-mi reach of Colorado River between Imperial Dam and Laguna Dam.
Construction period: 1963-65
Method of construction: Dredging

Length	0.57 mi
Maximum depth of settling basin, when cleaned	24 ft
Average width	450 ft
Sluicing flows	5,000-7,500 ft³/s
Flows downstream from Imperial Dam are usually less than 1,000 ft³/s. Flows of 3,000 ft³/s occur once or twice a year.	
Total volume of material removed from settling basin and inlet and outlet channels by dredging and land-based equipment	3,120,000 yd³
Average water salvaged per year (est.)	4,300 acre-ft
Inlet channel:	
Length	10,000 ft
Bottom width	90 ft
Designed depth at 5,000 ft³/s of flow	8 ft
Volume of riprap	4,200 yd³

Volume of material removed by dredging (est.)	1,100,000	yd³
Volume of material removed by land-based equipment	90,000	yd³
Outlet channel:		
Length	8,700	ft
Bottom width	120	ft
Designed depth at 5,000 ft³/s of flow	10	ft
Volume of material removed by dredging (est.)	1,500,000	yd³
Volume of material removed by land-based equipment	130,000	yd³

MITTRY LAKE DREDGING

Location: Mittry Lake was formed by Laguna Dam. On east side of original reservoir, it extends from dam upstream to within 1 mi of Imperial Dam.
Construction period: 1970-73
Method of construction: Dredging

Land and water area	3,575	acres
Reduction of Mittry Lake area from 1,200 to about 725 acres.		
Deepening 200 acres offshore in the 725-acre lake to minimum depth	10	ft
Clearing of phreatophytes	940	acres
Volume of material removed by dredging	2,019,000	yd³
Lake elevation	153.5	ft

GILA SLUICEWAY

Location: The original river channel from the Gila Gravity Main Canal to the California Sluiceway.
Construction period: Original dredging in 1970. Supplemental dredging in 1973.
Method of construction: Dredging

Length of dredged channel	0.5	mi
Width	150	ft
Depth	12	ft
Volume of material removed	125,105	yd³

Carriage Facilities

Yuma Division

LEVEES

Location: From Laguna Dam to the Southerly International Boundary.
Construction period: 1951-52
Description: Widening and raising existing Yuma Levee, widening and raising portion of existing Reservation Levee, constructing new stretch of the Reservation Levee around Yuma Island, and new levee and floodway along the Gila River.

YUMA LEVEE (IMPROVEMENT)

Type: Earth embankment and rock riprap
Location: Extends along left bank of Colorado River from Yuma, Ariz., to Southerly International Boundary.
Construction period: 1951-52

Length	23.7	mi
Dimensions:		
Top width	20	ft
Side slopes:		
River side	2:1	
Land side	3:1	
Volume of embankment	836,000	yd³
Thickness of riprap blanket	5	ft
Volume of riprap	247,000	yd³
Area protected—Yuma Valley	50,400	acres
Design flood	140,000	ft³/s

RESERVATION LEVEE (IMPROVEMENT AND NEW LEVEE)

Type: Earth embankment and rock riprap
Location: Extends south from Laguna Dam along California side of Colorado River to high ground about 4 mi west at Winterhaven, Calif.
Construction period: 1951-52

Length	17.4	mi
Dimensions:		
Top width	30	ft
Side slopes:		
River side	2:1	
Land side	3:1	
Volume of embankment	898,950	yd³
Thickness of riprap blanket	5	ft
Volume of riprap	297,000	yd³
Area protected—Lower Colorado River Valley in California	21,400	acres
Design flood	140,000	ft³/s

IMPERIAL LEVEE[3]

Type: Earth embankment
Location: Immediate vicinity of Hanlon Heading on the Alamo Canal.
Construction period: 1951-52

Length	0.23	mi
Dimensions:		
Top width	20	ft
Side slopes:		
River side	2:1	
Land side	3:1	
Volume of new embankment	19,000	yd³
Design flood	140,000	ft³/s

GILA LEVEES AND FLOODWAY

Type: Earth embankment
Location: Two parallel levees down the lower Gila Valley, about 0.5 mile apart with a floodway channel some 200 feet wide between the two levees. The channel and levees begin below McPhaul Bridge and the channel extends to developed mouth of Gila River. One levee ties to existing North Gila Levee and the other ends at high ground near Yuma.

Length	22	mi
Dimensions:		
Top width	20	ft
Volume of new embankment	1,420,000	yd³
Length of floodway	6.75	mi
Volume of excavation	2,000,000	yd³
Area protected	26,000	acres
Design flood	140,000	ft³/s

MAIN OUTLET DRAIN (MOD)

Type: Concrete lined
Location: Parallels Gila River and South Gila Valley Levee from Gila River Siphon to 0.5 mi upstream from confluence of Gila River with Colorado River.
Construction period: 1960-62

Length	8	mi
Capacity	353	ft³/s
Typical maximum section, concrete lined:		
Bottom width	8	ft

[3]This levee prevents floods in the Colorado River from bypassing Hanlon Heading in the United States and flowing into the Salton Sea via the Alamo channel.

Side slope	1.5:1
Water depth	4.3-6.0 ft
Lining thickness	2.5 in

MAIN OUTLET DRAIN EXTENSION (MODE) - DELIVERY OF WATER TO MEXICO

Location: Extends from end of Main Outlet Drain to below Morelos Dam.
Construction period: 1963-65

Length	12 mi
Capacity	353 ft³/s
Typical maximum section, concrete lined:	
Bottom width	12 ft
Side slope	1.5:1
Water depth	5.8 ft
Lining thickness	3 in

CHANNEL STABILIZATION

Location: From Laguna Dam to Rockwood Heading.
Construction period: 1969

Channel dredging and rectification	17.4 mi
Bottom width from Laguna to mouth of Gila River	120 ft
Side slopes	1.5:1
Gradient	0.00023
Bottom width from mouth of Gila River to Rockwood Heading	150 ft
Side slopes (approx.)	1.5:1
Maximum gradient from mouth of the Gila River to California Wasteway	0.00023
Gradient from California Wasteway to Rockwood Heading	0.000095
Design flow of channel	5,000 ft³/s
Grade control structures	2
Average flow from Laguna Dam to mouth of Gila River	250-300 ft³/s
Average flow from mouth of Gila River to California Wasteway	400-450 ft³/s
Average flow below California Wasteway	700-1,500 ft³/s
Average depth of water at maximum flow of 300 ft³/s	2.3 ft
Average depth of water at 700 ft³/s	3 ft
Volume of dredge spoil	4,213,000 yd³
Volume of rock riprap	264,000 yd³
Road construction	41 mi
Clearing	2,200 acres

YUMA VALLEY DRAINAGE WELL FIELD

Location: East side of Yuma Valley near toe of Yuma Mesa.
Construction period: 1965

Number of wells	6
Average depth	180 ft
Diameter of well at surface	24 in
Total annual production:	
Maximum design	31,500,000 acre-ft
Average yearly	10,000,000 acre-ft

PUMPING UNITS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
YVI-7	1	4.4	61	40
YVI-13	1	12.0	59	125
YVI-23	1	8.0	57	75
YVI-25	1	8.0	67	100
YVI-27	1	2.8	67	30
YVI-28	1	8.3	64	100

YUMA VALLEY DRAINAGE WELL COLLECTOR CHANNEL

Type: Concrete
Location: An open collector channel that collects the discharge from Yuma Valley Wells Nos. YVI-25, -27, -28, and Yuma County Water Users' Association's Well Nos. 17-1/2 Street and 18-1/4 Street and conveys the drainage water north to the Southeast Drain. This drain discharges into the Main Drain of the Yuma Project.
Construction period: 1965

Length	1.2 mi
Capacity:	
Maximum	26 ft³/s
Minimum	8 ft³/s
Typical section, concrete lined:	
Bottom width	2 ft
Side slope	1:1
Depth	3 ft
Lining thickness	3 in
Slope of bottom:	
Maximum	0.0008
Minimum	0.0001

SOUTH GILA VALLEY DRAINAGE WELL FIELD AND DRAIN PUMP OUTLET CHANNEL (DPOC)

Type: Gravel-packed, cased, and screened
Location: About 4 mi southeast of Yuma, Ariz., between the north toe of Yuma Mesa and the Gila River; extends from below Gila River Siphon to below confluence of Gila and Colorado Rivers.
Construction period: 1961-64

Number of wells	24
Average depth of wells, varies	160-300 ft
Nominal diameter of wells at surface	30 in
Casing: Protective casing nominal diameter 3 to 15 ft below concrete slab and 1.33 ft above ground surface. A 20-in-inside-diameter, 50-ft linear section reduced to 127 ft of 16-in linear pipe and screen.	
Total annual production	55,000 acre-ft
Average salinity of pumped drainage water	2,200 p/m

PUMPING UNITS

Designation	Number of units	Total capacity, est. from records, ft³/s	Pumping level, est. from records, ft: Actual	Initial	Total horsepower
BR-1	1	7.8	34	22	60
BR-2	1	9	38	32	60
BR-3	1	9	35	20	60
BR-4	1	11	32	26	60
BR-5	1	10	30	12	60
BR-6	1	11	28	32	60
BR-7	1	9	30	39	60
BR-8	1	9	37	35	60
BR-9	1	9	28	20	60
BR-10	1	11	52	42	60
BR-11	1	11	45	40	75
BR-12	1	9.5	55	42	75
716	1	7.8	34	33	60
717	1	8	32	36	60
718	1	9	27	30	60
719	1	9	24	29	60
720	1	10	23	31	60
721	1	9	33	37	60
713	1	6.7	50	37	60
714	1	7.4	40	41	60
708	1	7	32	85	40
709	1	8.5	49	52	40
710	1	10	40	44	60
711	1	10	24	40	100

DPOC No. 1

Location: In South Gila River Valley about 4 mi southeast of Yuma, Ariz.
Construction period: 1961

Length	3.44	mi
Open channel	3.40	mi
Pipeline	0.04	mi
System capacity for eight drainage wells, BR-1, -2, -3, -4, -9, -11, -12, and well 716:		
Maximum	40	ft³/s
Minimum	8	ft³/s
Typical section (open channel):		
Bottom width	2	ft
Side slopes	1.5:1	
Water depth:		
Maximum	3.5	ft
Minimum	1.5	ft
Lining concrete	2	in
Typical section (pipeline):		
Type: PCP pipe		
Length	0.04	mi
Size	30	in

DPOC No. 2

Location: In South Gila River Valley about 5.5 mi east of Yuma, Ariz.
Construction period: 1961-65

Length	2.72	mi
Open channel	2.62	mi
Pipeline	0.10	mi
System capacity for six drainage wells, BR-5, -6, -7, -8, 10, and well 717	50	ft³/s
Typical section (open channel):		
Bottom width	2	ft
Side slopes	1.5:1	
Water depth:		
Maximum	3.4	ft
Minimum	1.6	ft
Lining concrete	2	in
Typical section (pipeline):		
Type: PCP pipe		
Length	0.10	mi
Maximum diameter	36	in
Minimum diameter	24	in

DPOC No. 3

Location: In South Gila River Valley about 7 mi east of Yuma, Ariz.
Construction period: 1964

Length	5.8	mi
Open channel	1.8	mi
Pipeline	4.0	mi
System capacity for six wells, Nos. 713, 714, 718, 719, 720, and 721	60	ft³/s
Typical section (open channel):		
Maximum	7	ft
Minimum	3	ft
Side slopes	1.5:1	
Water depth:		
Maximum	3.4	ft
Minimum	2.6	ft
Lining concrete	2	in
Typical section (pipeline):		
Type: Cast-in-place concrete pipe		
Length	4.0	mi
Maximum diameter	42	in
Minimum diameter	24	in

DPOC No. 4

Location: In the South Gila River Valley about 2 mi east of Yuma, Ariz.
Construction period: 1965

Length	3.4	mi
Open channel	0.6	mi
Pipeline	2.8	mi
System capacity for four wells, Nos. 708, 709, 710, and 711	40	ft³/s
Typical section (open channel):		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth, varies	1-2	ft
Lining concrete	Unlined	
Typical section (pipeline):		
Type: Precast concrete		
Length	2.8	mi
Maximum diameter	42	in
Minimum diameter	24	in

Yuma Mesa Well Field

Location: Along western edge of Yuma Mesa about 2 mi south of Yuma, Ariz.
Construction period: 1968-71

Number of wells	12	
Depth of wells, varies	189-286	ft
Diameter of wells at the surface	24	in
Maximum total capacity of the wells	100	ft³/s
Total annual production	60,000,000	acre-ft
Salinity of the pumped water	1,330	p/m

Pumping Units

Designation	Number of units	Total capacity, ft³/s Actual	Total capacity, ft³/s Initial	Original total dynamic head ft	Total horsepower, original motor
YM-2	1	1.5	8.5	131.4	200
YM-3A	1	7.0	9.8	112.7	200
YM-4	1	2.0	8.1	138.8	[5]200
YM-5A	1	5.5	7.3	114.3	150
YM-6	1	5.5	7.9	140.1	200
YM-7	1	5.0	8.8	127.3	200
YM-8	1	6.5	6.7	126.8	[5]150
YM-9	1	5.5	8.2	136.8	200
YM-10	1	9.0	9.4	148.1	250
YM-11	1	9.0	9.1	153.7	250
YM-12	1	9.0	8.9	155.5	250
YM-13	1	8.5	7.3	154.3	200

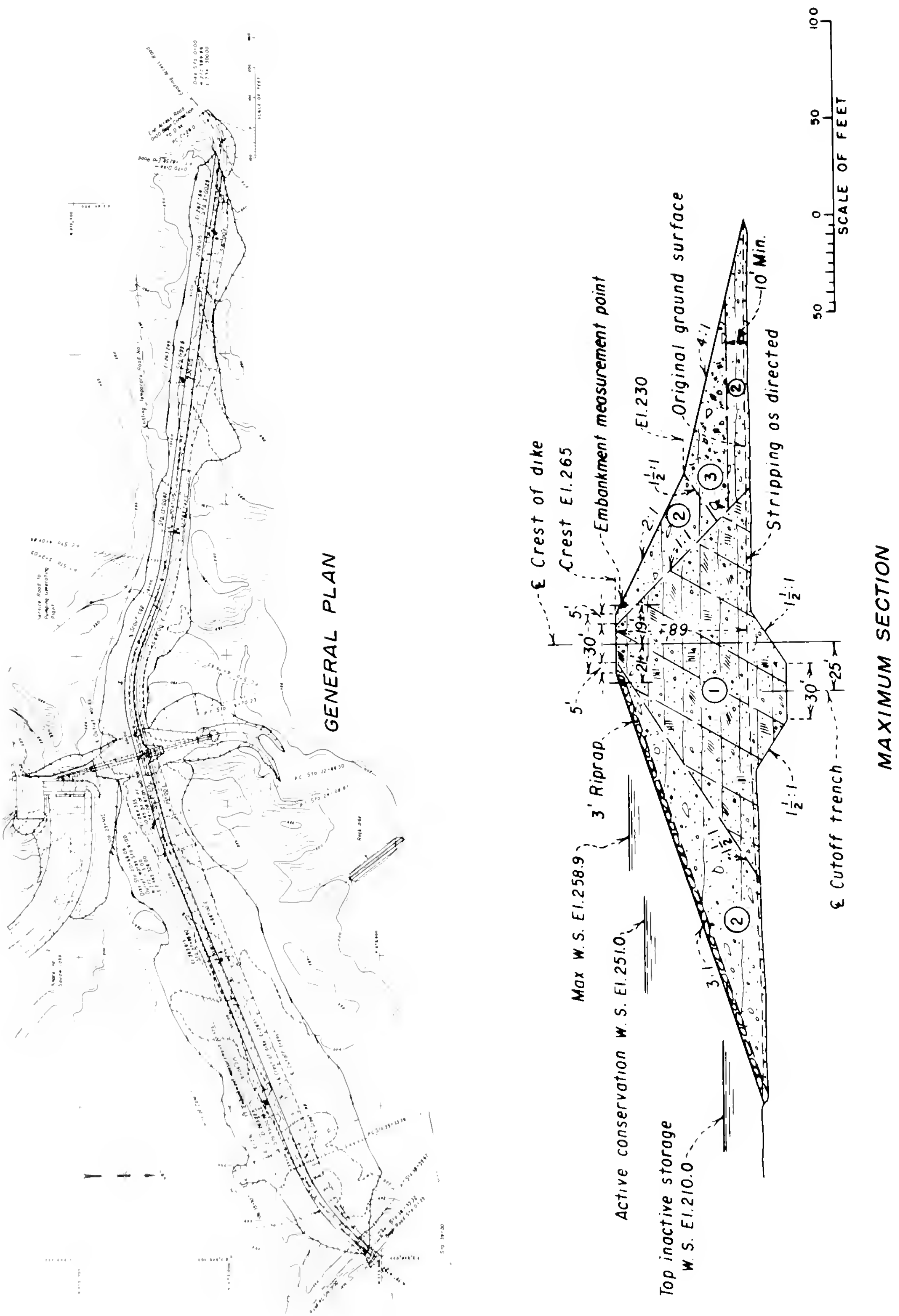
[5]In 1973, due to lost well capacity in YM-4, the horsepower of the motor was changed to 150. To offset this loss, the horsepower of the motor for YM-8 was increased to 200.

Conduit System

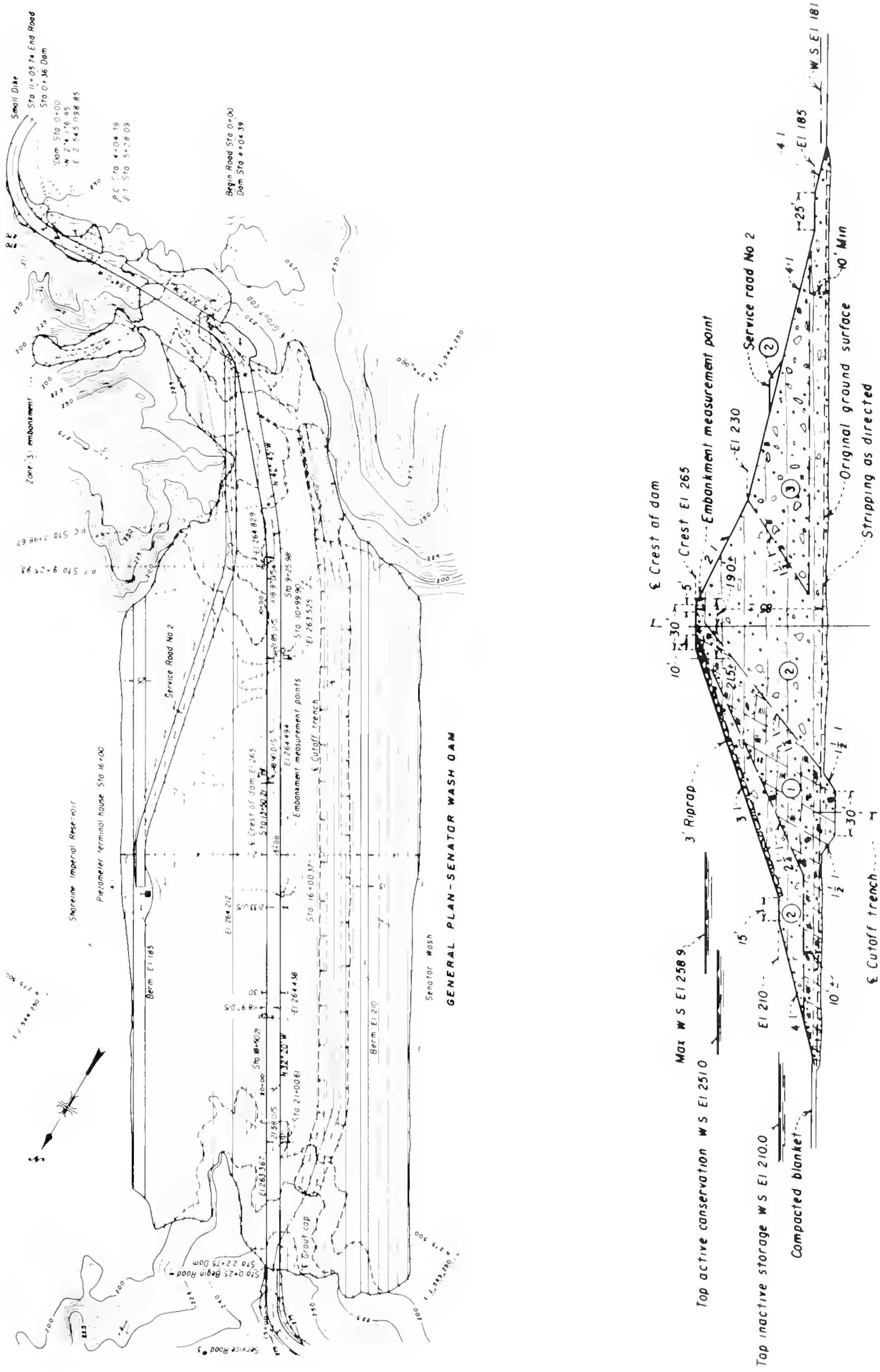
Type: Reinforced concrete pressure pipe
Location: Extends from center of the south line of Section 23, T.10S. R.24W. G&SRM, to a point on the Colorado River about 2.5 mi northwest of Yuma, Ariz.
Construction period: 1967-68

Total length of pipeline:		
Length of mainline	14.7	mi
Length of collector lines	5.1	mi
Diameter of main conduit (varies)	24-66	in
Diameter of collector conduit (varies)	18-24	in
Capacity of main conduit:[6]		
Maximum	125	ft³/s
Minimum	7.6	ft³/s
Velocity	2.6-5.5	ft/s

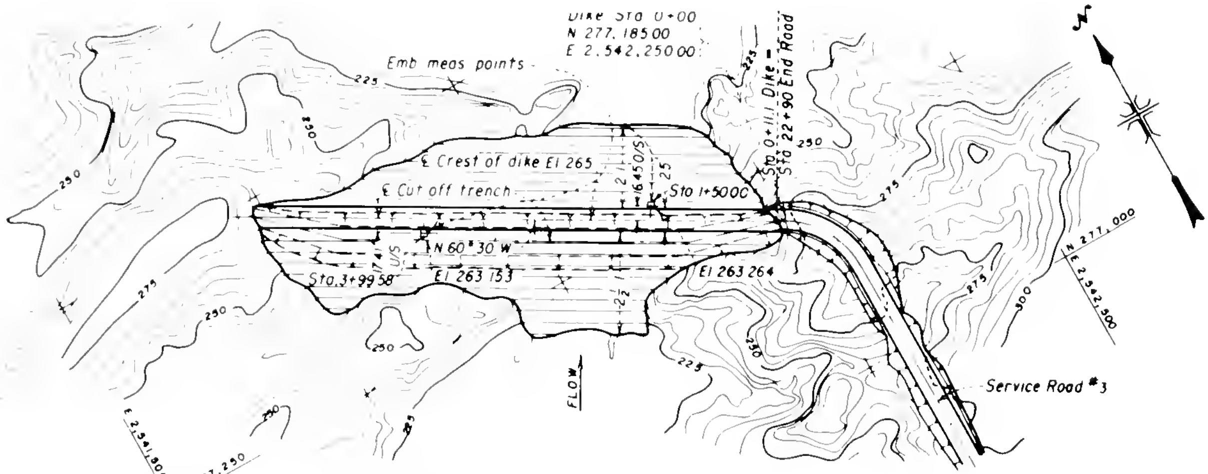
[6]Starting at well No. 13, the Yuma Mesa conduit increases in capacity by increments as it picks up the flows from each of the wells along the course.



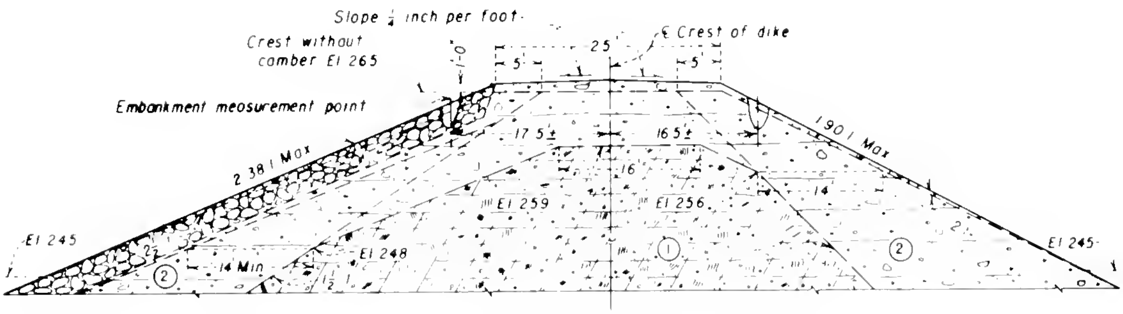
Squaw Lake Dike, Plan and Section



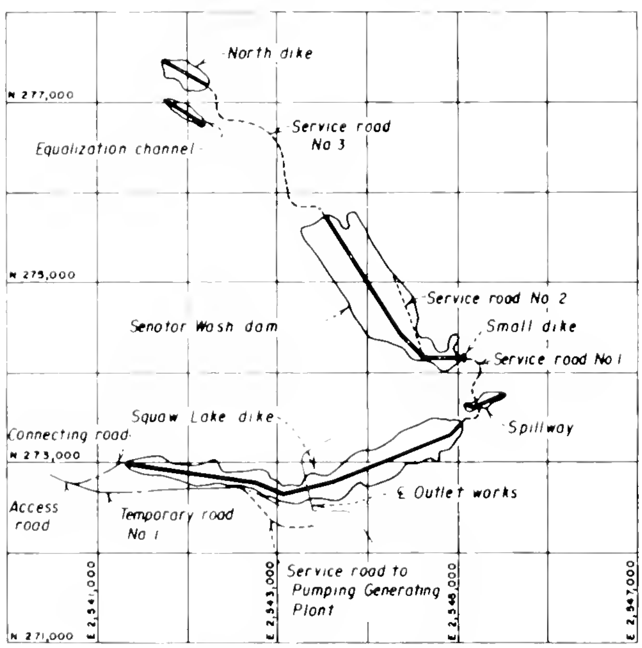
Senator Wash Dam, Plan and Section



GENERAL PLAN-NORTH DIKE



CREST DETAILS-NORTH DIKE



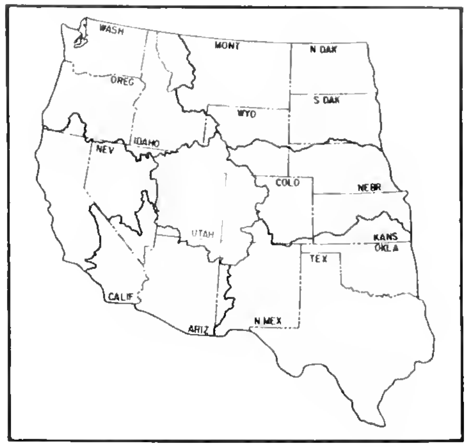
STRUCTURE LOCATION

North Dike, Plan, Section, and Location

Colorado River Storage Project
(Under Construction)

Arizona, New Mexico, Colorado, Utah, and Wyoming

Upper Colorado Region
Water and Power Resources Service



The Colorado River Storage Project (CRSP) provides for the comprehensive development of the Upper Colorado River Basin. The project furnishes the long-time regulatory storage needed to permit States in the upper basin to meet their flow obligation at Lees Ferry, Wyoming, as defined in the Colorado River Compact, and still utilize their apportioned water.

Water stored by the project provides a portion for direct use in the upper basin. Sediment and flooding are better controlled and recreation development and fish and wildlife conservation have benefited. Because of project development, a significant amount of electrical energy is produced to meet the needs of the upper basin and adjacent areas.

The project includes four storage units: Glen Canyon on the Colorado River in Arizona near the Utah border; Flaming Gorge on the Green River in Utah near the Wyoming border; Navajo on the San Juan River in New Mexico near the Colorado border; and Curecanti on the Gunnison River in west-central Colorado. Authorized with, but not part of, are a number of participating projects which will share in the power revenues of the larger project to help pay for irrigation construction costs. These participating projects are listed in the authorization paragraphs.

PLAN

The reservoirs formed by four units of the CRSP have a total capacity of nearly 34 million acre-feet. During periods of low streamflow, the stored water in the upper basin is released to meet the Lees Ferry obligation. Powerplants and other facilities are provided at each dam except Navajo, and a complex transmission system also has been provided. This transmission system carries CRSP power to key load points in the marketing area. The system is integrated with preference-user and private-company transmission lines to form the CRSP Interconnected Transmission System. CRSP hydropower is delivered to preference-user organizations for distribution to their consumers as required by Federal Reclamation Law.

Glen Canyon Unit

Glen Canyon Dam, Lake Powell, and Glen Canyon Powerplant

Glen Canyon Dam, 15 miles upstream from Lees Ferry, is the key feature of the CRSP. This 710-foot-high structure provides more storage capacity than all other storage features of the project combined. The concrete arch dam has a crest length of 1,560 feet and contains 4,901,000 cubic yards of concrete. Thickness of the dam at the crest is 25 feet, and the maximum base thickness is 300 feet.

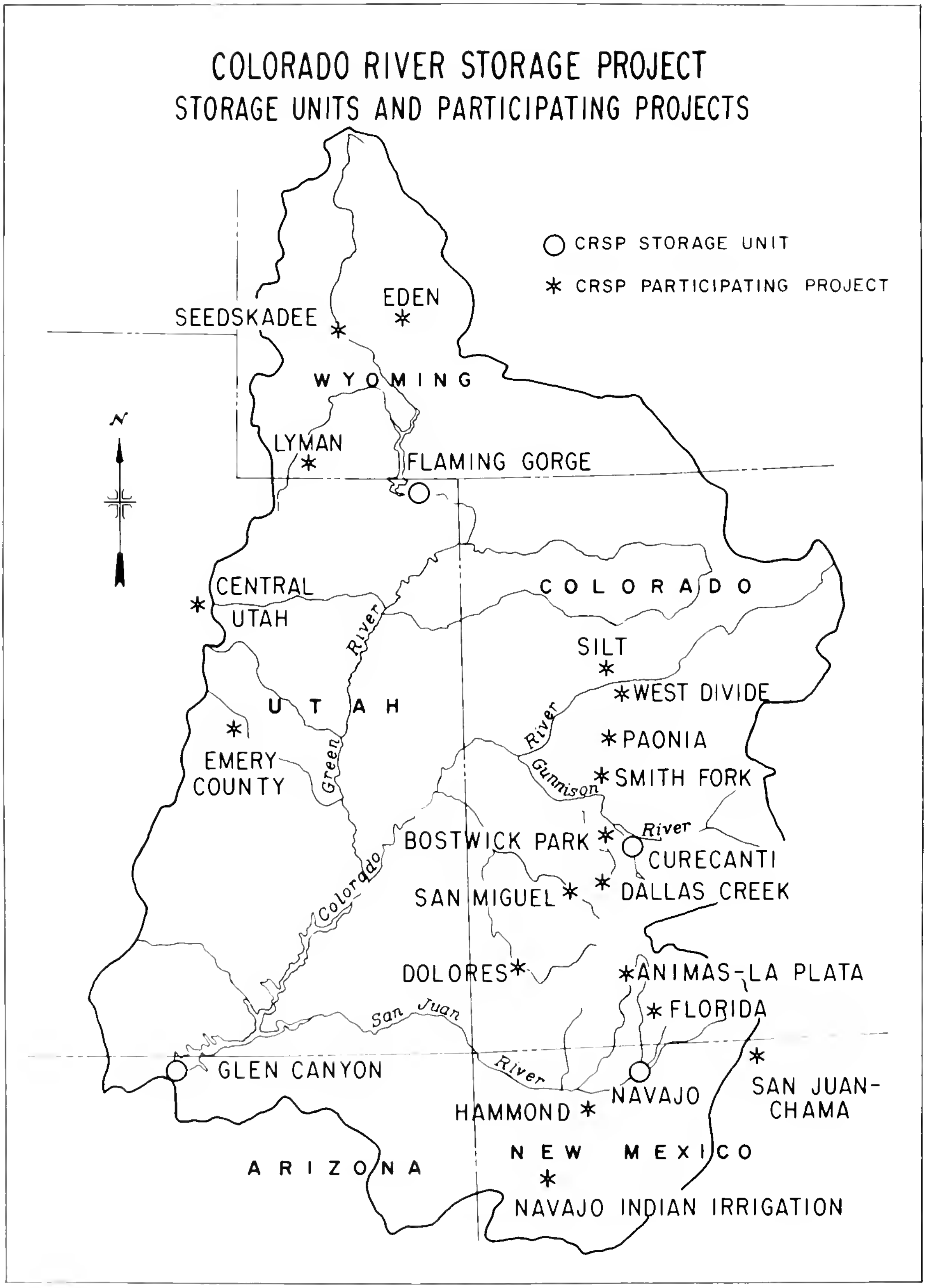
A separate spillway is constructed in each abutment. Each spillway consists of an intake structure with two

40- by 52.5-foot radial gates and a lined spillway tunnel. The downstream portions of the spillway tunnel were used during construction as diversion tunnels. Each spillway tunnel reduces in size from 48 to 41 feet in diameter. The combined spillway discharge capacity is 208,000 cubic feet per second at elevation 3700.

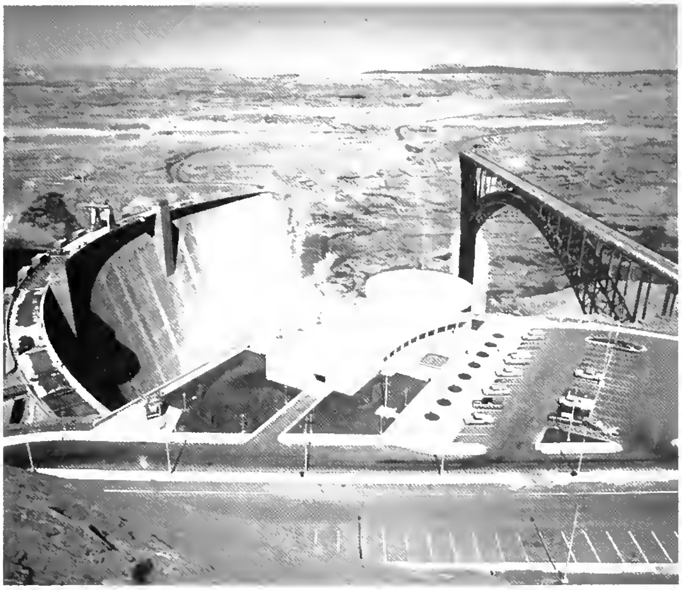
The outlet works near the left abutment of the dam consists of four 96-inch-diameter pipes. Each outlet is controlled by one 96-inch-ring follower gate and one 96-inch hollow-jet valve. The combined river outlet works capacity is 15,000 cubic feet per second.

Total capacity for Lake Powell is 27 million acre-feet, and the active capacity is 20,876,000 acre-feet. At normal water surface elevation, the reservoir has a length of 186 miles and a surface area of 161,390 acres.

The powerplant at the toe of the dam consists of eight 118,750-kilowatt generators, driven by eight 155,500-horsepower turbines. Total nameplate generating capacity for the powerplant is 950,000 kilowatts. Eight penstocks through the dam convey water to the turbines. Each penstock reduces in size from 15 to 14 feet in diameter.



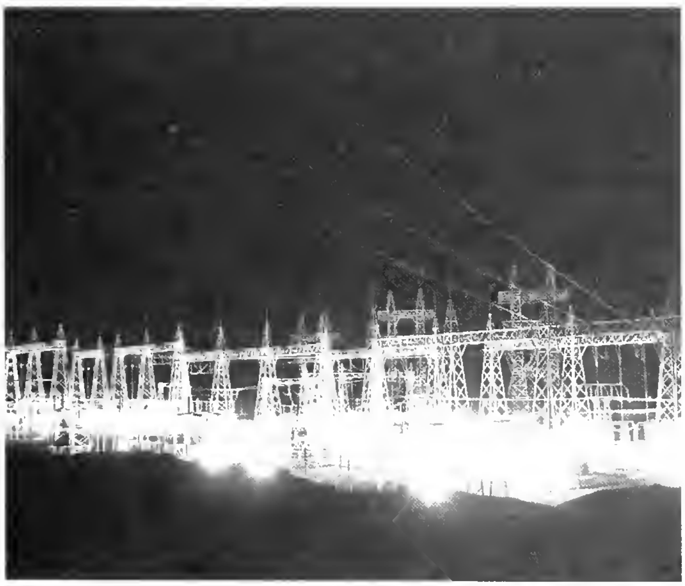
Colorado River Storage Project



Glen Canyon Dam and Bridge

Glen Canyon Bridge

The absence of rail facilities near the construction site of Glen Canyon Dam necessitated construction of Glen Canyon Bridge for the transportation of construction materials and equipment from railheads to the site. A single-span, steel-arch structure, the bridge has an overall length of 1,271 feet. At its completion in 1959, it was the highest arch bridge in the world and the second longest of its type in the United States. The bridge spans the Colorado River 865 feet downstream from the dam. The deck of the bridge is 700 feet above river level.



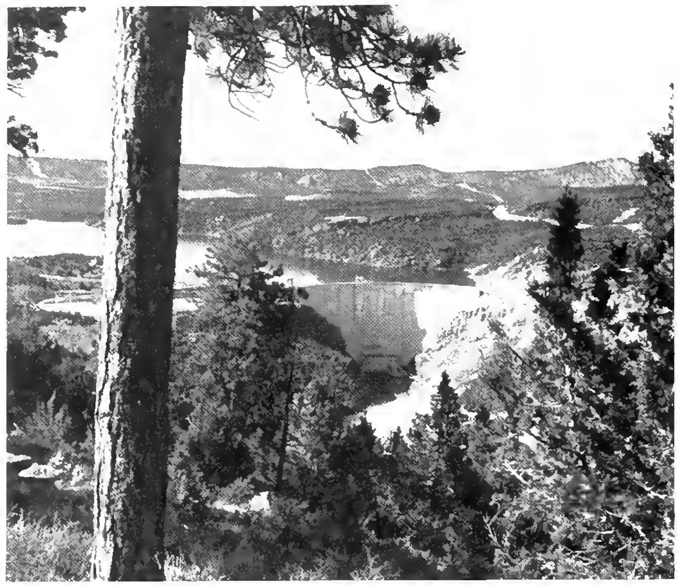
Glen Canyon Powerplant Switchyard

Flaming Gorge Unit

Flaming Gorge Dam, Reservoir, and Powerplant

Flaming Gorge Dam is on the Green River in northeastern Utah about 32 miles downstream from the Utah-Wyoming border. The concrete thin-arch structure has a maximum height of 502 feet and a crest length of 1,285 feet, and contains 987,000 cubic yards of concrete. The top thickness is 27 feet, and the maximum base thickness is 131 feet.

Floodwaters are spilled through a 675-foot-long tunnel spillway extending through the left abutment. The concrete-lined tunnel has a maximum capacity of 28,800 cubic feet per second and reduces in size from 26.5 feet in diameter at the upstream portal to 18 feet in diameter at the downstream portal. The spillway intake structure is controlled by two 16.75- by 34-foot hydraulically operated fixed-wheel gates.



Flaming Gorge Dam

The outlet works consist of two 72-inch steel pipes through the dam, reducing to 66 inches at the toe of the dam and continuing downstream to a valve structure on the left riverbank where discharge is directed into the river channel. Each outlet is controlled by a 66-inch hydraulically operated ring-follower gate at the downstream toe of the dam and a 66-inch hydraulically operated hollow-jet valve at the valve structure. Discharge capacity at elevation 6045.0 feet is 4,000 cubic feet per second.

The Flaming Gorge Reservoir has a total capacity of 3,788,900 acre-feet and an active capacity of 3,515,700 acre-feet. At normal water surface elevation, the reservoir has a surface area of 42,020 acres.

Three 10-foot-diameter penstock pipes near the center of the dam convey water to the powerplant. The powerplant is at the downstream toe of the dam and houses three 36,000-kilowatt generators driven by three 50,000-horsepower Francis-type turbines.

Navajo Unit

Navajo Dam and Reservoir

Navajo Dam is on the San Juan River in northwestern New Mexico about 34 miles east of Farmington. The dam is a rolled earthfill embankment with a structural height of 402 feet and a crest length of 3,648 feet. The dam contains 26,840,863 cubic yards of materials. The top width of the dam is 30 feet, and the maximum base width is 2,566 feet.

The spillway, on the right abutment, consists of an approach channel, concrete crest structure without gates, spillway bridge, concrete chute and stilling basin, and outlet channel. The width of the spillway ranges from 138 feet in the chute section to 195 feet in the stilling basin. The design capacity at maximum water surface elevation is 34,000 cubic feet per second.

Releases of water for downstream requirements are made through the outlet works, consisting of a concrete tower intake structure, an 18.75-foot-diameter concrete-lined tunnel, and valve house. Control is by one 6- by 13-foot fixed-wheel gate, two 72-inch ring-follower gates, and two 72-inch hollow-jet valves. The outlet works tunnel, located in the right abutment, is 1,603 feet long. Discharge capacity is 4,200 cubic feet per second at elevation 6101.5.

An auxiliary outlet works consisting of a concrete intake structure and a concrete-lined tunnel with gate chamber for two 4-foot-square gates also is located in the right abutment. Discharge is into the spillway stilling basin.

Navajo Reservoir extends 35 miles up the San Juan River, 13 miles up the Pine River, and 4 miles up the Piedra River in southern Colorado. When filled, the reservoir occupies 15,610 acres, with a total capacity of 1,708,600 acre-feet and an active capacity of 1,036,100 acre-feet.

Curecanti Unit

The Curecanti Unit developed the water storage and hydroelectric power generating potential along a 40-mile section of the Gunnison River in Colorado by the construction of three dams and powerplants: Blue Mesa, Morrow Point, and Crystal.

Blue Mesa Dam, Reservoir, and Powerplant

Blue Mesa Dam is on the Gunnison River about 30 miles below Gunnison, and 1.5 miles below Sapinero, Colo. The zoned earthfill embankment has a structural height of 390 feet, a crest length of 785 feet, and a volume of 3,093,000 cubic yards of materials.

The spillway consists of a concrete intake structure with two 25- by 33.5-foot radial gates, concrete-lined tunnel, concrete flip bucket structure, and stilling basin. Maximum discharge of the spillway is 34,000 cubic feet per second.

The outlet works consists of an intake structure, tunnel, and manifold anchor block. The outlet works is control-

Navajo Dam and Reservoir

Blue Mesa Dam, Powerplant, and Reservoir led by one 16- by 18-foot fixed-wheel gate in the intake structure and by two 84-inch ring-follower gates and two 84-inch hollow-jet valves in a gate house at the terminus of the outlet conduits. Maximum discharge from the outlet works is 5,000 cubic feet per second at maximum water surface elevation, with two 84-inch hollow-jet valves 62 percent open.

Blue Mesa Reservoir has a total capacity of 940,800 acre-feet and an active capacity of 748,500 acre-feet. At maximum water surface elevation, the reservoir occupies 9,180 acres.

The Blue Mesa Powerplant consists of two 30,000-kilowatt generators, driven by two 41,500-horsepower turbines. Each turbine is designed to operate at a maximum head of about 360 feet.

One 16-foot-diameter penstock conveys water to the two turbines and also carries water for the outlet works. After branching from the main penstock, each of the penstock laterals is controlled by 156-inch butterfly valves. The main penstock is reduced by a wye branch to the outlet works control valves.

Morrow Point Dam, Reservoir, and Powerplant

Morrow Point Dam, 12 miles downstream from Blue Mesa Dam, is Reclamation's first thin-arch, double-curvature dam. It is 468 feet high, 52 feet thick at the base, and 12 feet thick at the crest. The dam has a crest length of 724 feet and a volume of 365,180 cubic yards of concrete.

The spillway consists of four orifice-type openings in the top central part of the dam, providing a free-fall discharge higher than 350 feet to the concrete stilling basin at the toe of the dam. Each of the four spillway openings is controlled by a 15- by 16.83-foot fixed-wheel gate. Maximum capacity of the spillway is 41,000 cubic feet per second.

The outlet works consists of one stainless-steel lined 4-foot-square conduit through the dam. Control is by two 3.5-foot-square slide gates. Discharge capacity of the outlet works is 1,500 cubic feet per second.

Reservoir capacity behind Morrow Point Dam is 117,190 acre-feet at maximum water surface. The active capacity is 42,120 acre-feet. Surface area for Morrow Point Reservoir is 817 acres at elevation 7160.

The powerplant chamber is tunnelled into the canyon wall in the left abutment about 400 feet below the ground surface. The powerplant chamber is 231 feet long and 57 feet wide with a height ranging from 65 to 134 feet. There are two 60,000-kilowatt generators driven by two 83,000-horsepower turbines. The power penstocks consist of 13.5-foot-diameter steel liners in 18-foot-diameter tunnels.

Morrow Point Dam and Reservoir

Crystal Dam, Reservoir, and Powerplant

Crystal Dam is located 6 miles downstream from Morrow Point Dam and approximately 20 miles east of Montrose, Colo. The dam is a double-curvature thin-arch type, 323 feet high, with a crest length of 635 feet, and a volume of 147,000 cubic yards of materials.

The spillway consists of an ungated ogee crest on the right side of the dam and a plunge pool at the toe of the dam. The crest is at elevation 6756.0 feet, 1 foot above normal water surface. The plunge pool is unlined except for a downstream retaining wall to contain the river fill material.

Water is conveyed from the reservoir to the hydraulic turbine by an 11.5-foot-diameter concrete penstock, the lower portion of which is steel lined. The intake structure consists of a metal trashrack, a 10.58- by 17.27-foot bulkhead gate, an 8.33- by 13.58-foot fixed-wheel gate, and a transition. The fixed-wheel gate is provided for emergency closure and for inspection and maintenance of the penstock. Water from the turbine exits through the draft tube to the tailrace.

The river outlets consist of an intake structure on the upstream face of the dam and two 54-inch pipes through the dam and powerplant. The 54-inch ring-follower

Crystal Dam and Powerplant

emergency gates and 48-inch jet-flow regulating gates in the powerplant control outlet flows. The intake structure includes a metal trashrack, a concrete arch conduit to convey water to the 54-inch pipes, and provisions for installing a bulkhead gate. The Morrow Point Dam river outlet bulkhead gate can be used to close off the outlet pipes for inspection or maintenance.

The reservoir has a total capacity of 26,000 acre-feet and an active capacity of 13,000 acre-feet at above elevation 6700, with a surface area of 340 acres.

The powerplant, completed in 1978, has a generating capacity of 28,000 kilowatts from one unit driven by a 39,000-horsepower hydraulic turbine. It is connected to the main CRSP transmission system at the Curecanti substation by a 115-kilovolt line.

DEVELOPMENT

Early History

Settlement of the upper drainage basin began in 1854 when the early pioneers established Fort Supply in Wyoming on the Emigrant Trail and diverted water from Blacks Fork to the adjacent lands. Breckenridge, Colo., on the basin's eastern rim, was settled in 1859 by miners and prospectors pushing over the mountains from older mining districts on the eastern slope of the Continental Divide. Within the next decade, other mining camps were established nearby. Unsuccessful miners turned to farming and supplied agricultural products to the mining communities. Settlements grew downward from the mountains to the valleys, the advance being slowed somewhat by conflicts with the Indians who occupied the territory. Grand Junction, Colo., now the largest community in the upper drainage basin, was not settled until 1882. The greater part of the Uinta Basin in northeastern Utah was established as an Indian reservation in 1861, and lands unoccupied by Indians were not open to settlement until 1905. Numerous tributary streams in the upper drainage basin have been diverted to irrigate mountain meadows and valleys, farmlands, and broader valleys at the base of the mountains.

Investigations

Investigations of means to develop the waters of the Upper Colorado River system were started by the Reclamation Service in 1902, the year of its organization. Since that year, many of the larger irrigation projects within the basin have been undertaken with Federal assistance, and the Bureau of Reclamation has constructed, or is now constructing, 25 projects to utilize water in the upper basin. The need for the Colorado River Storage Project was envisioned at the time of the Colorado River Compact of 1922. In dividing Colorado River water between the Upper and Lower Colorado River Basins, the compact set aside for consumption in the upper basin 7,500,000 acre-feet of water each year. However, this allocation is contingent upon the upper basin's delivering to the lower basin not less than 75 million acre-feet of water in any period of 10 consecutive years and delivering additional water for use in Mexico under certain circumstances. The dividing point between the two basins is at Lees Ferry, near the northern border of Arizona.

Water allocated to the upper basin was further apportioned to the individual States of Arizona, Colorado, New Mexico, Utah, and Wyoming by the Upper Colorado River Basin Compact of 1948. This compact also created the Upper Colorado River Commission, consisting of representatives of the Federal Government and each contracting State except Arizona.

The flow of the Colorado River is extremely erratic, varying from 4 to 22 million acre-feet annually at Lees Ferry. There is a tendency for the high years or the low years to be grouped, thus accentuating problems of river regulation and use. In prolonged dry periods, there is not enough water to permit the upper basin to increase its use of water under the 1922 compact and, at the same time, make the required deliveries to the lower basin. In wetter periods, however, flows are more than sufficient for these purposes. Large storage reservoirs, that can be filled when flows are high and can provide additional water when needed for compact fulfillment, are required. Favorable sites for such reservoirs are found in the deep canyons of the Colorado River and its principal tributaries in the upper basin. A plan for the CRSP, including a series of dams and reservoirs to provide storage capacity in combination with power development and other services, was presented in a Bureau of Reclamation report in 1950, which was subsequently printed as House Document 364, 83d Congress, 2d session. The report was formulated in cooperation with other Federal agencies and with the Upper Colorado River Commission. An initial group of participating projects that would develop water for irrigation and other purposes in the upper basin and would be linked financially with the storage project also was described in the 1950 report.

Authorization

Construction of four storage units of the Colorado River Storage Project and 11 participating projects was authorized by the act of April 11, 1956 (Public Law 485, 84th Cong., 70 Stat. 105). Additional projects have been added since the original legislation was adopted.

Authorized developments are:
Glen Canyon Unit on the Colorado River in Arizona and Utah,
Flaming Gorge Unit on the Green River in Utah and Wyoming,
Navajo Unit on the San Juan River in New Mexico and Colorado, and
Curecanti Unit, consisting of three dams on the Gunnison River in Colorado.

Participating projects originally authorized are:
Central Utah (initial phase), Utah,
Emery County, Utah,
Florida, Colorado,
Hammond, New Mexico,
La Barge, Wyoming,[1]
Lyman, Wyoming and Utah,
Paonia, Colorado (works additional to existing project),
Pine River Extension, Colorado and New Mexico,[1]
Seedskadee, Wyoming,
Silt, Colorado, and
Smith Fork, Colorado.

The Eden Project in Wyoming, by terms of its authorizing act of June 28, 1949, became financially related to the Colorado River Storage Project as a participating project. In 1962, authorizing legislation named the following two as participating projects:

San Juan-Chama, Colorado and New Mexico, and Navajo Indian Irrigation (being constructed for the Bureau of Indian Affairs by the Bureau of Reclamation).

[1]Later found to be infeasible and deleted from the plan.

In 1964, the following three projects also were named:
Bostwick Park, Colorado,
Fruitland Mesa, Colorado, and
Savery-Pot Hook, Colorado and Wyoming.

The Colorado River Basin Project Act of September 30, 1968, authorized five additional projects as participating projects:
Animas-La Plata, Colorado and New Mexico,
Dallas Creek, Colorado,
Dolores, Colorado,
San Miguel, Colorado, and
West Divide, Colorado.

CONSTRUCTION

Construction of the Glen Canyon and Flaming Gorge Units began in October 1956. Glen Canyon Dam was topped out in 1963. Hydroelectric power from the powerplant started on line in 1964. Flaming Gorge Dam was topped out in late 1962, and the powerplant began commercial operation in 1963. Navajo Dam was commenced in 1957 and completed in 1963. Construction of the Curecanti Unit began with the start of Blue Mesa Dam in 1962. Blue Mesa was completed in 1966. Morrow Point Dam was started in 1963 and was completed in 1968. Power generation was initiated in September 1967 at the Blue Mesa Powerplant, and in December 1970 at Morrow Point. Construction on Crystal Dam commenced in June 1973 and was completed in 1976. The powerplant, completed in 1978, started power generation in July 1978.

Operating Agency

The Bureau of Reclamation operates and maintains the storage units of the CRSP.

BENEFITS

The Upper Colorado River Basin has a scarcely tapped potential of agricultural, industrial, and recreational assets. It contains tremendous quantities of uranium, coal, and other minerals. Realization of the potential in economic growth and contribution to the national welfare are dependent on maximum utilization of limited water supplies. The Colorado River Storage Project and participating projects conserve the very limited precipitation which falls principally in the form of snow in the high mountains and use it for municipal, industrial, and agricultural growth. Project development provides municipal and industrial water supplies, flood control, extensive recreation, and fish and wildlife preservation.

Morrow Point Powerplant

Recreation

Construction and completion of these major units of the CRSP with subsequent filling of the reservoirs have created scenic and recreational attractions of unique national significance. Visitors come from every State in the union as well as from many foreign countries. The Congress has officially designated Glen Canyon, Flaming Gorge, and the Curecanti Unit as National Recreation Areas. Glen Canyon National Recreation Area is administered by the National Park Service, where visitation during 1977 totaled 2,127,419. Flaming Gorge, administered by the Forest Service, had a visitation during 1977 of 680,870. Blue Mesa, Morrow Point, and Crystal recreation areas are administered by the National Park Service. Attendance there during 1977 totaled 869,895. Navajo Unit recreation areas are administered by Colorado Division of Parks and Outdoor Recreation, and the New Mexico State Parks and Recreation Commission; visitation during 1977 totaled 486,743.

PROJECT DATA

Facilities in Operation or Under Construction

Storage dams	6
Powerplants	5

ENGINEERING DATA

Water Supply

COLORADO RIVER

Drainage area at Glen Canyon Dam	108,335	mi²
Annual discharge:		
Maximum (1917)	21,859,000	acre-ft
Minimum (1934)	4,377,000	acre-ft
Average	11,724,000	acre-ft

GUNNISON RIVER—CRSP

Drainage area at Blue Mesa Dam	3,500	mi²
Annual discharge:		
Maximum (1957)	1,715,000	acre-ft
Minimum (1934)	537,000	acre-ft
Average	1,108,000	acre-ft

SAN JUAN RIVER

Drainage area at Navajo Dam[2]	3,558	mi²
Annual discharge:		
Maximum (1932)	1,856,000	acre-ft
Minimum (1934)	364,000	acre-ft
Average	928,000	acre-ft

[2]Gage station near Blanco, N. Mex., used as streamflow at Navajo Dam.

Storage Facilities

GLEN CANYON DAM

Type: Concrete arch
Location: On the Colorado River, 15 mi upstream from Lees Ferry, Ariz.
Construction period: 1957-64
Reservoir, Lake Powell:

Total capacity at El. 3700	27,000,000	acre-ft
Active capacity	20,876,000	acre-ft
Surface area	161,390	acres

Boating on Lake Powell

Dimensions:		
Structural height	710	ft
Hydraulic height	583	ft
Top thickness	25	ft
Maximum base thickness	300	ft
Crest length	1,560	ft
Crest elevation	3715.0	ft
Total volume	4,901,000	yd³
Spillways: One concrete-lined tunnel spillway in each abutment, controlled by two 40- by 52.5-ft radial gates.		
Elevation top of gates	3700.0	ft
Crest elevation	3648.0	ft
Combined capacity at El. 3700	208,000	ft³/s
Outlet works: Four 96-in-diameter pipes, each controlled by one 96-in ring-follower gate and one 96-in hollow-jet valve.		
Capacity of all outlets at El. 3648	15,000	ft³/s

Flaming Gorge Dam

Type: Concrete thin arch		
Location: On the Green River, 32 mi downstream from the Utah-Wyoming border.		
Construction period: 1956-64		
Reservoir, Flaming Gorge:		
Total capacity at El. 6040	3,788,700	acre-ft
Active capacity	3,515,700	acre-ft
Surface area	42,020	acres
Dimensions:		
Structural height	502	ft
Hydraulic height	455	ft
Top thickness	27	ft
Maximum base thickness	131	ft
Crest length	1,285	ft
Crest elevation	6047.0	ft
Total volume	987,000	yd³
Spillway: Concrete-lined tunnel through left abutment, controlled by two 16.75- by 34-ft hydraulically operated fixed-wheel gates.		
Crest elevation	6006.0	ft
Capacity at El. 6046	28,800	ft³/s
Outlet works: Two 72-in steel pipes reducing to 66-in, each controlled by a 66-in ring-follower gate and a 66-in hollow-jet valve.		
Capacity at El. 6045	4,000	ft³/s

Navajo Dam

Type: Zoned earthfill		
Location: On the San Juan River, about 34 mi east of Farmington, N. Mex.		
Construction period: 1957-63		
Reservoir, Navajo:		
Total capacity at El. 6085	1,708,600	acre-ft
Active capacity	1,036,100	acre-ft
Surface area	15,610	acres
Dimensions:		
Structural height	402	ft
Hydraulic height	388	ft
Top width	30	ft
Maximum base width	2,566	ft
Crest length	3,648	ft
Crest elevation	6108.0	ft
Total volume	26,840,863	yd³
Spillway: Uncontrolled concrete crest and concrete-lined chute at right abutment.		
Crest length	138	ft
Crest elevation	6085.0	ft
Capacity at El. 6101.5	34,000	ft³/s
Outlet works: Concrete-lined tunnel, controlled by one 6- by 13-ft fixed-wheel gate, two 72-in ring-follower gates, and two 72-in hollow-jet valves.		
Capacity at El. 6101.5	4,200	ft³/s
Auxiliary outlet works: Concrete-lined tunnel in right abutment, controlled by two 4-ft-square tandem outlet gates.		
Capacity at El. 6085	1,700	ft³/s

Blue Mesa Dam

Type: Zoned earthfill		
Location: On the Gunnison River, 30 mi below Gunnison, Colo.		
Construction period: 1962-66		
Reservoir, Blue Mesa:		
Total capacity at El. 7519.4	940,800	acre-ft
Active capacity	748,500	acre-ft
Surface area	9,180	acres
Dimensions:		
Structural height	390	ft
Hydraulic height	342	ft
Top width	30	ft
Maximum base width	1,550	ft
Crest length	785	ft
Crest elevation	7528.0	ft
Total volume	3,093,000	yd³
Spillway: Concrete-lined tunnel, controlled by two 25- by 33.5-ft radial gates.		
Elevation top of gates	7528.0	ft
Crest elevation	7487.9	ft
Capacity at El. 7519.4	34,000	ft³/s
Outlet works: Concrete-lined tunnel, controlled by one 16- by 18-ft fixed-wheel gate, two 84-in ring-follower gates, and two 84-in hollow-jet valves.		
Capacity at El. 7519.4 with hollow-jet valves 62 percent open	5,000	ft³/s

Morrow Point Dam

Type: Double-curvature, thin-arch concrete		
Location: On the Gunnison River, 12 mi downstream from Blue Mesa Dam.		
Construction period: 1963-68		
Reservoir, Morrow Point:		
Total capacity at El. 7160	117,190	acre-ft
Active capacity	42,120	acre-ft
Surface area	817	acres
Dimensions:		
Structural height	468	ft
Hydraulic height	400	ft
Top thickness	12	ft
Maximum base thickness	52	ft
Crest length	724	ft
Crest elevation	7165.0	ft
Total volume	365,180	yd³
Spillway: Four orifice-type free-fall spillways at the top center of the dam, each controlled by 15- by 16.83-ft fixed-wheel gates.		
Elevation top gates	7140.0	ft
Crest elevation	7123.0	ft
Capacity at El. 7165	41,000	ft³/s
Outlet works: One stainless steel-lined 4-ft-square conduit through the center of the dam near the base, controlled by two 3.5-ft-square slide gates.		
Capacity at El. 7165	1,500	ft³/s

Crystal Dam

Type: Double-curvature, thin-arch concrete		
Location: On the Gunnison River, 6 mi downstream from Morrow Point Dam.		
Construction period: 1973-76		
Reservoir, Crystal:		
Total capacity at El. 6755	26,000	acre-ft

Active capacity	13,000	acre-ft
Surface area	340	acres
Dimensions:		
Structural height	323	ft
Hydraulic height	227	ft
Top width	10	ft
Maximum base width	29	ft
Crest length	635	ft
Crest elevation	6772.0	ft
Total volume	147,000	yd³

Spillway: Ungated ogee crest on the right side of the dam and a plunge pool at the toe of the dam. Crest is at El. 6756 ft. 1 ft above normal water surface. Plunge pool is unlined except for downstream retaining wall to contain river fill material.

Outlet works: Two 54-in pipes through the dam and powerplant controlled by two 54-in ring-follower emergency gates and two 48-in jet-flow regulating gates.

Power Facilities

Glen Canyon Powerplant

Location: At the toe of Glen Canyon Dam.
Year of initial operation: 1964

Nameplate capacity	950,000	kW
Number and capacity of generators (8)	118,750	kW
Maximum head	560	ft

Flaming Gorge Powerplant

Location: At the toe of Flaming Gorge Dam.
Year of initial operation: 1963

Nameplate capacity	108,000	kW
Number and capacity of generators (3)	36,000	kW
Maximum head	440	ft

Blue Mesa Powerplant

Location: At the toe of Blue Mesa Dam.
Year of initial operation: 1967

Nameplate capacity	60,000	kW
Number and capacity of generators (2)	30,000	kW
Maximum head	360	ft

Morrow Point Powerplant

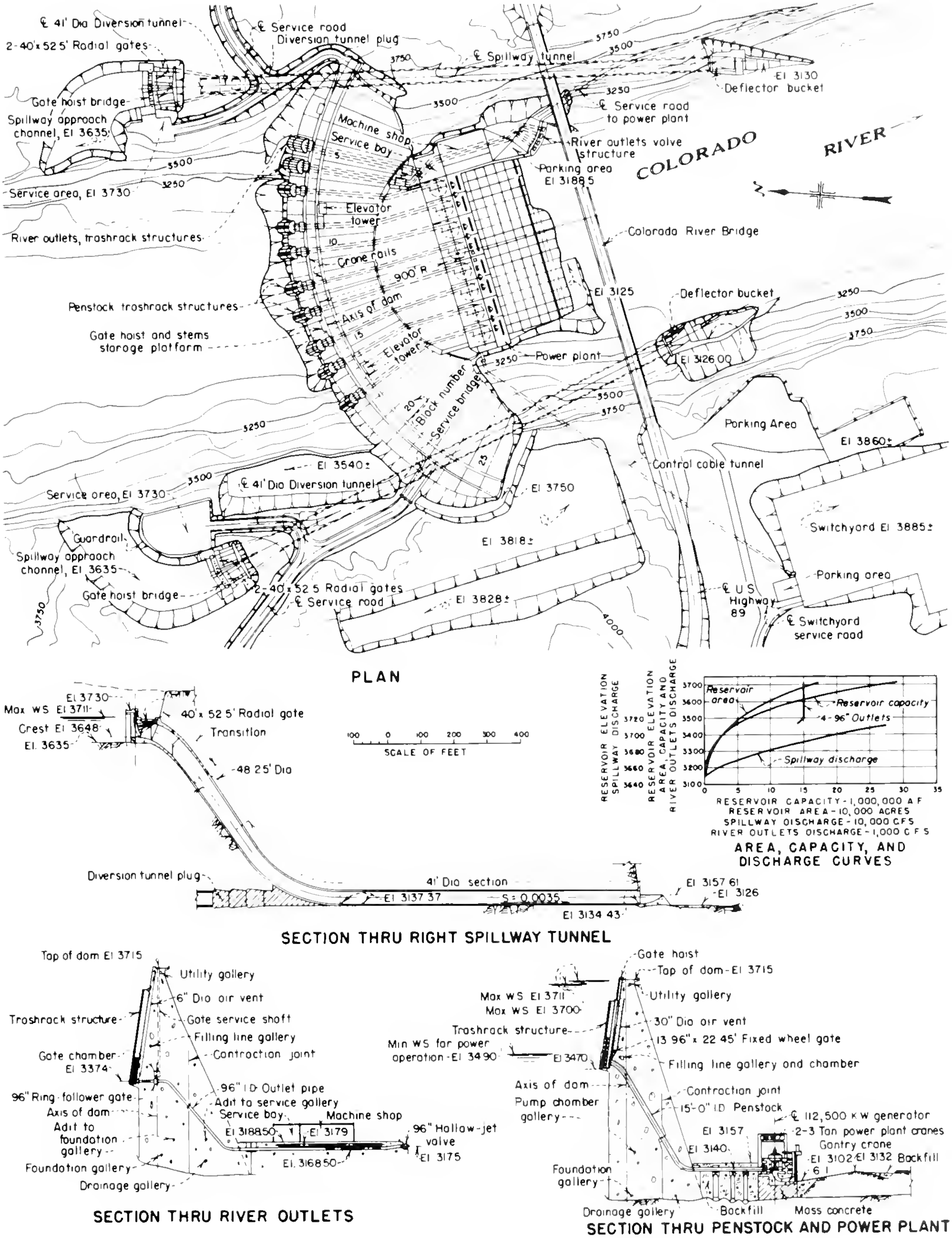
Location: Underground tunnel below left abutment of Morrow Point Dam.
Year of initial operation: 1970

Nameplate capacity	120,000	kW
Number and capacity of generators (2)	60,000	kW
Maximum head	405	ft

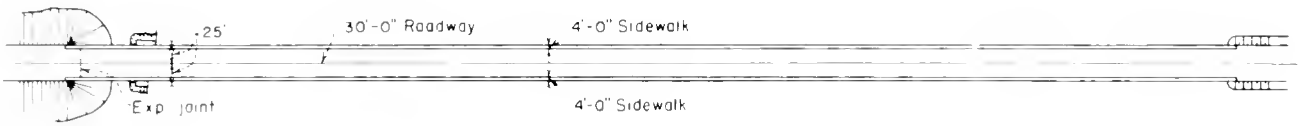
Crystal Powerplant

Location: At the toe of Crystal Dam.
Year of initial operation: 1978

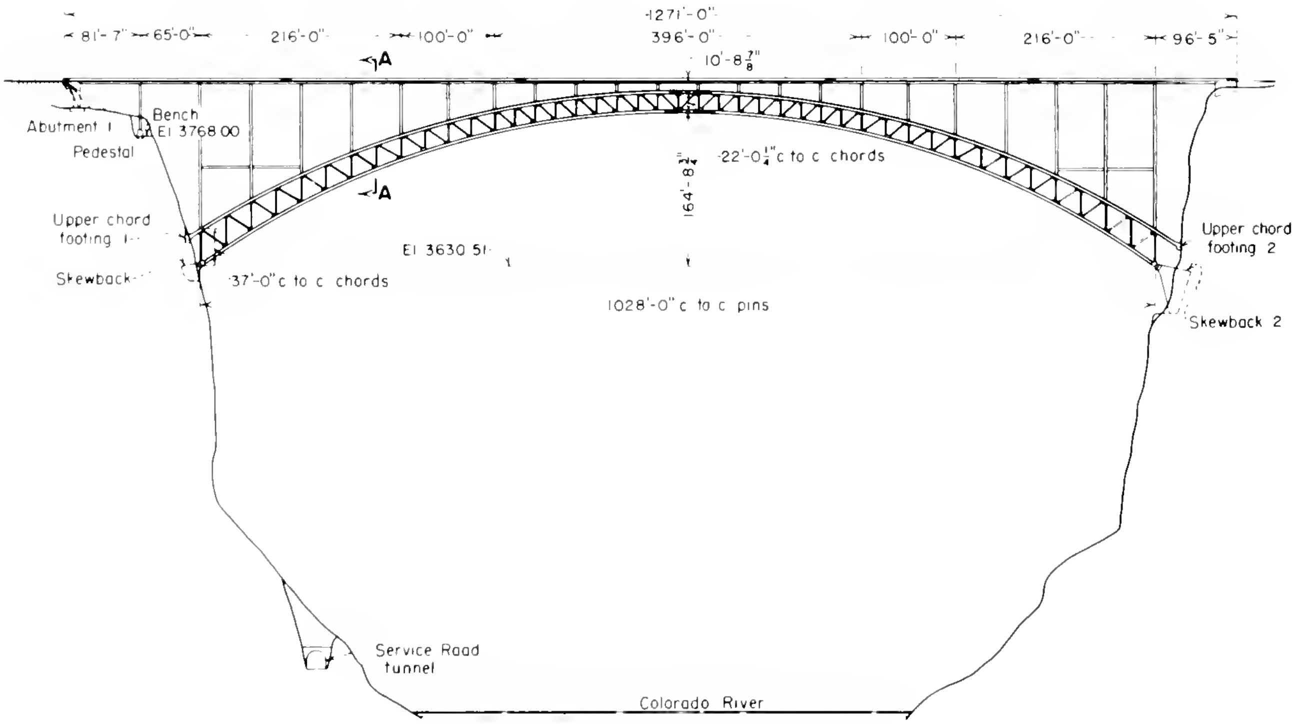
Nameplate capacity	28,000	kW
Number and capacity of generators (1)	28,000	kW
Maximum head	224	ft



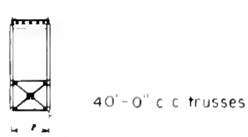
Glen Canyon Dam and Powerplant, Plan and Sections



PLAN

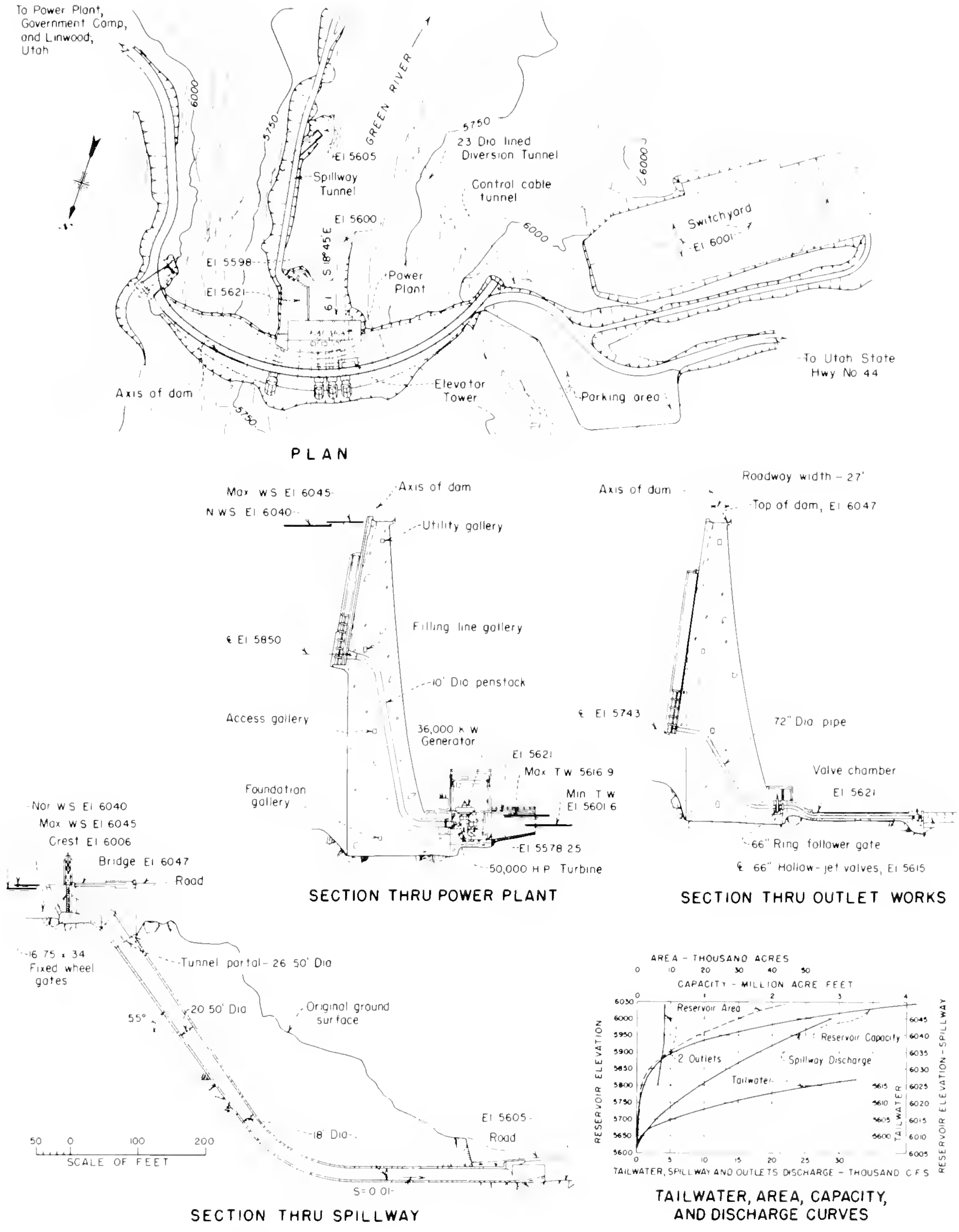


ELEVATION

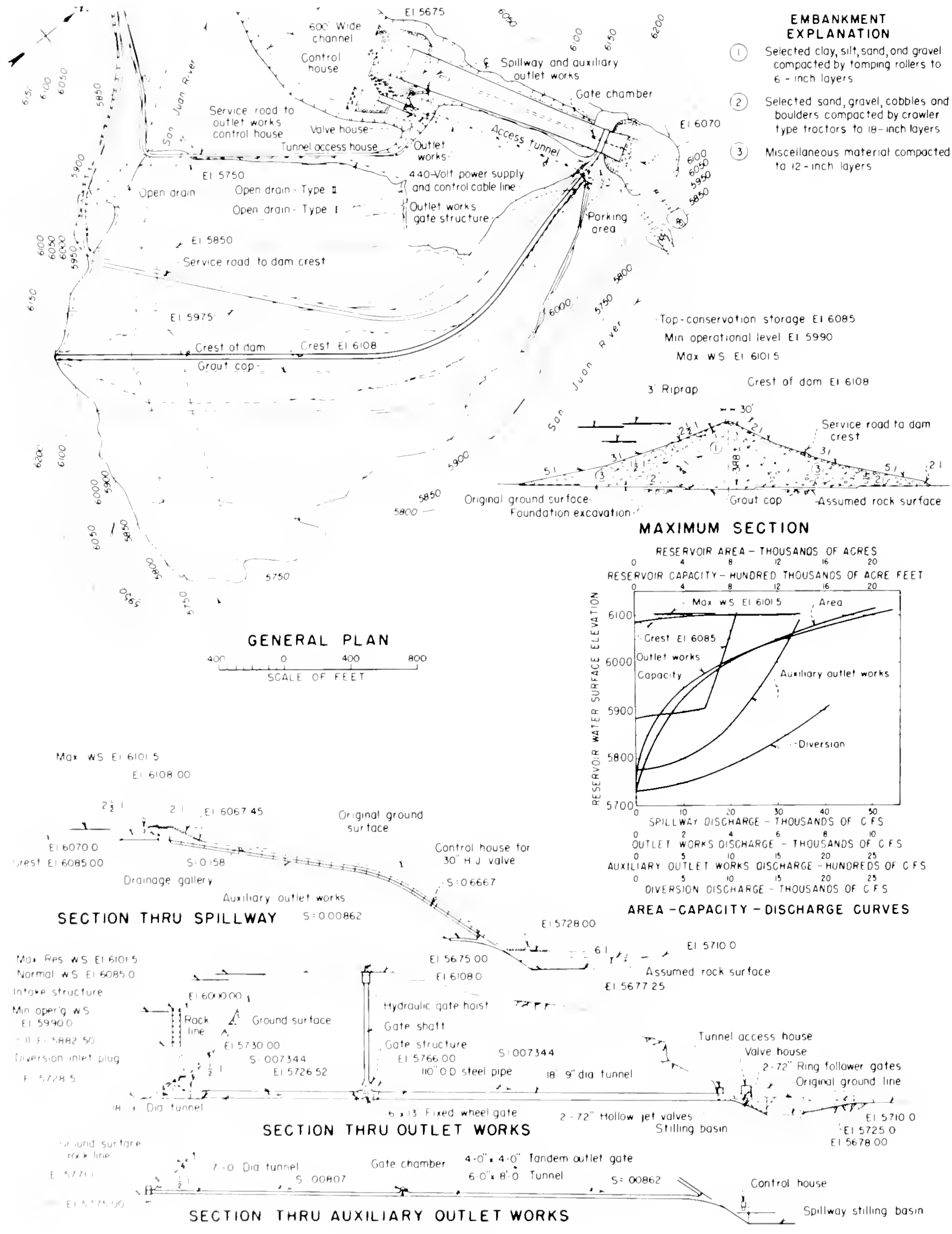


SECTION A-A

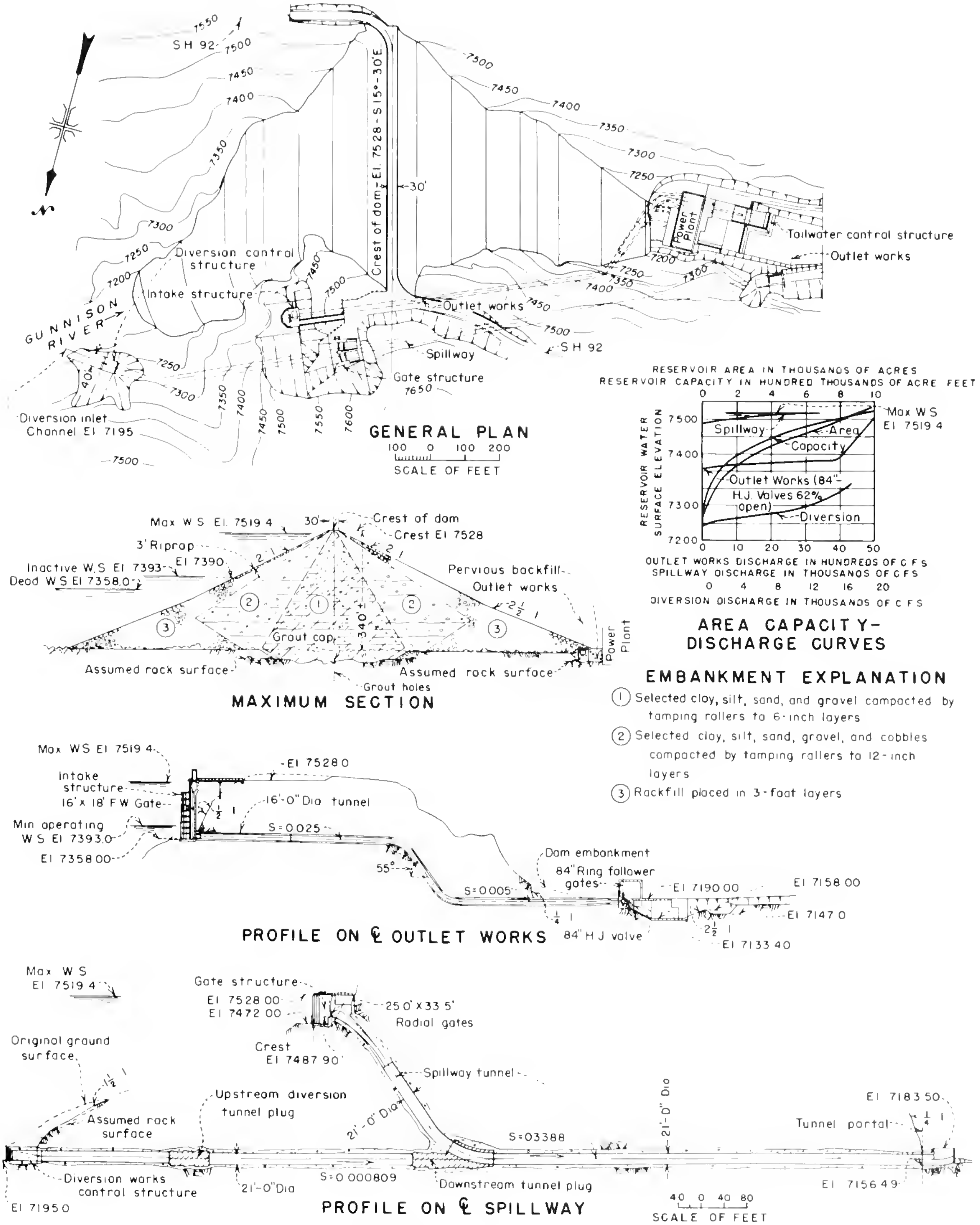
Glen Canyon Bridge, Plan and Elevation



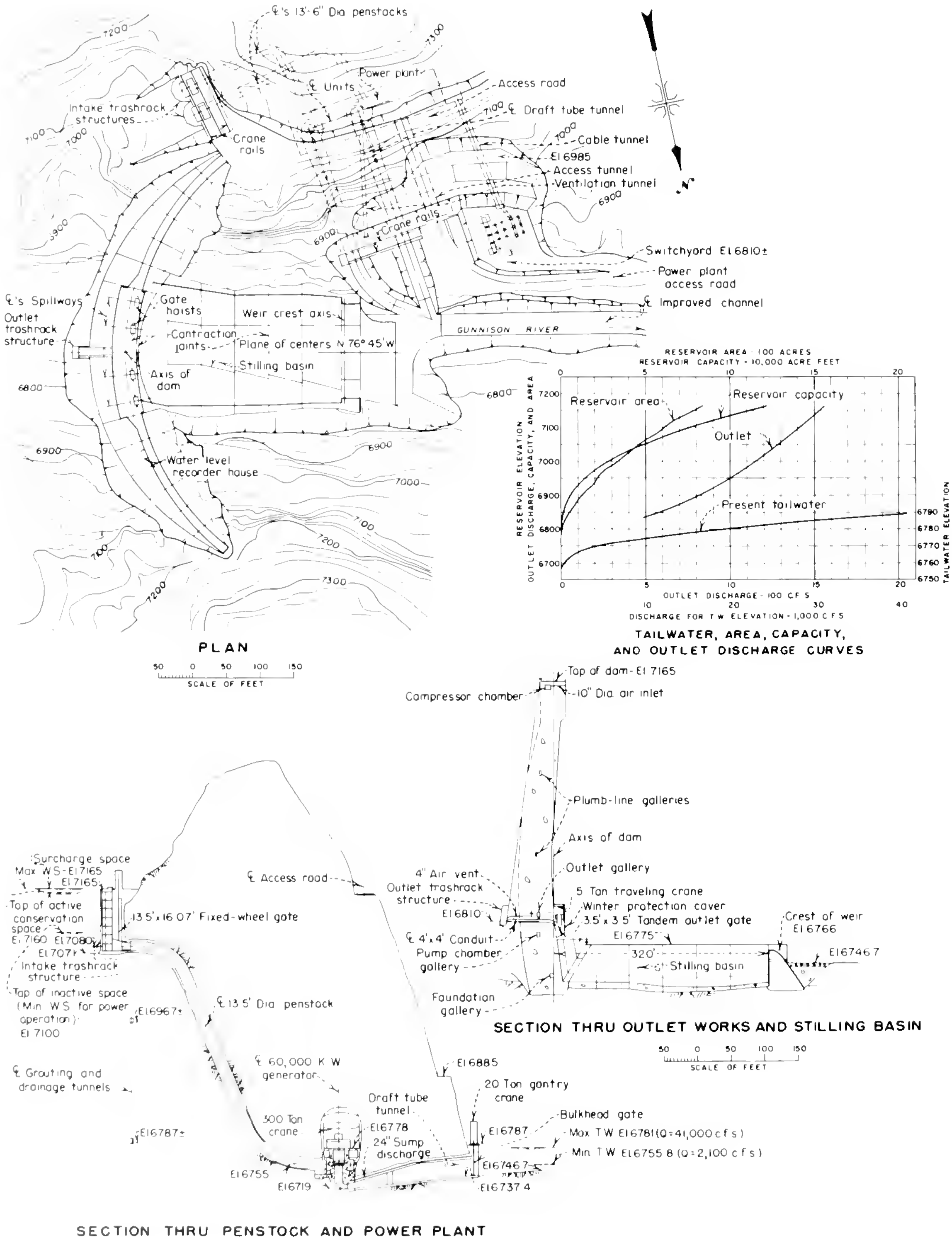
Flaming Gorge Dam and Powerplant, Plan and Sections



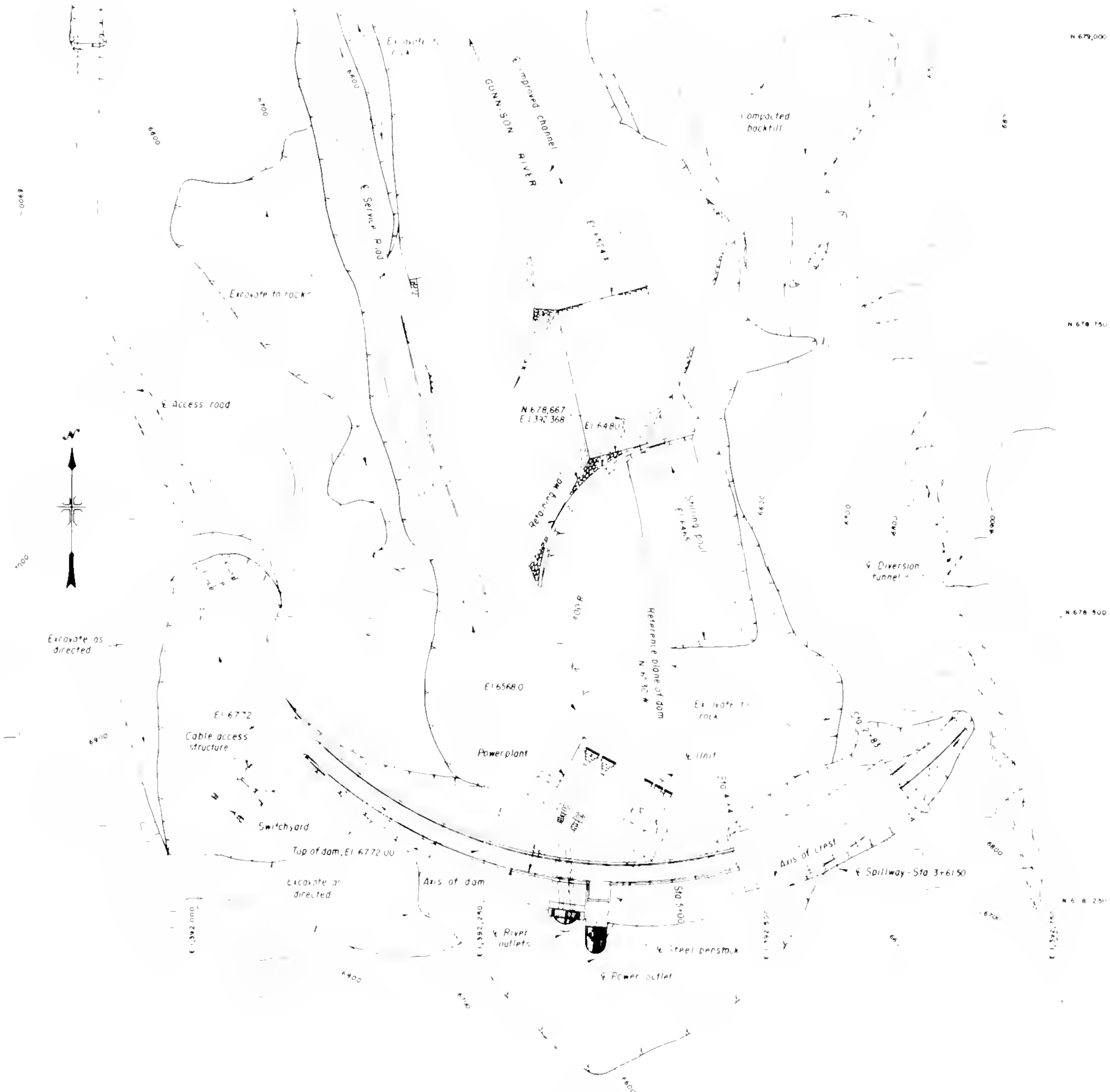
Navajo Dam, Plan and Sections



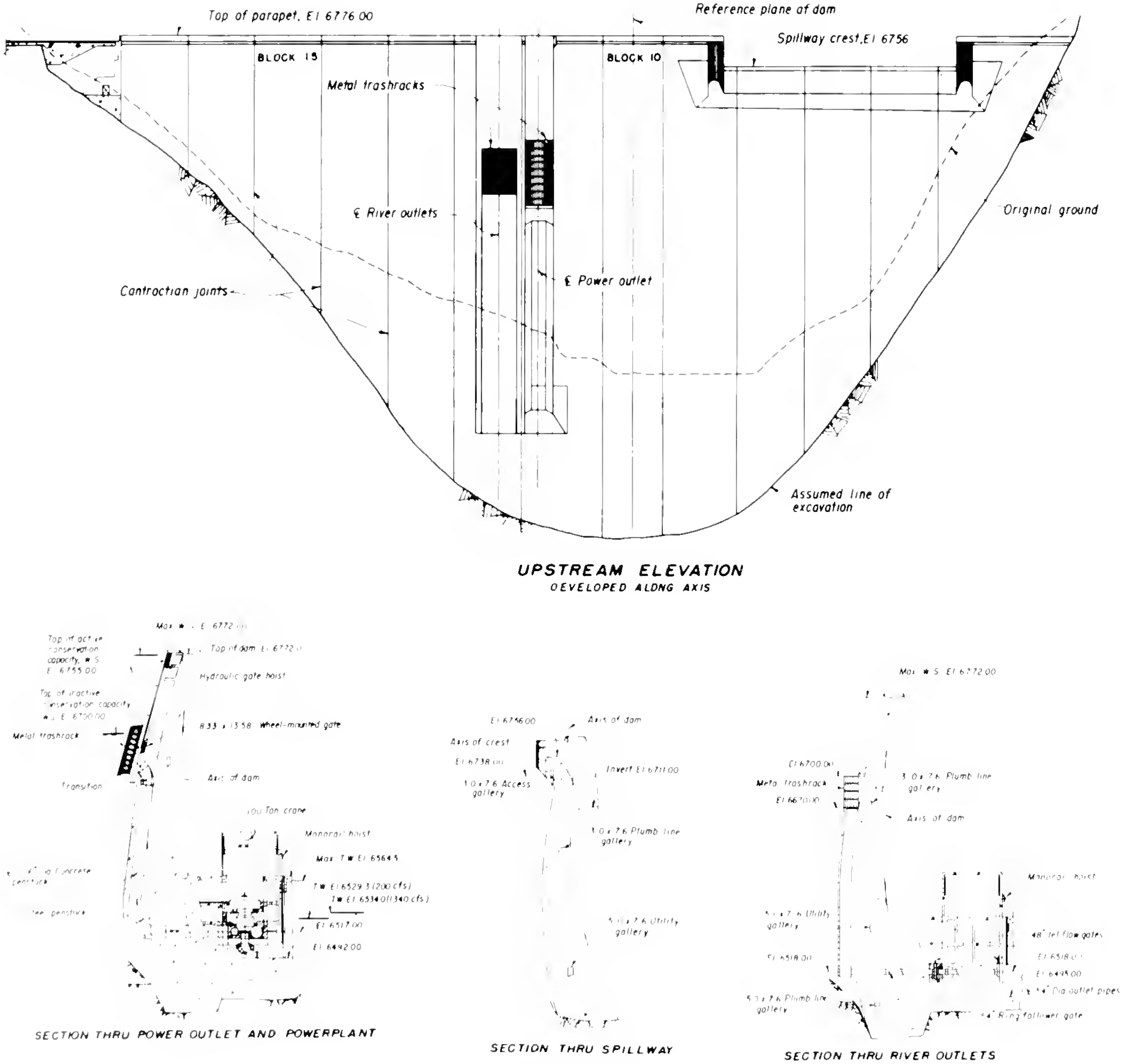
Blue Mesa Dam, Plan and Sections



Morrow Point Dam and Powerplant, Plan and Sections



Crystal Dam and Powerplant, Plan

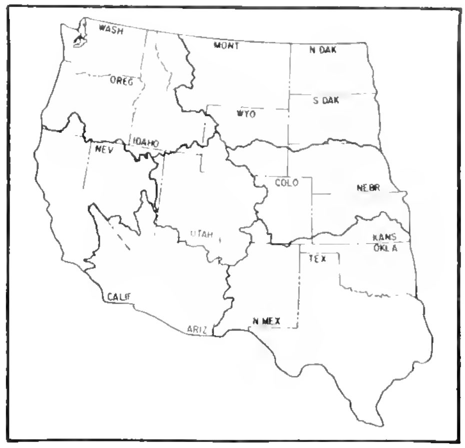


Crystal Dam and Powerplant, Profile and Sections

Colorado River Water Quality Improvement Program

Colorado, Utah, and Wyoming

Upper Colorado Region
Water and Power Resources Service

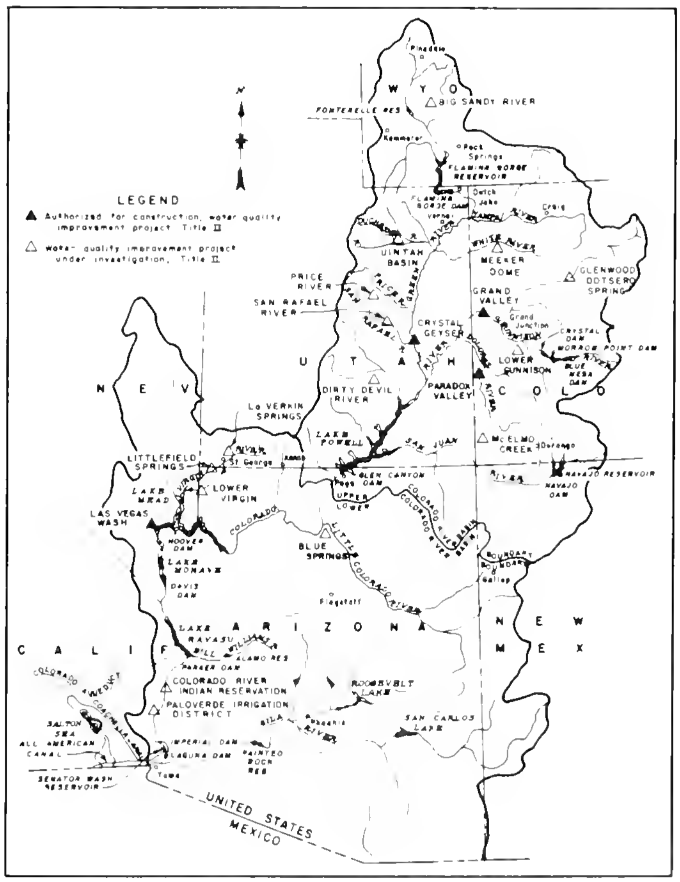


The Colorado River Water Quality Improvement Program provides for projects upstream of Imperial Dam, between Arizona and California, that are necessary to stabilize the salinity of the Colorado River. Four units are authorized as part of the initial stage of the program, three in the Upper Basin and one in the Lower Basin: Paradox Valley Unit and Grand Valley Unit in Colorado, and Crystal Geyser Unit in Utah (Upper Basin); and the Las Vegas Wash Unit in Nevada (Lower Basin). Further study and research is authorized on other salinity control units for the Colorado River Basin: In Utah, LaVerkin Springs in Washington County; Uinta Basin in Duchesne and Uintah Counties; and Price, San Rafael, and Dirty Devil Rivers in Emery, Carbon, Wayne, and Garfield Counties. In Utah and Colorado, McElmo Creek in San Juan and Montezuma Counties. In Colorado, Glenwood-Dotsero Springs in Garfield County; and Lower Gunnison Basin in Delta, Montrose, and Ouray Counties. In Wyoming, Big Sandy River in Sweetwater County. The Meeker Dome Unit in Rio Blanco County, Colorado, has been placed on the investigations program by request of the State of Colorado.

PLAN

The program plan is to construct, operate, and maintain certain works in the Colorado River Basin for control of the salinity of waters delivered to users in the United States and Mexico. Paradox Valley Unit, Colorado, would consist of facilities for collection and disposition of Paradox Valley saline ground water. Wells, pumps, pipelines, a hydrogen-sulphide stripping plant, solar evaporation ponds, and other necessary associated works could be included. Grand Valley Unit, Colorado, would consist of measures and works to reduce seepage of irrigation water from canals and laterals, limit excess water applications to irrigated lands, and improve onfarm practices. Crystal Geyser Unit, Utah, would involve collecting and disposing of saline geyser discharges. Las Vegas Wash Unit, Nevada, would provide facilities for collecting and disposing of Las Vegas Wash saline ground water.

Feasibility studies are underway on units for the Price, San Rafael, and Dirty Devil Rivers. Investigations include an assessment of the potential to improve irrigation water management and systems to reduce salt pickup in drainage return flows, and a determination of specific areas for control of salinity from natural or diffuse sources. Required sampling stations will be established in conjunction with geologic investigations in each river basin.



Colorado River Water Quality Improvement Program

Uinta Basin studies will investigate feasibility of controlling frequency and quantities of water applied during irrigation to reduce mineral content of return flows. Local areas contributing large quantities of salt will be investigated to determine specific places needing improved water systems and canal and lateral systems.

McElmo Creek methods of removing salt will be studied and investigated to identify the potential to reduce deep percolation and seepage from irrigated land.

Glenwood-Dotsero Springs desalting plant, which uses a multistage flash distillation process to treat spring discharges, is being studied. Alternative methods to collect and dispose of saline water in the most economical manner will be evaluated.

Lower Gunnison Basin will be investigated for rehabilitation of the canal and lateral systems where excessive seepage is occurring, and improvement of onfarm irrigation and management practices to reduce deep percolation and return flow from the lands.

Big Sandy River studies are continuing to determine the most effective methods to collect and dispose of numerous saline seeps along Big Sandy River. Other studies will examine improvement of irrigation system efficiency to reduce seepage and deep percolation into underlying saline aquifers. Other feasibility studies include Palo Verde Irrigation District, Colorado River Indian Reserve, and the Lower Virgin River in the Lower Basin.

DEVELOPMENT

History

Increases in the salinity levels of western rivers is not a new or unique situation. Water quality problems in the Colorado River were recognized as early as 1903. The Colorado River salinity problem has been the object of several studies and investigations and numerous surveys of salinity sources and control measures have been pursued over the years by the Bureau of Reclamation, Geological Survey, Environmental Protection Agency, the Water Resources Council, Colorado River Board of California, Basin States, and several universities. In 1972, a joint Federal-State enforcement conference on the subject of pollution of interstate waters of the Colorado River and its tributaries initiated formal efforts to establish an overall salinity control policy for the river. Conferees concluded that such a policy would have as its objective the maintenance of salinity concentrations at or below levels found in the lower main stem of the Colorado River in 1972. It also was recognized that States had rights to continue development of their compact-apportioned waters and that temporary rises in salinity might occur until the salinity control program became effective.

Authorization

Authorized by the Colorado River Basin Salinity Control Act of 1974, (P.L. 93-320, 88 Stat. 266, June 24, 1974). Title I provides for measures to enable the United States to comply with its obligation under the agreement with Mexico of August 30, 1973, Minute No. 242 of the International Boundary and Water Commission, United States and Mexico. Title II, essentially the Colorado River Water Quality Improvement Program, provides for measures upstream of Imperial Dam necessary to stabilize the salinity of the Colorado River.

The Public Works Appropriation Act of 1975 provided funding for the start of advance planning activities on the four authorized units. Title II provided for feasibility investigations and planning and implementing the other units.

Construction

Paradox Valley Unit, Grand Valley Unit, Crystal Geyser Unit, and Las Vegas Wash Unit are authorized for construction by Title II of Public Law 93-320. Major structural features involve construction of facilities such as wells, dikes, pipelines, pumps, desalters, and evaporation ponds to collect and dispose of saline water.

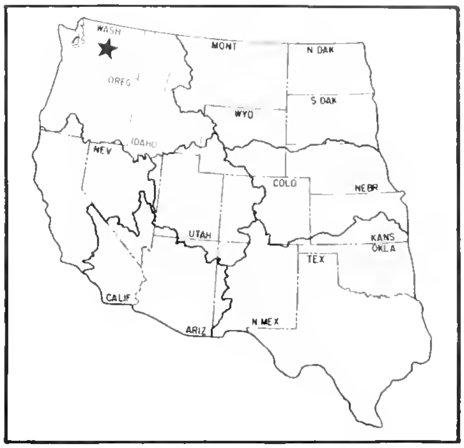
BENEFITS

Implementation of all salinity control units under Title II would reduce the salinity of the Colorado River at Imperial Dam by about 185 parts per million. The cumulative impact of the four authorized salinity control units would provide an initial reduction of about 72 parts per million. Annually, the estimated reductions would amount to 1,900,000 tons of salt removed from the river system for full program implementation, and 676,000 tons for the authorized control units. The beneficial impacts of salinity reduction would be reflected in all the Basin States in improved water quality deliveries to over 17 million people and more than 1 million acres of irrigated farmland.

Columbia Basin Project

Washington: Adams, Douglas, Franklin, Grant, Lincoln, and Walla Walla Counties

Pacific Northwest Region
Water and Power Resources Service



The Columbia Basin Project is a multipurpose development utilizing a portion of the resources of the Columbia River in the central part of the State of Washington. The key structure, Grand Coulee Dam, is on the main stem of the Columbia River about 90 miles west of Spokane, Wash. The extensive irrigation works extend southward on the Columbia Plateau 125 miles to the vicinity of Pasco, Wash., where the Snake and Columbia Rivers join.

Principal project features include Grand Coulee Dam, Franklin D. Roosevelt Lake, Grand Coulee Powerplant Complex, switchyards, and a pump-generating plant. Primary irrigation facilities are the Feeder Canal, Banks Lake, the Main, West, East High, and East Low Canals, O'Sullivan Dam, Potholes Reservoir, and Potholes Canal. There are 333 miles of main canals, 1,993 miles of laterals, and 3,163 miles of drains and wasteways on the project.

All of the principal features have been constructed, except the East High Canal and the extension of the East Low Canal, on which construction has been deferred.

The project irrigation facilities are designed to deliver a full water supply to 1,095,000 acres of land previously used only for dry farming or grazing. Power production facilities at Grand Coulee Dam are the largest in the world; the total authorized generating capacity is rated at 6,480,000 kilowatts.

PLAN

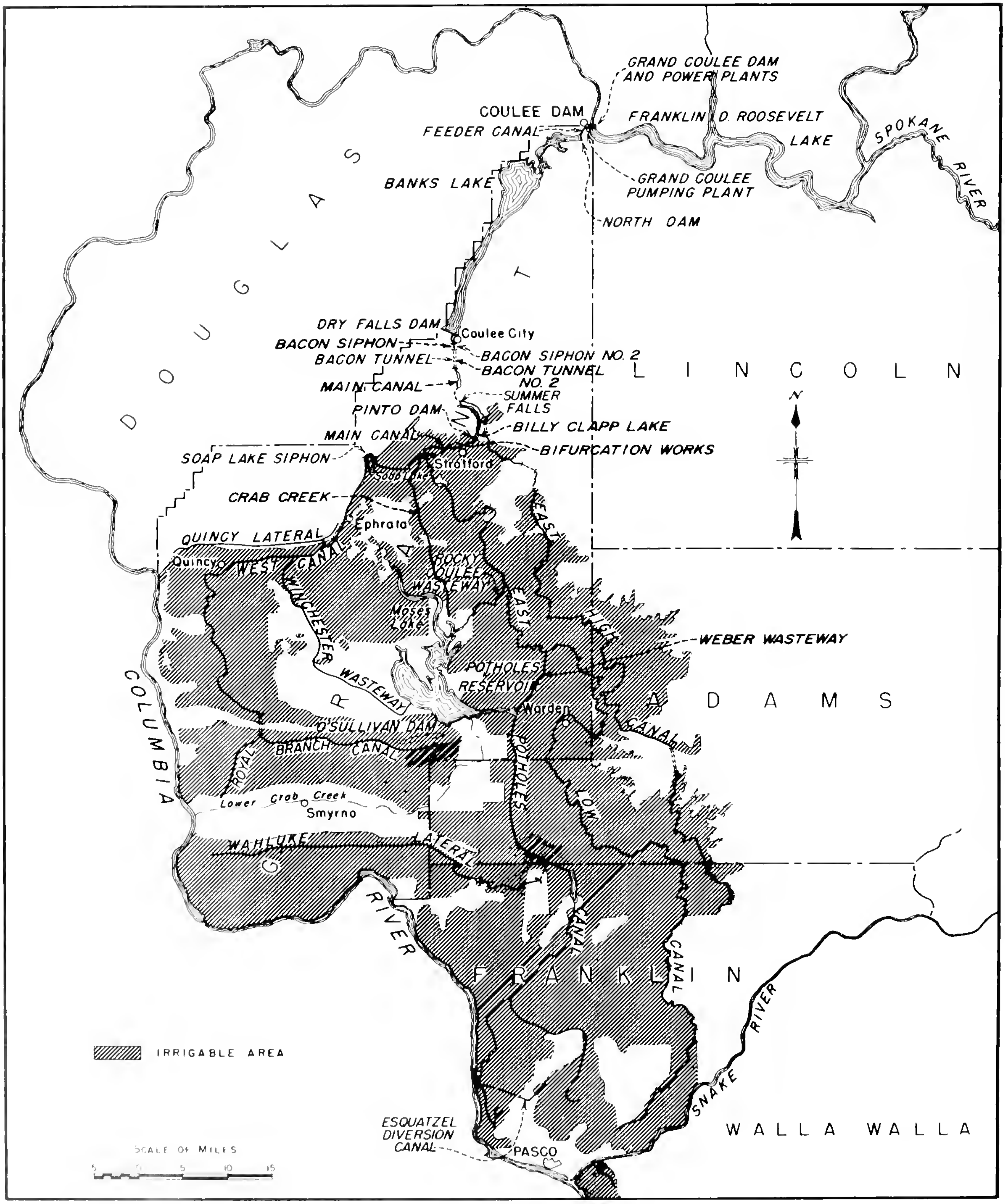
The Columbia River is characterized by heavy, sustained flows during the summer months, the peak flow usually occurring in mid-June. Most of the water comes from the forested slopes of the Rocky Mountains in British Columbia, western Montana, and northern Idaho, where snow and heavy rains result in prolonged summer riverflow. There is usually ample water for irrigation and power generation (both irrigation pumping and commercial) and for reversible pump-generation.

Irrigation water is pumped from Franklin D. Roosevelt Lake by the Grand Coulee Pump-Generating Plant, adjacent to the reservoir at the left abutment of the dam. Six irrigation pumps and two pump-generating units have been installed. Ultimately, a total of 12 pumping units to serve the fully developed project will be necessary; 6 will be pump-generating units.

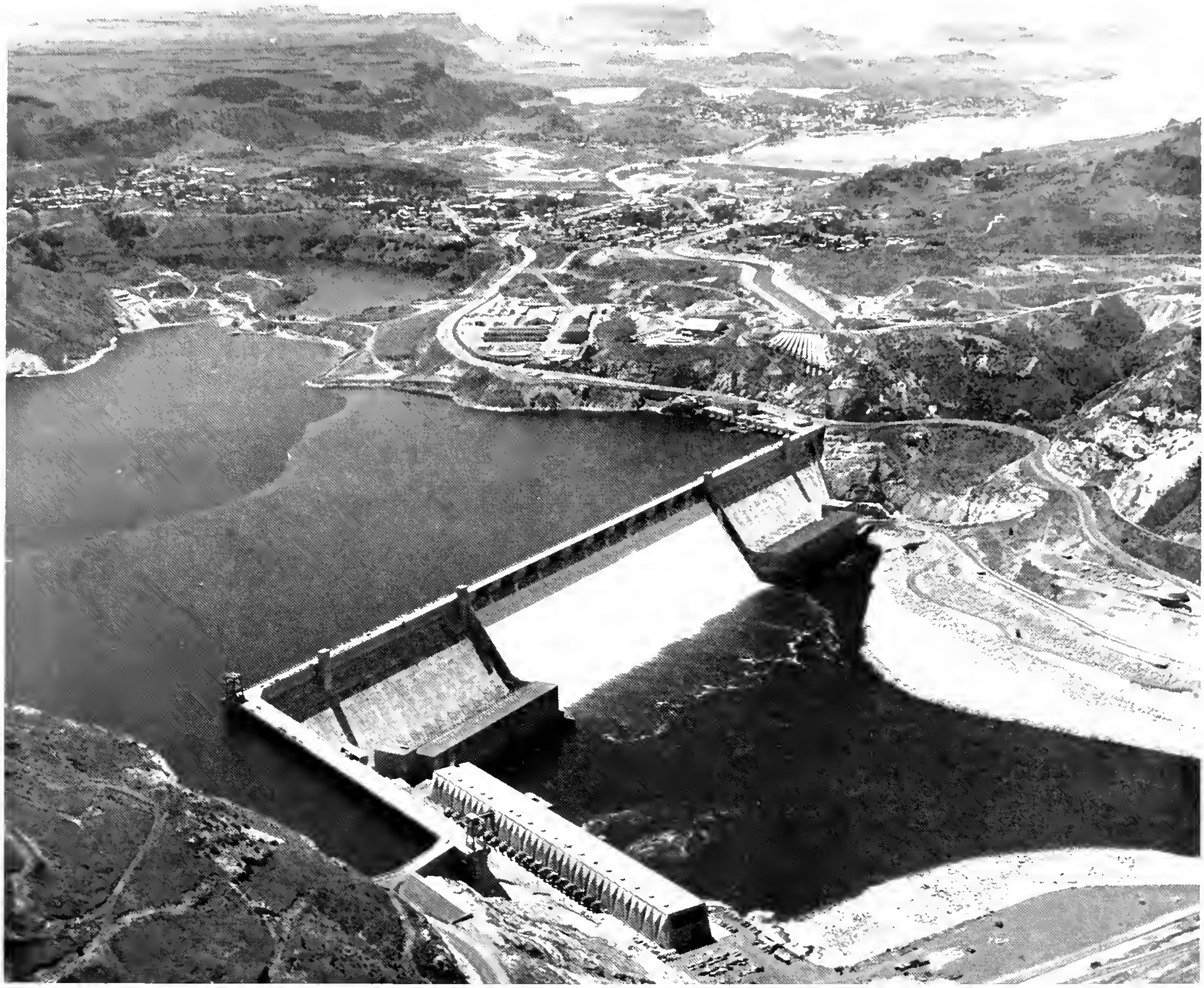
The widely distributed irrigation works that extend southward from the Grand Coulee Pump-Generating Plant begin with the short feeder canal which carries water to Banks Lake, the equalizing reservoir. This 27-mile-long reservoir occupies the floor of the upper Grand Coulee between North Dam near the town of Coulee Dam, Wash., and Dry Falls Dam near Coulee City. The Main Canal flows southward from the outlet works at Dry Falls Dam into the northern end of the irrigable area. The West, East High, and East Low Canals are fed by the Main Canal and carry water over a large portion of the project area. O'Sullivan Dam, in the central part of the project area, created the Potholes Reservoir where return flows from the northern part of the project are recaptured. The Potholes Canal extends into and serves the southern part of the project area.

Grand Coulee Dam and Franklin D. Roosevelt Lake

Grand Coulee Dam is the largest concrete structure ever built. This barricade, which raises the water surface 350 feet above the old riverbed, is 5,223 feet long, 550 feet high, and contains 11,975,500 cubic yards of concrete. The original dam was modified for the Third Powerplant by construction of a 1,170-foot-long, 201-foot-high forebay dam along the right abutment approximately parallel to the river and at an angle of 64 degrees to the axis of Grand Coulee Dam. The spillway of the dam is controlled by 11 drum gates, each 135 feet long, and is capable of spilling 1,000,000 cubic feet of water per second. The dam also contains forty 102-inch-diameter outlet tubes. Within the dam are 8.5 miles of inspection galleries and 2.5 miles of shafts.



Columbia Basin Project



Grand Coulee Dam, Powerplants, and Pumping Plant

Franklin D. Roosevelt Lake, the reservoir behind the dam, extends 151 miles northeast to the Canadian border and up the Spokane River, a tributary of the Columbia, to within 37 miles of Spokane. The total storage capacity of the reservoir is 9,652,000 acre-feet, and the active capacity is 5,185,400 acre-feet.

Grand Coulee Powerplant Complex

Power facilities at Grand Coulee Dam consist of a powerplant on both the left and right sides of the spillway on the downstream face of the dam, the Third Powerplant on the downstream face of the forebay dam, an 11.95/115-kilovolt switchyard, a 230-kilovolt consolidated switchyard, and the 500-kilovolt Third Powerplant cable spreading yard and switchyard located high on the hills west of Grand Coulee Dam.

As constructed, the left and right powerplants contained a total of eighteen 108,000-kilowatt units, nine in each powerplant. Rewinding these units has increased the capacity to 125,000 kilowatts each, for a total of 2,250,000 kilowatts for the 18 units. Three small station service units of 10,000 kilowatts each in the left powerplant increase the total to 2,280,000 kilowatts for the left and right powerplants.

The Third Powerplant has six units. The first three units have a nameplate rating of 600,000 kilowatts each and the last three are rated at 700,000 kilowatts each, for a total of 3,900,000 kilowatts in the Third Powerplant.

The pump-generating plant scheduled for completion in late 1981 will have six units capable of either pumping water or generating power. In the generating mode, each of these units will have a capacity of 50,000 kilowatts for a total of 300,000 kilowatts.

Grand Coulee Third Powerplant and Forebay Dam

Total generating capacity for the Grand Coulee hydropower installation will be 6,480,000 kilowatts.

Before construction could start on the Third Powerplant, it was necessary to modify the existing plants and route all generation to a new 230-kilovolt low-profile consolidated switchyard. Originally there was a switchyard on each side of the river, one for each of the existing powerplants. The right switchyard was in the area now occupied by portions of the forebay dam and the Third Powerplant. A new high-voltage cable system running through oil-filled pipes conveys the power from the left and right powerplants through galleries in Grand Coulee Dam and through an underground tunnel up to the new consolidated switchyard.

Power generated by the enormous units at the Third Powerplant is transmitted by 525-kilovolt cables, almost 5 inches thick, that run from the powerplant transformers through a gallery in the dam and through a tunnel to the 500-kilovolt cable spreading yard and then overhead to the switchyard on the hills west of the dam. About 4 miles of the 525-kilovolt cable is required for each of the six units in the Third Powerplant. The oil-impregnated insulation around the cable is efficient to the point where a hand can safely be placed on the cables only 1.5 inches from the copper core which carries enough electrical energy to supply the needs of 1.8 million people.

At the switchyards, power generated at Grand Coulee Dam in excess of station requirements is delivered to the lines of the Bonneville Power Administration, a marketing agency for federally produced power in the Pacific Northwest.

Grand Coulee Pump-Generating Plant

Six pumping units, each rated at 65,000 horsepower and with a capacity to pump 1,600 cubic feet per second at a 292- to 310-foot head, initially were installed in the plant.

Grand Coulee 230-kV consolidated switchyard

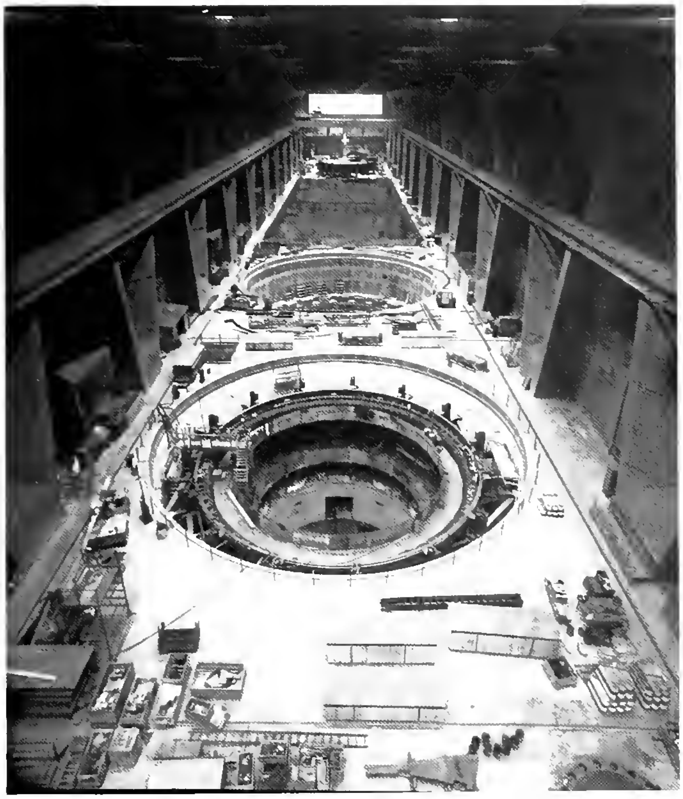
The plant was designed to accommodate 12 such units. In the early 1960's, with the Northwest facing power shortages, investigations showed the potential the site offered for pump-back storage. It was determined feasible that the last six units be reversible; that is, that water be returned from Banks Lake back through these units to generate power during peak power demand periods. Units 7 and 8 were constructed with each unit rated at 67,500 horsepower to lift 1,700 cubic feet per second in the pumping mode and rated at 50,000 kilowatts in the generating mode. The last four units are being installed and completion is scheduled for late 1981. These pumping units lift Columbia River water to the 1.6-mile-long feeder canal for delivery into Banks Lake.

Banks Lake

Banks Lake, the equalizing reservoir, was created by building two rock-faced, earthfill dams at the north and south ends of the Ice-Age channel of the Columbia River, now known as the Grand Coulee. This 27-mile-long reservoir, with an active storage capacity of 715,000 acre-feet, will feed Columbia River water into the Main Canal in sufficient quantity to irrigate more than 1 million acres. In addition, it will provide water on a return flow basis to produce power when the pump-generating units are operating in the generating mode.

Major features forming and serving Banks Lake are the feeder canal with a capacity of 16,000 cubic feet per second, North Dam, 2 miles west of Grand Coulee Dam, and Dry Falls Dam and Main Canal headworks near Coulee City, 29 miles south of Grand Coulee Dam.

The base width of the feeder canal is being increased from 50 to 80 feet; however, the operating capacity will remain at 16,000 cubic feet per second. Water depth will



Interior view at Coulee Third Powerplant

be reduced from 25 to about 20 feet to safely accommodate wave action when the waterflow is reversed as the pump-generators are changed from pumping to generating and vice-versa. Reconstruction is scheduled for completion in May 1980.

Main Canal

The Main Canal commences at the headworks at Dry Falls Dam and consists of unlined and concrete-lined sections. Total length of the canal, including siphons, tunnels, and Billy Clapp Lake, is 21 miles. The first 1.8 miles from Dry Falls Dam to the Bacon Siphon and Tunnel structures has been increased in capacity from 13,200 to 19,300 cubic feet per second. Bacon Siphon and Tunnel structures consist of two siphons, each about 1,000 feet long, and two tunnels, each about 2 miles long, that carry the water to Billy Clapp Lake. This lake, some 6 miles long and formed by the construction of the earthfill Pinto Dam, is a segment of the canal system. Construction of an equal length of very difficult and expensive canal was thus avoided. At present, 1,300 acres are served directly from the Main Canal; this will increase to about 5,000 acres.

West Canal

The West Canal has an initial capacity of 5,100 cubic feet per second and a length of 88 miles. It is one of two

Visitors Center at Grand Coulee Dam

canals formed by the bifurcation of the Main Canal. The West Canal skirts the northwest periphery of the project and enroute is carried across the lower Grand Coulee through the world's largest inverted siphon at the north end of Soap Lake. The canal continues around the upper margin of Quincy Basin to the northern base of Frenchman Hills, which it penetrates by a 9,000-foot tunnel, ending in an easterly branch across the Royal Slope. The West Canal will serve some 274,000 acres. The capacity of the canal is reduced progressively as water is diverted into lateral distribution systems built to serve the entire northwestern portion of the project.

East Low Canal

The East Low Canal, having an initial capacity of 4,500 cubic feet per second, also begins at the bifurcation of the Main Canal. The East Low Canal extends southerly in a contour course through the rolling eastern uplands, passes through or near the towns of Moses Lake and Warden, and terminates just east of the Scooteney Reservoir. An extension of the canal, on which construction has been deferred, would carry water southward and to the east of the towns of Connell, Mesa, and Eltopia. When complete, the East Low Canal will be about 127 miles long and will carry irrigation water for about 220,000 acres.

O'Sullivan Dam

O'Sullivan Dam, one of the larger zoned earthfill dams in the United States, is on Crab Creek about 15 miles south of Moses Lake. The 27,800-acre Potholes Reservoir formed by this dam collects return flows from all irrigation in the upper portion of the project for reuse in the southern portion. Active storage capacity of the reservoir is 332,200 acre-feet. A system of wasteways has been built on both the West and East Low Canals to provide operational safety for the canals and a means of delivering water into Potholes Reservoir to supplement the natural and return flows.

Potholes Canal

The Potholes Canal has a capacity of 3,900 cubic feet per second, commences at the headworks of O'Sullivan Dam, and extends 70 miles in a southerly direction to irrigate lands that eventually will total about 234,000 acres in the southwestern and south-central portions of the project. Irrigation Blocks 2 and 3, about 5,000 acres located in the southernmost tip of the South District, receive irrigation water pumped directly from the rivers: Block 2 from the Snake River and Block 3 from the Columbia River.

East High Canal

This proposed 88-mile-long canal, designed for an initial capacity of about 7,500 cubic feet per second, will divert water from the Main Canal immediately above Summer Falls and Billy Clapp Lake, and will serve lands east of the East Low Canal extending from the northernmost point of the project area south to Washtucna Coulee. Some 357,000 acres are proposed for service from the East High Canal.

Relift Pumping Plants

Approximately 360,000 acres of the irrigable lands within the project are located at elevations higher than the gravity canals and laterals. Some of these high lands are now being served by relift pumping plants at various points within the project. In 1978, there were 239 pumping plants with 484 individual pumps varying in size from 3 to 2,500 horsepower in those pumps delivering water to the irrigated area, including a few pumps required for drainage of low lying areas. In addition, there are six large pumps in the pump-generating plant rated at 65,000 horsepower each and two at 67,500 horsepower each.

DEVELOPMENT

Early History

The earliest settlement of the project area centered upon extensive use of the natural grasses for dryland grazing on unfenced rangeland. In the first decade of the 20th century, large numbers of homesteaders moved into the project area, acquired land under homesteading laws, and undertook conventional dry farming. Since the average annual rainfall over the entire area is less than 10 inches, dry farming could not result in permanent agricultural development. A few years of above-normal rainfall lent an appearance of success to farming operations after the grasslands were first plowed, but dry farming was doomed to failure on all but those lands with deep soils and high water-holding capacities. Even so, dry farming of cereal grains on a permanent basis was possible only through the consolidation of land holdings and the farming of very large tracts of land.

North Dam, Feeder Canal outlet, and Coulee Equalizing Reservoir

Investigations

With the establishment of the Reclamation Service in 1902 and the already apparent difficulties of dry farming in the area, interest developed in the possibility of irrigating with water from the Columbia River. The Reclamation Service undertook certain general investigations in 1904, but the basic problem of lifting Columbia

Banks Lake, Dry Falls Dam, outlet works, and Main Canal

O'Sullivan Dam

River water from its deep canyon onto the plateau surface was more than the young agency could hope to contend with at that time.

In 1918, local interests initiated a proposal for irrigation of the project area; they worked resolutely in the following years to achieve that goal. It was proposed that a high dam be built on the Columbia River at the head of the upper Grand Coulee, a unique geological feature in the ancient riverbed of the Columbia, formed when the original channel was blocked by glaciers during one of the Ice Ages. By building such a dam, irrigation water could be made available to the irrigable lands lying 50 miles to the south.

An alternative proposal, which had strong backing in the State of Washington, called for construction of a canal to convey water from the Pend Oreille River in northern Idaho generally westward across the plateau surface and into the middle portion of the project area.

Many engineering and economic studies were made by various organizations and governmental agencies. The conclusive and culminating study was prepared by the Corps of Engineers and published as House Document No. 103, 73d Congress, 1st session. The report recommended constructing the high Grand Coulee Dam at its present site and pumping irrigation water up into the Grand Coulee. In connection with this report, the Bureau of Reclamation submitted a report on the proposed irrigation plan for the Columbia Basin Project. The Reclamation report, dated January 7, 1932, recommended construction of the project essentially as it is now being built.

The landowners in the project area worked throughout the latter part of the 1930's to organize irrigation districts as a prerequisite to the construction of irrigation works. The three irrigation districts formed by February 1940 were the Quincy-Columbia Basin Irrigation District, the East Columbia Basin Irrigation District, and the South Columbia Basin Irrigation District.

In 1939, the Bureau of Reclamation, with the cooperation and assistance of about 45 different Federal, State, local, and private organizations, undertook a program of nonengineering studies important to settlement and development of this large project. This program of 28 problem studies was known as the Columbia Basin Joint Investigations. They were carried to completion, and the reports were published during World War II. The conclusions and recommendations made regarding the 28 problems were heavily drawn upon in drafting the Columbia Basin Project Act of 1943.

Main Canal

West Canal

A rapidly expanding power market in the Pacific Northwest experienced power shortages in 1951-52. Investigative studies were undertaken as a result of these shortages and in February 1954, the Bureau of Reclamation prepared a report on a proposed Third Powerplant at Grand Coulee Dam. It was concluded that the Third Powerplant was feasible from an engineering point of view; however, it was recommended that the development be held in abeyance until such time as prospective requirements for capacity, and energy resulting therefrom, provided definite prospects for financial feasibility. In January 1965, a feasibility report was issued recommending authorization to construct the Third Powerplant with a rated capacity of not less than 3.6 million kilowatts. Authorizing legislation followed in June 1966.

Authorization

The Columbia Basin Project was begun with the allocation of funds for Grand Coulee Dam pursuant to the National Industrial Recovery Act of June 16, 1933. The project was specifically authorized for construction by the Rivers and Harbors Act approved August 30, 1935. The Columbia Basin Project Act of March 10, 1943 (57 Stat. 14), reauthorized the project, bringing it under the provisions of the Reclamation Project Act of 1939.

Construction of the Third Powerplant was authorized by Public Law 89-448 (80 Stat. 200) dated June 14, 1966, as amended by Public Law 89-561 (80 Stat. 714) dated September 7, 1966.

Construction

Construction of the Columbia Basin Project, including Grand Coulee Dam and all related features, was assigned to the Bureau of Reclamation. Funds were made available by the Public Works Administration on July 27, 1933, by an allotment of $63 million under section 202 of the National Industrial Recovery Act.

A temporary project headquarters was established at Almira, Wash., 21 miles from the damsite. Excavation for the base of the dam, and construction of highway and railroad connections to the damsite and the necessary construction camp facilities was started in December 1933. In August 1934, the first of two major contracts for the construction of Grand Coulee Dam and Powerplant was awarded. Originally, the building of Grand Coulee Dam was planned in two stages. A low dam was to be built first, with a foundation designed so that a high dam could later be superimposed on it. A pumping plant and other components of the irrigation system also would be added in the second stage.

On August 30, 1935, the Congress authorized construction of the high dam and the irrigation project.

From 1933 to 1941, construction of the dam proper proceeded on a rapid schedule. By 1941, Grand Coulee Dam was essentially completed, the left powerhouse constructed, and the foundations placed for the right powerhouse and pumping plant.

During World War II, efforts centered entirely on the installation of hydroelectric power generating units in the left powerhouse. During this period, six 108,000-kilowatt Grand Coulee generators, two 75,000-kilowatt generators scheduled for Shasta Dam, and two 10,000-kilowatt station service generators were installed. After World War II, the two Shasta generating units were removed and three 108,000-kilowatt generators were installed in the left powerhouse to complete the nine planned units. A third station service generator was installed, and the right

Inlet of Bacon Siphon and Tunnel

powerhouse completed with nine 108,000-kilowatt units installed. The last of the eighteen 108,000-kilowatt generating units was placed in commercial operation in September 1951. Thus, about 18 years after the beginning of construction on Grand Coulee Dam, the powerplant was completed as originally planned, and maximum power production was available to meet power needs in the Pacific Northwest and to pump irrigation water for the Columbia Basin Project lands.

The eighteen 108,000-kilowatt generating units are being rewound to increase the rating of each unit to 125,000 kilowatts. The first unit was rewound in 1964, and the last unit was scheduled for completion in March 1980.

Construction of the Third Powerplant formally began July 12, 1967, when the contract was awarded to modify the then existing switchyards, especially the right powerhouse switchyard where the forebay and forebay dam would be located. Excavation of the forebay began with a contract award on December 5, 1967. The first unit in the powerplant, rated at 600,000 kilowatts, went into operation in August 1975, and the fourth unit, rated at 700,000 kilowatts, went on the line in April 1978. The sixth and last unit was scheduled for completion in January 1980, which will basically complete the Third Powerplant as authorized.

Outlet of Bacon Siphon and Tunnel

Construction of Irrigation Facilities

Construction of Grand Coulee Pumping Plant began in 1946. By 1951, six 65,000-horsepower pumps had been installed to serve the initial irrigation development on the project. Immediately following World War II, construction started on the primary irrigation facilities. In the spring of 1952, the first irrigation water was delivered to the irrigation system, then serving about 66,000 irrigable acres.

The delivery of irrigation water to this large acreage in 1952 did not mark the first irrigation of project lands. In 1948, a pumping plant on the Columbia River near Pasco was completed that served about 5,400 acres on Irrigation Block 1 (Pasco Pumping Unit). In 1950, the Burbank Pumping Plant on the Snake River south of Pasco brought water to about 1,200 acres in Irrigation Block 2 (Burbank Pumping Unit). Block 1 now receives water from the Potholes Canal.

In 1973, two of the pump-generator units were installed, each unit rated at 67,500 horsepower when pumping and 50,000 kilowatts when generating.

Since 1952, extending the major canals and constructing relift pumping plants and lateral systems has progressed on a regular schedule. As a result, irrigation of land on the Columbia Basin Project has proceeded in an orderly and efficient manner, which has brought about a well-rounded development. Roads, schools, towns to serve the newly irrigated lands, and many other aspects of the settlement and growth of a newly irrigated area have kept pace with the Bureau of Reclamation's schedule of construction.

Operating Agencies

All basic irrigation facilities applicable to the three Columbia Basin Irrigation Districts are operated by the districts. Irrigation facilities operated as reserved works by the Bureau of Reclamation include Dry Falls Dam, Main Canal through the bifurcation works including Pinto Dam and Billy Clapp Lake, and O'Sullivan Dam, Potholes Reservoir, and Potholes Canal headworks. Grand Coulee Dam, Powerplant, and Pumping Plant, and Banks Lake also are operated by the Bureau of Reclamation as reserved works.

BENEFITS

Irrigation

Eventually the project will bring over 1 million acres under irrigation.

The soil and climatic conditions are favorable to the growth of grain, alfalfa hay, ensilage crops, dry beans, fruit, sugar beets, potatoes, sweet corn, and seed and other specialty crops. Dairy farming and beef production are of significance in the area.

Flood Control

Sufficient space is maintained in Franklin D. Roosevelt Lake to control the Columbia River at The Dalles to no more than 450,000 cubic feet per second. Flood control parameter curves specify the amount of space required based on the forecasted runoff at The Dalles adjusted for available upstream storage capacity other than at Grand Coulee Dam. The forecast of runoff at The Dalles is made by the Portland River Forecast Center of the National Weather Service. The flood control operation is by formal agreement between the Bureau of Reclamation and the Corps of Engineers.

Power

The average annual net generation for the Grand Coulee Powerplant from 1968 through 1977 was about 17 billion kilowatt-hours. Hydroelectric power generated at Grand Coulee Dam furnishes a large share of the power requirements in the Pacific Northwest. The revenue derived from this power not only will repay the power investment but also will repay a large portion of the irrigation investment on the Columbia Basin Project and other Reclamation projects in the Northwest.

Energy produced by the 3,900,000 kilowatt Third Powerplant alone is sufficient to furnish the power needs for the cities of Seattle and Portland.

Pinto Dam

Recreation and Fish and Wildlife

Stretching from as far north as the Canadian border and south to Pasco, Wash., the Columbia Basin Project offers a vast recreation resource base characterized by long summers, mild winters, and an abundance of year-round sunshine. There are 350,000 acres of land and water available for recreation. Prior to development of the project, there were 35 lakes; there are now over 140 lakes, ponds, and reservoirs.

Franklin D. Roosevelt Lake is the largest reservoir on the project; it stretches for 151 miles with about 600 miles of shoreline. The lake area has been designated a National Recreation Area and is administered by the National Park Service. Reclamation's visitor center at Grand Coulee Dam is also the starting point for self-guided tours of the dam and powerplant complex. Recreation facilities have been constructed at many of the project reservoirs. There are State parks at Banks Lake, Billy Clapp Lake, and Potholes Reservoir, and a county park at Scooteney Reservoir.

The Columbia Basin is on the Pacific Flyway, a major waterfowl migration route, and the many acres of wetlands within the project area are used by numerous species. There is excellent hunting, and pheasant, a favorite upland game bird, has been stocked throughout the project. A portion of the Potholes Reservoir area has been included in the Columbia National Wildlife Refuge which is administered by the Fish and Wildlife Service.

The Bureau of Reclamation and the Washington State Department of Game have cooperated in stocking most bodies of water in the project area with a variety of fish which provide year-round fishing.

PROJECT DATA

Land Areas (1977)

Full irrigation service:		
Available for service	543,230	acres
Ultimate service	1,095,000	acres
Number of irrigated farms	2,148	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	457,060	90,040,866
1969	460,641	101,710,110
1970	446,596	96,036,493
1971	458,633	99,433,003
1972	463,472	120,262,374
1973	473,854	199,716,384
1974	493,657	264,465,262
1975	493,082	231,934,564
1976	505,804	208,414,416
1977	510,838	206,185,940

Power Generation

Fiscal Year	Grand Coulee Powerplant, kWh	Grand Coulee Pump-Generating, kWh	Total kWh
1968	14,495,713,000	--	14,495,713,000
1969	13,898,944,000	--	13,898,944,000
1970	15,830,303,000	--	15,830,303,000
1971	14,435,574,000	--	14,435,574,000
1972	14,004,088,000	--	14,004,088,000
1973	16,428,209,000	--	16,428,209,000
1974	13,897,254,000	1,714,000	13,898,968,000
1975	17,331,539,000	5,915,000	22,337,454,000
1976	26,615,885,000	--	[1]26,615,885,000
1977	17,857,713,000	[2]223,000	17,857,936,000

[1]15-month period. Transitional quarter July-September 1976 included. Fiscal year changed from July-June to October-September.
[2]Generation restricted due to widening feeder canal.

Facilities in Operation

Storage reservoirs	5	
Canals	333	mi
Laterals	1,933	mi
Pumping plants	240	
Drains	3,163	mi
Powerplants	1	
Transmission lines	21	mi
Substations	42	

Climatic Conditions

Annual precipitation	6.8	in
Temperature:		
Maximum	108	°F
Minimum	−16	°F
Mean	51	°F
Growing season	212	days
Elevation of irrigable area:		
Northern part	1500.0	ft
Southern part	500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	12,612
Other water service[3]	4,448
Total	17,060

[3]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

COLUMBIA RIVER

Drainage area above Grand Coulee Dam	74,100	mi²
Annual discharge:		
Maximum (1972)	101,000,000	acre-ft
Minimum (1977)	62,990,000	acre-ft
Average	81,060,000	acre-ft
Average annual project diversion (1963-77)	2,871,000	acre-ft

Storage Facilities

GRAND COULEE DAM

Type: Concrete gravity
Location: On Columbia River 28 mi northeast of Coulee City, Wash.
Construction period:
Main dam 1933-42
Forebay dam 1967-74
Date of closure (first storage): Spilled first water over the top in 1941.
Reservoir, Franklin D. Roosevelt Lake:

Total capacity to El. 1290[4]	9,652,000	acre-ft
Active capacity, El. 1208-1290	5,185,400	acre-ft
Surface area	80,000	acres
Dimensions:		
Structural height	550	ft
Hydraulic height	350	ft
Top width	30	ft
Maximum base width	500	ft
Crest length (total)	5,223	ft
Main dam	3,867	ft
Forebay dam	1,170	ft
Wing dam	186	ft
Crest elevation	1311.1	ft
Total volume of concrete	11,975,520	yd³
Original dam, power and pumping plants	10,585,000	yd³
306 feet of dam removed for forebay	−30,942	yd³
Forebay and wing dams	663,939	yd³
Third powerplant and miscellaneous	757,523	yd³

Spillway: Overflow section at center of dam, controlled by eleven 28- by 135-ft drum gates.

Elevation, top of gates	1290.0	ft
Crest elevation	1260.0	ft
Capacity at El. 1291.5	1,000,000	ft³/s

Outlet works:
Service: Forty steel conduits through dam in 2 tiers of 20 each; controlled by an 8.5-ft ring-seal gate.

Capacity at El. 1291.7	265,000	ft³/s

Power: Eighteen 18-ft-diameter and three 6-ft-diameter steel conduits through main dam, controlled by 15- by 29.65-ft coaster gates and 6-ft ring-seal gates, respectively.

[4]Includes estimated dead storage of 279,000 acre-ft below El. 1026.

Six 40-ft-diameter steel conduits through forebay dam controlled by 29- by 43.5-ft wheel mounted gates.

Capacity at El. 1291.7	280,000 ft^3/s

Foundation: Hard, sound, massive granite varying from coarse-grained in right abutment to fine-grained porphyritic in left abutment, with block joints and several crush-zones; two major and several minor crevices cross site; small springs throughout foundation.

Special treatment: Upstream cement grout curtain with adjacent drainage holes below drainage gallery; springs, joints, and crevices grouted.

Mass concrete (original main dam): Natural aggregate from riverbed near dam site, oversize crushed; modified and low-heat portland cement; temperature control by circulating river water through embedded pipe system.

Volume	9,738,000 yd^3
Maximum size aggregate	6 in
Cement content	1 bbl/yd^3
Average net water-cement ratio (by weight)	0.55

Contraction joints: Transversely spaced 25 to 51 ft; longitudinally spaced 31 to 57 ft; grouted after cooling of concrete.

North Dam and Dry Falls Dam

Type: Zoned earthfill
Location: North Dam is offstream about 2 mi southwest of Grand Coulee Dam; Dry Falls Dam is near Coulee City, Wash.
Construction period:
North Dam, 1949-51
Dry Falls Dam, 1946-49
Date of closure (first storage): 1951
Reservoir, Banks Lake:
Equalizing inflow from Lake Roosevelt through pumps via Feeder Canal.

Total capacity	1,275,000 acre-ft
Active capacity	715,000 acre-ft
Surface area	27,000 acres

	North Dam	Dry Falls Dam
Dimensions:		
Structural height	145 ft	123 ft
Hydraulic height	Offstream	Offstream
Top width	30 ft	42 ft
Maximum base width	1,000 ft	480 ft
Crest length	1,450 ft	9,800 ft
Crest elevation	1580.0 ft	1580.0 ft
Total volume	1,473,000 yd^3	1,658,000 yd^3

Spillway: None
Outlet works (at Dry Falls Dam):
Main Canal: Rectangular six-cell barrel conduit through dam near east end, controlled by six 12- by 18-ft radial gates.

Capacity at El. 1540	13,200 ft^3/s

Foundation: North Dam—granite on south abutment; interbedded disturbed basalt and shale overlain by sand, gravel, boulders, clay, and silt in the streambed, and a massive basalt slide block on north abutment. Dry Falls Dam—hard and dense to vesicular horizontal basalt flows cut by numerous old stream channels up to 50 ft deep.

Special treatment: Cement grout curtain under cutoff trench of Dry Falls Dam and under both abutments of North Dam.

Pinto Dam

Type: Zoned earthfill
Location: Offstream, 2.5 mi northeast of Stratford, Wash.
Construction period: 1946-48
Date of closure (first storage): August 1951
Reservoir, Billy Clapp Lake: Inflow from Main Canal.

Total capacity	64,200 acre-ft
Active capacity	21,200 acre-ft
Surface area	1,010 acres
Dimensions:	
Structural height	130 ft
Hydraulic height (Offstream)	
Top width	30 ft
Maximum base width	608 ft
Crest length	1,900 ft
Crest elevation	1351.0 ft
Total volume	1,462,000 yd^3

Spillway: Uncontrolled, open-cut channel in left abutment for emergency.

Crest length	150 ft
Crest elevation	1336.0 ft
Capacity at El. 1343.6	9,300 ft^3/s

Outlet works: Concrete-lined tunnel through left abutment controlled by one 4-ft-square slide gate.

Capacity at El. 1343.6	1,000 ft^3/s

Main Canal: Headworks structure at right abutment controlled by three 25-ft-square radial gates.

Capacity at El. 1335	5,400 ft^3/s

Foundation: Massive basalt flow consisting of successive flows of impervious dense basalt with vertical columnar jointing and interflow zones of somewhat pervious, broken, and vesicular basalt; several vertical fractures transverse to axis.

Special treatment: Cement grout curtain throughout entire length of dam. Fractures excavated and backfilled with concrete.

O'Sullivan Dam

Type: Zoned earthfill
Location: On Lower Crab Creek, about 22 mi south and 12 mi east of Ephrata, Wash.
Construction period: 1947-49
Spillway modified: 1973-75
Date of closure (first storage): 1951
Reservoir, Potholes:

Total capacity at El. 1048	511,700 acre-ft
Active capacity, El. 1020 to 1046.5	332,200 acre-ft
Surface area	27,800 acres
Dimensions:	
Structural height	200 ft
Hydraulic height	153 ft
Top width	30 ft
Maximum base width	860 ft
Crest length	19,000 ft
Crest elevation	1061.0 ft
Total volume	8,753,000 yd^3

Spillway: Located in rock cut to right of embankment section in streambed. Controlled by four 24-ft-wide by 19.4-ft-high radial gates with a 1.4-ft-high gate extension for wave prevention, and a chute 80 ft long and 105 ft wide for discharges into the original emergency spillway channel.

Crest length	105 ft
Crest elevation	1046.5 ft
Capacity at El. 1048	29,600 ft^3/s

Outlet works: Concrete conduit through base of dam to left of embankment section in streambed, controlled by one 4-ft-square slide gate and one 18-in gate valve.

Capacity at El. 1052	1,200 ft³/s

Foundation: Nearly horizontal basalt flows with interflow zones of pervious, broken, and vesicular basalt; western third of site is occupied by basalts severely crushed and sheared by folding and faulting of the Lind Coulee flexure.
Special treatment: Cement grout curtain under cutoff trench.

Carriage Facilities

Feeder Canal

Location: From end of Grand Coulee Pumping Plant discharge lines southwest to Banks Lake.
Construction period: 1946-51

Length	1.6 mi
Capacity	16,000 ft³/s
Canal section, concrete lined:	
Bottom width	50 ft
Side slopes	1.5:1
Canal depth	25 ft
Lining thickness	≤12 in
Length	6,130 ft
Cut-and-cover conduit:	
Description: Twin reinforced concrete barrels.	
Dimensions (each conduit):	
Length	2,100 ft
Diameter	25 ft

Terminal structures: Check structure with three 24- by 25-ft radial gates, a 410-ft-long concrete-lined chute, and a V-type weir.

Main Canal

Location: South from Dry Falls Dam to Long Lake, then west from Long Lake Dam to East Low and West Canals bifurcation works.
Construction period: 1946-51

Length (Including 5.5 mi in Long Lake)	21 mi
Diversion capacity	13,200 ft³/s
Typical maximum section in rock:	
Bottom width	50 ft
Side slopes	1.5:1
Water depth	35.8 ft
Typical maximum section, concrete lined:	
Bottom width	50 ft
Side slopes	1.5:1
Water depth	20.73 ft
Lining thickness	4.5 in

Bacon Tunnel No. 1 (Main Canal)

Location: On Main Canal beginning about 2 mi south of Dry Falls Dam.
Construction period: 1946-50

Length	10,045 ft
Capacity	7,250 ft³/s
Cross section: Horseshoe	
Diameter	23.25 ft

Lining: Concrete

Bacon Siphon No. 1 (Main Canal)

Location: On Main Canal about 2 mi south of Dry Falls Dam.
Construction period: 1946-50
Description: Reinforced concrete conduit

Length	1,038 ft
Diameter	23.25 ft
Capacity	7,250 ft³/s

Bacon Tunnel No. 2 (Main Canal)

Location: On Main Canal beginning about 2 mi south of Dry Falls Dam.
Construction period: 1976-80

Length	9,950 ft
Capacity	12,050 ft³/s
Cross section: Horseshoe	
Diameter	28.5 ft

Lining: Concrete

Bacon Siphon No. 2 (Main Canal)

Location: On Main Canal about 2 mi south of Dry Falls Dam.
Construction period: 1976-80

Length	1,041 ft
Diameter	28 ft
Capacity	12,050 ft³/s

West Canal

Location: From bifurcation on Main Canal about 2.5 mi north of Adrian, Wash., southwest to vicinity of Quincy, Wash., then south to Frenchman Hills Tunnel and east to vicinity of O'Sullivan Dam.
Construction period: 1946-55

Length	88 mi
Diversion capacity	5,100 ft³/s
Typical maximum section in earth:	
Bottom width	50 ft
Side slopes	1.5:1
Water depth	19.12 ft
Typical maximum section, concrete lined:	
Bottom width	38 ft
Side slopes	1.5:1
Water depth	16.4 ft
Lining thickness	4.5 in

Soap Lake Siphon (West Canal)

Location: On West Canal around north end of Soap Lake, and about 8 mi northeast of Ephrata, Wash.
Construction period: 1948-51
Description: Monolithic concrete pipe with steel liner in high-head sections

Length	2.45 mi

Diameter: 25-ft-diameter for the 0.88 mi of end sections where static head is less than 100 ft; 22.33-ft-diameter for remainder (static head greater than 100 ft).

Capacity	5,100 ft³/s

Frenchman Hills Tunnel (West Canal)

Location: On West Canal about 20 mi south of Quincy, Wash.
Construction period: 1951-53

Length	9,280 ft
Capacity	1,540 ft³/s
Cross section: Horseshoe	
Diameter	14 ft

Lining: Concrete

Royal Branch Canal (West Canal)

Location: From turnout of West Canal and outlet of Frenchman Hills Tunnel.
Construction period: 1956-57

Length	8.5 mi
Diversion capacity	900 ft³/s
Typical maximum section:	
Bottom width	37 ft
Side slopes	1.5:1
Water depth	7.24 ft

East Low Canal

Location: From Main Canal about 2.5 mi north of Adrian, Wash., generally south-south-east to the Snake River Valley about 8 mi northeast of Pasco, Wash.
Constrution period: 1946-54

Length:	
Present	87 mi
Ultimate	130 mi
Diversion capacity	4,500 ft³/s
Typical maximum section in earth:	
Bottom width	68 ft
Side slopes	1.5:1
Water depth	15.5 ft
Typical maximum section, concrete lined:	
Bottom width	20 ft
Side slopes	1.5:1
Water depth	18.92 ft
Lining thickness	4.5 in

Potholes Canal

Location: From O'Sullivan Dam generally south to vicinity of Pasco, Wash.
Construction period: 1949-53

Length	70 mi
Diversion capacity	3,900 ft³/s
Typical maximum section in earth:	
Bottom width	48 ft
Side slopes	1.5:1
Water depth	15.9 ft
Typical maximum section in rock:	
Bottom width	34 ft
Side slopes	0.25:1
Water depth	35.36 ft

Eltopia Branch Canal (Potholes Canal)

Location: From turnout on Potholes Canal about 8 mi northwest of Eltopia, Wash., then southeast to vicinity of Eltopia.
Construction period: 1953-54

Length	25 mi
Diversion capacity	555 ft³/s
Typical maximum section in earth:	
Bottom width	20 ft
Side slopes	1.5:1
Water depth	6.6 ft

Wahluke Siphon (Wahluke Branch Canal)

Location: On the Wahluke Branch Canal beginning at the turnout from the Potholes Canal.
Construction period: 1956-59

Length	3 mi
Diameter	15.33 ft
Capacity	2,000 ft³/s

Wahluke Branch Canal (Potholes Canal)

Location: Southwest from turnout on Potholes Canal about 6 mi south of Othello, Wash.
Construction period: 1957-67

Length	41 mi
Diversion capacity	2,000 ft³/s
Typical maximum section in earth:	
Bottom width	36 ft
Side slopes	1.5:1
Water depth	9 ft
Typical maximum section, concrete lined:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	10.4 ft
Lining thickness	4.5 in

Pumping Plants (Includes Drainage Pumping Plants)

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Grand Coulee Pump-Generating Plant	8	12,640	292-310	525,000
Block No. 1 — 5 relift plants	8	103	6-35	428
Block No. 2 —				
Burbank No. 1	3	40.5	90	600
Burbank BP 0.3	1	9	24	30
Block No. 3 —				
Burbank No. 2	3	57	81	750
Burbank No. 3	4	29.5	85	400
Block No. 11 —				
Lower Scooteney	3	76	149	1,500
Upper Scooteney	3	24	97	300
Upper Scooteney (P.E. 27A second relift)	1	9	155	200
2 plants	2	5.75	14	15
Block No. 12 — 2 plants	3	17	4-27	45
Block No. 13 — 6 plants	6	25.3	10.5-22	75
Block No. 14 —				
Mesa	4	160	82	1,800
9 plants	18	103	5.5-28	241
Block No. 15 —				
Ringold	4	232	35-38	1,230
Ringold relift	3	118	14.5	480
12 plants	17	153.7	6-52	923
Block No. 16 —				
Eltopia Branch	3	72	50	600
11 plants	20	110	10.5-70	870
Block No. 161 — 1 plant	3	28	26	120
Block No. 17 —				
Sagemoor	4	88	91	1,200
Block No. 18 —				
13 plants	26	177.8	5.5-34.5	355.5
Block No. 19 — 5 plants	8	37.6	7.5-70	205
Block No. 20 —				
White Bluffs No. 1	4	178	85	2,000
9 plants	17	95.7	8-72	500
Blocks No. 21 and 48 —				
Radar	5	256	118-277	8,100
Blocks No. 23 and 201 —				
White Bluffs No. 2	6	222	63-106	2,250
Block No. 23 — 3 plants	7	20	15-18	72.5
Block No. 24 — 1 plant	3	36	260	1,500
Block No. 201 — 1 plant	2	10.2	11	20
Block No. 40 — 5 plants	8	40	11-45	125
Block No. 401 — 2 plants	3	35.8	11-25.5	125
Block No. 41 — 7 plants	13	95	5-35	297.5
Block No. 42 — 9 plants	18	135	10-32	522.5
Block No. 43 — 7 plants	9	54.1	4-64	268
Block No. 44 —				
Warden	3	135	55	1,050
North Warden	3	72	57	600
Warden Relift	4	57	51-96	550
6 plants	8	49	12-125	525
Block No. 45 — 15 plants	24	165.5	7-45	538
Block No. 46 — 1 plant	2	8	22-23	32.5
Block No. 47 — 5 plants	8	43	8.5-23	130
Block No. 48 — 1 plant	2	14.4	17	40

PUMPING PLANTS (INCLUDES DRAINAGE PUMPING PLANTS)-Cont'd.

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horse-power
Block No. 49 —				
Lower Saddle Gap	4	112	94	1,600
Upper Saddle Gap	4	90	15-113	1,365
PE-17	1	14	86	200
Block No. 70 —				
W-9	3	47	85-230	1,100
2 plants	2	25	7-54	140
Block No. 71 — 2 plants	2	17	6-29.5	63
Block No. 72 — 11 plants	12	60	5-90	302.5
Block No. 73 —				
Quincy	9	421	59-260	10,018
2 plants	3	17.3	13-80	90
Block No. 74 —				
Babcock	10	292	44-221	6,200
Babcock W.W. disposal	2	20	32	120
Block No. 741 — 1 plant	3	17.2	70	190
Block No. 75 —				
3 plants	5	35	8-18	85
1 plant	1	3	21.5	12.5
Block No. 76 — 2 plants	10	99.6	5-20	185
Block No. 77 —				
Evergreen	8	253	83-222	6,800
2 plants	4	47.2	18-20	127.5
Block No. 78 — 4 plants	6	51	6-13	102.5
Block No. 79 —				
Frenchman Springs	8	197	57-264	4,700
Block No. 80 —				
Hope Valley	3	60	84	760
Blocks No. 80 and 81 —				
Frenchman Hills	9	432	170-314	13,500
Block No. 81 —				
Low Gap	4	85.6	72	900
Block No. 83 —				
Sand Hollow	4	178	65	1,600
6 plants	11	44.4	6-20	95
Block No. 85 — 4 plants	6	21.4	9-18	65
Block No. 86 — 1 plant	1	3	16	10
Block No. 87 — 5 plants	10	47	6.5-51	220
Block No. 88 — 1 plant	2	11	7	15
Block No. 89 — 14 plants	28	134.3	5-33	365
Soap Lake Protective Works Block No. 70 —				
Lake Lenore No. 1	4	35	60	350
Lake Lenore No. 2	5	40	197	1,200
Lake Lenore No. 3	1	4	250	150
6 deep wells	6	16.8	220-304	800

Power Facilities

GRAND COULEE POWERPLANT COMPLEX

Location: Two powerplants, one on each side of river at toe of Grand Coulee Dam. Third powerplant at base of Forebay Dam. Pump-generator plant adjacent to reservoir at left abutment of main dam.
Original two powerplants:
Year of initial operation: 1941
Year last generator in operation: 1951
Third Powerplant:
Year of initial operation: 1975
Year last generator scheduled: 1980
Pump-generator plant:
Year of initial pump-generator operation: 1973
Year last pump-generator scheduled: 1981

Nameplate capacity		6,480,000 kW
Number and capacity of generators	(18)	125,000 kW
	(3)	10,000 kW
	(3)	600,000 kW
	(3)	700,000 kW
	(6)	50,000 kW
Maximum head		345 ft

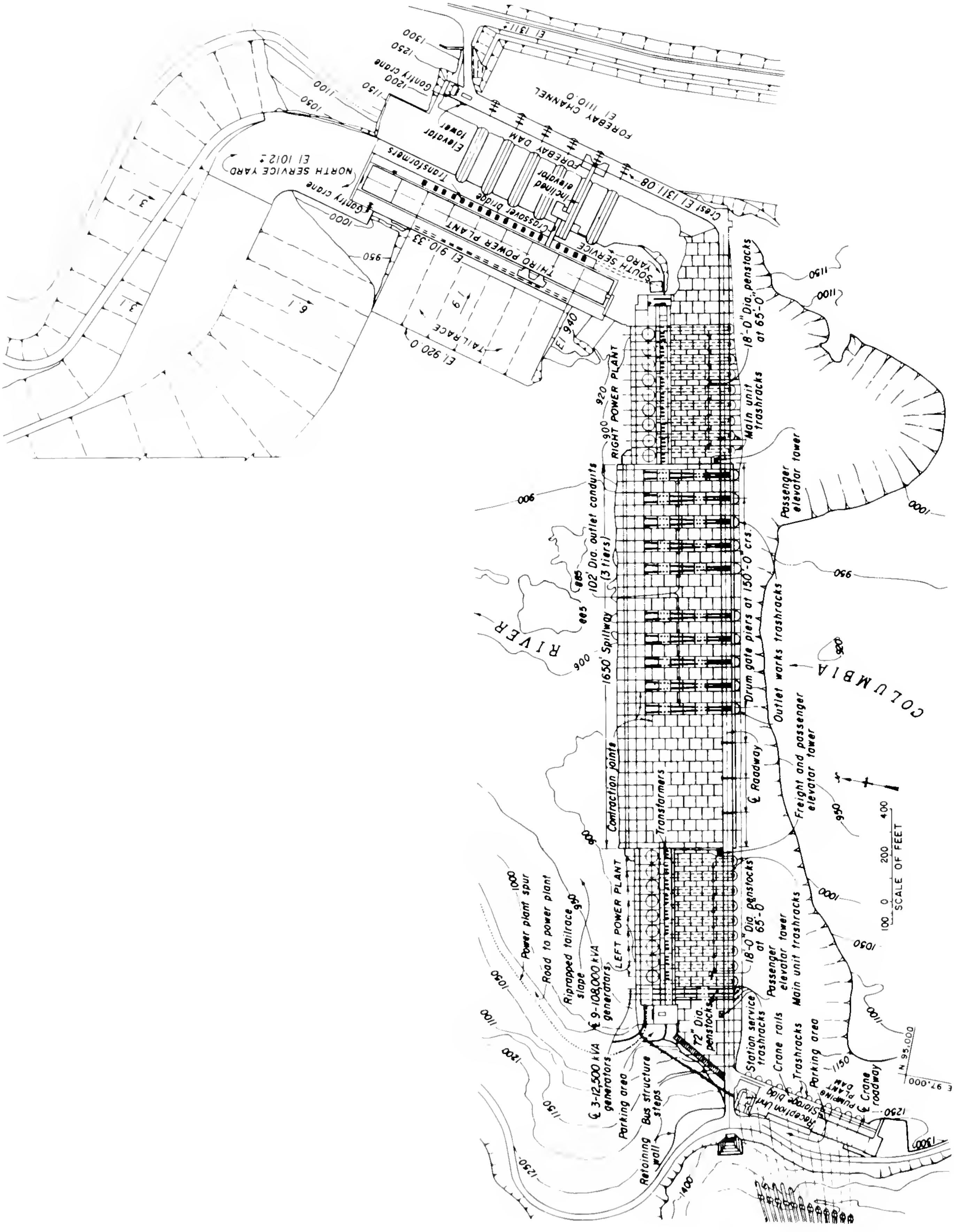
SUBSTATIONS

Number in operation	42
Total capacity of transformers	7,575,748 kVA

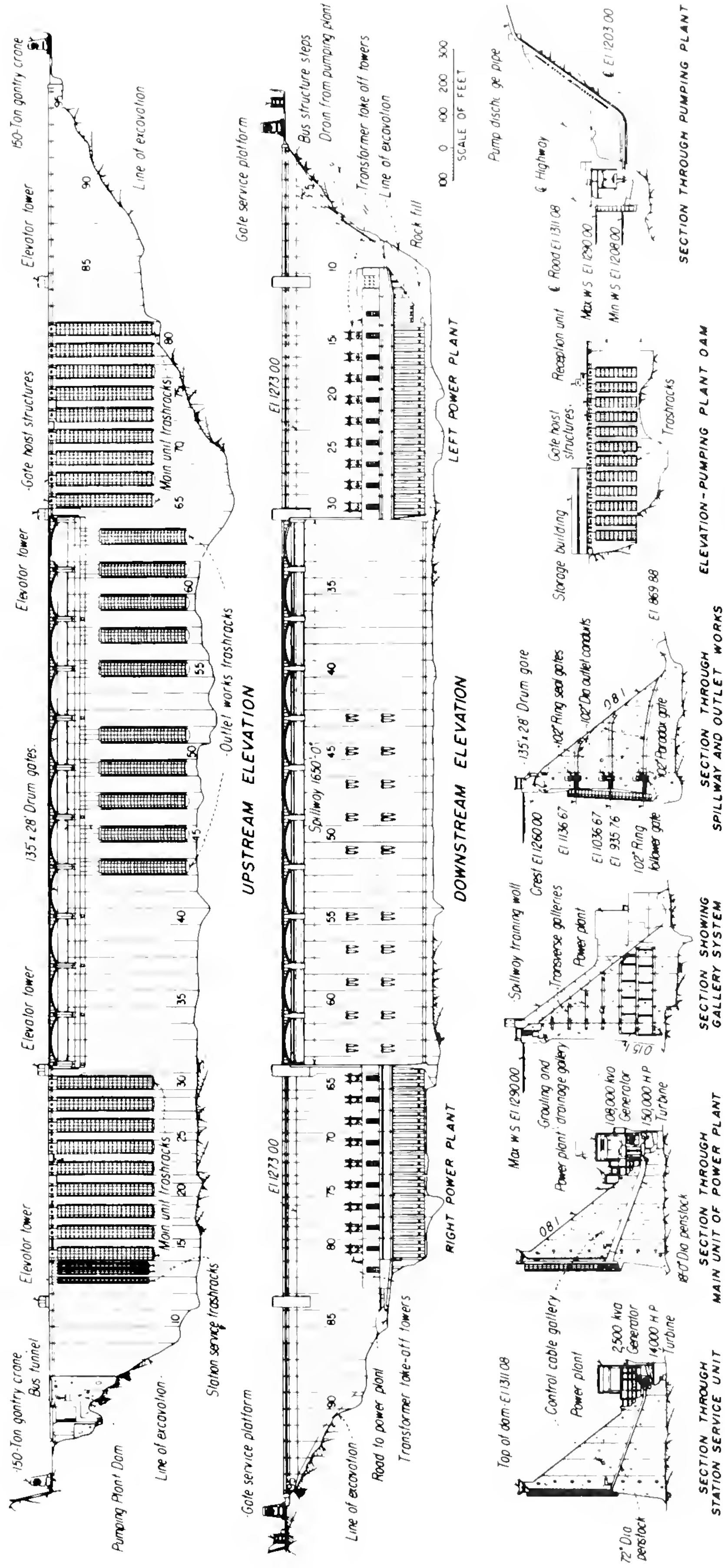
TRANSMISSION LINES

Total number of lines	21
Total circuit miles	44.66

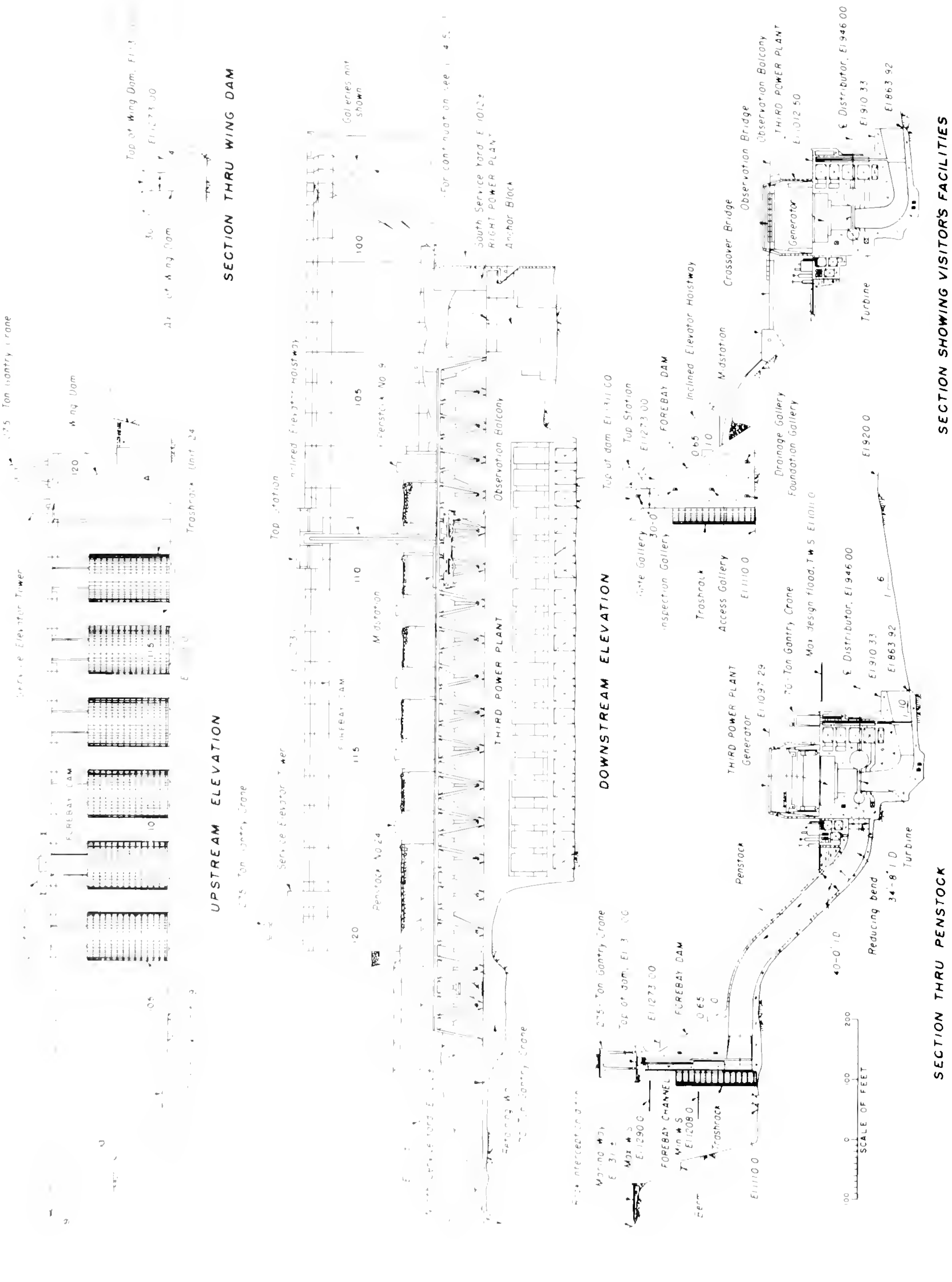
Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Consolidated switchyard — 500-kV switchyard	500	1,500,000	1.24	1974
500-kV Spreading Yard — 500-kV switchyard (6 circuits)	500	---	7.40	---
115-kV Cable Spreading Yard—115-kV switchyard (2 circuits)	115	---	0.06	---
Grant PUD Line — Frenchman Springs Pumping Plant	115	4,000	0.21	1958
Grant PUD Line — Evergreen Pumping Plant	110	5,000	3.35	1957
Grant PUD Line — Frenchman Hills Pumping Plant	115	5,000	0.36	1961
Grant PUD Line — Radar Pumping Plant	115	5,000	1.94	1967
Grant PUD Line — Quincy Pumping Plant	110	6,600	1.70	1953
Quincy Substation — Babcock Pumping Plant	13.8	5,000	2.70	1953
Ringold Substation — Ringold and PE 51	13.8	5,000	4.00	1954
Ringold Substation — EB1 Pumping Plant	13.8	500	4.22	1955
Warden Substation — Warden Pumping Plant	13.8	2,250	2.66	1954
Glade Substation — Pasco Relift Pumping Plants	13.8	3,000	11.10	1948
Burbank Substation — Burbank Pumping Plant	13.8	1,500	0.88	1950
Jericho Substation — Sand Hollow Pumping Plant	13.8	1,500	2.84	1960



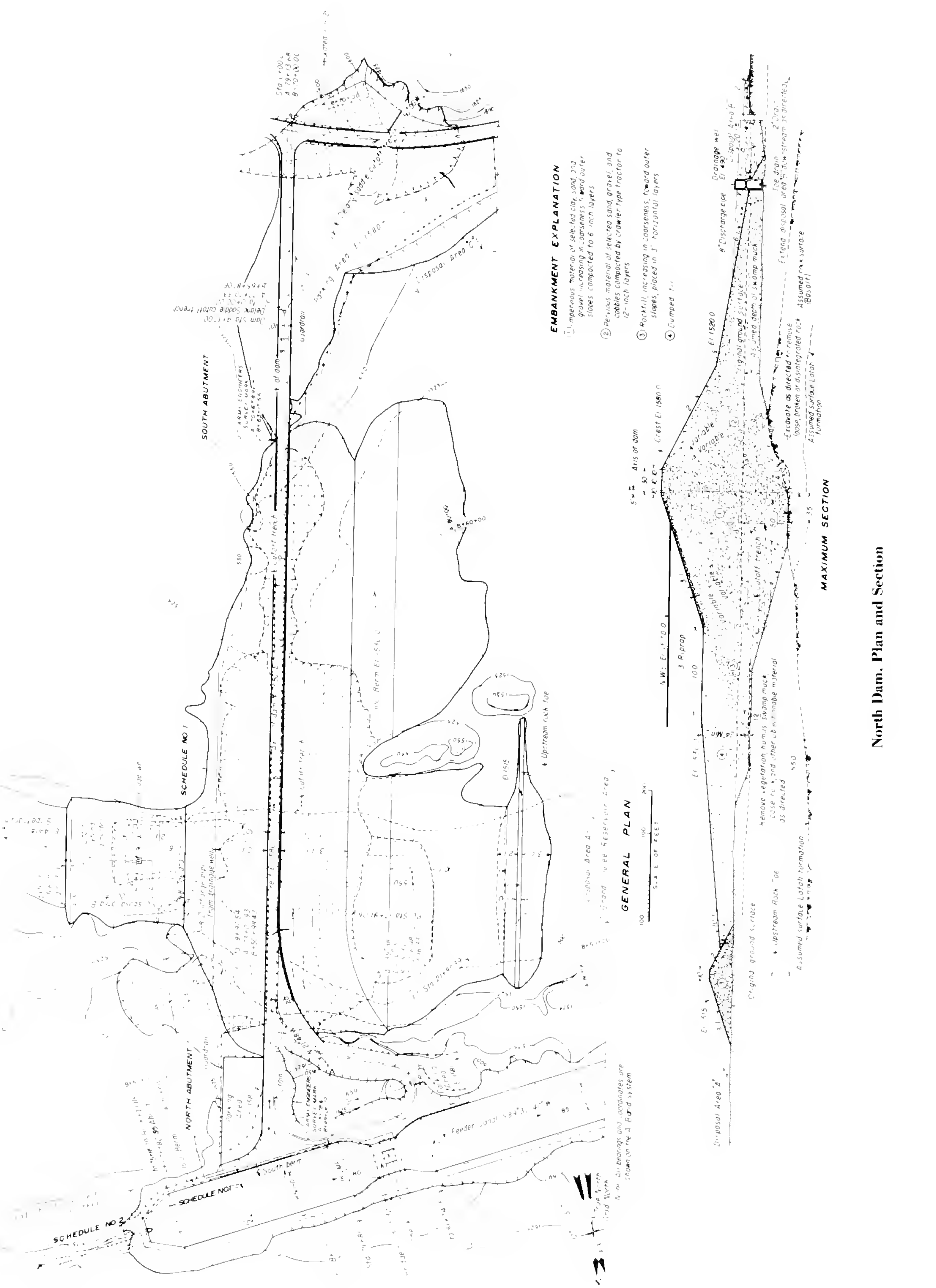
Grand Coulee Dam. General Plan



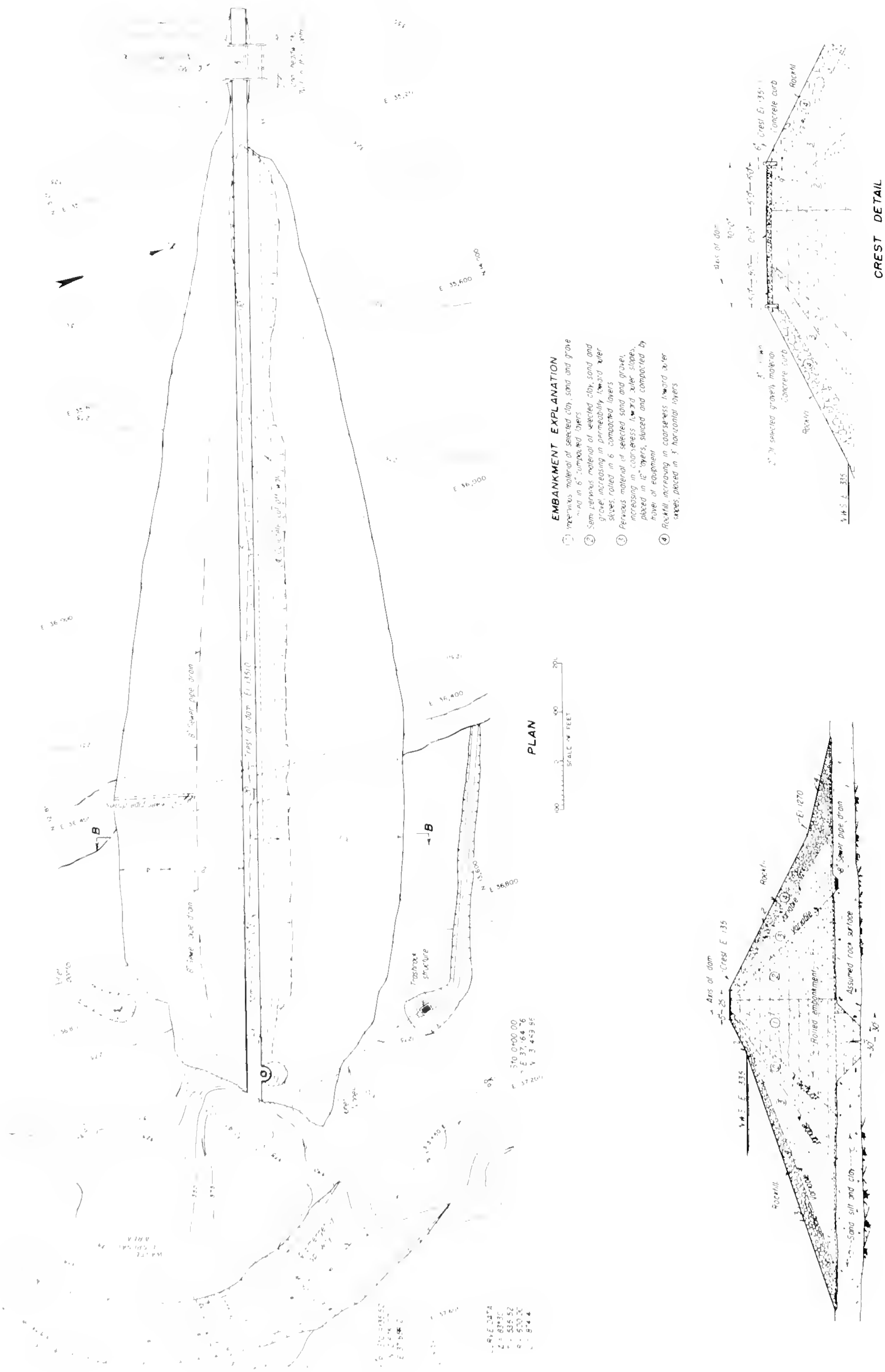
Grand Coulee Dam, Elevations and Sections



Grand Coulee Forebay Dam, Elevations and Sections



North Dam, Plan and Section

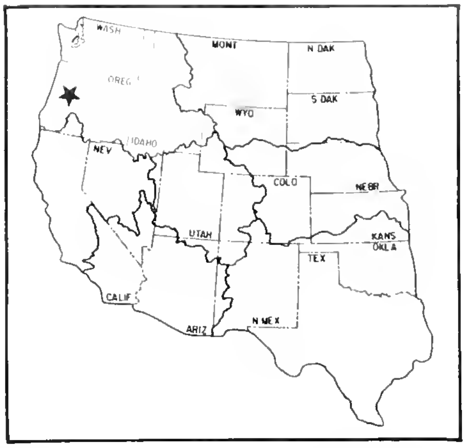


Pinto Dam, Plan and Sections

Crescent Lake Dam Project

Oregon: Deschutes and Klamath Counties

Pacific Northwest Region
Water and Power Resources Service



The Crescent Lake Dam Project is composed of lands of the Tumalo Irrigation District on the west side of the Deschutes River near Bend, Oreg.

The principal feature of the project is Crescent Lake Dam, located at the outlet of Crescent Lake. The lake is a large natural body of water formed in a glacial deposit high on the eastern slopes of the Cascade Range. There are about 25 miles of canals and some 70 miles of distribution laterals in the project that furnish a full irrigation water supply to 8,000 acres of land. Developed by private interests, the project has been rehabilitated by the Bureau of Reclamation.

PLAN

Water rights are owned on Tumalo Creek, Little Crater Creek, Crater Creek, Three Springs, and the Deschutes River. Water from the Deschutes River is stored and released when required from Crescent Lake. The water is diverted and delivered to project lands through the privately constructed canal and lateral system.

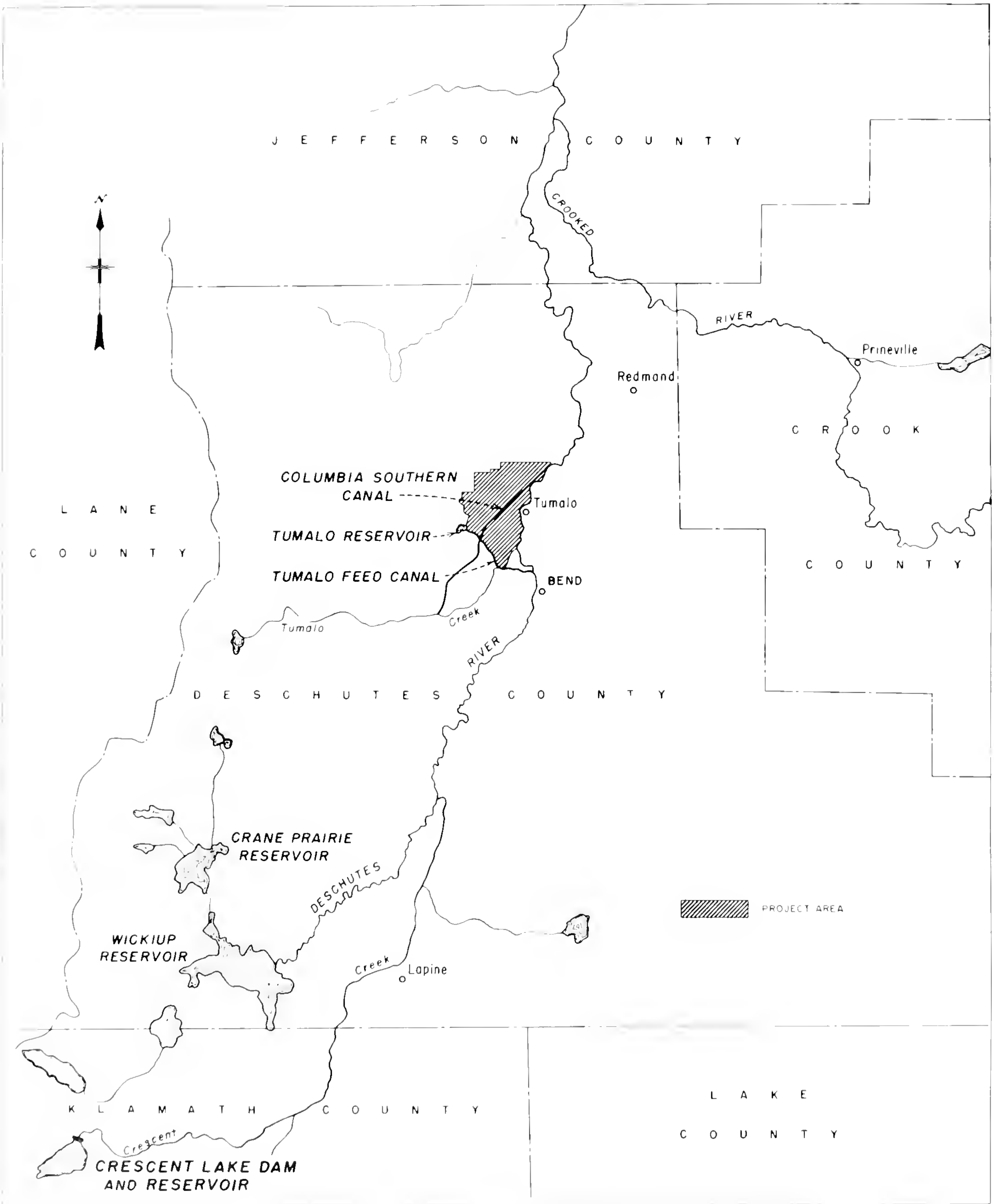
Crescent Lake Dam and Crescent Lake

The original dam was removed and a new Crescent Lake Dam was constructed by Reclamation to store 86,900 acre-feet. The new earthfill dam has a maximum height of 40 feet. The outlet works conduit has a capacity of 1,325 cubic feet per second. An uncontrolled spillway, 45 feet wide, is in a saddle on the right abutment.

Canals and Laterals

The district had been experiencing high water losses in its carriage system that included over 13,300 feet of old wood-trestle supported, metal Lennon flumes. Major

Crescent Lake Dam and Reservoir



Crescent Lake Dam Project

Crescent Lake Dam

Crescent Lake Dam at outlet of Crescent Lake

facilities rehabilitated included replacing three flumes on the Bend Feed Canal, totaling 10,500 feet, with 72-inch pipeline. The 750-foot tunnel section of the canal, originally lined with untreated wood, was replaced with 78-inch asbestos bonded and coated corrugated metal pipe. The headworks and rubble masonry section at the diversion dam was gunite lined with a 2.5-inch-thick reinforced concrete layer. One Lennon flume on the Tumalo Feed Canal was replaced with 2,830 feet of 54-inch pipeline. Other minor rehabilitation work was completed on the canal and lateral systems.

DEVELOPMENT

Early History

The history of irrigation in the general project area dates back to 1871 when individual farmers diverted water from Squaw Creek, a tributary of the Deschutes River. Following the simple individual diversions, community irrigation enterprises were developed.

The Deschutes County Municipal Improvement District had its beginning in 1902 as a State project for the irrigation of lands under provisions of the Carey Act. At first, only direct flow from Tumalo Creek was available, but later Tumalo Reservoir was constructed in a dry basin near the upper edge of the project and was to be filled through a 7-mile feeder canal from Tumalo Creek. The reservoir failed to hold water. In 1922, the project was reorganized into the present district organization and, because of water shortages, the acreage was reduced from the initially contemplated area of 27,000 acres to 15,400 acres. On March 9, 1959, the organization changed its name to the Tumalo Irrigation District. To augment the water supply from Tumalo Creek, the storage right of the Walker Basin Irrigation Company at Crescent Lake was purchased, and a reservoir with a capacity of 86,900 acre-feet constructed. A 9.5-cubic-foot-per-second continuous flow water right in the Deschutes River was obtained from the city of Bend. Also constructed at that time was the diversion dam in the Deschutes River at Bend, the Bend Feed Canal, and other physical works. The irrigated acreage has been reduced considerably from the initial plan. A timber-crib dam was built across Crescent Creek at the outlet of Crescent Lake, and storage was begun in 1922. In the intervening years, there had been a steady deterioration in the timbering and fill, and after 1946, storage was limited to 54,860 acre-feet, 32,000 acre-feet less than the reservoir's capacity.

At the end of the 1953 irrigation season, storage was further reduced to 36,000 acre-feet, and the outlet gates were difficult to operate. A program of reconstruction was urgently required to ensure both the safety of the dam and a dependable storage water supply to maintain productiveness on district lands.

Investigations

Assistance was requested by the local organization, and Crescent Lake Dam was investigated by the Bureau of Reclamation. Investigations of the canal and lateral system were performed by a private organization. Both investigations led to authorization for rehabilitation.

Authorization

The emergency rehabilitation of Crescent Lake Dam was authorized on July 1, 1954, by the Interior Department Appropriation Act, 1955 (68 Stat. 361, 365). Rehabilitation of the canal and lateral system was authorized on October 7, 1970, by the Public Works Appropriation Act, 1971 (84 Stat. 890).

Construction

Reconstruction of Crescent Lake Dam was begun in 1955 and completed in 1956. Rehabilitation of the canal and lateral system began in 1974 and was completed in 1977.

Operating Agency

The Tumalo Irrigation District operates and maintains the project.

BENEFITS

Irrigation

Grain, alfalfa, grass hay, and irrigated pasture are the principal crops produced.

Recreation

Crescent Lake lies wholly within the Deschutes National Forest which administers recreation on the reservoir. Located less than 7 miles from the crest of the Cascade Mountain Range, the reservoir area has 1,985 acres of land available for recreational use, and 4,000 acres of water surface provide 21 miles of shoreline. Facilities for camping, picnicking, and boat launching and mooring have been constructed and an area has been designated for swimming. In addition to these public facilities, a Boy Scout camp and 72 private cabins have been built at Crescent Lake. A commercial resort has been developed on the reservoir that provides lodging and supplies for visitors. One of the many attractions of the reservoir is the trout fishing.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	8,000	acres
Number of irrigated farms	365	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,837	395,811
1969	6,929	384,003
1970	6,929	381,370
1971	7,144	406,612
1972	6,829	355,418
1973	7,053	649,164
1974	6,626	503,681
1975	7,082	563,515
1976	7,732	432,939
1977	7,680	595,246

Facilities in Operation

Storage dams	1	
Diversion dams	3	
Canals	25	mi
Laterals	70	mi

Climatic Conditions

Annual precipitation	11	in
Temperature:		
Maximum	102	°F
Minimum	−24	°F
Mean	46	°F
Growing season	93	days
Elevation of irrigable area	3620.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,300
Municipal water service	5,400
Other water service[1]	220
Total	6,920

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

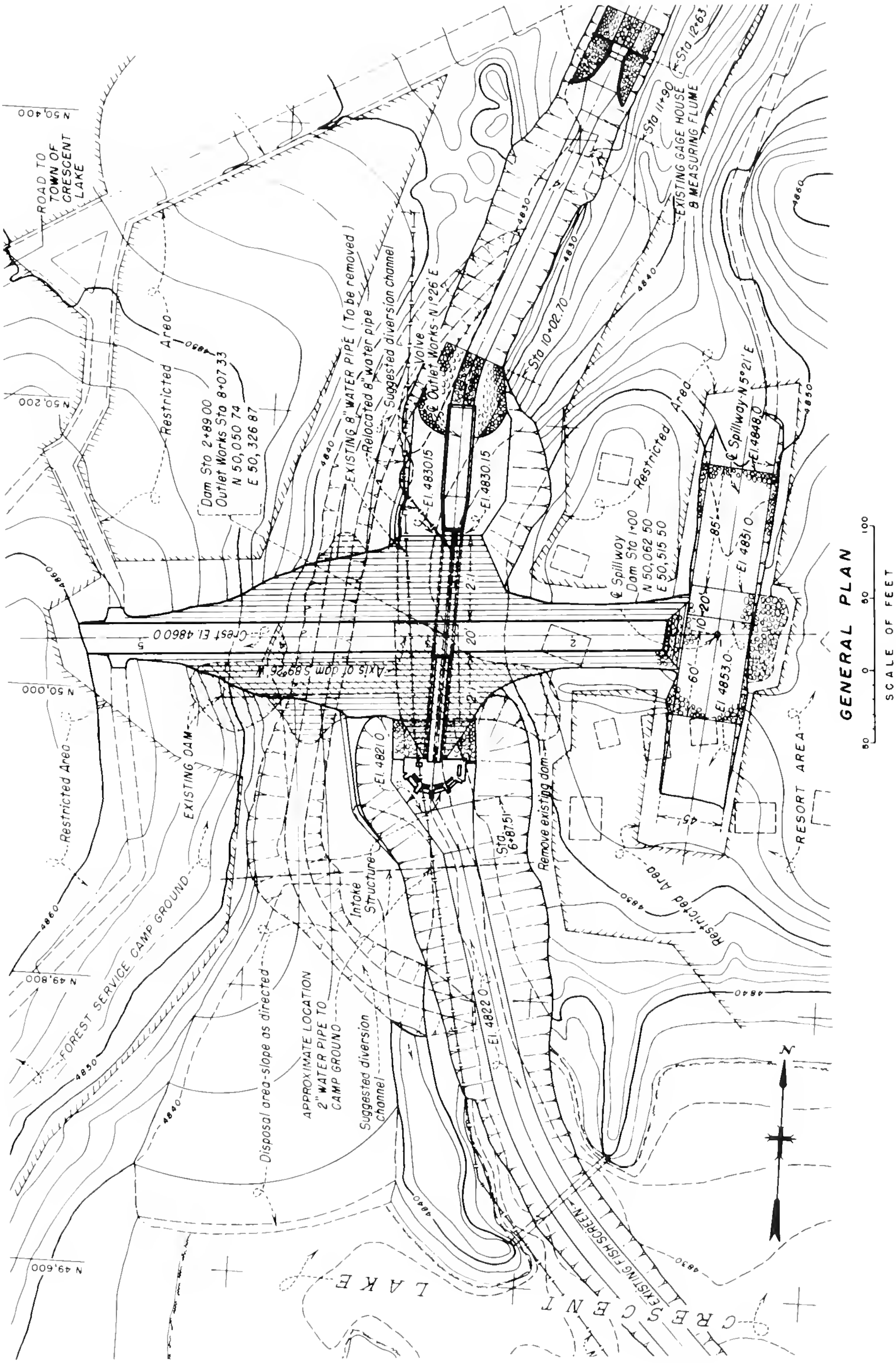
CRESCENT LAKE

Drainage area	61	mi²
Annual discharge:		
Maximum (1972)	78,200	acre-ft
Minimum (1977)	19,600	acre-ft
Average	45,400	acre-ft
Average annual diversion (1963-77)	62,400	acre-ft

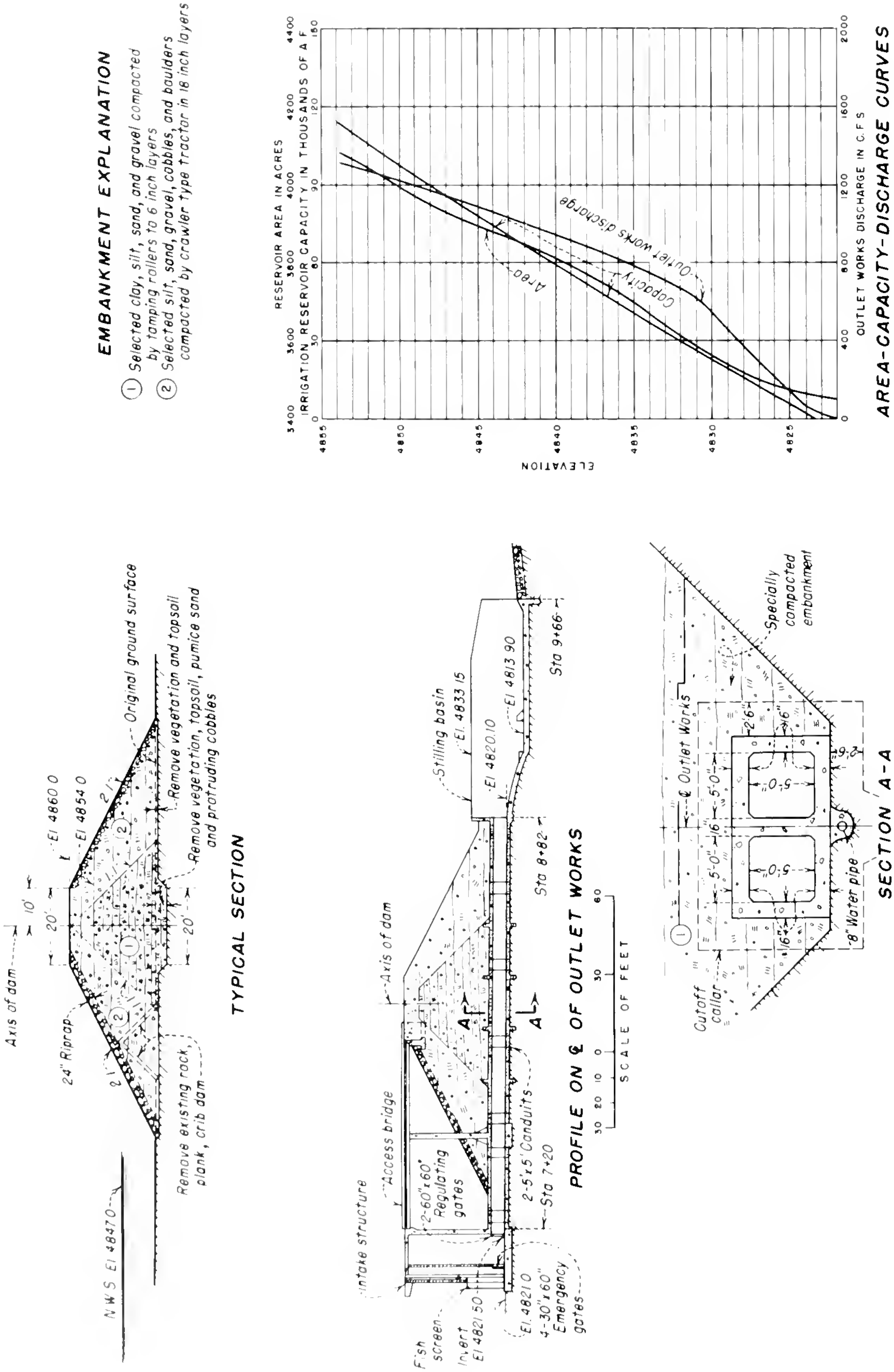
Storage Facilities

CRESCENT LAKE DAM

Type: Zoned earthfill		
Location: At outlet of Crescent Lake, 0.7 mi from Crescent Lake, Oreg.		
Construction period: Reconstructed 1955-56. Existing timber and rockfill dam removed.		
Reservoir, Crescent Lake:		
Average annual inflow, 1963-77	45,400	acre-ft
Active capacity at El. 4823.4-4847	86,900	acre-ft
Surface area	4,050	acres
Dimensions:		
Structural height	40	ft
Hydraulic height	33	ft
Top width	20	ft
Maximum base width	120	ft
Crest length	450	ft
Crest elevation	4860.0	ft
Volume	19,000	yd³
Spillway: Uncontrolled riprap-lined open channel at right abutment acts as emergency spillway.		
Crest length	45	ft
Crest elevation	4853.0	ft
Outlet works: Concrete conduit through base of dam, controlled by two 5-ft-square slide gates.		
Capacity at El. 4853	1,325	ft³/s



Crescent Lake Dam, Plan

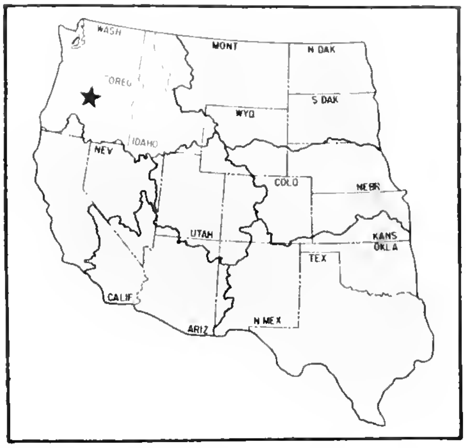


Crescent Lake Dam, Sections

Crooked River Project

Oregon: Crook County

Pacific Northwest Region
Water and Power Resources Service



The main body of the Crooked River Project lies north and west of Prineville, Oreg. The water resources of Ochoco Creek and Crooked River are used to furnish irrigation water for 23,840 acres.

Project features include Arthur R. Bowman Dam on the Crooked River, Ochoco Dam on Ochoco Creek, a diversion canal and headworks on the Crooked River, Lytle Creek Diversion Dam and Wasteway, two major pumping plants, nine small pumping plants, and Ochoco Main and distribution canals.

By congressional approval in 1964, the 3,450-acre Crooked River Extension was added to the project. This additional acreage was made possible by constructing six small pumping plants and using a portion of the unassigned space in Prineville Reservoir.

A 5-year rehabilitation and betterment program is underway to install some 20 miles of concrete pipe laterals and drains to replace existing open and unlined channels.

PLAN

The project provides water for irrigation through the addition of works to the Ochoco Irrigation District. The rehabilitated Ochoco Dam, with a usable reservoir capacity of 46,500 acre-feet, supplemented by the 70,282 acre-feet of assigned space in Prineville Reservoir, furnishes an adequate water supply to both district and nondistrict lands. Releases from Ochoco Reservoir flow into the Ochoco Main Canal, which serves high-elevation project lands east and north of Prineville. Storage from Prineville Reservoir is released into the river and diverted to project lands by a diversion canal 6 miles above Prineville. From the headworks, the diversion canal runs north 8.3 miles across Ochoco Creek to the Barnes Butte Pumping Plant. The diversion canal serves irrigable lands along its course.

The Barnes Butte Pumping Plant lifts the water to the 15.8-mile-long distribution canal which runs through the center of the district lands. The Ochoco Relift Pumping Plant lifts the water to replenish flows in the Ochoco Main Canal that serves lands west of McKay Creek. Lytle Creek Diversion Dam and Wasteway capture return flows from project lands in the Lytle Creek area and divert them into the project-built Rye Grass Ditch.

Arthur R. Bowman Dam and Prineville Reservoir

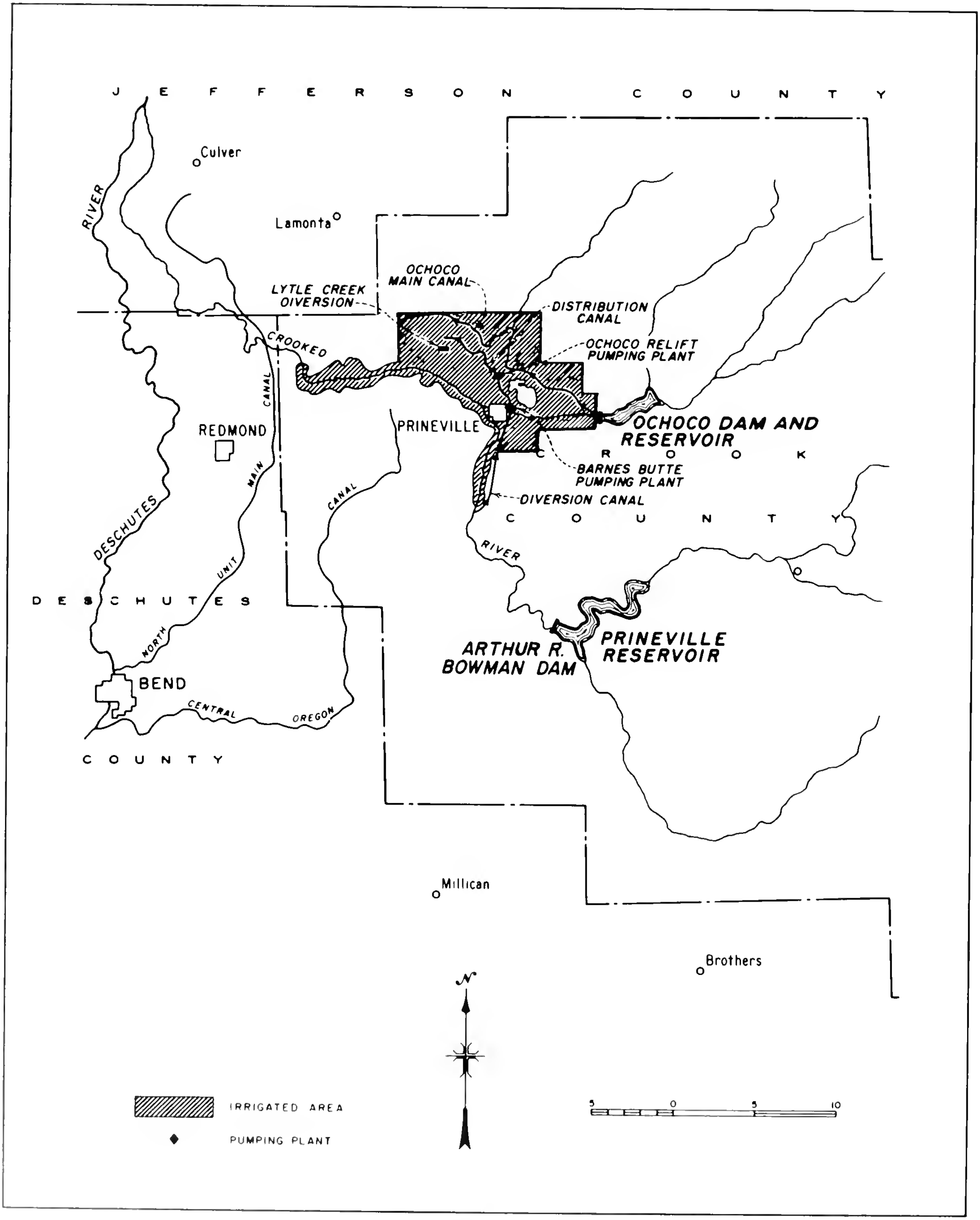
Arthur R. Bowman Dam (formerly Prineville Dam) is an earthfill structure on the Crooked River about 20 miles upstream from Prineville. The dam has a height of 245 feet, crest length of 800 feet, and a volume of 1,424,000 cubic yards of material.

The spillway consists of an uncontrolled-crest inlet structure, chute, and stilling basin. Capacity of the spillway is 8,120 cubic feet per second at maximum water surface elevation 3257.9. The outlet works has an intake structure with an 11-foot-diameter circular tunnel upstream from the gate chamber, an 11-foot modified horseshoe tunnel downstream from the gate chamber, and a stilling basin which is shared with the spillway. The capacity of the outlet works is 3,300 cubic feet per second at normal water surface elevation 3234.8.

Prineville Reservoir has a total capacity of 154,700 acre-feet and an active capacity of 152,800 acre-feet. The water surface area of the reservoir is 3,030 acres at normal water surface elevation.

Ochoco Dam and Reservoir

Ochoco Dam, a hydraulic-fill structure on Ochoco Creek 6 miles east of Prineville, was constructed immediately after World War I as a part of the Veterans Farm Settlement Program undertaken by the State of Oregon. The left abutment is an alluvial fan, and the right abutment is a slide mass consisting of fine earth and rock. The original dam was about 126 feet high and 1,000 feet long, with an average crest width of 15 feet. The dam leaked badly through the main section, with heavy leakage at or through the right abutment. Since the dam was a constant hazard to life and property in the valley and the city of Prineville, some rehabilitation was required. The



Crooked River Project

Arthur R. Bowman Dam

dam provides flood control of Ochoco Creek in addition to storing water for irrigation. As repaired and reconstructed by the Bureau of Reclamation, the dam is 125 feet high with a crest length of 1,350 feet. The spillway is an open concrete chute at the south end of the dam. The reservoir has an active capacity of 46,500 acre-feet.

Lytle Creek Diversion Dam and Wasteway

Lytle Creek Diversion Dam is a rockfill structure with timber cutoff and embankment wing on Lytle Creek near Prineville. The dam has a streambed height of 4 feet, a crest length of 200 feet, and diversion capacity of 72 cubic feet per second.

The wasteway heads at Lytle Creek Diversion Dam, has an initial capacity of 160 cubic feet per second, and empties into Rye Grass Ditch. Headworks are controlled by one 18-inch and two 36-inch slide gates.

Barnes Butte Pumping Plant

Barnes Butte Pumping Plant lifts a maximum of 147 cubic feet per second from the end of the diversion canal to the head of the distribution canal. The pump site is at the foot of Barnes Butte, about 0.75 mile east of the city limits of Prineville. The plant consists of five pumping units that total 1,800 horsepower.

Distribution Canal

The distribution canal serves all Ochoco District lands west of Barnes Butte below an elevation of 2950 feet and above Rye Grass Ditch. In addition, the canal carries water lifted by Ochoco Relift Pumping Plant to Ochoco Main Canal near McKay Creek to serve lands below this main canal. The distribution canal carries water 15.8 miles in a northerly direction and has an initial capacity of 102 cubic feet per second.

Ochoco Relift Pumping Plant

The Ochoco Relift Pumping Plant pumps a maximum of 80 cubic feet per second from the distribution canal to the Ochoco Main Canal to irrigate lands west of McKay Creek. The plant contains four units, operates against a total dynamic head of 99 feet, and produces a total of 1,300 horsepower.

Extension Pumping Plants

New features completed to serve the additional 3,450 acres in the Crooked River Project Extension include six small pumping plants and associated canals, laterals, and drains. These features serve lands of six separate areas located generally east and north of the original project area. Combs Flat Pumping Plant pumps water from the

Diversion Canal, and the Hudspeth Pumping Plant pumps water from the Barnes Butte Canal. The remaining four pumping plants, Johnson Creek, Tunnel, McKay Creek, and Grimes Flat, pump from the Ochoco Main Canal. Three much smaller pumping plants, Houston, and Stahancyk Nos. 1 and 2, were later installed in the extension area by the Ochoco Irrigation District.

Because of the increased water requirement for the additional acres in the extension area, it was necessary to install an additional pumping unit at both the Barnes Butte and Ochoco Relift Pumping Plants.

Rehabilitation and Betterment Program

A 5-year rehabilitation and betterment program has been authorized and is underway to install concrete pipe laterals and drains to replace existing open and unlined channels. Some 17.75 miles of open laterals will be enclosed with concrete pipe ranging from 10 to 24 inches in diameter. In addition, about 2.75 miles of open drain will be enclosed with concrete pipe ranging from 6 to 18 inches in diameter. The program will increase the efficiency of system operation and result in substantial water savings.

DEVELOPMENT

Early History

Immigrants to the Oregon area arrived in increasing numbers after 1842, usually bound for the valleys west of the Cascade Mountains. The first attempt at settlement in Ochoco Valley was made in the fall of 1867. The earliest diversion of water recognized by the courts in adjudication of water rights in the basin was from the South Fork of Crooked River in 1866.

As early as 1905, plans were made to irrigate a large portion of the Ochoco Valley. Because of difficulty in financing, this proposed development did not materialize until 1916, when the Ochoco Irrigation District was organized to build a dam and reservoir on Ochoco Creek to irrigate 22,000 acres of land. Those features were constructed with private capital in 1917-18. The area was reduced to 8,500 acres in 1933.

Investigations

In 1905, the Geological Survey issued a bulletin describing geology and water resources in central Oregon. An agreement dated May 5, 1913, between the United States and the State of Oregon provided for cooperative investigation of potential irrigation projects in the same area. In June 1915, a report issued by the Reclamation Service and the State of Oregon proposed several irriga-

Prineville Reservoir

tion plans for the Crooked River Basin. During 1918-21, the Ochoco Project was constructed by private interests in cooperation with the State of Oregon.

In the course of a basinwide investigation, the Bureau of Reclamation issued reports in 1936, 1940, and 1944, the last report proposing that the Prineville damsite be used. This site was adopted to secure control of a greater drainage area for flood detention and to inundate a lesser acreage of arable land. A report issued in 1949 embodied the present plan of development except that a storage capacity of 79,000 acre-feet was recommended. The report of February 1953, upon which authorized construction plans were based, recommended a storage capacity for Prineville Reservoir of 155,000 acre-feet. A report on the project extension was prepared in March 1960. The rehabilitation and betterment of the lateral and drainage system was covered by a report completed in April 1973.

Authorization

The reconstruction of Ochoco Dam was authorized in the Interior Department Appropriation Act of June 29, 1948. The Crooked River Project was authorized by the Congress on August 6, 1956, under Public Law 992, 84th Congress, 2d session, which incorporated the Ochoco Project. The Crooked River Extension was authorized by Public Law 88-598, dated September 18, 1964. Rehabilitation and betterment of the lateral and drainage system is being accomplished under the act of October 7, 1949, as amended (63 Stat. 724, 64 Stat. 11).

Construction

Ochoco Dam was rehabilitated in 1949-50. Construction of Prineville Dam began in 1958, and was completed in

Ochoco Dam and Reservoir

1961. Work on the Crooked River Extension began in 1966, and was completed in 1970.

Operating Agency

The Ochoco Irrigation District operates the project facilities.

BENEFITS

Irrigation

Irrigation in the project area has been successful over a period of many years. Principal crops are grain, hay, potatoes, and mint. Size of operating units varies widely, ranging from small suburban residential tracts to large livestock ranches which own or lease considerable grazing land outside the project area.

Flood Control

In addition to the major purpose of furnishing an increased stable supply of irrigation water, the plan provides long-needed flood protection for Prineville and adjacent farm land areas. Flood control space is held in Ochoco Reservoir on a forecast basis to control Ochoco Creek, below the dam, to no more than 500 cubic feet per second. Similarly, space is held in Prineville Reservoir to control the Crooked River below Arthur R. Bowman Dam to no more than 3,000 cubic feet per second.

Recreation and Fish and Wildlife

State parks located on both reservoirs are among the most heavily used in Oregon. Ochoco Reservoir has 8 miles of shoreline, but there are only 20 acres of publicly owned lands in the reservoir area. Camping, swimming, picnicking, and boat launching and mooring facilities are available. Ochoco Reservoir is stocked annually with rainbow trout.

The Prineville Reservoir area encompasses over 8,700 acres with a reservoir surface of 3,030 acres providing 43 miles of shoreline. Camping, picnicking, swimming, lodging, dining, and boat launching and mooring facilities are provided by the State Park, by Crook County through its park system, and by a concessionaire. The reservoir offers excellent fishing for both warm- and cold-water species. A trout fishery has developed in Crooked River below the dam since the reservoir was created. The upper end of the reservoir has been designated a wildlife management area, and 3,800 acres of land and water provide habitat for a variety of wildlife including mule deer and numerous species of waterfowl.

Open, concrete-chute spillway at Ochoco Dam

Barnes Butte Pumping Plant

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service (district lands)	19,070	acres
Supplemental irrigation service (nondistrict lands)	4,770	acres
Total	23,840	acres

Area Irrigated and Crop Value[1]

Year	Area irrigated, acres	Crop value, dollars
1968	16,286	1,517,024
1969	16,809	1,678,144
1970	16,990	1,408,798
1971	17,151	1,632,069
1972	15,412	1,707,634
1973	17,647	3,556,292
1974	17,976	5,336,668
1975	18,084	4,284,759
1976	18,147	3,106,336
1977	17,570	4,030,690

[1]Data represents only district lands.

Facilities in Operation

Storage dams	2	
Diversion structures	2	
Pumping plants	11	
Canals	49	mi
Laterals	48	mi
Drains	11	mi

Climatic Conditions

Annual precipitation	9.9	in
Temperature:		
Maximum	105	°F
Minimum	−34	°F
Mean	47	°F
Growing season	108	days
Elevation of irrigable area	2800-3050.0	ft

ENGINEERING DATA

Water Supply

OCHOCO CREEK

Drainage area at Ochoco Reservoir	291	mi²
Annual discharge:		
Maximum (1965)	91,100	acre-ft
Minimum (1977)	4,400	acre-ft
Average	41,100	acre-ft

CROOKED RIVER

Drainage area at station a few miles below Arthur R. Bowman Dam [2]	2,810	mi²
Annual discharge:		
Maximum (1965)	413,300	acre-ft
Minimum (1977)	42,200	acre-ft
Average	215,600	acre-ft

[2]About 500 mi² of this area are noncontributing.

Storage Facilities

ARTHUR R. BOWMAN DAM

Type: Zoned earthfill		
Location: On Crooked River about 20 mi upstream from Prineville, Oreg.		
Construction period: 1958-61		
Reservoir, Prineville:		
Total capacity to El. 3234.8	154,700	acre-ft
Active capacity	152,800	acre-ft
Surface area	3,030	acres
Dimensions:		
Structural height (approx.)	245	ft
Top width	35	ft
Maximum base width (approx.)	950	ft
Crest length	800	ft
Crest elevation	3264.0	ft
Volume (approx.)	1,424,000	yd³
Spillway: Concrete chute at right abutment, uncontrolled.		
Capacity at El. 3257.9	8,120	ft³/s

Outlets: Tunnel of 11 ft diameter through right abutment, controlled by two 6- by 4-ft gates and two 6- by 4-ft emergency gates.		
Capacity at El. 3234.8	3,300	ft³/s

OCHOCO DAM

Type: Zoned earthfill		
Location: On Ochoco Creek, 6 mi east of Prineville, Oreg.		
Construction period: 1918-20. Reclamation blanketed and riprapped the upstream face and right abutment, placed rockfill on the downstream face, and repaired spillway, outlet works, and wasteway in 1949-50.		
Reservoir, Ochoco:		
Average annual inflow, 1963-77	41,100	acre-ft
Total capacity to El. 3130.9	48,000	acre-ft
Active capacity	46,500	acre-ft
Surface area	1,100	acres
Dimensions:		
Structural height	125	ft
Top width	30	ft
Maximum base width	700	ft
Crest length	1,350	ft
Crest elevation	3143.0	ft
Volume	750,000	yd³
Spillway: Uncontrolled crest, concrete and mortar-lined channel at left abutment.		
Crest length	275	ft
Crest elevation	3130.9	ft
Capacity at El. 3136.2	11,200	ft³/s
Outlet works: Concrete conduit through base of dam housing a 44-in steel pipe, controlled by one 3.25-ft-square slide gate.		
Capacity at El. 3130.9	415	ft³/s

Diversion Facilities

LYTLE CREEK DIVERSION DAM

Type: Rockfill with timber cutoff, embankment wing		
Location: On Lytle Creek near Prineville, Oreg.		
Year completed: 1962		
Dimensions:		
Height above streambed	4	ft
Crest length	200	ft
Crest elevation	2870.3	ft
Volume	284	yd³
Headworks: One 18-in and two 36-in slide gates.		
Diversion capacity	72	ft³/s

DIVERSION CANAL HEADWORKS

Type: Canal headworks and concrete wingwalls		
Location: On Crooked River, 6 mi upstream from Prineville, Oreg.		
Year completed: 1961		
Dimensions:		
Height above streambed	15	ft
Crest length	130	ft
Crest elevation	2900.0	ft
Volume	508	yd³
Headworks: Three 4-ft-square slide gates.		
Diversion capacity	160	ft³/s

Carriage Facilities

DIVERSION CANAL

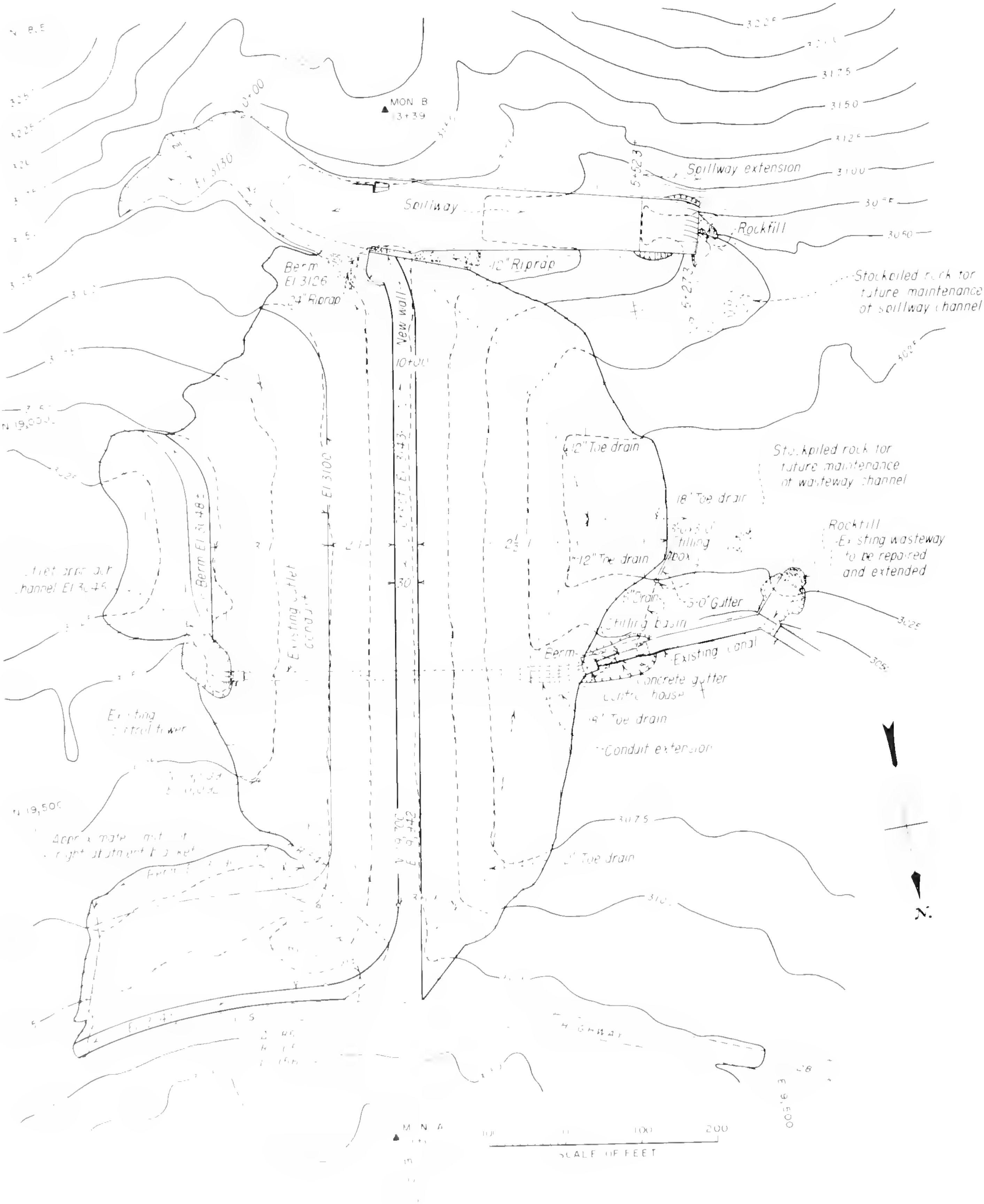
Location: From Lytle Creek Diversion Dam to Barnes Butte Pumping Plant.		
Construction period: 1960-61		
Length	8.3	mi
Initial capacity	160	ft³/s
Typical maximum section:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4.1	ft

DISTRIBUTION CANAL

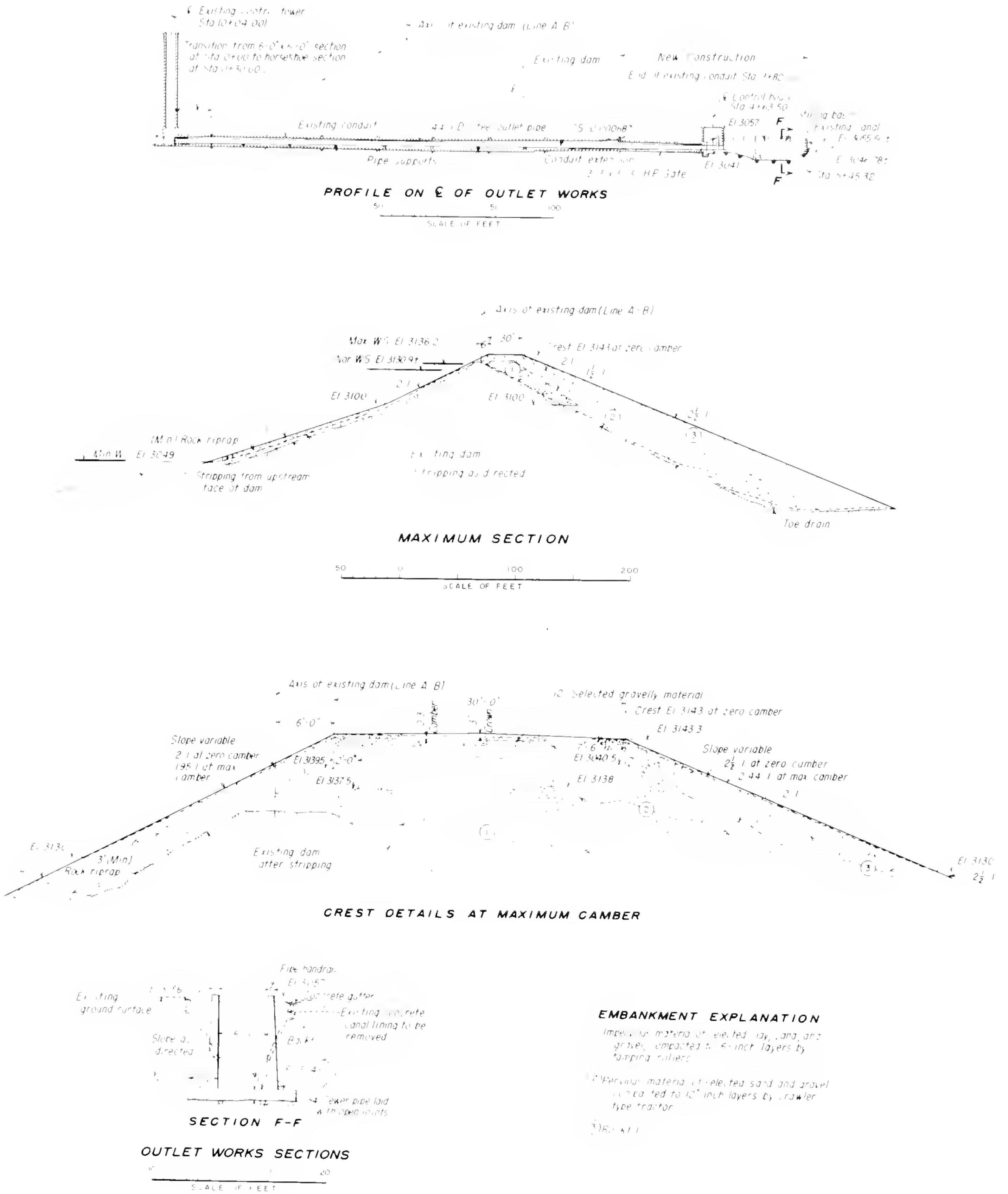
Location: From Barnes Butte Pumping Plant to an area near McKay Creek.		
Construction period: 1960-61		
Length	15.8	mi
Initial capacity	102	ft³/s
Typical maximum section:		
Bottom width	9	ft
Side slopes	1.5:1	
Water depth	3.6	ft

PUMPING PLANTS

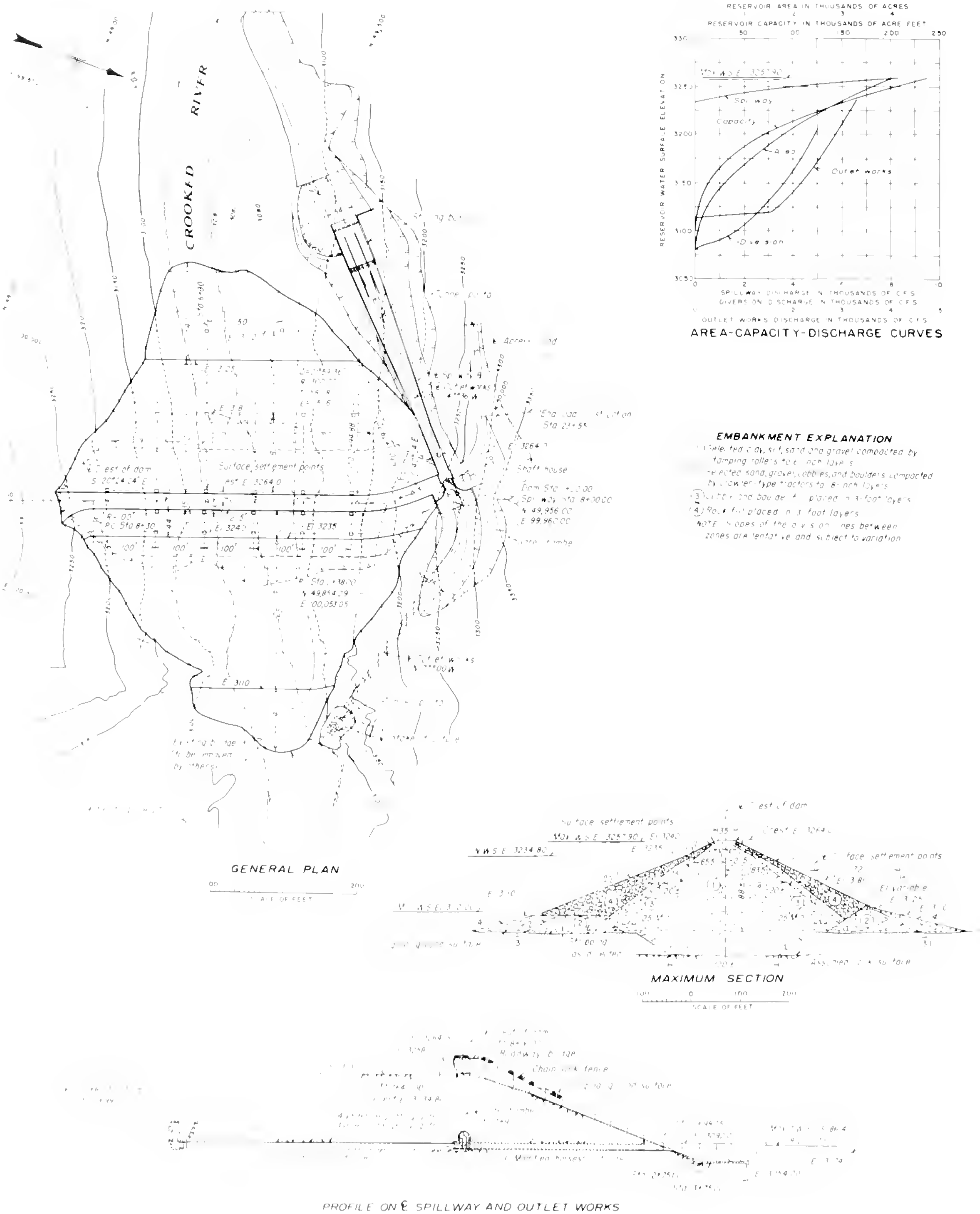
Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Barnes Butte	5	147	82	1,800
Ochoco Relift	4	80	99	1,300
Combs Flat	2	6.5	140	135
Hudspeth	1	2	59	20
Johnson Creek	2	14.2	125	250
Tunnel	2	7.8	92	120
McKay Creek	1	3	49	25
Grimes Flat	3	21	78	260
Houston	2	4	4	3
Stahancyk No. 1	2	4	4	3
Stahancyk No. 2	2	4	4	3



Ochoco Dam, Plan



Ochoco Dam, Sections

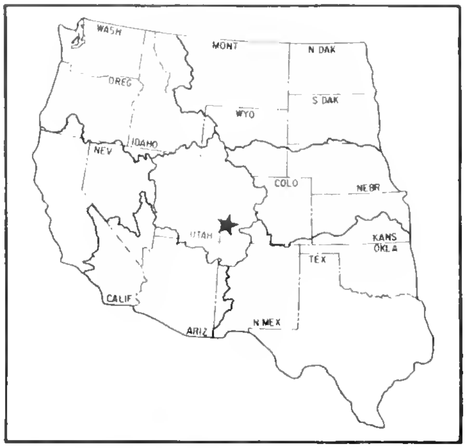


Arthur R. Bowman Dam, Plan and Sections

Dallas Creek Project
(Under Construction)

Colorado: Montrose, Delta, and Ouray Counties

Upper Colorado Region
Water and Power Resources Service



The Dallas Creek Project, located in west-central Colorado, is named after a major tributary of the Uncompahgre River, which in turn is a tributary of the Gunnison River in the Upper Colorado River Basin. The project area encompasses most of the Uncompahgre River Basin covering portions of Montrose, Delta, and Ouray Counties; it includes the communities of Delta, Olathe, Montrose, Colona, and Ridgway. A new community, Loghill Village, is under construction in the project area between Colona and Ridgway.

PLAN

Under the Dallas Creek Project, Ridgway Dam will be constructed on the Uncompahgre River to increase usable water supplies for irrigation and municipal and industrial purposes, and to provide flood control. The project also includes recreational development at the reservoir and measures to enhance fishing opportunities on the Uncompahgre River, improve wildlife habitat, and mitigate wildlife losses caused by the reservoir development. No distribution facilities will be constructed as part of the project. Water supplies are to be distributed through existing facilities or facilities constructed by the Tri-County Water Conservancy District or the water users.

Ridgway Dam and Reservoir

Ridgway Reservoir will be formed by Ridgway Dam on the Uncompahgre River about 6 miles north of Ridgway and 1 mile upstream from the confluence with Cow Creek. The reservoir will have a capacity of 80,000 acre-feet of water and will extend southwardly up the Uncompahgre River for 4.6 miles, with a 1-mile branch up the drainage of Alkali Creek. Active storage capacity will be 55,000 acre-feet; dead and inactive capacity will be 25,000 acre-feet. There could be a sediment accumulation of 4,100 acre-feet in 100 years. The surface area of the reservoir at the normal water surface elevation of 6871.3 feet will be 1,030 acres. Ridgway Dam will be a rolled-earthfill structure with a volume of 9,191,000 cubic yards and a height of 227 feet above streambed. The dam crest, at elevation 6886, will be 2,430 feet long and 30 feet wide.

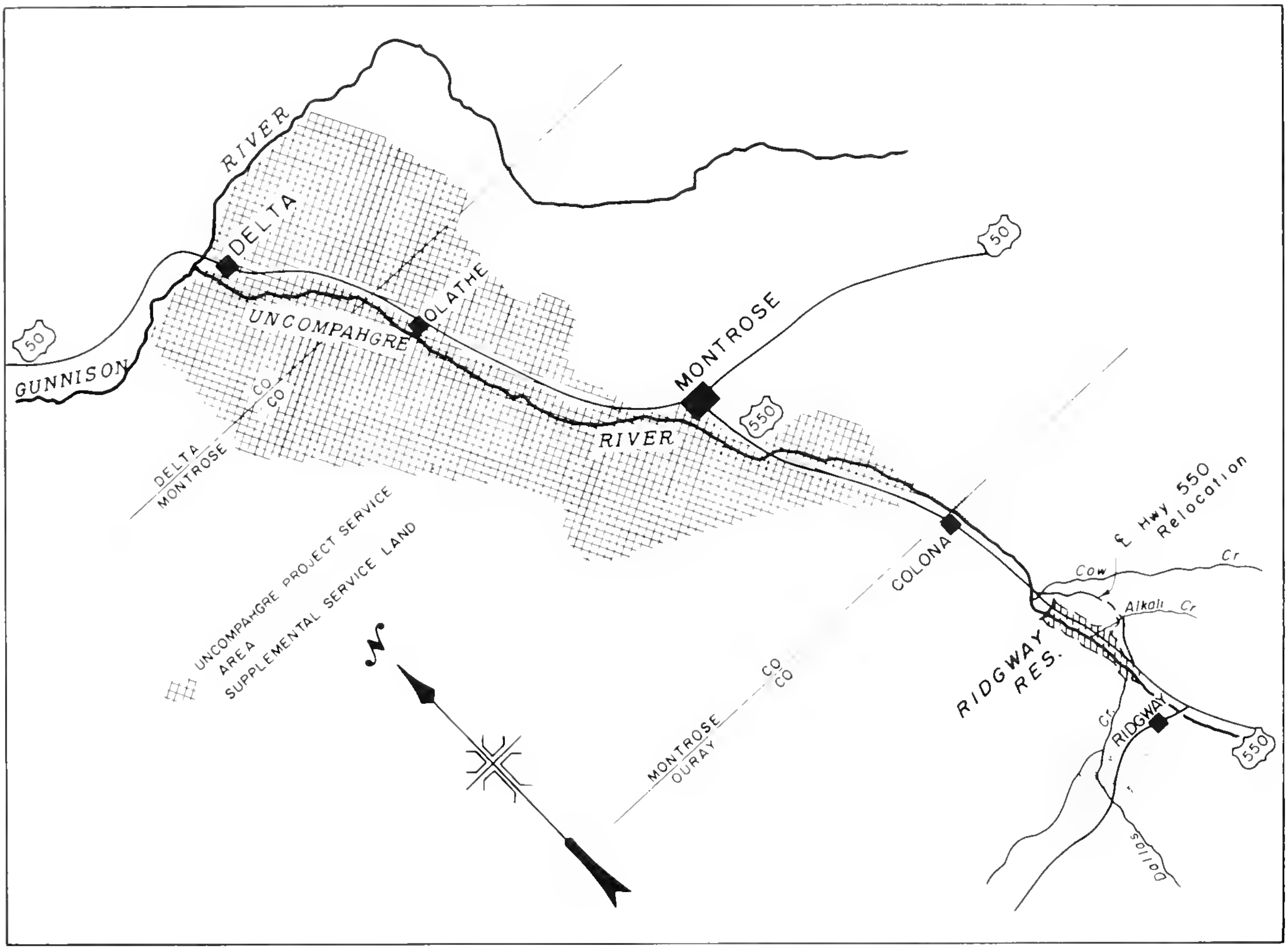
DEVELOPMENT

Early History

When the Ute Indians were expelled from western Colorado in 1881, a rush of settlers poured into the Uncompahgre Valley attracted by new farming and ranching opportunities. The town of Delta was founded that year, followed by Montrose in 1882, Olathe in 1883, and Ridgway in 1890. Irrigated agriculture expanded rapidly throughout the valley with the construction of small, privately financed diversion structures. Restrictions imposed by private financing limited these developments to lands close to the streams.

In 1912, the Uncompahgre Project, one of the first Federal reclamation developments, began delivering water from the Gunnison River through the Gunnison Tunnel to lands around Montrose, Olathe, and Delta. After the successful irrigation of lands in the lower Uncompahgre Valley, interest developed in constructing a water delivery system for potential farmlands on Log Hill Mesa, south of Ridgway, and along the upper Uncompahgre River and its tributaries.

Irrigated meadowland below San Juan Mountains



Dallas Creek Project

Investigations

Soon after World War II, the Bureau of Reclamation began to study the possibility of a water project for the upper Uncompahgre River Basin. Early planning was directed toward irrigation. One of the first plans, called the Ouray Project, was never formally published, but it was the starting point for ensuing years of study.

In February 1951, the Bureau of Reclamation published a reconnaissance report on the Gunnison River Project. One part of this extensive project was the Dallas Creek Unit, which included many of the features of the Ouray Project.

After publication of the 1951 report, the Bureau of Reclamation studied a number of alternative plans. A plan to produce hydroelectric power in addition to irrigation power generation would not have interfered with irrigation proposals being considered, so it was added to the 1951 reconnaissance plan. Investigation of a damsite in Ironton Park indicated that it was not a geologically satisfactory site. This fact and the possibility of a conflict over water rights caused the proposal to be dropped from consideration.

The cost of the project, to eventually be repaid, was a problem for proposed irrigation developments in high elevation valleys like the upper Uncompahgre Basin because the cash value of crops produced per acre was comparatively low. This problem was largely alleviated for Dallas Creek in 1956 when the Congress passed the Colorado River Storage Project (CRSP) Act. One of the features of this act was to provide money from power revenues from CRSP facilities to assist designated participating irrigation projects in their repayment. The Dallas Creek Project was designated as one of these participating projects and was given priority for feasibility studies and financial assistance if authorized by the Congress.

After designation as a CRSP participating project, concentrated feasibility investigations were made of the project, which became a refinement of the 1951 reconnaissance plan, and published in a 1966 feasibility report. Municipal water was included in the plan for the first time. This plan was the basis for congressional authorization of the project in 1968.

A definite plan report, published in November 1976, presents results of studies made since the project was authorized and outlines revisions of the project plan brought about by changing conditions.

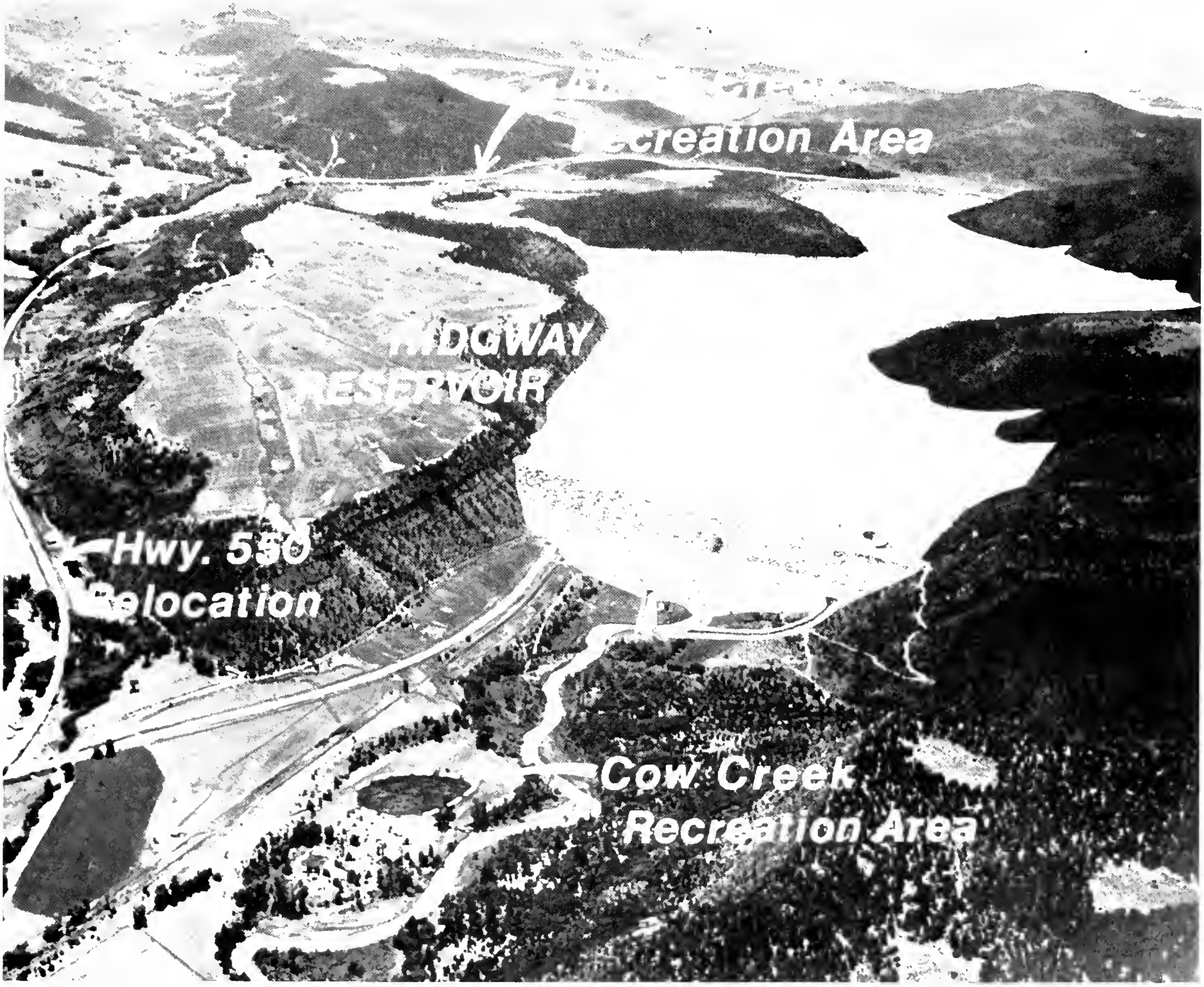
The final environmental statement was filed with the Council on Environmental Quality September 28, 1976, after a public hearing on the draft statement in Montrose, Colo., on April 17, 1976. Included in the statement are analyses of the impacts of the project on water quality, fisheries and aquatic life, wildlife and vegetation, vectors, recreation, economic and social conditions, geology, aesthetics, and historical and archeological resources.

Authorization

The Dallas Creek Project was authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537), as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485), based on the feasibility report of the Secretary of Interior transmitted to the Congress on May 3, 1966, and published as House Document 433, 89th Congress, 2nd Session.

Construction

Construction started in fiscal year 1978. A 5-year development program is expected to complete the project.



Artist's conception of Ridgway Dam and Reservoir

Operating Agency

Tri-County Water Conservancy District will serve as the general administrative agency for project reclamation and joint use facilities and will be the contracting and marketing agency for all project water.

BENEFITS

Irrigation

Production of livestock, predominantly cattle and sheep, is the leading enterprise in the area. Crops consist primarily of livestock feeds such as alfalfa, meadow hay, pasture, and small grains. Irrigated lands in the area also produce pinto beans, malt barley, shelling and ensilage corn, alfalfa, onions, and some fruit. Project water supply for irrigation purposes will total 11,200 acre-feet, the largest portion of which will be supplemental supplies for the Uncompahgre Project.

Municipal and Industrial Water

A supply of 28,100 acre-feet of water will be provided each year for municipal and industrial uses in Montrose, Olathe, Delta, and surrounding rural areas.

Recreation and Fish and Wildlife

Specific plans for recreation development include an inactive pool of 20,900 acre-feet in Ridgway Reservoir and facilities in the reservoir area for picnicking, camping, boating, hiking, and enjoyment of the scenic setting. Measures to protect and enhance the fish and wildlife resources have been incorporated into the project plans. They include minimum flows in Uncompahgre River, a dual-level outlet at Ridgway Dam, acquisition of easements for fishing access, a deer fence along a relocated highway, and acquisition of a wildlife range to offset losses associated with the reservoir.

Flood Control

Ridgway Reservoir will be operated to aid in controlling snowmelt floods. Reservoir storage would be evacuated to provide space for floodflows if heavy snowmelt were predicted. Although the reservoir would not be operated specifically for control of rain floods, it would aid in control as storage space would be available in the reservoir in late summer when such floods normally occur.

PROJECT DATA

Land Areas (1977)

Irrigation system area[1]	61,810	acres
Number of irrigated farms	2,350	

Climatic Conditions

Annual precipitation	10	in
Temperature:		
Maximum	89	°F
Minimum	14	°F
Mean	49	°F
Elevation	5794.0	ft

ENGINEERING DATA

Water Supply

UNCOMPAHGRE RIVER

Drainage basin above Ridgway Dam	264	mi²
Project supply (average annual)	39,400	acre-ft
Effects on Colorado River:		
Stream depletion (average annual)	17,100	acre-ft
Increase in salt load	9,800	tons
At Imperial Dam:		
From salt load	0.9	p/m
From stream depletion	1.8	p/m

Storage Facilities

RIDGWAY DAM[2]

Type: Rolled earthfill
Location: On the Uncompahgre River about 6 mi north of Ridgway, Colo.
Construction period: 1978 - (Under construction)
Reservoir, Ridgway:

Total capacity	80,000	acre-ft
Active capacity	55,000	acre-ft
Dead and inactive capacity	25,000	acre-ft
Surface area at El. 6871.3	1,030	acres
Dimensions:		
Structural height	227	ft
Top width	30	ft
Crest length	2,430	ft
Crest elevation	6886.0	ft
Total volume	9,191,000	yd³

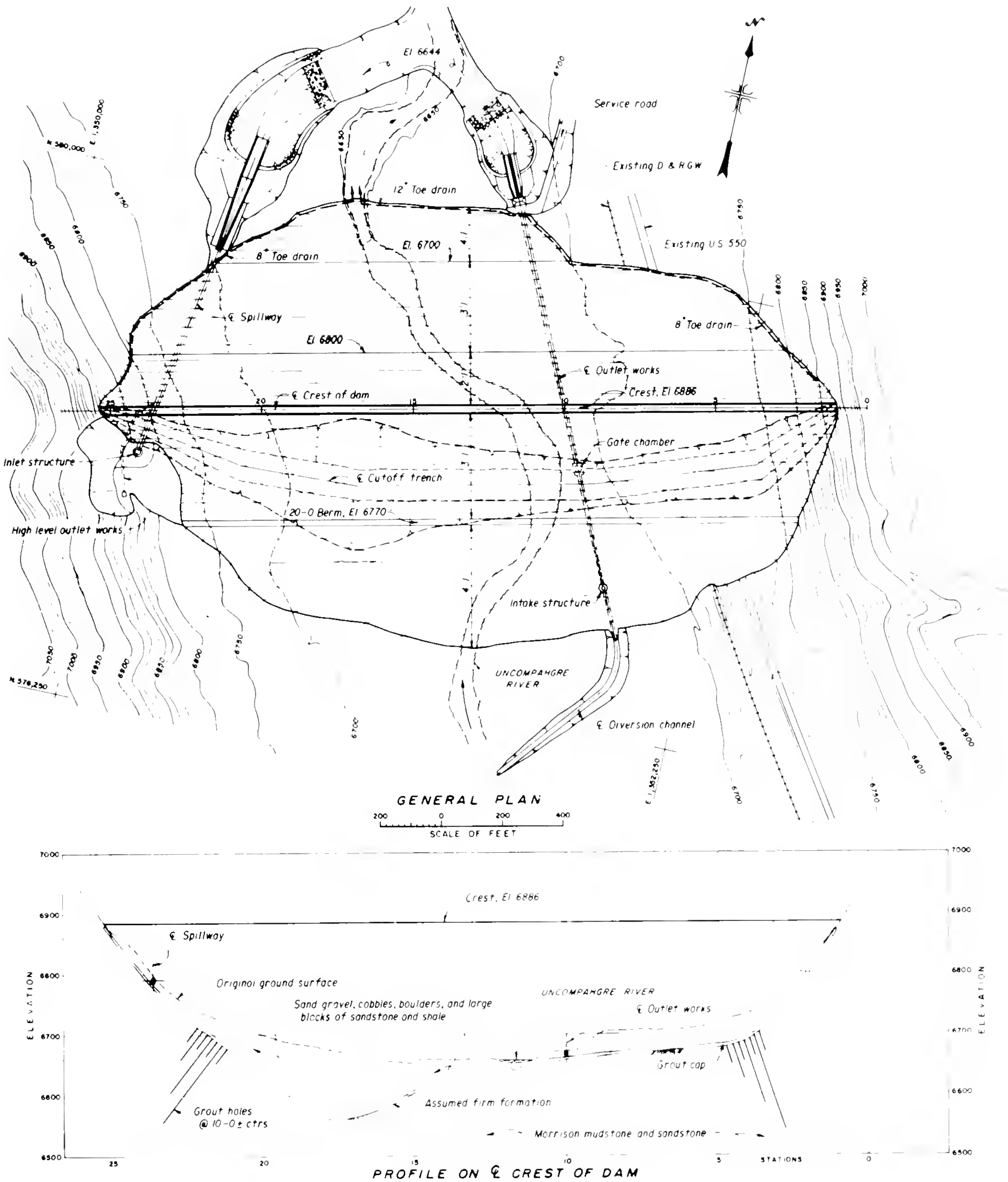
Spillway: Uncontrolled concrete morning-glory inlet, conduit buried under embankment on left abutment, discharging into a stilling basin. Intake structure, with trashracks near upstream end of conduit, a gate chamber, and control house and stilling basin at downstream end of conduit. Inlet El. 6871.3 ft; discharge capacity, 8,660 ft³/s; surface elevation required for capacity discharge, 6879.9 ft.

Outlet works: High level outlet in left abutment discharges into spillway conduit; El. 6829.5 ft; discharge capacity 500 ft³/s; surface elevation required for capacity discharge, 6854.5 ft.

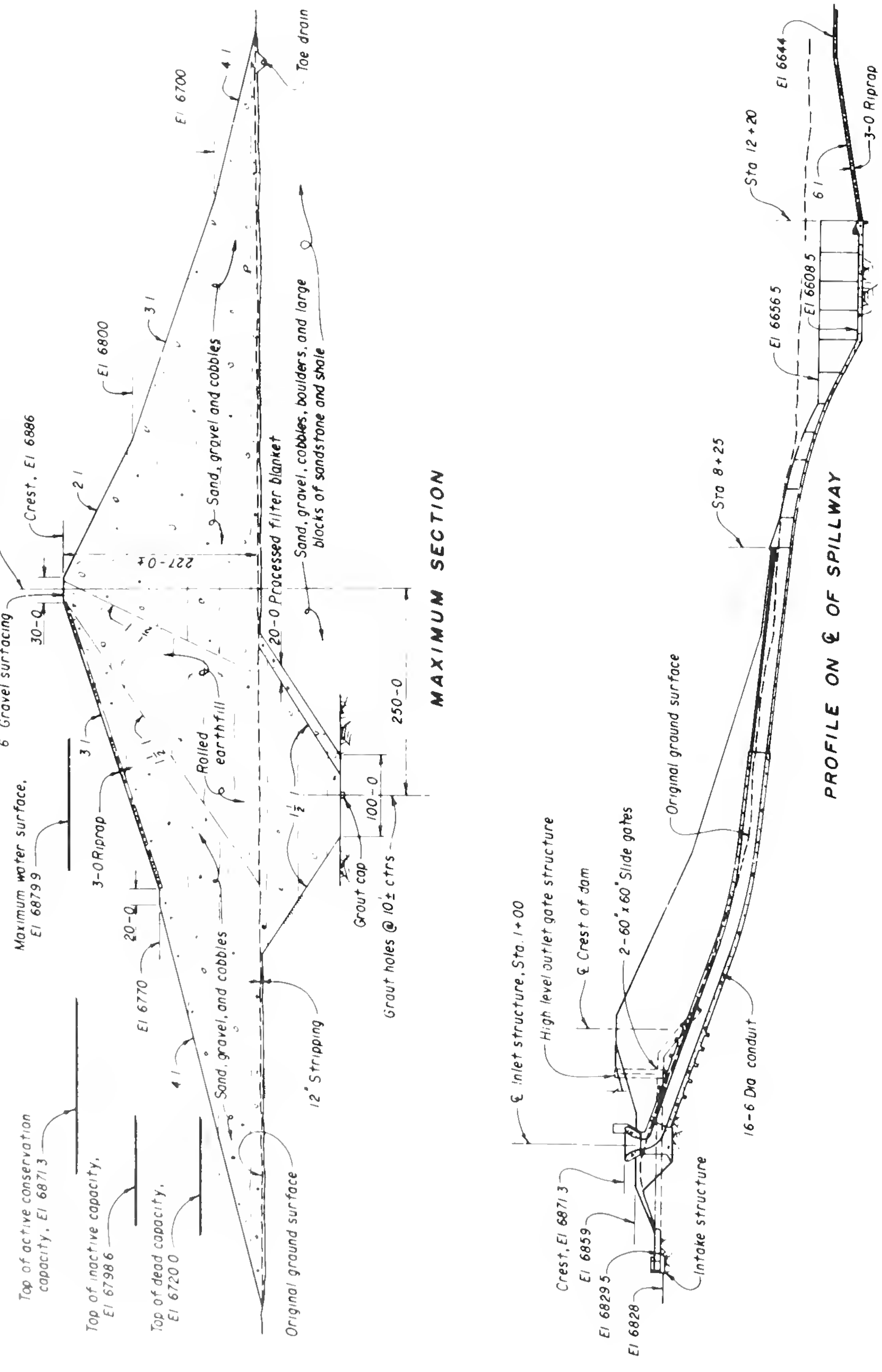
Low level outlet, in right abutment, discharges into separate stilling basin; El. 6720 ft; discharge capacity, 1,110 ft³/s; surface elevation required for capacity discharge, 6879.9 ft.

[1]All of this land would be eligible to receive water, but the portion actually served will be determined by subscription.

[2]Under construction.



Ridgway Dam, Plan and Profile

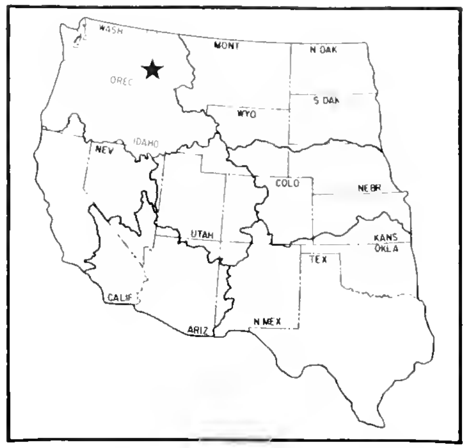


Ridgway Dam, Sections

Dalton Gardens Project

Idaho: Kootenai County

Pacific Northwest Region
Water and Power Resources Service



Dalton Gardens is a privately developed project 2 miles north of Coeur d'Alene, Idaho, and 30 miles east of Spokane, Wash., on the eastern edge of the extensive Spokane Valley plain, known as Rathdrum Prairie. The project's irrigation works include a pumping plant, equalizing reservoir and main line, and a distribution system that has been reconstructed to supply 979 acres of land with an adequate sprinkler irrigation water supply.

Hayden Lake Tank Reservoir

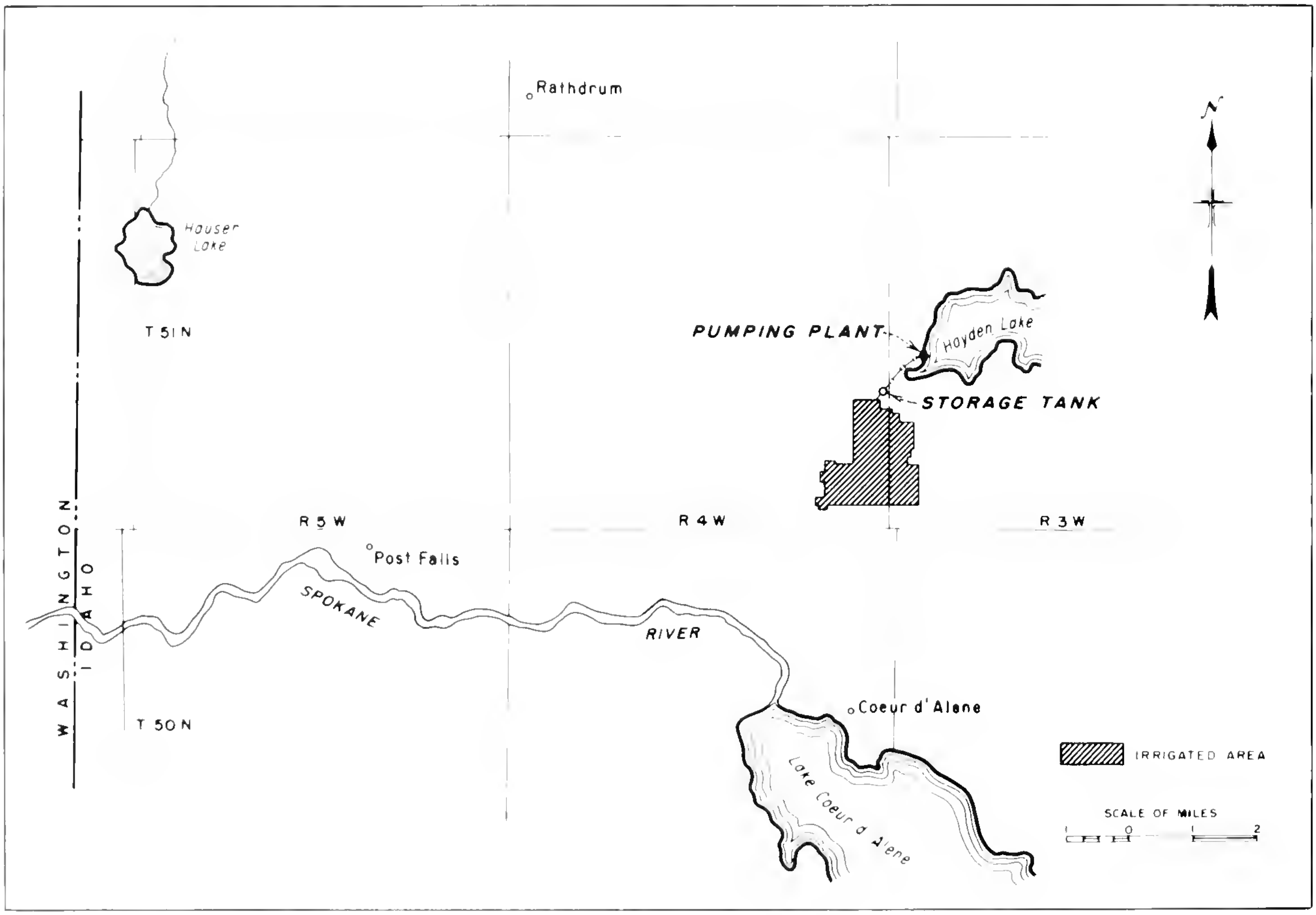
The project was rehabilitated by the Bureau of Reclamation in 1954-55. Additional pipe rehabilitation work was completed in 1962-64.

PLAN

The water supply for the project is pumped from Hayden Lake, which has a surface area of 5 to 6 square miles and a water surface elevation fluctuating between 2220.0 and 2242.0 feet. The lake has a drainage area of 62 square miles with an average annual inflow of 45,000 acre-feet. Two small irrigation districts are using water from the lake. The Dalton Gardens Irrigation District requirement averages 1,715 acre-feet annually. There is no conflict in water rights between the districts using Hayden Lake water as the available supply exceeds the demand.

At the beginning of the 1955 irrigation season the old facilities, with the exception of the pumphouse structure, were abandoned and the new facilities were placed in operation. The new facilities were a remodeled pumping plant, new equalizing reservoir, main line, and distribution system.

The pumphouse is on Hayden Lake 1.25 miles northeast of the district lands. It contains the pumping units for both the domestic water supply, which uses a separate system for which no reconstruction was required, and the irrigation water supply. Two pumps, each with a capacity of 6.7 cubic feet per second, lift the water through a 24-inch welded steel pipe 3,436 feet long to a 20,052-cubic-foot steel reservoir, erected between the district lands and Hayden Lake. The reservoir is elevated approximately 100 feet above the lands and supplies the 55,270 feet of pipe distribution lines that vary in size from 4 to 16 inches in diameter with a minimum delivery head of 81 feet. Seventy-five irrigation turnouts were arranged so that each 5-acre plot has one turnout available for use. Zoning valves and line drains were strategically located to complete the irrigation installation. The number of hookups increases with additional users.



Dalton Gardens Project

Sprinkling systems are installed by the water user from the turnouts.

Because of severe corrosion problems in some portions of the steel pipe distribution system, rehabilitation of the distribution system was reauthorized in 1961. The steel discharge pipe and the larger diameter pipe in the steel distribution system were mortar lined. The smaller, lightweight pipe in the distribution system was replaced with asbestos cement pipe.

DEVELOPMENT

Early History

Settlement of the Rathdrum Prairie area began in the 1860's after Mullan Road was rerouted around the northern end of Lake Coeur d'Alene. This primitive military and commercial thoroughfare was a link for the traffic between the Missouri and Columbia Rivers. Fort Sherman was established as a way-station on this road in 1878 at the site of the city of Coeur d'Alene. The first extensive agriculture on Rathdrum Prairie resulted from the existence of this fort. It created a market for livestock feed, as about 100 Army horses and mules were kept there.

Logging, mining, and construction of the Northern Pacific Railroad brought more settlers during the 1880's, and further expanded the market for local agricultural products. Although numerous irrigation schemes were promoted during the 1890's to stimulate land sales, little in the way of irrigation construction was accomplished until after 1900. The Dalton Gardens development was one of several small irrigation ventures in this vicinity during 1900-10. It was developed in small tracts as a fruit-raising area. The distribution system was built by a private company and put into operation in 1905. In 1917, the company was reorganized as an irrigation district.

Investigations

The Dalton Gardens Irrigation District had been regarded by the Bureau of Reclamation as a possible unit of a much larger potential development known as the Rathdrum Prairie Project. The Eastern Division of the project consisted of three small irrigation districts that pumped their water supply from Hayden Lake: Dalton Gardens, 979 acres; Avondale, 860 acres; and Hayden Lake, 1,577 acres. In early 1953, each district submitted its separate plan for reconstruction to the Congress, and it was decided to proceed with the work on the basis of separate projects rather than risk further delay by pressing for the larger development.

Authorization

The Congress, through a provision in the Department of the Interior Appropriations Act for fiscal year 1954, dated July 31, 1953 (67 Stat. 261), authorized the Bureau of Reclamation to undertake the rehabilitation. Emergency pipe rehabilitation was authorized by act of September 22, 1961 (75 Stat. 588).

Construction

Rehabilitation of the irrigation works began June 11, 1954, and was completed on April 28, 1955. Emergency pipe rehabilitation work began in 1962 and was completed in 1964.

Operating Agency

The project is operated and maintained by the Dalton Gardens Irrigation District.

BENEFITS

Irrigation

Although fruit production was the major enterprise during the early years, there has been a gradual shift to pasture and hay crops. Most of the farm units are operated on a part-time basis.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	979	acres
Number of irrigated farms	135	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	701	57,100
1969	697	52,918
1970	701	53,179
1971	685	55,161
1972	664	62,021
1973	693	81,375
1974	718	121,689
1975	718	161,400
1976	668	160,801
1977	619	75,439

Facilities in Operation

Equalizing reservoir	1	
Main supply line	7,176	ft
Laterals	11	mi
Pumping plant	1	

Climatic Conditions

Annual precipitation	25.6	in
Temperature:		
Maximum	104	°F
Minimum	−26	°F
Mean	48	°F
Growing season	180	days
Elevation of irrigable area	2230-2280.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	650
Other water service[1]	1,059
Total	1,709

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

HAYDEN LAKE

Drainage area at Hayden Lake	62.3	mi^2
Average annual inflow to lake	45,000	acre-ft
Average annual diversions (1963-77)	1,715	acre-ft

Storage Facilities

EQUALIZING RESERVOIR

Location: Near Hayden Lake, about 4 mi north of Coeur d'Alene, Idaho.
Construction period: 1954
Description: 20,052-cubic-foot steel tank

Carriage Facilities

PUMPING PLANT INTAKE PIPE, DISCHARGE LINE, AND MAIN SUPPLY LINE

Location: From Hayden Lake southwest to irrigated area.
Description: 24-in outside diameter steel pipe
Construction period: 1954

Length	7,176	ft
Capacity	13.4	ft^3/s

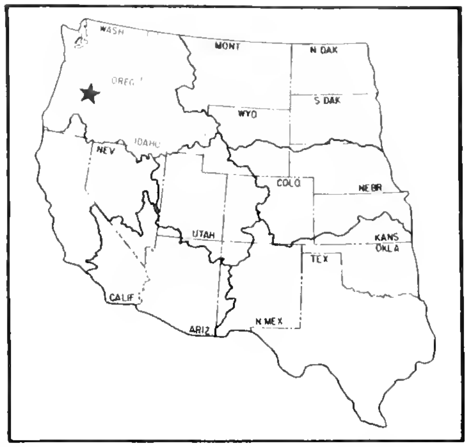
DALTON GARDENS PUMPING PLANT

Number of units	2	
Total capacity	13.4	ft^3/s
Total dynamic head	180	ft
Total horsepower	400	

Deschutes Project

Oregon: Crook, Deschutes, and Jefferson Counties

Pacific Northwest Region
Water and Power Resources Service



The Deschutes Project lands are in the vicinity of Madras, Oreg. Principal features include Wickiup Dam and Reservoir, Crane Prairie Dam and Reservoir, Haystack Dam and Reservoir, North Unit Main Canal and lateral system, and the Crooked River Pumping Plant. The project furnishes a full supply of irrigation water for about 50,000 acres of land within the North Unit Irrigation District, and a supplemental supply for more than 47,000 acres in the Central Oregon Irrigation District and Crook County Improvement District No. 1.

PLAN

Storage for the North Unit Irrigation District is provided in Wickiup Reservoir on the main Deschutes River, about 35 miles southwest of Bend, Oreg. Releases from the reservoir are diverted from the river at North Canal Dam, which was built by local interests before Reclamation construction work began. Water is carried to the project lands by the North Unit Main Canal and distributed through a system of laterals. Water stored in Crane Prairie Reservoir is also diverted by the North Canal Dam into delivery and distribution systems privately built and operated by Central Oregon Irrigation District and Crook County Improvement District No. 1.

Wickiup Dam, Dike, and Reservoir

Wickiup Reservoir stores 200,000 acre-feet of water for the irrigation of lands in the North Unit Irrigation District. The dam is a rock-faced earthfill structure, 100 feet high. The dam and dike contain 1,852,000 cubic yards of material. The dike closes a low area on the east side of the reservoir. The spillway is an open rock cut with a concrete crest in the north end of the east dike.

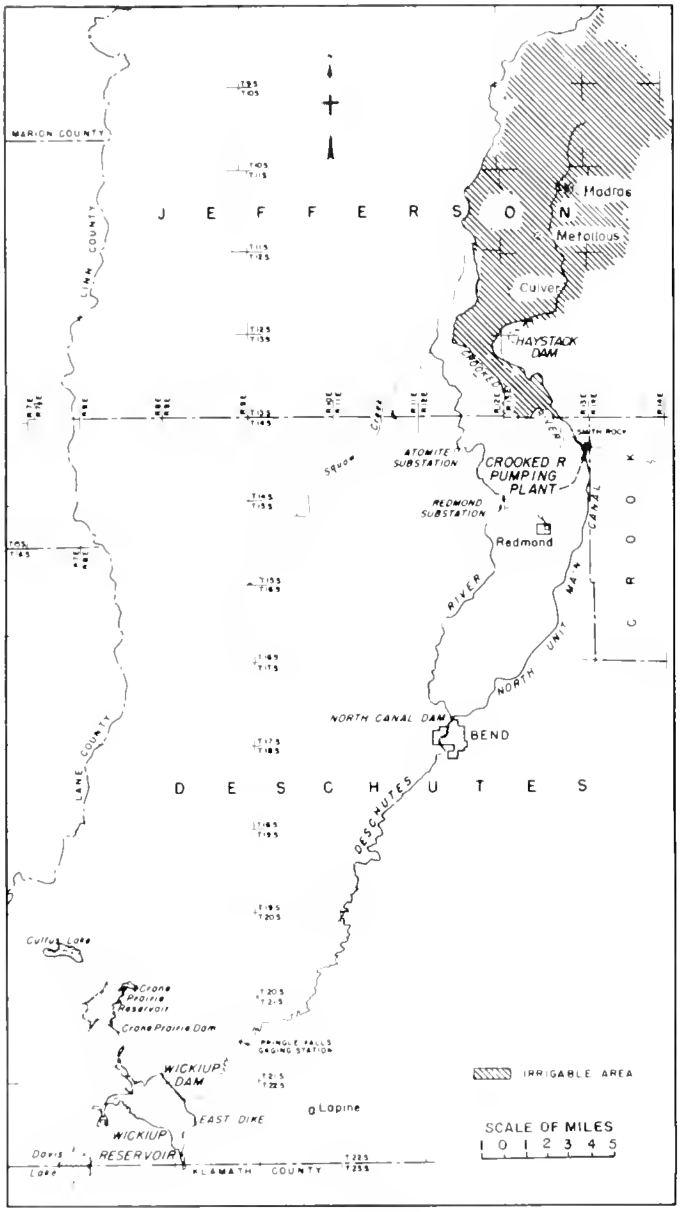
Haystack Dam and Reservoir

Flow from Haystack Creek is stored in the reservoir created by Haystack Dam, about 10 miles south of Madras. However, most of the stored water in the reservoir is supplied by feeder canal from the Main Canal. Because of the distance from Wickiup Reservoir to the lands of the North Unit, the regulatory storage provided by the 5,635-acre-foot Haystack Reservoir is required. The dam is an earthfill structure 105 feet high, containing 535,000 cubic yards of material.

Crane Prairie Dam and Reservoir

Several local irrigation districts serving lands south of the North Unit, principally the Central Oregon Irrigation District, joined in building a rockfilled timber-crib dam at the Crane Prairie site, about 2 miles above Wickiup Reservoir on the Deschutes River. By the time work began on the North Unit, the dam had become unsafe and was rehabilitated by the Bureau of Reclamation. Crane Prairie Dam is an earthfill structure 36 feet high, 285 feet long at the crest, and contains 30,000 cubic yards of material. The spillway is an uncontrolled weir in the floor of an open cut channel in the left abutment. The reservoir has a capacity of 55,300 acre-feet.

Wickiup Dam and Reservoir



Deschutes Project

North Unit Main Canal

The North Unit Main Canal, with an initial capacity of 1,000 cubic feet per second, heads at the diversion dam near Bend and extends about 65 miles to the vicinity of Madras. Structures included are a concrete flume crossing Crooked River Gorge, and two tunnel sections in the vicinity of Smith Rock that have an aggregate length of 1.3 miles.

Crooked River Pumping Plant

In 1968, the North Unit Irrigation District constructed a pumping plant adjacent to and at the point where the North Unit Main Canal crosses the Crooked River. The purpose of the plant is to furnish a supplemental water supply, when needed, by pumping from the Crooked River and discharging into the North Unit Main Canal.

The plant consists of nine vertical shaft pumps with a total capacity of 200 cubic feet per second at a total dynamic head of 150 feet. Each pump is powered by a 450-horsepower motor that pumps the water into a 60-inch steel-pipe discharge line 220 feet long.

To create a firm supplemental water supply, the district is negotiating for the purchase of 15,000 acre-feet of storage space in Prineville Reservoir, located some 25 miles upstream on the Crooked River.

DEVELOPMENT

Early History

The valley's plains were first devoted to grazing sheep and cattle, but this was replaced gradually by dryland wheat farming. Farmers harvested yields as high as 25 to 30 bushels per acre; however, as soil moisture became depleted and the area was subjected to a series of dry years, the yields dropped. By the 1930's, dryland wheat production became generally unprofitable. Early settlers acquired average land holdings of 160 acres under the Timber Culture and Desert Land Acts, but with the lessening wheat yields, ownership of land became concentrated in fewer parcels.

Irrigation in the Deschutes River Basin dates back to 1871 when farmers diverted water from Squaw Creek, a tributary of the Deschutes River. In 1895, construction of the Squaw Creek Canal was begun. By 1905, irrigation had been developed to include the Swalley Canal in 1899, the Central Oregon Irrigation District canals in 1900, and the Arnold Canal in 1905.

Haystack Dam and Reservoir

Investigations

In 1914, a comprehensive report of the Deschutes Basin was issued under the joint sponsorship and financing of the State of Oregon and the Federal Government.

Private consulting engineers investigated irrigation possibilities for the North Unit from 1917 to 1921. The North Unit Irrigation District, formed in 1916, issued bonds to finance investigation and construction of a project to irrigate 133,000 acres. The results of this investigation were covered in a report dated April 1921. However, due to financial reverses, the investors backing the project did not undertake construction.

The Reclamation Service reviewed the original plan and supplemented it by a brief field study in 1921. This was followed by another study in 1924, under the joint sponsorship of the State of Oregon and the Bureau of Reclamation. The Bureau of Reclamation published a comprehensive study in 1936 of all storage possibilities above the Crooked River in the report upon which project authorization was based.

Authorization

The project was authorized by a finding of feasibility by the Secretary of the Interior dated September 24, 1937, approved by the President on November 1, 1937, pursuant to subsection 4(B) of the act of December 5, 1924 (43 Stat. 702). Construction of Haystack Dam and equalizing reservoir was authorized by act of Congress on August 10, 1954, Public Law 573 (68 Stat. 679).

Construction

Project construction began in 1938 on the North Unit Main Canal and in 1939 on Wickiup and Crane Prairie Dams. The Crane Prairie Dam was completed in 1940; however, World War II delayed completion of other features until 1949. Haystack Dam construction began in 1956 and was completed in 1957.

Operating Agency

Operation and maintenance of the North Unit, including Wickiup Dam, was transferred to the North Unit Irrigation District on January 1, 1955.

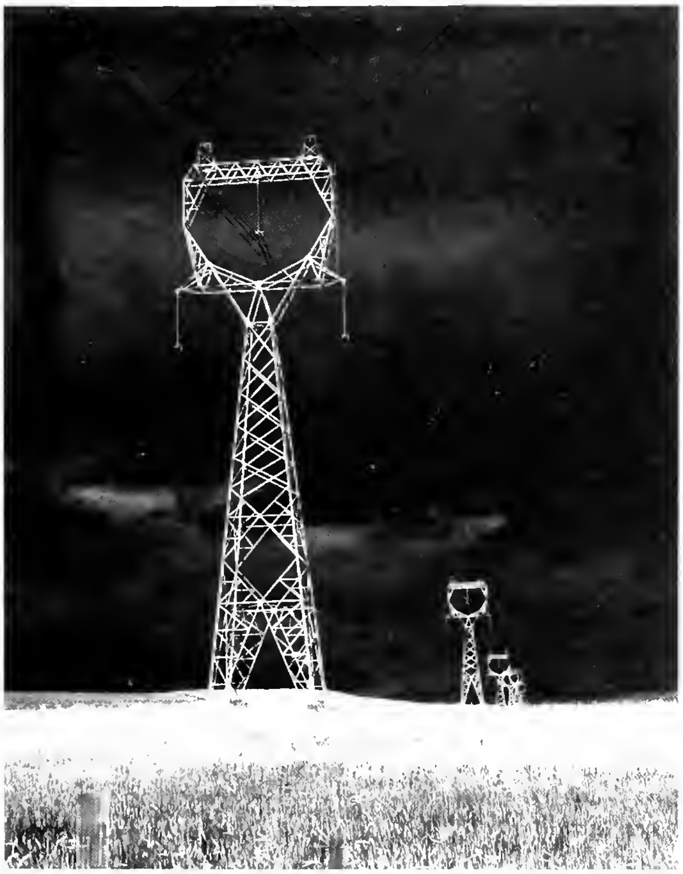
BENEFITS

Irrigation

Principal crops produced are grain, hay, pasture, mint, potatoes, and seeds.

Recreation and Fish and Wildlife

Crane Prairie and Wickiup Reservoirs are located in the Deschutes National Forest near the crest of the Cascade Mountain Range. The Forest Service administers recreation for both reservoirs. The Wickiup Reservoir area encompasses 5,717 acres of land and 11,200 acres of water



High-voltage transmission line near Madras, Oreg.

Crane Prairie Dam

surface, with about 48 miles of shoreline. The Crane Prairie Reservoir area encompasses 2,200 acres of land and 4,940 acres of water surface; there are about 24 miles of shoreline. There are several campgrounds at each reservoir in addition to facilities for picnicking and for boat launching and mooring. Each reservoir has a private concession that provides lodging and supplies for recreationists. Both reservoirs are heavily used by migrating waterfowl, and are excellent for fishing.

The Haystack Reservoir area encompasses 271 acres of land and 233 acres of water surface, with 5 miles of shoreline. There are facilities for camping, picnicking, boat launching and mooring, and designated areas for swimming. Lodging and boat rental are available from a private concessionaire. Planted rainbow trout provide excellent fishing.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service[1]	50,000	acres
Supplemental irrigation service[2]	47,386	acres
Total	97,386	acres
Number of irrigated farms	1,365	

[1]North Unit only.
[2]Central Oregon Irrigation District and Crook County Improvement District No. 1.

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	91,840	12,052,025
1969	95,267	12,474,281
1970	91,750	10,126,495
1971	91,130	12,328,932
1972	88,313	13,165,502
1973	91,408	22,627,187
1974	92,326	27,960,266
1975	91,995	26,646,432
1976	92,704	23,153,825
1977	90,549	25,667,297

Facilities in Operation

Storage dams	3	
Diversion dams[3]	1	
Canals	66	mi
Laterals	233	mi
Drains	6	mi
Pumping plants	1	

[3]North Canal Diversion Dam constructed by local interests.

Climatic Conditions

Annual precipitation	9.7	in
Temperature:		
Maximum	106	°F
Minimum	-29	°F
Mean	49	°F
Growing season	135	days
Elevation of irrigable area	2000-2800.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	5,319
Other water service[4]	12,154
Total	17,473

[4]Municipal, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

DESCHUTES RIVER

Drainage area at Wickiup Dam[5]	482	mi²
Annual discharge:[6]		
Maximum (1976)	732,600	acre-ft
Minimum (1968)	390,000	acre-ft
Average	544,800	acre-ft
Annual diversion:		
North Unit Main Canal (average, 1963-77)	231,280	acre-ft

[5]Hydrologic drainage boundary uncertain due to ground-water exchange.
[6]Inflow to Wickiup includes inflow to Crane Prairie.

Storage Facilities

CRANE PRAIRIE DAM

Type: Zoned earthfill		
Location: On Deschutes River, 15 mi northwest of Lapine, Oreg.		
Construction period: 1939-40		
Reservoir, Crane Prairie:		
Annual discharge:		
Maximum (1968)	313,400	acre-ft
Minimum (1972)	134,300	acre-ft
Average	212,600	acre-ft
Active capacity, El. 4424-4445	55,300	acre-ft
Surface area	4,940	acres
Dimensions:		
Structural height	36	ft
Hydraulic height	27	ft
Top width	25	ft
Maximum base width	200	ft
Crest length	285	ft
Crest elevation	4455.0	ft
Volume	30,000	yd³
Spillway: Uncontrolled concrete weir in floor of open cut channel in left abutment.		
Crest length	80	ft
Crest elevation	4445.0	ft
Capacity at El. 4450	2,500	ft³/s
Outlet works: Twin-section concrete conduit through base of dam, each section controlled by a 4.8- by 6-ft slide gate from gate tower at inlet.		
Capacity at El. 4445	1,800	ft³/s

WICKIUP DAM AND DIKE

Type: Zoned earthfill. East Dike closes low area on east side of reservoir.		
Location: On Deschutes River, 9 mi west of Lapine, Oreg.		
Construction period: 1939-49		
Reservoir, Wickiup:		
Active capacity, El. 4265-4337.66	200,000	acre-ft
Surface area	11,170	acres

Dimensions:		
Structural height	100	ft
Hydraulic height	81	ft
Top width	30	ft
Maximum base width	550	ft
Crest length:		
Dam	13,860	ft
Dike	3,420	ft
Crest elevation	1347.0	ft
Total volume, dam and dike	1,852,000	yd³
Spillway: Open rock cut in the north end of the east dike with concrete crest and earth plug.		
Crest elevation	1336.0	ft
Crest elevation, earth plug	1339.0	ft
Crest length	400	ft
Capacity at El. 1339	5,000	ft³/s
Outlet works: Twin-section concrete conduit through base of dam, controlled at outlet end by two 90-in tube valves.		
Capacity at El. 1339	1,000	ft³/s
Foundation: Pumice, volcanic ash clay, sand, and gravel on badly disintegrated ancient lava of unknown thickness, seams in all directions filled with clay.		

Haystack Dam

Type: Zoned earthfill		
Location: Offstream, about 10 mi south of Madras, Oreg.		
Construction period: 1956-57		
Reservoir, Haystack Equalizing:		
Inflow through feeder canal from North Unit Main Canal.		
Active capacity, El. 2780-2842	5,635	acre-ft
Surface area	233	acres
Dimensions:		
Structural height	105	ft
Hydraulic height	73.5	ft
Top width	25	ft
Maximum base width	755	ft
Crest length	1,200	ft
Crest elevation	2853.0	ft
Total volume	535,000	yd³
Outlet works: Concrete conduit through base of dam controlled by one 3.25-ft-square high-pressure slide gate.		
Capacity at El. 2842	160	ft³/s

Diversion Facilities

North Canal Diversion Dam[7]

Type: Concrete arch, weir		
Location: On Deschutes River, near Bend, Oreg.		
Year completed: 1912		
Dimensions:		
Structural height	40	ft
Hydraulic height	28	ft
Crest length	293	ft
Spillway length	160	ft
Crest elevation	3558.0	ft
Volume	4,900	yd³
Diversion capacity	1,000	ft³/s
Spillway capacity	10,000	ft³/s

[7]Constructed by local interests prior to start of Reclamation construction. Currently owned by the North Canal Corp. but maintained jointly by North Unit Irrigation District, Central Oregon Irrigation District, and Deschutes Reclamation and Irrigation Co. (Swalley Canal).

Carriage Facilities

North Unit Main Canal

Location: From Bend, Oreg., generally north about 65 mi to vicinity of Madras, Oreg.		
Construction period: 1938-48		
Length	65	mi
Diversion capacity	1,000	ft³/s
Typical maximum section in earth:		
Bottom width	60	ft
Side slopes	1.5:1	
Water depth	5.64	ft
Typical maximum section in rock: (lined with pneumatically applied mortar in 1948)		
Bottom width	20	ft
Side slopes	0.25:1	
Water depth	10.2	ft

Crooked River Crossing (Main Canal)

Location: On the Crooked River about 3 mi east of Terrebonne, Oreg. Closed concrete box flume and roadway supported on an arch-type concrete bridge.		
Construction period: 1944-46		
Length:		
Total (including transitions)	672	ft
Flume	521	ft
Middle span	266	ft
Capacity	1,000	ft³/s
Typical section of flume:		
Width	10	ft
Water depth	8.05	ft

Tunnels No. 1 and 2 (Main Canal)

Location: About 7 mi north of Redmond, Oreg.		
Constructon period: 1944-45		
Length (both tunnels)	6,804	ft
Capacity	1,000	ft³/s
Diameter	11.25	ft
Cross section: Horseshoe		
Lining: Concrete, 5 to 10 in thick.		

Haystack Feeder Canal

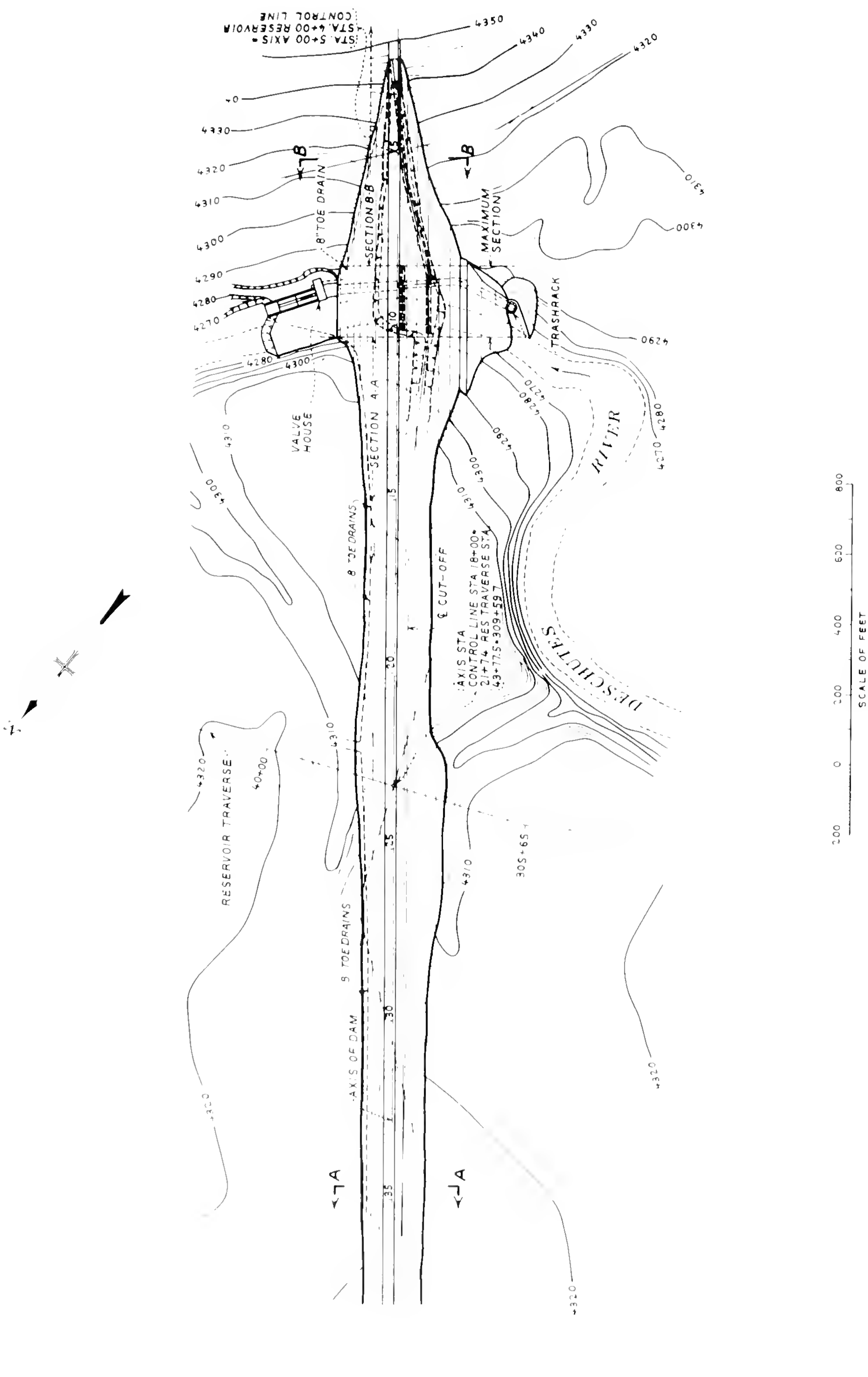
Location: From North Unit Main Canal to Haystack Dam.		
Construction period: 1956-57		
Length	0.5	mi
Capacity	703	ft³/s
Typical maximum section in earth:		
Bottom width	32	ft
Side slopes	1.5:1	
Water depth	6.4	ft

Pumping Plant Discharge Line (District constructed)

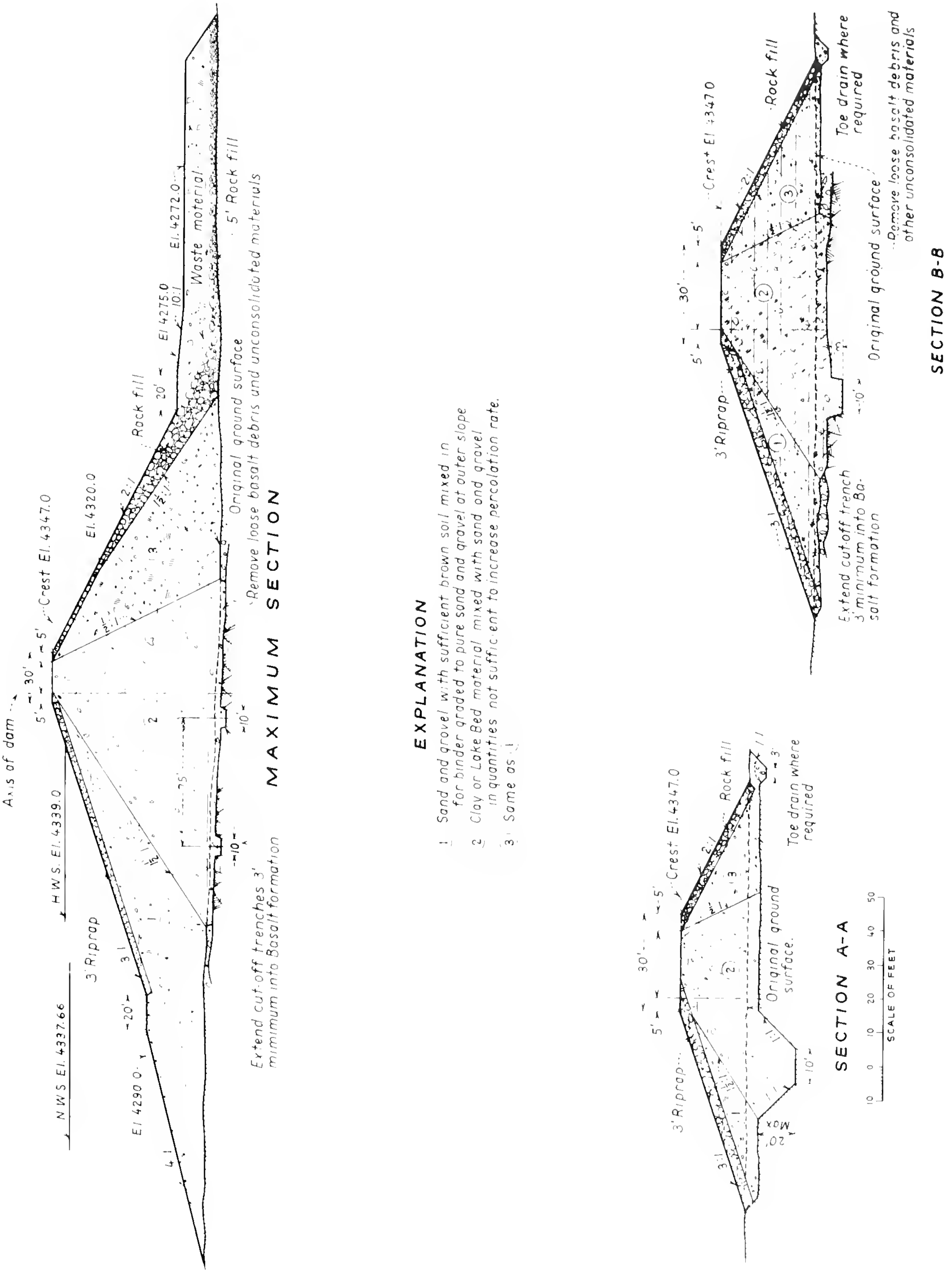
Location: Pumping plant at Crooked River crossing.		
Construction period: 1968		
Description: Steel pipe		
Length	220	ft
Diameter	5	ft
Capacity	200	ft³/s

Pumping Plant—Crooked River (District constructed)

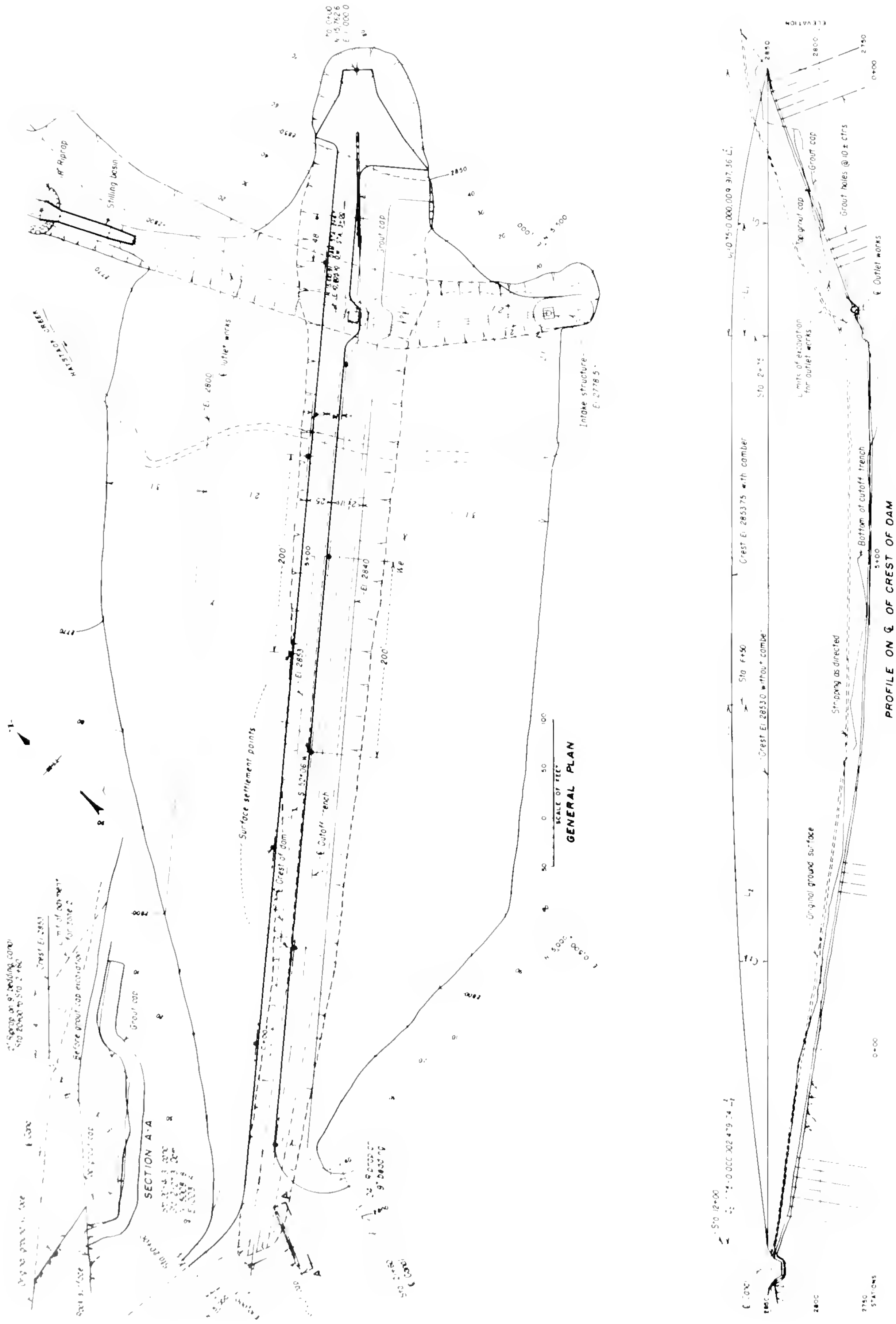
Construction period: 1968		
Number of units	9	
Total capacity	200	ft³/s
Total dynamic head	150	ft
Total horsepower	4,050	



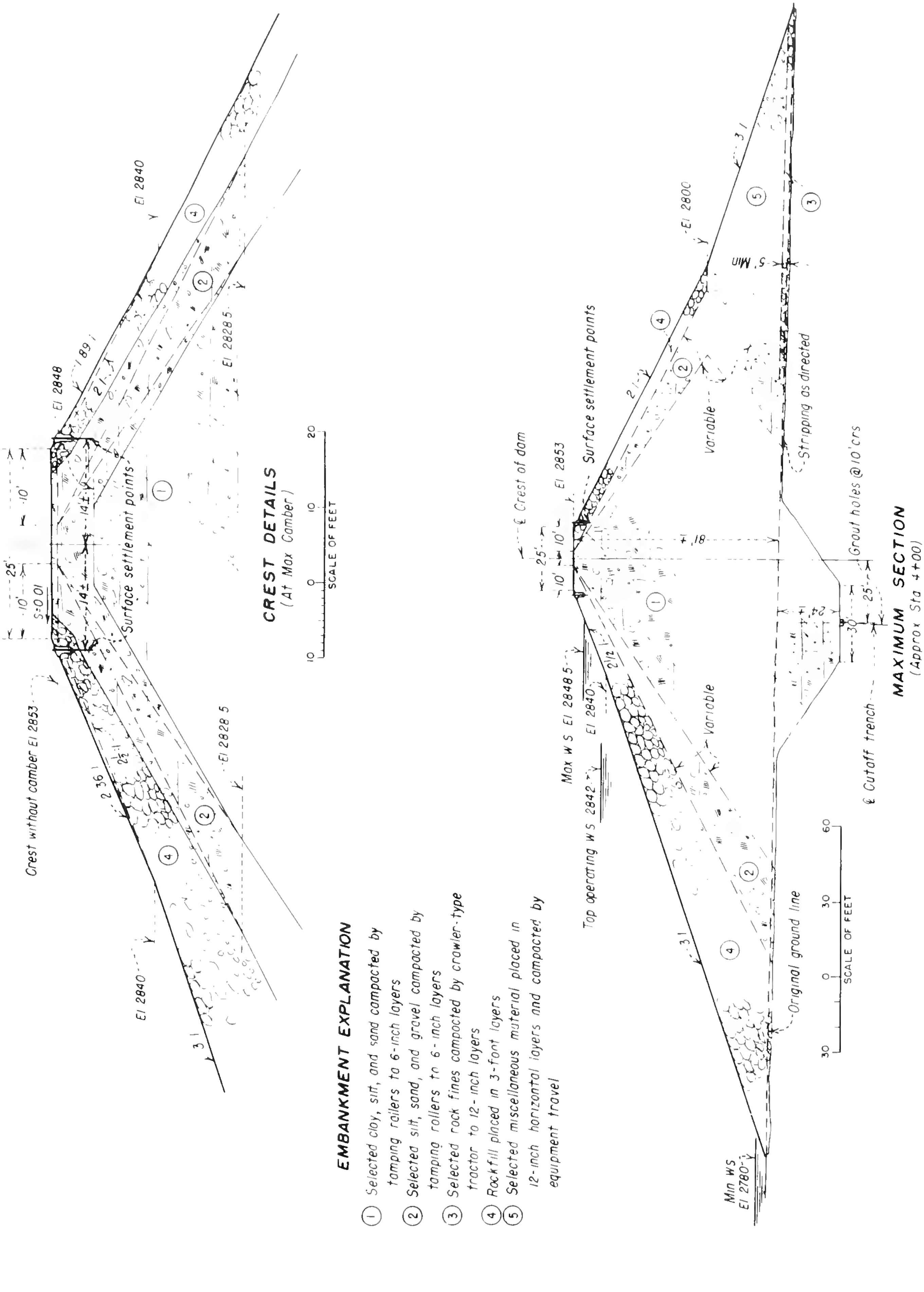
Wickiup Dam. Plan



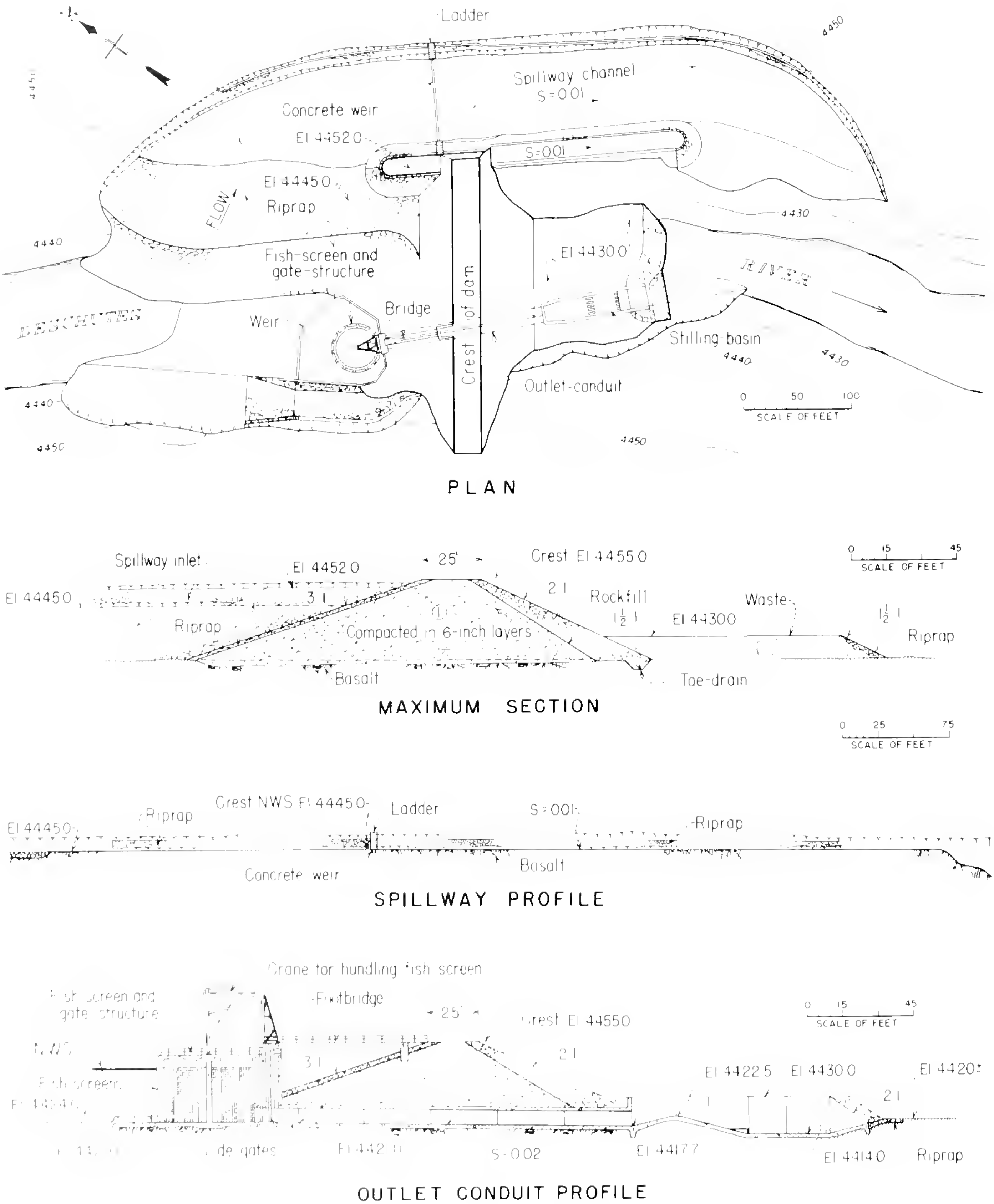
Wickiup Dam, Sections



Haystack Dam. Plan and Profile



Haystack Dam, Sections



Crane Prairie Dam, Plan and Sections

Dolores Project
(Under Construction)

Colorado: Montezuma and Dolores Counties

Upper Colorado Region
Water and Power Resources Service

The Dolores Project, located in the Dolores and San Juan River Basins in southwestern Colorado, will develop water from the Dolores River for irrigation, municipal and industrial use, recreation, and fish and wildlife. It also will provide flood control and aid in economic redevelopment. Service will be provided to the northwest Dove Creek area, central Montezuma Valley area, and south to the Towaoc area on the Ute Mountain Ute Indian Reservation.

PLAN

Primary storage of Dolores River flows for all project purposes will be provided by McPhee Reservoir, formed by McPhee Dam and Great Cut Dike. Secondary storage for municipal and industrial water will be furnished by Monument Creek Reservoir, located near the town of Dove Creek, which will receive water diverted from McPhee Reservoir. Dawson Draw Reservoir, located west of McPhee Reservoir, will be constructed specifically for fish and wildlife enhancement and will be supplied primarily from irrigation return flows.

An average annual supply of 90,900 acre-feet of water will be provided to 27,860 acres of full service land in Dove Creek, 7,500 acres of full service land in Towaoc, and 26,300 acres of supplemental service land in Montezuma Valley. Water for the Dove Creek area will be pumped from McPhee Reservoir by the Great Cut Pumping Plant and conveyed 39.5 miles through the Dove Creek Canal and its 7.6-mile branch, the South Canal. Water for the Towaoc area will be conveyed 48 miles from the reservoir by the Dolores Tunnel and the Dolores and Towaoc Canals. Both areas will be served by sprinkler irrigation systems. The Montezuma Valley area will be served by releases at Great Cut Dike and the Dolores Tunnel and Canal to an existing gravity distribution system.

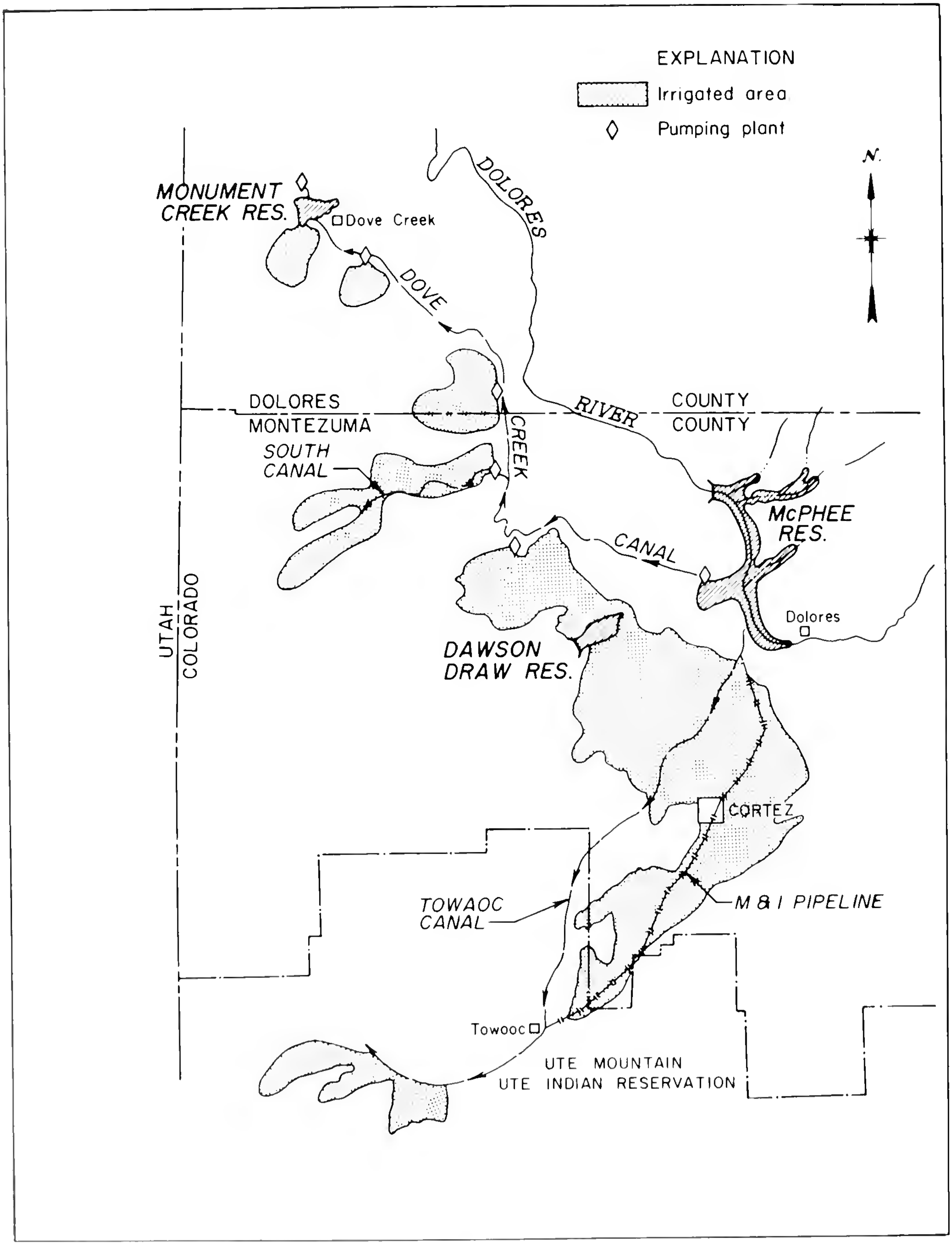
McPhee Dam and Reservoir and Great Cut Dike

McPhee Dam, located on the Dolores River, will be a rolled earth, sand, gravel, and rockfill structure with a volume of approximately 5,029,000 cubic yards. The crest of the dam will be 270 feet high above streambed, 1,300 feet in length, and 30 feet wide. A gated spillway located in the right abutment will include a concrete chute leading to a stilling basin. The outlet works, located in the left abutment of the dam, will have two separate intake structures, and a total capacity of 5,000 cubic feet per second.

Great Cut Dike will be a rolled earthfill structure with a crest length of 1,900 feet, and crest width of 30 feet. It will have a maximum height of 64 feet above original ground surface. The embankment will have a volume of about 189,000 cubic yards.

McPhee Reservoir will be created with the construction of McPhee Dam and the Great Cut Dike in a saddle on the Dolores-San Juan Divide. The reservoir will have a total capacity of 381,100 acre-feet, including 229,000 acre-feet of active capacity, 152,000 acre-feet of inactive capacity, and 100 acre-feet of dead storage. The water surface area will total 4,470 acres at the top of the active capacity at an elevation of 6924.0 feet. The reservoir will

McPhee Dam and the Great Cut Dike



Dolores Project

Dawson Draw Dam and Reservoir

extend approximately 10 miles up the Dolores River, 4 miles up Beaver Creek, 1 mile up Dry Creek, 2 miles up House Creek, and 2 miles up the Great Cut saddle to the dike.

Accumulated sediments would occupy a total volume of 11,000 acre-feet in 100 years, with about 2,800 acre-feet in the active pool.

Monument Creek Dam and Reservoir

Monument Creek Dam, to be located on an offstream site that drains into Monument Creek, is to be a rolled earthfill structure with a total volume of 152,000 cubic yards of material. It will have a maximum height of 43 feet above the original ground surface, and will be 2,850 feet long and 30 feet wide, with a crest elevation of 6810.0 feet.

Monument Creek Reservoir will have a total capacity of 690 acre-feet. It will have a water surface area of 84 acres at an elevation of 6798.0 feet. Accumulated sediments would occupy a volume of 92 acre-feet after 100 years.

Dawson Draw Dam and Reservoir

Dawson Draw Dam, to be constructed on Dawson Draw about 9 miles north of Cortez, will be an earth, sand, gravel, and rock structure with a volume of 106,000 cubic yards of material. At a crest elevation of 6556.0 feet, the dam will be 56 feet high, 1,085 feet long, and 30 feet wide. Dawson Draw Reservoir will provide habitat for fish, waterfowl, and other wildlife, and will have a total capacity of 3,310 acre-feet, consisting of 3,210 acre-feet of inactive capacity and 100 acre-feet of dead capacity. A surcharge capacity of 2,360 acre-feet will be provided to store floodflows temporarily until they can be discharged over the spillway. Sediments would occupy a volume of 480 acre-feet after 100 years.

Great Cut Pumping Plant

Great Cut Pumping Plant at Great Cut Dike will consist of ten vertical, mixed-flow pumping units. Eight of the pumps will be multistage and will lift water from the reservoir through a discharge line into the Dove Creek Canal. The two remaining pumps will lift water through a discharge line into the "U" lateral should the reservoir water surface be too low for gravity releases. Annual energy requirements for the eight pumps are estimated to average 5,800,000 kilowatt-hours, with the additional two averaging an annual requirement of 99,000 kilowatt-hours.

Sprinkler Pumping Plants

Six pumping plants, including four along the Dove Creek Canal and two along the South Canal, will provide water to pipe laterals for sprinkler irrigation. The average annual energy requirement for operating the plants is estimated to be approximately 10,890,000 kilowatt-hours.

Dove Creek Canal

The Dove Creek Canal will head at the end of the pump discharge line at Great Cut Dike and extend northwest for 39.5 miles to Monument Creek Reservoir. It will have an initial capacity of 380 cubic feet per second and a terminal capacity of 30 cubic feet per second. It will include a turnout to the South Canal and to the four sprinkler pumping plants.

South Canal

The South Canal will head on the Dove Creek Canal near Pleasant View and extend for 7.6 miles to the south and west. It will have an initial capacity of 160 cubic feet per second and a terminal capacity of 30 cubic feet per second. It will include turnouts to three pressure pipeline sprinkler irrigation systems.

Dolores Tunnel

The Dolores Tunnel will be drilled through the Dolores-San Juan Divide about 2 miles west of the town of Dolores and 1 mile downstream from the existing tunnel of the Montezuma Valley Irrigation Company. Maximum capacity will be 520 cubic feet per second.

Dolores Canal

The Dolores Canal will head at the outlet of the Dolores Tunnel and extend for 1.3 miles to the south and east.

The canal will replace approximately 0.5 mile of the existing West Lateral and 0.8 mile of the existing East Lateral. Initial capacity will be 520 cubic feet per second; the terminal capacity will be 70 cubic feet per second.

Towaoc Canal

The Towaoc Canal will head on the Dolores Canal 1.1 miles below the outlet of the Dolores Tunnel and extend southward for 45.4 miles to the full service lands in the Towaoc area. The canal will be earth lined for 32.8 miles and concrete lined for 7.5 miles. It will have an initial capacity of 135 cubic feet per second and a terminal capacity of 86 cubic feet per second.

Cortez-Towaoc Pipeline

The Cortez-Towaoc Pipeline will head just above the terminus of the Dolores Canal and extend southward 19.5 miles to near Towaoc. The initial section to Cortez will carry 17.3 cubic feet per second and the remainder extending to Towaoc will carry 2.9 cubic feet per second.

Laterals and Drains

Twelve lateral systems with a total of 84.7 miles will be constructed to deliver water to farms in the Dove Creek and Towaoc areas. Project drainage facilities will be provided for both areas.

DEVELOPMENT

Early History

In 1873, modern development began in southwest Colorado when the Federal Government opened the nearby San Juan Mountains to mining. In the early 1880's, settlers moved into the Montezuma Valley.

These early settlers began farming the land but soon realized that to ensure good harvests they would need more water than was available from the small streams in the Montezuma Valley. To meet this need, they built irrigation canals that conveyed water from the Dolores River to the fertile but dry valleys in the San Juan River Basin. The canals have helped, but they carry too little water and shortages still plague the farmers and residents. When completed, the Dolores Project will ensure an adequate supply of water to meet existing and future agricultural and municipal needs.

Investigations

Definite plan studies were made and published in April 1977. The report updates the physical data and includes revised financial and economic analyses of the project, based on the feasibility report transmitted to the Congress on March 17, 1966, which led to authorization.

Anticipated environmental impacts were detailed in the final environmental statement filed with the Council on Environmental Quality on May 9, 1977. Included in the studies were analyses of water resources, water quality, fisheries, wildlife, threatened or endangered species, scenery, economic and social conditions, historic and archeological sites, recreation, and a summary of unavoidable adverse impacts with short-term losses compared to long-term gains.

Archeological investigations disclosed that although the project would not affect any properties listed on the *National Register of Historic Places*, it could disturb about 487 known archeological sites, either within proposed rights-of-way or in other areas that would be altered by project construction. An excavation program will precede each stage of construction to remove and preserve all significant findings.

Authorization

The Dolores Project was authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537), as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485).

Construction

A groundbreaking ceremony for the project was held September 24, 1977, at the site of the Great Cut Dike, northwest of Cortez.

Operating Agencies

The Dolores Water Conservancy District will administer project and joint-use facilities within its boundaries, and the Ute Mountain Ute Indian Tribe and the Bureau of Indian Affairs will administer facilities serving the reservation. The Forest Service, Bureau of Land Management, Colorado Division of Wildlife, and the town of Dove Creek will participate in managing recreational and cultural facilities and wildlife lands.

BENEFITS

Irrigation

Water developed by the project will be available for 61,660 acres and will benefit the area's economy by increasing agricultural production, and strengthening service-related enterprises dependent on agriculture. Main crops will be alfalfa, pasture, barley, oats, and corn silage for livestock feed.

Municipal and Industrial Water

The municipal and industrial water supply of 8,700 acre-feet will permit a moderate but healthy future growth in the area.

Recreation and Fish and Wildlife

Water releases from McPhee Reservoir will create a stream fishery. Releases from the reservoir in anticipation of snowmelt flows will be managed to benefit white-water boaters. The project reservoirs and facilities will provide new recreation opportunities for the public. Land acquired and managed for wildlife conservation will create valuable and unthreatened habitat for a variety of wildlife species.

Flood Control

McPhee Dam will provide flood protection for downstream landowners.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	35,360	acres
Supplemental irrigation service	26,300	acres
Total	61,660	acres

Climatic Conditions

Annual precipitation:		
Dove Creek	12.3	in
Montezuma Valley:		
Northern area	12.6	in
Southern area	11.0	in
Towaoc	11.0	in
Temperature:		
Maximum	100	°F
Minimum	−25	°F
Mean:		
Dove Creek	47	°F
Montezuma Valley:		
Northern area	48	°F
Southern area	50	°F
Towaoc	52	°F

ENGINEERING DATA

Water Supply

Dolores River

Drainage area	809	mi²
Annual discharge:		
Maximum (1941)	793,000	acre-ft
Minimum (1934)	129,800	acre-ft
Average	349,900	acre-ft
Colorado River annual stream depletion	80,900	acre-ft

Storage Facilities

McPhee Dam

Type: Rolled earth, sand, gravel, and rockfill		
Location: On the Dolores River, 15 mi north of Cortez.		
Reservoir, McPhee:		
Total capacity	381,100	acre-ft
Active capacity at El. 6924	229,000	acre-ft
Surface area	4,470	acres
Dimensions:		
Structural height	270	ft
Crest width	30	ft
Crest length	1,300	ft
Crest elevation	6936.0	ft
Total volume	5,029,000	yd³
Spillway: Gated, located in the right abutment of the dam, would include a concrete chute leading to the stilling basin.		
Outlet works: Located in left abutment, two separate intake structures including a selective level intake.		
Spillway discharge capacity	33,300	ft³/s
Inlet elevation	6897.0	ft
Reservoir surface elevation required for capacity discharge	6928.0	ft

Great Cut Dike

Type: Rolled earthfill		
Location: In a saddle of the Dolores-San Juan Divide (with McPhee Dam creates McPhee Reservoir).		
Dimensions:		
Structural height	64	ft
Crest width	30	ft
Crest length	1,900	ft
Crest elevation	6736.0	ft
Total volume	189,000	yd³
Outlet works: Located near center of dike, consisting of intake structure, trashrack, gate chamber, and gate house. An unlined inlet channel will convey water to the outlet works, 20 ft bottom width, 2 mi long.		
Discharge capacity	820	ft³/s
Inlet elevation	6852.0	ft
Surface water elevation required for capacity discharge	6876.0	ft

Monument Creek Dam

Type: Rolled earthfill		
Location: West of Dove Creek at an off-stream site that drains into Monument Creek.		
Reservoir, Monument Creek:		
Total capacity	690	acre-ft
Active capacity at El. 6798	560	acre-ft
Surface area	84	acres
Dimensions:		
Structural height	43	ft
Crest width	30	ft
Crest length	2,850	ft
Crest elevation	6810.0	ft
Total volume	152,000	yd³
Spillway: Ungated with baffled drop located in right abutment.		
Outlet works: Located in left abutment, consist of intake structure trashrack, concrete encased 2-ft-diameter pipe, gate structure, and stilling well.		
Spillway discharge capacity	432	ft³/s

Inlet elevation	6798.0 ft
Reservoir surface elevation required for capacity discharge	6804.0 ft
Outlet discharge capacity	55 ft³/s
Inlet elevation	6783.0 ft
Reservoir surface elevation required for capacity discharge	6798.0 ft

DAWSON DRAW DAM

Type: Earth, sand, gravel, and rock
Location: On Dawson Draw, about 9 mi north of Cortez.
Dimensions:

Height above streambed	56 ft
Crest width	30 ft
Crest length	1,085 ft
Volume	106,000 yd³

Reservoir, Dawson Draw:

Total capacity at El. 6543	3,310 acre-ft
Surface area	294 acres

Outlet works: Located in right abutment, consist of an intake structure, trashracks, a 3-ft-diameter conduit leading to a gated structure, and a 3.75-ft-diameter conduit from the gated structure to a stilling basin.
Spillway: Ungated ogee crest, concrete chute leading to a stilling basin.

Carriage Facilities

DOVE CREEK CANAL

Location: From Great Cut Dike, extends northwest 39.5 mi to Monument Creek Reservoir.

Length	39.5 mi
Initial diversion capacity	380 ft³/s
Terminal diversion capacity	30 ft³/s

SOUTH CANAL

Location: Heads on Dove Creek Canal near Pleasant View, extends south and west.

Length	7.6 mi
Initial diversion capacity	160 ft³/s
Terminal diversion capacity	30 ft³/s

DOLORES TUNNEL

Location: Through Dolores-San Juan Divide, 2 mi west of the town of Dolores.

Length	1.3 mi
Diameter, concrete lined	9 ft
Maximum capacity	520 ft³/s

DOLORES CANAL

Location: Heads at outlet of Dolores Tunnel, extends south and east.

Length	1.3 mi
Initial capacity	520 ft³/s
Terminal capacity	70 ft³/s

TOWAOC CANAL

Location: Heads on Dolores Canal 1.1 mi below outlet of Dolores Tunnel, extends southward.

Length	45.4 mi
Initial capacity	135 ft³/s
Terminal capacity	86 ft³/s

CORTEZ-TOWAOC PIPELINE

Location: Heads above terminus of Dolores Canal, extends southward to near Towaoc.

Length	19.5 mi
Diversion capacity, maximum	17.3 ft³/s

LATERALS

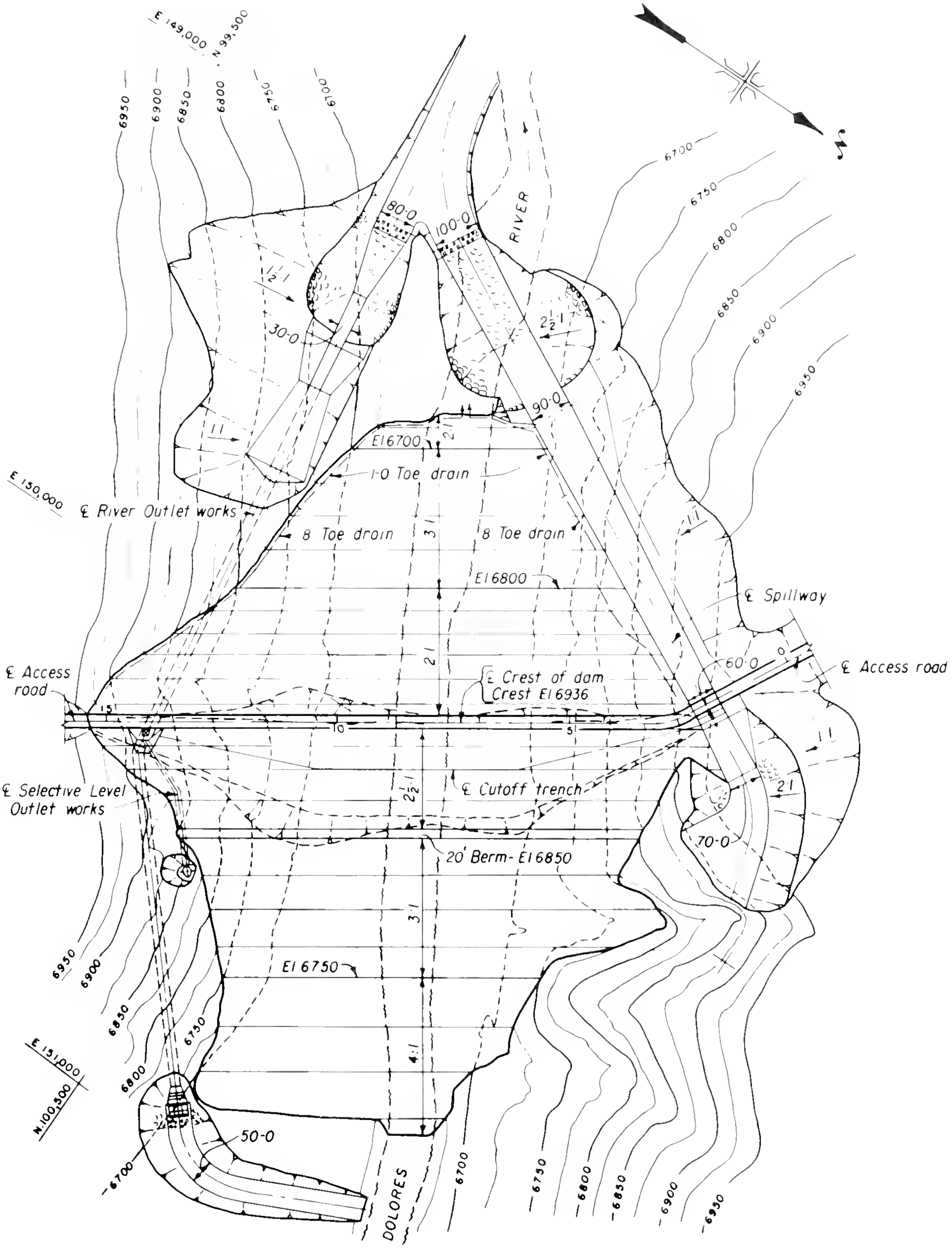
Twelve lateral systems to be constructed.

Length, total	84.7 mi
Maximum capacity	Various

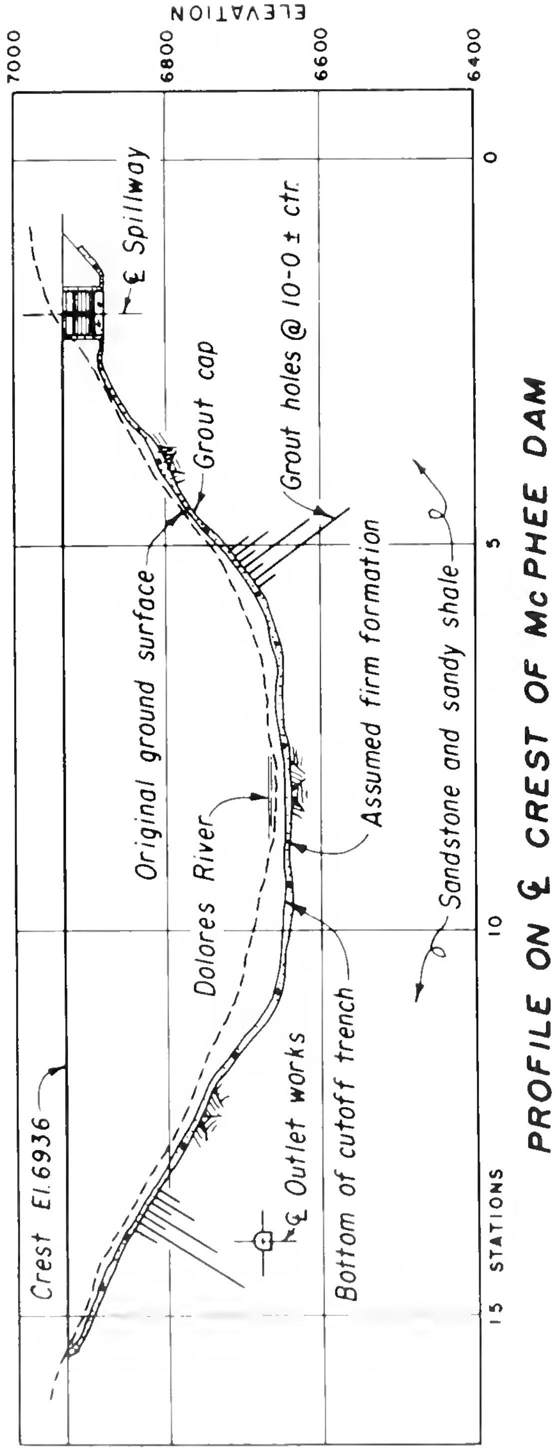
GREAT CUT PUMPING PLANT

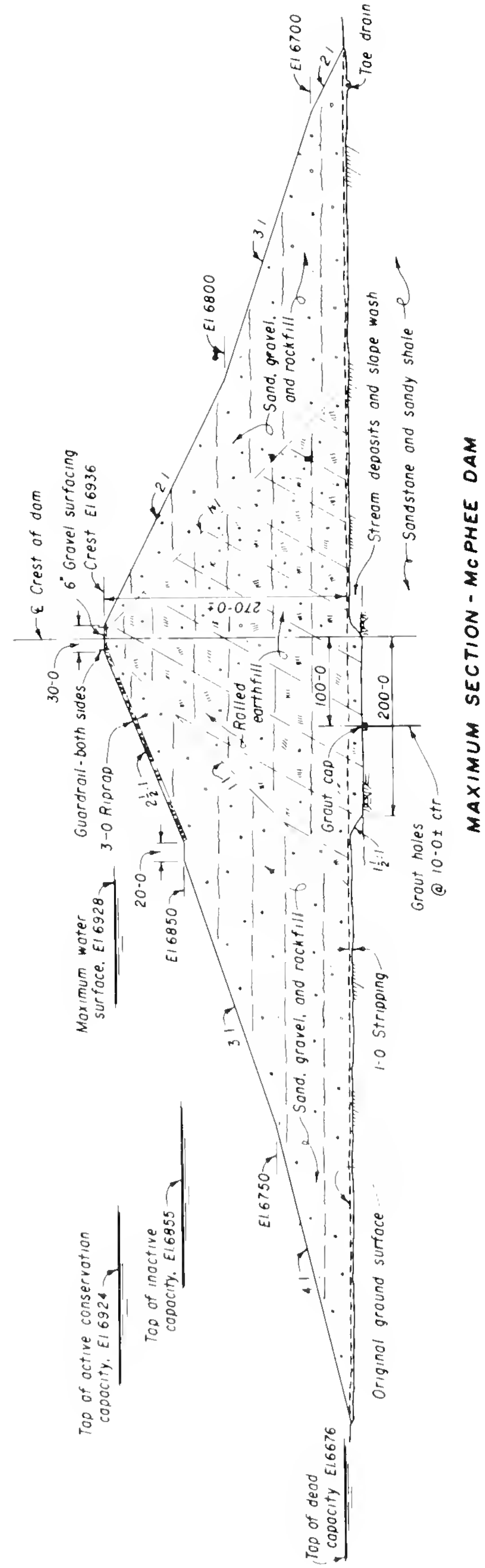
Location: At the downstream toe of the Great Cut Dike.

	Maximum lift, ft	Capacity, ft³/s
To Dove Creek Canal	108	380
To U Lateral	29	72
Along Dove Creek Canal		
Fairview	169	98
Cahone	162	72
Cross Canyon	83	20
Monument Creek	110	23
Along South Canal		
Pleasant View	147	36
Ruin Canyon	171	85

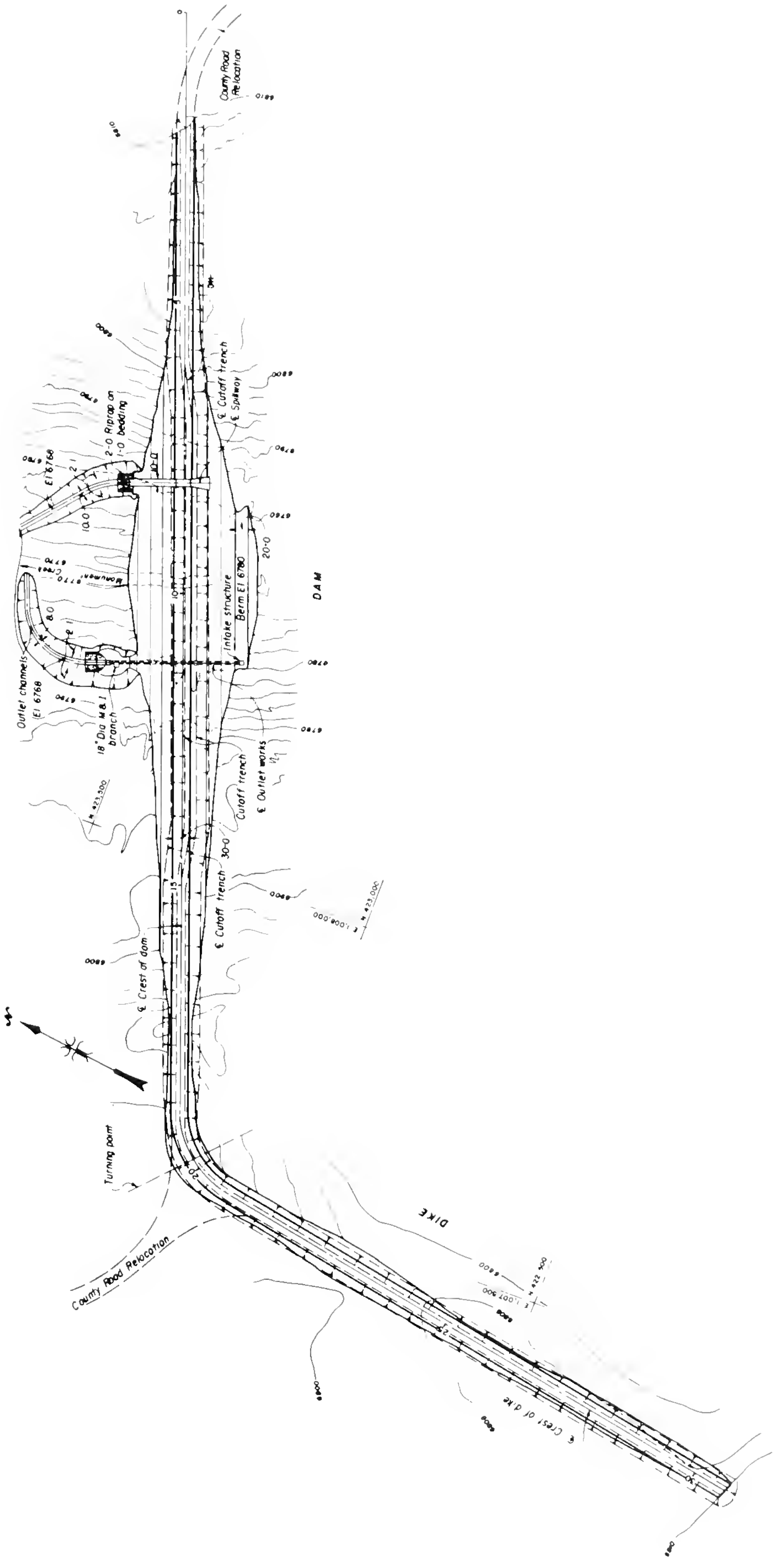


McPhee Dam, Plan

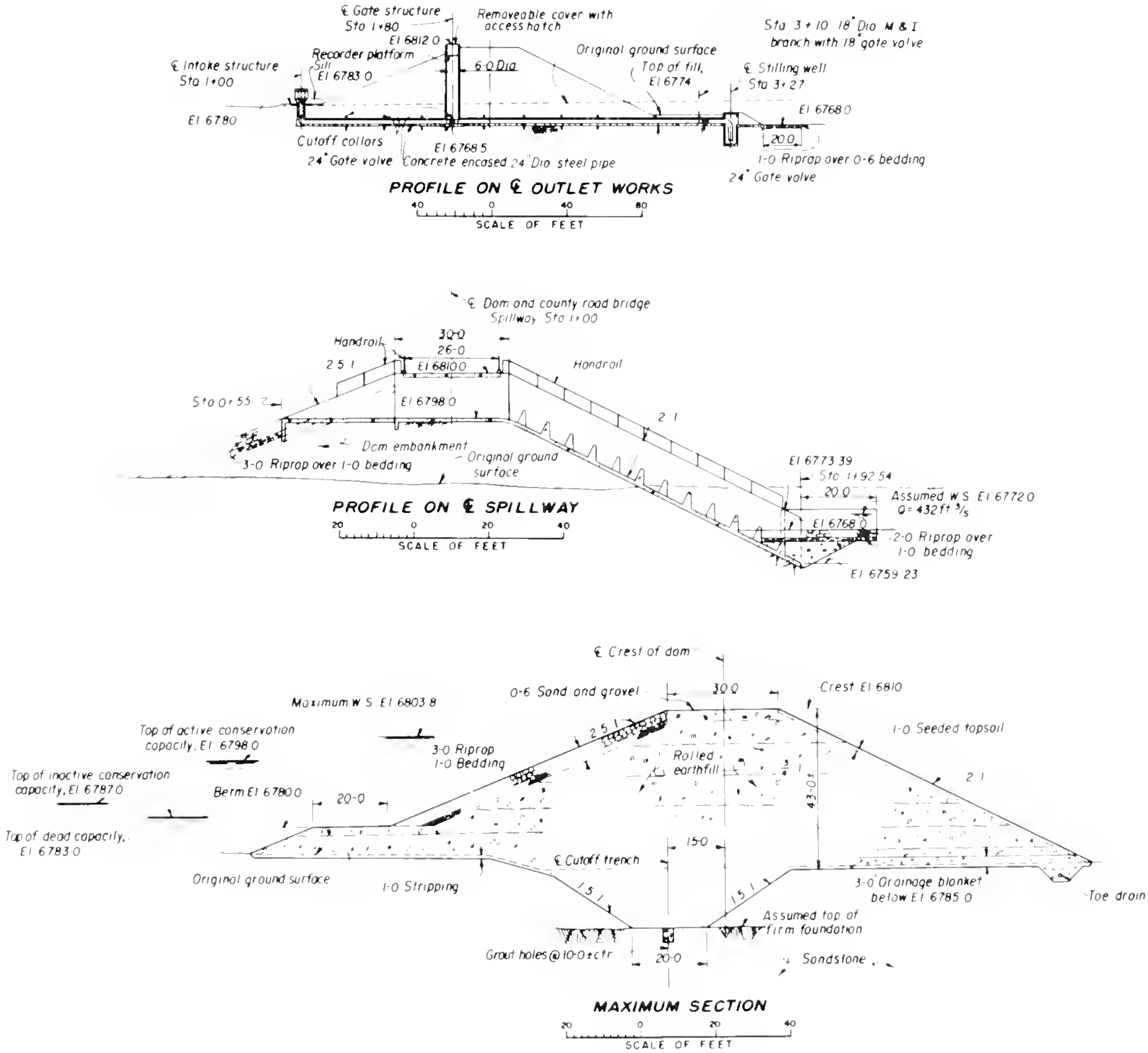




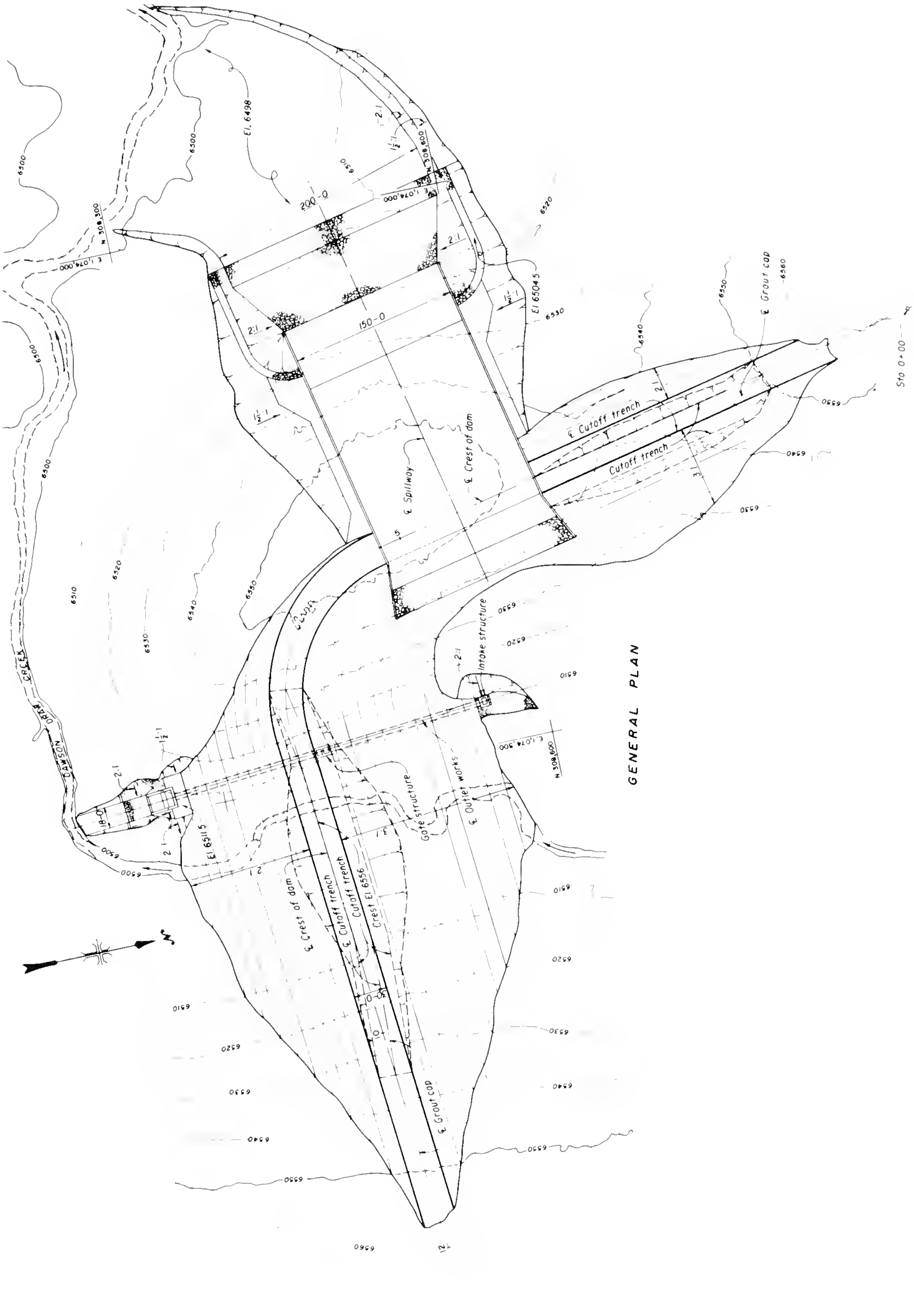
McPhee Dam. Sections



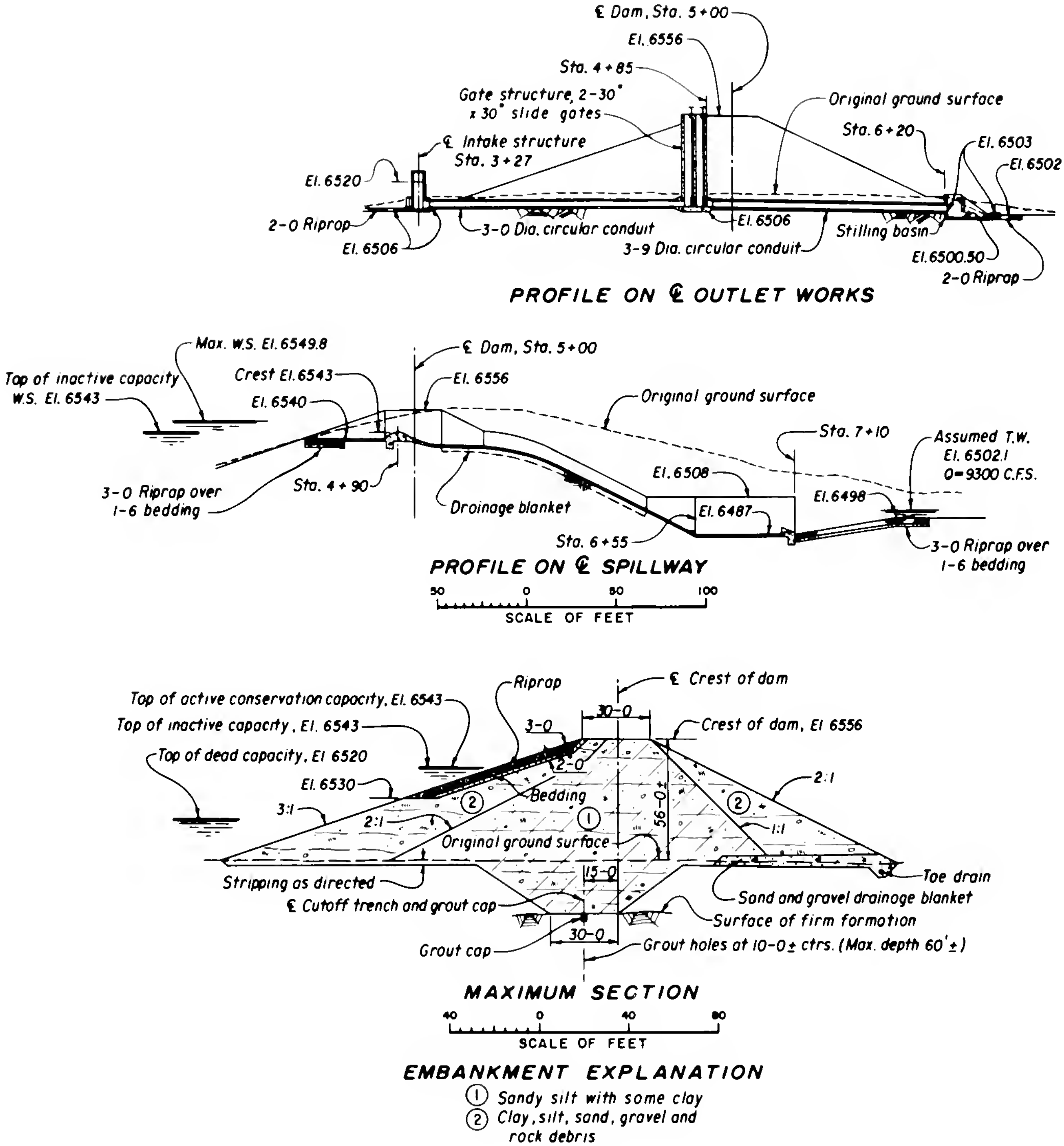
Monument Creek Dam, Plan



Monument Creek Dam, Sections



Dawson Draw Dam, Plan

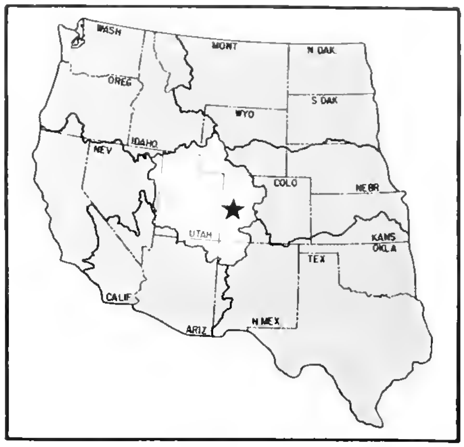


Dawson Draw Dam, Sections

Dominguez Reservoir Project
(Proposed)

Colorado: Delta and Mesa Counties

Upper Colorado Region
Water and Power Resources Service



The Dominguez Reservoir Project would be a multipurpose project that would develop water of the Gunnison River for hydroelectric power, municipal and industrial use, recreation, and fish and wildlife enhancement.

PLAN
(Preliminary)

The recommended plan is centered around the major feature, Dominguez Dam on the Gunnison River near the community of Whitewater, Colo. Other project features would be a run-of-the-river powerplant to be located at the base of the dam and a pumpback peak demand powerplant on the east shore of the reservoir about 8 miles upstream from the dam. A forebay reservoir, called Rim Basin, would be constructed on the canyon rim about 700 feet upstream from Dominguez Reservoir. This power development would have an ultimate capacity of 500 megawatts and could be built in stages to satisfy future needs as they develop. Other benefits to the area would be municipal and industrial water for population growth in the Grand Valley area and for a potential fossil fuel powerplant in Delta, Colo.

DEVELOPMENT

Early History

The discovery of metallic minerals in mountainous areas near the Continental Divide provided the impetus for initial settlement in the region. Towns like Ouray, Silverton, Telluride, and Gunnison sprang up and railroads were constructed in the area to support mining operations. Later, these towns were important markets for area farms and ranches.

Early attempts at irrigation consisted of simple diversions, but soon irrigation companies were formed and larger scale projects, financed by private companies, were attempted. The farmers sought Federal aid from the newly established Bureau of Reclamation to construct the storage and delivery systems in use today.

Investigations

Possible reservoir sites in the Lower Gunnison River area were first studied by the Bureau of Reclamation in the late 1920's. A 1946 report on the Colorado River Basin proposed a Whitewater Reservoir on the Gunnison River as part of the Cisco-Thompson Project. In 1950, a report on the Colorado River Storage Project (CRSP) included a proposed Whitewater Unit to be located about 2 miles above the town of Whitewater. A 1951 Gunnison River Project reconnaissance report included the Whitewater Unit with plans almost identical to those presented in the CRSP report. In the 1972 special report on the Uncompahgre Project improvement and extension, the plan was basically the same as for the CRSP and the Gunnison River Project. These reports were the basis for authorization of feasibility investigations in October 1972. A multiobjective planning team selected three alternatives to be included in a feasibility report: 1) a recommended plan; 2) a plan with economic emphasis; and 3) a plan with environmental emphasis. The feasibility report is scheduled for completion in 1980.

Authorization

The Dominguez Reservoir Project was authorized by Public Law 92-577, and the feasibility studies by act of October 27, 1972, for Water Resources Developments.

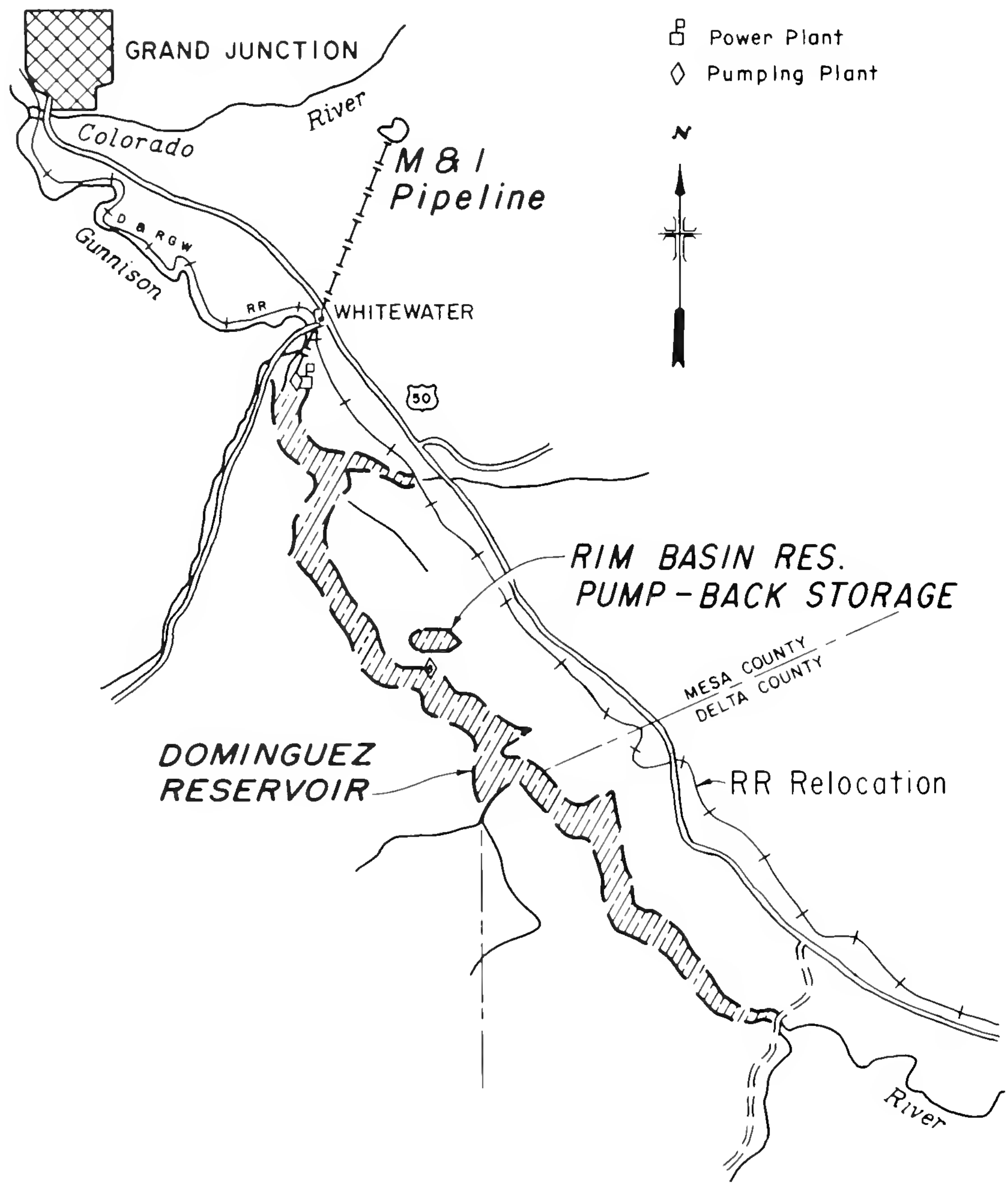
Operating Agency

Mesa County is the sponsor of project development, and the contracting entity for municipal and industrial water.

BENEFITS

Municipal and Industrial Water

Up to 57,800 acre-feet of water, needed for the population growth in the Grand Valley area and for a potential fossil fuel powerplant in the Delta area, could be provided.



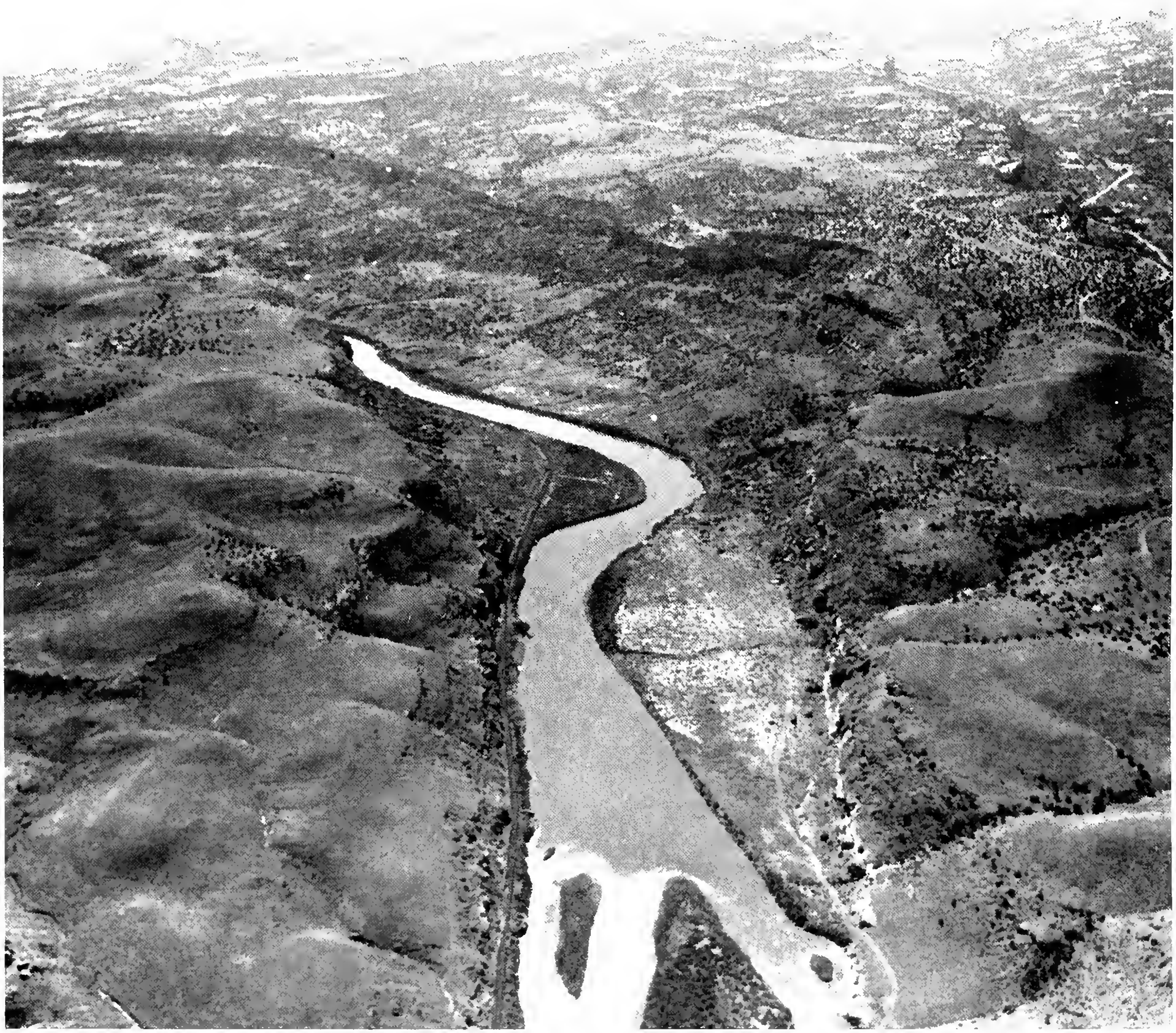
Dominguez Reservoir Project

Hydroelectric Power

The project would include two hydroelectric generating plants. An 18-megawatt conventional powerplant would be constructed in the base of Dominguez Dam, which would produce power with the normal flow of the river. A pumpback peak demand powerplant with an ultimate capacity of 500 megawatts would be constructed on the east shore of the reservoir about 8 miles upstream from the dam. The forebay reservoir for the pumpback plant would be located on the canyon rim some 700 feet above the reservoir.

Recreation and Fish and Wildlife

The relatively constant level of the reservoir would provide recreation and fishing benefits, and the quality, temperature, and sediment control provided by the reservoir would enhance the downstream fishery and recreation values of the Gunnison River.



Project site on Gunnison River

PROJECT DATA

Climatic Conditions

Annual precipitation	8.4	in
Temperature:		
Maximum	105	°F
Minimum	−23	°F

ENGINEERING DATA

Water Supply

Industrial	36,000	acre-ft
Municipal and industrial (light)	21,800	acre-ft
Total	57,800	acre-ft

Storage Facilities

DOMINGUEZ DAM

Type: Earthfill
Location: 1.5 mi south of Whitewater, Colo.

Height above streambed	Not known[1]	
Crest width	30	ft
Crest length	1,170	ft
Reservoir, Dominguez:		
Total capacity	302,000	acre-ft
Active capacity	93,900	acre-ft
Surface area at El. 4800	5,079	acres

RIM BASIN DAM

Type: Earthfill
Location: 8 mi south of Dominguez Dam.

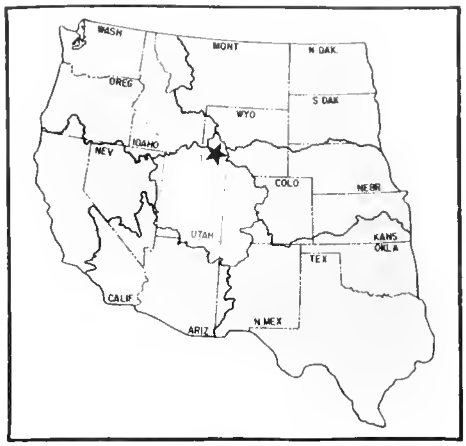
Height	Not known[1]	
Crest width	25	ft
Crest length	8,220	ft
Reservoir, Rim Basin:		
Total capacity	9,870	acre-ft

[1]Design not complete.

Eden Project

Wyoming: Sweetwater and Sublette Counties

Upper Colorado Region
Water and Power Resources Service



The Eden Project furnishes an irrigation water supply for 17,010 acres. Project lands are in the vicinity of the towns of Farson and Eden in southwestern Wyoming about 40 miles north of Rock Springs. Project features are Big Sandy Dam and Reservoir, Eden Dam and Reservoir, Little Sandy Diversion Dam, Little Sandy Canal, Means Canal, Eden Canal, and a lateral and drainage system.

PLAN

Big Sandy Dam was constructed to replace some storage in the existing offstream Eden Reservoir and to supply water for additional project lands. The Means Canal conveys water from Big Sandy Reservoir to the Westside Lateral, which serves lands on the west side of Big Sandy Creek, and to the Eden Canal which serves lands east of the creek. Little Sandy Diversion Dam diverts water into the Little Sandy Canal which also supplies water to the Eden Canal. Water is diverted from Big Sandy Dam to Eden Reservoir and from Little Sandy Canal into Eden Reservoir. Water is drawn from Eden Reservoir to serve Eden Canal and Farson Lateral.

Big Sandy Dam and Means Canal

Big Sandy Dam and Reservoir

Big Sandy Dam is on Big Sandy Creek 10 miles north of Farson, Wyo. It is a zoned earthfill dam 85 feet high, having a crest length of 2,350 feet and containing about 840,000 cubic yards of material. The uncontrolled open side-channel spillway has a capacity of 7,350 cubic feet per second.

The outlet works, consisting of a concrete conduit through the base of the dam controlled by two high-pressure slide gates, has a capacity of 635 cubic feet per second. An earthfill dike with a maximum height of 18 feet, 8,300 feet long, and containing 107,000 cubic yards of material lies north of the left abutment of the dam along the eastern rim of the reservoir basin.

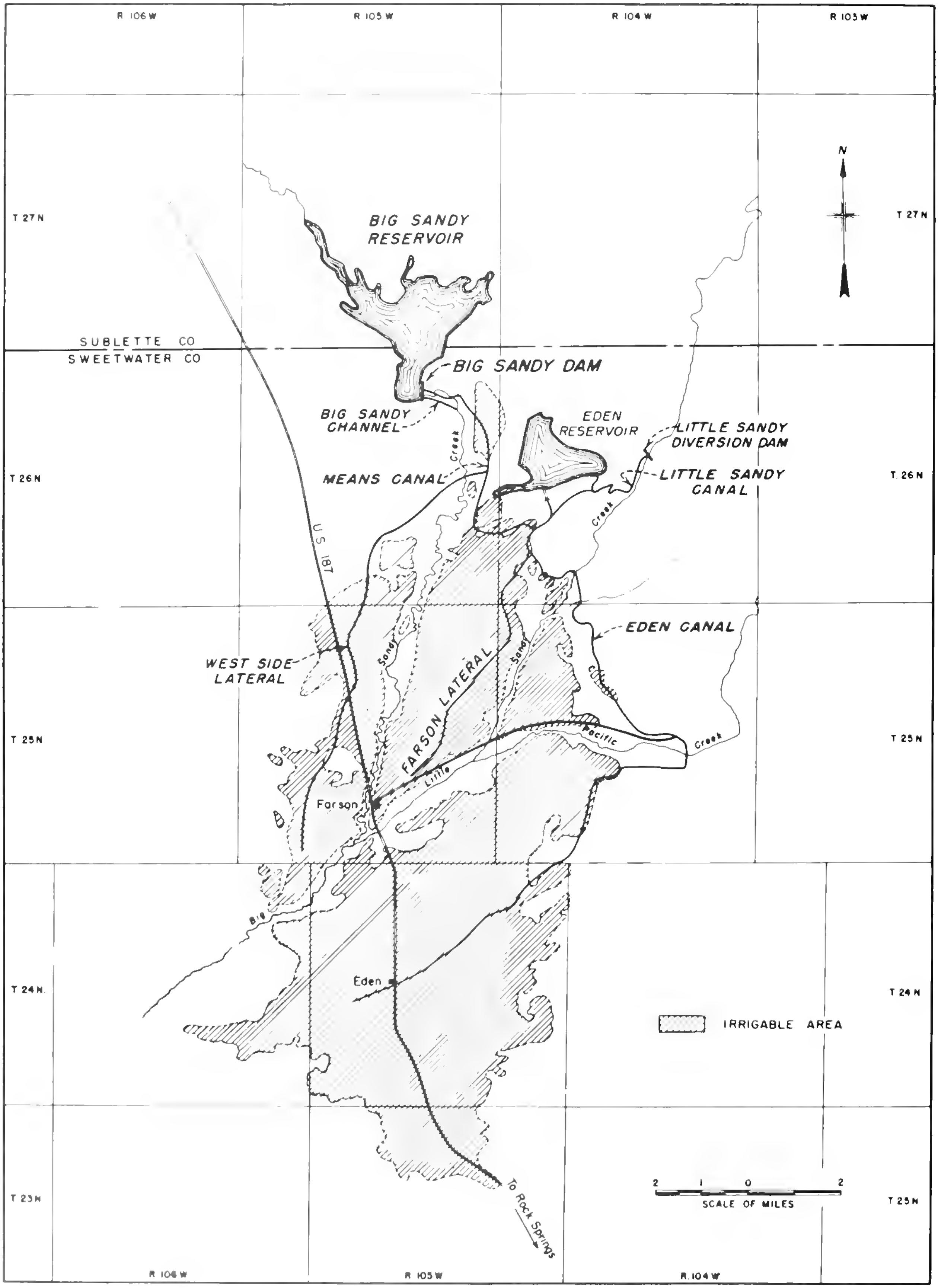
Eden Dam and Reservoir

Eden Dam is a series of irregular dikes originally built under the Carey Act by Eden Irrigation and Land Company about 1907. In 1959, the Bureau of Reclamation constructed a new outlet works from the reservoir through the abutment of the southeast side of the reservoir to supply the old Eden Canal.

The reservoir is approximately 2.5 miles at its widest point, and 2 miles in length with a surface area of about 900 acres.

The outlet works consists of a concrete-lined tunnel controlled by constant head orifice gates and an overflow control structure.

The spillway is contained in the outlet works as an uncontrolled concrete overflow structure above the orifice gates. The spillway has a crest width of 15 feet and crest elevation of 6713.4 feet. The spillway is used only in emergency since the water inflow to the reservoir is controlled by diversions through the Little Sandy Feeder Canal.



Eden Project

Big Sandy River and Eden Canal

Canal and Drainage Systems

The three main canals on the project are the 4-mile-long Little Sandy Canal, the 6-mile Means Canal, and the 10.8-mile Eden Canal. The diversion capacities of these canals are 150, 635, and 475 cubic feet per second, respectively. Irrigation water is distributed to project farms by the Westside, Farson, and Eden lateral systems. The laterals range in capacity from 6 to 160 cubic feet per second and have an aggregate length of 94 miles.

The 53-mile drainage system includes subsurface drains averaging 10 feet in depth, and surface drains about 2.5 feet deep.

DEVELOPMENT

Early History

The route adopted by the first immigrant trains in 1842 on their journey to Oregon and California traversed an opening in the Wind River Mountains now known as South Pass. Emerging from this pass, the pioneer caravans traveled in a southwesterly direction for 25 miles to the Big Sandy drainage and the area now comprising the Eden Project. The project area is centered on the old Oregon, Mormon, and Pony Express trails. Territorial records of 1886 show that permits were issued for settlers to divert water from Big Sandy Creek to lands within the present project area. The present irrigation development was initiated in 1907 under the Carey Act by the Eden Irrigation and Land Company.

This company created the Eden Reservoir by building dikes and an outlet works in an offstream basin to impound flows of the Big Sandy and Little Sandy Creeks. Although the company went into receivership in 1927, some land improvements were performed up to 1940.

Investigations

During the late 1930's, the Bureau of Reclamation and the Department of Agriculture investigated the project.

The report of the investigations and recommended plan of development prompted the authorization.

Authorization

A plan of development and rehabilitation was approved by the President on September 18, 1940, as a Great Plains project under the water conservation provision of the Interior Department Appropriation Act of 1940 (53 Stat. 685). Because of the long delay in construction caused by World War II, completion of the project was reauthorized by an act of the Congress on June 28, 1949 (Public Law 132, 81st Congress, 1st session).

Construction

Construction was started in July 1941. In December 1942, the construction phases were stopped by order of the War Production Board. The Department of Agriculture intermittently carried on land development during the years after 1941. The Bureau of Reclamation resumed construction activities on July 17, 1950, and, under the provisions of a 1949 act of the Congress, relieved the Department of Agriculture of responsibility for operation and maintenance and for collection of reimbursable construction costs. The act gave the Department of Agriculture authority to complete land development and settlement features of the general plan. Construction of the project, including rehabilitation work on the existing Eden Dam and Reservoir, was substantially completed by December 1959.

Operating Agency

The Bureau of Reclamation operated and maintained the project during construction under contract with the Eden Valley Irrigation and Drainage District. In January 1970, operation and maintenance functions were transferred to the district.

BENEFITS

Irrigation

Livestock production is the principal enterprise. Crops are alfalfa and grass hay, wheat, barley, oats, and pasture.

Recreation

Recreation facilities are administered by the Wyoming Recreation Commission, the chief activities being camping, boating, fishing, and picnicking. During 1977, annual visitation totaled 10,390.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	16,850	acres
Number of irrigated farms	93	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	14,679	581,971
1969	15,323	731,917
1970	14,630	617,363
1971	15,200	604,247
1972	14,886	744,386
1973	15,343	1,095,051
1974	15,271	1,031,070
1975	15,515	1,060,014
1976	15,702	1,180,399
1977	13,253	[1]787,383

[1]Reduced acreage and crop values because of 1976-77 drought.

Facilities in Operation

Storage dams	2	
Diversion dams	1	
Canals	21	mi
Laterals	94	mi
Drains	53	mi

Climatic Conditions

Annual precipitation	6.3	in
Temperature:		
Maximum	95	°F
Minimum	−48	°F
Mean	38	°F
Growing season	90	days
Elevation of irrigable area	6500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	287

ENGINEERING DATA

Water Supply

BIG SANDY CREEK

Drainage area above Big Sandy Dam	439	mi²
Annual discharge at Big Sandy Dam:		
Maximum (1967)	96,750	acre-ft
Minimum (1977)	27,804	acre-ft
Average	62,900	acre-ft
Average estimated annual diversion	61,227	acre-ft

LITTLE SANDY CREEK

Drainage area above Little Sandy Diversion	192	mi²
Mean annual discharge at Little Sandy Diversion	15,800	acre-ft

Storage Facilities

BIG SANDY DAM AND DIKE

Type: Zoned earthfill
A 8,300-ft-long and 18-ft-high dike closes a low saddle immediately north of the dam.
Location: On Big Sandy Creek, 10 mi north of Farson, Wyo.
Construction period: 1941-52
Date of closure (first storage): May 13, 1952

Reservoir, Big Sandy:

Average annual inflow, 1921-48	69,200	acre-ft
Total storage to El. 6757.5	39,700	acre-ft
Active storage, El. 6731.7-6757.5	38,300	acre-ft
Surface area	2,510	acres

Dimensions:	*Dam*	*Dike*
Structural height	85 ft	18 ft
Hydraulic height	69 ft	---
Top width	30 ft	30 ft
Maximum base width	540 ft	120 ft
Crest length	2,350 ft	8,300 ft
Crest elevation	6769.0 ft	6769.0 ft³
Volume	840,000 yd³	107,000 yd³

Spillway: Uncontrolled side channel ogee weir and concrete-lined chute on right abutment.

Crest length	170	ft
Crest elevation	6757.5	ft
Capacity at El. 6762.8	7,350	ft³/s

Outlet works: Concrete conduit through base of dam, controlled by two 3.5-ft-square high-pressure slide gates.

Capacity at El. 6762.8	635	ft³/s

Foundation: Horizontal, laminated sandstone and shale, relatively free from weathering and jointing, overlain with sand and silt in riverbed and on left abutment.
Special treatment: Concrete grout cap beneath cutoff trench.

EDEN DAM

Type: Earthfill
Location: Offstream basin of Little Sandy and Big Sandy Creek, about 7 mi north of Farson, Wyo.
Construction: Completed 1910, rehabilitated by Reclamation in 1959.

Reservoir, Eden:

Total capacity	7,500	acre-ft
Active capacity	7,100	acre-ft
Surface area	900	acres
Dimensions:		
Structural height	25	ft
Crest length	3,500	ft
Volume	92,000	yd³

Spillway: Uncontrolled concrete overflow structure above orifice gates. Used only as emergency spillway.

Crest length	15	ft
Crest elevation	6713.4	ft

Outlet works: Concrete-lined tunnel controlled by constant head orifice gates and overflow control structure.

Carriage Facilities

EDEN CANAL

Location: From Eden Reservoir generally south.
Construction period: 10.8 mi of Eden Canal below junction with Means Canal enlarged and relocated in 1952-55.

Length	10.8	mi
Diversion capacity	475	ft³/s
Typical maximum section in earth:		
Bottom width	18	ft
Side slopes	2:1	
Water depth	5.2	ft
Typical maximum section, earth lined:		
Bottom width	18	ft
Side slopes	2:1	
Water depth	5.2	ft
Lining thickness:		
Side slopes	8	ft
Bottom	2	ft

MEANS CANAL

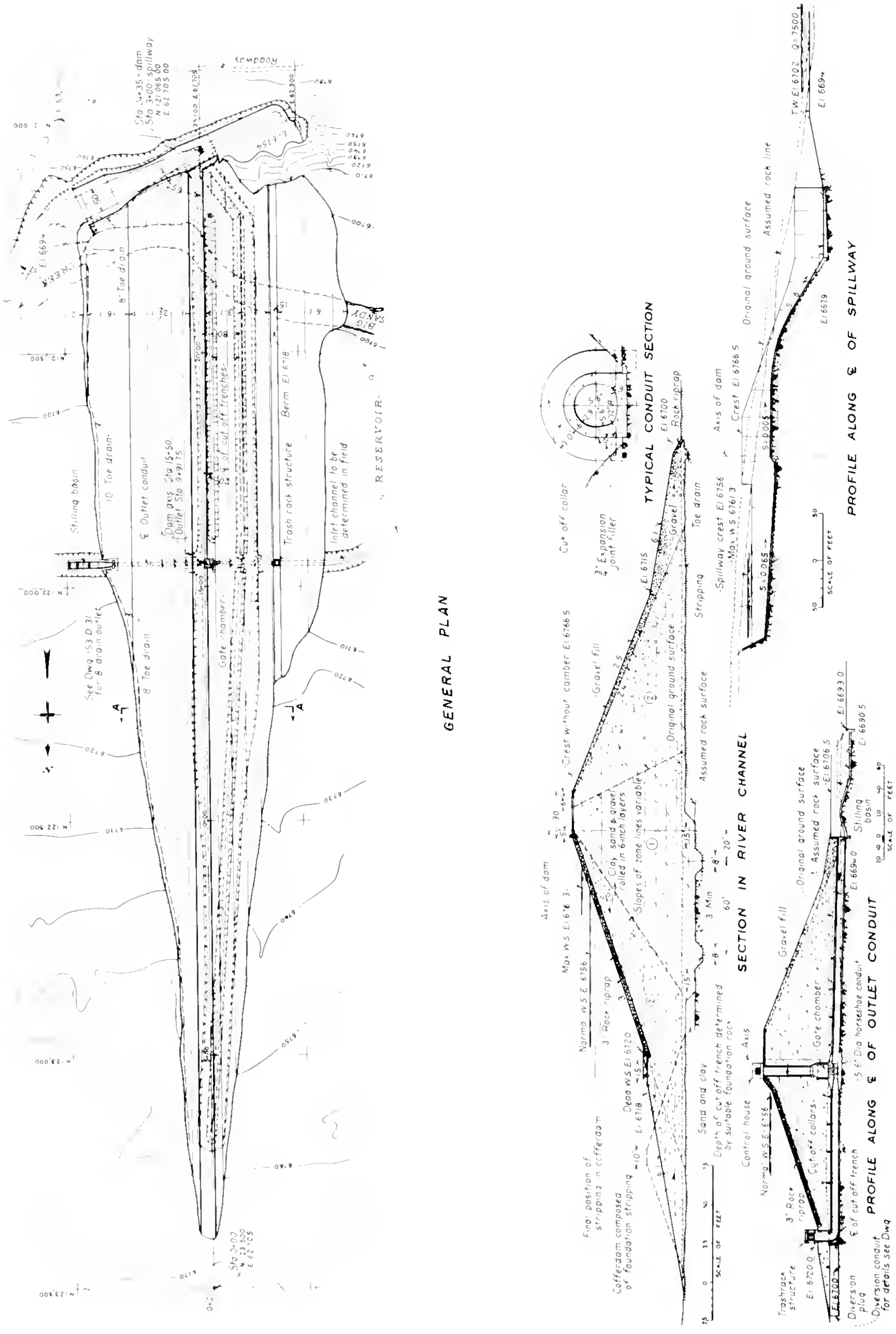
Location: From Big Sandy Dam generally south to Eden Canal.
Construction period: 1952

Length	6	mi
Diversion capacity	635	ft³/s
Typical maximum section in earth:		
Bottom width	22	ft
Side slopes	2:1	
Water depth	5.85	ft
Typical maximum section, earth lined:		
Bottom width	28	ft
Side slopes	1.5:1	
Water depth	6.9	ft
Lining thickness:		
Side slopes	8	ft
Bottom	2	ft

LITTLE SANDY CANAL

Location: From Little Sandy Diversion Dam generally west to Eden Canal below Eden Reservoir.
Construction period: Consists of 2.2 mi of existing canal to be rehabilitated and 1.1 mi of new canal completed in 1957.

Length	4	mi
Diversion capacity	150	ft³/s

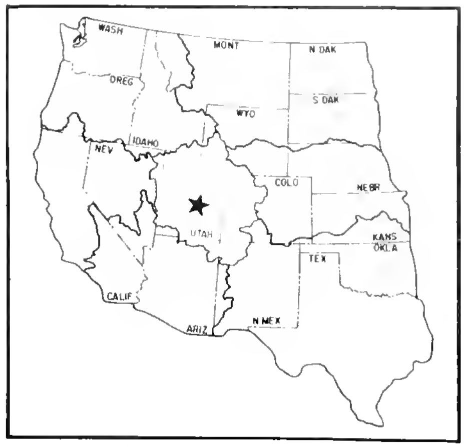


Big Sandy Dam, Plan and Sections

Emery County Project

Utah: Emery County

Upper Colorado Region
Water and Power Resources Service



The Emery County Project is in east-central Utah near the towns of Huntington, Castledale, and Orangeville. The project, including an irrigable area of almost 19,000 acres, is in the Green River Basin. Principal construction features of the project are Joes Valley Dam and Reservoir on Seely Creek; the Swasey Diversion Dam 10 miles downstream from Joes Valley Dam; the Cottonwood Creek-Huntington Canal; the Huntington North Service Canal; and the Huntington North Dam and East and West Dikes, which form the Huntington North Reservoir.

PLAN

The project provides an estimated average of 28,100 acre-feet of water annually for irrigation of 18,775 acres, of which 771 acres is land previously unirrigated. In the mid-1970's, the irrigable acreage was reduced to 14,171 with 4,604 acres designated "not for service". The project will supply 6,000 acre-feet of water for industrial and municipal purposes. Recreation facilities have been constructed at both Joes Valley and Huntington North Reservoirs.

Joes Valley Dam and Reservoir

Joes Valley Dam and Reservoir

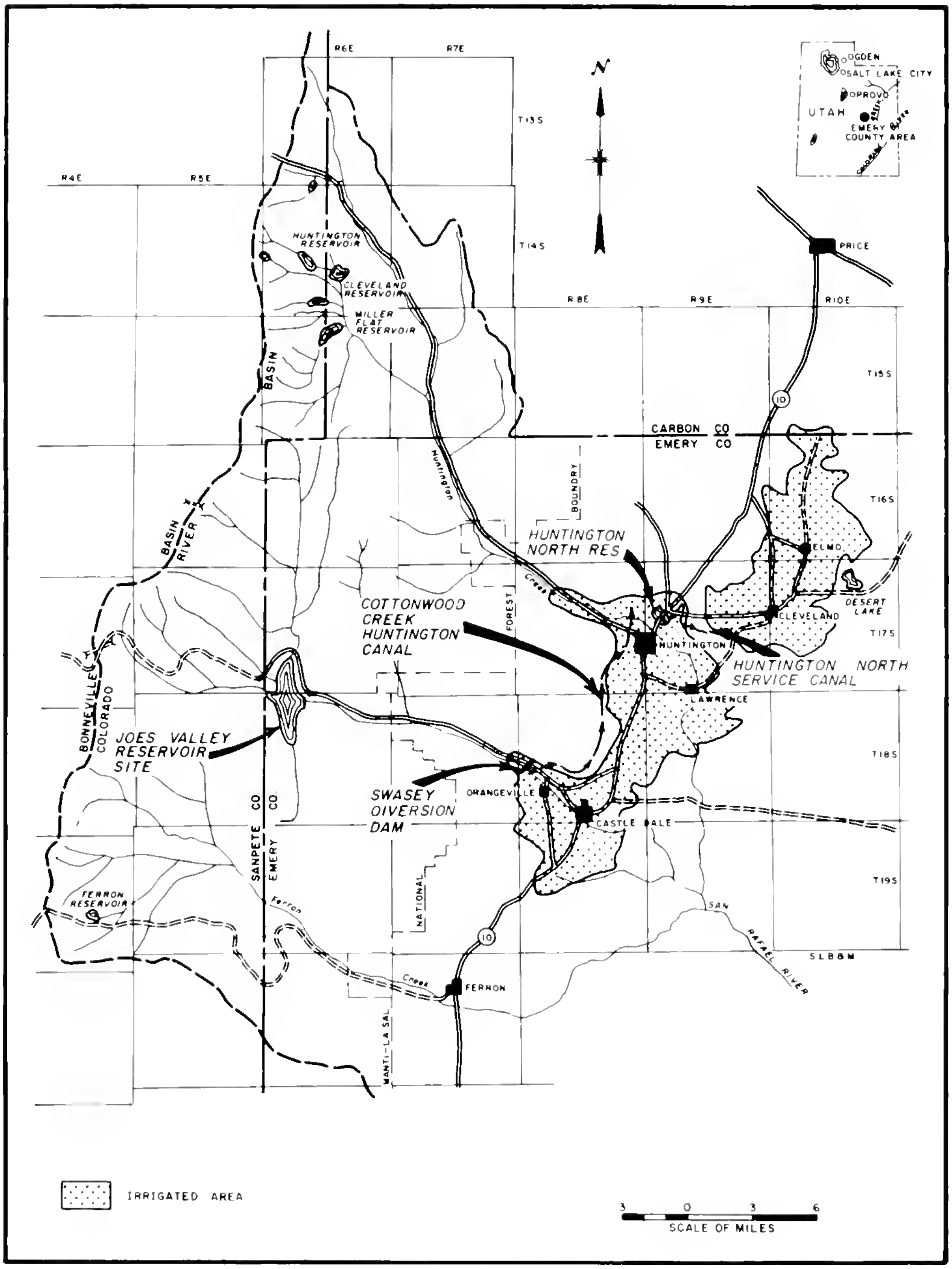
Joes Valley Dam is an earthfill dam 1,290,000 cubic yards in volume, 192 feet above streambed, and 750 feet long at the crest. The project provides for regulation of Seely Creek, a major tributary of Cottonwood Creek. The reservoir has a total capacity of 62,460 acre-feet and a surface area of 1,170 acres.

Water released from storage flows from Seely Creek to Cottonwood Creek and the Cottonwood Creek-Huntington Canal, which heads at Swasey Diversion Dam.

Swasey Diversion Dam, a concrete ogee weir type, is located 10 miles downstream from Joes Valley Dam on Cottonwood Creek. It has a diversion capacity of 165 cubic feet per second, height of 11 feet, crest length of 75 feet, and volume of 9,000 cubic yards.

Cottonwood Creek-Huntington Canal extends 16.7 miles from Swasey Diversion Dam northward to the vicinity of Huntington where it terminates at North Ditch, which diverts from Huntington Creek. A short distance below this juncture, water is released from North Ditch into the Huntington North Reservoir.

Huntington North Reservoir, created by the Huntington North Dam and the East and West Dikes, has a total capacity of 5,420 acre-feet and a surface area of 242 acres. Storage water from this reservoir is released into the Huntington North Service Canal and carried to numerous canals and ditches to be distributed for irrigation. Sections of existing canals and ditches have been lined and rehabilitated. Land drainage also is included in the project plan.



Emery County Project

DEVELOPMENT

Early History

From its original settlement in 1875 until about 1920, the population of Emery County grew slowly. Then the population gradually decreased, largely as a result of the absence of major industries to supplement the agricultural economy, the decreasing need for farm labor as a result of mechanization, and the retirement of land from cultivation because of restricted drainage and excessive salinity. Livestock raising is the principal industry, with the cultivated lands providing the base for operations.

Natural flows from Huntington Creek were first appropriated in 1876 when small ditches were dug to divert water onto about 320 acres of land. In 1878, canals were constructed to divert irrigation water from Cottonwood and Huntington Creeks. By about 1900, all dependable natural flows of the two creeks had been appropriated. Originally, the water users under each canal organized independent canal companies. During the 1930's, these individual companies joined to form the Huntington

Cleveland Irrigation Company and the Cottonwood Creek Consolidated Irrigation Company. These two companies then serviced the irrigated lands. Over the years, several small industries centered around agricultural production have developed. Coal mining is a leading industry, and uranium ore mining and processing are other important activities. Substantial supplies of natural gas also have been discovered and are being developed on the Wasatch Plateau in the Huntington and Cottonwood drainage areas.

Investigations

Irrigation development of Emery County Project lands had been considered by local groups and Government agencies at various times since the turn of the century. The Bureau of Reclamation's first basin-type report of March 1946 served as a supplement to the December 1950 report on the Colorado River Storage Project and participating projects. The 1950 report was amended in 1953, and the final report in 1961 provided updated material leading to authorization of the project.

Authorization

The Emery County Project was authorized as one of the initial participating projects of the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

Construction of the Emery County Project commenced on June 20, 1963, and was substantially completed in 1966. The first irrigation water was delivered that year. Water for municipal and industrial purposes was first made available in 1973.

Operating Agency

Project irrigation facilities were turned over to Emery Water Conservancy District for operation and maintenance on January 1, 1970.

BENEFITS

Irrigation

Through an improved irrigation water supply, the agricultural production of project lands was improved. Agriculture continues to center around the livestock industry with more than 90 percent of the irrigated area producing hay and grain. The increased production in livestock feed permits increased production of beef, sheep, and dairy products.

Recreation

Recreation facilities at Joes Valley Reservoir are operated by, or under the direction of, the Forest Service. Those at Huntington North Reservoir are operated by the Utah Division of Parks and Recreation. The Forest Service also administers nine small reservoirs upstream of Joes Valley Reservoir, which were acquired as part of the project. During 1977, visitor days to the area totaled 229,961.

Industrial Uses

The project supplies 6,000 acre-feet of water for coal-fired electric power generation. This industry has bolstered the economy of Emery County.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental service	14,170	acres
Number of irrigated farms	318	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	16,544	994,162
1969	16,617	1,067,081
1970	17,201	1,221,973
1971	16,861	1,296,586
1972	16,891	1,105,159
1973	16,821	1,679,181
1974	16,938	1,610,720
1975	17,219	1,788,587
1976[1]	12,656	1,533,836
1977	12,569	1,215,767

[1] 4,604 acres put in "not for service" status.

Facilities in Operation

Storage dams	2	
Reservoirs	2	
Diversion dams	1	
Canals	20.5	mi

Climatic Conditions

Annual precipitation, average	7.6	in
Temperature:		
Maximum	104	°F
Minimum	−35	°F
Mean	45	°F
Growing season	127	days
Elevation of irrigable area	5000.0	ft

ENGINEERING DATA

Water Supply

SEELY CREEK

Drainage area	135	mi²
Annual discharge, near Orangeville (at Joes Valley damsite):		
Maximum (1952)	152,600	acre-ft
Minimum (1934)	23,800	acre-ft
Average	65,270	acre-ft

COTTONWOOD CREEK

Drainage area	200	mi²
Annual discharge, near Orangeville:		
Maximum (1952)	152,700	acre-ft
Minimum (1934)	23,600	acre-ft
Average	68,050	acre-ft

HUNTINGTON CREEK

Drainage area	188	mi²
Annual discharge, near Huntington:		
Maximum (1952)	150,600	acre-ft
Minimum (1934)	26,300	acre-ft
Average	69,338	acre-ft
Effects on Colorado River:		
Stream depletion (average annual)	16,500	acre-ft

Storage Facilities

JOES VALLEY DAM

Type: Zoned earthfill
Location: Seely Creek
Construction: Completed 1966

Reservoir, Joes Valley:		
Total capacity	62,460	acre-ft
Active capacity	55,000	acre-ft
Surface area	1,170	acres
Dimensions:		
Structural height	192	ft
Hydraulic height	187	ft
Crest length	750	ft
Volume	1,290,000	yd³

Spillway: 24.125-ft-diameter, uncontrolled morning-glory concrete crest structure on left abutment.

Crest elevation	6989.7	ft

Water drops 188.7 ft through a 13-ft-diameter shaft and tunnel into the concrete stilling basin.

Outlet works: On left abutment of dam. Two 2.25-ft-square regulating gates designed to release 385 ft³/s.

HUNTINGTON NORTH DAM

Type: Offstream, zoned earthfill
Location: Huntington Creek
Construction: Completed 1966

Dimensions:		
Height	71	ft
Crest length	2,897	ft
Volume²	967,000	yd³

Spillway Outlet works: Combined spillway and outlet works for normal operations and flood releases. Spillway has a crest elevation of 5838 ft. In case of flash flood, spillway provides emergency releases. Cast iron 2.5-ft-square gate in outlet works. Gates operated by hand cranks.

East Dike, offstream, zoned earthfill:		
Height	31	ft
Crest length	1,185	ft
West Dike, offstream, zoned earthfill:		
Height	21	ft
Crest length	1,919	ft
Reservoir, Huntington North:		
Total capacity	5,420	acre-ft
Active capacity	4,000	acre-ft
Surface area	242	acres

²Huntington North Dam and East and West Dikes form one reservoir. Volume of dikes included with volume of dam.

Diversion Facilities

SWASEY DIVERSION DAM

Type: Concrete ogee weir, embankment wings
Location: 10 mi downstream from Joes Valley Dam, on Cottonwood Creek.
Construction: Completed 1965

Dimensions:		
Height	11	ft
Crest length	75	ft
Volume	9,000	yd³
Diversion capacity	165	ft³/s

Carriage Facilities

COTTONWOOD CREEK-HUNTINGTON CANAL

Location: Heads at Swasey Diversion Dam, extends northward to vicinity of Huntington, terminating at the North Ditch.
Construction period: 1963-65

Length	16.7	mi
Initial capacity	165	ft³/s
Bottom width	12	ft
Side slopes	2:1	
Water depth	4	ft

HUNTINGTON NORTH RESERVOIR FEEDER CANAL

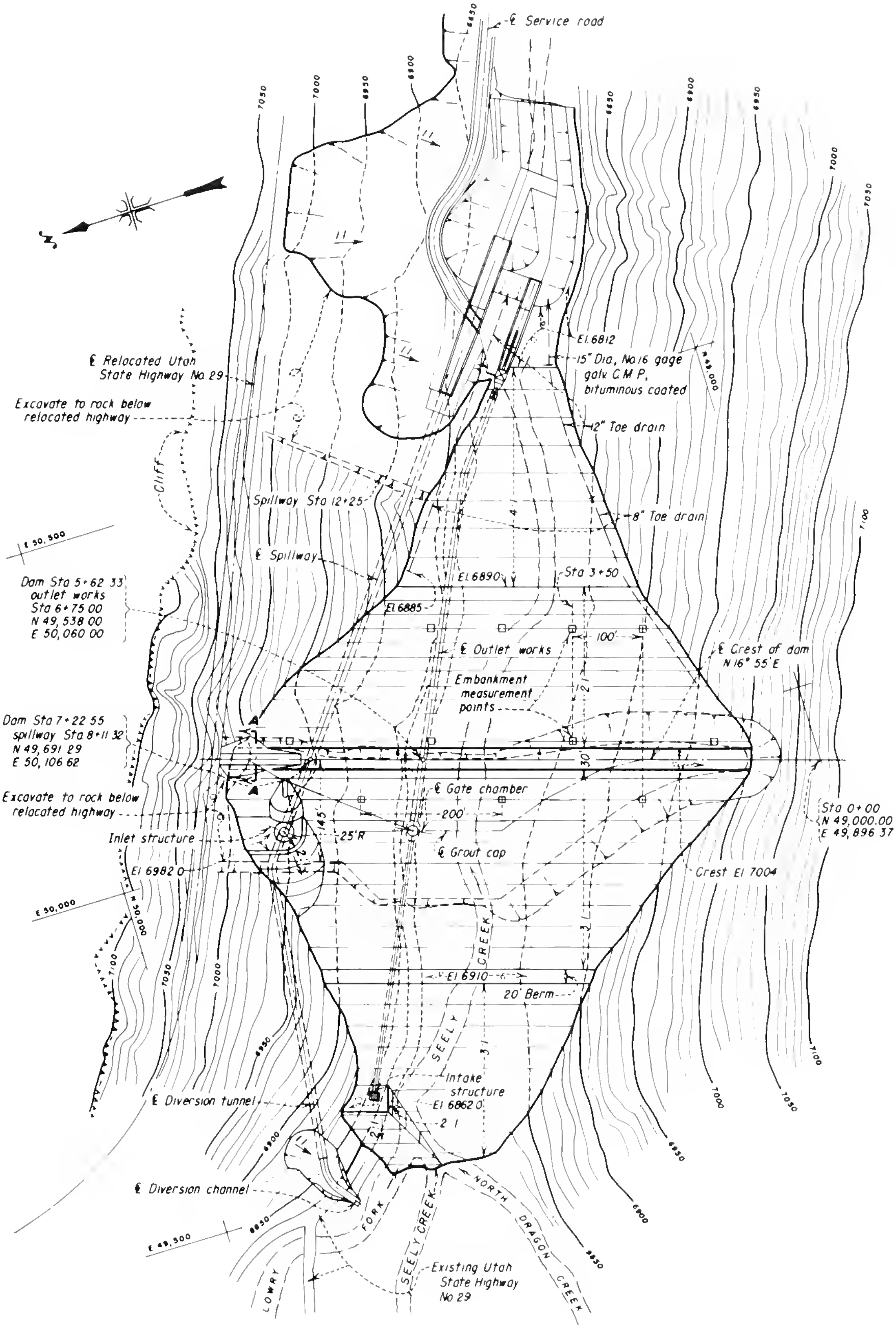
Location: Heads at North Ditch, extends southward to Huntington North Reservoir.
Construction period: 1965-66

Length	0.3	mi
Initial capacity	100	ft³/s
Bottom width	8	ft
Side slopes	2:1	
Water depth	3.4	ft

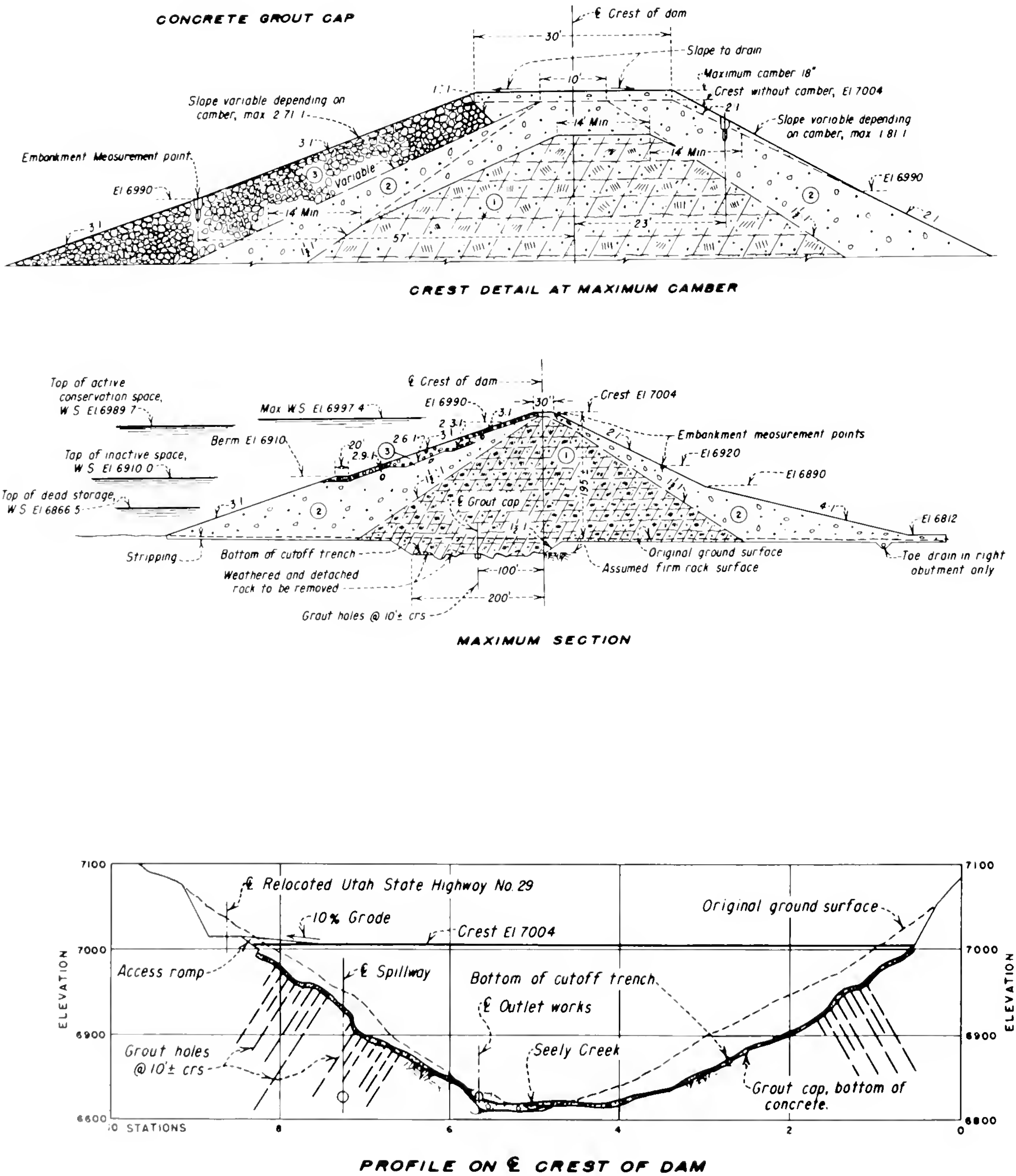
HUNTINGTON NORTH SERVICE CANAL

Location: Heads at outlet works of Huntington North Reservoir; meanders eastward to terminus at south branch of Cleveland Canal.
Construction period: 1965-66

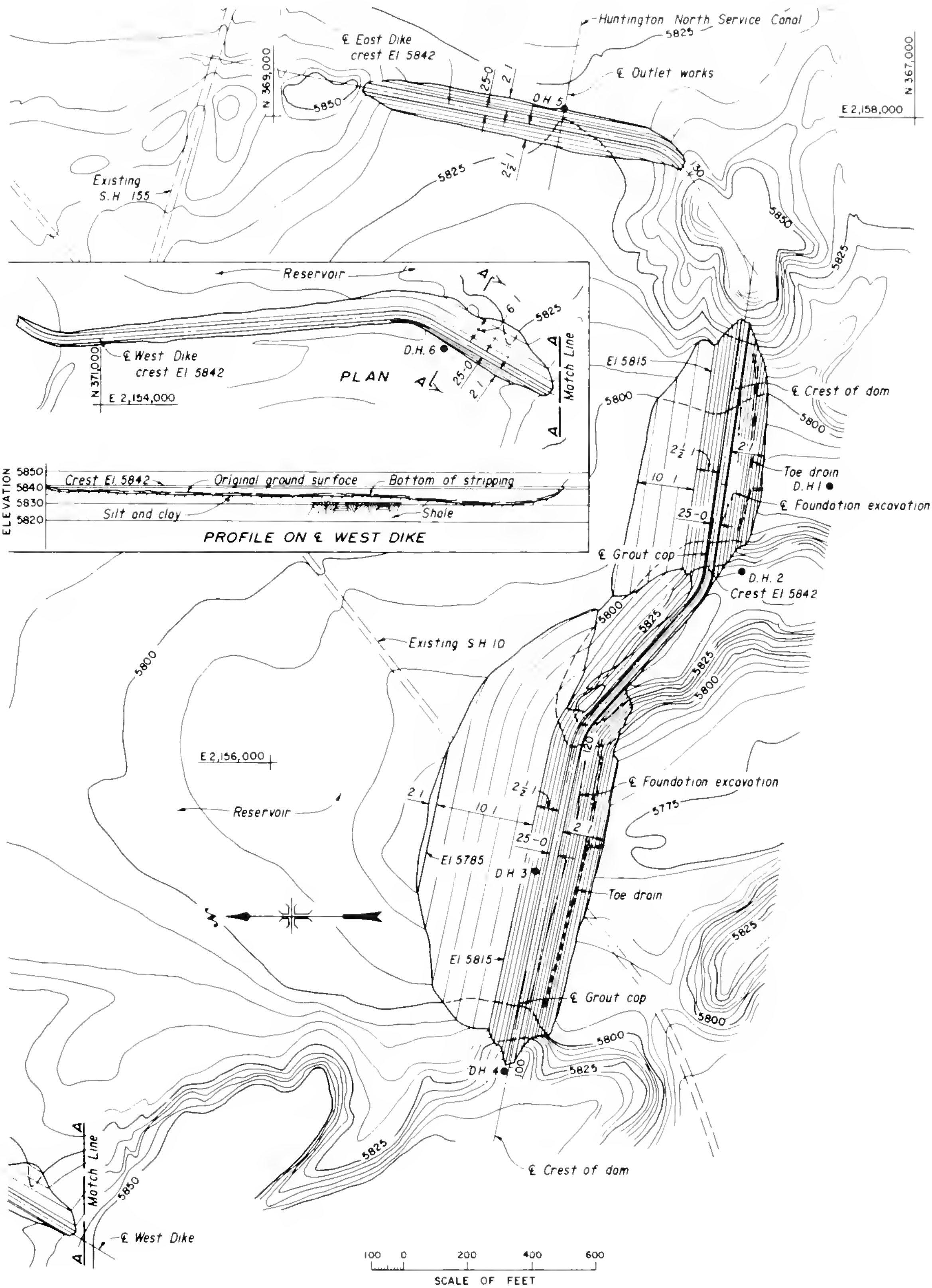
Length	3.5	mi
Initial capacity	35	ft³/s
Bottom width	6	ft
Side slopes	2:1	
Water depth	6	ft



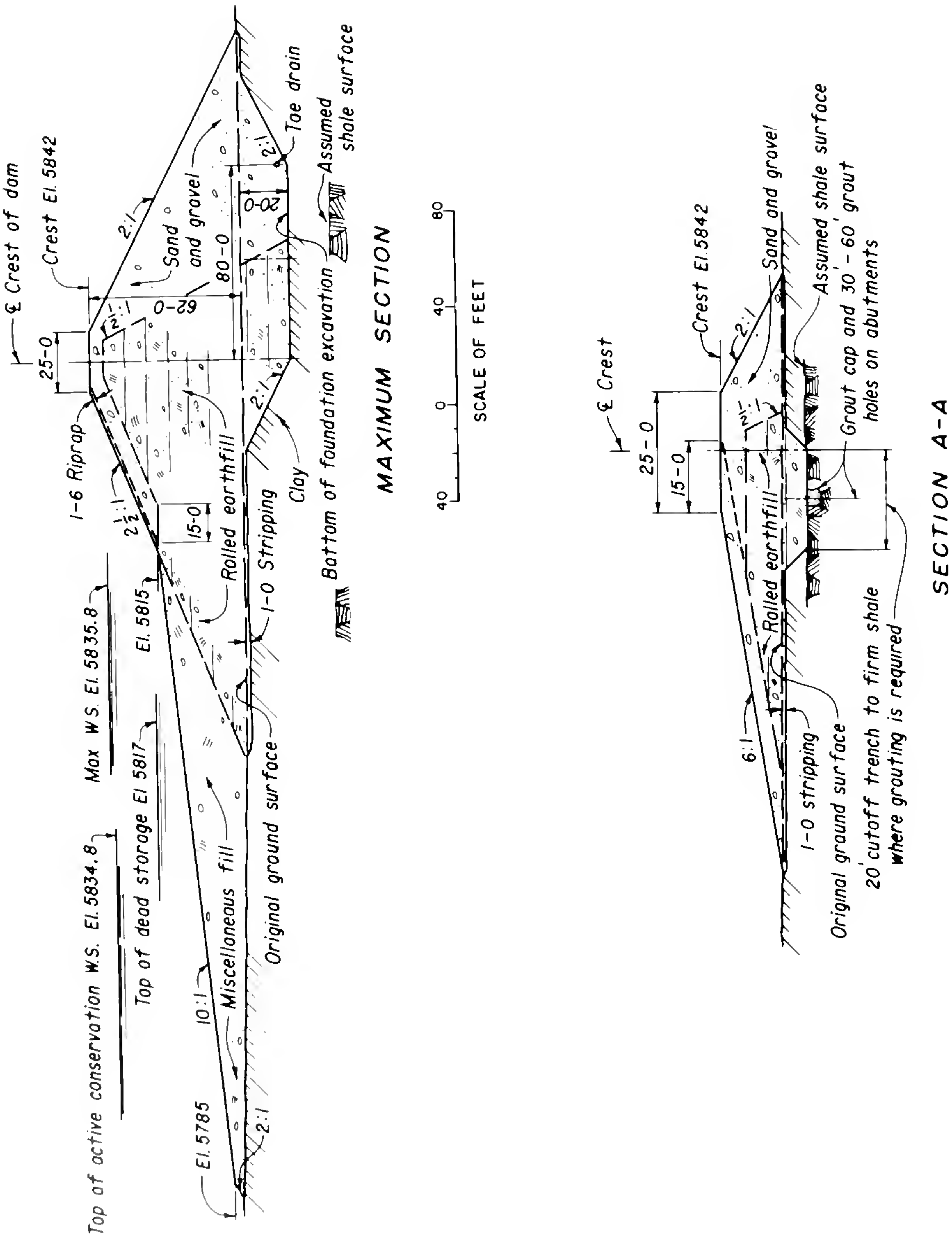
Joes Valley Dam, Plan



Joes Valley Dam, Sections



Huntington North Dam, Plan

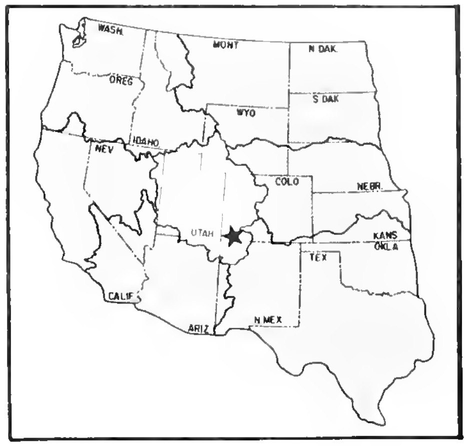


Huntington North Dam, Sections

Florida Project

Colorado: La Plata County

Upper Colorado Region
Water and Power Resources Service



Lemon Dam is the principal feature of the Florida Project, which is a participating project of the Colorado River Storage Project. The dam is located in southwestern Colorado on the Florida River, approximately 14 miles northeast of Durango in La Plata County. Floodwaters of the Florida River are stored in the reservoir formed by the dam, and regulated releases can provide supplemental irrigation water for 13,720 acres of land and a full water supply for 5,730 acres not previously irrigated.

PLAN

Water is released from the reservoir as needed and conveyed in the natural river channel to the heads of the various downstream canals and ditches that divert the flow and distribute the water to project lands.

In addition to the construction of Lemon Dam, Bureau of Reclamation work included rebuilding the Florida Farmers Diversion Dam, enlarging 3.9 miles of the Florida Farmers Ditch to its bifurcation with the Florida Canal, enlarging 1.8 miles of the Florida Canal, and building a new lateral system to serve about 3,360 acres of land on the southeast portion of Florida Mesa. Project funds were advanced to the Florida Water Conservancy District to rehabilitate, enlarge, and extend the portions of the Florida Farmers Ditch and Florida Canal distribution systems that serve remaining lands on Florida Mesa. The 1,190 acres of project land located in the Florida River Valley will continue to be served by numerous small ditches without the expenditure of project funds.

Florida Canal

Lemon Dam and Reservoir

Lemon Dam is a zoned earthfill structure with a structural height of 284 feet and a crest length of 1,360 feet. The dam embankment has a maximum base width of 1,170 feet, a crest width of 30 feet, and contains a volume of 3,042,000 cubic yards of earth and rock materials.

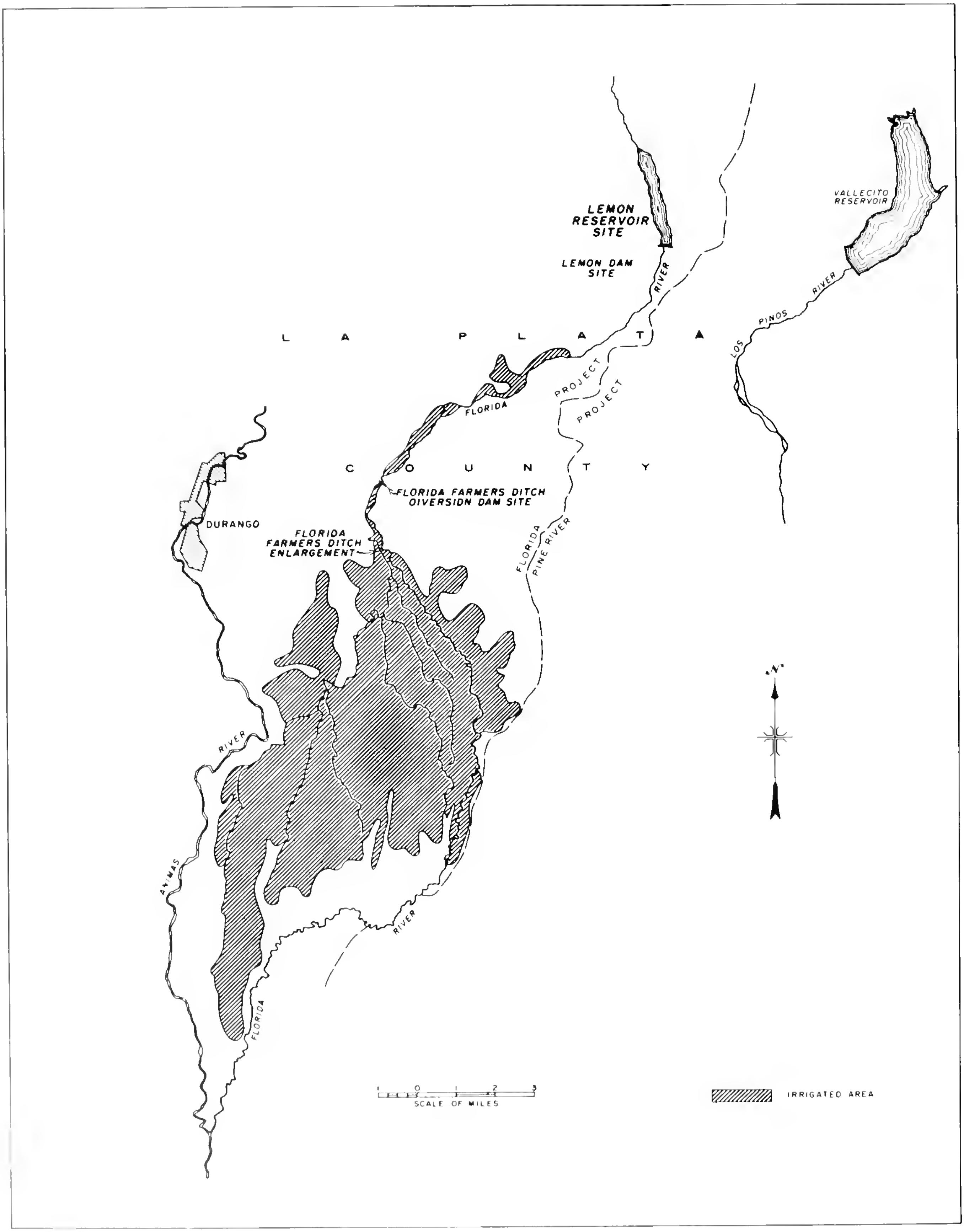
The spillway is on the right abutment of the dam and consists of an approach channel, concrete inlet structure, concrete ogee crest section, open concrete chute, concrete stilling basin, and outlet channel discharging into the Florida River. The design capacity of the spillway is 9,600 cubic feet per second.

The outlet works is also in the right abutment of the dam and consists of an approach channel, a concrete intake structure, and a concrete-lined tunnel with gate chamber for two 2.25-foot-square high pressure gates. The 9-foot horseshoe-shaped tunnel has a design capacity of 900 cubic feet per second.

Lemon Reservoir is approximately 0.5 mile wide and 3 miles long with a surface area of 622 acres. The total capacity is 40,146 acre-feet, of which 39,030 acre-feet are active conservation.

Florida Farmers Diversion Dam and Ditch

Major rehabilitation of the Florida Farmers Diversion Dam was conducted in 1962-63. This included construction of an earthfill section for the diversion dam approximately 500 feet long at the crest, and construction of an



Florida Project

Lemon Dam and Reservoir

overflow weir, headworks, sluiceway, wingwalls, and fish screens.

During the same construction period, the Florida Farmers Ditch was enlarged and relocated along 3.9 miles, and Florida Canal was enlarged and relocated over 1.8 miles. The first irrigation water was delivered in 1964.

DEVELOPMENT

Early History

After the territory was acquired by the United States from Mexico, a large area which includes the Florida Project was set aside as a reservation for the Ute Indians. The discovery of gold and other minerals in the northern mountainous part of the reservation led to encroachment by miners and prospectors on reservation lands. The resulting conflict was settled in 1874 when the United States purchased that part of the reservation containing the mineral lands. Following the 1874 purchase, the better agricultural lands thus removed from the reservation were developed and settled. In 1899, reservation lands which had not been allocated to individual Indians were opened to homesteaders, with resulting settlement and irrigation development.

Investigations

Project planning investigation of the Florida Project was undertaken, together with a number of other western slope projects in Colorado, as part of a Public Works Project with an allotment of $150,000 from the appropriation made available under the National Industrial Recovery Act of June 16, 1933. In September 1938, work in progress under the original appropriation was transferred to Colorado River Basin Investigations and was continued with appropriations for that purpose under the provisions of section 15 of the Boulder Canyon Act.

The first reconnaissance classification survey of project lands was made in 1933. A more detailed land classification survey, based on standards in existence at that time, was made in 1942. During 1956 and 1957, the final detailed land classification survey, based on the latest standards, was made.

The first planning report prepared specifically for the Florida Project was completed in 1939, following investigations started in 1936. As investigations continued after 1939, more detailed data were compiled and were used in the report entitled "Colorado River Storage Project and Participating Projects," dated December 1950. This report, as amended in 1953, and the supplementary report of January 1951 (feasibility report covering Florida Project separately) were the bases for authorization of the project in 1956.

Authorization

The project is one of the initial group of participating projects authorized with the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

The contract for construction of Lemon Dam was awarded June 30, 1961, and all contract work was completed in December 1963. Rehabilitation of Florida Farmers Diversion Dam and enlargement and relocation of Florida Farmers Ditch and Florida Canal were conducted in 1962-63. Construction of the lateral system, with a total length of 14 miles, ranging in capacity from 2 to 50 cubic feet per second, was initiated in June 1963 and essentially completed in November 1964. The Florida Water Conservancy District began rehabilitation of the existing lateral system in March 1963 and completed the work in 1965.

Irrigated lands on the Florida Project

Operating Agency

Diversion works, main canals, and laterals were turned back to the Florida Water Conservancy District for operation and maintenance on April 1, 1967. Lemon Dam was turned over to the district on January 1, 1968.

BENEFITS

Irrigation

Irrigated lands are used largely for the support of livestock enterprises. Climatically adaptable crops such as small grains, alfalfa, pasture, and corn are the principal product.

Recreation

Recreation facilities at Lemon Reservoir were constructed by the National Park Service and are operated by the Forest Service. There were 96,615 visitors days in 1977.

Flood Control

Flood control benefits will result from reduced snowmelt flooding because of the planned operation of Lemon Reservoir.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	5,730	acres
Supplemental irrigation service	13,720	acres
Total	19,450	acres

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	16,208	1,196,143
1969	15,852	1,224,315
1970	15,934	1,307,256
1971	16,169	1,555,433
1972	16,015	1,471,914
1973	16,093	1,973,895
1974	15,863	1,791,203
1975	16,306	2,449,562
1976	15,767	1,987,536
1977	14,452	[1]1,251,994

[1]Spring runoff in 1977 was the lowest in 61 years of record. In most areas of Colorado, precipitation for the year was considerably below average resulting in reduced areas served and lower yields because of the extreme drought.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	5.7	mi

Laterals	14.1 mi
Canal rehabilitation by district	50 mi

Climatic Conditions

Annual precipitation	15.8 in
Temperature:	
Maximum	101 °F
Minimum	−38 °F
Mean	46 °F
Growing season	112 days
Elevation of irrigable area	7000.0 ft

ENGINEERING DATA

Water Supply

Florida River

Drainage area at Lemon Dam	67.6 mi²
Annual discharge at Lemon Dam:	
Maximum (1941)	143,870 acre-ft
Minimum (1934)	25,170 acre-ft
Average	65,833 acre-ft

Storage Facilities

Lemon Dam

Type: Rolled earth and rockfill
Location: On Florida River, 14 mi northeast of Durango, Colo.
Construction period: 1961-63
Reservoir, Lemon:

Total capacity	40,146 acre-ft
Active capacity to El. 8148	39,030 acre-ft
Surface area	622 acres
Dimensions:	
Structural height	284 ft
Hydraulic height	215 ft
Top width	30 ft
Maximum base width	1,170 ft
Crest length	1,360 ft
Crest elevation	8167.0 ft
Total volume	3,042,000 yd³

Spillway: Ungated concrete ogee, approach channel, concrete inlet structure, open concrete chute, concrete stilling basin, and outlet channel.

Crest elevation	8167.0 ft
Capacity	9,600 ft³/s

Outlet works: 9-ft horseshoe-shaped tunnel, controlled by two 2.25-ft-square high pressure gates.

Capacity	900 ft³/s

Diversion Facilities

Florida Farmers Diversion Dam

Type: Concrete overflow weir, embankment wing
Location: On Florida River, about 7 mi east of Durango, Colo.
Year completed: (Rebuilt) 1963
Dimensions:

Height above streambed	14 ft
Weir crest length	50 ft
Weir crest elevation	7075.0 ft
Crest length	630 ft
Crest elevation	7085.0 ft
Volume (concrete)	700 yd³
Overflow weir capacity	2,900 ft³/s

Sluiceway: One 10- by 13-ft radial gate.
Headworks: One 12-ft-square radial gate.

Diversion capacity	185 ft³/s

Carriage Facilities

Florida Farmers Ditch

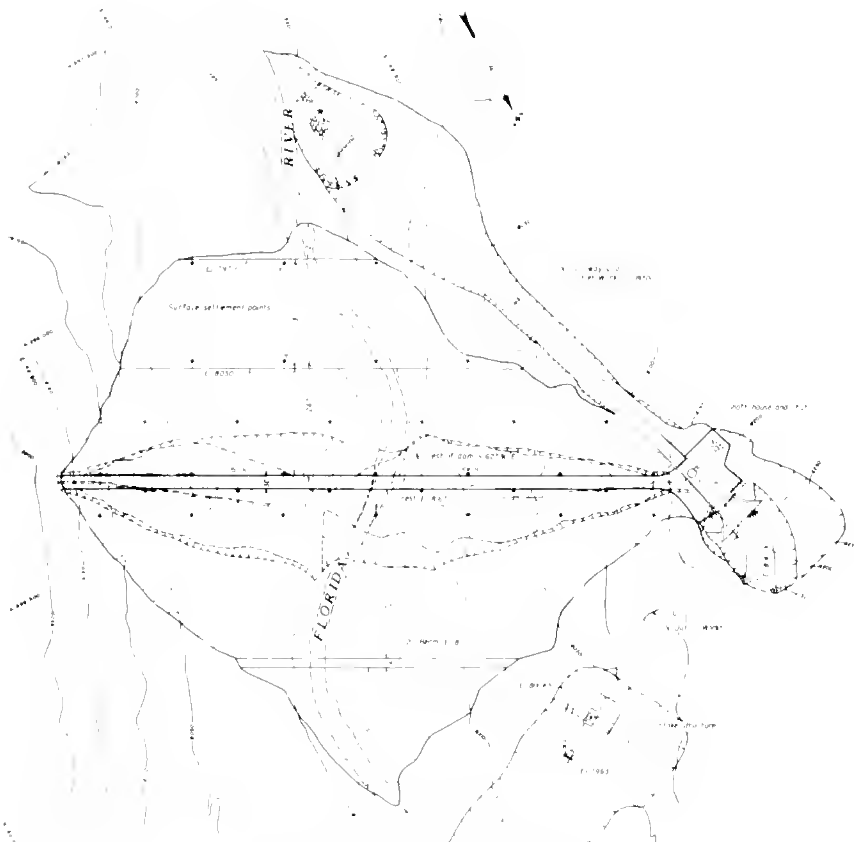
Location: Generally southwest from Florida Farmers Diversion Dam in the Florida Mesa area.
Construction period: (Enlargement) 1962-63

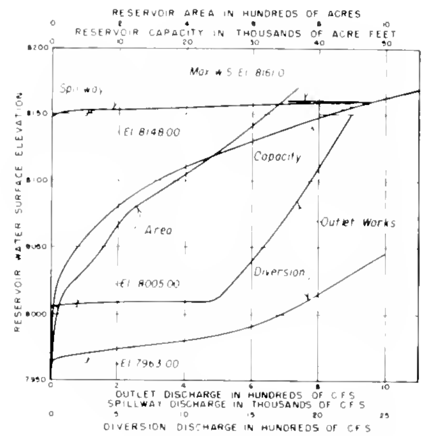
Length	3.9 mi
Diversion capacity	185 ft³/s
Typical maximum section in earth:	
Bottom width	12 ft
Side slopes	2:1
Water depth	4 ft

Florida Canal

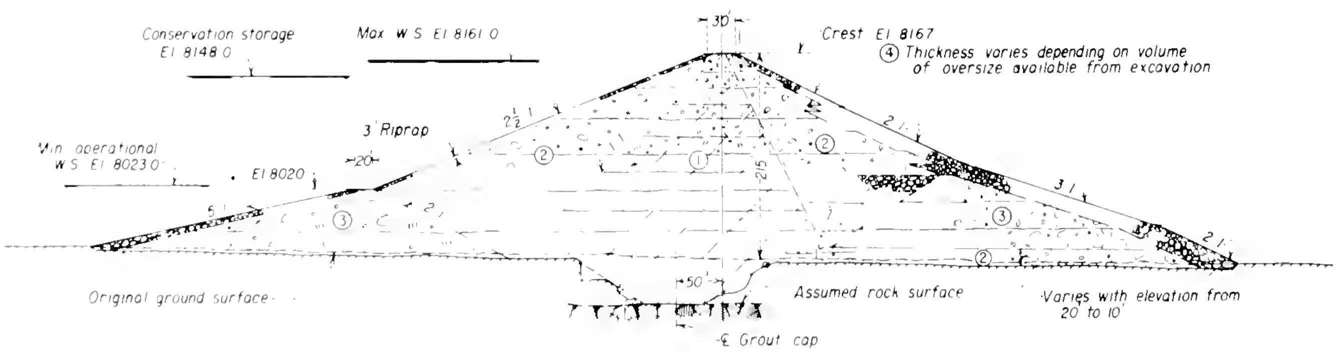
Location: Generally south from the Florida River in the Florida Mesa area.
Construction period: (Enlargement) 1962-63

Length	1.8 mi
Diversion capacity	150 ft³/s
Typical maximum section in earth:	
Bottom width	10 ft
Side slopes	2:1
Water depth	3.8 ft
Lateral system (Reclamation-constructed):	
Total length	14.1 mi
Capacity range	2-50 ft³/s
Canal rehabilitation (by district):	
Total length	50 mi
Capacity range	3-150 ft³/s

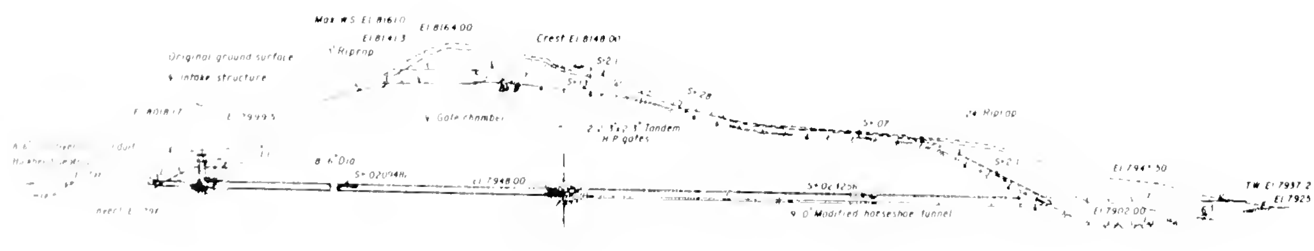




AREA - CAPACITY - DISCHARGE CURVES



MAXIMUM SECTION



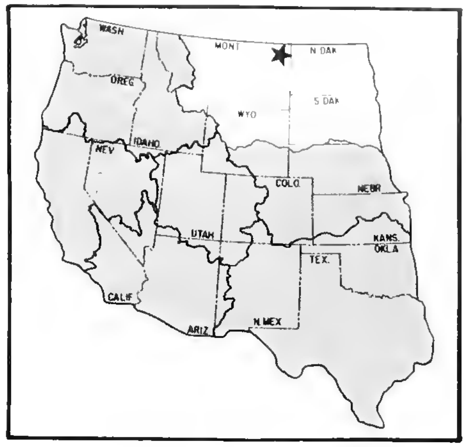
COMBINED PROFILE

Lemon Dam, Plan and Sections

Fort Peck Project

Montana and North Dakota: 17 Counties[1]

Upper Missouri Region
Water and Power Resources Service



The Fort Peck Project markets and distributes the electrical energy generated by the Fort Peck Powerplant. The Fork Peck Dam, Powerplant, and Lake were constructed by the Corps of Engineers. Principal features of Reclamation's project include 105 miles of 230-kilovolt transmission lines, 291 miles of 161-kilovolt transmission lines, 543 miles of 115-kilovolt transmission lines, 25 miles of 69-kilovolt transmission lines, and 54 miles of line at lower voltage. From Fort Peck Dam the transmission lines extend to Great Falls, Havre, Shelby, Miles City, and Glendive, Mont., and to Williston, N. Dak.

PLAN

Electrical energy from Fort Peck Dam is furnished to commercial and irrigation pumping load centers in the Great Plains area of eastern Montana and western North Dakota. The project serves the area along the Yellowstone River below Miles City, the area along the Missouri River from Fort Peck, Mont., to Williston, N. Dak., and the area along the Milk River from Fort Peck to Havre, Mont., then to Shelby and Great Falls, Mont.

Power is furnished to customers directly from substations on these lines or by wheeling agreements over the lines of interconnecting power systems. Fort Peck power is transmitted to Great Falls via Havre, Mont., 291 miles over a 161-kilovolt transmission line. Approximately 543 miles of 115-kilovolt transmission lines serve the cities of Shelby, Glendive, and Miles City, Mont., and connect with the Pick-Sloan Missouri Basin Program (formerly Missouri River Basin Project) at Williston, N. Dak. The total installed transformer capacity in all substations as of October 1, 1977, was 361,200 kilovolt-amperes. The Fort Peck power system has been integrated with the Pick-Sloan Missouri Basin Program to serve a common market area.

[1]Montana: Blaine, Cascade, Chouteau, Custer, Dawson, Hill, Liberty, McCone, Phillips, Prairie, Richland, Roosevelt, Sheridan, Toole, and Valley Counties. North Dakota: McKenzie and Williams Counties.

DEVELOPMENT

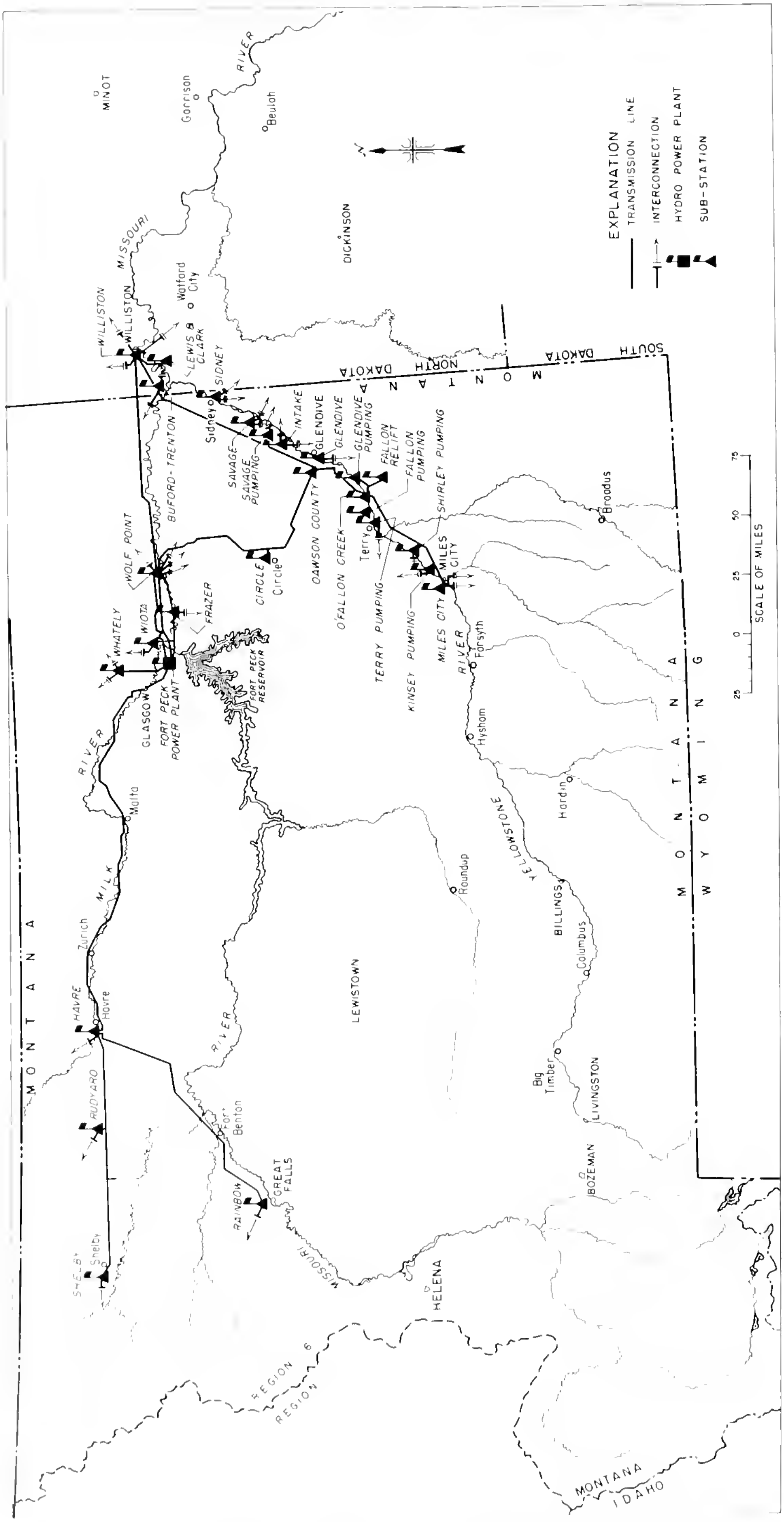
The Fort Peck Dam and Lake were built by the Corps of Engineers. Construction began under an Executive Order in October 1933 as part of the Public Works Administration Program. The Congress, in the River and Harbor Act of August 30, 1935, authorized construction of Fort Peck Dam primarily for navigation but with provisions for future power development. The act of May 18, 1938, authorized the Corps, in addition to completing Fort Peck Dam, to construct, maintain, and operate a powerplant and to install additional generating facilities when deemed necessary by the Bureau of Reclamation. The act authorized Reclamation to provide, operate, and maintain transmission lines to market energy.

Authorization

The Fort Peck Project Act of May 18, 1938 (52 Stat. 403), authorized the completion, maintenance, and operation of the Fort Peck Project. The Secretary of War was made responsible for completion, maintenance, and operation of the dam and powerplant. The Bureau of Reclamation is responsible for construction, maintenance, and operation of facilities for transmitting and marketing the electrical energy generated by the powerplant. By approving Senate Document No. 191, 78th Congress, proposing the plan, the Flood Control Act of 1944 authorized integration of operation of Fort Peck Project with the Pick-Sloan Missouri Basin Program.

Construction

The dam was substantially completed in 1939. The first power unit with a generator rating of 35,000 kilowatts commenced operation on July 1, 1943. A second generator with a rating of 15,000 kilowatts was installed in 1948, and a third with a rating of 35,000 kilowatts was placed in operation in 1951. A second powerplant of 80,000 kilowatts was constructed by the Corps of Engineers and Units 4 and 5 began operation in June 1961. Presently the nameplate generating capacity of the



Fort Peck Project

Fort Peck Dam

project is 165,000 kilowatts. The 161-kilovolt transmission line, originally built to furnish power for construction operations at the dam, is now delivering electricity to The Montana Power Company load centers in the Havre and Shelby areas and to The Montana Power Company at Great Falls. Transmission facilities are constructed as required to market the power in accordance with the scheduled installations of additional generating facilities at the powerplant.

BENEFITS

Power

Power from the Fort Peck Project has brought increased domestic and industrial benefits to a large area in Montana and North Dakota.

PROJECT DATA

Power Generation

Fiscal year	Fort Peck Powerplant (kWh)	Fiscal year	Fort Peck Powerplant (kWh)
1949	369,643,800	1965	1,075,597,000
1950	374,813,000	1966	1,572,594,000
1951	327,673,000	1967	1,098,786,000
1952	471,273,000	1968	1,300,332,000
1953	618,938,000	1969	1,423,522,000
1954	614,962,000	1970	1,407,152,000
1955	554,485,000	1971	1,630,480,000
1956	461,335,000	1972	1,342,802,000
1957	522,997,000	1973	1,179,973,000
1958	471,972,000	1974	857,748,000
1959	647,911,000	1975	1,358,199,000
1960	715,178,000	1976	1,663,466,000
1961	764,501,000	Transitional Quarter	446,442,000
1962	899,401,000	1977	1,187,534,000
1963	560,777,000		
1964	585,478,000		

Facilities in Operation

Powerplants[2]	1	
Transmission lines	1019.86	mi
Substations	27	

[2]Operated by Corps of Engineers.

ENGINEERING DATA

Power Facilities

Substations

Number in operation	27	
Total capacity of transformers	361,200	kVA

Transmission Lines

Total number of lines	26
Total circuit miles	1019.86

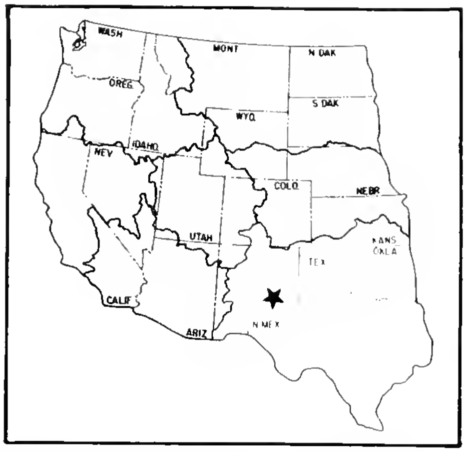
Designation	Capacity (kV)	Capacity (kW)	Circuit miles	Year placed in service
Fort Peck—Dawson County	230	---	105.20	1961
Fort Peck Powerplant—Rainbow Substation	161	50,000	291.27	1935
Dawson County—Williston	115	---	92.01	1954
Havre Substation—Shelby Substation	115	30,000	98.58	1951
Havre-Shelby Line—Tiber Substation	115	2,500	11.88	1953
Fort Peck Powerplant—Dawson County	115	20,000	135.15	1945
Dawson County Substation—Miles City Substation	115	40,000	71.92	1949
Fort Peck Powerplant—Williston Substation	115	40,000	129.74	1951
Dawson County Substation—Glendive Substation	115	20,000	2.72	1945
Shirley Tap—Shirley Pumping Plant	115	---	0.77	1973
Fort Peck Powerplant—Whately Substation	69	10,000	14.45	1934
O'Fallon Creek Substation—Fallon Substation	69	5,000	0.74	1949
O'Fallon Creek Substation—Fallon Relift	69	5,000	2.27	1949
Fallon Relift Substation—Glendive P.P. Substation	69	5,000	2.12	1956
MDU[3] Line Tap—Buford-Trenton Substation	57	1,500	2.50	1942
MDU Line Tap—Kinsey Substation[4]	57	1,000	2.50	1940
Fort Peck Powerplant—Frazer Substation	34.5	1,500	22.18	1944
Frazer Substation—Wolf Point Substation	34.5	1,500	16.50	1945
Nashua Tap—Nashua	34.5	---	7.51	1944 Rebuilt 1947
Valley Tap—Valley	34.5	---	0.88	1964
Frazer Pumping Tap—Frazer Pumping Plant	34.5	---	0.76	1944
Terry Tap—Terry Pumping Plant	34.5	---	2.80	1973
Intake Pumping Plant Tap Line	2.3	---	2.71	1947
Kinsey Substation—North Line[4]	2.3	---	1.20	1940
Kinsey Substation—South Line[4]	2.3	---	1.50	1940

[3]Montana-Dakota Utilities Co.
[4]Owned by Kinsey Irrigation District, operated by Bureau of Reclamation.

Fort Sumner Project

New Mexico: De Baca County

Southwest Region
Water and Power Resources Service



The Fort Sumner Project is a private irrigation project reconstructed and rehabilitated by the Bureau of Reclamation. The irrigable area of 6,500 acres that can receive a full supply of water from the project is northeast of the Pecos River immediately south of the town of Fort Sumner, N. Mex.

Principal structures are the Fort Sumner Diversion Dam and Pumping Plant, the Main and High Line Canals, and several large drains.

PLAN

The rehabilitation plan was designed to provide security for the project area and to utilize its land and water resources to the greatest practical extent. The irrigated area was increased to 6,500 acres by improving drainage and by more efficiently distributing the district's water allotment.

Fort Sumner Diversion Dam

The Fort Sumner Irrigation District holds a senior water right for not more than 100 cubic feet per second from the natural flow of the Pecos River. The district's water passes through Sumner Dam and Lake Sumner, formerly Alamogordo Dam and Reservoir, constructed on the Pecos River in 1937 to store water for the Carlsbad Irrigation Project. Water is released from the reservoir to the district in amounts equal to the reservoir inflow, but not exceeding 100 cubic feet per second.

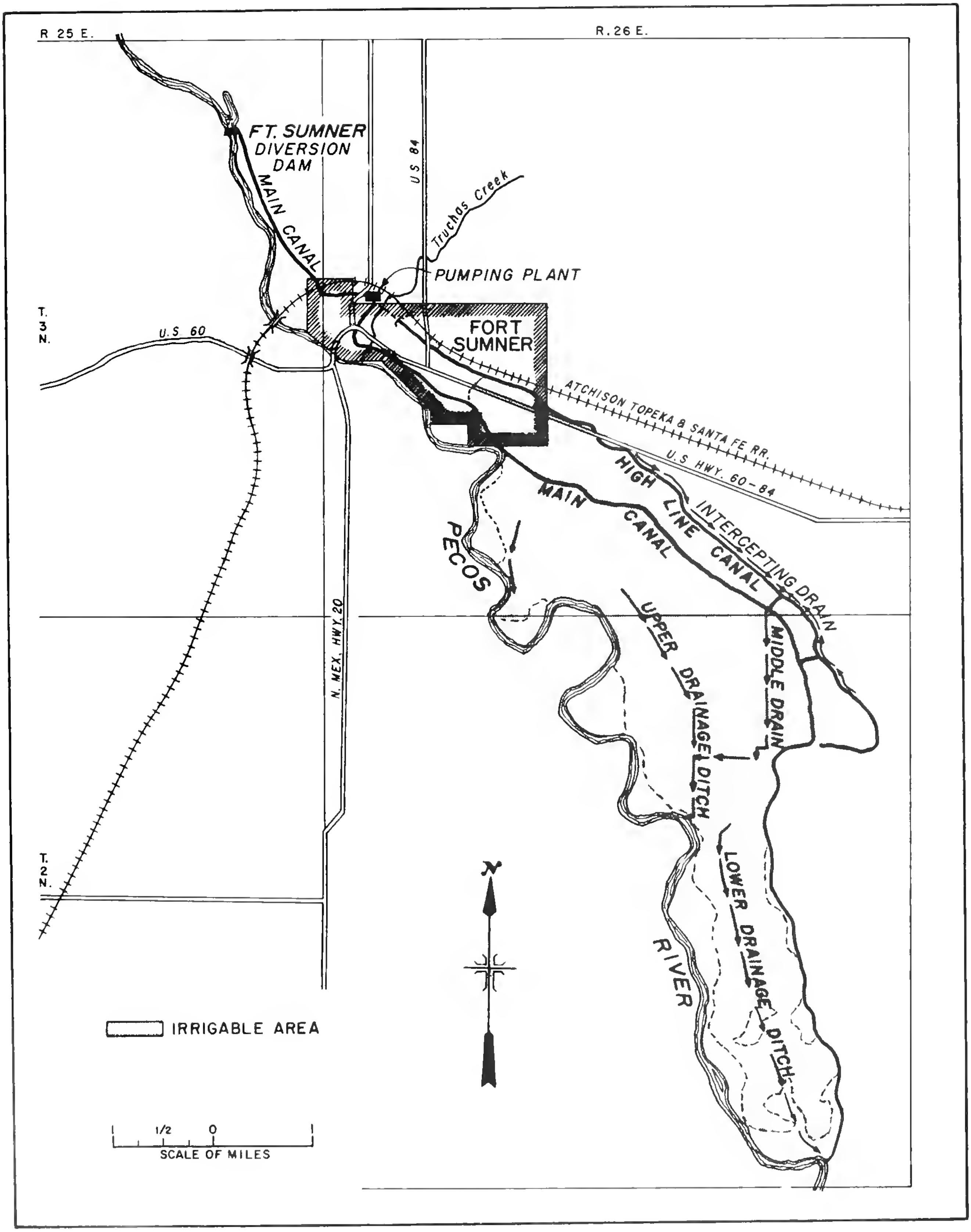
Water diverted from Pecos River by the Fort Sumner Diversion Dam, approximately 3 miles north of Fort Sumner, is carried to the land through a main canal and distribution system which was rehabilitated and enlarged by Reclamation.

Fort Sumner Diversion Dam

The dam is a concrete gravity-type with an overflow weir, designed to raise the water surface 11 feet. The overflow section is 650 feet long. The dam is 150 feet downstream from the remnants of a damaged diversion dam that it replaces.

Canal System and Pumping Plant

The Main Canal is over 16 miles long and has an initial capacity of 100 cubic feet per second. The High Line Canal is over 8 miles long and has a capacity of 20 cubic feet per second. The pumping plant was constructed at the northwest limit of Fort Sumner to lift 20 cubic feet per second of water from the Main Canal and deliver it to the rehabilitated High Line Canal. In addition, the Fort Sumner Irrigation District has installed a small pumping plant near the southern end of the project which lifts drainage return flows back into the lateral system.



Fort Sumner Project

DEVELOPMENT

Early History

Irrigation was begun in 1863 in the valley of the Pecos River near old Fort Sumner, established in 1852. The first irrigators were Navajo Indians, held in captivity by United States troops under the command of Kit Carson. In spite of efforts to farm the land, hardships suffered by the Navajo people were so great that the irrigation experiment on almost 3,000 acres was abandoned in 1868.

Private organizations built an irrigation project in 1907. The system was sold to the Fort Sumner Irrigation District in 1919. The district had recurring financial and operating difficulties. By 1943, indebtedness was so great and the project works so unstable that further rehabilitation work appeared to be virtually impossible by private financing and construction, and the water users appealed to the Bureau of Reclamation for assistance.

Investigations

Investigations by Reclamation resulted in the plan for rehabilitating Fort Sumner Irrigation Project that was approved by the Secretary of the Interior on March 13, 1947.

Authorization

The President approved a congressional act on July 29, 1949 (Public Law 192, 81st Congress, 1st session, 63 Stat. 483), authorizing the project.

Construction

Reconstruction was started in January 1950 and was essentially complete in the spring of 1951.

Operating Agency

The project is maintained and operated by the Fort Sumner Irrigation District.

BENEFITS

The 5,886 acres of irrigated land are divided into 226 individual farms. Principal crops produced are alfalfa, corn, grain sorghum, vegetables, apples, and grapes.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	6,500	acres
Number of irrigated farms	226	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	5,870	436,411
1969	5,623	403,828
1970	5,065	493,776
1971	5,374	571,577
1972	5,204	620,056
1973	5,487	689,464
1974	5,605	741,452
1975	5,590	686,835
1976	5,886	976,466
1977	6,009	805,958

Facilities in Operation (1977)[1]

Diversion dams	1	
Canals	24.8	mi
Laterals	25	mi
Pumping plants	2	
Drains	13.7	mi

[1]Facilities constructed by Bureau of Reclamation and by the Fort Sumner Irrigation District.

Climatic Conditions

Annual precipitation	12.56	in
Temperature:		
Maximum	108	°F
Minimum	−27	°F
Mean	58	°F
Growing season	253	days
Elevation of irrigable area	4000.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	513

ENGINEERING DATA

Water Supply

PECOS RIVER

Drainage area above Fort Sumner Diversion Dam[2]	5,340	mi²
Discharge at gage below Sumner Dam		
Maximum (1942)	42,800	ft³/s
Minimum	0	ft³/s
Average	214	ft³/s
Average annual diversions at Fort Sumner Diverson Dam, 1960-69	36,504	acre-ft

[2]Approximately 4,390 mi² is controlled by Sumner Dam and Lake Sumner. Drainage area between Sumner Dam and Fort Sumner Diversion Dam is 950 mi².

Diversion Facilities

FORT SUMNER DIVERSION DAM

Type: Concrete gravity weir, overflow
Location: On the Pecos River, about 3 mi northwest of Fort Sumner, N. Mex.
Year completed: 1951
Dimensions:
Structural height .... 50 ft

Fort Sumner Diversion Dam

Hydraulic height	11	ft
Weir crest length	650	ft
Crest elevation	4040.0	ft
Volume	27,258	yd³
Diversion capacity	100	ft³/s
Spillway capacity	82,200	ft³/s

Carriage Facilities

MAIN CANAL

Location: From Fort Sumner Diversion Dam about 3 mi northwest of Fort Sumner, N. Mex., generally southeast along the Pecos River.

Construction period: 1950-51

Length	16.3	mi
Diversion capacity	100	ft³/s
Typical maximum section, concrete lined:		
Bottom width	6	ft
Side slopes	1.25:1	
Water depth	4.42	ft
Lining thickness	3	in
Length	2.6	mi
Typical maximum section, lined with pneumatically applied mortar:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	2.94	ft
Lining thickness	2	in
Length	3.5	mi
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	3.08	ft
Length	10.2	mi

HIGH LINE CANAL

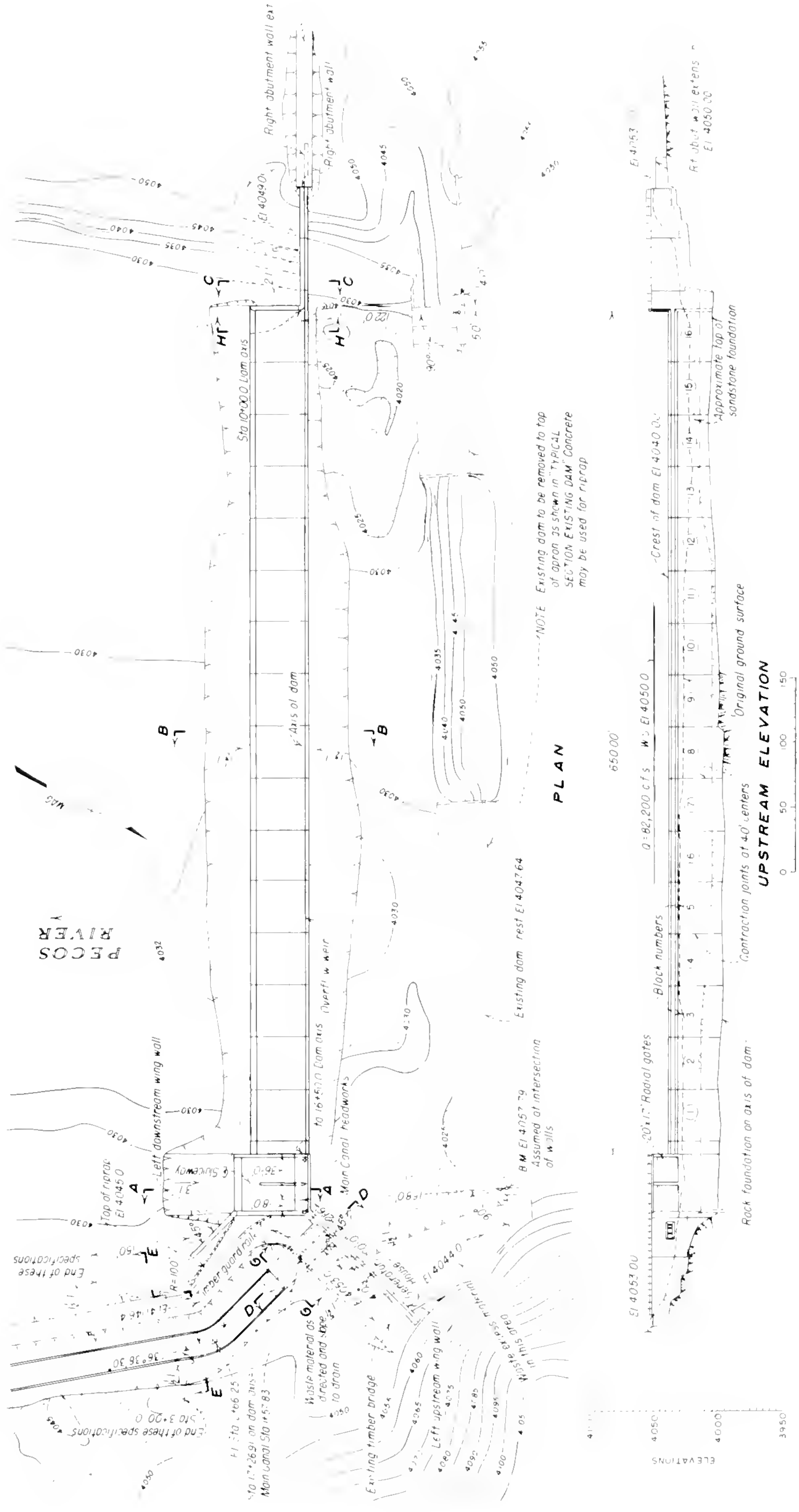
Location: From Fort Sumner Pumping Plant on Main Canal near Fort Sumner, N. Mex.

Construction period: 1950-51

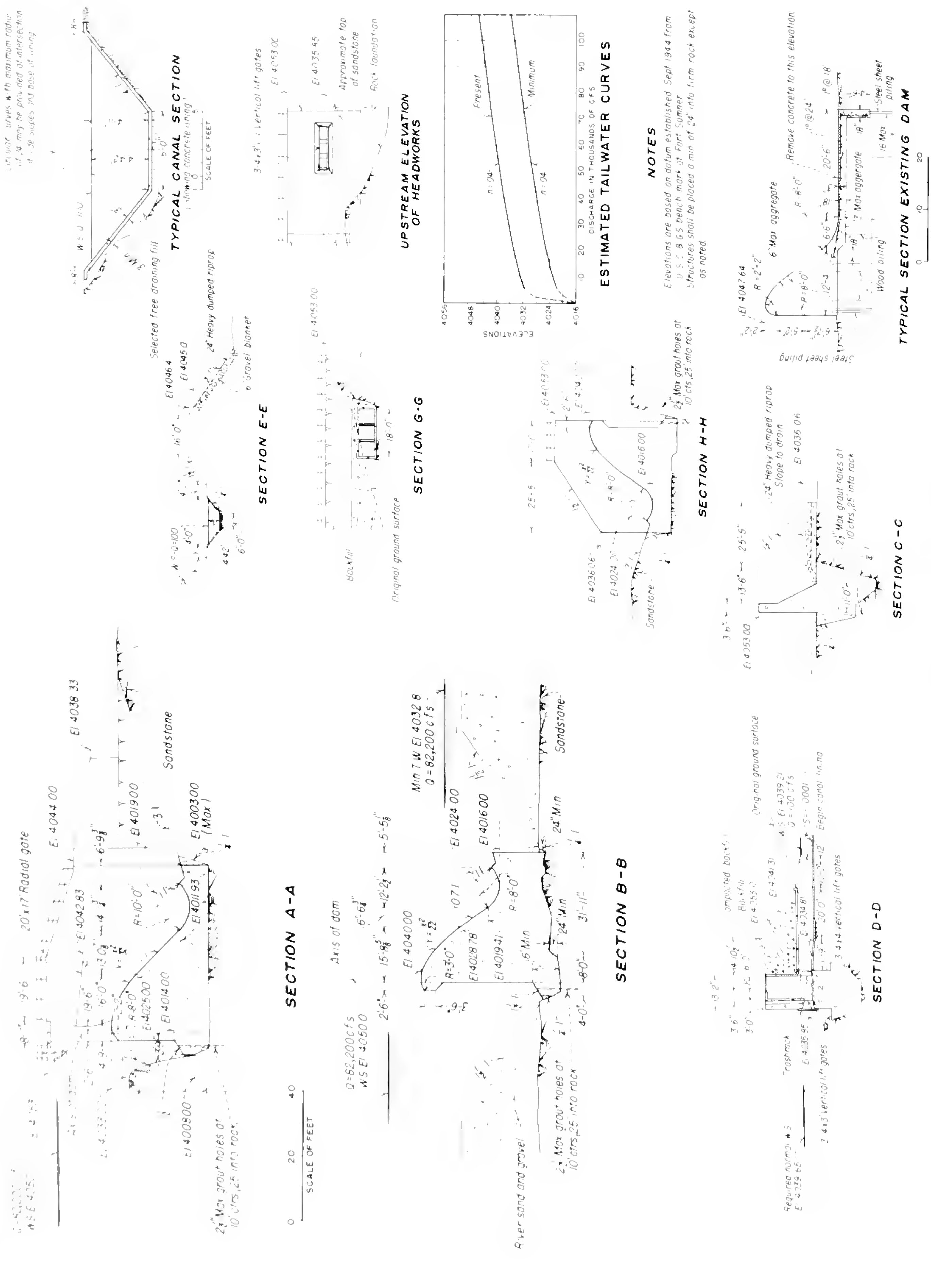
Length	8.5	mi
Diversion capacity	20	ft³/s
Typical maximum section, lined with pneumatically applied mortar:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.94	ft
Lining thickness	1.5	in
Length	8	mi
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.4	ft
Length	0.5	mi

FORT SUMNER PUMPING PLANT

Number of units	1	
Total capacity	20	ft³/s
Total dynamic head	21.3	ft
Total horsepower	70	



Fort Sumner Diversion Dam, Plan and Profile

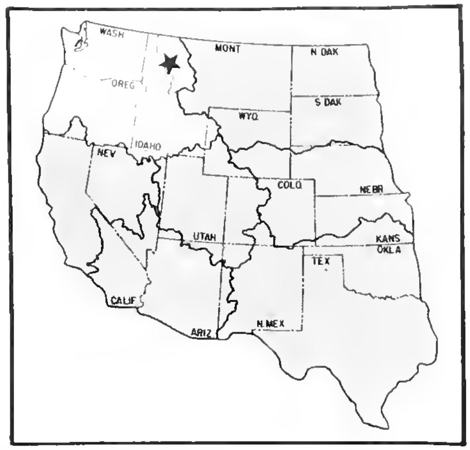


Fort Sumner Diversion Dam, Sections

Frenchtown Project

Montana: Missoula County

Pacific Northwest Region
Water and Power Resources Service



The Frenchtown Project consists of the Frenchtown Diversion Dam on a side channel of the Clark Fork River, and a gravity-flow distribution system that includes 17 miles of main canal and 21 miles of laterals. The system diverts water from the river to irrigate about 4,600 acres of land between Grass Valley and Huson, Mont. An ample supply of water makes storage unnecessary.

PLAN

Water diverted from Clark Fork River is carried through a gravity distribution system which originates at Frenchtown Diversion Dam.

Frenchtown Diversion Dam

The Frenchtown Diversion Dam, an earth- and rockfill structure, is on a side channel of the Clark Fork River about 6 miles west of Missoula, Mont. The dam is 13 feet high, has a crest length of 489 feet, and contains 12,000 cubic yards of material. Two 4-foot-square gates control the canal headworks, which has a capacity of 172 cubic feet per second.

Main Canal and Distribution System

The Main Canal originates at the Frenchtown Diversion Dam and extends 17 miles along the northeast side of the Clark Fork River to a point near Huson. The canal has an initial capacity of 172 cubic feet per second. A total of 21 miles of laterals distributes the water to the project lands.

DEVELOPMENT

Early History

The lands of the project were settled in 1860 by French-Canadian immigrants. The farms were operated without irrigation and with varying degrees of success until the irrigation features of the project were completed.

Investigations

Although the Reclamation Service and a consulting engineer studied the irrigation possibilities in the valley as early as 1919, it was not until 1935 that a concerted effort was made by local farmers to develop an irrigation project. In 1935, the farmers organized the Frenchtown Irrigation District and petitioned the Bureau of Reclamation for assistance in developing irrigation. Further studies were made, and after it was found feasible, the project was authorized.

Authorization

The project was authorized by the President on September 21, 1935, pursuant to section 4 of the act of June 25, 1910 (36 Stat. 836), and subsection B of section 4 of the act of December 5, 1924 (43 Stat. 702).

Construction

Construction of the Frenchtown Diversion Dam, Main Canal, and laterals was started in 1936. By 1937, the project was physically completed and the first water was available on May 18, 1937.

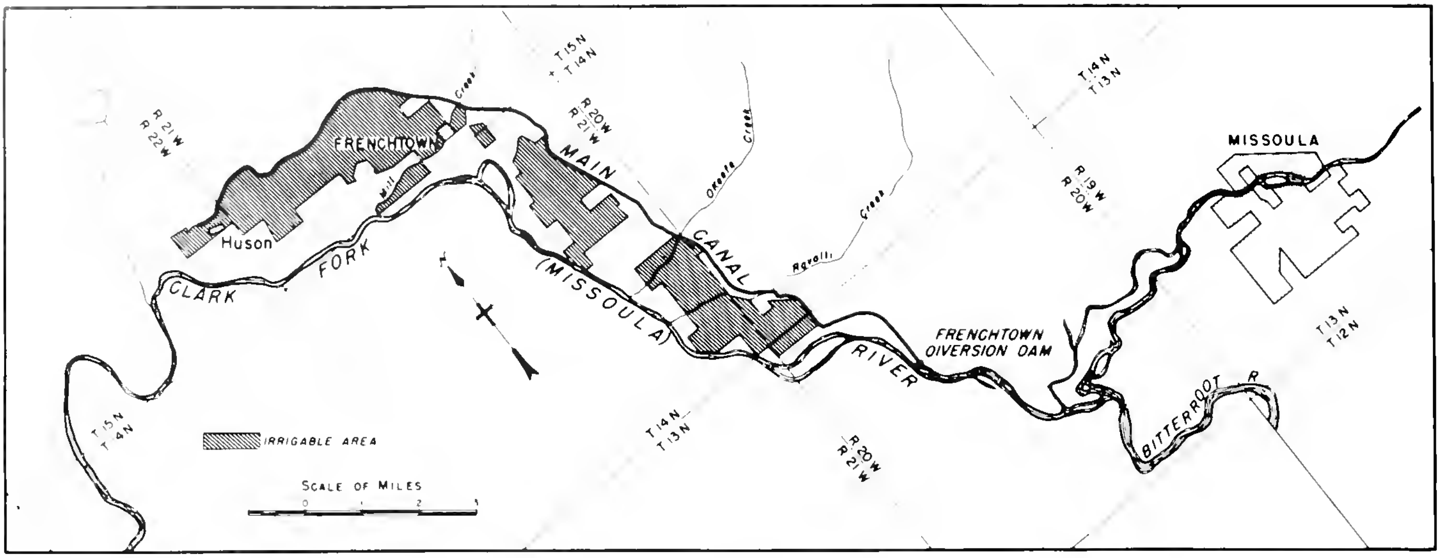
Operating Agency

The project has been operated and maintained by the Frenchtown Irrigation District since December 31, 1938.

BENEFITS

Irrigation

Principal crops are hay, grain, and pasture.



Frenchtown Project

Frenchtown Diversion Dam

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	4,574	acres
Number of irrigated farms	48	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,130	258,262
1969	4,027	218,591
1970	4,025	201,940
1971	4,033	200,031
1972	3,845	234,386
1973	3,602	597,324
1974	3,600	424,633
1975	3,600	424,905
1976	3,574	501,795
1977	3,439	394,705

Facilities in Operation

Diversion dams	1	
Canals	17	mi
Laterals	21	mi

Climatic Conditions

Annual precipitation	13.1	in
Temperature:		
Maximum	103	°F
Minimum	−30	°F
Mean	44	°F
Growing season	142	days
Elevation of irrigable area	3100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	128
Other water service[1]	325
Total	453

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

CLARK FORK RIVER

Drainage area at gaging station below Missoula, Mont.[2]	9,003	mi²
Annual discharge at gaging station:		
Maximum	6,412,000	acre-ft
Minimum	997,000	acre-ft
Average	4,407,000	acre-ft
Average annual diversions by project (1963-77)	24,310	acre-ft

[2]About 2 mi above diversion point for Frenchtown Project.

Diversion Facilities

FRENCHTOWN DIVERSION DAM

Type: Earthfill and rockfill, nonoverflow
Location: Offstream on side channel of the Clark Fork River, about 6 mi west of Missoula, Mont.
Year completed: 1936
Dimensions:

Structural height	16	ft
Hydraulic height	13	ft
Crest length	489	ft
Crest width	15	ft
Crest elevation	3090.0	ft
Volume	12,000	yd³

Headworks: Two 4-ft-square gates.

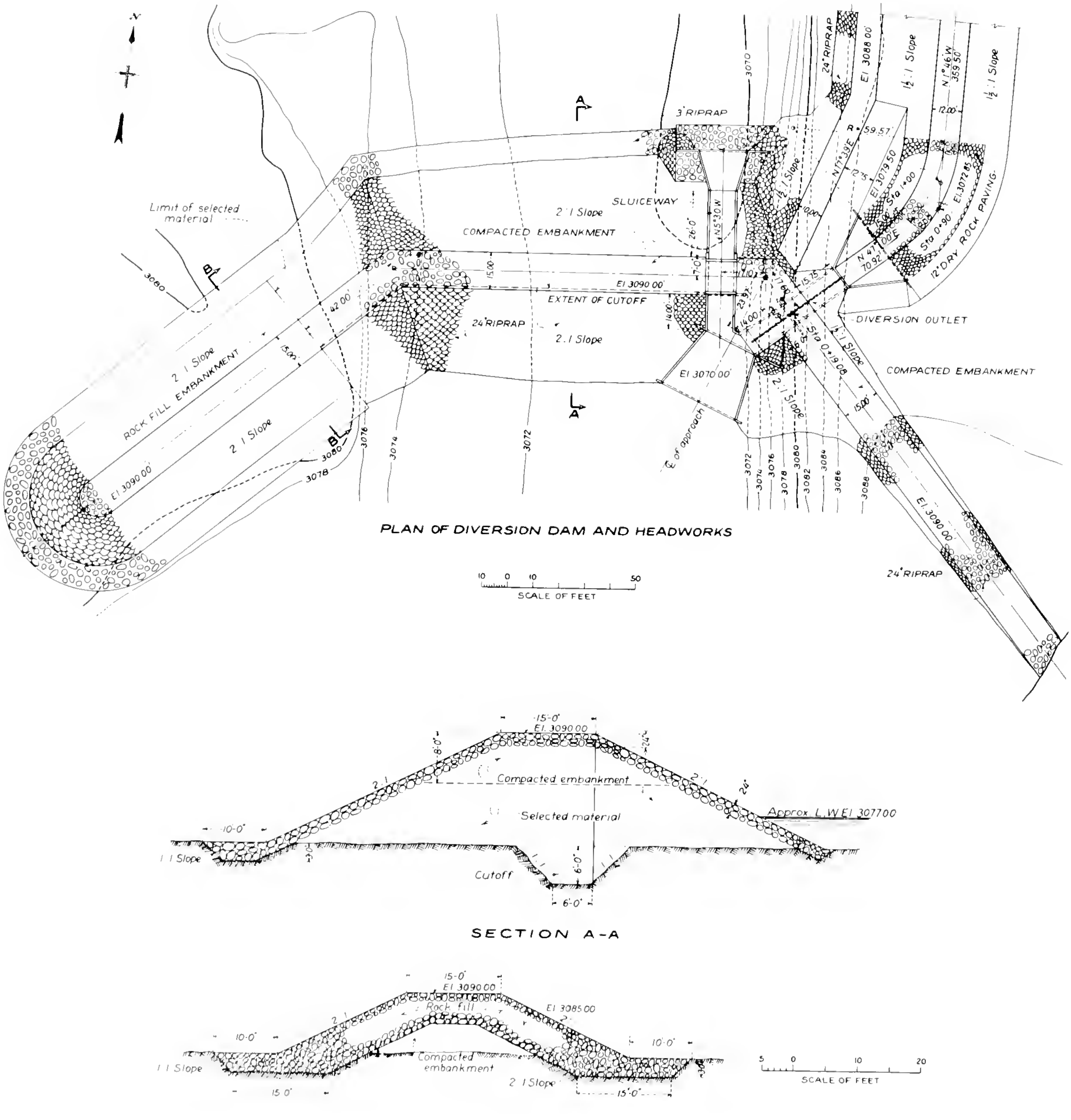
Diversion capacity	172	ft³/s

Carriage Facilities

MAIN CANAL

Location: From Frenchtown Diversion Dam generally northwest along the Clark Fork River to vicinity of Huson, Mont.
Construction period: 1936-37

Length	17	mi
Diversion capacity	172	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4.4	ft
Typical maximum section, concrete lined:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	3.7	ft
Lining thickness	3	in

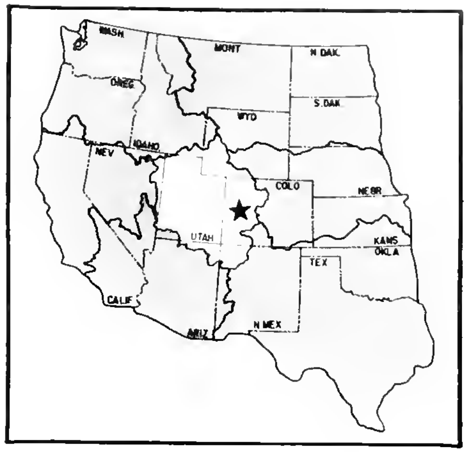


Frenchtown Diversion Dam, Plan and Sections

Fruitgrowers Dam Project

Colorado: Delta County

Upper Colorado Region
Water and Power Resources Service



The Fruitgrowers Dam Project in southwestern Colorado furnishes a dependable irrigation water supply to nearly 2,700 acres of highly developed land immediately downstream from the dam. Structures built by the Bureau of Reclamation are Fruitgrowers Dam, Dry Creek Diversion Dam, and Dry Creek Diversion Ditch. Other diversion structures and the canal and lateral system were constructed by private interests.

PLAN

The reservoir behind Fruitgrowers Dam is filled from the natural flow of Alfalfa Run and by diversions from Surface and Dry Creeks. The flow of Dry Creek is diverted by the Dry Creek Diversion Dam, and conveyed through the Dry Creek Diversion Ditch. Water from Surface Creek is carried through the privately owned Alfalfa Ditch. Water stored in Fruitgrowers Reservoir is released and delivered to project lands through a privately owned system of canals and laterals.

Fruitgrowers Dam

Fruitgrowers Dam and Reservoir

The dam is located on Alfalfa Run 3 miles north of Austin, Colo. It is an earthfill, rock-faced structure, 55 feet high and 1,520 feet long at the crest, containing 136,000 cubic yards of material. The reservoir stores a total of 4,540 acre-feet of water. The spillway is an uncontrolled structure, located on the left abutment. A 76-foot-long concrete-lined channel discharges into a stilling basin. The outlet works consists of one circular conduit 3 feet in diameter controlled by two slide gates.

Dry Creek Diversion Dam and Canal

This diversion dam is 13 feet high and has a crest length of 36 feet. It contains 200 cubic yards of concrete. The Dry Creek Diversion Ditch is about 3 miles long and has a capacity of 100 cubic feet per second.

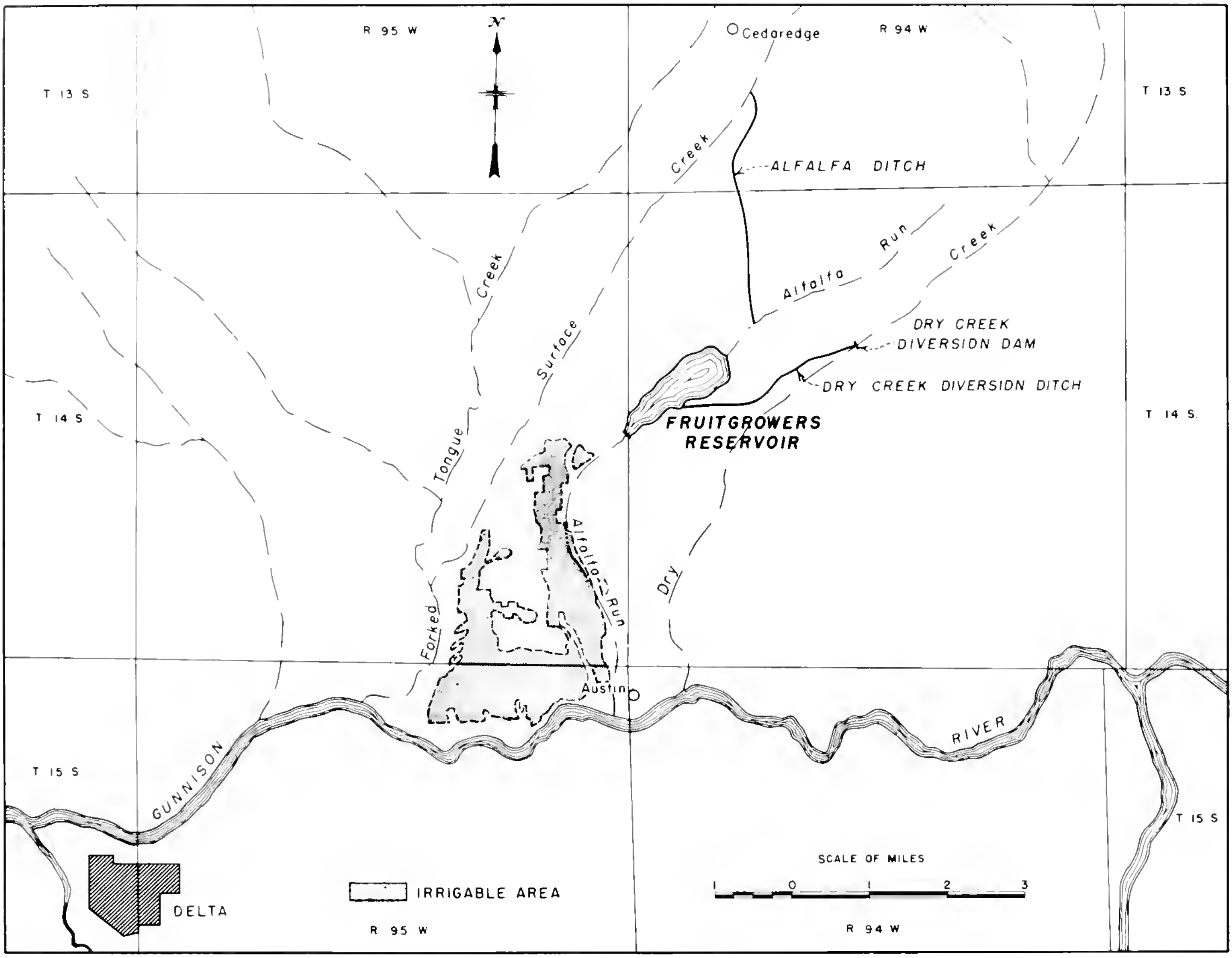
DEVELOPMENT

Early History

Irrigation of lands now encompassed by the Fruitgrowers Dam Project was initiated about 1890. In 1898, settlers built a small dam on Alfalfa Run to provide water storage for their irrigation system. This dam failed on June 13, 1937, resulting in extensive damage. Since the highly developed agricultural area could not be sustained without storage of the late summer water supply, the settlers requested the Bureau of Reclamation to investigate the building of a new dam.

Investigations

On the basis of studies made by the Bureau of Reclamation, work started on rehabilitation of the project in May 1938.



Fruitgrowers Dam Project

Authorization

Under the provisions of section 4 of the act of June 25, 1910 (36 Stat. 835), construction of the project was recommended by the Secretary of the Interior on January 5, 1938, and was approved by the President on January 11, 1938.

Construction

Construction of the new dam started in May 1938, and was completed in time for stored water to be delivered to project lands for the irrigation season of 1939.

Operating Agency

Orchard City Irrigation District assumed the operation and maintenance of project works on March 1, 1940.

BENEFITS

Irrigation

Supplemental irrigation can be provided by the project for 2,690 acres of land. Principal crops are fruit, small grains, corn, alfalfa, and pasture.

Recreation

Fruitgrowers Reservoir has a surface area of 476 acres at total capacity and is used locally for boating, swimming, and fishing. In 1977, visitors totaled only 1,545 because of the severe 1977 drought. Visitation normally exceeds 4,000 annually. There are no recreation facilities.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Supplemental irrigation service	2,690	acres
Number of irrigated farms	126	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,923	761,524
1969	1,923	699,002
1970	1,926	671,297
1971	2,099	629,339
1972	2,099	290,813
1973	2,099	1,016,759
1974	2,340	1,089,848
1975	2,295	1,065,402
1976	2,295	884,896
1977	2,295	[1]593,171

[1]Spring runoff in 1977 was the lowest in 61 years of record. In most areas of Colorado, precipitation for the year was considerably below average resulting in lower yields because of the extreme drought.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	3	mi

Climatic Conditions

Annual precipitation	11.9	in
Temperature:		
Maximum	101	°F
Minimum	−25	°F
Mean	49	°F
Growing season	183	days
Elevation of irrigable area	5400.0	ft

ENGINEERING DATA

Water Supply

Direct flows of Alfalfa Run and diversions from Surface Creek and Dry Creek. Annual inflow to Fruitgrowers Reservoir during 1946-55 was 7,400 acre-ft, part of which was required to satisfy direct flow rights.

Storage Facilities

FRUITGROWERS DAM

Type: Homogeneous earthfill
Location: On Alfalfa Run, about 3 mi north of Austin, Colo.
Construction period: 1938-39
Reservoir, Fruitgrowers:

Average annual inflow, 1946-55	7,400	acre-ft
Total storage to El. 5485	4,540	acre-ft
Active storage, El. 5460-5485	4,460	acre-ft
Surface area	476	acres

Dimensions:

Structural height	55	ft
Hydraulic height	40	ft
Top width	25	ft
Maximum base width	300	ft
Crest length	1,520	ft
Crest elevation	5493.0	ft
Total volume	136,000	yd³

Spillway: Uncontrolled concrete-lined channel at left abutment.

Crest length	76	ft
Crest elevation	5485.0	ft

Outlet works: Concrete conduit through base of dam controlled by two 24-in slide gates.

Diversion Facilities

DRY CREEK DIVERSION DAM

Type: Concrete overflow ogee weir
Location: On Dry Creek, about 6 mi northeast of Austin, Colo.
Year completed: 1940
Dimensions:

Structural height	13	ft
Hydraulic height	5	ft
Weir crest length	36	ft
Crest elevation	5619.5	ft
Volume	200	yd³

Sluiceway: Concrete, one 6- by 9-ft radial gate.
Headworks: Concrete, one 8-ft-square radial gate.

Diversion capacity	100	ft³/s

Carriage Facilities

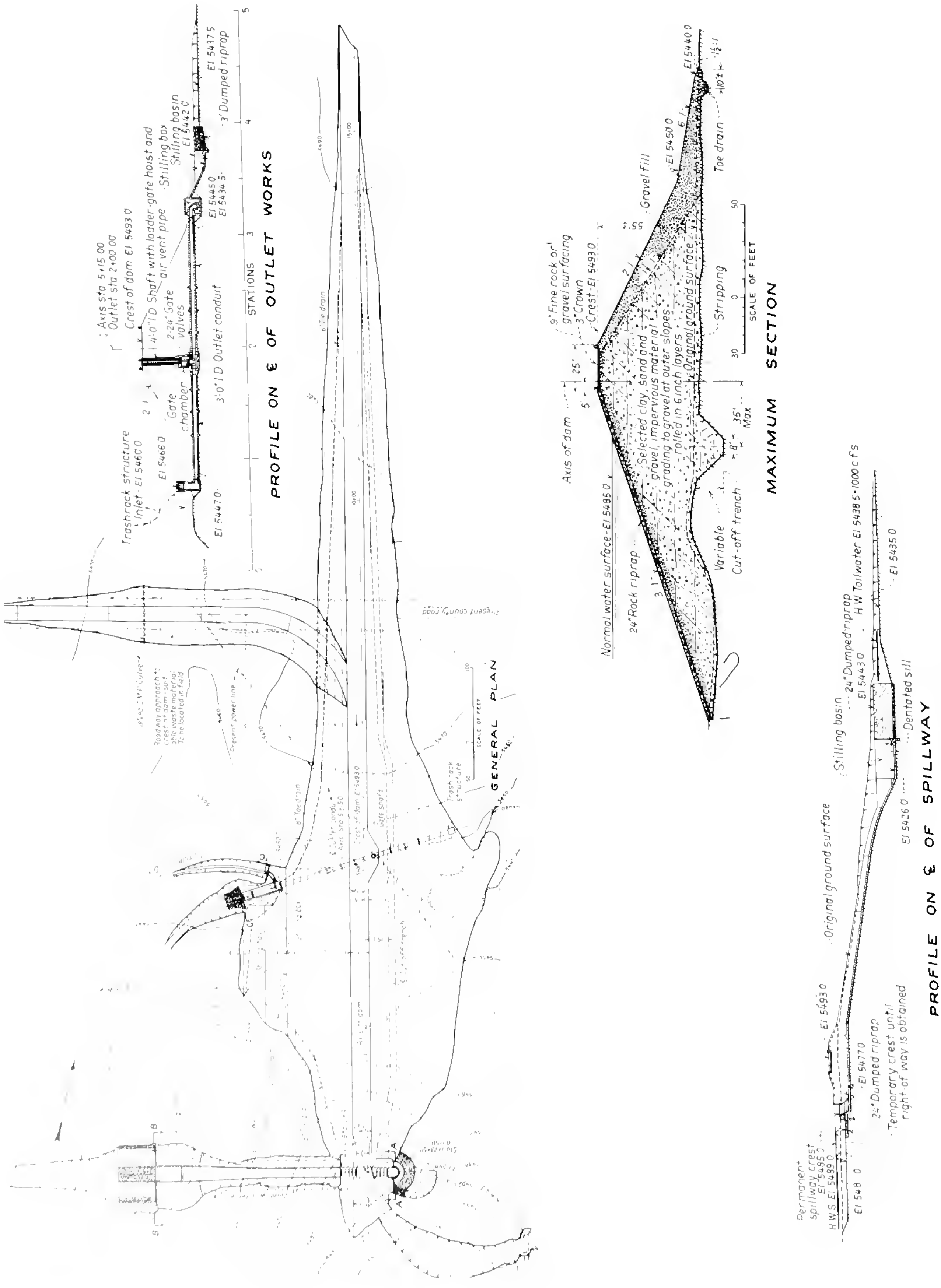
DRY CREEK DIVERSION DITCH

Location: From Dry Creek Diversion Dam west to Fruitgrowers Reservoir.
Construction period: 1940

Length	3	mi
Diversion capacity	100	ft³/s
Typical maximum section in earth:		
Bottom width	8	ft
Side slopes	1.5:1	
Water depth	2.4	ft

In March 1965, construction was completed on a pumping plant located on the Gunnison River 7 mi northeast of Delta, Colo., a short access road, a pump discharge pipeline, and two gravity-flow canals to convey pumped water into the existing distribution system serving lands irrigated by the district. These facilities were financed by the district through a Small Reclamation Projects loan. Operation of these works provides an average annual supplemental water supply of 2,600 acre-ft of water to 2,093 acres of land.

Fruitgrowers Reservoir water, formerly used in the lower 1,400-acre area, is now used on the higher 693 acres which provides a full supply for that area. By delivery of the additional 2,600-acre-foot supply to the lower 1,400-acre area, the entire 2,093 acres receive a full water supply.

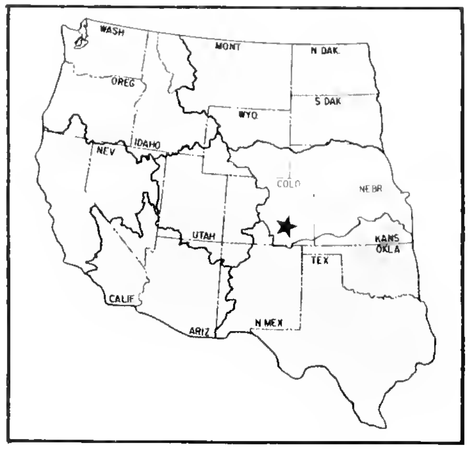


Fruitgrowers Dam, Plan and Sections

Fryingpan-Arkansas Project
(Under Construction)

Colorado: Eagle, Pitkin, Lake, Chaffee, Fremont, El Paso, Pueblo, Otero, Crowley, Bent, Prowers, and Kiowa Counties

Lower Missouri Region
Water and Power Resources Service



The Fryingpan-Arkansas Project is a multipurpose transmountain diversion development in southeastern Colorado. It will make possible an average annual diversion of 69,200 acre-feet of surplus water from the Fryingpan River and other tributaries of the Roaring Fork River on the western slope of the Rocky Mountains to the Arkansas River on the eastern slope.

Water diverted from the western slope, together with available water supplies in the Arkansas River Basin, will provide an average annual water supply of 163,100 acre-feet for supplemental irrigation of 280,600 acres in the Arkansas Valley. The project also will provide an annual supply of 40,988 acre-feet of water for use in several eastern slope municipalities (20,100 acre-feet to Colorado Springs, 8,040 acre-feet to Pueblo, and the remainder to other valley cities and towns which have requested project water to replace unsatisfactory supplies).

Ruedi Dam and Reservoir

The authorized plan for the project included two powerplants, with a total capacity of 211 megawatts. However, the potential power system is subject to modification and further study.

PLAN

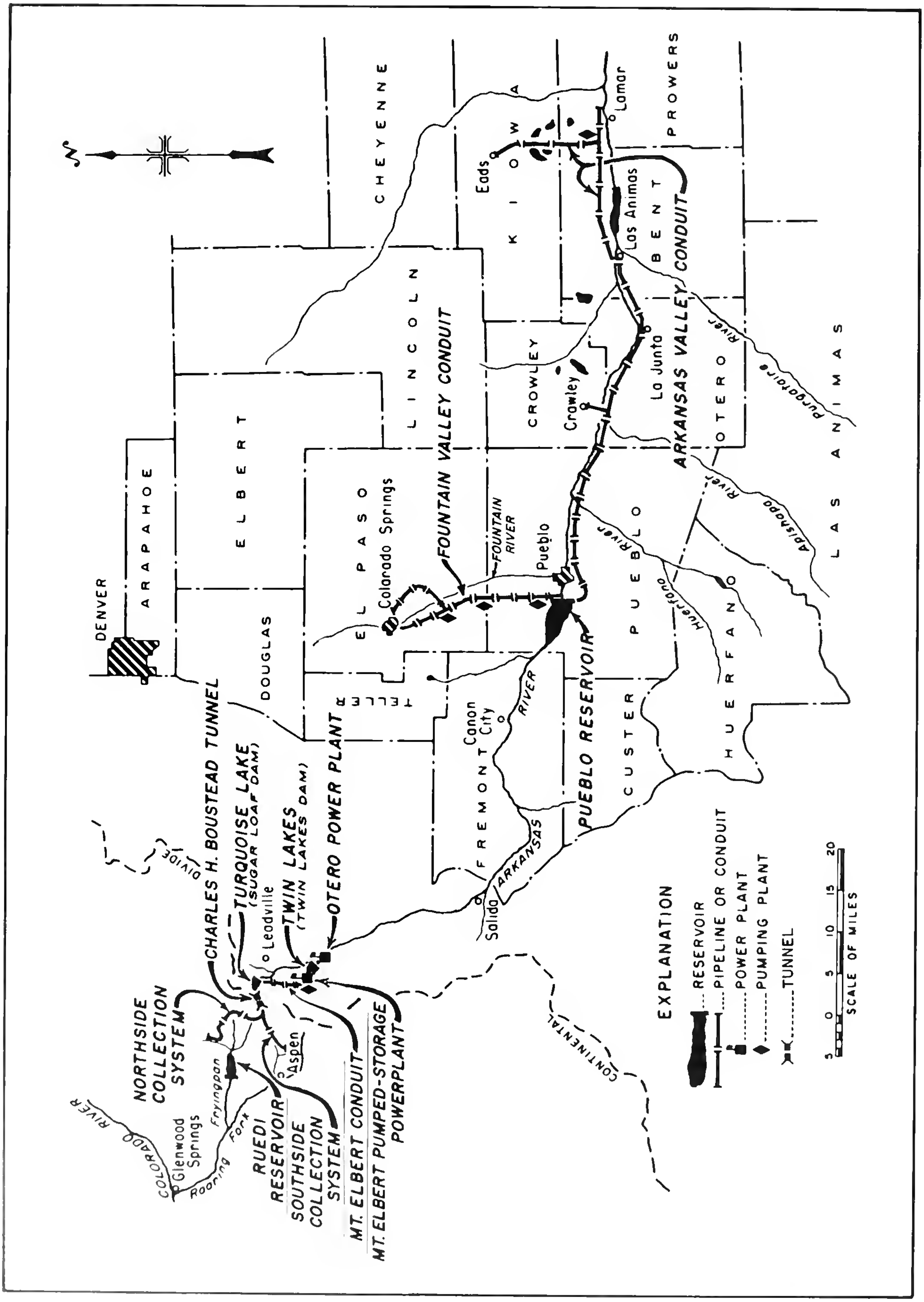
There are two distinct areas of the project: The western slope, located within the boundaries of the White River National Forest at elevations above 10,000 feet; and the eastern slope in the Arkansas River Valley. These areas are separated by the Continental Divide which, in many places, exceeds an elevation of 12,000 feet. The project plan consists of facilities designed primarily to divert water from the western slope to the water-short areas of the eastern slope.

There are six dams and reservoirs in the project: Ruedi Dam and Reservoir, on the western side of the mountain, is located on the Fryingpan River upstream from Basalt, Colo.; four dams and reservoirs on the eastern slope in the upper regions include Sugar Loaf Dam and Turquoise Lake, Mt. Elbert Forebay Dam and Reservoir, Twin Lakes Dam and Reservoir, and Clear Creek Dam and Reservoir. The largest of the Fryingpan-Arkansas Project storage units, Pueblo Dam and Reservoir, is on the Arkansas River west of Pueblo, Colo.

Sixteen diversion structures on the western slope are used to divert water into the Fryingpan-Arkansas Project collection system. The plan includes nine tunnels with a combined length of 26.7 miles.

The Western Slope

Ruedi Dam and Reservoir provide storage for replacement and regulation of approximately 100,000 acre-feet of water for the western slope users. This water will be used for irrigation and municipal benefits, and recreation and fish and wildlife enhancement.



Fryingpan-Arkansas Project

Ruedi Dam and Reservoir

The North and South Side Collection Systems on the western slope are being built to collect the melting snows and runoff from the high mountains. The diverted waters of the Fryingpan and Roaring Fork River Basins flow into the inlet portal of the Charles H. Boustead Tunnel. This tunnel conveys all the water from the North and South Collection Systems through the Continental Divide to Turquoise Lake.

The Eastern Slope

Turquoise Lake and Sugar Loaf Dam are located just east of the Continental Divide, approximately 5 miles west of Leadville, Colo. The lake provides storage capacity for the regulation of project water flowing from the Charles H. Boustead Tunnel.

Mt. Elbert Conduit, a 10.5-mile-long, 90-inch-diameter pipe, will convey water from Turquoise Lake to Mt. Elbert Forebay. The Halfmoon Diversion Dam will intercept the excess flows of Halfmoon Creek for diversion to Mt. Elbert Conduit. Water delivered to the forebay will be used for generation of power in the Mt. Elbert Pumped-Storage Powerplant. The powerplant is at the northwest corner of the lower lake of Twin Lakes. After going through the powerplant, the water will flow into Twin Lakes.

The plan provides for a new dam approximately 2,500 feet downstream from the present Twin Lakes. From Twin Lakes, the water will be conveyed through the Otero Canal to the Otero Powerplant at Clear Creek Reservoir. Power generated at the Mt. Elbert Pumped-Storage Powerplant and the Otero Powerplant will be delivered to existing power transmission systems in the area.

From Clear Creek Reservoir, the water will flow down the Arkansas River to Pueblo Dam where some of the project water will be diverted to the Fountain Valley and Arkansas Valley Conduits for delivery to municipal and industrial water users. The Pueblo Reservoir is the terminal storage feature for the project.

The Arkansas Valley Conduit transports water for municipal and industrial uses from Pueblo Reservoir to towns in the Arkansas Valley as far east as Lamar, Colo.

When completed, the project will provide an average annual diversion of 69,200 acre-feet of water from the western slope to the eastern slope.

Ruedi Dam and Reservoir

Ruedi Dam is on the Fryingpan River about 15 miles east of Basalt, Colo. The dam creates a reservoir with a total capacity of 102,369 acre-feet. Ruedi Dam is a rock and earthfill structure that stands about 285 feet high above streambed, has a crest length of 1,042 feet, and contains approximately 3,745,200 cubic yards of material.

The concrete spillway structure has an uncontrolled ogee-type crest, a chute section, a stilling basin, and a bridge over the spillway. The spillway has a capacity of 5,540 cubic feet per second. The outlet works, located under the right abutment of the dam, consists of a hexagonal intake structure with trashracks and a bulkhead gate, a 10-foot-diameter concrete-lined circular tunnel to a gate chamber housing a 5- by 6-foot high-pressure gate, an 11-foot-diameter concrete-lined horseshoe tunnel to a gate chamber housing a 5- by 6-foot high-pressure gate, an 11-foot-diameter concrete-lined horseshoe tunnel with a 76-inch-diameter steel pipe, a control house with two sets of 3.5- by 4-foot tandem gates and wye to a 76-inch-diameter steel pipe stub with a bulkhead just ahead of the control house. This bulkhead is to provide service to a future pipeline which will supply water to the potential Basalt Project. A shaft house and adit give access to the gate chamber of the outlet works and auxiliary works. The capacity of the outlet works is 1,810 cubic feet per second.

The auxiliary outlet works consists of an intake structure with trashracks, a 6-foot-diameter concrete-lined circular tunnel to a gate chamber housing a set of 2.5- by 3-foot tandem gates, and a concrete-lined 5- by 6-foot flat-bottom tunnel. The capacity is 600 cubic feet per second.

A concrete bypass, consisting of a concrete chute and stilling basin, bypasses flows of Rocky Fork Creek past the discharge of the spillway and auxiliary outlet.

Sugar Loaf Dam and Turquoise Lake

Sugar Loaf Dam and Turquoise Lake are east of the Continental Divide on the Lake Fork of the Arkansas River in Lake County, approximately 5 miles west of

Leadville. The reservoir storage capacity is 129,432 acre-feet. Sugar Loaf Dam is an earthfill structure, has a length of 2,020 feet, a height above riverbed of 135 feet, and contains approximately 1,833,700 cubic yards of material. In addition to the main earthfill section of the dam, there is a dike about 6,000 feet to the northeast. This dike is 475 feet long and 11 feet high. The spillway has a capacity of 2,920 cubic feet per second and consists of a morning-glory intake structure, a 16.5-foot-diameter monolithic concrete conduit, a chute and a stilling basin. The outlet works consists of an intake structure with trashracks, a 7-foot-diameter concrete conduit with a steel liner, a gate chamber housing a 5- by 6-foot high-pressure gate, an 11-foot-diameter concrete conduit with a steel liner, a 72-inch-diameter steel outlet pipe which bifurcates into two parallel branches just ahead of the control house for the river outlet, a river outlet control house with two 3.5-foot-square high-pressure gates for each branch, and a chute and stilling basin discharging to Lake Fork. A short 72-inch-diameter steel branch outlet pipe with a bulkhead was provided upstream from the bifurcation for future use, and as an outlet to the Mt. Elbert Conduit. The capacity of the river outlet is 1,120 cubic feet per second, and the capacity of the outlet to the Mt. Elbert Conduit is 370 cubic feet per second.

Pueblo Dam and Reservoir

Pueblo Dam is the terminal storage feature for the Fryingpan-Arkansas Project. The dam is located on the Arkansas River in Pueblo County about 6 miles upstream and west of the city of Pueblo. The reservoir has a total storage capacity of 357,000 acre-feet: 30,000 acre-feet of dead and inactive capacity; 234,000 acre-feet of conservation capacity; 66,000 acre-feet of joint-use capacity; and 27,000 acre-feet of exclusive flood-control capacity. The concrete dam and massive-head buttress-type spillway structure is the principal control structure for the reservoir. The concrete section is 1,750 feet wide with a maximum structural height of 250 feet. The spillway has a crest width of 550 feet and was designed for a maximum spill discharge of 191,500 cubic feet per second. The river outlet works is controlled by two 4-foot-square high-pressure gates and regulates normal water releases into the river. Additional releases may be made to the river through three separate spillway outlet works. Each is controlled by two 6- by 6.5-foot high-pressure gates. Delivery of water for municipal and industrial use is made from the south outlet works, which is a multilevel intake structure capable of taking water from the reservoir at different levels, thus providing a degree of control over water temperature and quality. Water deliveries from the fish hatchery outlet works have similar controls. Included in the outlet works are a stilling basin and outlet channel, a concrete river plug in the river channel, and the Bessemer Ditch headworks.

Sugar Loaf Dam and Turquoise Lake

Mt. Elbert Forebay Dam and Reservoir

Mt. Elbert Forebay occupies a saddle on a ridge above Twin Lakes Reservoir. The forebay will be impounded by a dam on the north side and a dike on the south rim. An outlet channel from the southeast corner of the reservoir will connect to the inlet-outlet structure for the powerplant penstock. The rolled earthfill forebay dam is about 2,600 feet long and 92 feet high. A 130-foot-long earth dike closes a low saddle at the southwest end of the reservoir. The forebay is lined with a 5-foot-thick, watertight layer of impervious silt clay. There is no spillway in the forebay dam. There is also no outlet works, other than the penstock inlet-outlet structure. Natural flow into the reservoir is negligible.

Twin Lakes Dam and Reservoir

Twin Lakes Dam and Reservoir will be located approximately 13 miles south of Leadville, in Lake County. The reservoir will have a total capacity of 141,000 acre-feet. The dam will be a zoned, rolled earthfill structure with a height above streambed of 53 feet. The crest of the dam will be 30 feet wide and 3,150 feet long. The spillway will be on the left abutment of the dam, and will have a capacity of 1,400 cubic feet per second. The spillway will be an uncontrolled concrete morning-glory inlet structure with a 12-foot-diameter concrete conduit under the dam embankment and a concrete stilling basin. A channel downstream from the stilling basin will carry the water to Lake Creek. The outlet works located in the right abutment will deliver 3,465 cubic feet per second to the river. It will have an inlet structure with trashracks, twin 8-foot-diameter concrete conduits with steel liners, and a gate chamber housing two 6.5- by 8-foot high-pressure gates. Twin 12.5-foot-diameter concrete conduits, each containing a 98-inch-diameter steel outlet pipe, will lead from the gate chamer to the river outlet control house where two 6.5- by 7.5-foot high-pressure gates will be located. A chute, stilling basin, and a 400-foot-long outlet channel will lead to Lake Creek. The Otero Canal will be served by a wye-junction structure appurtenant to the outlet works upstream from the river outlet control house, a 98-inch-diameter steel pipe, a control house with four 5-foot-square high-pressure gates, and a chute and stilling basin.

Clear Creek Dam and Reservoir

Clear Creek Dam and Reservoir will be located on Clear Creek a short distance from its confluence with the Arkansas River. The dam will be an earth and rockfill embankment with a crest length of 2,200 feet and will have a height of 75 feet above streambed. There is an earthfill dike with a crest length of 600 feet on the north side of the lake. The Pueblo Board of Water Works has storage rights of 11,440 acre-feet in Clear Creek Reservoir, and the reservoir will act as an afterbay for the Otero Powerplant. The spillway will be a combined concrete spillway and outlet works structure. It will have a gated inlet structure, a concrete chute passing under U.S. Highway 24, and a stilling basin and channel leading to the Arkansas River.

The Collection System

The North and South Side Collection Systems are located at approximately 10,000 feet elevation. The facilities are designed to divert and carry water from the Fryingpan and Roaring Fork River Basins to the inlet portal of the Charles H. Boustead Tunnel. This tunnel transports water from the collection system through the Continental Divide to the Arkansas River Basin.

The North Side Collection System is designed to divert, collect, and transport an average of 18,400 acre-feet of water annually through facilities of the Mormon, Carter, Ivanhoe, Granite, Lily Pad, North Cunningham, Middle Cunningham, and South Cunningham Creeks.

Pueblo Dam

The South Side Collection System is designed to transport an average of 50,800 acre-feet of project water annually from the Fryingpan and Roaring Fork River Basins. Facilities located on Hunter, Midway, and No Name Creeks will collect and divert water from Sawyer and Chapman Creeks, the South Fork of the Fryingpan River, and the main stem of the Fryingpan River downstream of Marten Creek.

North Side Collection System

Carter Tunnel: Carter Tunnel will be the first collection tunnel on the North Side Collection System. Water will be diverted into the tunnel by the Carter Diversion Dam through the 300-foot, 42-inch Carter Feeder Conduit to the inlet of the Carter Tunnel. The North Fork Diversion Dam will be a drop-inlet structure that will divert North Fork Creek water into the Carter Tunnel by the 280-foot-long North Fork Feeder Conduit. Carter Tunnel is 0.54 mile long and has an 8-foot horseshoe cross section with a capacity of 130 cubic feet per second. Water from Carter Tunnel will flow to the Mormon Conduit.

Mormon Tunnel: The Mormon Creek diversion structure will be connected to the intake portal of the Mormon Tunnel by the Mormon Feeder Conduit. The conduit will be a 250-foot-long structure, including a Parshall flume measuring device. The tunnel is 1.4 miles long, with an 8.25-foot horseshoe-shaped section having a capacity of 190 cubic feet per second. The water from Mormon Tunnel will flow to the Cunningham Tunnel.

Cunningham Tunnel: The North Cunningham, Middle Cunningham, and South Cunningham diversion structures will be connected to the Cunningham Conduit by feeder conduits which extend to the Cunningham Tunnel. The length of the three feeder conduits is 2,700 feet, and the Cunningham Conduit is 4,170 feet long. The Cunningham Tunnel is 2.86 miles long and has a horseshoe shape of two sizes: 8.75 and 7.5 feet. The capacity is 270 cubic feet per second. The Cunningham Tunnel flows into the Nast Tunnel.

Nast Tunnel: Ivanhoe Diversion Dam diverts water from Ivanhoe Creek and the Cunningham Tunnel through the Ivanhoe Creek crossing into the inlet of Nast Tunnel. The Granite Diversion Dam diverts water through the Granite Siphon to the Granite Adit, which drops the flow into the Nast Tunnel. The Lily Pad Diversion Dam drops the flow into Nast Tunnel. Nast Tunnel is 3 miles long, with a circular-shaped section with two diameters: 7.67 and 9.33 feet. The capacity of the tunnel is 360 cubic feet per second. The flow is conveyed to the Charles H. Boustead Tunnel by the Fryingpan Conduit, which is 2,481 feet long and 84 inches in diameter.

South Side Collection System

Hunter Tunnel: Hunter Tunnel will be 7.6 miles long. It will transport the flows diverted at No Name, Midway, and Hunter Creeks to Chapman Gulch at the Chapman Diversion Dam. The design capacity ranges from 90 cubic feet per second at No Name Creek, the point of the beginning of the South Side Collection System, to Midway Creek with 270 cubic feet per second at Chapman Gulch on the Chapman diversion site. No Name, Midway, and the Hunter Creeks diversion structures are all similar. Each has a sluicegate for bypassing all streamflow when water is not being diverted. When diversions are being made, minimum flow will be released through a bypass to maintain the stream. A side overflow section provides for passing floodflows. Flows will be diverted through a short flume section to a shaft which will drop the water into the Hunter Tunnel. Hunter Tunnel is a semihorseshoe-shaped structure with two sizes: 8.5 and 7.33 feet.

Chapman Tunnel: The Sawyer diversion drop inlet diverts water from Sawyer Lake into Sawyer Feeder Conduit (3,098 feet in length), and drops the water at Chapman Gulch. The water then flows to Chapman Diversion Dam, with the flow from Hunter Tunnel, to be diverted into Chapman Tunnel. Chapman Tunnel is a 2.8-mile-long, 7-foot horseshoe-shaped structure, with a capacity of 300 cubic feet per second.

South Fork Tunnel: The South Fork Diversion Dam diverts water from South Fork Creek to the South Fork Siphon, where it continues with the flow from the South Fork Creek and is conveyed by the South Fork Feeder Conduit to the inlet of the South Fork Tunnel. The South Fork Tunnel is a 3.1-mile-long, 8-foot horseshoe-shaped section, and has a capacity of 450 cubic feet per second. The tunnel discharges water into the Charles H. Boustead Tunnel. The Fryingpan Diversion Dam diverts water into the Fryingpan Siphon under the Fryingpan River to the inlet structure at Charles H. Boustead Tunnel.

Charles H. Boustead Tunnel: The Charles H. Boustead Tunnel conveys all the water collected at the Fryingpan diversion and in the North and South Side Collection Systems under the Continental Divide and into Turquoise Lake. The 10.5-foot-diameter, horseshoe-shaped tunnel is approximately 5.4 miles long. The capacity of the tunnel is 945 cubic feet per second. The Fryingpan Valley control structure at the inlet portal of the tunnel will regulate flows entering the Charles H. Boustead Tunnel. It is a concrete junction structure which contains two overflow weirs, one for each of the collection systems, a baffled apron wasteway drop structure to return the excess flows to the Fryingpan River, a connection and access hatchway structure to receive the flows from the Fryingpan Feeder Conduit, and a control structure housing a 10.5- by 12-foot radial gate. The entire structure is underground.

Mt. Elbert Conduit: Mt. Elbert Conduit will convey project water from Sugar Loaf Dam to the Mt. Elbert Forebay. Water delivered to the forebay will be used for the generation of power in the Mt. Elbert Pumped-Storage Powerplant. At Halfmoon Creek, additional water will be diverted to the conduit for delivery to the Mt. Elbert Forebay. A pipe turnout and conduit will deliver supplemental water from the conduit to the Leadville National Fish Hatchery. The conduit will be a 90-inch-diameter pipe, 10.5 miles long, and designed for a flow of 370 cubic feet per second from Sugar Loaf Dam to the forebay. It will consist of a series of siphon and free-flow conduit reaches. The Halfmoon Diversion Dam will intercept the excess flows of the Halfmoon Creek for diversion to Mt. Elbert Conduit. The diversion dam will consist of a concrete spillway overflow structure, earth wing dike structures, a gated concrete structure to bypass irrigation flows for downstream use, and a heading for a feeder conduit. The Halfmoon Feeder Conduit will be a 60-inch-diameter pipe, 3,202 feet long, and will deliver the flow diverted at Halfmoon Creek to the Mt. Elbert Conduit. Flow capacity of the feeder conduit will be 150 cubic feet per second.

Fountain Valley Conduit: The Fountain Valley Conduit will begin at Pueblo Dam, about 6 miles west of Pueblo, and end near Academy Boulevard, about 2 miles south of Colorado Springs. The conduit will convey approximately 20,100 acre-feet of project water annually to the communities of Stratmoore Hills, Widefield, Security, and Fountain. The Fountain Valley Conduit will be 45 miles long and will range from a 42- to 14-inch-diameter conduit. It will have five pumping plants, two regulating tanks, two surge tanks, and four terminal tanks. The capacity will be 31 cubic feet per second.

Arkansas Valley Conduit: The Arkansas Valley Conduit will convey an estimated average annual requirement of 9,648,000 acre-feet of project water from Pueblo Dam east to 42 organizations and communities in the Arkansas Valley. The length of the conduit will be 218 miles and will range from 42 to 2 inches in diameter. It will contain five pumping plants with three storage tanks and five flow-control structures. The capacity will be 38 cubic feet per second.

Otero Canal: Otero Canal will carry water from Twin Lakes to the Otero Powerplant and the Homestake Turnout near the powerplant intake structure. The canal will be 5.5 miles long; of this, 0.7 mile will be a bench flume, 0.2 mile a pipe siphon, 0.3 mile a tunnel, and the remaining 4.3 miles will be an open trapezoidal concrete-lined canal section. The canal will have a capacity of 725 cubic feet per second.

Mt. Elbert Forebay Dam and Reservoir

Power System

The Mt. Elbert Pumped-Storage Powerplant is on the north shore of picturesque Twin Lakes, approximately 13 miles southwest of Leadville, Colo., at the foot of 14,433-foot Mt. Elbert, Colorado's highest mountain peak. The powerplant was designed with modern architectural lines and is an all-concrete structure equivalent to a 14-story building, although most of the structure is below ground.

Power is generated from water stored in the Mt. Elbert Forebay. The water drops through the penstocks an average of 445 feet, spinning each of two 138,000 horsepower hydroelectric turbine-generators and developing 200,000 kilowatts of electrical power.

To supplement the flow-through water received from Turquoise Lake through the Mt. Elbert Conduit, these generators have been designed to operate as a 170,000-horsepower electric motor which drives the turbines in reverse, and pumps the same water back up to refill the forebay. This pumping mode normally will be used during the very early morning hours, when power demands are low and surplus low-rate power is received from other generating stations. This pump-back storage principle is advantageous since the generating units can be started quickly and adjustments of power output can be made rapidly to respond to varying patterns of daily and seasonal power demands.

Mt. Elbert Forebay Dam and Reservoir

DEVELOPMENT

Early History

The eastern slope area of the project north of the Arkansas River was a part of the Louisiana Purchase in 1803. The remainder of the basin was claimed by Texas following the war with Mexico. Mexican claims to the territory were relinquished in 1845 when Texas entered the Union.

The project area was visited by various Spanish explorers during 1760-80. The first official exploration by the United States was made in 1806-07 by Lieutenant Zebulon Pike. Later explorations were directed by Captain John C. Fremont and Captain John W. Gunnison. The first permanent settlements were not established until after the discovery of gold in 1859-61. With the mining boom came immigrants who turned to agriculture to supply foodstuffs for the expanding population. Large cattle ranches appeared as the result of the cattle drives from Texas.

Investigations

Studies by the Bureau of Reclamation on a transmountain diversion project began in 1936. Intensive investigation started in 1941 resulted in a potential planning report in 1947 and 1948, followed by a special report in 1949 and official recommendations in 1951.

A revised planning report under the name Fryingpan-Arkansas Project in 1953 led to congressional approval of the project. In September 1959, a report that supplemented House Document No. 187, 83d Congress, 1st session, recommended Ruedi Dam and Reservoir instead of the previously recommended Aspen Dam and Reservoir.

Authorization

Construction of the Fryingpan-Arkansas Project was authorized by Public Law 87-590 (77 Stat. 393) signed by the President on August 16, 1962.

Construction

Construction began with Ruedi Dam and Reservoir in 1964, and numerous project features are completed or under construction. Initial project water for irrigation and municipal and industrial use was available in September 1975. Initial power is scheduled in January 1981 (100,000 kilowatts) and an additional 100,000 kilowatts is scheduled to be available in 1983.

Initial project water delivery to Colorado Springs and Fountain Valley towns is scheduled for 1982; for the Arkansas Valley towns, delivery is scheduled for 1985.

Operating Agencies

The Bureau of Reclamation operates and maintains the dams and reservoirs. The recreation and fish and wildlife facilities and resources at Ruedi Reservoir and Turquoise Lake are managed by the Forest Service. At Pueblo Dam and Reservoir, these facilities and resources are under the management of the Colorado Department of Natural Resources.

BENEFITS

Irrigation

Water diverted from the western slope and regulation of the Arkansas River flows will provide supplemental irrigation supplies for 280,600 irrigable areas in the Arkansas Valley. The project will enable farms to sustain and possibly increase the level of present agricultural productivity per acre. It will permit farmers to diversify the crops produced and be more responsive to market demands for food and fiber.

Because of the ability to diversify crops and meet peak demands, the value of total crop production of the Arkansas Valley will be increased. Major crops grown are alfalfa, corn, sorghum, and sugar beets. Specialty crops such as onions, beans, tomatoes, and melons are grown extensively in the valley.

Municipal and Industrial Water

Water for municipal and industrial use will be developed by the project to supplement existing supplies. Two separate water delivery pipeline systems, the Fountain Valley and Arkansas Valley Conduits, will begin at Pueblo Dam and convey water to organizations and communities on the eastern slope.

The cities of Colorado Springs and Aurora have contracted to use the conveyance system of the Fryingpan-Arkansas Project from Turquoise Lake to Clear Creek Reservoir for transportation of municipal water supplies owned by the two cities. Homestake Project water will be pumped by that entity from Clear Creek Reservoir into the Upper South Platte River Basin for delivery to the city water systems.

Chapman Diversion, South Side Collection System

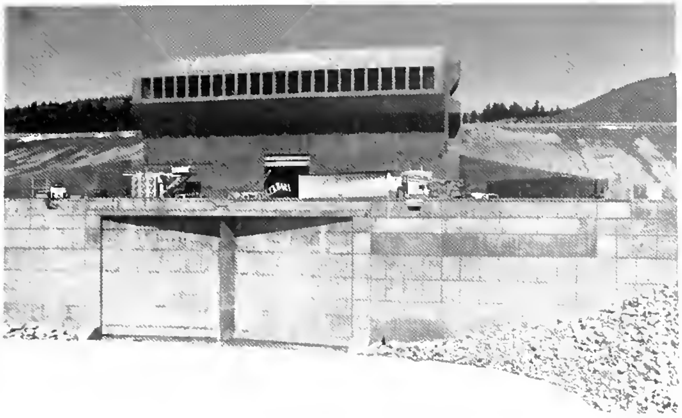
Recreation and Fish and Wildlife

Recreation facilities are being developed throughout the Fryingpan-Arkansas Project by the Bureau of Reclamation in cooperation with the National Park Service, Forest Service, and State and local agencies.

Ruedi Reservoir and the North and South Side Collection Systems are on the western slope, where snow-capped mountain peaks reach over 13,000 feet in elevation and thickly forested slopes provide an exceptionally beautiful background for swimming, boating, water skiing, fishing, picnicking, camping, and general relaxation. The Forest Service is developing and managing these recreation facilities.

Dominant game fish found in the rivers on the western slope include rainbow, brown, cutthroat, and brook trout. Development of Ruedi Dam and Reservoir has increased the available fish habitat in the area. Operation of the dam has exposed about six acres of gravel which now serve as a brown trout spawning ground immediately downstream from the dam. The gravel areas and

South Fork Diversion, South Side Collection System



Mt. Elbert Pumped-Storage Powerplant

regulated streamflow have improved the fishery through increased natural reproduction, and increased recreation opportunities in the immediate area. The most common big game species are deer and elk; black bears are seen occasionally.

Recreation activities at Turquoise Lake include sightseeing, camping, swimming, water skiing, boating, and hunting. Development of the lake has increased the aquatic habitat and surface acreage available for fish. Species in this area include kokanee salmon, and rainbow, brown, and lake trout. Recreation facilities are administered by the Forest Service.

Since the completion of Ruedi Dam and Reservoir, the Turquoise Lake enlargement in 1969, and Pueblo Dam and Reservoir in 1975, 2,051,947 visitor days of recreation have been recorded.

Existing recreation development in the area of Twin Lakes and the Mt. Elbert Forebay and Powerplant complex is water-oriented, with fishing and boating the major activities. Facilities consist of a boat ramp, boat and trailer parking lot, and two parking lots with minimum sanitary facilities. Construction of the Mt. Elbert Conduit will permit delivery of up to 3,000 gallons per minute of high quality water to the Leadville National Fish Hatchery. Dominant big game species are deer and elk, which migrate into the Twin Lakes area each winter and scatter throughout the area during the summer. Elk range north of the lakes in winter. Big and small game hunting in season is allowed in the areas adjacent to Twin Lakes.

Major recreation development planned for Pueblo Reservoir will provide water-oriented recreation in the Arkansas Valley. Facilities are being constructed by the Bureau of Reclamation and managed by the Colorado Department of Natural Resources. North and South Shore boat ramp, marina, parking, and harbor excavations have been completed.

A combination warm water fish hatchery and cold water rearing unit, to be managed and administered by the State of Colorado's Department of Natural Resources, will be constructed downstream from Pueblo Dam. This hatchery will provide most of the fingerlings for stocking Pueblo Reservoir and other reservoirs, streams and lakes within the project.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	280,600	acres
Number of irrigated farms	1,529	

Facilities in Operation[1]

Storage dams	6	
Diversion dams and structures	17	
Canals	4.3	mi
Conduit (includes siphons)	281.6	mi
Powerplants	2	
Transmissions lines	11.6	mi
Switchyards	2	
Substations[1]	2	
Tunnels	27	mi

[1]The facilities data include all project features, either completed, under construction, or proposed.

Climatic Conditions

Annual precipitation	11.6	in
Temperature:		
Maximum	114	°F
Minimum	59	°F
Mean	37-54	°F
Growing season	83-173	days
Elevation of irrigable area	3620-8350.0	ft

Settlement

Number of persons served with project water:	
Rural	64,700
Cities	272,700
Other water service	27,600
Total	365,000

ENGINEERING DATA

Water Supply

Arkansas River

Drainage area near Pueblo Dam	4,686	mi²
Annual discharge:		
Maximum	980,100	acre-ft
Minimum	224,600	acre-ft
Average	519,000	acre-ft
(Does not include water diverted from the western slope.)		

Fryingpan River

Drainage area near Ruedi Dam	226	mi²
Annual discharge:		
Maximum	86,700	acre-ft
Minimum	341,200	acre-ft
Average	195,900	acre-ft

LAKE FORK CREEK

Drainage area near Sugar Loaf Dam	334	mi^2
Average annual discharge	173,000	acre-ft

LAKE CREEK

Drainage area near Twin Lakes Dam	75	mi^2
Average annual discharge	123,900	acre-ft

Storage Facilities

RUEDI DAM

Type: Earth and rockfill
Location: On the Fryingpan River about 15 mi east of Basalt, Colo.
Construction period: 1964-68
Reservoir, Ruedi:

Total capacity to El. 7766	102,369	acre-ft
Active capacity	101,280	acre-ft
Surface area	997	acres
Dimensions:		
Height above streambed	285	ft
Top width	30	ft
Maximum base width	1,453	ft
Crest length	1,042	ft
Crest elevation	7788.0	ft
Total volume (embankment)	3,745,200	yd^3
Spillway: Uncontrolled concrete chute at the right abutment.		
Crest elevation	7766.0	ft
Capacity at El. 7781.8	5,540	ft^3/s
Outlet works: A 10-ft-diameter concrete-lined tunnel through the right abutment, a gate chamber for a 5- by 6-ft high-pressure gate, and an 11-ft concrete-lined horseshoe tunnel with a 76-in-diameter steel pipe controlled by two sets of 3.5- by 4-ft tandem gates.		
Capacity at El. 7781.8	1,810	ft^3/s
Auxiliary outlet works: A 6-ft-diameter concrete-lined tunnel, a chamber for two 2.5- by 2-ft tandem slide gates, and a concrete-lined 5- by 6-ft flat-bottomed tunnel.		
Capacity at El. 7766	600	ft^3/s

SUGAR LOAF DAM

Type: Earth and rockfill
Location: On the Lake Fork of the Arkansas River, approximately 5 mi west of Leadville, Colo.
Construction period: 1965-68
Reservoir, Turquoise Lake:

Total capacity to El. 9869.4	129,432	acre-ft
Active capacity	120,490	acre-ft
Surface area	1,788	acres
Dimensions:		
Height above streambed	135	ft
Top width	30	ft
Maximum base width	810	ft
Crest length	2,020	ft
Crest elevation	9879.0	ft
Total volume (embankment)	1,833,700	yd^3
Spillway: Uncontrolled spillway entrance into concrete conduit.		
Crest elevation	9869.4	ft
Capacity at El. 9872.8	2,920	ft^3/s
Outlet works: An 11-ft concrete conduit, controlled by a 1- by 6-ft high-pressure gate and four 3.5-ft-square high-pressure gates.		
Capacity at El. 9872.8	1,120	ft^3/s

PUEBLO DAM

Type: Earthfill dam with massive concrete buttresses with overflow section
Location: On the Arkansas River 6 mi west of Pueblo, Colo.
Construction period: 1970-75
Reservoir, Pueblo:

Total capacity to El. 4898.7	357,000	acre-ft
Active capacity	234,000	acre-ft
Surface area	4,646	acres
Dimensions:		
Height above streambed	191	ft
Top width	30	ft
Maximum base width	1,040	ft
Crest length	10,200	ft
Crest elevation	4925.0	ft
Total volume:		
Concrete	540,000	yd^3
Embankment	12,000,000	yd^3
Excavation	2,800,000	yd^3
Spillway: An uncontrolled, overflow type spillway crest is provided with converging training wall and a concrete flip bucket.		
Crest length	550	ft
Crest elevation	4898.7	ft
Capacity at El. 4919	191,500	ft^3/s
Outlet works: Has three 6- by 6.5-ft steel-lined concrete conduits located in the spillway buttresses 9, 11, and 13, with one 13.4- by 11.1-ft bulkhead gate and six 6.5-by 6.0-ft high-pressure slide gates. Also one 4-ft-square stainless steel-lined concrete conduit located in the river gorge area with a 9.8- by 7.4-ft bulkhead gate and two 4-ft-square high-pressure slide gates. Near buttress 8 are four mortar-lined steel conduits which converge to one conduit with only one sliding bulkhead gate, 5.3 by 6.4 ft, and a single level conduit intake located in buttress 7. There are three 4-ft-diameter conduits, and one 4-ft-diameter concrete conduit with one sliding bulkhead gate, 8.6 by 8.9 ft, and four 4-ft butterfly gates, plus a 9.5- by 8.4-ft concrete horseshoe-shaped conduit with four 3.5-ft-square high-pressure slide gates.		
Total capacity of the seven outlet works	5,767	ft^3/s

MT. ELBERT FOREBAY DAM

Type: Earthfill
Location: In Lake County approximately 12 mi southwest of Leadville, Colo.
Construction period: 1977- (Under construction)
Reservoir, Mt. Elbert Forebay:

Total capacity to El. 9645.7	11,530	acre-ft
Active capacity	7,160	acre-ft
Surface area	279	acres
Dimensions:		
Structural height	92	ft
Top width	30	ft
Maximum base width	500	ft
Crest length	2,600	ft
Total volume	3,101,000	yd^3
Inlet-outlet works: A concrete inlet-outlet structure which separates into two 15-ft steel penstock pipes.		
Capacity at El. 9645.7	3,590	ft^3/s

TWIN LAKES DAM

Type: Earthfill
Location: On Lake Creek approximately 13 mi south of Leadville, Colo.
Construction period: 1978- (Under construction)
Reservoir, Twin Lakes:

Total capacity to El. 9200	141,000	acre-ft
Active capacity	68,000	acre-ft
Surface area	2,805	acres
Dimensions:		
Height above streambed	53	ft
Top width	30	ft
Maximum base width	300	ft
Crest length	3,150	ft
Crest elevation	9210.0	ft
Total volume:		
Embankment	624,000	yd³
Excavation	590,000	yd³

Spillway: Uncontrolled spillway entrance into a concrete conduit. (40-ft-diameter morning glory)

Crest elevation	9200.0	ft
Capacity at El. 9202.3	1,400	ft³/s

Outlet works: A 12-ft-diameter steel-lined conduit with a gate chamber and 16.75-ft horseshoe conduit with a 12-ft-diameter steel outlet pipe to a bifurcation structure with one 9- by 12-ft outlet gate and two 6.5- by 8-ft high-pressure gates.

Capacity at El. 9202.3	3,465	ft³/s

CLEAR CREEK DAM

Type: Earthfill
Location: On Clear Creek about 14 mi northwest of Buena Vista, Colo.
Construction period: Proposed
Reservoir, Clear Creek:

Total capacity to El. 8875	8,924	acre-ft
Active capacity	1,116	acre-ft
Surface area	382	acres
Dimensions:		
Height above streambed	75	ft
Top width	25	ft
Maximum base width	450	ft
Crest length	2,200	ft
Crest elevation	8885.0	ft
Total volume (embankment)	60,000	yd³

Spillway: Controlled spillway with four 8-ft high-pressure slide gates.

Crest elevation	8859.0	ft
Capacity at El. 8881.2	5,865	ft³/s

Diversion Facilities

CHAPMAN DIVERSION DAM

Location: On the Chapman Gulch, to divert water into Chapman Tunnel.
Construction period: 1965-71

Dimensions:		
Height above streambed	9	ft
Weir crest length	20	ft
Weir crest elevation	10,038.23	ft

Spillway: Concrete gravity spillway with retaining walls in combination with an earth embankment.

Capacity	810	ft³/s

Sluiceway: One 5- by 6-ft cast iron slidegate with pedestal lift, and one 5-ft-wide overflow section.
Headworks: Four 4-ft-square cast iron slide gates with pedestal lifts.

Capacity	300	ft³/s

SOUTH FORK DIVERSION DAM

Location: On the South Fork of the Fryingpan River, about 7.5 mi south of Norrie, Colo.
Construction period: 1965-71

Dimensions:		
Height above streambed	8	ft
Weir crest length	20	ft
Weir crest elevation	10,003.0	ft

Spillway: Concrete gravity with retaining walls in combination with earth embankment.

Capacity	740	ft³/s

Sluiceway: A 5-ft-square cast iron slidegate with a pedestal lift, and 5-ft-wide overflow section adjacent to gate structure.
Headworks: Four 3.5-ft-square cast iron slidegates with pedestal lifts.

Capacity	215	ft³/s

FRYINGPAN DIVERSION DAM

Location: On the Fryingpan River, 9 mi south of Norrie, Colo.
Construction period: 1965-71

Dimensions:		
Height above streambed	9	ft
Weir crest length	25	ft
Weir crest elevation	9961.9	ft

Spillway: Concrete gravity with retaining walls in combination with earth embankment.

Capacity	1,100	ft³/s

Sluiceway: One 5- by 6-ft cast iron slide gate with pedestal lift, with 5-ft overflow section adjacent to gate.
Headworks: Four 5- by 4-ft cast iron slide gates with pedestal lifts.

Capacity	400	ft³/s

IVANHOE DIVERSION DAM

Location: On the Ivanhoe Creek approximately 7 mi east of Norrie, Colo.
Construction period: 1973-76

Dimensions:		
Height above streambed	10	ft
Weir crest length	20	ft
Weir crest elevation	10,008.8	ft

Spillway: Concrete gravity, with a retaining wall in combination with a Parshall flume.

Capacity	605	ft³/s

Sluiceway: One 3-ft-square cast iron slide gate with pedestal lifts.
Headworks: Two 4-ft-square cast iron slide gates with pedestal lifts.

Capacity	150	ft³/s

LILY PAD DIVERSION INLET

Location: 9.5 miles southeast of Norrie, Colo.; diverts water into the Nast Tunnel.
Construction period: 1970-73

Dimensions:		
Interceptor ditch length	230	ft
Crest elevation	10,207.0	ft

Spillway: Dike, formed by an interceptor ditch, to drop inlet

Capacity	20	ft³/s

Sluiceway: A 2-ft-diameter cast iron slide gate covers a 2-ft-diameter precast concrete sluiceway pipe.
Headworks: 5- by 2.5-ft steel slide gate with a pedestal lift.

Capacity	20 ft³/s

Halfmoon Diversion Dam

Location: On Halfmoon Creek, 9 mi southwest of Leadville, Colo.
Construction period: 1977- (Under construction)
Dimensions:

Height of structure	15 ft
Spillway overflow crest length	50 ft
Spillway overflow crest elevation	9715.5 ft

Sluiceway: One 5- by 3-ft cast iron slide gate with pedestal lift.
Headworks: One 5-ft-square cast iron slide gate with pedestal lift.

Capacity	510 ft³/s

Spillway: Concrete gravity

Capacity	150 ft³/s

North Cunningham Diversion Structure

Location: On Cunningham Creek about 6 mi east of Norrie Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height of structure	12 ft
Inlet size	6 by 10 ft
Inlet elevation	10,084.36 ft

Sluiceway: One 1-ft-square cast iron slide gate with flush bottom opening, motor-operated lift stem.
Headworks: One 2.5-ft-square cast iron slide gate, motor-operated lift and stem.

Capacity	30 ft³/s

Spillway: An embankment dike, which flows into concrete drop inlet.

Capacity	30 ft³/s

Carter Creek Diversion Structure

Location: On Carter Creek, 7 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	8 ft
Weir crest length	25 ft
Total crest length	50 ft
Weir crest elevation	10,130.25 ft

Spillway: Gated structure leading to an overflow weir.

Capacity	100 ft³/s

Sluiceway: 7- by 8.5-ft cast iron radial gate, a 24-in-diameter concrete pipe bypass, and a 2-ft-square cast iron slide gate.
Headworks: A 5-ft-square cast iron slide gate with pedestal and stem hoist.

Capacity	100 ft³/s

Sawyer Diversion Structure

Location: On Sawyer Creek, 4.5 miles south of Norrie, Colo.
Construction period: 1970-73
Dimensions:

Height above streambed	6 ft
Weir crest length	20 ft
Total crest length	20 ft
Weir crest elevation	10,084.5 ft

Spillway: Dike embankment with a concrete inlet.

Capacity	30 ft³/s

Sluiceway: One 5-ft-diameter cast iron slide gate with a nonprojecting lift.
Headworks: One 2.5-ft-diameter cast iron slide gate with a nonprojecting lift.

Capacity	30 ft³/s

Midway Creek Diversion Structure

Location: On Midway Creek, 7 mi east of Aspen, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Inlet size	10 ft
Overflow weir length	20 ft
Diversion elevation	10,186.7 ft
Overflow weir length	50 ft
Weir crest elevation	10,190.2 ft

Spillway: A gated structure with an 8-ft diversion channel leading to an 8-ft-diameter vertical shaft.

Capacity	85 ft³/s

Sluiceway: One 10- by 12-ft cast iron radial gate with a walled channel.
Headworks: One 5-ft-square cast iron slide gate with motor-operated lift and stem.

Capacity	85 ft³/s

Middle Cunningham Diversion Structure

Location: On Cunningham Creek, 5.5 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	10 ft
Inlet length	25 ft
Diversion length	40 ft
Diversion elevation	10,042.5 ft

Spillway: A gated structure with a 5-ft-square diversion channel leading to a vertical shaft.

Capacity	50 ft³/s

Sluiceway: One 5- by 9-ft cast iron radial gate into a walled channel.
Headworks: 4-ft-square cast iron slide gate, with motor-operated lift and stem, to a 30-in feeder conduit.

Capacity	50 ft³/s

Mormon Creek Diversion Structure

Location: On Mormon Creek, 6.5 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	10 ft
Inlet size	5 by 5 ft
Overflow weir length	15 ft
Diversion elevation	10,092.0 ft
Weir length	25 ft
Weir crest elevation	10,094.65 ft

Spillway: A gated structure with a 5-ft-square diversion channel.

Capacity	60 ft³/s

Sluiceway: One 5- by 10-ft cast iron radial gate.
Headworks: One 4-ft-square cast iron slide gate with a motor-operated lift and stem, to one 3-ft-diameter feeder conduit.

Capacity	60 ft³/s

No Name Creek Diversion Structure

Location: On No Name Creek, 5.5 mi east of Aspen, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	13	ft
Diversion elevation	10,167.0	ft
Weir length	26	ft
Weir crest elevation	10,170.5	ft

Spillway: A gated structure with a 7- by 8-ft diversion channel to a vertical shaft.

Capacity	95	ft³/s

Sluiceway: One 8- by 12-ft cast iron radial gate.
Headworks: One 5-ft-square cast iron slide gate with motorized stem and hoist.

Capacity	95	ft³/s

Hunter Creek Diversion Structure

Location: On Hunter Creek, 7.5 mi east of Aspen, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height of shaft	52	ft
Drop inlet size (diameter)	12	ft
Top of inlet (elevation)	10,175.5	ft
Weir crest length (headworks)	30	ft
Weir crest elevation (headworks)	10,179.0	ft
Weir crest length (sluiceway)	60	ft
Weir crest elevation (sluiceway)	10,182.5	ft

Spillway: A gated structure with a 5- by 8-ft diversion channel to a vertical shaft.
Sluiceway: One 8- by 10-ft cast iron radial gate.
Headworks: One 6-ft-square cast iron slide gate with motorized stem and hoist.

Capacity	140	ft³/s

North Fork Diversion Structure

Location: On the North Fork, 7 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	13	ft
Weir crest length	10	ft
Weir crest elevation	10,211.9	ft

Spillway: A concrete inlet with a dike embankment.

Capacity	30	ft³/s

Sluiceway: Overflow, one 2-ft-square cast iron slide gate with pedestal lift.
Headworks: One 2.5-ft-square cast iron slide gate and diversion channel to the intake of Carter Tunnel.

Capacity	30	ft³/s

South Cunningham Creek Diversion Structure

Location: On South Cunningham Creek, 5.5 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)
Dimensions:

Height above streambed	12	ft
Weir crest length	8	ft
Inlet elevation	10,534.0	ft

Spillway: A concrete inlet with dike embankment.

Capacity	20	ft³/s

Sluiceway: Overflow, one 2-ft-square cast iron slide gate and with pedestal lift.
Headworks: One 2.5-ft-square cast iron slide gate with pedestal lift and stem.

Capacity	20	ft³/s

Carriage Facilities

Mormon Tunnel

Location: 7 mi east of Norrie, Colo.
Construction period: 1976- (Under construction)

Length	1.4	mi
Capacity	190	ft³/s

Cross section: Horseshoe

Diameter	8 and 8.25	ft

Lining: Concrete and shotcrete

Cunningham Tunnel

Location: 5.5 mi east of Norrie, Colo.
Construction period: 1974-76

Length	2.9	mi
Capacity	270	ft³/s

Cross section: Horseshoe

Diameter	7.5 and 8.75	ft

Lining: Concrete and shotcrete

Nast Tunnel

Location: 6 mi southeast of Norrie, Colo.
Construction period: 1970-74

Length	3	mi
Capacity	360	ft³/s

Cross section: Circular

Diameter	7.67 and 9.33	ft

Lining: Concrete and shotcrete

Chapman Tunnel

Location: 5 mi south of Norrie, Colo., on Chapman Gulch.
Construction period: 1965-71

Length	2.8	mi
Capacity	300	ft³/s

Cross section: Horseshoe

Diameter	7	ft

Lining: Concrete

South Fork Tunnel

Location: 7 mi south of Norrie, Colo., on South Fork Creek.
Construction period: 1965-71

Length	3.1	mi
Capacity	450	ft³/s

Cross section: Horseshoe

Diameter	8	ft

Lining: Concrete

Carter Tunnel

Location: 7 mi northeast of Norrie, Colo., on Carter Creek.
Construction period: 1976- (Under construction)

Length	0.54	mi
Capacity	100 and 130	ft³/s

Cross section: Horseshoe

Diameter	8	ft

Lining: Concrete and shotcrete

CHARLES H. BOUSTEAD TUNNEL

Location: About 5 mi southeast of Norrie, Colo., on the Fryingpan River.
Construction period: 1965-71
Length .... 5.4 mi
Capacity .... 945 ft³/s
Cross section: Horseshoe
Diameter .... 10.5 ft
Lining: Concrete

HUNTER TUNNEL

Location: 5 mi east of Aspen, Colo., on No Name Creek.
Construction period: 1970- (Under construction)
Length .... 7.6 mi
Capacity .... 90, 175, and 270 ft³/s
Cross section: Semihorseshoe, horseshoe
Diameter .... 8.5 and 7.33 ft
Lining: Concrete and shotcrete

GRANITE ADIT

Location: 3 mi southeast of Nast, Colo.
Construction period: 1970-74
Length .... 0.14 mi
Capacity .... 50 ft³/s
Cross section: Horseshoe
Diameter .... 7.67 and 9.33 ft
Lining: Concrete and shotcrete

FRYINGPAN CONDUIT

Location: 9 mi southeast of Norrie, Colo., between Nast Tunnel and South Side Collection System.
Construction period: 1970-73
Length .... 0.47 mi
Capacity .... 360 ft³/s
Cross section: Circular
Diameter .... 7 ft

SAWYER CONDUIT

Location: 4 mi south of Norrie, Colo., between Sawyer Creek and Hunter Tunnel.
Construction period: 1970-73
Length .... 0.59 mi
Capacity .... 30 ft³/s
Cross section: Circular
Diameter .... 2.25 ft

CHAPMAN FEEDER CONDUIT

Location: 5 mi south of Norrie, Colo., between Chapman Diversion Dam and the Chapman Tunnel.
Construction period: 1970-73
Length .... 0.05 mi
Capacity .... 300 ft³/s
Cross section: Rectangular
Size .... 8.33 by 11.00 ft
Type: Concrete

MT. ELBERT CONDUIT

Location: 4 mi west of Leadville, Colo., in Lake County from Turquoise Lake to Mt. Elbert Forebay.
Construction period: 1977- (Under construction)
Length .... 10.5 mi
Capacity .... 370 ft³/s
Cross section: Circular
Diameter .... 7.5 ft

MORMON CONDUIT

Location: 7 mi east of Norrie, Colo., between the Carter Tunnel and Mormon Tunnel.
Construction period: 1976- (Under construction)
Length .... 0.33 mi
Capacity .... 130 ft³/s
Cross section: Circular
Diameter .... 3.75 ft

CUNNINGHAM CONDUIT

Location: 5.5 mi east of Norrie, Colo., between Mormon Tunnel and Cunningham Tunnel.
Construction period: 1976- (Under construction)
Length .... 0.8 mi
Capacity .... 220 ft³/s
Cross section: Circular
Diameter .... 5 ft

SOUTH FORK FEEDER CONDUIT

Location: 7 mi south of Norrie, Colo., between Chapman Tunnel and South Fork Tunnel.
Construction period: 1970-73
Length .... 0.07 mi
Capacity .... 215 ft³/s
Cross section: Rectangular
Size .... 7.5 by 9.0 ft
Type: Concrete

FRYINGPAN FEEDER CONDUIT

Location: 8.5 mi southeast of Norrie, Colo., between South Fork Tunnel and Charles H. Boustead Tunnel.
Construction period: 1970-73
Length .... 0.06 mi
Cross section: Rectangular
Capacity .... 400 ft³/s
Size .... 9.25 by 13.0 ft
Type: Concrete

IVANHOE FEEDER CONDUIT

Location: 6 mi east of Norrie, Colo., between Cunningham Tunnel and Nast Tunnel.
Construction period: 1975-76
Length .... 0.05 mi
Capacity .... 150 ft³/s
Cross section: Circular
Diameter .... 7 ft
Type: Concrete

SOUTH CUNNINGHAM CONDUIT

Location: 5.5 miles east of Norrie, Colo., between Cunningham Tunnel and Nast Tunnel.
Construction period: 1976- (Under construction)
Length .... 0.4 mi
Capacity .... 20 ft³/s
Cross section: Circular
Diameter .... 1.5, 1.75, and 2 ft
Type: Precast concrete pressure pipe

MT. ELBERT PUMPED-STORAGE POWERPLANT PENSTOCKS

Location: 13 mi southwest of Leadville, Colo., between Mt. Elbert Forebay and Mt. Elbert Powerplant on Twin Lakes Reservoir.
Construction period: 1972- (Under construction)

Length (each)	0.57	mi
Capacity (each)	3,590	ft^3/s

Cross section: Circular

Diameter (two)	15	ft

Type: Steel pipe

FOUNTAIN VALLEY CONDUIT

Location: 6 mi west of Pueblo, Colo., to 2 mi. south of Colorado Springs, Colo.
Construction period: (Construction pending issuance of specifications)

Length	45	mi
Capacity	31	ft^3/s
Diameter	42 to 14	in

ARKANSAS VALLEY CONDUIT

Location: From Pueblo Dam to the Arkansas Valley.
Construction period: Proposed

Length	218	mi
Capacity	38	ft^3/s
Diameter	42 to 2	in

OTERO CANAL

Location: From Twin Lakes to the Otero Powerplant and the Homestake Turnout.
Construction period: Proposed

Length[2]	5.5	mi
Capacity	725	ft^3/s

[2]0.7 mi (bench flume), 0.2 mi (pipe siphon), 0.3 mi (tunnel), 4.3 mi (open trapezoidal concrete-lined canal).

Power Facilities

MT. ELBERT PUMPED-STORAGE POWERPLANT

Location: In Lake County, approximately 13 mi southwest of Leadville, Colo., on the north shore of Twin Lakes.
Construction period: 1972- (Under construction)

Nameplate capacity	200	MW
Number and capacity of generators .. (2)	100	MW
Maximum head	477	ft

OTERO POWERPLANT

Location: In Chaffee County on Clear Creek Reservoir about 14 mi northwest of Buena Vista, Colo.
Construction period: Feasibility

Nameplate capacity	11	MW
Number and capacity of generators .. (1)	11	MW
Maximum head	270	ft

SUBSTATIONS AND SWITCHYARDS

Substations	2	
Switchyards	2	
Total capacity of transformers	284,800	kVA

TRANSMISSION LINES

Total number of lines	3
Total circuit miles	11.6

DESIGNATION

Mt. Elbert Pumped-Storage Powerplant to Mt. Elbert Switchyard:

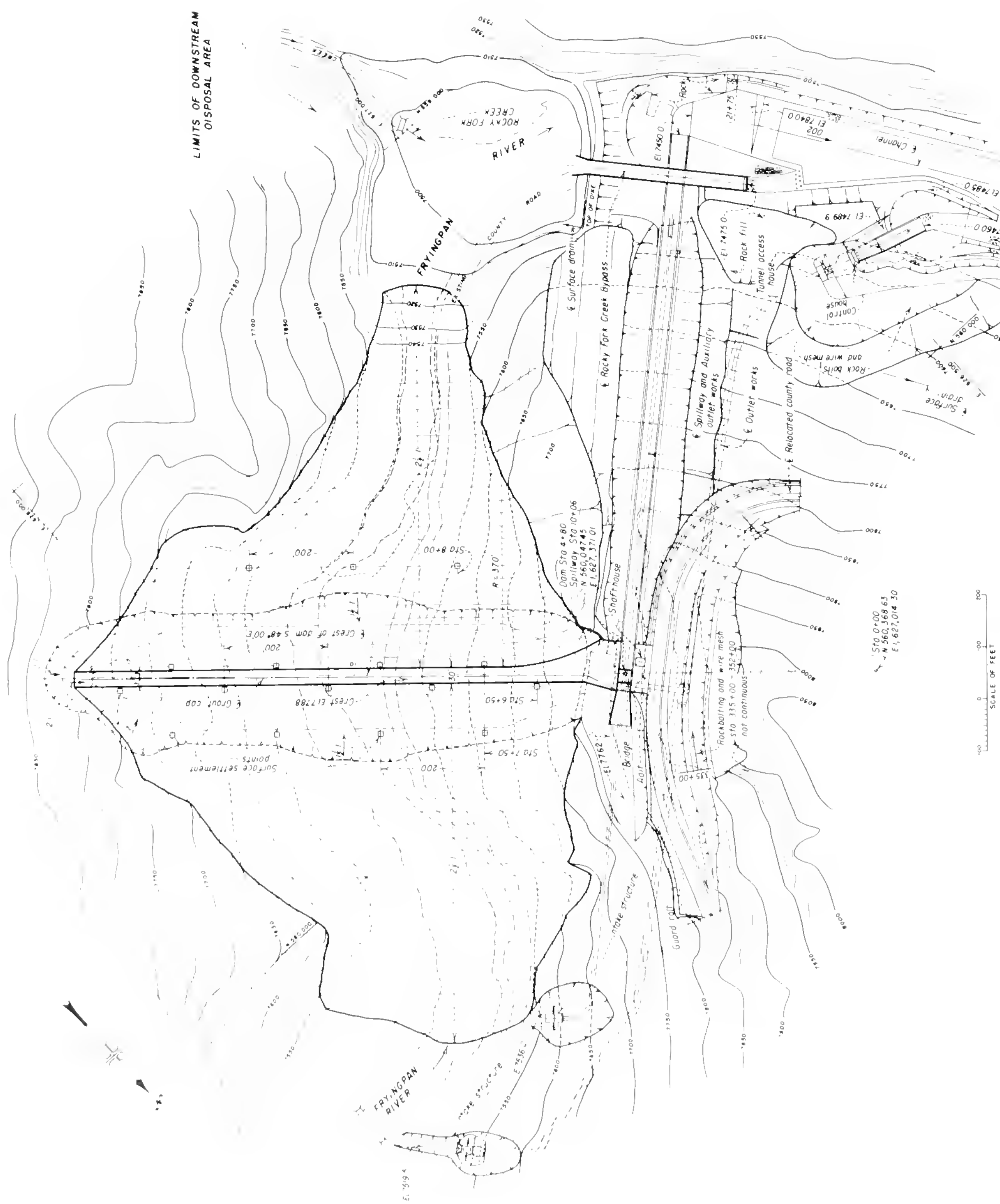
Voltage	230	kV
Power	447,120 kW at 0.9	P.F.
Circuit miles	1	

Mt. Elbert Switchyard to Malta Substation:

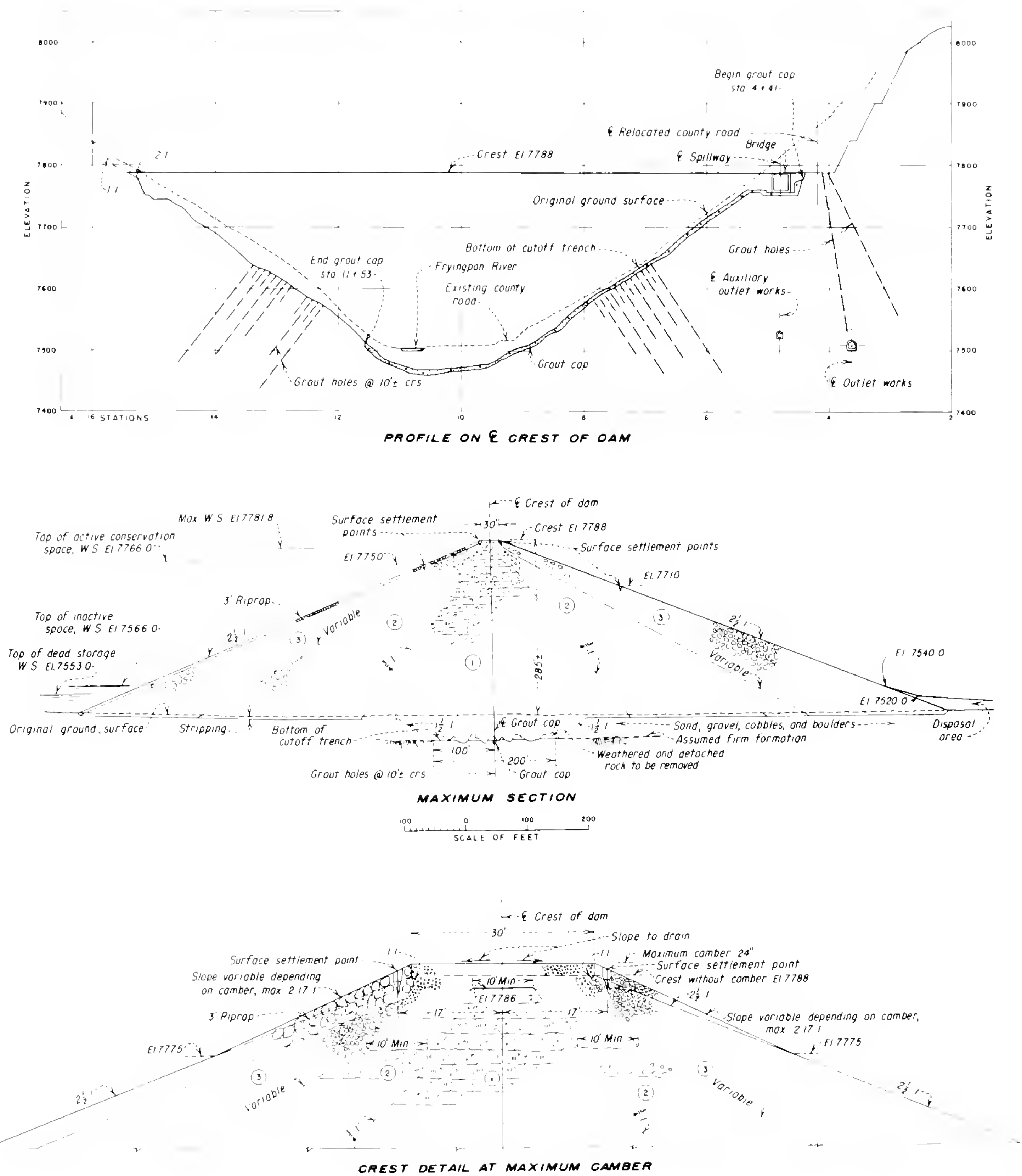
Voltage	230	kV
Power	312,130 kW at 0.9	P.F.
Circuit miles	7.6	

Otero Switchyard to the Malta-Poncha 115 kV line:

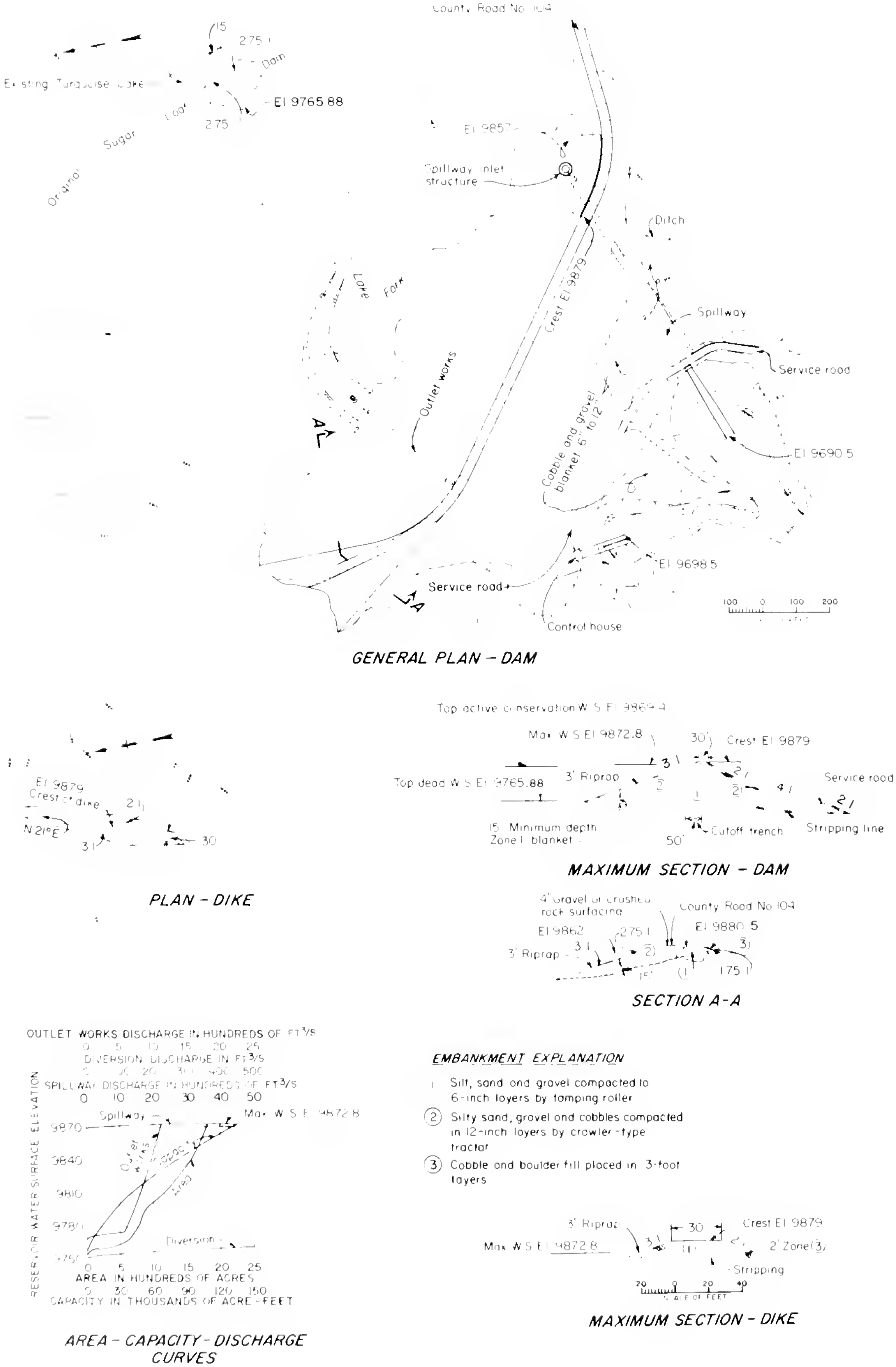
Voltage	115	kV
Circuit miles	3	



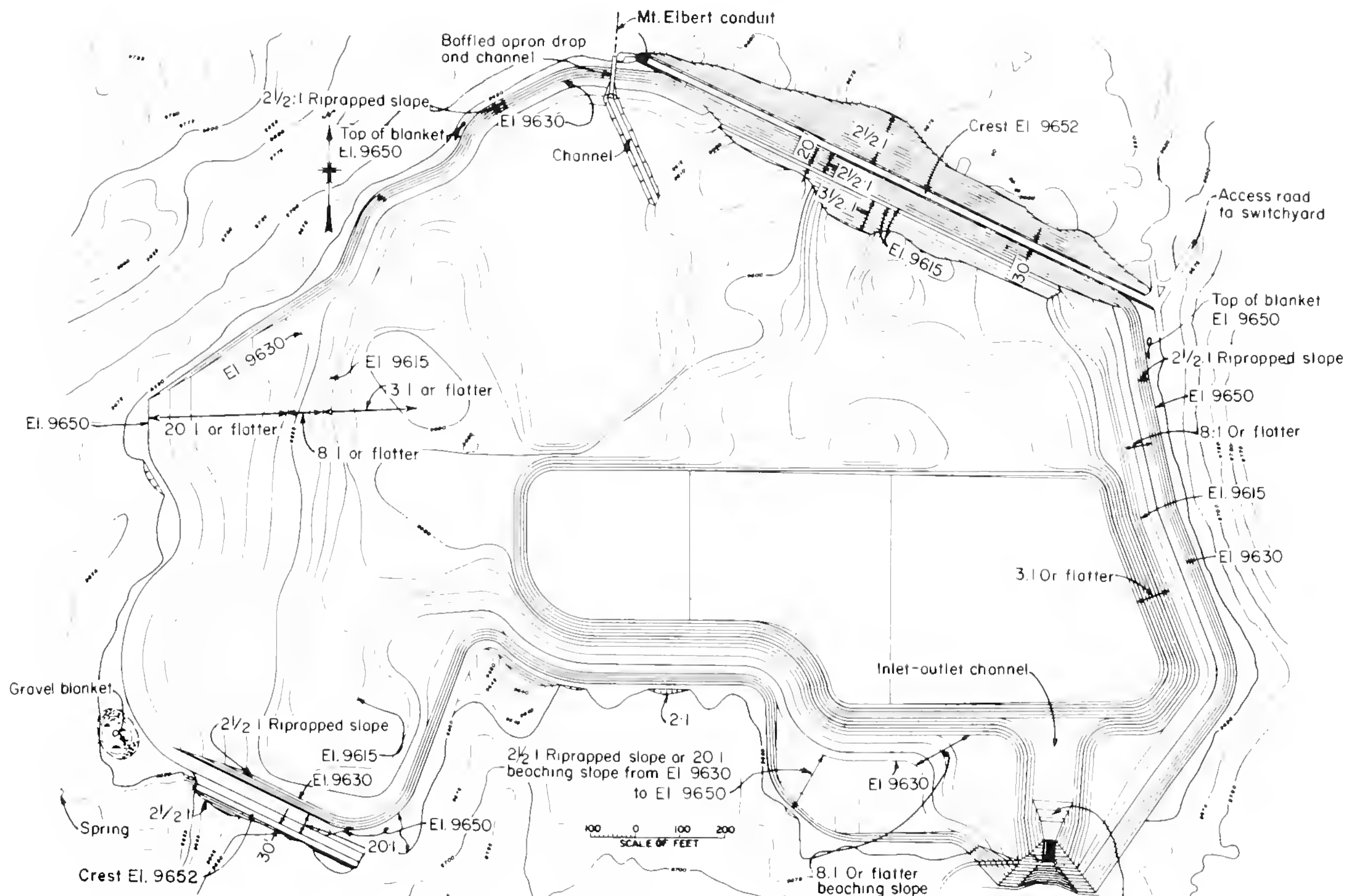
Ruedi Dam, Plan



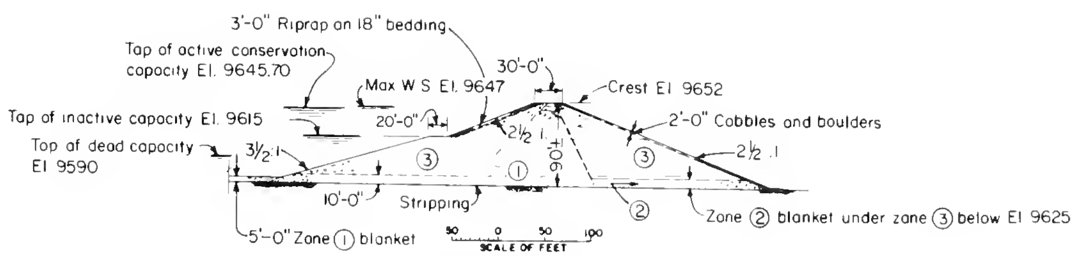
Ruedi Dam, Sections



Sugar Loaf Dam, Plan and Sections



GENERAL PLAN



MAXIMUM SECTION

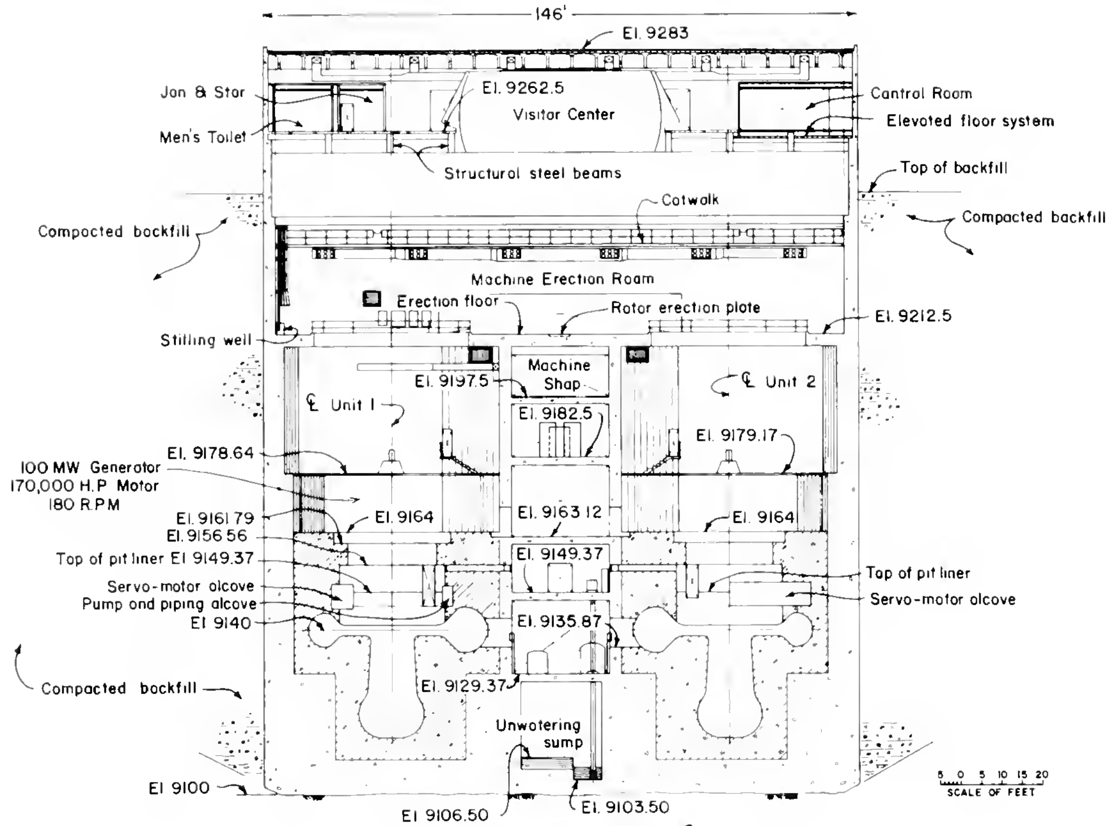
EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.

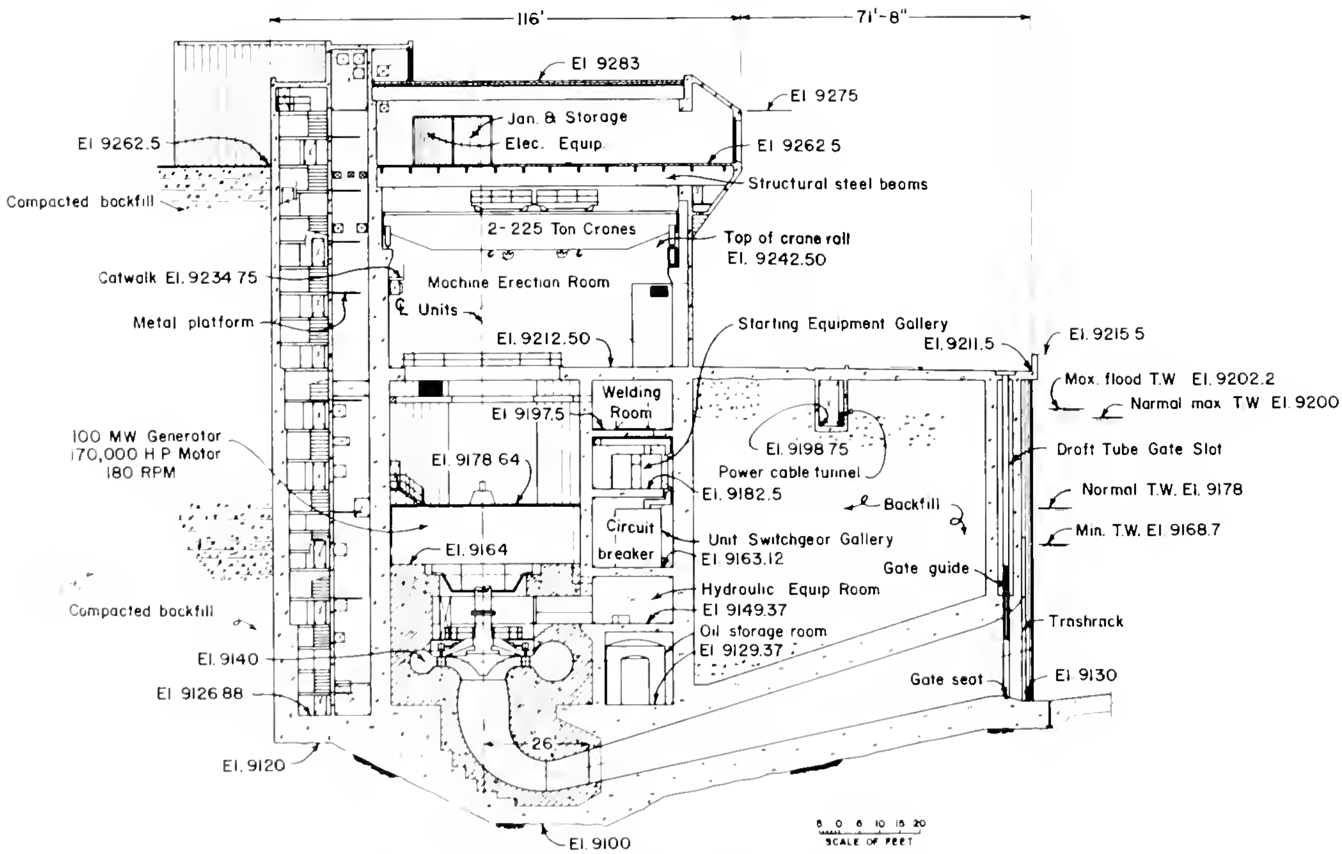
② Selected sand, gravel, and cobbles compacted by rubber-tired rollers to 12-inch layers.

③ Miscellaneous clay, silt, sand, gravel and cobbles compacted by rubber-tired rollers to 12-inch layers.

Mt. Elbert Forebay Dam, Plan and Section

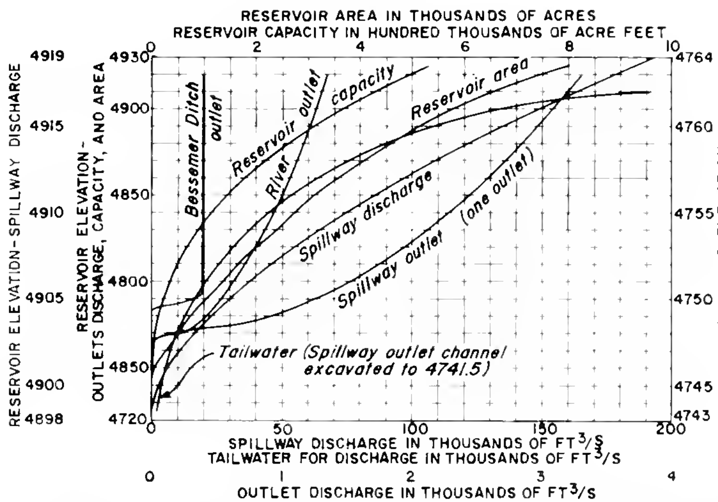


LONGITUDINAL SECTION THRU ℄ UNITS

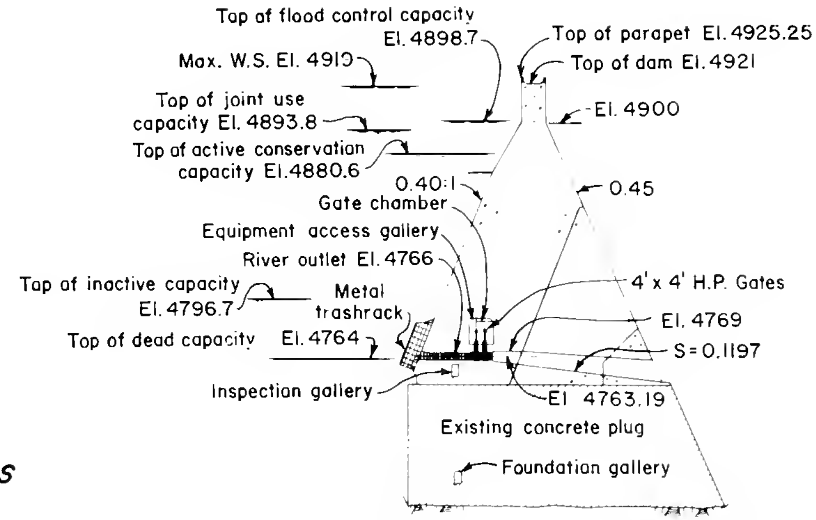


TRANSVERSE SECTION THRU ℄ UNIT 1

Mt. Elbert Pumped-Storage Powerplant, Sections



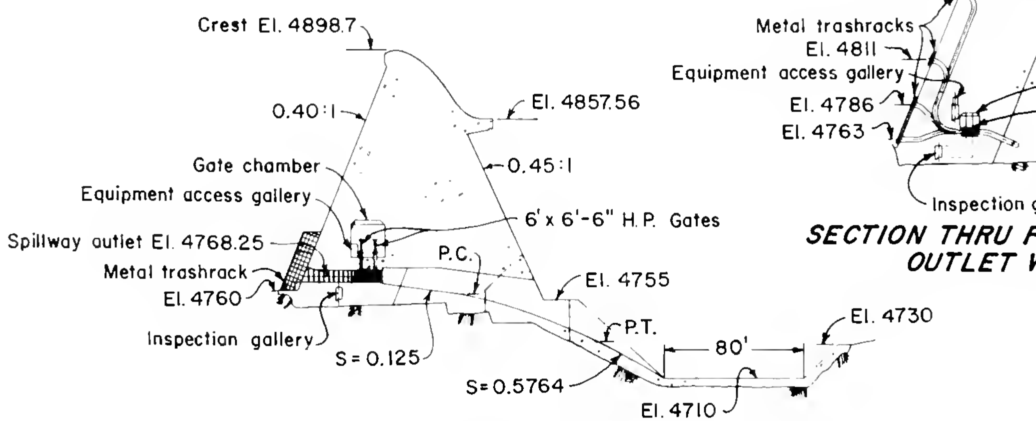
TAILWATER, AREA, CAPACITY, AND DISCHARGE CURVES



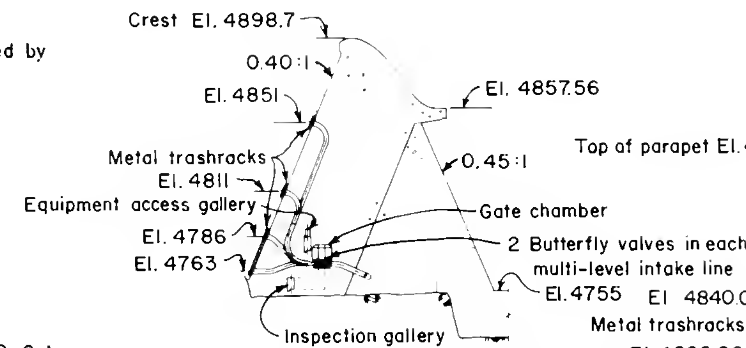
SECTION THRU RIVER OUTLET WORKS

EMBANKMENT EXPLANATION

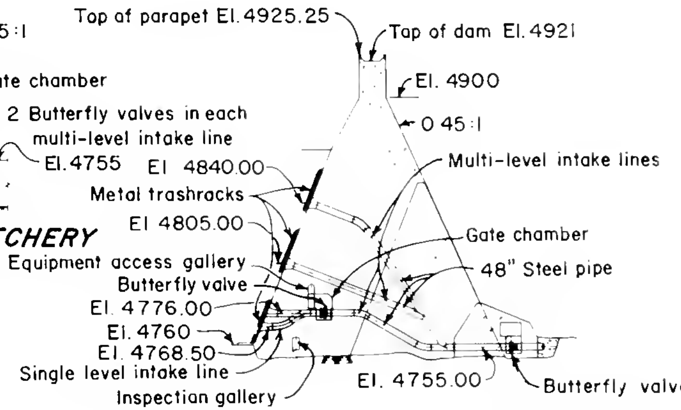
1. Clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
2. Sand, gravel, and cobbles compacted by crawler-type tractors to 12-inch layers.
3. Miscellaneous formation material compacted by tamping rollers to 6-inch layers.



SECTION THRU SPILLWAY OUTLET WORKS AND STILLING BASIN

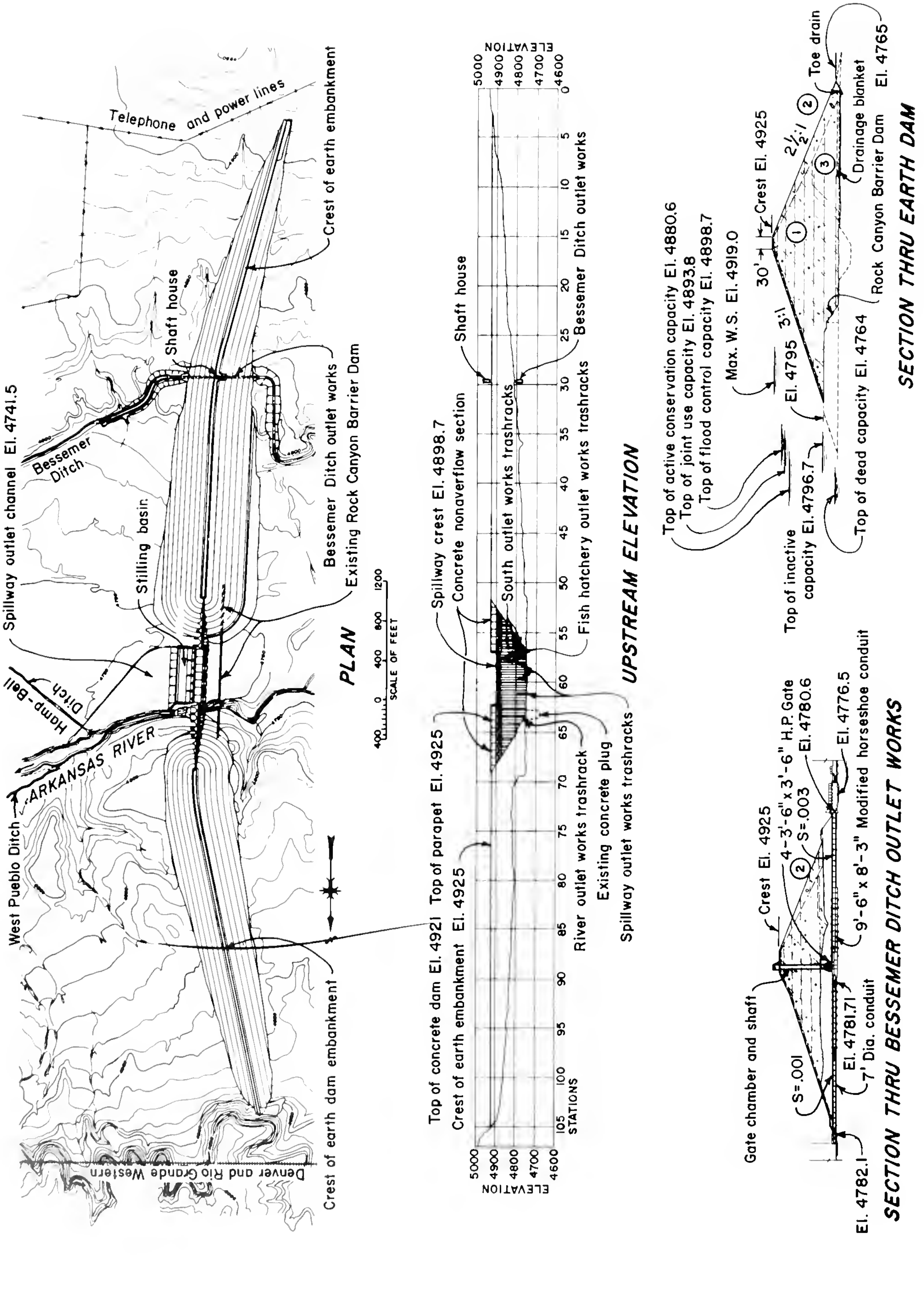


SECTION THRU FISH HATCHERY OUTLET WORKS



SECTION THRU SOUTH OUTLET WORKS

Pueblo Dam, Sections

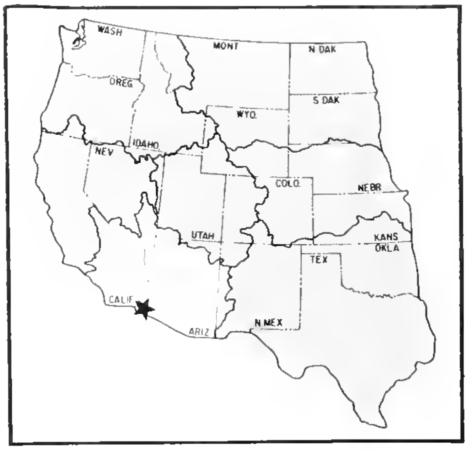


Pueblo Dam, Plan and Sections

Gila Project

Arizona: Yuma County

Lower Colorado Region
Water and Power Resources Service



The Gila Project, located in southwestern Arizona, is divided into two divisions. The Wellton-Mohawk Division begins about 12 miles east of the city of Yuma and continues upstream on both sides of the Gila River for about 45 miles. The Yuma Mesa Division is subdivided into three units; the Mesa Unit, located south and southeast of Yuma, and the North and South Gila Valley Units, which lie northeast and east of Yuma.

Upon full development, the project could provide irrigation service to 65,000 acres in the Wellton-Mohawk Division (this acreage was reduced from 75,000 acres by the Colorado River Basin Salinity Control Act of 1974) and 40,000 acres in the Yuma Mesa Division, which includes 15,000 acres in the North Gila and South Gila Valleys. The project authorization limits diversions from the Colorado River for beneficial consumptive use to 600,000 acre-feet annually, with the quantity divided equally between the Wellton-Mohawk and the Yuma Mesa Divisions.

Project features include the Gila desilting works at Imperial Dam, the Gila Gravity Main Canal, the Mesa Unit Canals and distribution system, the lateral system in the North Gila Valley (originally constructed as part of the Yuma Project), the canal and pipeline distribution in the South Gila Valley, and the Wellton-Mohawk Canal distribution and drainage systems and protective works.

Yuma Mesa Pumping Plant and Gila Substation

PLAN

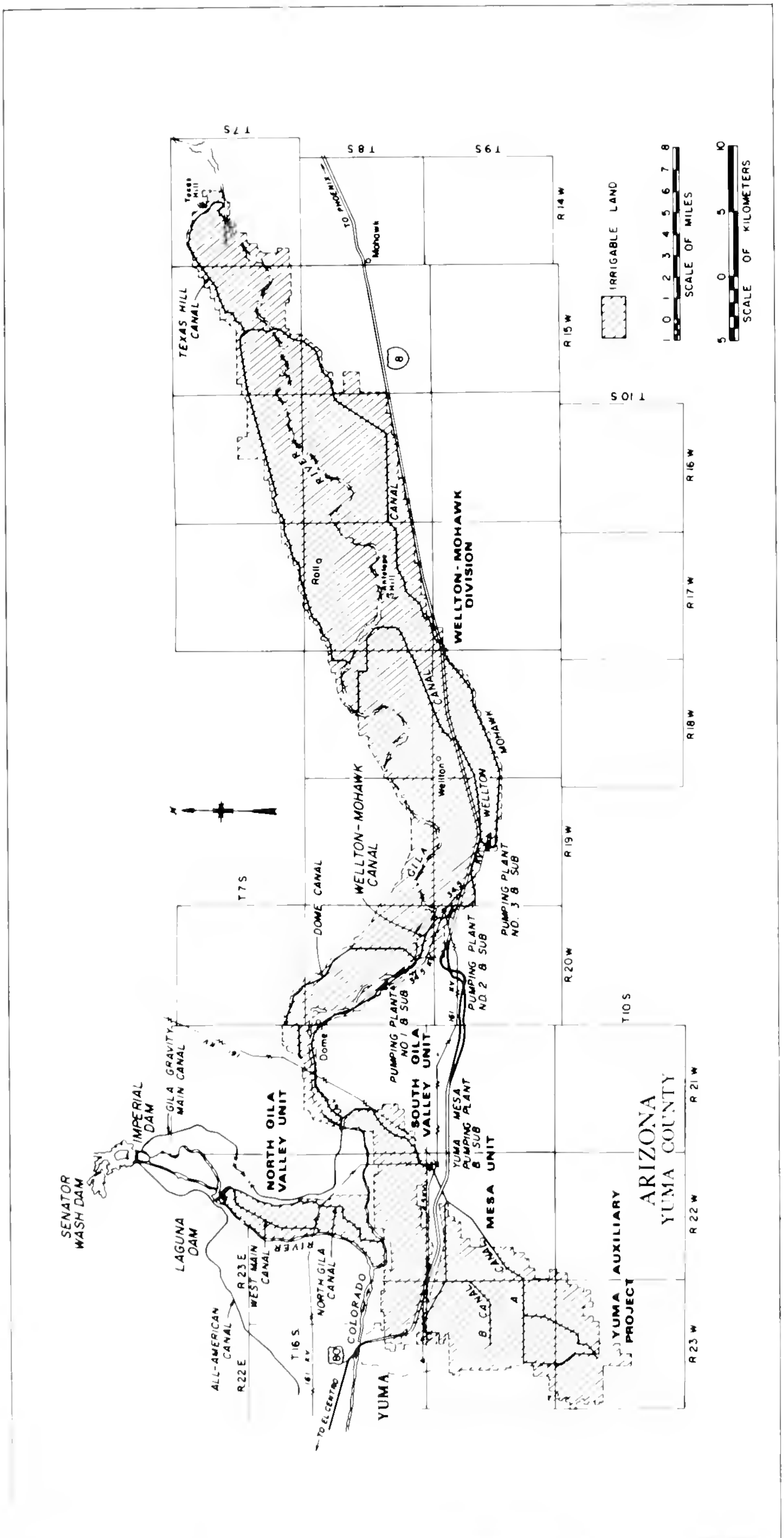
Imperial Dam, which also serves the All-American Canal system of the Boulder Canyon Project, diverts Colorado River water at its east abutment through the desilting basin into the Gila Gravity Main Canal. From turnouts in this canal, irrigation water is diverted to serve the North and South Gila Valleys and the Wellton-Mohawk area. The canal ends at the Yuma Mesa Pumping Plant, where water is lifted 52 feet to the head of the Yuma Mesa distribution system which conveys irrigation water to the Mesa Unit lands and to the Yuma Auxiliary Project.

Imperial Dam

(See All-American Canal System.)

Gila Canal Headworks and Gravity Main Canal

The Gila headworks of Imperial Dam was constructed with three sets of outlet units, each with three radial gates; water discharges through one gate unit into a settling basin. Original plans contemplated diversions to 585,000 acres, but the area of the Gila Project was reduced by the act of July 30, 1947 (61 Stat. 628), to 115,000 acres. The acreage was reduced again to 105,000 acres by the Colorado River Basin Salinity Control Act. One desilting basin, 870 feet in length, is located between the Gila headworks of Imperial Dam and the Gila Canal headworks. This permits settlement of sediment before the water enters the Gila Gravity Main Canal, and periodic sluicing moves the sediment downstream into the Colorado River. The single basin is of sufficient capacity to serve the acreage of the Gila Project as now authorized.



Gila Project

Water is discharged from the desilting basin into the Gila Gravity Main Canal, which has a capacity of 2,200 cubic feet per second and extends from the desilting works 20.5 miles in a southerly direction to the Yuma Mesa Pumping Plant. The canal consists of two tunnels, one 0.33 mile long and the other 0.78 mile long; the 0.39-mile Gila River Siphon; and about 19 miles of open unlined canal. It has 10 turnouts to divert water to the project area.

North Gila Valley Unit — Canals and Laterals

This unit receives water from two turnouts in the Gila Gravity Main Canal, one 7 and the other 11 miles from Imperial Dam. They have a capacity of 150 and 50 cubic feet per second, respectively. The unit contains 10.2 miles of canals and about 15 miles of laterals. Drainage is provided by open drains and the adjacent Colorado and Gila Rivers.

South Gila Valley Unit — Canals and Laterals

Water is diverted to the South Gila Valley Unit from the Gila Gravity Main Canal through six laterals and, from a turnout just upstream from the Yuma Mesa Pumping Plant, through the 7.7-mile South Gila Canal. The unit has 27 miles of underground pipeline laterals. The total capacity diverted from the Gila Gravity Main Canal to the unit is 282 cubic feet per second. There are 24 drainage wells to maintain adequate ground-water levels.

Mesa Unit Distribution System

The Yuma Mesa Pumping Plant lifts water about 52 feet from the Gila Gravity Main Canal into the main canal of the Yuma Mesa distribution system, which carries water to about 25,000 acres in the Mesa Unit and to about 3,400 acres in the Yuma Auxiliary Project. The main canal of the distribution system divides into the A and B Canals, which have a total length of 23 miles. There are 43 miles of laterals within the system. The present capacity of the pumping plant is 700 cubic feet per second.

Wellton-Mohawk Canal and Distribution System

The 18.5-mile Wellton-Mohawk Canal diverts from the Gila Gravity Main Canal about 15 miles below Imperial Dam and has a capacity of 1,300 cubic feet per second. Its branches, the Wellton Canal and the Mohawk Canal, are 19.9 and 46.8 miles long respectively. The Wellton Canal has a diversion capacity of 300 cubic feet per second and the Mohawk Canal has a diversion capacity of 900 cubic feet per second. Three large pumping plants along the Wellton-Mohawk Canal lift the water a total of 170 feet. Fifteen smaller relift pumps are scattered throughout the Wellton-Mohawk Division on 227 laterals. The Texas Hill Canal takes water from the Mohawk Canal north of the Mohawk Mountains and extends 9.8 miles to the east to irrigate lands in the Texas Hill area. It has an initial capacity of 125 cubic feet per second.

The 11-mile Dome Canal branches off the Wellton-Mohawk Canal about 10 miles from its beginning and serves the western end of the division. Its diversion capacity is about 220 cubic feet per second. It has 7.5 miles of laterals.

Power for pumping is furnished through the Department of Energy's Parker-Davis transmission system.

DEVELOPMENT

Early History

Spain dominated the Arizona desert for nearly 300 years after its discovery. The United States acquired the territory north of the Gila River in 1848 and, in 1856, took formal possession of the lands south of the Gila.

Early history of agricultural development in the Wellton-Mohawk area dates back to 1538 when the Pima Indians irrigated some of the bottom land adjacent to the Gila River. Early pioneer settlement started with the establishment of the Butterfield Stage Line in 1857. The Southern Pacific Railroad began serving the area on February 1, 1879. In the late 1800's, the Mohawk Canal was constructed with diversion headworks on the Gila River at Texas Hill and the Antelope Canal was constructed to serve the Wellton area. However, calamitous floods that washed out crops and destroyed diversion works, alternating with long periods of drought, continuously plagued the early settlers. These conditions resulted in the settlers turning to the use of the abundant ground water in the area for irrigation and other purposes.

In 1906, the Antelope Irrigation District was formed and a wood-burning steam generating plant was built near Wellton to provide energy for pumping. In 1921, the Gila Valley Power District was organized to develop and supply electric power for pumping irrigation water and for municipal and industrial uses. The settlers continued to drill wells but, by 1934, Wellton-Mohawk farms were facing another hazard. Excessive salt appeared in many wells and the water table had declined alarmingly.

One after another, farms were abandoned as water and soil became too saline for successful farming. Spring floods in 1941 and cloudbursts in 1951 furnished short reprieves, but these served to emphasize the fact that permanent relief would come only with the importation of Colorado River water. To that end, the Gila Project was completed in 1957 by the Bureau of Reclamation.

Irrigation with water from the Colorado River caused the water table to rise and threatened crops with drowning.

Drainage wells were constructed to remove the excess ground water. The drainage water was highly saline, initially averaging about 6,000 parts per million. This drainage water was discharged into the Gila River.

Late in 1961, the Wellton-Mohawk Main Conveyance Channel was constructed for the entire length of the Wellton-Mohawk Division to carry drainage water from about 67 wells. Additional wells were installed in 1963 to allow for selective pumping to reduce the salinity of the effluent during the winter months and to provide drainage to other areas with high ground water.

Investigations

In 1934, the Bureau of Reclamation submitted a favorable report based on an investigation of Gila Project potentialities. The investigations were authorized by the Boulder Canyon Project Act of 1928.

Authorization

The project was originally authorized for construction under a finding of feasibility approved by the President on June 21, 1937, pursuant to section 4 of the act of June 25, 1910 (36 Stat. 836), and subsection B of section 4 of the act of December 5, 1924 (43 Stat. 701). It was reauthorized and reduced in area to 115,000 acres by the act of July 30, 1947 (61 Stat. 628). Further reduction in irrigable acreage of the Wellton-Mohawk Division was authorized by the Colorado River Basin Salinity Control Act of June 24, 1974 (88 Stat. 266).

Construction

Project construction was begun in 1936, and the first water was available for irrigation from the Gila Gravity Main Canal on November 4, 1943. Construction was postponed during World War II. Canal and lateral construction was resumed as soon as hostilities ended.

Construction of the Wellton-Mohawk Division features was started in August 1949. On May 1, 1952, water from the Colorado River was turned onto the Wellton-Mohawk fields for the first time. The project was essentially complete by June 30, 1957.

Operating Agencies

The Bureau of Reclamation operates the Gila diversion works and the Gila Gravity Main Canal. The South Gila Valley Unit Distribution System is operated by the Yuma Irrigation District. The distribution system in the North Gila Valley Unit is owned and operated by the North Gila Valley Irrigation District. The Yuma Mesa Irrigation and Drainage District operates the Yuma Mesa Pumping Plant and the distribution system downstream from the pumping plant. The Wellton-Mohawk Irrigation and Drainage District operates the irrigation facilities in the Wellton-Mohawk Division.

BENEFITS

The Yuma Mesa Unit grows citrus, alfalfa hay and seed, peanuts, cotton, and grains. Alfalfa, cotton, melons, citrus, winter vegetables, small grains, and Bermuda grass seed are grown in the North and South Gila Units and the Wellton-Mohawk Division. Sheep are brought from summer ranges into the area and are wintered on irrigated pastures of the project before being shipped to feed lots and markets. Cattle feed lots of various sizes operate in the area.

PROJECT DATA

Land Areas (1977)

Full irrigation service:		
In service	103,368	acres
Ultimate	105,000	acres
Number of irrigated farms[1]	547	

[1]Consistent with acreage reduction and the farms bought out in the Wellton-Mohawk Division (see Colorado River Basin Salinity Control Project, Desalting Complex Unit)

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	93,665	33,765,132
1969	93,460	35,679,522
1970	94,158	32,227,301
1971	94,468	42,775,112
1972	96,288	42,893,886
1973	98,579	56,453,917
1974	99,532	64,353,004
1975	100,158	58,894,517
1976	99,113	65,806,250
1977	94,233	69,799,347

Facilities in Operation

Diversion dams[2]	1	
Canals	167.3	mi
Laterals	246	mi
Pumping plants	25	
Drains	14.2	mi

[2]Imperial Dam (see All-American Canal System).

Climatic Conditions

Annual precipitation	3.5	in
Temperature:		
Maximum	120	°F
Minimum	19	°F
Mean	73	°F
Growing season:		
Yuma	348	days
Wellton	350	days
Elevation of irrigable area	150-340.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	1,162
Municipal water service	5,338
Other water service[3]	5,635
Total	12,135

[3]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

Colorado River

(See Boulder Canyon Project, All-American Canal System)

Average annual diversion, 1959-75[4]	880,300 acre-ft

[4]Includes land in North and South Gila Valleys.

Carriage Facilities

Gila Gravity Main Canal

Location: From Imperial Dam generally south about 13 mi to the vicinity of Arizona Western College.
Construction period: 1936-39

Length	20.5 mi
Diversion capacity	2,200 ft³/s
Typical maximum section in earth:	
Bottom width	22 ft
Side slopes	2:1
Water depth	13.5 ft
Lining	Unlined

Tunnel No. 1 (Main Canal)

Location: On the Main Canal about 5.7 mi south of Imperial Dam.
Construction period: 1936-38

Length	10.33 mi
Capacity	2,058 ft³/s
Cross section: Horseshoe	
Diameter	20 ft
Depth of water	17.4 ft
Lining: Concrete	10-16 in

Tunnel No. 2 (Main Canal)

Location: On the Main Canal about 6.7 mi south of Imperial Dam.
Construction period: 1937-38

Length	10.78 mi
Capacity	2,031 ft³/s
Cross section: Horseshoe	
Diameter	20 ft
Water depth	17.4 ft
Lining: Concrete	10-16 in

Gila River Siphon (Main Canal)

Location: On Main Canal at Gila River, about 10 mi south of Imperial Dam.
Description: Monolithic concrete pipe siphon.
Construction period: 1939

Length	10.39 mi
Capacity	2,200 ft³/s
Diameter	19.5 ft
Wall thickness	20-25 in

"A" Canal

Location: From end of Gila Gravity Main Canal near Yuma Mesa Pumping Plant southwest.
Construction period: 1941-42

Length	13.6 mi
Diversion capacity	620 ft³/s
Typical maximum section, concrete lined:	
Bottom width	8 ft
Side slopes	1.5:1
Water depth	10.1 ft
Lining thickness	3 in

"B" Canal

Location: From the A Canal about 2 mi downstream from Yuma Mesa Pumping Plant west to the vicinity of Yuma, Ariz.
Construction period: 1941-42

Length	9.3 mi
Diversion capacity	280 ft³/s
Typical maximum section, concrete lined:	
Bottom width	8 ft
Side slopes	1.5:1
Water depth	6.3 ft
Lining thickness	3 in

Wellton-Mohawk Canal

Location: From Gila Gravity Main Canal near the Gila River Siphon generally southeast along south side of Gila River to Pumping Plant No. 3 about 5 mi southwest of Wellton, Ariz.
Construction period: 1949-51

Length	18.5 mi
Diversion capacity	1,300 ft³/s
Typical maximum section, concrete lined:	
Bottom width	16 ft
Side slopes	1.25:1
Water depth	12.8 ft
Lining thickness	3.5 in
Length	6.5 mi
Typical maximum section, earth lined:	
Bottom width	44 ft
Side slopes	2:1
Water depth	8.8 ft
Lining thickness compacted earth:	
On bottom	2 ft
On sides	6 ft
Length	10.1 mi

Southern Pacific Railroad Tunnel

Location: On the Wellton-Mohawk Canal under the Southern Pacific Railroad, 0.3 mi upstream from Pumping Plant No. 2.
Construction period: 1950

Length	224 ft
Capacity	1,200 ft³/s
Cross section: Horseshoe	
Diameter	15.33 ft
Lining: Concrete	10-16 in

Dome Canal

Location: From point on Wellton-Mohawk Canal near Ligurta, Arizona, across the Gila River and generally northwest about 8 mi along the Gila River.
Construction period: 1953-54

Length	11 mi

Diversion capacity	220 ft³/s
Typical maximum section, concrete lined:	
Bottom width	7 ft
Side slopes	1.25:1
Water depth	5 ft
Lining thickness	2.5 in

Wellton Canal

Location: From end of Wellton-Mohawk Canal about 10 mi northeast to a point near the Gila River.
Construction period: 1951-53

Length	19.9 mi
Diversion capacity	300 ft³/s
Typical maximum section, concrete lined:	
Bottom width	7 ft
Side slopes	1.25:1
Water depth	6.5 ft
Lining thickness	2.5 in

Mohawk Canal

Location: From end of Wellton-Mohawk Canal generally northeast along the south side of Gila River, then across the river and westward.
Construction period: 1950-53

Length	46.8 mi
Diversion capacity	900 ft³/s
Typical maximum section, concrete lined:	
Bottom width	12 ft
Side slopes	1.25:1
Water depth	11.3 ft
Lining thickness	3 in

Texas Hill Canal

Location: From Mohawk Canal north of of the Mohawk Mountains, generally east.
Construction period: 1955-56

Length	9.8 mi
Diversion capacity	125 ft³/s
Typical maximum section, concrete lined:	
Bottom width	5 ft
Side slopes	1.25:1
Water depth	5 ft
Lining thickness	2.5 in

South Gila Canal

Location: From the Gila Gravity Main Canal, 0.4 mi upstream of the Yuma Mesa Pumping Plant.
Construction period: 1963-65

Length	7.7 mi
Diversion capacity	282 ft³/s
Typical maximum section, concrete lined:	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	4.2 ft
Lining thickness	2 in

North Gila Canal

Location: From Gila Gravity Main Canal, 0.3 mi downstream of Tunnel No. 2.
Construction period: 1909-12[5]

Length	10.2 mi
Diversion capacity	200 ft³/s
Typical maximum section:	
Bottom width	42 ft
Side slopes	2:1
Water depth	3 ft
Lining thickness	Unlined

Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Wellton-Mohawk Division:				
Wellton-Mohawk No. 1	9	1,300	35	7,500
Wellton-Mohawk No. 2	8	1,200	90	17,250
Wellton-Mohawk No. 3	7	900	60	8,750
Unit 1, Dome distribution system: 7 plants	12	215	4-21.5	515
Texas Hill distribution system: 3 plants	7	210	3.5-21	535
Ralph's Mill area, Mohawk Laterals: 5 plants	13	240	12-45	1,115
Yuma Mesa Division:				
Plant No. 1, Gravity Main Canal	4	968	50-54	7,100
Unit 1, 6 plants	6	98	2.3-4.3	65

[5]Constructed by the North Gila Valley Irrigation District.

Grand Valley Project

Colorado: Mesa County

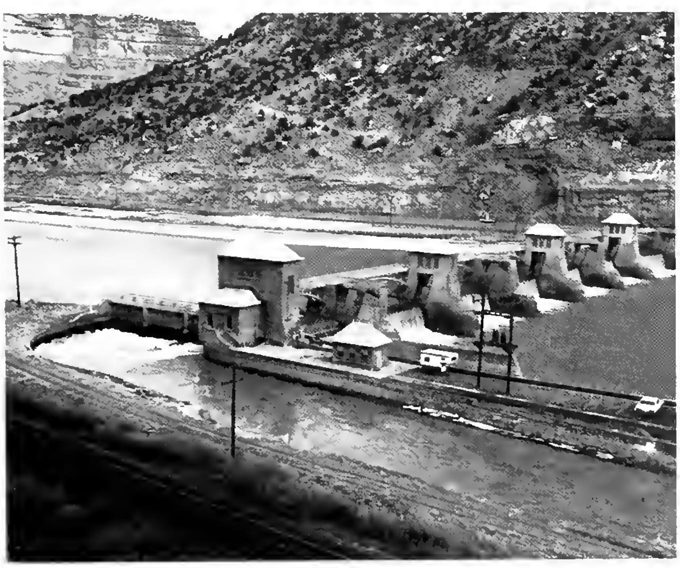
Upper Colorado Region
Water and Power Resources Service

Grand Valley Project is in west-central Colorado in the Colorado River Basin. Water is furnished to about 42,000 acres of land along the Colorado River in the vicinity of Grand Junction, Colo. The project works include a diversion dam, a powerplant, two pumping plants, two canal systems totaling 90.1 miles, 166 miles of laterals, and 112 miles of drains.

PLAN

Water for project use is diverted into the Government High Line Canal at Grand Valley Diversion Dam, about 23 miles northeast of Grand Junction. About 4.6 miles below the main diversion, water for the Orchard Mesa Division is diverted from the canal. This water passes through the Orchard Mesa Siphon across the Colorado River, through the Orchard Mesa Power Canal to the Grand Valley Powerplant, or to the Orchard Mesa Pumping Plant, where it is pumped into Orchard Mesa Canals No. 1 and 2 for distribution to the water users.

From the Orchard Mesa diversion, the Government High Line Canal continues westward, approximately paralleling the river, distributing water to laterals of the Garfield Gravity Division. Water also is furnished to 8,580 acres in the Mesa County and Palisade Irrigation Districts which were served by private facilities prior to project construction.



Grand Valley Dam and Canal

Grand Valley Diversion Dam

The diversion dam is on the Colorado River about 8 miles northeast of Palisade, Colo. This concrete weir is 14 feet high. Flow over its 546-foot crest is controlled by six roller gates. These gates were the first of their type designed in the United States.

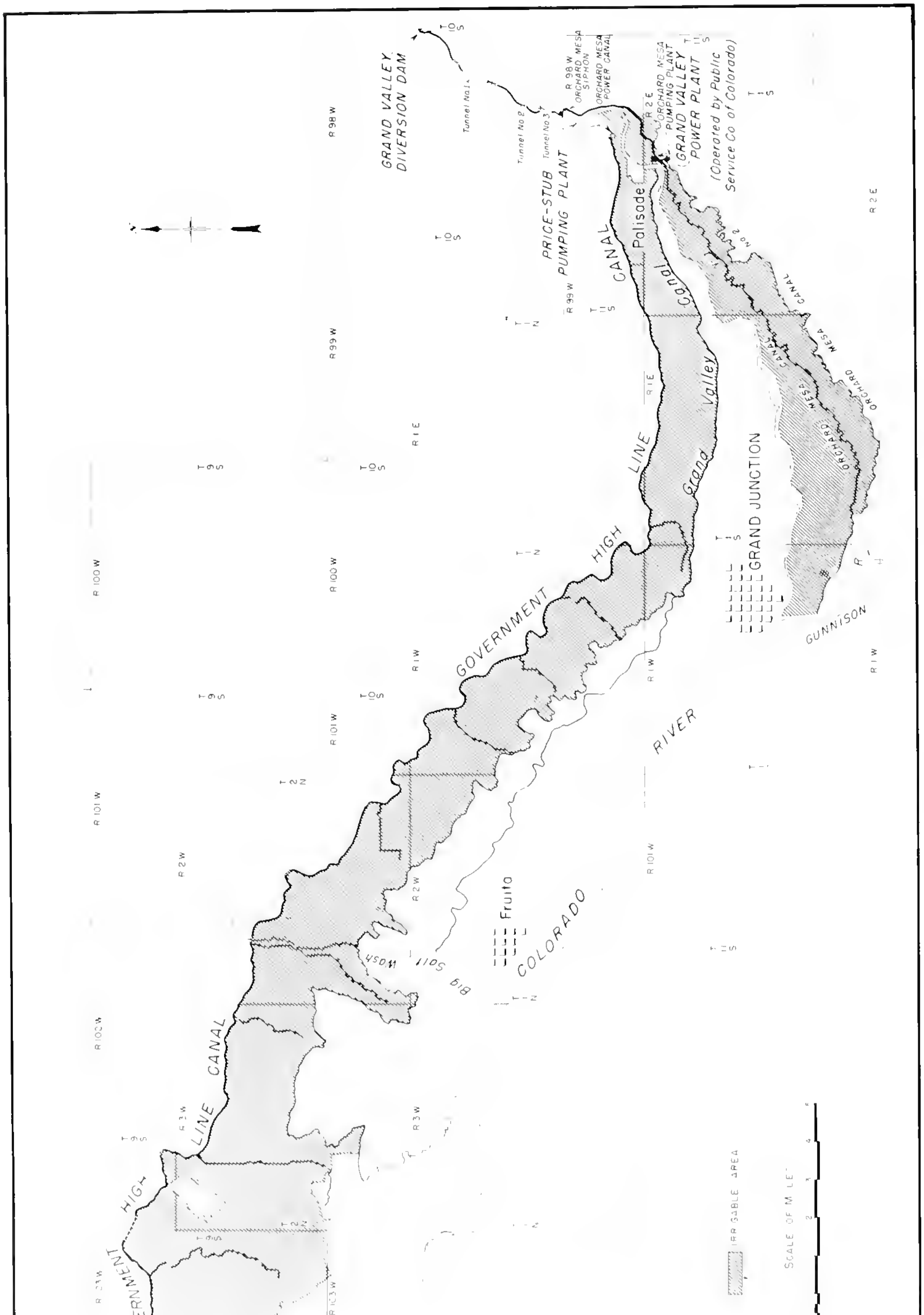
Government High Line Canal System

The canal is on the west and north side of the river and extends from the Grand Valley Diversion Dam south and west a distance of 55 miles. It has a diversion capacity of 1,675 cubic feet per second, which includes 800 cubic feet per second for the Orchard Mesa Power Canal. The remaining flows are distributed through the Government High Line Canal and Price-Stub Pumping Plant. The distribution system for the Garfield Gravity Division consists of 166 miles of laterals. The drainage system consists of 2 miles of closed drains and 110.5 miles of deep open drains.

The Price-Stub Pumping Plant is on the canal near Tunnel No. 3 Outlet at the east end of Grand Valley. It lifts 25 cubic feet per second of water 31 feet to the Stub Ditch to serve land of the Mesa County Irrigation District. Power is provided to the hydraulic pump by water delivered to the Price Ditch for the Palisade Irrigation District.

Orchard Mesa Canal System

Orchard Mesa Siphon conveys water from the Government High Line Canal to the head of the 3.5-mile-long Orchard Mesa Power Canal on the east side of the river. The siphon is reinforced concrete with a capacity of 800 cubic feet per second. Orchard Mesa Pumping Plant lifts



Grand Valley Project

water from the Orchard Mesa Power Canal to the distribution system. The plant contains four pump units: Two have a combined capacity of 80 cubic feet per second and a lift of 41 feet to Canal No. 1; two have a combined capacity of 60 cubic feet per second with a lift of 130 feet to Canal No. 2. Water is conveyed to privately owned and operated laterals by Orchard Mesa Canals No. 1 and 2. The canals have capacities of 85 and 65 cubic feet per second, respectively, and a combined length of 31.6 miles.

Grand Valley Powerplant

The plant is about 1 mile south of Palisade at the lower end of the Orchard Mesa Power Canal adjacent to the Orchard Mesa Pumping Plant. It operates under a maximum head of 79 feet and has a capacity of 3,000 kilowatts. The plant was constructed by the United States with funds advanced by Public Service Company of Colorado. The company operates and maintains the plant under a rental agreement with the United States and the Grand Valley Water Users Association. Power generation averages approximately 19,350,600 kilowatt-hours annually.

DEVELOPMENT

Early History

Soon after their arrival in Grand Valley in 1881, settlers began work on ditches to irrigate lowlands adjacent to the north side of the Colorado River. By 1886, the Grand Valley Canal (not part of the Grand Valley Project) was completed and the canal system expanded to serve approximately 45,000 acres of land. From 1886 to 1902, several attempts were made by private interests to construct a canal to higher lands in the valley but because of initial technical difficulties private investors were unwilling to back the project.

Investigations

After passage of the Reclamation Act in 1902, an evaluation of the proposed Government High Line Canal, now a part of the Grand Valley Project, was requested by the local citizens. In 1905, the Grand Valley Water Users Association was organized to cooperate with the Reclamation Service in developing a project. After investigation, the Reclamation Service proposed a project consisting of a diversion dam and distribution canal to irrigate lands at higher valley levels than those being operated by private interests. A board of engineers approved feasibility of the project December 15, 1908.

Authorization

The Grand Valley Project was one of the projects examined and reported upon favorably by a board of

Grand Valley Diversion Dam

Army Engineers in accordance with the act of June 25, 1910 (36 Stat. 835), and approved by the President on January 5, 1911.

Construction

The Reclamation Service was authorized by the Secretary of the Interior on September 23, 1912, to begin construction on one of the smaller tunnels. First irrigation was provided June 29, 1915, at which time the entire project was less than 60 percent completed. Cooperative drainage work in the Grand Valley Drainage District was begun in March 1918.

The Price-Stub Pumping Plant was completed and water supplied through Government-constructed facilities to Palisade and Mesa County Irrigation Districts in April 1919. A powerplant was constructed in 1932-33 using funds advanced by Public Service Company of Colorado. One of the tunnels on the Government High Line Canal collapsed in March 1950 because of ground slides. In a dramatic effort to open the canal before the start of the irrigation season, a contract to construct a section of new tunnel to bypass the slide area was negotiated and the contractor broke all records in finishing the tunnel in time for the irrigation season.

Operating Agencies

On January 1, 1949, the Grand Valley Water Users Association assumed the care, operation, and maintenance of project facilities except those of the Orchard Mesa Division and the powerplant. Previously, operation was by the Bureau of Reclamation with funds advanced by the association. The powerplant is operated and maintained by the Public Service Company of Colorado. The

Grand Valley Irrigation Canal

Orchard Mesa Division of the project is operated by the Orchard Mesa Irrigation District under cooperative agreements with the Grand Valley Water Users Association.

BENEFITS

Irrigation

Since it first delivered water in 1917, the Grand Valley Project has furnished a full supply of irrigation water to approximately 33,368 acres and supplemental water to about 8,600 acres of fertile land. The project has made possible diversified and intensified farming in the area, regularly bringing to maturity such late-season crops as fruit, alfalfa, beans, seed, corn, oats, barley, potatoes, and wheat. Favorable climate, cheap winter forage, and proximity to good range combine to make the area desirable for profitable raising of livestock. Dairying and poultry raising are also important to the project area.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	33,368	acres
Supplemental irrigation service	8,580	acres
Total	41,948	acres
Number of irrigated farms/parcels (5 acres or more)	1,089	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	33,735	7,845,019
1969	32,871	7,622,438
1970	31,511	6,932,635
1971	31,505	7,618,315
1972	31,628	7,067,877
1973	31,875	11,952,125
1974	31,300	15,048,138
1975	32,569	13,115,629
1976	31,961	11,660,152
1977	31,666	11,733,366

Facilities in Operation

Diversion dams	1	
Canals	90.1	mi
Laterals	166	mi
Pumping plants	2	
Drains	112	mi
Powerplants[1]	1	

[1]Leased to Public Service Co. of Colorado for operation.

Climatic Conditions

Annual precipitation	8.8	in
Temperature:		
Maximum	108	°F
Minimum	−21	°F
Mean	53	°F
Growing season	190	days
Elevation of irrigable area	4700.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	5,660
Other water service[2]	21,782
Total	27,442

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

Colorado River

Drainage area above Grand Valley Diversion Dam	8,055	mi²
Annual discharge at Cameo, Colo.:		
Maximum (1914)	5,475,000	acre-ft
Minimum (1963)	1,749,000	acre-ft
Average	3,132,000	acre-ft
Average annual diversion (all purposes)	777,000	acre-ft

Diversion Facilities

Grand Valley Diversion Dam

Type: Concrete, ogee (gated) weir
Location: Colorado River, about 8 mi northeast of Palisade, Colo.
Year completed: 1916
Dimensions:

Hydraulic height	14	ft
Crest length	546	ft
Weir crest elevation	4782.0	ft
Volume	25,700	yd³

Spillway: Weir surmounted by six roller gates 70 ft long by 10.25 ft in diameter, and one sluiceway 60 ft wide with roller gate 15.33 ft high.

Capacity	75,000	ft³/s

Headworks: Nine gates, each 7-ft-square, adjacent to west dam abutment.

Diversion capacity	1,675	ft³/s

Carriage Facilities

Government High Line Canal

Location: From Grand Valley Diversion Dam southwest about 20 mi along the Colorado River to vicinity of Grand Junction, Colo., then generally northwest about 35 mi.
Construction period: 1912-17

Length	55	mi
Diversion capacity	1,675	ft³/s
Typical maximum section in earth:		
Bottom width	38	ft
Side slopes	1.5:1	
Water depth	10.5	ft
Typical maximum section, concrete lined:		
Bottom width	34	ft
Side slopes	2:1	
Water depth	10.5	ft
Lining thickness	4	in

Tunnel No. 1 (Government High Line Canal)

Location: Near the Colorado River 2 mi south of Grand Valley Diversion Dam.
Construction period: 1912-14

Length	3,723	ft
Capacity	1,675	ft³/s
Cross section: Horseshoe		
Height	14	ft
Width	17.5	ft

Lining: Concrete

Tunnel No. 2 (Government High Line Canal)

Location: Near the Colorado River about 4 mi south of Grand Valley Diversion Dam.
Construction period: 1913-14

Length	1,655	ft
Capacity	1,675	ft³/s
Cross section: Horseshoe		
Height	14	ft
Width	16	ft

Lining: Concrete

Tunnel No. 3 (Government High Line Canal)

Location: Near the Colorado River, about 5 mi south of Grand Valley Diversion Dam.

Construction period: 1913-15. Bypass bore constructed around collapsed section in 1950.

Length	7,486 ft
Diversion capacity	730 ft³/s
Cross section: Horseshoe (original tunnel)	
Height	11 ft
Width	11.5 ft
Lining: Concrete, thickness	4 in

ORCHARD MESA POWER CANAL

Location: From Government High Line Canal between Tunnels No. 2 and 3 across river through Orchard Mesa Siphon and generally south to Grand Valley Powerplant and Orchard Mesa Pumping Plant.

Construction period: 1922-24

Length	3.5 mi
Diversion capacity	800 ft³/s
Typical maximum section—open canal:	
Bottom width	20 ft
Side slopes	1:1
Water depth	9.8 ft
Lining thickness	4 in
Typical maximum section—bench flume:	
Bottom width	17 ft
Side slopes: Vertical	
Water depth	6.6 ft
Wall thickness:	
Top	6 in
Bottom	9 in
Typical maximum section—cut and cover conduit:	
Bottom width	11 ft
Height	11.4 ft
Side slopes: Vertical	
Water depth	10.3 ft
Concrete thickness:	
Bottom	10 in
Sidewall	9 in

MANN'S GULCH SIPHON (ORCHARD MESA POWER CANAL)

Location: Station 57+87 on the canal, about 1.5 miles east of Palisade, Colo.

Type: Reinforced monolithic concrete

Length	193 ft
Capacity	800 ft³/s
Cross section: Circular	
Diameter	12 ft

APPLEGATE DRAW SIPHON AND WASTEWAY (ORCHARD MESA POWER CANAL)

Location: Station 139+11 on the canal, about 0.5 mile southeast of Palisade, Colo.

Type: Twin-barrel reinforced monolithic concrete

Length	110 ft
Capacity	800 ft³/s
Cross section: Two 8-ft- square barrels	

ORCHARD MESA CANAL NO. 1

Location: From Orchard Mesa Pumping Plant, about 0.5 mile south of Palisade, Colo., southwesterly to a point about 1 mile south of Grand Junction, Colo.

Length	15.5 mi
Diversion capacity	85 ft³/s
Typical maximum section:	
Bottom width	8 ft
Side slopes	1.5:1
Water depth	3.1 ft

BIG WASH SIPHON (ORCHARD MESA CANAL NO. 1)

Location: Station 3+18.4 on the canal.

Type: Precast concrete pipe

Length	780.6 ft
Capacity	80 ft³/s
Cross section: Circular	
Diameter	4.5 ft

STEEL SIPHON (ORCHARD MESA CANAL NO. 1)

Location: Station 4+50 on the canal.

Type: Riveted plate steel

Length	1,321.5 ft
Capacity	80 ft³/s
Cross section: Circular	
Diameter	4.5 ft

DOUBLE WASH SIPHON NO. 1 (ORCHARD MESA CANAL NO. 1)

Location: Station 346+62 on the canal.

Type: Precast concrete pipe

Length	375.5 ft
Capacity	80 ft³/s
Cross section: Circular	
Diameter	4.5 ft

DOUBLE WASH SIPHON NO. 2 (ORCHARD MESA CANAL NO. 1)

Location: Station 356+44 on the canal.

Type: Precast concrete pipe

Length	503 ft
Capacity	80 ft³/s
Cross section: Circular	
Diameter	4.5 ft

CONCRETE SIPHON (ORCHARD MESA CANAL NO. 1)

Location: Station 8+16 on the canal.

Type: Precast concrete pipe

Length	737.8 ft
Capacity	14.3 ft³/s
Cross section: Circular	
Diameter	1.75 ft

ORCHARD MESA CANAL NO. 2

Location: From Orchard Mesa Pumping Plant, about 0.5 mi south of Palisade, Colo., southwesterly to a point about 2.5 mi southeast of Grand Junction, Colo.

Length	16.1 mi
Diversion capacity	65 ft³/s
Typical maximum section:	
Bottom width	7 ft
Side slopes	1.5:1
Water depth	2.8 ft

STEEL SIPHON (ORCHARD MESA CANAL NO. 2)

Location: Station 13+24 on the canal.

Type: Riveted plate steel pipe

Length	426.5 ft
Capacity	60 ft³/s
Cross section: Circular	
Diameter	4 ft

STEEL SIPHON (ORCHARD MESA CANAL NO. 2)

Location: Station 21+29 on the canal.

Type: Riveted plate steel pipe

Length .... 319 ft
Capacity .... 60 ft³/s
Cross section: Circular
Diameter .... 4 ft

Big Wash Siphon No. 1 (Orchard Mesa Canal No. 2)

Location: Station 357+95 on the canal.
Type: Precast concrete pipe
Length .... 191.7 ft
Capacity .... 50 ft³/s
Cross section: Circular
Diameter .... 3.75 ft

Big Wash Siphon No. 2 (Orchard Mesa Canal No. 2)

Location: Station 419+41 on the canal.
Type: Precast concrete pipe
Length .... 2,817.1 ft
Capacity .... 50 ft³/s
Cross section: Circular
Diameter .... 3.75 ft

Double Wash Siphon (Orchard Mesa Canal No. 2)

Location: Station 501+23 on the canal.
Type: Reinforced monolithic concrete pipe
Length .... 180 ft
Capacity .... 50 ft³/s
Cross section: Circular
Diameter .... 3.75 ft

Concrete Siphon (Orchard Mesa Canal No. 2)

Type: Reinforced monolithic concrete pipe
Length .... 500 ft
Capacity .... 60 ft³/s
Cross section: Circular
Diameter .... 4 ft

Pumping Plants[3]

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Price-Stub	1	25	31	125
Orchard Mesa	4	140	41-130	1,500

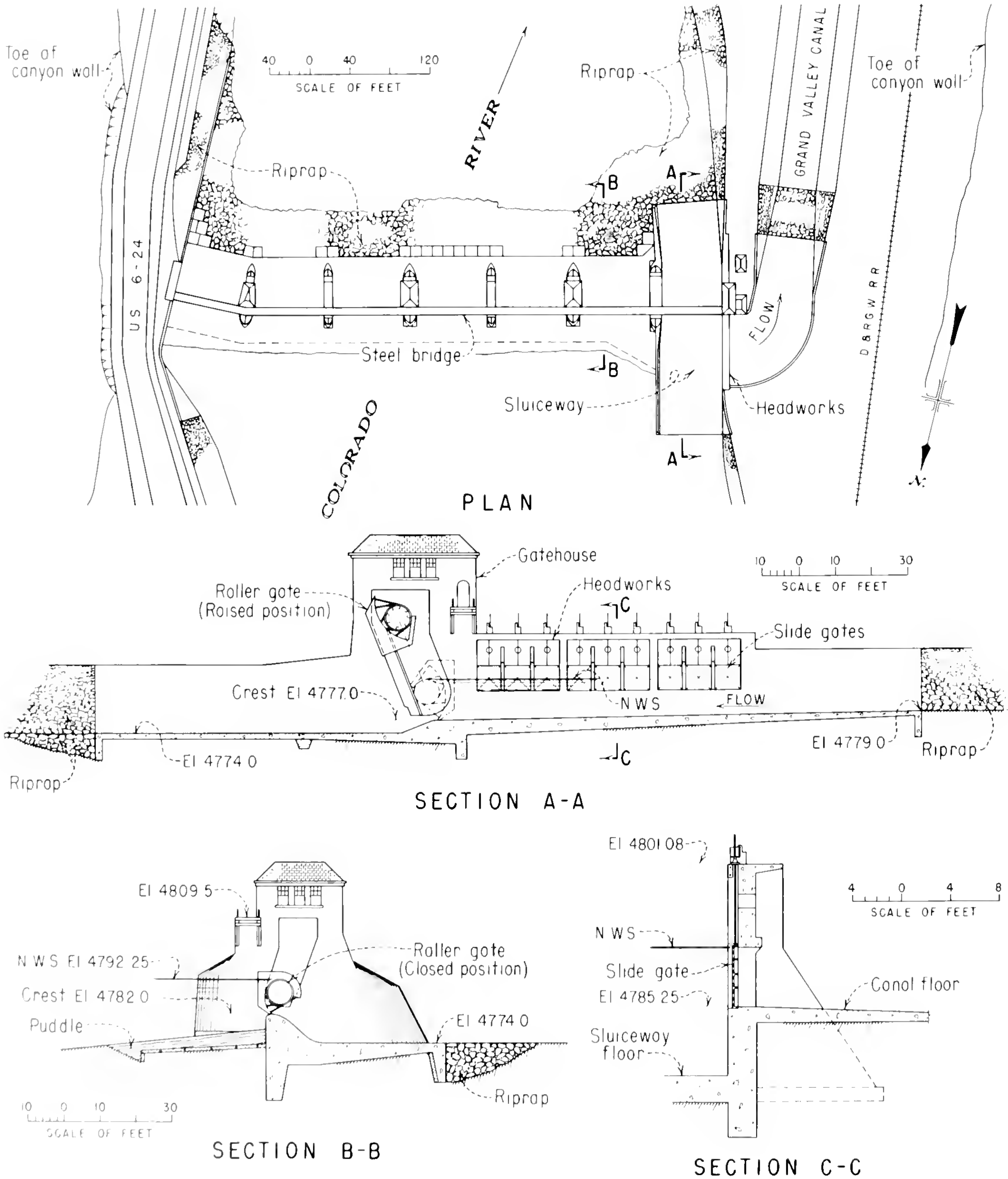
[3]These plants have direct-connected turbine-driven pumps. The Orchard Mesa Plant has two high-lift units pumping a total of 60 ft³/s against a total maximum head of 130 ft, and two low-lift units pumping a total of 80 ft³/s against a total maximum head of 41 ft.

Power Facilities

Grand Valley Powerplant[4]

Location: 1 mi south of Palisade, Colo.
Year of initial operation: 1933
Year last generator placed in operation: 1933
Nameplate capacity .... 3,000 kW
Number and capacity of generators ...... (2) 1,500 kW
Maximum head .... 79 ft

[4]Power marketed by the Public Service Co. of Colorado.

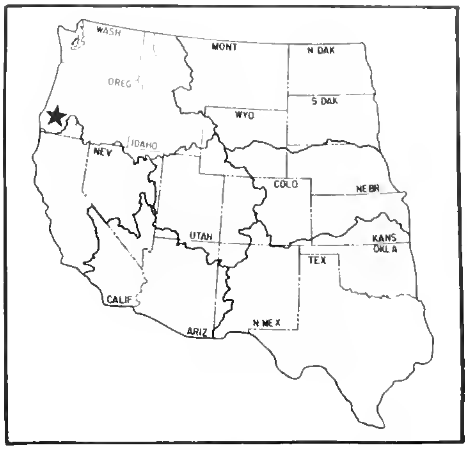


Grand Valley Diversion Dam, Plan and Sections

Grants Pass Project

Oregon: Jackson and Josephine Counties

Pacific Northwest Region
Water and Power Resources Service



The Grants Pass Project lies within the Rogue River Basin in southwestern Oregon. The project was constructed by private interests beginning in the 1920's and rehabilitated by the Bureau of Reclamation in 1949-55. The project furnishes irrigation water to 10,081 acres of land surrounding the town of Grants Pass, Oreg. Principal project features are the Savage Rapids Diversion Dam on the Rogue River, and the associated pipelines, pumping plants, canals, and laterals.

PLAN

The Savage Rapids Diversion Dam diverts water from the Rogue River into the South Main Canal to serve the lowlands on the south side of the river. The main pumping plant pumps water from the reservoir to the Tokay Canal to serve lands on the north side of the river, and to the South Highline Canal to irrigate lands above the gravity-type South Main Canal. There are also four lateral relift pumping plants along the canals.

Savage Rapids Diversion Dam

The Savage Rapids Diversion Dam is on the Rogue River 5 miles east of Grants Pass, Oreg. It is about 456 feet long and consists of a 16-bay spillway section and a hydraulic-driven pumping plant section at the right abutment. Maximum height of the spillway section is about 39 feet. The first seven bays at the right end of the dam are multiple arches with buttresses on 25-foot centers; the remaining nine bays have a concrete gravity section below the gates. Spillway control was originally provided by 16 wooden-faced radial gates, each 23 feet wide and 10 feet high. During rehabilitation, the radial gates were replaced with metal stoplogs, and one double-gated river outlet with a capacity of 6,000 cubic feet per second was installed at the center of the dam. During the irrigation season, the stoplogs are used to raise the reservoir elevation 11 feet.

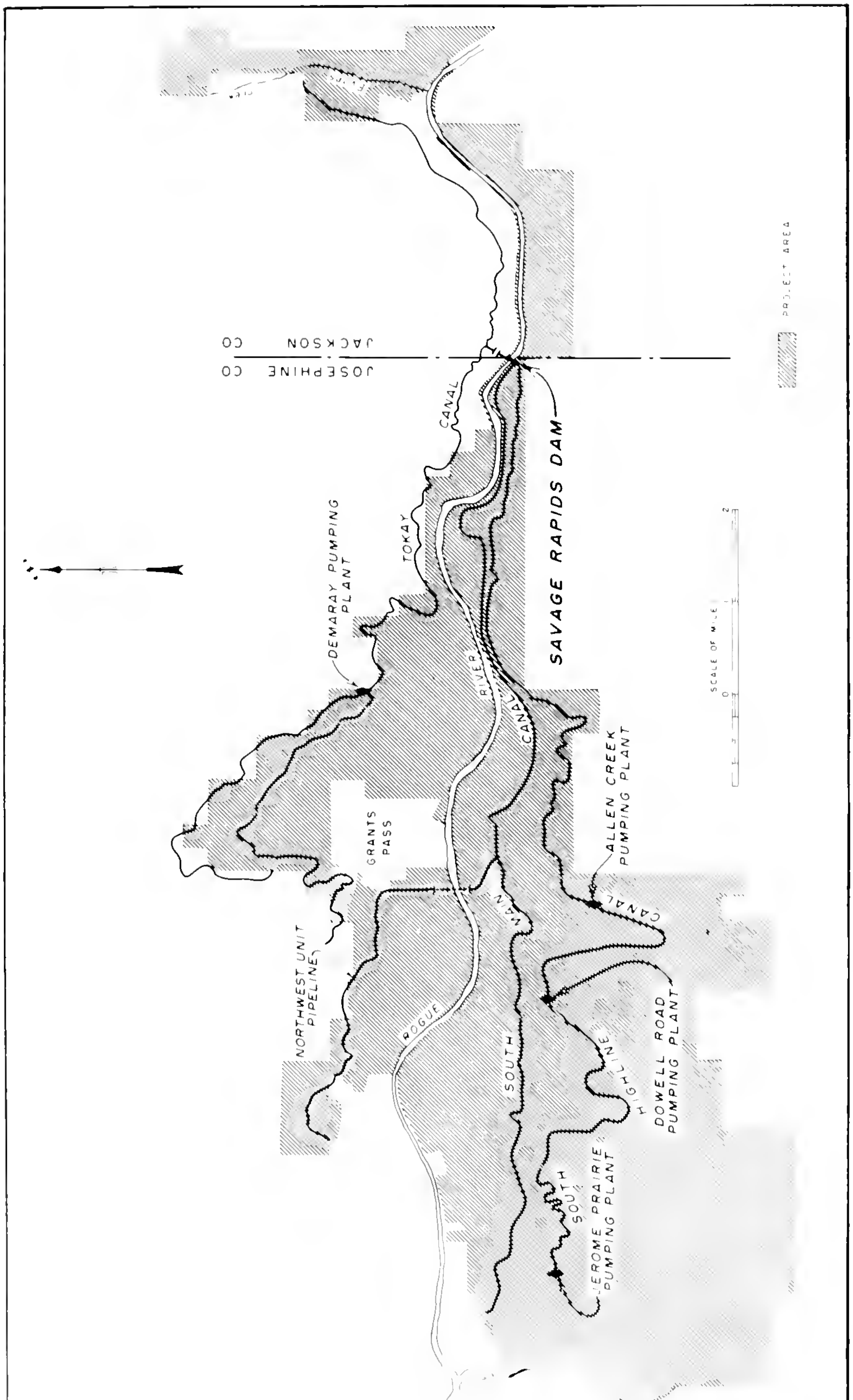
Savage Rapids Dam

Pumping Plants

The main pumping plant is at the diversion dam and consists of two hydraucone turbine units that operate under a 29-foot head. One turbine drives a centrifugal pump with a capacity of 75 cubic feet per second against a 90-foot head, and supplies water to the South Highline Canal. The other turbine drives two pumps connected in series, with a capacity of 50 cubic feet per second against a head of 150 feet, and supplies water to the Tokay Canal. In addition to the main pumping plant, there are relift pumping plants to laterals at Allen Creek, with a head of 75.5 feet; at Demaray lateral, with a head of 114 feet; at Dowell Road, with a head of 66 feet; and at Jerome Prairie, with a head of 90 feet. Another small pumping plant, the C-Back, has a 30-foot head.

Canal System

The Main Canal extends from Savage Rapids Dam westward on the south side of the Rogue River for 9.2 miles and has a diversion capacity of 100 cubic feet per second. At about mile 6, the canal divides, with one branch serving an area north of the river through the Northwest Unit pipeline. The South Highline Canal, 14 miles long with a diversion capacity of 70 cubic feet per second, extends from the dam westward on the south side



Grants Pass Project

of the valley at a higher elevation than the Main Canal. The Tokay Canal extends from the dam westward on the north side of the river to a few miles beyond Grants Pass. This canal has a total length of 12.5 miles and a diversion capacity of 40 cubic feet per second. Other highline canals, including one on each side of the river eastward to Evans Creek, increase the total canal length to about 67 miles. There are 40 miles of laterals to deliver the water to project lands.

Anadromous Fish Passage Facilities

Pursuant to a report prepared in 1974, work was authorized and is being completed on anadromous fish passage facilities at Savage Rapids Dam. Fishways on the south side of the river have been repaired and modified. The work includes modifying some of the weirs in the short ladder section leading from the resting pool immediately below the dam up to the gravity canal, adding concrete to one of the pool floors in this ladder section to make it more uniform, removing broken concrete in the short ladder spur leading up from the river immediately below the radial gates, adding another pool at the lower end of this same ladder spur, excavating rock and constructing weirs to create a better channel over parts of the rocks, increasing the height of some of the ladder sidewalls, and adding another pool at the lower end of the westernmost ladder leading from the river.

After the 1978 irrigation season, the existing north fish ladder will be removed, and a new fishway constructed. Primary operational differences are that the new fishway will use turbine discharge for attraction flow, and will accommodate a larger range of streamflow variation without adjustment.

DEVELOPMENT

Early History

The Grants Pass Irrigation District was organized by water users in January 1917. The area of the district was then about 6,000 acres. It originally was planned to irrigate by an extension of the Gravity Canal of the Goldhill Irrigation District, which was further upstream on the Rogue River and was being organized at the same time. That plan was abandoned in 1920 and the present design was adopted to provide for a direct diversion system with permanent pumping units. The original works were constructed with private funds.

The Savage Rapids Diversion Dam was dedicated November 5, 1921, marking the beginning of the operating history of the district. Settlement and clearing of the undeveloped lands, which constituted a high proportion of the district's area, did not develop to the extent of the expectations upon which the district was founded and financed. As a result, just over one-half of the irrigable area was in production and therefore carried the entire tax burden.

The Savage Rapids Dam and the Northwest Unit pipeline were badly damaged by a flood in 1927. Emergency repairs were made at that time, but lack of sufficient funds prevented satisfactory completion of the work. The cost of maintenance on the pipeline had become almost prohibitive by 1949.

Investigations

In 1949, the Bureau of Reclamation was requested to replace the old suspension pipeline and siphon with a new buried line under the Rogue River. Several years later Reclamation was asked to rehabilitate Savage Rapids Dam. After thorough investigations, both requests were undertaken and completed. In 1974, the Bureau of Reclamation and Bureau of Sport Fisheries and Wildlife investigated and prepared a report on anadromous fish passage improvements at Savage Rapids Dam.

Investigations have been underway in the 1970's to consider replacing the Grants Pass Irrigation District's distribution system, the feasibility of irrigating additional district land, and the possibility of developing water supplies for other uses.

Authorization

The Interior Department Appropriation Act of 1950 (63 Stat. 765, October 12, 1949), in effect authorized the emergency reconstruction of the Northwest Unit pipeline of the Grants Pass Irrigation District. Rehabilitation of Savage Rapids Dam was authorized by the Congress in the Department of Interior Appropriation Act of 1953 (July 9, 1952, 66 Stat. 445, Public Law 470, 82d Cong). Anadromous fish passage improvements to Savage Rapids Dam were authorized by the Reclamation Development Act of 1974 (October 27, 1974, Public Law 93-493, 88 Stat. 1498).

Construction

Construction of the new buried pipeline under the river to replace the old suspension pipeline was completed during the winter of 1949-50. Savage Rapids Dam was rehabilitated from March 25, 1953, to February 22, 1955. Construction on the fish passage facilities at the dam began late in 1976.

Operating Agency

The project is operated and maintained by the Grants Pass Irrigation District.

BENEFITS

Irrigation

Land ownerships within the project historically have consisted of small acreages. Residential subdivision has been taking place and is expected to continue. Hay and pasture are the principal crops produced on the irrigated areas.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	10,081	acres
Number of irrigated farms	959	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,898	554,282
1969	7,356	687,284
1970	7,360	518,194
1971	7,350	598,403
1972	5,697	452,947
1973	5,000	620,286
1974	5,535	797,120
1975	5,535	800,310
1976	4,740	619,069
1977	3,461	569,203

Facilities in Operation

Diversion dams	1	
Canals	67	mi
Laterals	40	mi
Pumping plants	6	

Climatic Conditions

Annual precipitation	31.6	in
Temperature:		
Maximum	108	°F
Minimum	−1	°F
Mean	55	°F
Growing season	242	days
Elevation of irrigable area	900.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	4,002
Other water service[1]	23,228
Total	27,230

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

ROGUE RIVER

Drainage area at Grants Pass	2,459	mi²
Annual discharge at gaging station at Grants Pass:		
Maximum (1974)	4,538,000	acre-ft
Minimum (1977)	918,000	acre-ft
Average	2,659,000	acre-ft
Average annual diversions by project (1963-77)	56,760	acre-ft

Diversion Facilities

SAVAGE RAPIDS DAM

Type: Concrete, combination gravity and multiple arch, stoplogged crested
Location: On Rogue River, about 5 mi east of Grants Pass, Oreg.
Year completed: 1921[2]
Dimensions:

Structural height	39	ft
Hydraulic height	30	ft
Crest length	456	ft
Crest elevation	953.0	ft
Volume	5,600	yd³

Spillway: Overflow through stoplog-controlled gate openings. Metal stoplogs in one 11- by 19-ft and fifteen 11- by 23-ft bays.
Sluiceways: Four 4- by 6-ft gates at north end of dam, capacity of 2,000 ft³/s.
River outlets: Two 7- by 16-ft top seal radial gates at center of dam, capacity of 6,000 ft³/s.
Headworks:
Gravity diversion: Two gates at left abutment with a capacity of 100 ft³/s for Grants Pass Irrigation District.
Pumping diversion: Pumping plant at right abutment with two pumps in series that have a capacity of 50 ft³/s and a lift of 150 ft for Tokay Canal. Also, a 75-ft³/s capacity pump with a 90-ft lift for South Highline Canal.

[2]Built in 1921 by private irrigators, rehabilitated by Bureau of Reclamation in 1955.

Carriage Facilities

PUMPING PLANTS[3]

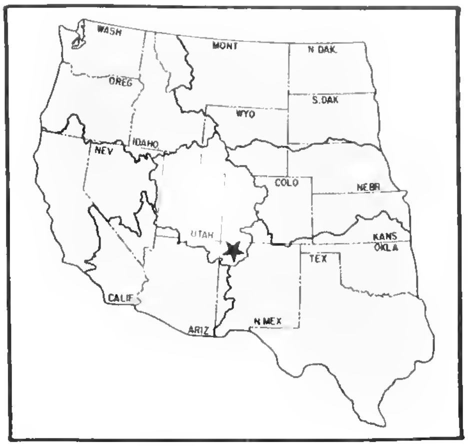
Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Savage Rapids	2	125	90-150	1,800
Jerome Prairie	2	24.5	90	325
Demaray	1	8	114	125
Allen Creek	1	4.2	75.5	50
Dowell Road	1	2	66	25
C-Back	1	1	30	25

[3]Constructed by private funds.

Hammond Project

New Mexico: San Juan County

Upper Colorado Region
Water and Power Resources Service



The Hammond Project is in northwestern New Mexico along the southern bank of the San Juan River and opposite the towns of Blanco, Bloomfield, and Farmington, N. Mex. Project lands lie in a narrow strip 20 miles long. The project provides an irrigation supply for 3,933 acres, 3,213 of which had been limited mostly to grazing before project development. During the land classification process, investigations indicated that 1,200 acres had been intermittently irrigated by pumping from the San Juan River. In 1962, 720 acres were incorporated as full-service lands when project water became available and the pumps were abandoned.

Major project works consist of the Hammond Diversion Dam on the San Juan River, the Main Gravity Canal, a hydraulic-turbine-driven pumping plant and an auxiliary pumping plant, three major laterals, minor distribution laterals, and the drainage system.

PLAN

Most of the irrigation supply is obtained from direct diversions of the natural streamflow of the San Juan River. When necessary, these flows are supplemented by storage releases from Navajo Reservoir, a major feature of the Colorado River Storage Project.

Water is diverted from the river by the Hammond Diversion Dam and turned into the 27.4-mile-long Main Canal. Major diversions from the canal are made by the East and West Highline laterals, which are served by the Hammond Pumping Plant, and the Gravity Extension lateral. Small diversions are made by minor laterals.

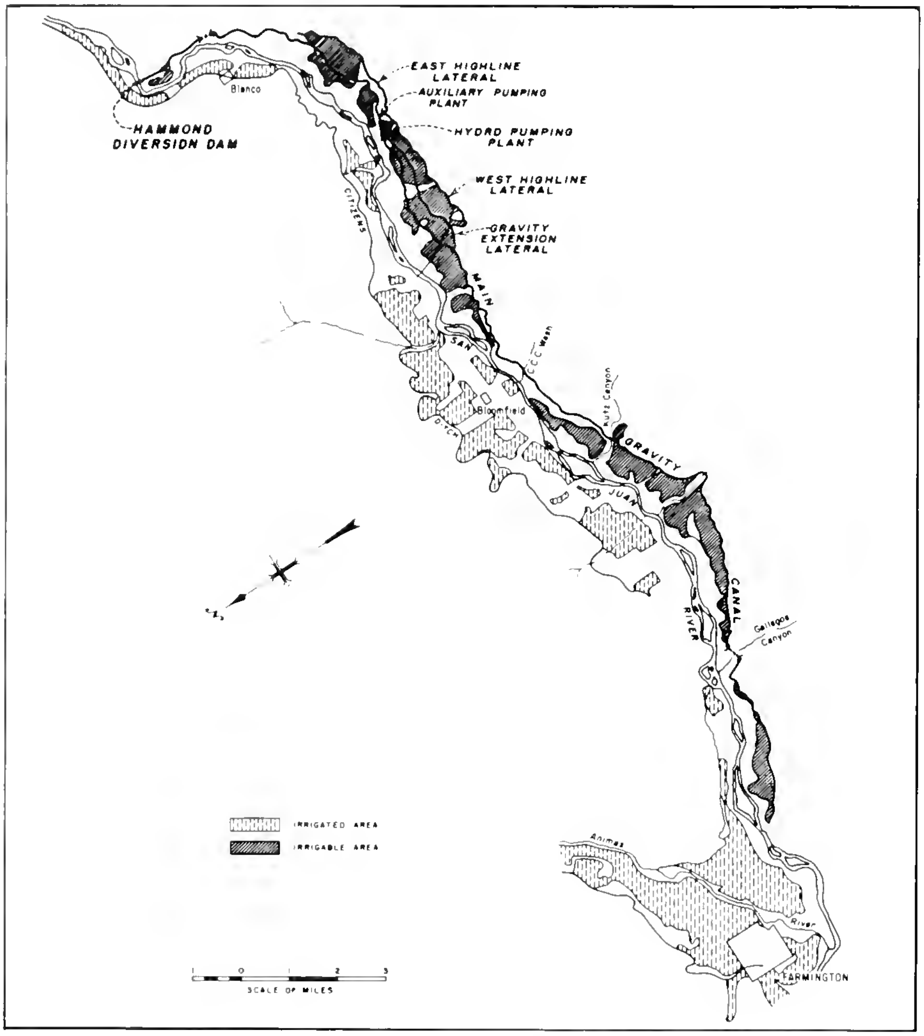
Hammond Diversion Dam

Hammond Diversion Dam is on the San Juan River about 2 miles upstream from Blanco. It consists of a rockfill overflow weir with embankment wings. The weir section has a design capacity of 16,300 cubic feet per second. The dam, with a crest length of 1,370 feet, includes headworks with apron and training walls, sluiceway with wing walls, and an overflow weir section of concrete sheet piling.

Main Gravity Canal and Lateral System

The Main Gravity Canal heads at the Hammond Diversion Dam on the San Juan River and meanders in a southwesterly direction 27.4 miles through the project area. The canal has an initial capacity of 90 cubic feet per second. From the pumping plant to the lower end of the project, the canal capacity is reduced progressively from 55 to 10 cubic feet per second. Project lands can generally be served from turnouts at the major canals and laterals; however, additional short laterals are used to reach isolated delivery points. A number of natural drainage channels that cross the project have been improved to prevent flood damage to project lands and irrigation structures.

Hammond Main Canal



Hammond Project

Hammond Pumping Plant

The pumping plant is about 6 miles below the canal heading and utilizes a 30-foot drop to lift 18 cubic feet per second of water to the East and West Highline laterals.

In 1968, an auxiliary pumping plant was constructed about 1,000 feet upstream from the original plant. This plant services the East Highline lateral.

DEVELOPMENT

Early History

Corn, beans, and squash were cultivated by the prehistoric cliff dwellers and their descendants. The Aztec Ruins National Monument, 9 miles north of the project, preserves some of the culture of this civilization. Although Spanish explorers and missionaries visited the area, most of the early Spanish expeditions did not result in settlement.

Settlers came in about 1870, and with them came the first attempts to irrigate the land. Lack of funds prevented construction of adequate irrigation facilities, and although some small projects were partially successful for short periods, they eventually failed. Reconstruction and repair of flood-damaged structures became so burdensome that the project area was gradually abandoned from 1912 to 1916.

Investigations

Possibilities for irrigation development on the San Juan River Basin have been explored by local groups and governmental agencies for more than 50 years. In 1946, the Bureau of Reclamation described a plan for the Hammond Project in a basin-type report. A feasibility report was prepared in 1947, and in 1950 a second report on the Hammond Project was prepared as a supplement to the 1950 report on the Colorado River Storage Project and participating projects. This second report was amended in 1953, and the project was later authorized. The definite plan report was completed in 1958.

Authorization

The project was authorized as one of the initial participating projects of the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

Contracts for construction were awarded in 1960 and 1961 and the project was completed in 1962.

Operating Agency

The project was turned over to the Hammond Conservancy District for operation and maintenance effective January 1, 1974.

BENEFITS

Irrigation

The principal crops grown on the project lands are alfalfa, apples, corn, beans, pasture, wheat, oats, and barley. Irrigation has contributed to the economy of the area through the production of dairy products and fruit.

PROJECT DATA

Land Areas (1977)

Irrigation area	3,933	acres
Number of irrigated farms	171	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	2,035	165,906
1969	2,095	212,008
1970	2,319	243,971
1971	2,203	295,180
1972	2,445	415,846
1973	2,432	434,037
1974	3,588	616,866
1975	3,596	668,153
1976	3,416	845,460
1977	3,418	938,076

Facilities in Operation

Diversion dams	1	
Pumping plants	2	
Canals	27.4	mi
Laterals	13	mi
Drains	8	mi

Climatic Conditions

Annual precipitation	8.8	in
Temperature:		
Maximum	107	°F
Minimum	−35	°F
Mean	51	°F
Growing season	155	days
Elevation of irrigable area	5300-5600.0	ft

ENGINEERING DATA

Water Supply

San Juan River

Drainage area at Navajo Dam	3,260	mi²
Annual discharge:		
Maximum (1941)	2,351,000	acre-ft
Minimum (1951)	331,000	acre-ft
Average	946,000	acre-ft

Diversion Facilities

Hammond Diversion Dam

Type: Rockfill overflow embankment wings
Location: San Juan River, 2 mi upstream from Blanco, N. Mex.
Construction period: 1961-62
Dimensions:

Height above streambed	12	ft
Weir crest length	350	ft
Total crest length	1,370	ft
Weir crest elevation	5569.0	ft
Volume (rockfill and concrete)	25,100	yd³

Sluiceway: Three 16- by 9-ft radial gates. One 10- by 9-ft radial gate.
Headworks: One 5-ft-square slide gate.

Diversion capacity	90	ft³/s

Carriage Facilities

Main Canal

Location: From Hammond Diversion Dam in a general southwesterly direction.
Construction period: 1960-62

Length	27.4	mi
Initial capacity	90	ft³/s
Typical maximum section:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	3.2	ft

Hammond Pumping Plant

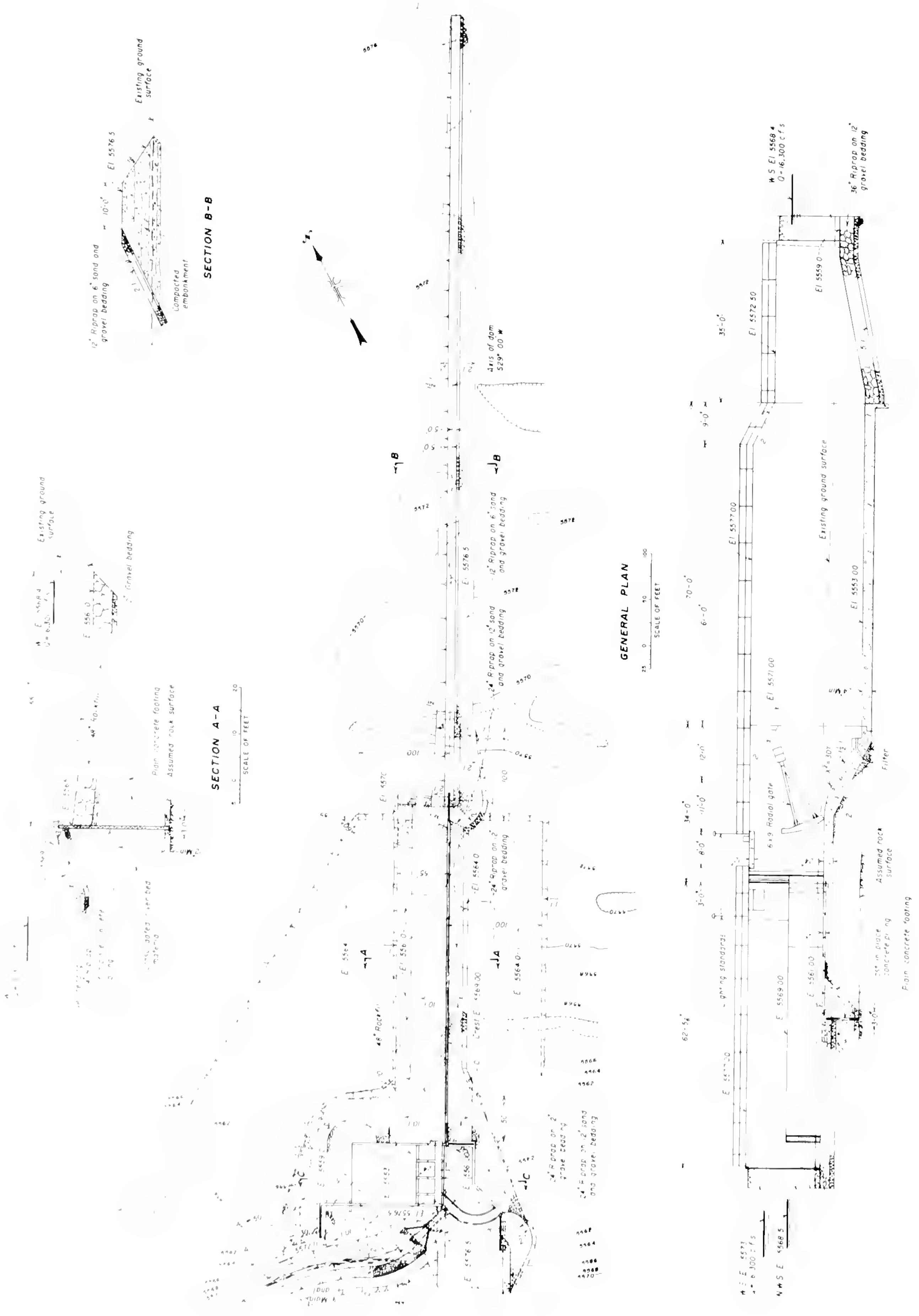
Location: Six miles downstream from canal head.

Number of units	1	
Total capacity	18	ft³/s
Total dynamic head	65	ft
Total power	155	hp

Auxiliary Pumping Plant

Location: Main canal
Constructed: 1968

Capacity	12	ft³/s
Total dynamic head	56	ft

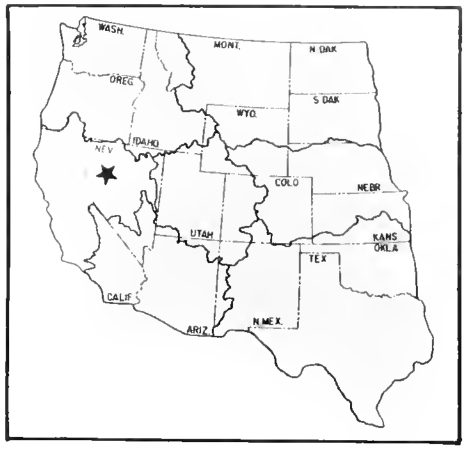


Hammond Diversion Dam, Plan and Sections

Humboldt Project

Nevada: Pershing County

Mid-Pacific Region
Water and Power Resources Service



The Humboldt Project is located in northwestern Nevada on the Humboldt River. The project lands are in Lovelock Valley on the lower flood plains of the river in an area of approximately 45,000 acres. Rye Patch Dam and Reservoir, on the Humboldt River about 26 miles upstream from Lovelock and 22 miles from the northern extremity of the service area, stores the flow of the river for diversion to the irrigated lands.

PLAN

The Humboldt Project provides for storage at Rye Patch Dam, acquisition of lands and water rights upstream in the Battle Mountain area for supplementing the water supply for project lands, and utilization of the Pitt-Taylor Reservoirs. The plan is designed to provide seasonal and long-term regulation of the Humboldt River and to increase the amount of water available.

Rye Patch Dam and Reservoir

Rye Patch Dam and Reservoir

Rye Patch Dam is an earthfill structure with a structural height of 78 feet and a crest length of 1,074 feet. The outlet works will release 1,000 cubic feet per second and the spillway will discharge 20,000 cubic feet per second. The dam was completed and began storing water in 1936. The reservoir is 21 miles long and has a capacity of 213,000 acre-feet.

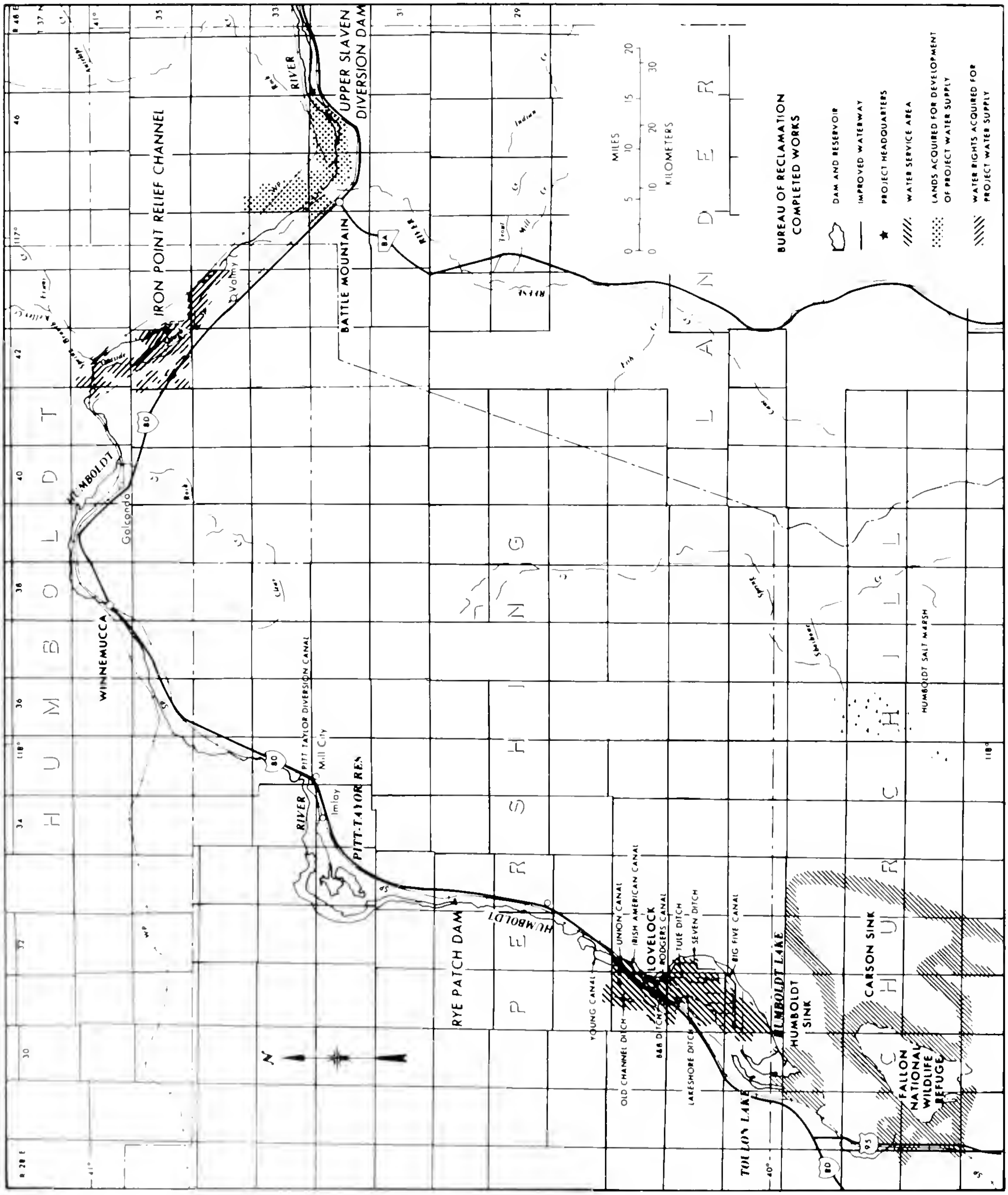
DEVELOPMENT

Early History

Irrigation of the lands in the project area was first started in 1862. Because of the erratic natural flow, a full-season water supply without storage facilities was dependable for only a small portion of the 40,000 acres of irrigable land. During cycles of wet years, larger areas produced crops, but during dry cycles there were crop failures. The first attempt to provide storage facilities was started by the Humboldt-Lovelock Light & Power Co., which in 1911 filed an application for 57,000 acre-feet of floodwater from the Humboldt River. This company built the two Pitt-Taylor Reservoirs, which have a total capacity of about 45,000 acre-feet. Storage in these reservoirs has been limited because of high evaporation and inferior quality water. The Pershing County Water Conservation District purchased the water rights in these reservoirs in 1945, and uses the present safe storage capacity of 35,000 acre-feet in conjunction with Rye Patch Reservoir.

Investigations

A preliminary investigation of reservoir sites and a study of the Humboldt River runoff were undertaken by the Reclamation Service in 1919. Final investigations in 1933 resulted in selection of the Rye Patch Dam site and indicated that a reservoir of nearly 200,000 acre-feet



Humboldt Project

capacity was required for a dependable water supply. The report of this investigation resulted in an allotment of Public Works Administration construction funds.

Authorization

On August 24, 1933, the Federal Emergency Administrator of Public Works approved an allotment of $2 million for construction. The President approved the project on November 6, 1935.

Construction

Construction of Rye Patch Dam commenced on January 31, 1935, and was completed June 1, 1936. Purchase of lands and water rights and construction of minor works by Government forces in the vicinity of Battle Mountain, collectively called the Battle Mountain Water Collection and Development System, were completed by January 21, 1939. A rehabilitation and betterment program, consisting of a control dam and improvements to existing dikes and river channel, was started December 5, 1955, in the Battle Mountain area.

In 1976, a rehabilitation and betterment project raised the height of the dam by 3 feet and the normal water surface elevation by 2 feet. This increased the storage capacity of the reservoir an additional 23,000 acre-feet to a total storage capacity of 213,000 acre-feet.

Operating Agency

The operation and maintenance of the project were transferred from the Bureau of Reclamation to the Pershing County Water Conservation District on January 15, 1941.

BENEFITS

Irrigation

The principal crops are alfalfa hay, alfalfa seed, wheat, and barley. Much of the produce is used for feeding the large numbers of cattle and sheep brought in from the upper Humboldt Basin and the Central Valley of California. The livestock are fattened before being shipped, principally to west coast markets.

Recreation

The Rye Patch Reservoir provides the usual types of water-based recreation. Facilities have been developed and operated under the administration of the Nevada Division of Parks. Fishing for trout and warm water species is under the management of the State Fish and Game Commission.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	39,623	acres
Number of irrigated farms	85	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	29,356	2,990,024
1969	31,018	3,873,599
1970	30,933	4,065,820
1971	31,029	4,963,300
1972	31,086	5,504,985
1973	31,130	9,768,789
1974	31,711	10,249,835
1975	32,375	9,244,447
1976	32,887	7,295,964
1977	27,063	9,895,630

Facilities in Operation

Storage dams	1
Diversion dams	1

Climatic Conditions

Annual precipitation	7.1	in
Temperature:		
Maximum	108	°F
Minimum	−29	°F
Mean	51	°F
Growing season	137	days
Elevation of irrigable area	3900-3977.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	210

ENGINEERING DATA

Water Supply

HUMBOLDT RIVER

Drainage area at Imlay	15,700	mi²
Average annual discharge at Rye Patch Dam	150,000	acre-ft

Storage Facilities

RYE PATCH DAM

Type: Homogeneous earthfill
Location: On the Humboldt River about 26 mi northeast of Lovelock, Nev.
Construction period: 1935-36; enlarged in 1976.

Reservoir, Rye Patch:		
Average annual inflow, 1937-68	121.2	acre-ft
Total capacity to El. 4136	213,000	acre-ft
Active capacity to El. 4136	213,000	acre-ft
Surface area	12,000	acres
Length	21	mi
Dimensions:		
Structural height	78	ft
Hydraulic height	65	ft

Top width	30	ft
Maximum base width	475	ft
Crest length	1,074	ft
Crest elevation	4144.0	ft
Total volume	361,000	yd³

Spillway: Concrete open channel in left abutment, controlled by five 20- by 17-ft radial gates.

Elevation top of gates	4136.38	ft
Crest elevation	4119.0	ft
Capacity, El. 4133	20,000	ft³/s

Outlet works: Concrete tunnel through left abutment, controlled by two sets of 3.5-ft-square high-pressure slide gates.

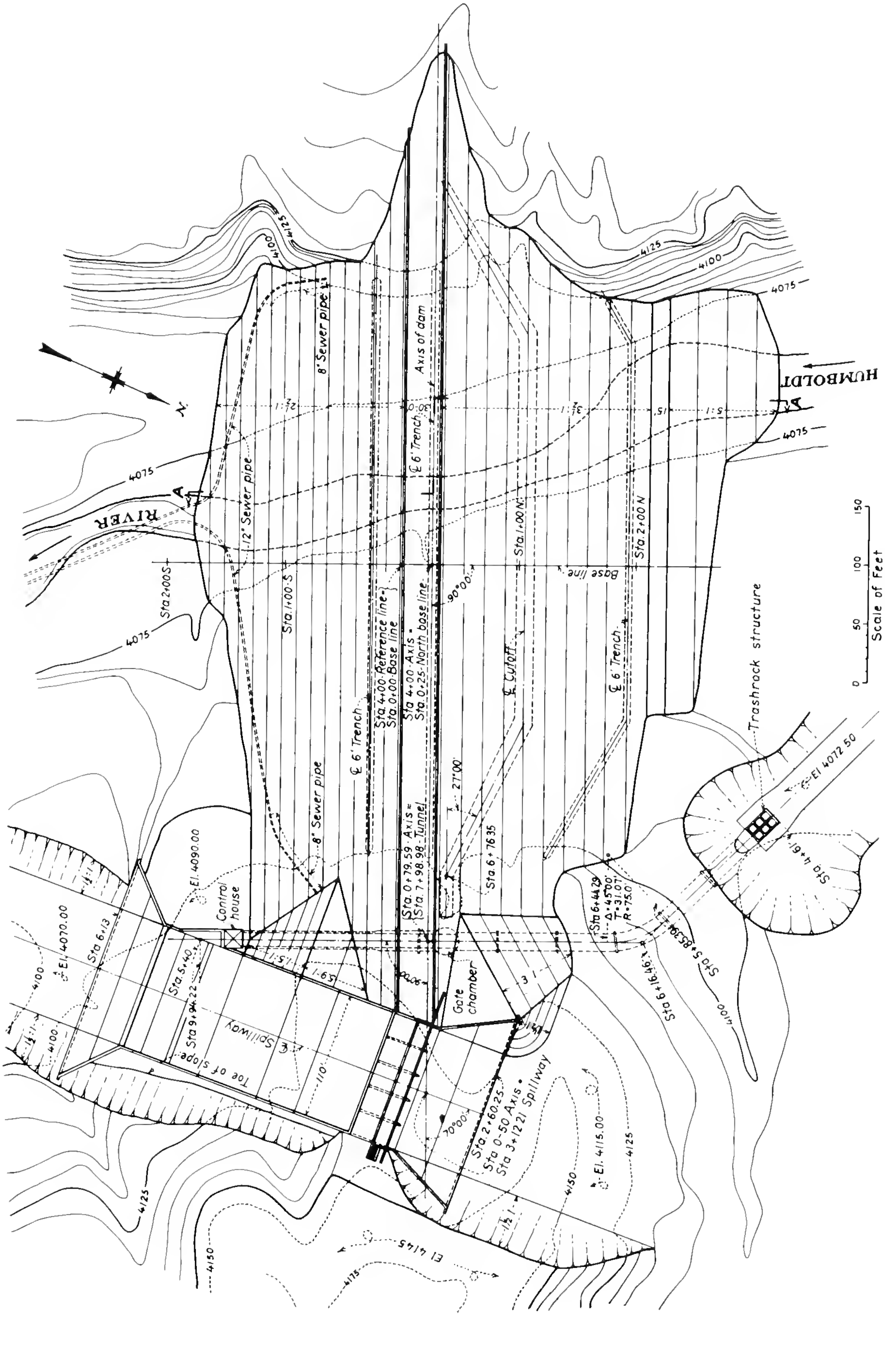
Capacity at El. 4120	1,000	ft³/s

Diversion Facilities

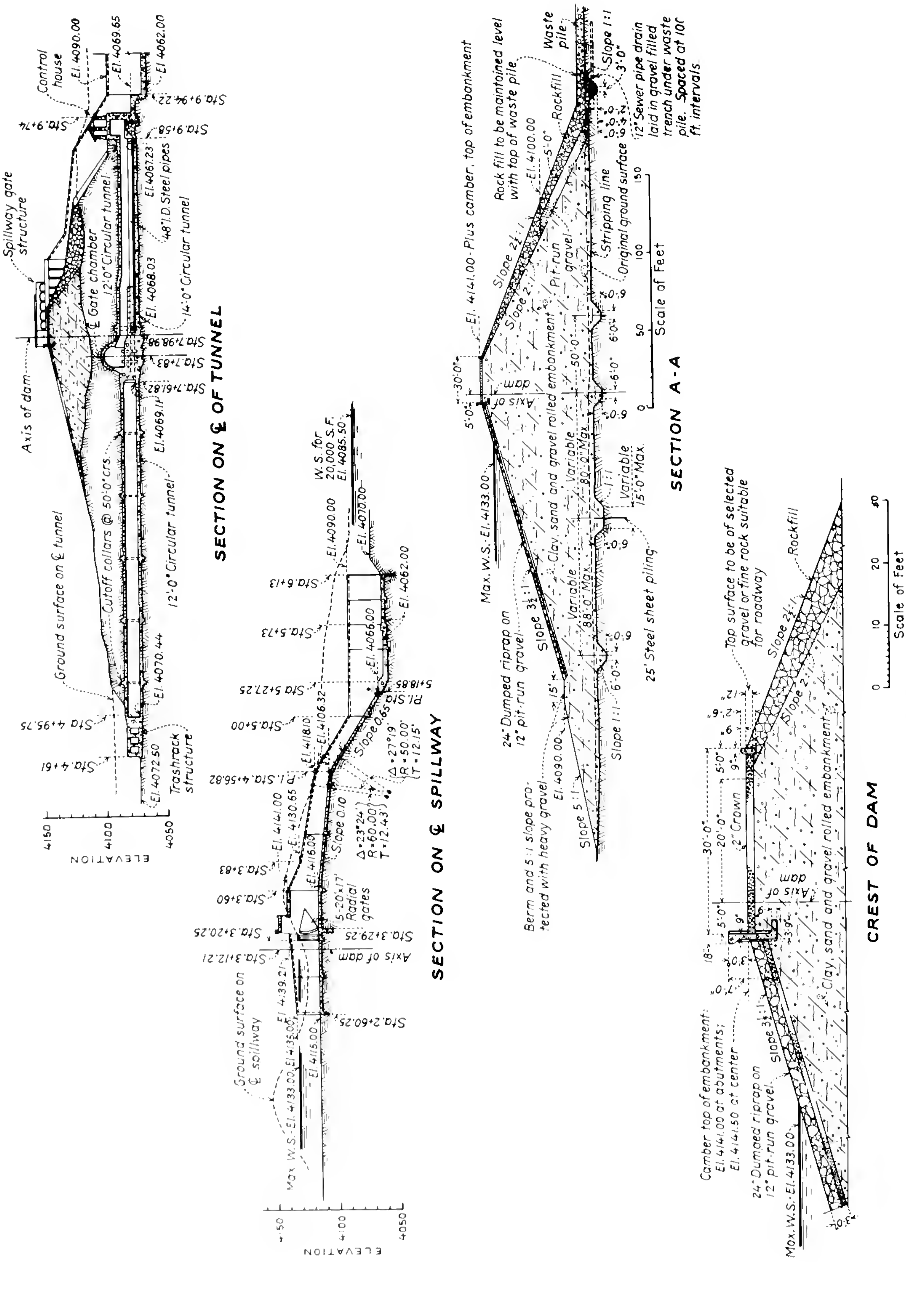
Upper Slaven Diversion Dam

Type: Slab and buttress
Location: On the Humboldt River about 11 mi east of Battle Mountain, Nev.
Year completed: 1958
Dimensions:

Structural height	18	ft
Hydraulic height	8	ft
Crest length	88	ft
Crest elevation	4560.0	ft
Volume	450	yd³
Diversion capacity	30	ft³/s



Rye Patch Dam, Plan

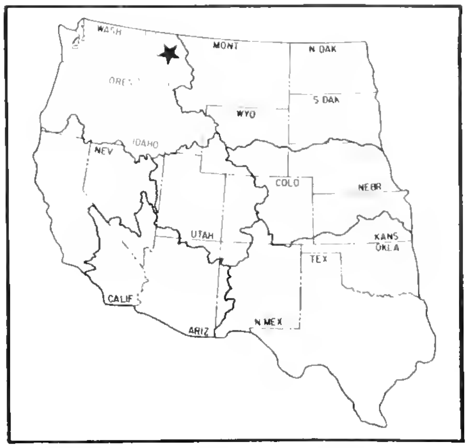


Rye Patch Dam, Sections

Hungry Horse Project

Montana: Flathead County

Pacific Northwest Region
Water and Power Resources Service



Hungry Horse Dam is on the South Fork of the Flathead River, 15 miles south of the west entrance to Glacier National Park and 20 miles northeast of Kalispell, Mont. The damsite is in a deep, narrow canyon, approximately 5 miles southeast of the Fork's confluence with the main stem of the Flathead River. Hungry Horse Project is in the Flathead National Forest, Flathead County, Montana.

The project includes a reservoir, dam and appurtenant works, powerplant, and switchyard. At the time of its completion, the dam was the third largest and second highest concrete dam in the world. The project plays an important role in the program for meeting the growing need for power in the Pacific Northwest and in the plans for providing a storage system for control of devastating floods. It also contributes to irrigation, navigation, and other uses.

PLAN

Hungry Horse is a key project in the Department of the Interior's long-range program for multiple-purpose development of the water resources of the vast Columbia River drainage basin. The dam creates a large reservoir by withholding water in times of heavy runoff to minimize downstream flooding. This stored water is released for power generation when the natural flow of the river is low. Downstream power benefits are of major importance since more than five times as much power can be produced from water releases downstream than is produced at Hungry Horse Powerplant.

Hungry Horse Dam and Reservoir

Hungry Horse Dam and Reservoir

The 564-foot-high dam is a variable-thickness concrete arch structure with a crest length of 2,115 feet. The dam and appurtenant works contain 3,086,200 cubic yards of concrete. The spillway is the highest morning-glory structure in the world. Water cascading over the spillway rim drops a maximum distance of 490 feet. The capacity of the spillway is 50,000 cubic feet per second, and the reservoir has a total capacity of 3,468,000 acre-feet.

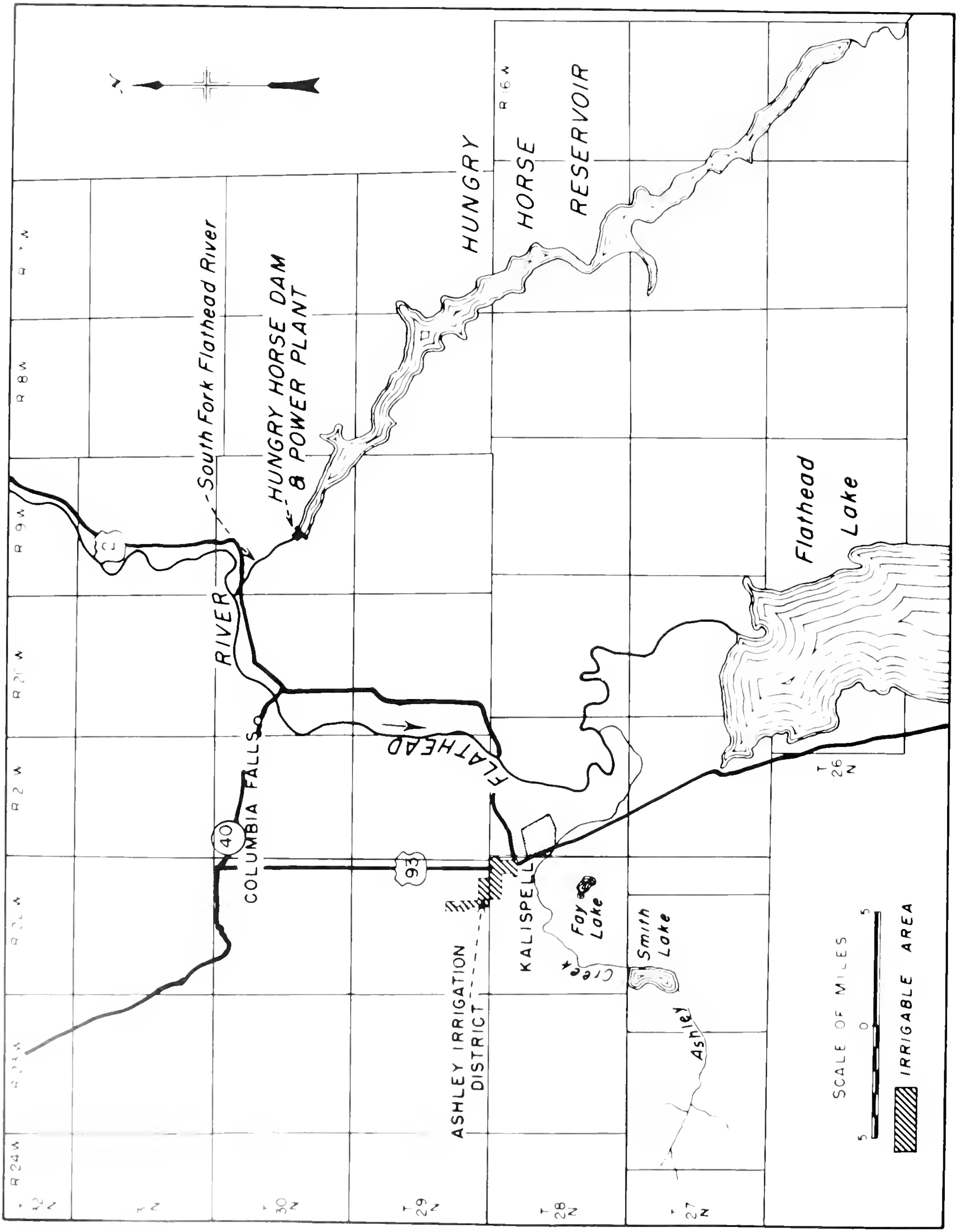
Powerplant

Power generating facilities are housed in a building with a structural steel framework surmounting a reinforced concrete substructure 394 feet long, 76 feet wide, and 157 feet high, constructed across the river channel at the downstream toe of the dam. The plant includes four 71,250-kilowatt generators—a total of 285,000 kilowatts installed capacity. The generators are capable of meeting peak loads of 328,000 kilowatts.

DEVELOPMENT

Early History

The Flathead Valley was entered in the early 1800's by the Northwest Fur Company and the Hudson's Bay Company, which established trading posts north of Flathead Lake. The first permanent settler in the valley arrived in 1860.



Hungry Horse Project

Individual farmers irrigated the Ashley Creek area of the Flathead River Valley as early as 1885. The Ashley Irrigation District was formed in 1897 to serve 1,637 acres. In 1909, the Montana legislature passed a revised State irrigation district law and the Ashley Irrigation District was formed.

Investigations

For a third of a century, Montana worked toward development of a project to harness the waters of the Flathead River for irrigation, flood control, and power. Original surveys in the drainage basin were initiated in 1921 by the Geological Survey. They were continued by the Bureau of Reclamation and other Federal agencies as a basis for seeking congressional approval of a project.

In June 1943, due to the wartime need for power, serious consideration was given to raising the level of Flathead Lake. This would have permitted the installation of additional capacity at Kerr Dam at Polson and would have firmed up the power production at the Thompson Falls, Grand Coulee, Rock Island, and Bonneville plants. Local opposition to this proposal, together with the need for multiple-purpose projects and war-emergency water storage for power production, gave impetus to serious consideration and investigations of constructing Hungry Horse Dam as an alternative.

Studies began in 1977 to evaluate the provision of additional generating capacity of about 200,000 kilowatts at the existing Hungry Horse Powerplant, including a new regulating dam downstream, and to increase the capacity of the present generators from 285,000 kilowatts to 360,000 kilowatts. In effect, the proposals being considered would increase the at-site power generation from 285,000 to about 560,000 kilowatts. Other aspects of the

Hollow-jet valve outlets at Hungry Horse Dam studies include fish and wildlife, recreation, stream regulation, water quality, and flood control.

Authorization

Construction of Hungry Horse Dam was authorized by the Congress under Public Law 329, 78th Congress, 2d session, approved June 5, 1944 (58 Stat. 270).

Construction

The prime contract for the construction of Hungry Horse Dam and Powerplant was awarded April 21, 1948, and the work was completed July 18, 1953.

Operating Agency

The project is maintained and operated by the Bureau of Reclamation.

BENEFITS

Hydroelectric Power

Hungry Horse Project creates power benefits that extend from the Continental Divide westward to the Pacific Ocean. At-site production averages about a billion kilowatt-hours annually. The principal power benefit from the project arises from its ability to store water through the spring flood season for later release when needed. In an average year, this water will generate about 4.6 billion kilowatt-hours of power as it passes through a series of 19 downstream powerplants. Ultimately, benefits will be further increased as more of the downstream head is developed.

Flood Control

Following the disastrous floods in the Columbia River Basin during the spring of 1948, which caused damage estimated at $100 million, the Hungry Horse Project was included in a "main control plan" system of reservoirs for control of floods in the basin. Hungry Horse Dam now contributes materially toward controlling floods on the Columbia River. The dam helped minimize floods in Flathead Valley and reduced peak discharges between the valley and Grand Coulee Dam by 10 to 25 percent, and at Portland, Oreg., by about 5 percent. Approximately 3 million acre-feet of Hungry Horse Reservoir storage capacity can be used for flood control.

Recreation and Fish and Wildlife

Hungry Horse Reservoir is located high in the Rocky Mountains, less than 30 miles from the Continental Divide, and is surrounded by more than 25 mountain peaks. The reservoir is about 34 miles long and offers excellent opportunities for fishing, boating, water skiing, and swimming. The surrounding mountains are popular big game hunting areas and several of the small tributaries to the reservoir have their headwaters in nearby alpine lakes. The reservoir area is located entirely within the boundaries of the Flathead National Forest, and the Forest Service administers recreational use of the reservoir. Facilities have been constructed for camping, picnicking, and boat launching.

Hungry Horse Reservoir

PROJECT DATA

Facilities in Operation

Storage dams	1
Powerplants	1
Transmission lines	1.2 mi
Substations	1

Power Generation

Fiscal year	Hungry Horse Powerplant (kWh)	Fiscal year	Hungry Horse Powerplant (kWh)
1968	814,312,000	1973	757,936,000
1969	1,078,626,000	1974	1,098,088,000
1970	957,314,000	1975	1,048,300,000
1971	912,778,000	1976[1]	1,318,466,000
1972	1,050,104,000	1977	979,062,000

[1]This encompasses a 15-month period because of fiscal year change.

ENGINEERING DATA

Water Supply

South Fork, Flathead River

Drainage area above Hungry Horse Dam	1,654 mi²
Annual discharge at gaging station 3 mi downstream from Hungry Horse Dam:	
Maximum (1971)	3,770,300 acre-ft

Minimum (1977)	1,478,600	acre-ft
Average	2,777,700	acre-ft

Storage Facilities

Hungry Horse Dam

Type: Concrete thick arch
Location: On South Fork of the Flathead River about 9 mi southeast of Columbia Falls, Mont.
Construction period: 1948-53
Date of closure (first storage): Sept. 1, 1951
Reservoir, Hungry Horse:

Total storage to El. 3560	3,468,000	acre-ft
Active storage, El. 3336-3560	2,982,000	acre-ft
Surface area	23,800	acres

Dimensions:

Structural height	564	ft
Hydraulic height	520	ft
Top width	39	ft
Maximum base width	330	ft
Crest length	2,115	ft
Crest elevation	3565.0	ft
Total volume	3,086,200	yd^3

Spillway: Morning-glory, with inclined shaft and tunnel through right abutment, controlled by one 64- by 12-ft ring gate.

Elevation top of gate	3560.0	ft
Crest elevation	3548.0	ft
Capacity at El. 3565	50,000	ft^3/s

Outlet works: Three 96-in-diameter conduits through dam, each controlled by one 96-in hollow-jet valve, provide for river releases.

Capacity at El. 3565	14,000	ft^3/s

Power outlets: Four 162-in-diameter penstocks, each controlled by one 13.5- by 18.93-ft fixed-wheel gate, deliver water through the dam to the powerplant.

Capacity at El. 3560	9,000	ft^3/s

Foundation: Siyeh limestone in regular beds ranging from a few inches to several feet thick, made highly insoluble by impurities cut by one major and several minor shear zones and one major bedding-plane slip.
Special treatment: Blanket grouting over foundation area; grout curtain under dam. Bedding-plane clay seam washed out and filled with grout. Cutoff shafts in major shear zone filled with concrete and sealed by grouting.
Mass concrete: Natural aggregate from deposit 5 mi downstream, deficiencies in smaller sizes made up by crushing and borrow sand from natural pit 4 mi downstream; Type II (low alkali) cement with 32.1 percent pozzolan (fly ash) by weight for interior concrete and 24.2 percent by weight for exterior concrete; artificial cooling through embedded pipe system using river water.

Volume	2,935,000	yd^3
Maximum size aggregate	6	in

Average net water-cement ratio by weight:

Interior concrete	0.57	
Exterior concrete	0.48	

Cement-pozzolan content:

Interior concrete	278	lb/yd^3
Exterior concrete	372	lb/yd^3

Contraction joints: Transverse joints at 80-ft centers on upstream face; one longitudinal joint in longer blocks, offset in adjacent blocks. Joints grouted after cooling of concrete.

Power Facilities

Hungry Horse Powerplant

Location: Hungry Horse Dam
Year of initial operation: 1952
Year last generator placed in operation: 1953

Nameplate capacity	285,000	kW
Number and capacity of generators ...... (4)	71,250	kW
Maximum head	477.4	ft

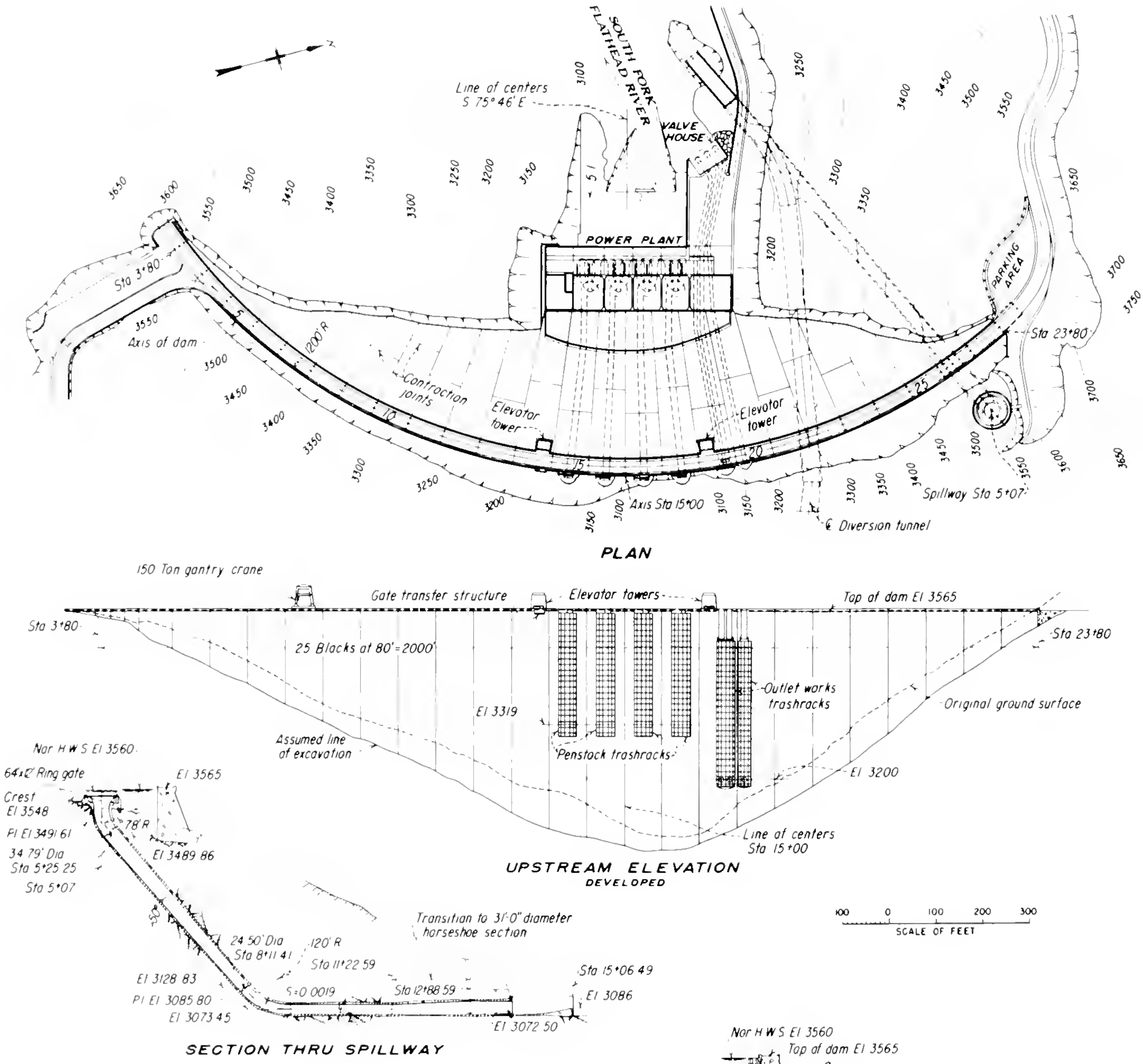
Substations

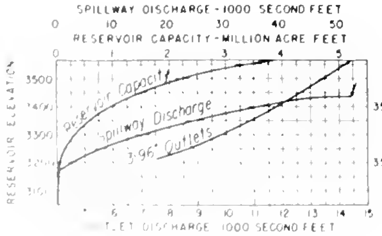
Number in operation	1	
Total capacity of transformers	438,650	kVA

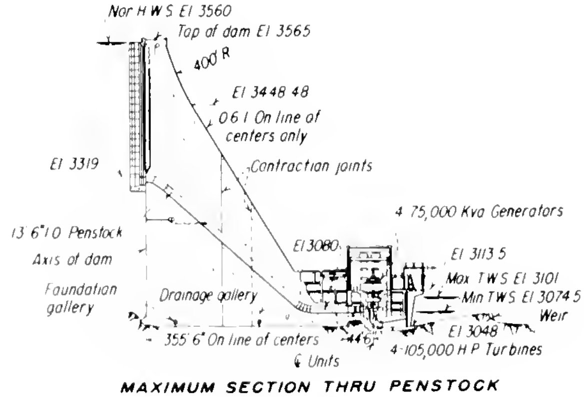
Transmission Lines

Total number of lines	3
Total circuit miles	4.2

Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Powerplant—Switchyard, C1T1	230	180,000	0.24	1952
Powerplant—Switchyard, C2T1	230	180,000	0.24	1953
Powerplant—Government Camp	12.47	3,500	3.75	1953





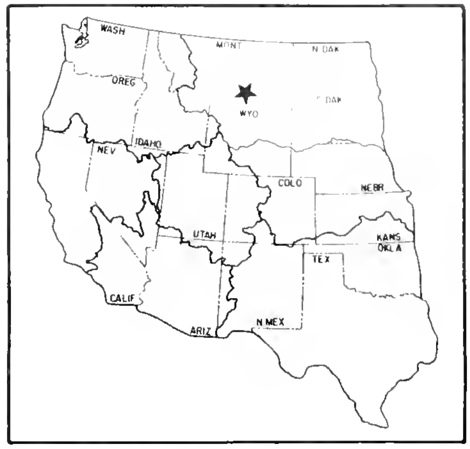


Hungry Horse Dam and Powerplant, Plan and Sections

Huntley Project

Montana: Yellowstone County

Upper Missouri Region
Water and Power Resources Service



The Huntley Project is in south-central Montana. Project works include a rockfill and concrete diversion dam, 32 miles of main canal, 22 miles of carriage canals, 202 miles of laterals, 186 miles of drains, a hydraulic turbine-driven pumping plant and an auxiliary electric pumping plant, both in the main canal, and an offstream storage reservoir. The project can furnish water to irrigate 27,333 acres.

PLAN

The project diverts water from the Yellowstone River to irrigate lands on the south side of the river between Huntley and Pompeys Pillar, Mont. The gravity distribution system extends from the intake of the Main Canal, at the diversion dam on the Yellowstone River, in a northeasterly direction for about 32 miles. At mile 13.77, a 35-foot drop in the Main Canal is utilized to lift water into the High Line Canal, which originates at this point. Two-thirds of the 300-cubic-foot-per-second capacity of the Main Canal at the pumps drops through the turbines and develops sufficient power to lift the remaining 100 cubic feet per second to the High Line Canal. An auxiliary 150-horsepower electric pump was installed in 1975 to lift approximately 25 cubic feet per second to the High Line Canal. Anita Reservoir is filled during slack periods with water delivered through the High Line Canal to supplement the supply from the hydraulic pumps during periods of heavy demand.

Water is released from Anita Reservoir into the Reservoir Canal, which flows across Fly Creek to the vicinity of Pompeys Pillar. The High Line Extension Canal diverts from the High Line Canal through a siphon crossing at the downstream toe of Anita Dam to irrigate lands above the Reservoir Canal as far as Fly Creek.

Main Canal and Distribution System

The inlet to the Main Canal of the Huntley Project is located near a 10.5-foot-high diversion dam in the Yellowstone River about 2.5 miles west of Huntley. The Main Canal is about 32 miles long with an operating capacity of 730 cubic feet per second. Three diversion points supply the canal. The Main Canal headworks and auxiliary headworks are located near the Yellowstone River Diversion Dam and a diversion from Pryor Creek is located on the Main Canal 1.8 miles downstream from the dam. This canal extends in a northeasterly direction and passes through several deep rock cuts and three tunnels.

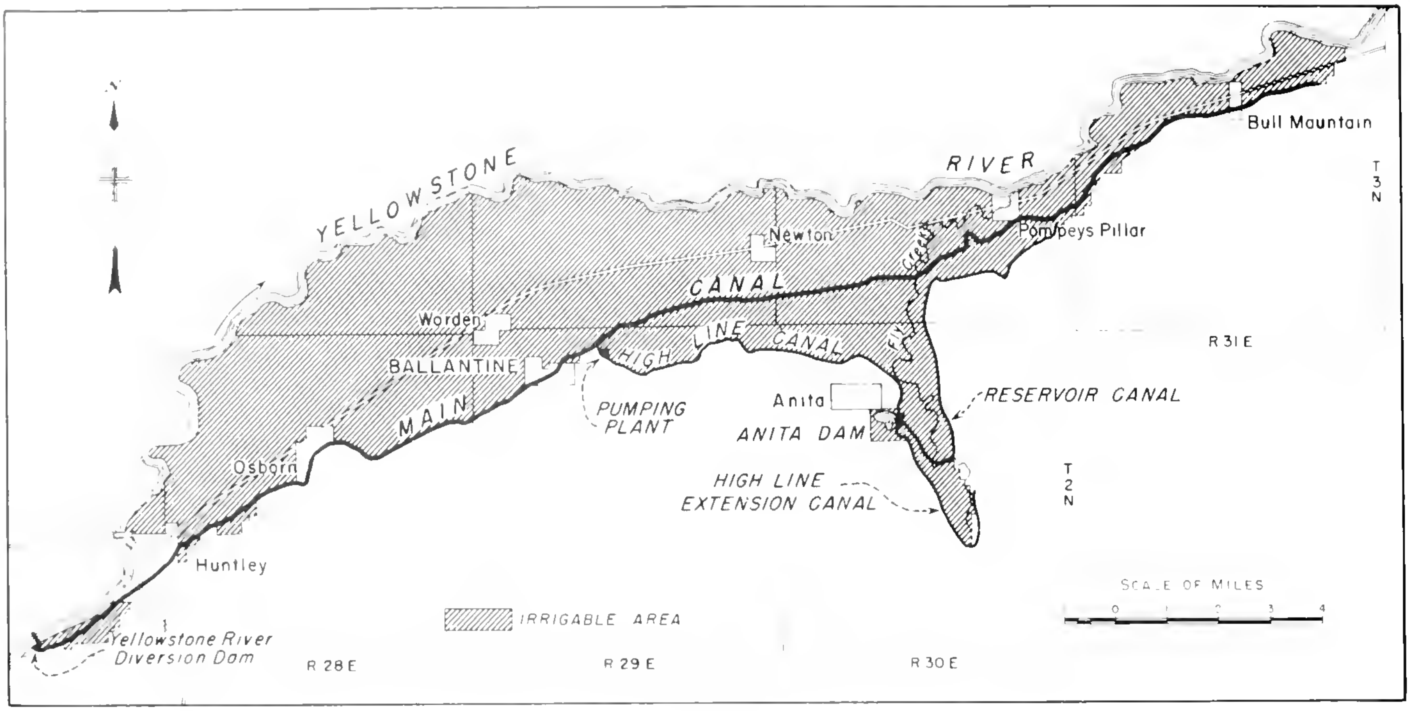
The distribution system includes 202 miles of laterals and 186 miles of drains.

Pumping Plant

About 1 mile east of Ballantine, a 35-foot drop in the Main Canal develops energy to lift water 42 feet for irrigation of approximately 5,000 acres of otherwise nonirrigable land. There are two direct-connected turbines and pumps, each capable of delivering about 50 cubic feet per second. The pumping plant is semiautomatic in operation, requiring only occasional checking by a ditchrider.

Anita Dam and Reservoir

Anita Dam was not required in the original project plans. Subsequent development of additional lands by local interests necessitated its construction for hold-over storage of water lifted by the turbine-driven pumps during slack periods, to reduce the extensive operating time of the pumps. This offstream storage dam was completed by the Civilian Conservation Corps (CCC) in 1937. The dam is an earth structure, 42 feet high with a volume of 143,000 cubic yards, located 1 mile southeast of the Anita Railroad Station. The combination spillway-wasteway adjoining the High Line Canal on the north abutment is a concrete-lined chute 40 feet wide with a capacity of 1,500 cubic feet per second. The dam impounds a reservoir that has a capacity of 400 acre-feet.



Huntley Project

Rehabilitation and Betterment of the Yellowstone River Diversion Dam

An inspection of the Yellowstone River Diversion Dam in 1956 revealed a crack in the dam due to settlement. Extensive erosion of the streambed had resulted in undercutting of the dam foundation. On January 4, 1957, the Bureau of Reclamation and the Huntley Project Irrigation District signed a repayment contract to repair the dam. The repairs were completed in the fall of 1957.

DEVELOPMENT

Early History

As the first representative of the United States in the Upper Missouri Valley, Captain Clark of the Lewis and Clark expedition scratched his name and the date of July 25, 1806, on Pompeys Pillar, a large rock landmark overlooking the Yellowstone River. Later, the Yellowstone River became a route for traders, trappers, and pioneers. The earliest settlers in the district were the fur traders, then prospectors and other pioneers came to the area. Some of these people turned to agriculture, cattle raising, or other pursuits; some continued to mine. All contended with difficulties common to western pioneer life.

The Crow Indian Reservation, established under the ratified treaty of May 7, 1868, included an area much larger than the present reservation. The lands in the Huntley Project, being within the reservation, were not subject to homestead entry and consequently remained undeveloped long after other fertile tracts in the Yellowstone Valley were settled. The cession of lands to the United States by the Crow Indians in 1904 included those in the Huntley Project and opened the way for irrigation and settlement.

Investigations

An act of Congress approved April 27, 1904, provided that the Reclamation Service should make surveys and investigations for the irrigation of the irrigable area lying south of Yellowstone River and extending along the Bighorn River as far southeast as the Fort Custer military reservation.

Surveys began in August 1904, and in October 1904 the project was designated for early development. Detailed plans were prepared and reviewed by a board of engineers which, on February 26, 1905, declared the project feasible.

Authorization

The project was authorized by the Secretary of the Interior on April 18, 1905.

Construction

Construction began October 6, 1905. The first water was delivered in 1908. The Pryor Division was completed in 1908, the Eastern Division in 1914, and the Fly Creek

Anita Dam

Yellowstone River Diversion Dam

Division in 1915. The High Line Canal was enlarged in 1917 from 60- to 100-cubic-foot-per-second capacity.

Initial construction of the project did not require a diversion dam since the Main Canal intake on the Yellowstone River was level with the riverbed. Development of additional lands by local interests requiring increased diversion necessitated the construction of a small diversion dam which was completed by the Huntley Project Irrigation District in 1934. Anita Dam and Reservoir were constructed by CCC forces and completed in 1937.

Operating Agency

The project is maintained and operated by the Huntley Project Irrigation District.

BENEFITS

Irrigation

The principal crops are alfalfa and other hay crops, sugar beets, silage, irrigated pasture, and small grains. The project is a stabilizing influence on the livestock industry in the area, through the production of feed crops.

Municipal Water

The towns of Huntley, Pompeys Pillar, Ballantine, and Worden are served with Huntley Project water.

Recreation

In 1977, the facility had 900 visitor days.

PROJECT DATA

Land Area (1977)

Irrigable area:		
Full irrigation service	27,333	acres
Number of irrigated farms	255	

Area Irrigated and Crop Values

Year	Area irrigated, acres	Crop value, dollars
1968	24,573	1,825,667
1969	24,010	2,223,300
1970	23,924	2,127,149
1971	24,547	2,554,287
1972	24,523	3,008,028
1973	24,880	3,819,441
1974	24,922	6,329,704
1975	24,692	5,029,392
1976	25,015	4,119,440
1977	25,218	4,038,921

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	54	mi
Laterals	202	mi
Pumping plants	6	
Drains	186	mi

Climatic Conditions

Annual precipitation	12.6	in
Temperature:		
Maximum	107	°F
Minimum	−53	°F
Mean	45	°F
Growing season	131	days
Elevation of irrigable area	3,000	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	952
Other water service[1]	970
Total	1,922

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

YELLOWSTONE RIVER

Drainage area at Billings, Mont. (10 mi upstream from diversion point)	11,795	mi^2
Annual discharge at Billings:		
Maximum (1975)	7,489,600	acre-ft
Minimum (1934)	2,915,100	acre-ft
Average	5,072,900	acre-ft
Average annual diversion:	133,500	acre-ft

Storage Facilities

ANITA DAM[2]

Type: Modified homogeneous earthfill
Location: Offstream, 6 mi southeast of Ballantine, Mont.
Construction period: 1933-37
Reservoir, Anita (offstream): Water supply from Yellowstone River through Main and High Line Canals.

Total capacity to El. 3003	400	acre-ft
Active capacity, El. 2973.2-3003	400	acre-ft
Surface area	34	acres
Dimensions:		
Structural height	42	ft
Hydraulic height	30	ft
Top width	20	ft
Maximum base width	252	ft
Crest length	1,050	ft
Crest elevation	3010.0	ft
Total volume	143,000	yd^3
Spillway: Uncontrolled concrete-lined chute at north abutment.		
Crest length	40	ft
Crest elevation	3003.0	ft

[2]Constructed by the Civilian Conservation Corps.

Capacity at El. 3007.8	1,500 ft³/s

Outlet works: Concrete box conduit through base of dam near south abutment, controlled by one 2.4- by 3-ft slide gate.

Capacity at El. 2980	50 ft³/s

Diversion Facilities

Yellowstone River Diversion Dam[3]

Type: Concrete weir
Location: On the Yellowstone River, about 2 mi southwest of Huntley, Mont.
Construction period: Completed 1934. Rehabilitated in 1957.
Dimensions:

Structural height	10.5 ft
Hydraulic height	8 ft
Crest length	325 ft
Weir crest length	250 ft
Crest elevation	3004.0 ft
Volume	2,000 yd³

Headworks: Concrete with two steel regulating gates, each 5 by 7 ft.

Diversion capacity	600 ft³/s

[3]Constructed by Huntley Project Irrigation District. Rehabilitated by Reclamation in 1957.

Carriage Facilities

Main Canal

Location: From Yellowstone River Diversion Dam near Huntley, Mont., generally northeast along south side of Yellowstone River to vicinity of Pompeys Pillar, Mont.
Construction period: 1906-08

Length	32.2 mi
Diversion capacity	730 ft³/s
Typical maximum section in earth:	
Bottom width	14.5 ft
Side slopes	1.5:1
Water depth	7 ft

High Line Canal

Location: From the High Line Pumping Plant on the Main Canal, extends down the river 6.2 mi to Anita Reservoir.
Construction period: 1906-08, 1917

Length	8.2 mi
Capacity	100 ft³/s
Typical maximum section in earth:	
Bottom width	7 ft
Side slopes	1.5:1
Water depth	2.5 ft

High Line Extension Canal

Location: Water is diverted from High Line Canal near the inlet to Anita Reservoir. Water flows through an inverted siphon across the toe of Anita Dam to serve lands on Fly Creek.
Construction period: 1915-17

Length	4.4 mi
Capacity	24.8 ft³/s
Typical maximum section in earth:	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2.5 ft

Reservoir Line Canal

Location: Water is released from Anita Reservoir to Reservoir Canal, which flows across Fly Creek to the vicinity of Pompeys Pillar, Mont.
Construction period: 1915-17

Length	9.2 mi
Capacity	22.4 ft³/s
Typical maximum section in earth:	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2 ft

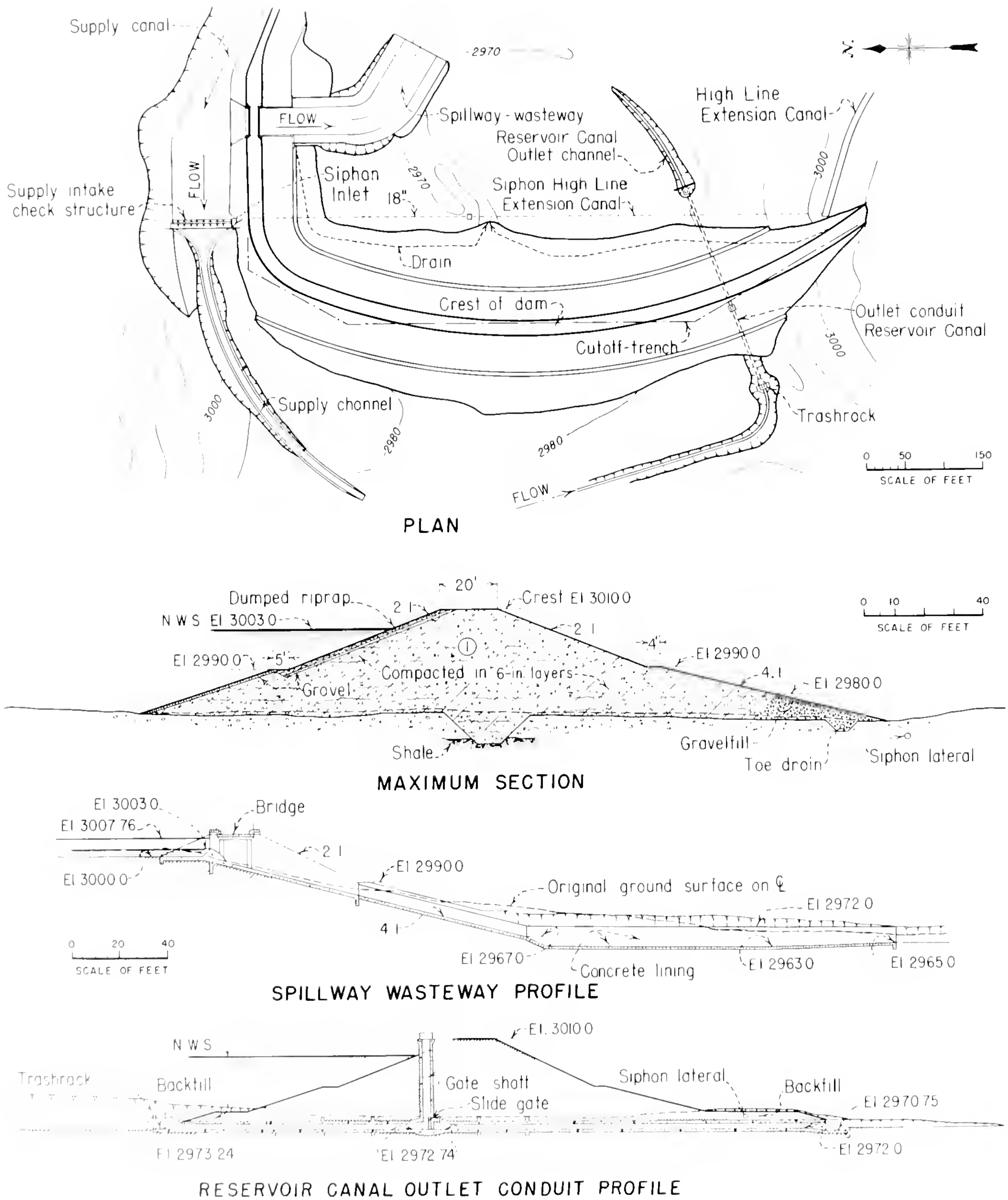
High Line Canal Pumping Plants

Number of units[4]	2
Total capacity	100 ft³/s
Total dynamic head	48.5 ft
Total horsepower[5]	620

[4]Vertical direct-connected turbine-driven centrifugal pump units.
[5]The 620-hp rating was for the two initial units. The 1946 replacements include two improved turbines operating with a 35-ft head and a normal capacity of 100 ft³/s total.

Auxiliary Power

Number of units	1
Total capacity	25 ft³/s
Total horsepower	150

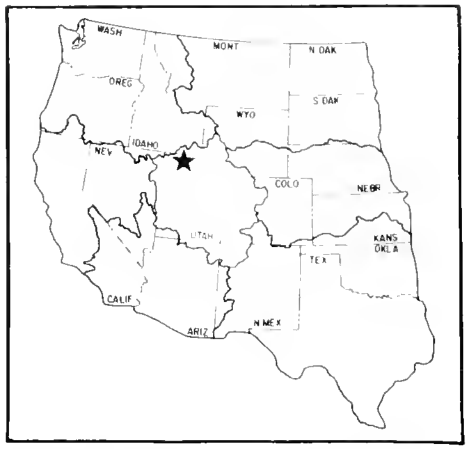


Anita Dam, Plan and Sections

Hyrum Project

Utah: Cache County

Upper Colorado Region
Water and Power Resources Service



The Hyrum Project in northern Utah includes as its principal construction features the Hyrum Dam and Reservoir, the Hyrum Feeder Canal, the Hyrum-Mendon Canal, the Wellsville Canal, and appurtenant structures. The system stores and diverts water from the Little Bear River to furnish supplemental water supplies to approximately 6,800 acres of privately owned and intensely cultivated land.

PLAN

Storage for the project is provided by the Hyrum Dam and Reservoir, which stores the flood runoff of Little Bear River. Water for the irrigation system is diverted from the outlet works of the dam. Three canals, the Hyrum Feeder Canal, the Hyrum-Mendon Canal, and the Wellsville Canal divert from this point. The Hyrum Feeder Canal extends north for about 1 mile and discharges into a lateral of the Hyrum Irrigation Company. The 14-mile-long Hyrum-Mendon Canal crosses the valley in an inverted siphon and delivers water to lands on the west side of the valley. The 5.4-mile-long Wellsville Canal receives water from a pumping plant and supplies lands on the west side of the valley which lie about 70 feet above those watered by the Hyrum-Mendon Canal. Water is made available to lands upstream of the reservoir by exchange.

Hyrum Project

Hyrum Dam

Hyrum Dam, a rolled earthfill structure, is 116 feet high and contains about 430,000 cubic yards of material. The dam is near the southwest corner of the town of Hyrum and creates a reservoir with a total capacity of 18,800 acre-feet. The spillway is a concrete-lined chute controlled by radial gates, with a discharge capacity of 6,000 cubic feet per second. The 300-cubic-foot-per-second capacity outlet works is a concrete-lined pressure tunnel to the gate chamber. The flow is in two steel pipes to the outlet well.

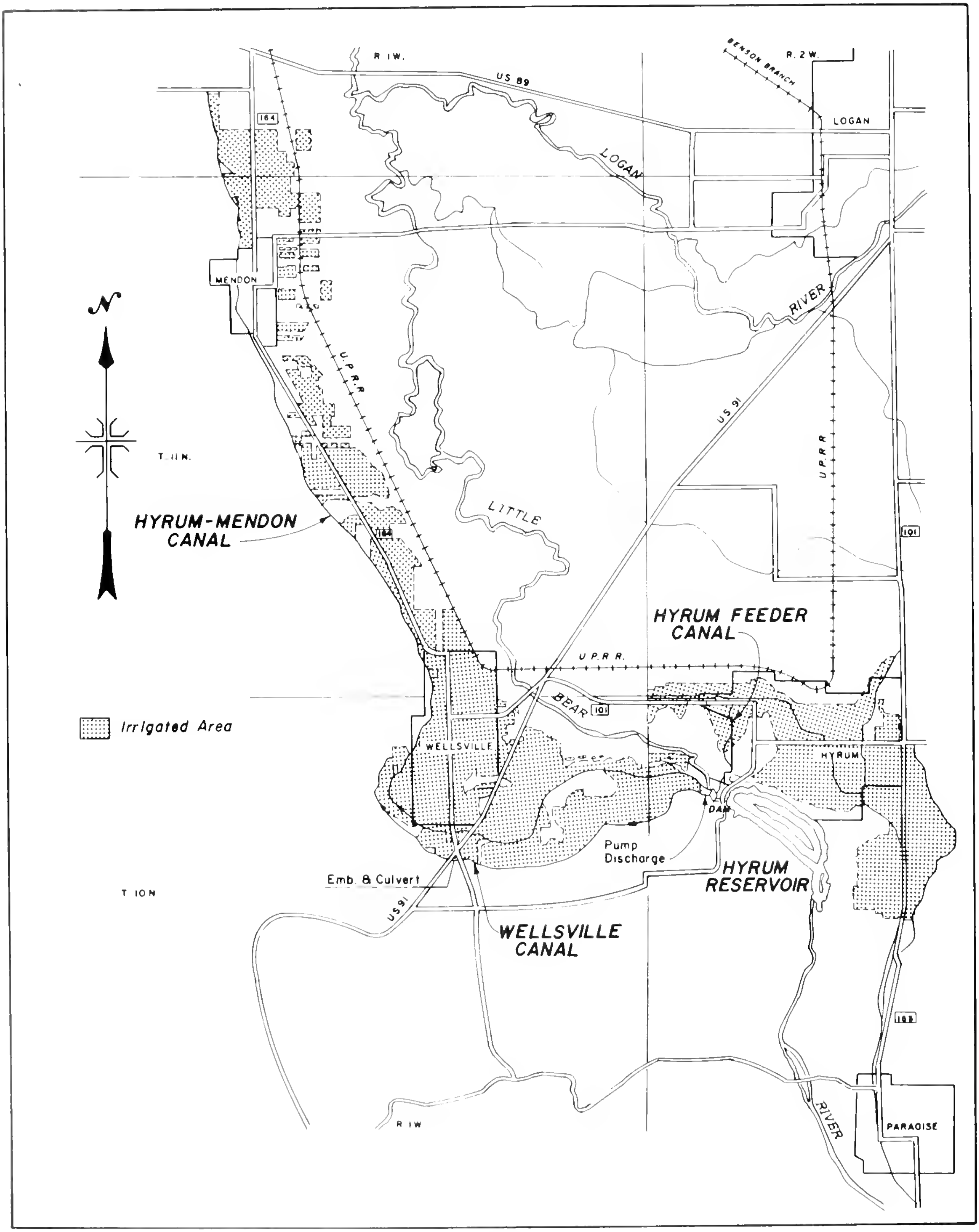
DEVELOPMENT

Early History

Although fur trappers visited Cache Valley frequently from 1824 to 1856, actual settlement of lands now included in the Hyrum Project commenced in September 1856, when "Maughan's Fort" was built at the site of the present city of Wellsville. From that time through the early 1860's, settlement of the valley was rapid and communities were located on several streams where water could readily and cheaply be conveyed to the land.

Investigations

The Reclamation Service investigated irrigation possibilities for the Hyrum Project area during 1902-04. After this early study, interest lagged until 1922 when the Department of Agriculture made a report on the land and water resources of the valley. This report revived the interest of the community in irrigation and on March 21, 1923, representatives of the Cache Valley Water Users Association petitioned the Utah Water Storage Commission for assistance in developing a plan for using the



Hyrum Project

Hyrum Dam and Reservoir

water resources of the valley. Funds were subsequently allotted for investigation of the water resources of Cache Valley. Investigation continued at intervals until 1932, when a report by the Bureau of Reclamation formed the basis for project construction.

Authorization

The project was initiated under the provisions of the National Industrial Recovery Act of 1933 (48 Stat. 195), and an allotment of funds for construction was made on August 19, 1933. The President approved the project on November 6, 1935, under the terms of section 4, act of June 25, 1910 (36 Stat. 835), and subsection b of section 4, act of December 5, 1924 (43 Stat. 701).

Construction

Construction of the project was begun on March 26, 1934, and the first water was made available in July 1935.

During 1977, rehabilitation work was completed. The Wellsville Canal steel discharge line of the pumping plant was replaced by a 24-inch-diameter reinforced concrete pipe buried in the same location. Rehabilitation of the Hyrum-Mendon Canal consisted of removing five steel flumes and replacing them with sections of 42-inch concrete pipe siphons.

Operating Agency

The project is operated and maintained by the South Cache Water Users Association.

BENEFITS

Irrigation

Irrigation of project lands has greatly increased their productivity and has improved the general economy of the community. Alfalfa, wheat, barley, and pasture are the principal crops in the area. A large proportion of the farms are small and are owned by part-time farmers.

Recreation

Reservoir facilities are administered by the Utah Division of Parks and Recreation. Recreational activities include picnicking, swimming, boating, and fishing. During 1977, visitor days totaled 164,195.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	6,800	acres
Number of irrigated farms	226	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,256	411,700
1969	5,832	378,908
1970	5,755	408,822
1971	5,858	369,716
1972	5,486	432,900
1973	5,679	598,297
1974	6,058	664,987
1975	6,182	668,351
1976	6,389	718,559
1977	6,376	621,292

Facilities in Operation

Storage dams	1	
Canals	21	mi
Laterals	17	mi
Pumping plants	1	
Drains	10	mi

Climatic Conditions

Annual precipitation	16.5	in
Temperature:		
Maximum	102	°F
Minimum	−25	°F
Mean	48	°F
Growing season	140	days
Elevation of irrigable area	4420-4800.0	ft

ENGINEERING DATA

Water Supply

LITTLE BEAR RIVER

Drainage area above Hyrum Dam	220	mi^2
Annual discharge at head of Hyrum Reservoir:		
Maximum (1971)	119,900	acre-ft
Minimum (1961)	28,500	acre-ft
Average	69,300	acre-ft
Average annual diversion	12,700	acre-ft

Storage Facilities

HYRUM DAM

Type: Homogeneous earthfill
Location: On Little Bear River near Hyrum, Utah, about 30 mi northeast of Ogden.
Construction period: 1934-35
Date of closure (first storage): April 1, 1935
Reservoir, Hyrum:

Average annual inflow, 1939-54	63,350	acre-ft
Total capacity to El. 4672	18,800	acre-ft
Active capacity, El. 4595.77-4672	15,300	acre-ft
Surface area	475	acres
Dimensions:		
Structural height	116	ft
Hydraulic height	82	ft
Top width	35	ft
Maximum base width	600	ft
Crest length	540	ft
Crest elevation	4680.0	ft
Total volume	430,000	yd^3

Spillway: Concrete-lined chute 100 ft north of right abutment, controlled by three 16- by 12-ft radial gates.

Elevation top of gates	4672.0	ft
Crest elevation	4660.0	ft
Capacity at El. 4672	6,000	ft^3/s

Outlet works: Concrete-lined tunnel through right abutment controlled by two sets of 33-in-square high-pressure slide gates in gate chamber. Two steel pipes continue to outlet well.

Capacity at El. 4660	300	ft^3/s

Foundation: Gravel and sand, some clay covering bed of well-cemented conglomerate.
Special treatment: Grout curtain beneath cutoff wall.

Carriage Facilities

HYRUM FEEDER CANAL

Location: Near Hyrum, Utah.
Construction period: 1934-35

Length	1.3	mi
Diversion capacity	9	ft^3/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.1	ft

WELLSVILLE CANAL

Location: From Wellsville Canal Pumping Plant near Hyrum, Utah, generally west.
Construction period: 1934-35. Rehabilitation - 1977.

Length	5.4	mi
Diversion capacity	15	ft^3/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.5	ft

HYRUM-MENDON CANAL

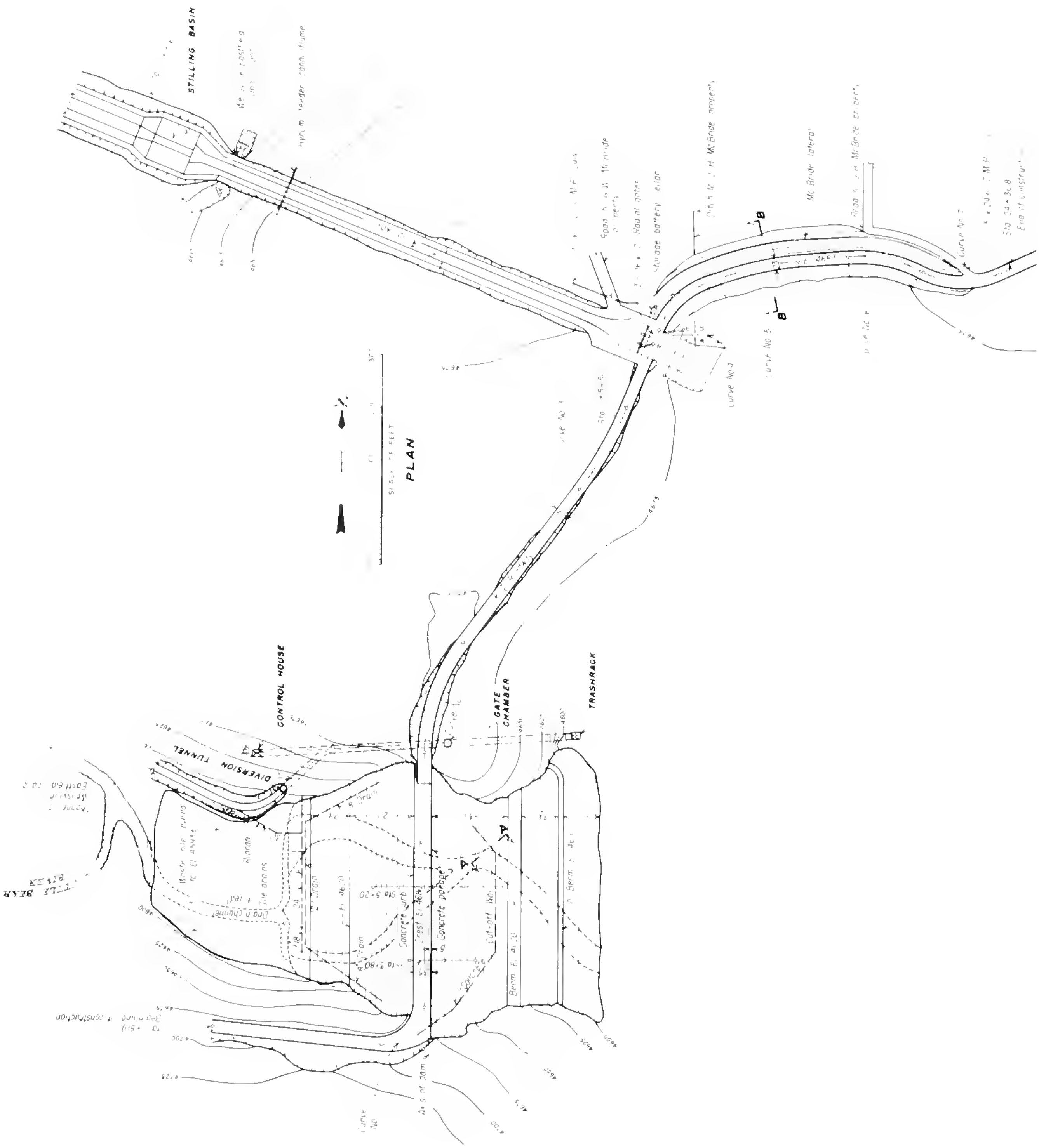
Location: From vicinity of Hyrum, Utah, generally northwest along Little Bear River to vicinity of Mendon.
Construction period: 1934-35. Rehabilitation - 1977.

Length	14	mi
Diversion capacity	89	ft^3/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	3.4	ft
Typical maximum section, lined:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	3	ft
Lining thickness	3	in

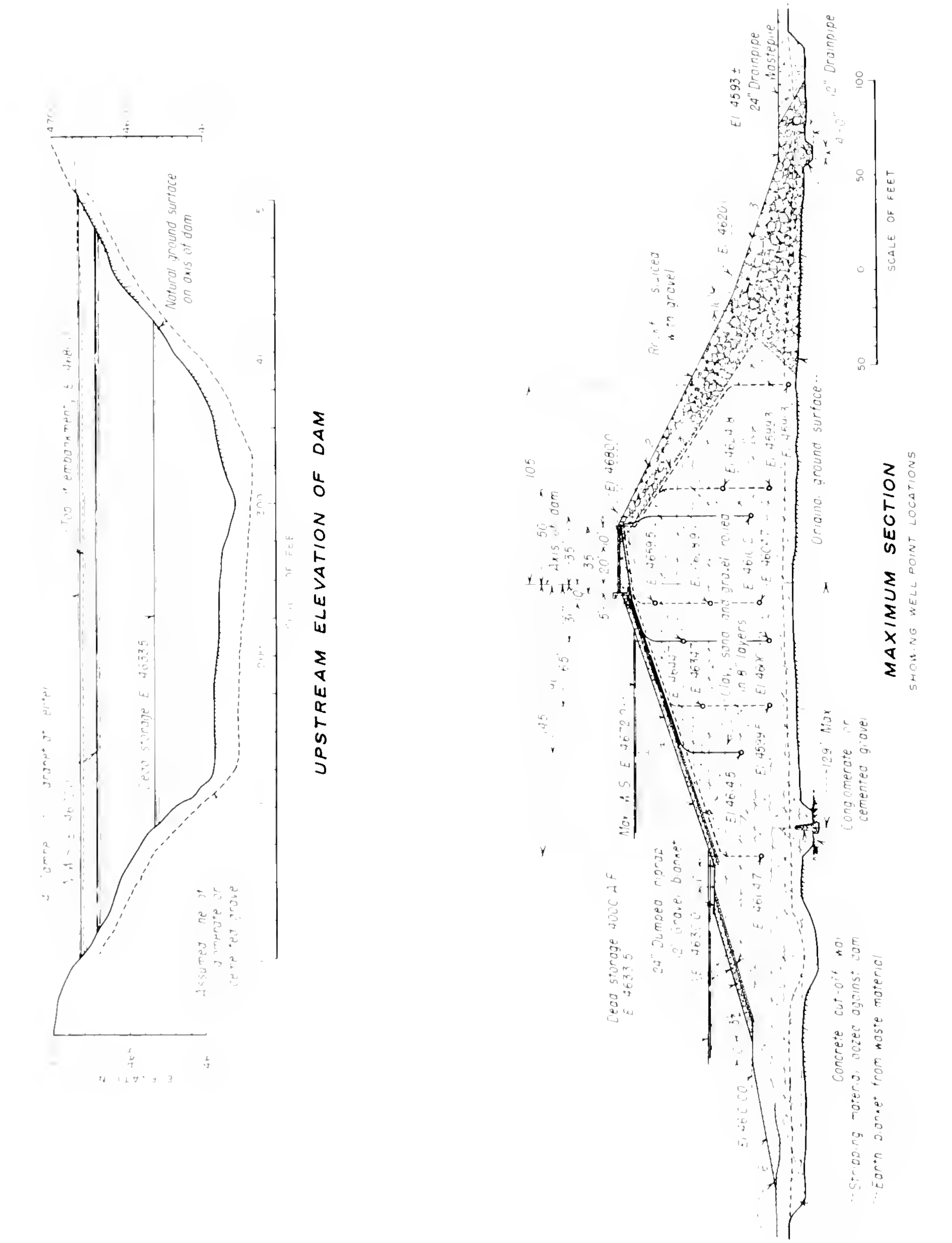
WELLSVILLE CANAL PUMPING PLANT

Number of units[1]	1	
Total capacity	16	ft^3/s
Total dynamic head	81	ft
Total horsepower	550	

[1]Direct-connected to hydraulic turbine.



Hyrum Dam, Plan

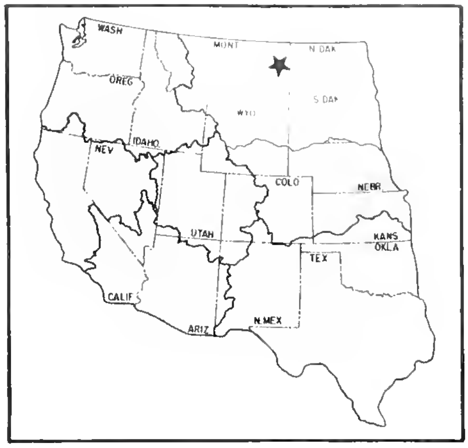


Hyrum Dam, Profile and Section

Intake Project

Montana: Dawson County

Upper Missouri Region
Water and Power Resources Service



The Intake Project includes a pumping plant and an irrigation distribution system serving 881 acres in Dawson County, Montana, adjacent to the Lower Yellowstone Project. The pumping plant is located on the Main Canal of the Lower Yellowstone Project about 1.5 miles downstream from Intake, Mont.

PLAN

Pumping Plant and Distribution System

The project facilities include a pumphouse, two electric motors, and two pumps. One pump lifts 3 cubic feet per second of water 10 feet and discharges into Lateral A-2, which is 1 mile long. The other pump lifts 15 cubic feet per second of water 16 feet to supply Lateral A-3, which is 2.9 miles long. The pumping power requirements are supplied by the Pick-Sloan Missouri Basin Program from the Fort Peck Project by wheeling over facilities of the Montana-Dakota Utilities Company.

DEVELOPMENT

Early History

The early settlers of the area depended on raising stock for their livelihood. During years of sufficient rainfall, abundant crops were produced, but those years were infrequent and the need for irrigation soon became apparent. The Reclamation Service began investigations of the Lower Yellowstone Valley in 1903 and constructed the adjacent Lower Yellowstone Project in 1905 to 1909. Upon its completion, about 260 acres, in what is now the Intake Project, were irrigated by privately operated pumps which lifted water from the Lower Yellowstone Main Canal to the land.

Investigations

The Bureau of Reclamation made an investigation of the general area of the Intake Project and submitted its findings in a report dated April 1942. The project was authorized on the basis of this report.

Authorization

The project was authorized by the President on January 20, 1944, under terms of the Water Conservation and Utilization Act of August 11, 1939 (53 Stat. 1418), as amended.

The project also was included in the Yellowstone River Pumping Unit, authorized as part of the Missouri River Basin Project's (renamed Pick-Sloan Missouri Basin Program) initial development in the Flood Control Act of 1944, Public Law 534, 78th Congress. However, construction proceeded under the original authorization so the Intake Project is not a part of the Pick-Sloan Missouri Basin Program.

Construction

Construction began in July 1945 and was completed in time for delivery of water during the 1946 irrigation season.

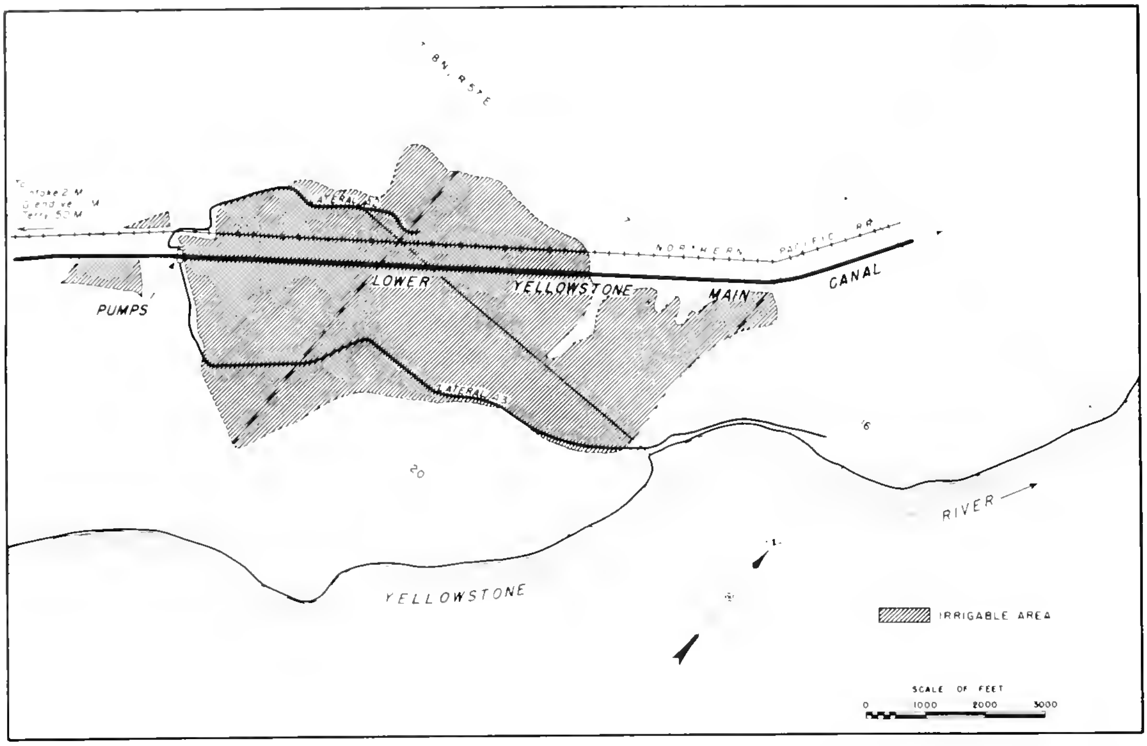
Operating Agency

The Board of Control of the Lower Yellowstone Project operates and maintains the Intake Project.

BENEFITS

Irrigation

The principal crops grown in the Intake Project include oats, alfalfa and other hay crops, pasture, silage, and sugar beets.



Intake Project

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service .... 881 acres
Number of farms 3

Area Irrigated and Crop Values

Year	Area irrigated, acres	Crop value, dollars
1968	704	61,446
1969	739	65,514
1970	742	59,712
1971	716	71,695
1972	728	64,354
1973	724	100,558
1974	755	163,472
1975	762	151,924
1976	756	119,454
1977	670	98,683

Facilities in Operation

Laterals .... 3.9 mi
Pumping plants 1

Climatic Conditions

Annual precipitation .... 14.1 in
Temperature:
Maximum .... 105 °F
Minimum .... 40 °F
Mean .... 44 °F
Growing season .... 135 days
Elevation of irrigable area .... 2000.0 ft

Settlement

Number of persons served with project water (1977):
Farm irrigation service 10

ENGINEERING DATA

Water Supply

YELLOWSTONE RIVER
(See Lower Yellowstone Project for details.)

Average annual diversion (1970-77) .... 1,700 acre-ft

Carriage Facilities

LATERAL A-3

Location: From Intake Pumping Plant near Intake, Mont., northeast.
Length .... 2.9 mi
Diversion capacity .... 15 ft³/s
Typical maximum section in earth:
Bottom width .... 4 ft
Side slopes 1.5:1
Water depth .... 3 ft

LATERAL A-2

Location: From Intake Pumping Plant near Intake, Mont., northeast.
Length .... 1 mi
Diversion capacity .... 3 ft³/s
Typical maximum section in earth:
Bottom width .... 2 ft
Side slopes 1.5:1
Water depth .... 0.9 ft

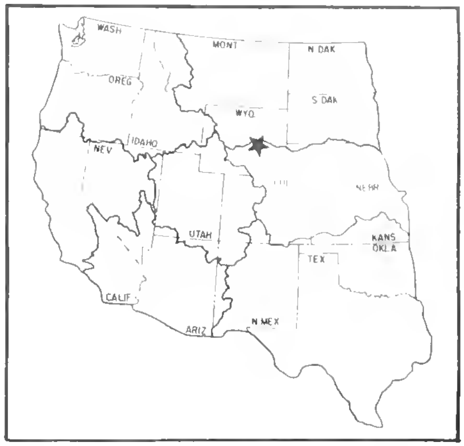
INTAKE PUMPING PLANT

Number of units 2
Total capacity .... 18 ft³/s
Total dynamic head .... 17-24 ft
Total horsepower 50.2

Kendrick Project

Wyoming: Carbon and Natrona Counties

Lower Missouri Region
Water and Power Resources Service



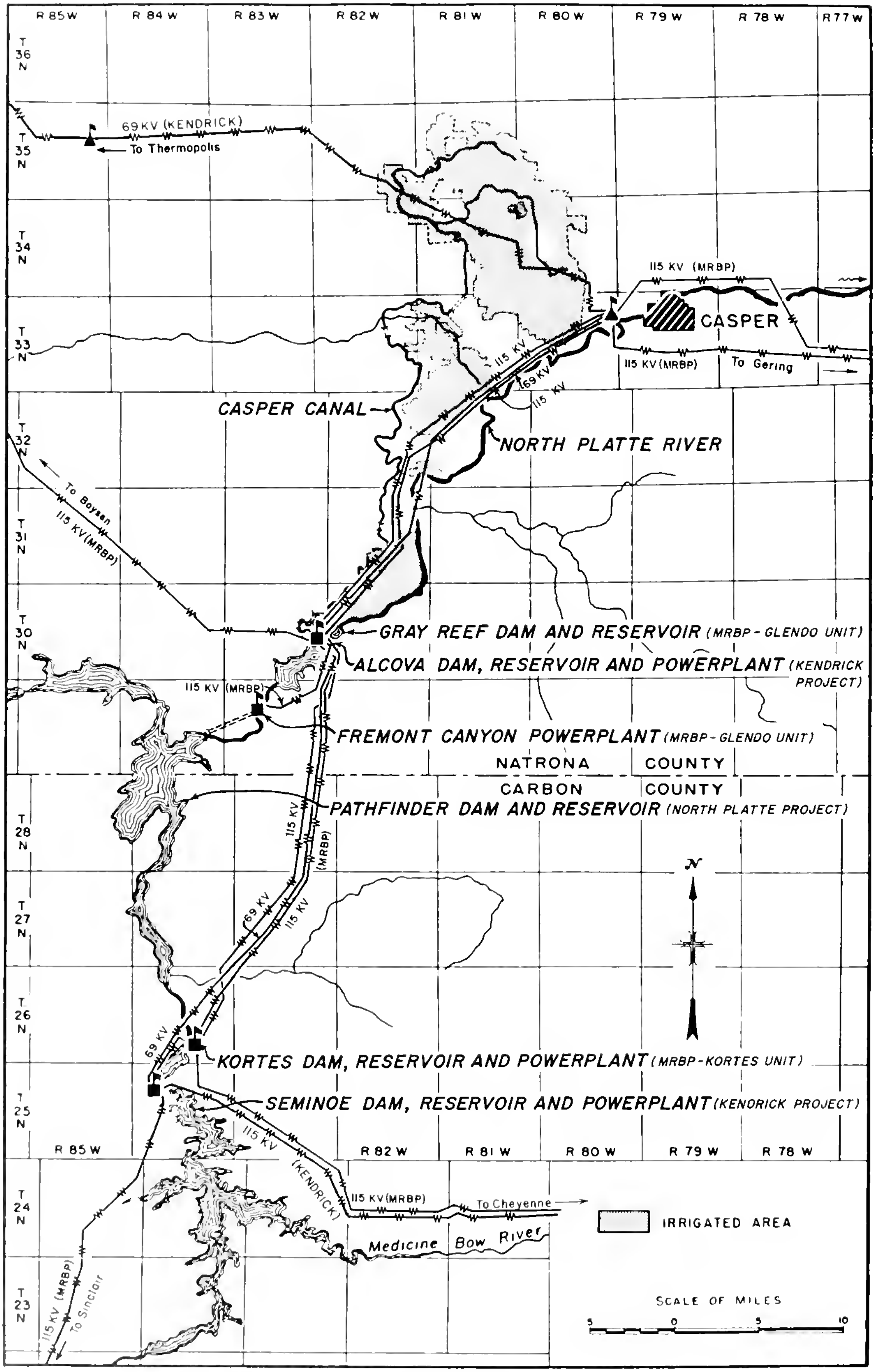
The Kendrick Project (formerly Casper-Alcova) conserves the waters of the North Platte River for irrigation and electric power generation. Major features of the project are Seminoe Dam and Powerplant, Alcova Dam and Powerplant, the Casper Canal and laterals, and drainage and power distribution systems. About 24,000 acres of irrigable project lands lie in an irregular pattern on the northwest side of the North Platte River between Alcova and Casper, Wyo.

Some features of the North Platte Project and the Kortes Unit of the Pick-Sloan Missouri Basin Program are interspersed along the North Platte River with features of the Kendrick Project, and these features operate together in the control of the river waters.

PLAN

The project is a multiple-purpose development that involves storage at Seminoe Reservoir and diversion at Alcova Dam to project lands. Operation of the reservoirs and powerplants is integrated with other river basin developments. Deferred plans for the addition of a second unit to the project would require extension of the main canal.

Seminoe Dam and Powerplant



Kendrick Project

Alcova Dam and Powerplant

Seminoe Dam and Powerplant

The Seminoe Dam and Powerplant are on the North Platte River about 72 miles southwest of Casper, Wyo. Seminoe Reservoir, with a total capacity of 1,017,280 acre-feet, provides storage capacity for the water to irrigate the project lands. The powerplant generates electric power as the water is released for irrigation or stored in Pathfinder Reservoir for later release as required. The dam is a concrete-arch structure containing 210,000 cubic yards of concrete and rising 295 feet above the rock foundation. Water is released from the reservoir through penstocks to the Seminoe Powerplant, or over a controlled spillway and outlet tunnel. The powerplant is located at the base of the dam, and has a rated head of 166 feet. The plant contains three units, each composed of a 13,500-kilowatt generator driven by a 20,800-horsepower turbine.

Alcova Dam and Powerplant

Alcova Dam is on the North Platte River about 37 miles downstream from Seminoe Dam and 10 miles downstream from Pathfinder Dam of the North Platte Project. The dam forms a reservoir from which water is diverted into Casper Canal for irrigation of lands in the Kendrick Project. The dam is a zoned earthfill structure rising 265 feet above its foundation, and containing 1,635,000 cubic yards of material. Water is released for other irrigation rights downstream through the Alcova Powerplant or over a controlled spillway. Alcova Powerplant was authorized and built after completion of Alcova Dam. It is on the right bank of the river opposite the toe of the dam.

The plant uses the 165-foot drop from the reservoir to the river for power generation. It consists of two units, each an 18,000-kilowatt vertical-shaft generator driven by a 26,500-horsepower turbine. The reservoir has a total capacity of 184,295 acre-feet, of which only the top 30,698 acre-feet is active capacity available for irrigation.

Casper Canal and Distribution System

The irrigation distribution system for the existing unit (unit 1) consists of the Casper Canal, 59 miles long; 190 miles of laterals and sublaterals; and 42 miles of drains. Principal structures include the headgates located on Alcova Reservoir about 1 mile west of the dam; six concrete-lined tunnels having a total length of 3.4 miles;

several siphons, and highway and farm road bridges; and many measuring and control structures. The main canal has a capacity of 1,200 cubic feet per second.

Power Transmission System

The power transmission system carries the energy generated at the hydroelectric powerplants to load centers in Wyoming, western Nebraska, and northern Colorado, and to interconnections with other Bureau of Reclamation power systems. The Kendrick Project power transmission system consists of 572.8 circuit miles of transmission lines and 6 substations and switchyards.

DEVELOPMENT

Early History

In the early days of Western settlement, the main route for immigrants and traders was along the Platte and Sweetwater Rivers, crossing the Continental Divide at South Pass. Such well known trails as the Oregon, Mormon, Overland, and California, and the Pony Express, followed this route. Many stage stations, trading posts, and army forts were scattered along the trails. Fort Laramie and Fort Caspar have been restored for their historical value. With the advent of the railroad in the late 1860's, these trails began to disappear.

The area was first used as open range, followed by homesteading, and then by irrigation farming. The general area is also rich in oil and mineral resources, which have played an important part in development of the State.

Investigations

In 1904, the Reclamation Service first investigated lands now included in the Kendrick Project in connection with a plan to build the Casper Canal, one of several irrigation ditches along the North Platte River. In December 1904, application for a permit authorizing the desired water appropriation for this canal was made, but no further action was taken. Until 1933, the lands now included in the Kendrick Project remained part of the open range used by the sheep ranchers in the area. In that year, however, as a result of further investigations by the Bureau of Reclamation, the Public Works Administration allocated funds to develop irrigation and hydroelectric power facilities on the North Platte River in the vicinity of Casper, Wyo.

Authorization

The Kendrick Project was authorized by a finding of feasibility approved by the President on August 30, 1935. The Alcova Powerplant was authorized for construction on August 22, 1950, under the provisions of section 9(a) of the Reclamation Project Act of 1939. Originally known as Casper-Alcova, the project was renamed Kendrick in 1937.

Construction

Seminoe Dam was constructed during 1936-39, and first delivery of power from the powerplant was made on August 3, 1939. Construction of Alcova Dam was started in 1935 and completed in 1938. The first irrigation water was diverted into the Casper Canal on June 14, 1946. Alcova Powerplant started power production in July 1955.

Operating Agencies

The Bureau of Reclamation operates all power facilities, Seminoe Dam and Reservoir, and Alcova Dam and Reservoir. All carriage, distribution, and drainage works are operated by the Casper-Alcova Irrigation District. The Wyoming Recreation Commission administers a portion of the Seminoe recreation areas; the Natrona County Parks and Pleasure Grounds administers the recreation areas at Alcova Reservoir. Grazing areas at Seminoe are administered by the Bureau of Land Management. The Wyoming Game and Fish Commission administers the Morgan Creek drainage area for wildlife.

BENEFITS

Irrigation

Water was first delivered to 14 farms irrigating 600 acres in 1946. Settlement has progressed steadily, and in 1976 a total of 23,549 acres were irrigated on 172 farms. Principal crops are alfalfa, small grains, and irrigated pasture.

Hydroelectric Power

All electric energy is marketed through the Pick-Sloan Missouri Basin Program's integrated system.

Recreation

The Alcova Reservoir and its surrounding lands provide excellent water-oriented recreation facilities. Recreational activities include camping, water skiing, boating, fishing, picnicking, and hiking. Seminoe Reservoir and its surrounding areas provide recreation opportunities similar to those of Alcova Reservoir, although the development of facilities is not as extensive and public access is not available to a large portion of the reservoir lands. The reservoirs are stocked with fish by the Wyoming Game and Fish Commission.

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service .... 24,265 acres
Number of irrigated farms 291

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	22,829	1,104,338
1969	23,092	1,393,818
1970	23,254	1,472,010
1971	23,301	1,466,633
1972	23,447	1,499,148
1973	23,617	2,039,248
1974	22,955	2,282,647
1975	22,951	2,458,666
1976	23,549	2,423,933
1977	22,894	2,572,626

Facilities in Operation:

Storage dams 2
Canals .... 59 mi
Laterals .... 190 mi
Drains .... 42 mi
Powerplants 2
Transmission lines .... 572.8 mi
Substations 6

Climatic Conditions

Annual precipitation .... 14.2 in
Temperature:
Maximum .... 109 °F
Minimum .... −41 °F
Mean .... 45 °F

Settlement

Number of persons served with project water (1977):
Farm irrigation service 643

Power Generation (kilowatt-hours)

Fiscal year	Alcova Powerplant	Seminoe Powerplant	Total
1968	83,616,000	99,820,500	183,436,500
1969	130,469,000	138,992,000	269,461,000
1970	112,828,000	154,407,000	267,235,000
1971	137,536,000	229,912,000	367,448,000
1972	132,928,000	157,889,000	290,817,000
1973	146,165,000	157,396,500	303,561,500
1974	207,420,000	212,893,600	420,313,600
1975	138,179,000	162,798,000	300,977,000
1976	137,589,000	148,136,000	285,725,000
1977	125,070,000	98,788,000	223,858,000

ENGINEERING DATA

Water Supply

North Platte River

Drainage area at Alcova Dam .... 10,800 mi²
Annual discharge at Alcova Dam:
Maximum (1899) .... 2,563,000 acre-ft
Minimum (1934) .... 485,000 acre-ft
Average .... 1,105,700 acre-ft
Average annual diversion, 1946-76 .... 30,300 ft³/s

Storage Facilities

Seminoe Dam

Type: Concrete arch
Location: On the North Platte River, 31 mi northeast of Rawlins, Wyo.
Construction period: 1936-39
Date of closure (first storage): April 1, 1939
Reservoir, Seminoe:
Average annual inflow .... 1,068,780 acre-ft
Total capacity to El. 6357 .... 1,017,279 acre-ft
Active capacity, El. 6239-6357 .... 985,608 acre-ft
Surface area .... 20,291 acres
Dimensions:
Structural height .... 295 ft
Hydraulic height .... 206 ft
Top width .... 15 ft
Maximum base width .... 85 ft
Crest length .... 530 ft
Crest elevation .... 6361.0 ft
Volume .... 210,000 yd³
Spillway: Concrete crest and concrete-lined shaft and tunnel through right abutment controlled by three 14- by 50-ft fixed-wheel gates.
Elevation top of gates .... 6357.0 ft
Crest elevation .... 6307.0 ft
Capacity at El. 6357 .... 48,500 ft³/s
Outlet works:
River: Two 72-in steel conduits through dam, each controlled by one 60-in needle valve.
Capacity at El. 6357 .... 3,000 ft³/s
Power: Three 120-in steel penstocks through dam, each controlled by one 96-in ring-seal gate.
Foundation: Hard granite cut by close joints, generally tight but locally open, with two intersecting major faults under dam.
Special treatment: Cement grout curtain under upstream toe, extensive mining, excavation to maximum of 149 ft below streambed, and concrete-filling and pressure grouting of major fault seams; abutments grouted.
Mass concrete: Natural aggregate from riverbed 2.5 to 4 mi upstream from damsite; modified portland cement; artificial cooling by pumping river water through embedded pipe system.
Volume .... 173,127 yd³
Maximum size aggregate .... 6 in
Cement content .... 1.0 bbl/yd³
Average net water-cement ratio 0.54
Contraction joints: Radial spacing at upstream face on 35- to 54-ft centers. Pressure grouted after cooling of concrete.

Alcova Dam

Type: Zoned earthfill
Location: On the North Platte River, 30 mi southwest of Casper, Wyo.
Construction period: 1935-38
Date of closure (first storage): February 8, 1938
Reservoir, Alcova:

Average annual inflow	1,127,150	acre-ft
Total capacity to El. 5500	184,300	acre-ft
Active capacity, El. 5490-5500	30,693	acre-ft
Surface area	2,470	acres

Dimensions:

Structural height	265	ft
Hydraulic height	180	ft
Top width	40	ft
Maximum base width	1,202	ft
Crest length	763	ft
Crest elevation	5510.0	ft
Volume	1,635,000	yd³

Spillway: Concrete-lined open channel in left abutment, controlled by three 25.75- by 40-ft fixed-wheel gates.

Elevation top of gates	5500.0	ft
Crest elevation	5460.0	ft
Capacity at El. 5500	55,000	ft³/s

Power outlet works: Concrete-lined tunnel through right abutment, controlled by two 84-in needle valves to powerplant.
Casper Canal headworks: Inlet structure at Casper Canal Tunnel No. 1, on Alcova Reservoir about 1 mi west of Alcova Dam, controlled by one 14- by 12-ft radial gate.
Foundation: Competent fine-grained sandstone overlain by soft porous limestone beneath upstream toe with local flows of warm water.
Special treatment: Blanket grouting beneath impervious section and cement-grout curtains beneath cutoff walls; supplementary grouting of crevices and bedding planes.

Carriage Facilities

Casper Canal

Location: From headworks at Alcova Reservoir about 1 mi west of Alcova Dam near Alcova, Wyo., generally north-northeast along west side of irrigated area to a point about 15 mi northwest of Casper, Wyo.
Construction period: 1934-39

Length	59	mi
Diversion capacity	1,200	ft³/s

Typical maximum section in earth:

Bottom width	34	ft
Side slopes	1.5:1	
Water depth	9.75	ft

Casper Canal Tunnels

Location: Six tunnels at various locations along Casper Canal.
Construction period: 1934-39

Length (total)	3.4	mi
Capacity	1,200-964	ft³/s

Cross section: Horseshoe, ranging from 14- to 13.75-ft-diameter.
Lining: Concrete

Power Facilities

Seminoe Powerplant

Location: Seminoe Dam
Year of initial operation: 1939
Year last generator placed in operation: 1939

Nameplate capacity	40,500	kW
Number and capacity of generators (3)	13,500	kW
Maximum head	218	ft

Alcova Powerplant

Location: Alcova Dam
Year of initial operation: 1955
Year last generator placed in operation: 1955

Nameplate capacity	36,000	kW
Number and capacity of generators (2)	18,000	kW
Maximum head	165	ft

Substations

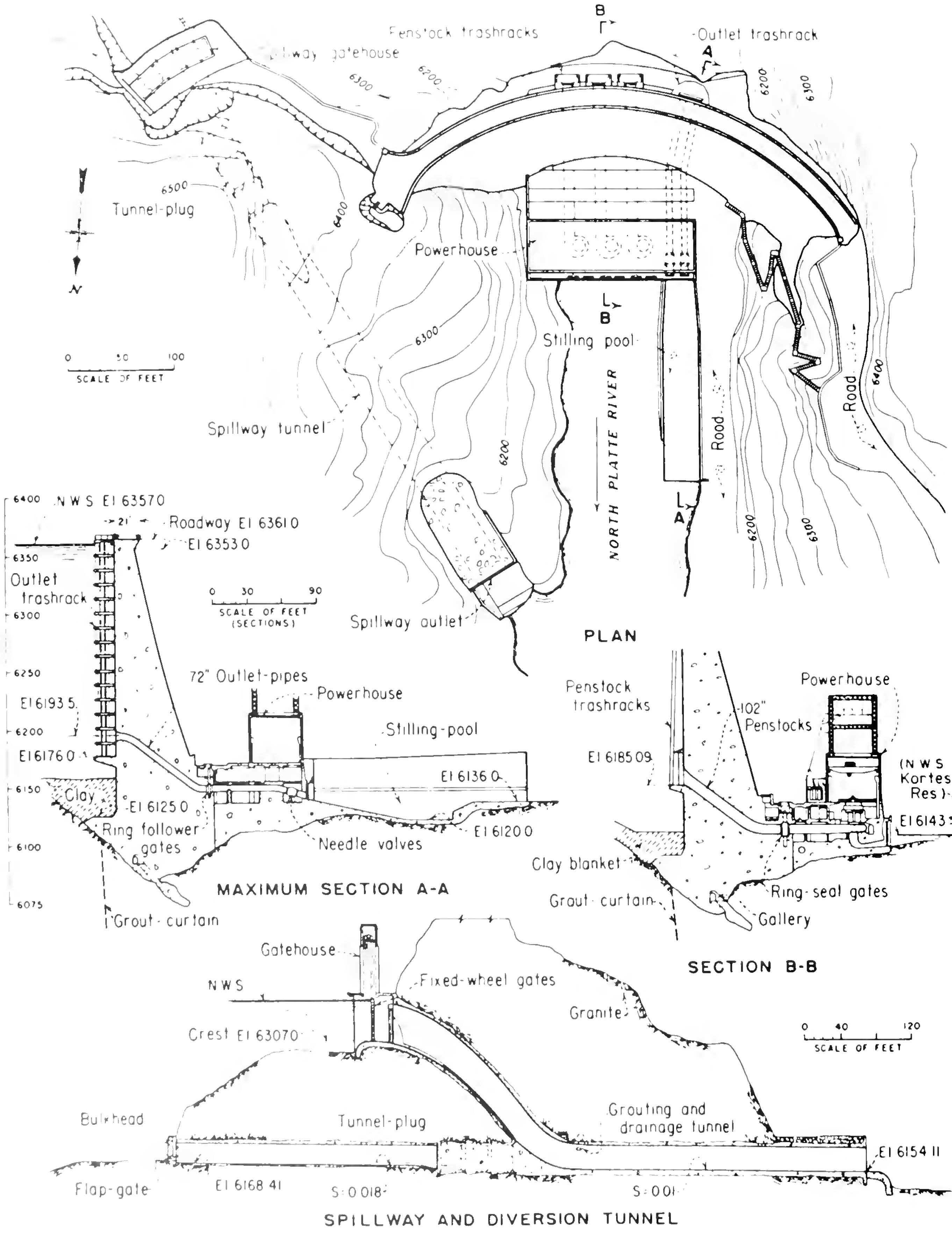
Number in operation	6	
Capacity of transformers	168,875	kVA

Transmission Lines

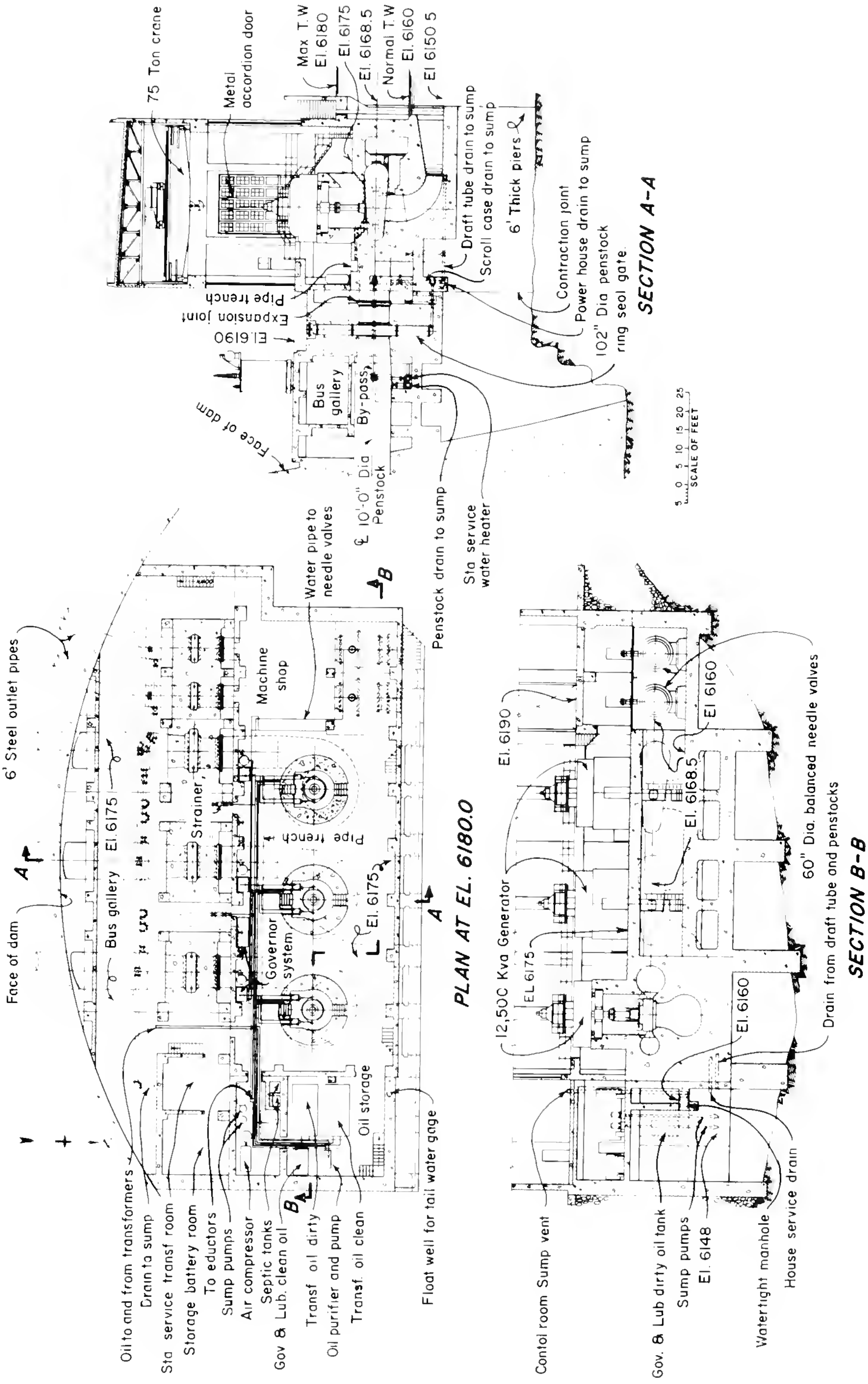
Total number of lines	13	
Total circuit length	572.8	mi

Designation	Capacity kV	Circuit miles	Year placed in service
Alcova-Casper (South)	115	28.62	1949
Archer-Gering			
Archer-Pole Creek Tap	115	15.30	1939
Pole Creek Tap Round Top Tap	115	19.67	1939
Round Top Tap La Grange	115	18.78	1939
Wyrulec La Grange Tap-Gering	115	35.37	1939
Cheyenne-Archer (North)	115	9.29	1966
Cheyenne-Flatiron			
Cheyenne-Nunn	115	26.58	1939
Nunn-Tap near Ault	115	4.79	1939
		4.04	1974
Kortes-Alcova (West)	115	28.62	1949
Seminoe-Cheyenne			
Seminoe-Medicine Bow Tap	115	42.20	1939
Medicine Bow Tap-Laramie	115	51.40	1939
Laramie-Cheyenne	115	47.86	1939
Seminoe-Kortes	115	2.73	1949
Weld-Greeley	115	5.44	1939
Seminoe-Casper			
Seminoe-H.S. REA (Kortes Tap)	69	6.41	1934
H.S. REA (Kortes Tap) H.S. REA (Alcova Tap)	69	23.99	1934
H.S. REA (Alcova Tap) Iron Creek (PP&L)	69	13.00	1934
Iron Creek-Casper (PP&L)	69	15.24	1934

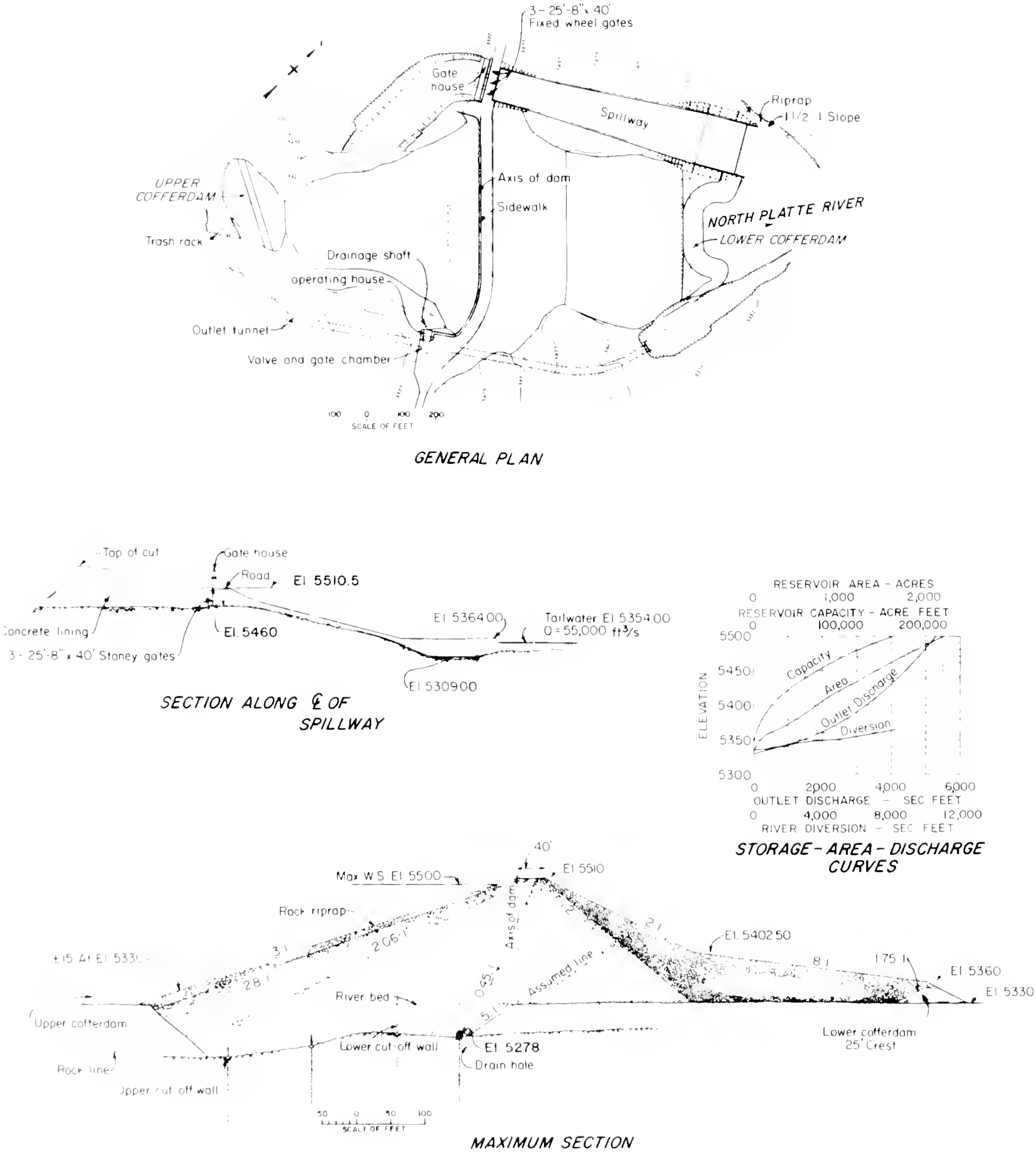
Designation	Capacity kV	Circuit miles	Year placed in service
Casper-Waltman			
Casper-Culvert (PP&L)	69	0.07	1949
	69	2.68	1949
Culvert (PP&L)-H.S. REA (Powder River)	69	2.04	1949
	69	4.29	1949
	69	27.27	1940
H.S. REA (Powder River) -H.S. REA (Waltham)	69	12.19	1940
Waltman-Thermopolis			
H.S. REA (Waltman)-H.S. REA (Arminto) No. 2	69	4.10	1940
H.S. REA (Arminto) No. 2-H.S. REA (Arminto) No. 1	69	8.50	1940
H.S. REA (Arminto) No. 1-H.S. REA (Lost Cabin)	69	15.09	1940
H.S. REA (Lost Cabin)-PP&L Bridger	69	26.10	1940
PP&L Bridger-Thermopolis	69	18.74	1940
Medicine Bow-CP&L Walcott Jct.			
Medicine Bow-CP&L Chace Tap	34.5	6.00	1949
CP&L Chase Tap-PP&L Hanna Tap	34.5	11.48	1949
PP&L Hanna Tap-CP&L Walcott Jct.	34.5	18.00	1952
CP&L Walcott Jct.- Sinclair			
CP&L Walcott Jct. Tap CP&L Ft. Steele Tap	34.5	7.90	1952
CP&L Ft. Steele Tap-Sinclair	34.5	8.98	1952



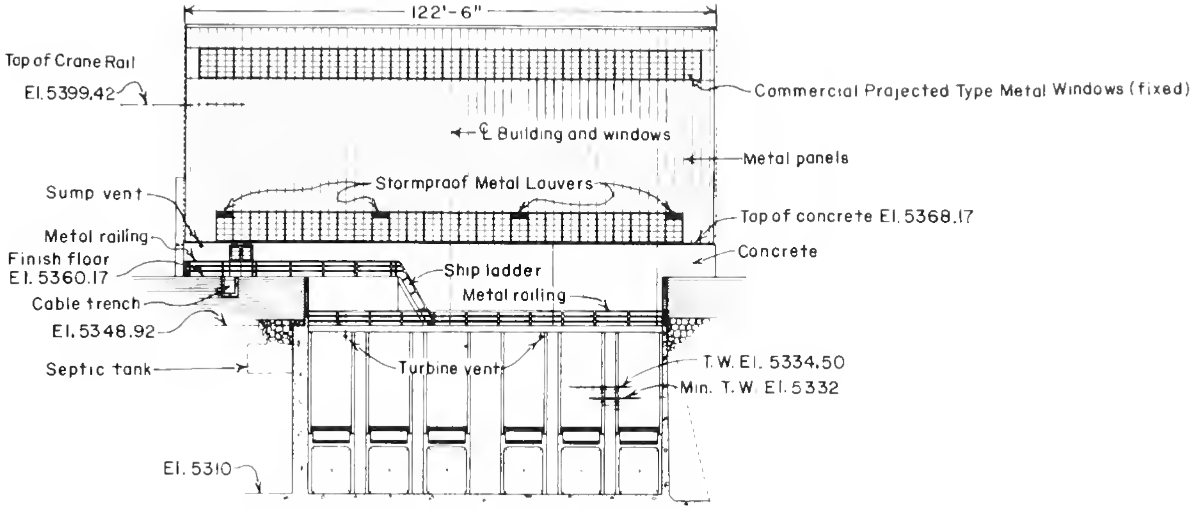
Seminoe Dam, Plan and Sections



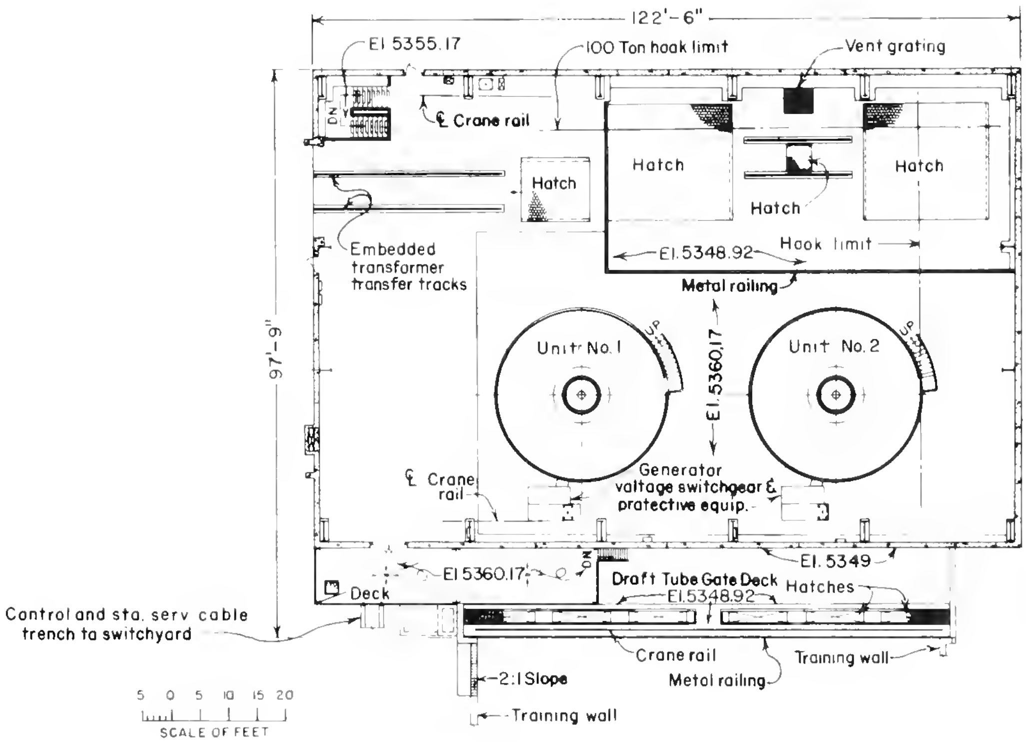
Seminoe Powerplant, Plan and Sections



Alcova Dam, Plan and Sections

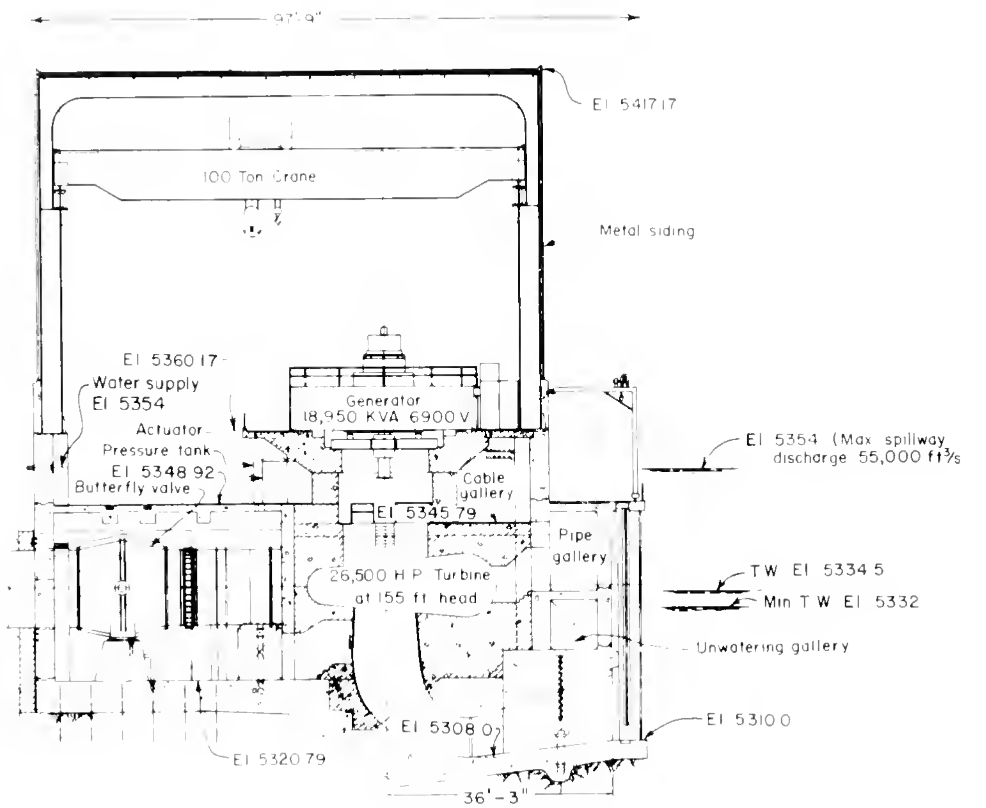


DOWNSTREAM (NORTH) ELEVATION

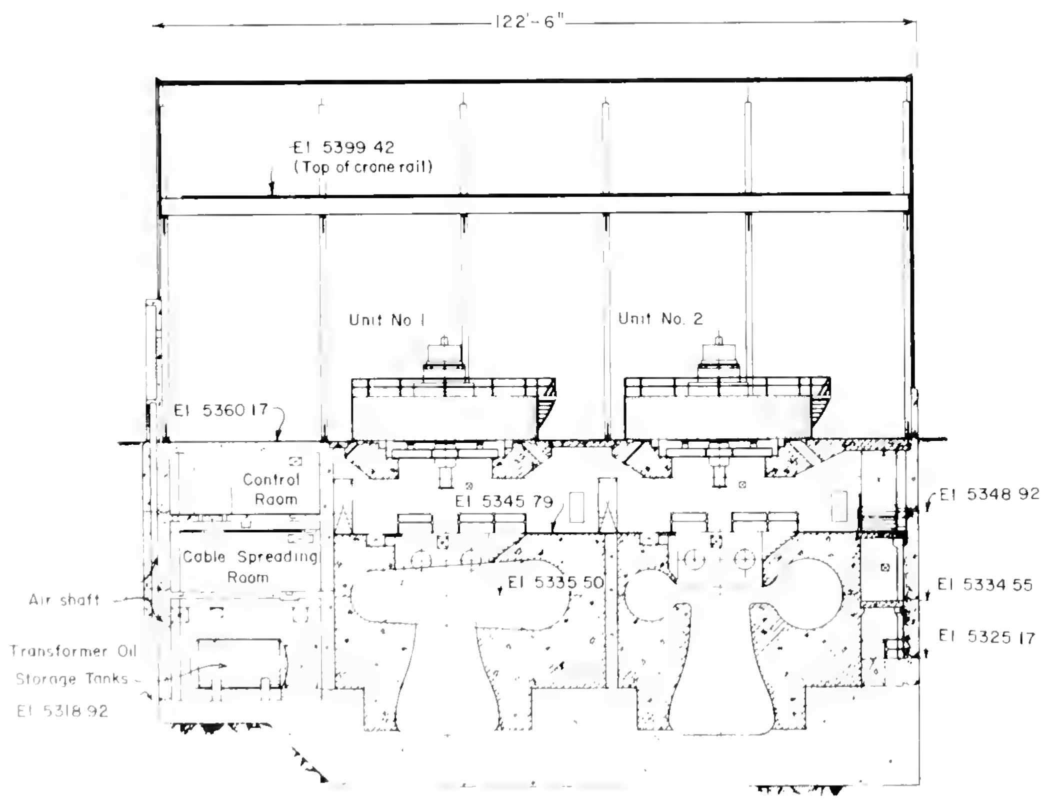


FLOOR PLAN - EL. 5360.17

Alcova Powerplant, Plan and Elevation



TRANSVERSE SECTION THRU UNIT



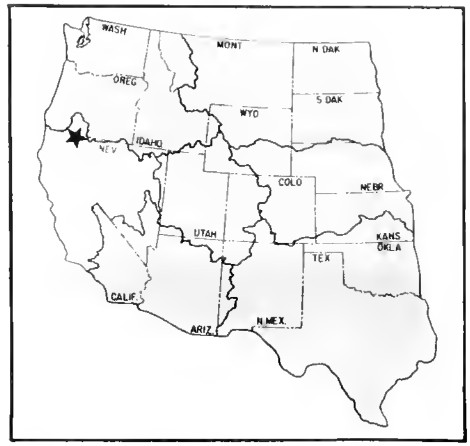
LONGITUDINAL SECTION THRU UNITS

Alcova Powerplant, Sections

Klamath Project

California: Siskiyou and Modoc Counties
Oregon: Klamath County

Mid-Pacific Region
Water and Power Resources Service



The irrigable lands of the Klamath Project are in south-central Oregon (62 percent) and north-central California (38 percent). Two main sources supply water for the project: Upper Klamath Lake and the Klamath River; and Clear Lake Reservoir, Gerber Reservoir, and Lost River, which are located in a closed basin. The total drainage area, including the Lost River and the Klamath River watershed above Keno, Oreg., is approximately 5,700 square miles.

PLAN

The Upper Klamath River Basin has extensive land and water resources which are not fully developed. The terrain varies from rugged, heavily timbered mountain slopes to rolling sagebrush benchlands and broad, flat valleys. The project plan includes construction of facilities to divert and distribute water for irrigation of basin lands, including reclamation of Tule and Lower Klamath Lakes, and control of floods in the area.

Clear Lake Dam and Reservoir

Clear Lake Dam and Reservoir

Clear Lake Dam and Reservoir on the Lost River in California, about 19 miles southeast of Malin, Oreg., provide storage for irrigation and reduce flow into the reclaimed portion of Tule Lake and the restricted Tule Lake Sumps in Tulelake National Wildlife Refuge. The dam is an earth and rockfill structure with a height of 42 feet and a crest length of 840 feet. The reservoir has a capacity of 527,000 acre-feet.

Gerber Dam and Reservoir

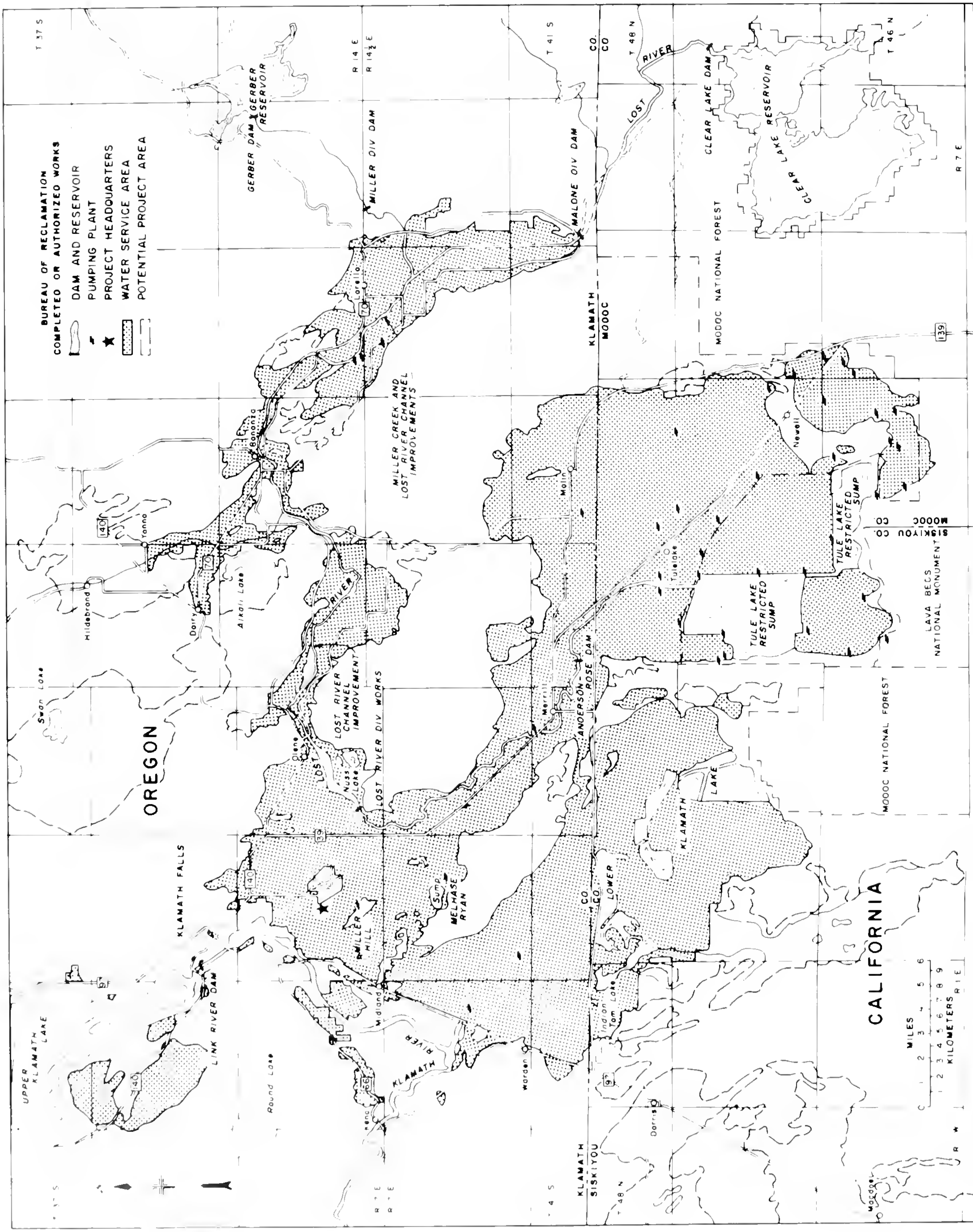
Gerber Dam and Reservoir, on Miller Creek 14 miles east of Bonanza, Oreg., provides storage for irrigation and reduces flow into the reclaimed portions of Tule Lake and the restricted Tule Lake Sumps in the Tulelake National Wildlife Refuge. The dam, a concrete arch structure, has a height of 84.5 feet and a crest length of 485 feet. Reservoir capacity is 94,000 acre-feet.

Link River Dam

Link River Dam on Link River at the head of Klamath River and just west of Klamath Falls, Oreg., regulates flow from Upper Klamath Lake Reservoir. This reservoir is a principal source of water for the project. The dam is a reinforced concrete slab structure with a height of 22 feet and a crest length of 435 feet. The reservoir has a capacity of 873,000 acre-feet and is operated by the Pacific Power and Light Company, subject to Klamath Project rights.

Lost River Diversion Dam

Lost River Diversion Dam is on Lost River about 4 miles below Olene, Oreg. The dam diverts excess water to the Klamath River through the Lost River Diversion Channel and restrains downstream flow in Lost River to control or restrict flooding of the reclaimed portions of the Tule Lake bed and to regulate the flow into the restricted sumps of the Tulelake National Wildlife Refuge. It is a



Klamath Project

Gerber Dam and Reservoir

horseshoe shaped, multiple-arch concrete structure with earth embankment wings. The structural height is 42 feet and crest length is 675 feet.

Anderson-Rose Dam

Anderson-Rose Dam (formerly Lower Lost River Diversion Dam), on Lost River about 3 miles southeast of Merrill, Oreg., diverts water to serve the lands reclaimed from the bed of Tule Lake. The dam is a reinforced concrete slab and buttress structure with a height of 23 feet and a crest length of 324 feet.

Malone Diversion Dam

Malone Diversion Dam, on Lost River about 11 miles downstream from Clear Lake Dam, diverts water to serve lands in Langell Valley. This dam, an earth embankment with a concrete gate structure, has a height of 32 feet and a crest length of 515 feet.

Miller Diversion Dam

Miller Diversion Dam, on Miller Creek 8 miles below Gerber Dam, diverts water to serve lands in Langell Valley. The dam is a concrete weir, removable crest, and earth embankment wing structure with a height of 10 feet and a crest length of 290 feet.

Lost River Diversion Channel

Lost River Diversion Channel extends nearly 8 miles from the Lost River Diversion Dam to the Klamath River. The channel carries excess water to the Klamath River and supplies additional irrigation water for the reclaimed lake bed of Tule Lake by reverse flow from the Klamath River.

Canals, Laterals, and Drains

There are 19 canals that total 185 miles and have diversion capacities ranging from 35 to 1,150 cubic feet per second. Laterals total 516 miles and drains 728 miles.

Pumping Plants

There are 3 major pumping plants with power input ranging from 1,120 to 3,650 horsepower and capacities from 60 to 388 cubic feet per second, and 33 pumping plants of less than 1,000 horsepower. Two pumping plants are under construction, each with 750 horsepower and capacity of 300 cubic feet per second.

Tule Lake Tunnel

Tule Lake Tunnel, a concrete-lined structure 6,600 feet in length with a capacity of 250 cubic feet per second, conveys drainage water from Tule Lake restricted sumps to Lower Klamath Lake.

"A" Canal Tunnel

This 3,300-foot tunnel, a part of the "A" Canal, has a capacity of 1,150 cubic feet per second and conveys irrigation water from Upper Klamath Lake to serve approximately 63,000 acres.

Klamath Straits Drain

This drain is being enlarged from 300 to 600 cubic feet per second, with estimated completion in 1980-81. The drain conveys drainage water from Lower Klamath National Wildlife Refuge and from irrigated land which has been reclaimed from Lower Klamath Lake. The drain extends from the State Line Road approximately 20 miles northwesterly to Klamath River. The drain removes the excess winter flows and the drainage from the lower closed basin to the Klamath River.

DEVELOPMENT

Early History

Irrigation of agricultural lands in the area now comprising the Klamath Project was initiated in 1882 with construction of an irrigation ditch to the land from White Lake. Private interests further developed the project by constructing the Adams Canal in 1886, which was supplied also from White Lake, and the Ankeny Canal in 1887, which diverted water from Link River. By 1903, approximately 13,000 acres were irrigated by private interests.

Investigations

In 1903, the Reclamation Service made investigations which led in 1904 to the first withdrawal of land by the Secretary of the Interior for developing a Federal irrigation project. Early in 1905, California and Oregon ceded certain rights in Upper and Lower Klamath Lakes and Tule Lake to the United States. On May 1, 1905, a board of engineers made a report that served as the basis for authorization.

Authorization

The Secretary of the Interior authorized development of the project on May 15, 1905, under provisions of the Reclamation Act of 1902 (32 Stat. 388).

Construction

Construction began on the project in 1906 with the building of the main "A" Canal. Water was first made available May 22, 1907, to the lands now known as the Main Division. This initial construction was followed by the completion of Clear Lake Dam in 1910, the Lost River Diversion Dam and many of the distribution structures in 1912, and the Lower Lost River Diversion Dam in 1921. (In 1970, a public dedication at the Lower Lost River Diversion Dam officially changed the name of the structure to Anderson-Rose Dam.) The Malone Diversion Dam on Lost River was built in 1923 to divert water to Langell Valley. The Gerber Dam on Miller Creek was completed in 1925; the Miller Diversion Dam was built in 1924 to divert water released from Gerber Dam.

A contract executed February 24, 1917, between the California-Oregon Power Company (now the Pacific Power and Light Company) and the United States authorized the company to construct Link River Dam for the benefit of the project and for the company's use, and in particular extended to the water users of the Klamath Project certain preferential power rates. The dam was completed in 1921. The contract was amended and further extended for a 50-year period on April 16, 1956.

Operating Agencies

Clear Lake Dam, Gerber Dam, and the Lost River Diversion Dam are operated by the Bureau of Reclamation. The Link River Dam is operated by the Pacific Power and Light Company in accordance with project needs. The Anderson-Rose Dam is operated by the Tulelake Irrigation District, and the Langell Valley Irrigation District operates the Malone and Miller Diversion Dams. The canals and pumping plants are operated by the various irrigation districts.

BENEFITS

Irrigation

Approximately 225,000 acres of rangeland have been transformed into productive farmland. Principal irrigated crops are barley, irrigated pasture, alfalfa hay and other hay, oats, potatoes, and wheat.

Recreation

Project reservoirs offer various recreational activities, including boating, water skiing, fishing, hunting, camping, and picnicking. Recreation facilities at Lower Klamath Lake, Tule Lake, and Upper Klamath Lake are administered by the Fish and Wildlife Service. The Bureau of Land Management administers Gerber Reservoir recreation facilities, while facilities at Malone and Wilson Reservoirs are administered by the Bureau of Reclamation. Clear Lake Reservoir is a part of Clear Lake National Wildlife Refuge, and the recreation opportunities are limited.

PROJECT DATA

Land Areas (1977

Irrigable area:

Full irrigation service	223,693	acres
Number of irrigated farms	1,451	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	202,305	26,807,833
1969	201,939	25,506,186
1970	200,728	29,015,890
1971	200,225	26,040,219
1972	196,457	33,268,098
1973	202,551	62,017,964
1974	202,442	58,311,925
1975	202,417	52,187,721
1976	201,437	47,071,133
1977	203,009	46,467,128

Facilities in Operation

Storage dams	3	
Diversion dams	4	
Canals	185	m
Pumping plants	37	
Drains	728.2	mi
Tunnels	1.9	mi
Laterals	532	mi

Climatic Conditions

Annual precipitation	13.8	in
Temperature:		
Maximum	105	°F
Minimum	−24	°F
Mean	49	°F
Growing season	120	days
Elevation of irrigable area	4093.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	2,490
Urban/suburban irrigation service	12,571
Total	15,061

ENGINEERING DATA

Water Supply

Lost River

Drainage area at Clear Lake Reservoir	670	mi²
Annual discharge at Clear Lake Reservoir:		
Maximum (1938)	269,700	acre-ft
Minimum (1934)	9,700	acre-ft
Average	88,600	acre-ft

Miller Creek

Drainage area at Gerber Reservoir	220	mi²
Annual discharge at Gerber Reservoir:		
Maximum (1938)	109,710	acre-ft
Minimum (1934)	9,300	acre-ft
Average	44,910	acre-ft

Upper Klamath Lake

Drainage area at Link River Dam	3,812	mi²
Annual discharge at Link River Dam:		
Maximum (1956)	2,590,400	acre-ft
Minimum (1931)	791,400	acre-ft
Average	1,462,700	acre-ft
Annual diversion	422,600	acre-ft

Storage Facilities

Clear Lake Dam

Type: Earth and rockfill
Location: On the Lost River 19 mi southeast of Malin, Oreg., 20 mi east of Tulelake, Calif.
Construction period: 1908-10

Reservoir, Clear Lake:		
Average annual inflow, 1905-70	121,200	acre-ft
Total capacity to El. 4543	527,000	acre-ft
Active capacity	513,000	acre-ft
Surface area	25,800	acres
Shoreline	65	mi
Dimensions:		
Structural height	42	ft
Hydraulic height	27	ft
Top width	20	ft
Maximum base width	177	ft
Crest length	840	ft
Crest elevation	4543.0	ft
Total volume	63,000	yd³
Spillway: Uncontrolled overflow side-channel weir and open cut at north end of dam.		
Crest elevation	4552.0	ft
Capacity at El. 4545.7	5,650	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by two 4- by 5-ft slide gates at upstream end.		
Capacity at El. 4537.6	1,000	ft³/s

Foundation: Seamy lava flows in horizontal beds varying from hard basalt to volcanic mud.
Special treatment: Cement grout placed in seams.

Gerber Dam

Type: Concrete medium thick arch
Location: On Miller Creek, 33 mi southeast of Klamath Falls, Oreg., 14 mi east of Bonanza, Oreg.
Construction period: 1924-25

Reservoir, Gerber:		
Average annual inflow, 1905-70	52,400	acre-ft
Total capacity	94,000	acre-ft
Active capacity	94,000	acre-ft
Surface area	3,800	acres
Shoreline	17	mi
Dimensions:		
Structural height	84.5	ft
Hydraulic height	63	ft
Top width	5	ft
Maximum base width	24	ft
Crest length	485	ft
Crest elevation[1]	4841.9	ft
Total volume	12,000	yd³
Spillway: Uncontrolled overflow section at center of dam.		
Crest elevation	4835.4	ft
Capacity at El. 4841.9	10,000	ft³/s
Outlet works: Three steel pipes through base of dam controlled by three 2.5-ft-square high-pressure slide gates.		
Capacity at El. 4841.9	1,000	ft³/s

Foundation: Blocky and seamy lava rock in hard and soft layers with occasional layers of conglomerate separated by tight, clay-filled seams.
Special treatment: Cement grout curtain with additional grouting of seams and softer areas throughout.

Link River Dam

Type: Reinforced concrete slab
Location: Upper Klamath Lake inlet.
Construction period: 1921

Reservoir, Upper Klamath Lake:		
Average annual inflow, 1905-70	1,318,200	acre-ft
Total capacity	873,000	acre-ft
Active capacity	465,000	acre-ft
Surface area	90,900	acres
Shoreline	98	mi
Dimension :		
Structural height	22	ft
Hydraulic height	8	ft
Top width	7	ft
Crest length	435	ft
Total volume	2,200	yd³

[1]Top of parapet at El. 4845.4.

Diversion Facilities

Lost River Diversion Dam

Type: Concrete multiple-arch weir, embankment wings
Location: On the Lost River about 4 mi below Olene, Oreg.
Year completed: 1912

Dimensions:

Structural height	12	ft
Hydraulic height[2]	31	ft
Crest length	675	ft
Crest elevation[3]	4097.0	ft
Volume	20,000	yd³
Diversion capacity	3,000	ft³/s

ANDERSON-ROSE DIVERSION DAM

Type: Reinforced concrete slab and buttress
Location: On the Lost River about 3 mi southeast of Merrill, Oreg.
Year completed: 1921
Dimensions:

Structural height	23	ft
Hydraulic height	12	ft
Crest length	324	ft
Crest elevation[4]	4064.0	ft
Volume	1,000	yd³
Diversion capacity	800	ft³/s

MALONE DIVERSION DAM

Type: Concrete gate structure, embankment wing
Location: On the Lost River about 11 mi downstream from Clear Lake Dam.
Year completed: 1923
Dimensions:

Structural height	32	ft
Hydraulic height	18	ft
Crest length	515	ft
Crest elevation	4160.3	ft
Volume	25,000	yd³
Diversion capacity	220	ft³/s

MILLER DIVERSION DAM

Type: Concrete weir, removable crest, embankment wing
Location: On Miller Creek 8 mi below Gerber Dam.
Year completed: 1924
Dimensions:

Structural height	10	ft
Hydraulic height	5	ft
Crest length	290	ft
Crest elevation	4227.0	ft
Volume	2,000	yd³
Diversion capacity	190	ft³/s

[2]With flashboards installed, otherwise it is 26 ft to top of spillway crest.
[3]USBR datum. USC & GS datum is 2.25 ft lower.
[4]Dam crest: spillway crest El. 4055.5.

Carriage Facilities

"A" CANAL

Location: From Upper Klamath Lake near Klamath Falls, Oreg. southeast about 8 mi.
Construction period: 1906-07

Length	8.7	mi
Capacity	1,150	ft³/s
Section (initial reach):		
Bottom width	41	ft
Side slopes	0.5:1	
Water depth	11	ft

"B" CANAL

Location: From end of "A" Canal east to vicinity of Olene, Oreg.
Construction period: 1906-12

Length	4.1	mi
Capacity	290	ft³/s
Section (initial reach):		
Bottom width	16	ft
Side slopes	0.5:1	
Water depth	6	ft

"C" CANAL

Location: From Main Canal generally southeast to vicinity of Merrill, Oreg.
Construction period: 1907-08; upper end above "C-G" Canal enlarged in 1921.

Length	13.5	mi
Capacity	330	ft³/s
Section (initial reach):		
Bottom width	32	ft
Side slopes	2:1	
Water depth	9	ft

"C-G" CANAL

Location: From "C" Canal to "G" Canal near Lost River.
Construction period: 1921

Length	0.9	mi
Capacity	400	ft³/s
Section (initial reach):		
Bottom width	25	ft
Side slopes	2:1	
Water depth	Varies	

"D" CANAL

Location: From the vicinity of Merrill, Oreg., southeast about 15 mi.
Construction period: 1913-14

Length	18.6	mi
Capacity	300	ft³/s
Section (initial reach):		
Bottom width	22	ft
Side slopes	2:1	
Water depth	5.3	ft

"E" CANAL

Location: From vicinity of Olene, Oreg., east along north side of Lost River.
Construction period: 1912

Length	10.5	mi
Capacity	35	ft³/s
Section (initial reach):		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.2	ft

"F" CANAL

Location: From vicinity of Olene, Oreg., east along south side of Lost River.
Construction period: 1912

Length	11.6	mi
Capacity	90	ft³/s
Section (initial reach):		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	4.7	ft

"G" CANAL

Location: From the vicinity of Lost River Diversion Works southeast along the Lost River to the vicinity of Merrill, Oreg.
Construction period: 1913-15

Length	8.5	mi

Capacity	400 ft³/s
Section (initial reach):	
Bottom width	22 ft
Side slopes	2:1
Water depth	6.5 ft

"J" Canal

Location: From Anderson-Rose Diversion Dam generally southeast to vicinity of Newell, Calif.
Construction period: 1921; enlarged in 1935-37.

Length	23.4 mi
Capacity	800 ft³/s
Section (initial reach):	
Bottom width	26 ft
Side slopes	1.5:1
Water depth	9.5 ft

"M" Canal

Location: Vicinity of Newell, Calif.
Construction period: 1947-48

Length	6.5 mi
Capacity	100 ft³/s
Section (initial reach):	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	4.2 ft

"N" Canal

Location: East side of Tule Lake Restricted Sump.
Construction period: 1935-66

Length	26.5 mi
Capacity	300 ft³/s
Section (initial reach):	
Bottom width	30 ft
Side slopes	2:1
Water depth	Varies

"P" Canal

Location: East side of Lower Klamath Lake.
Construction period: 1941-42

Length	1.8 mi
Capacity	200 ft³/s
Section (initial reach):	
Bottom width	16 ft
Side slopes	1.5:1
Water depth	6.3 ft

"P-1" Canal

Location: East Side of Lower Klamath Lake.
Construction period: 1941-42

Length	9 mi
Capacity	250 ft³/s
Section (initial reach):	
Bottom width	16 ft
Side slopes	1.5:1
Water depth	6.3 ft

"Q" Canal

Location: From Tule Lake Restricted Sump generally southward.
Construction period: 1960

Length	3.9 mi
Capacity	130 ft³/s
Section (initial reach):	
Bottom width	10 ft
Side slopes	2:1
Water depth	5.1 ft

"R" Canal

Location: From Tulelake Restricted Sump generally northwest.
Construction period: 1960

Length	3.2 mi
Capacity	76 ft³/s
Section (initial reach):	
Bottom width	8 ft
Side slopes	2:1
Water depth	4.2 ft

Lost River Diversion Channel

Location: From the Lost River at a point about 7 mi southeast of Klamath Falls, generally northwest to the Klamath River.
Construction period: 1911-12; enlarged in 1930 and in 1950.

Length	7.8 mi
Capacity	3,000 ft³/s
Section (initial reach):	
Bottom width	60 ft
Side slopes	2:1
Water depth	Varies

North Canal

Location: From Miller Diversion Dam west to Dry Lake.
Construction period: 1924-25

Length	14.4 mi
Capacity	190 ft³/s

West Canal

Location: From Malone Diversion Dam west to Dry Lake.
Construction period: 1924-25

Length	12.1 mi
Capacity	190 ft³/s

"A" Canal Tunnel

Construction period: 1907

Length	3,300 ft
Capacity	1,150 ft³/s
Diameter	11-13.5 ft

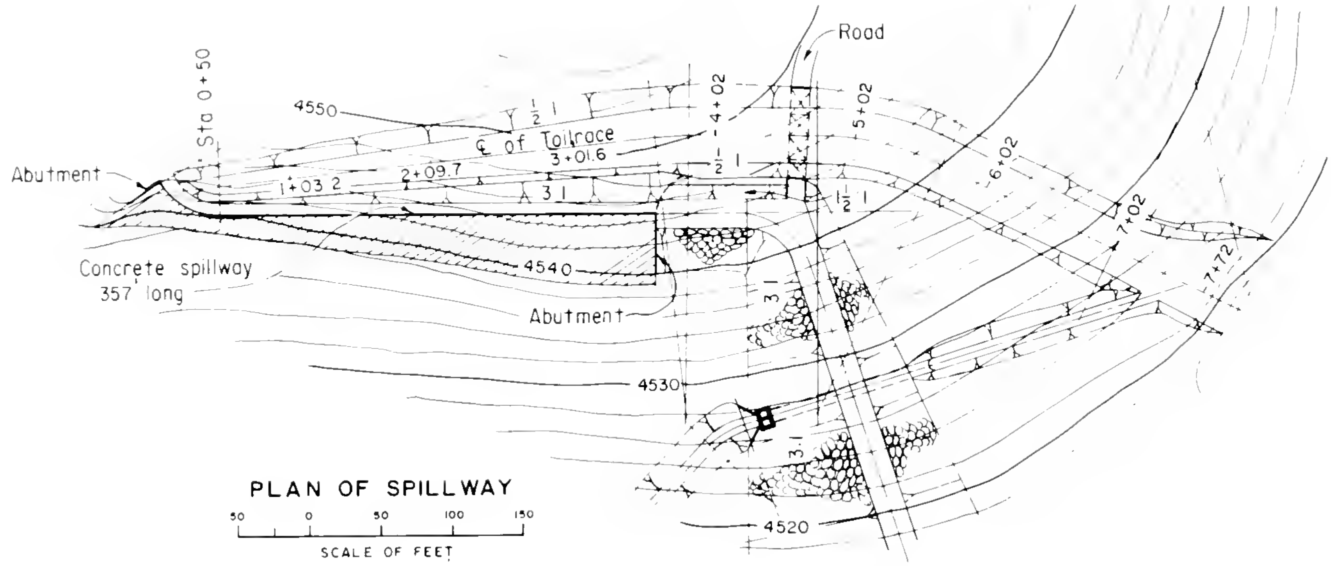
Tule Lake Tunnel, Pumping Plant "D" Discharge Conduit

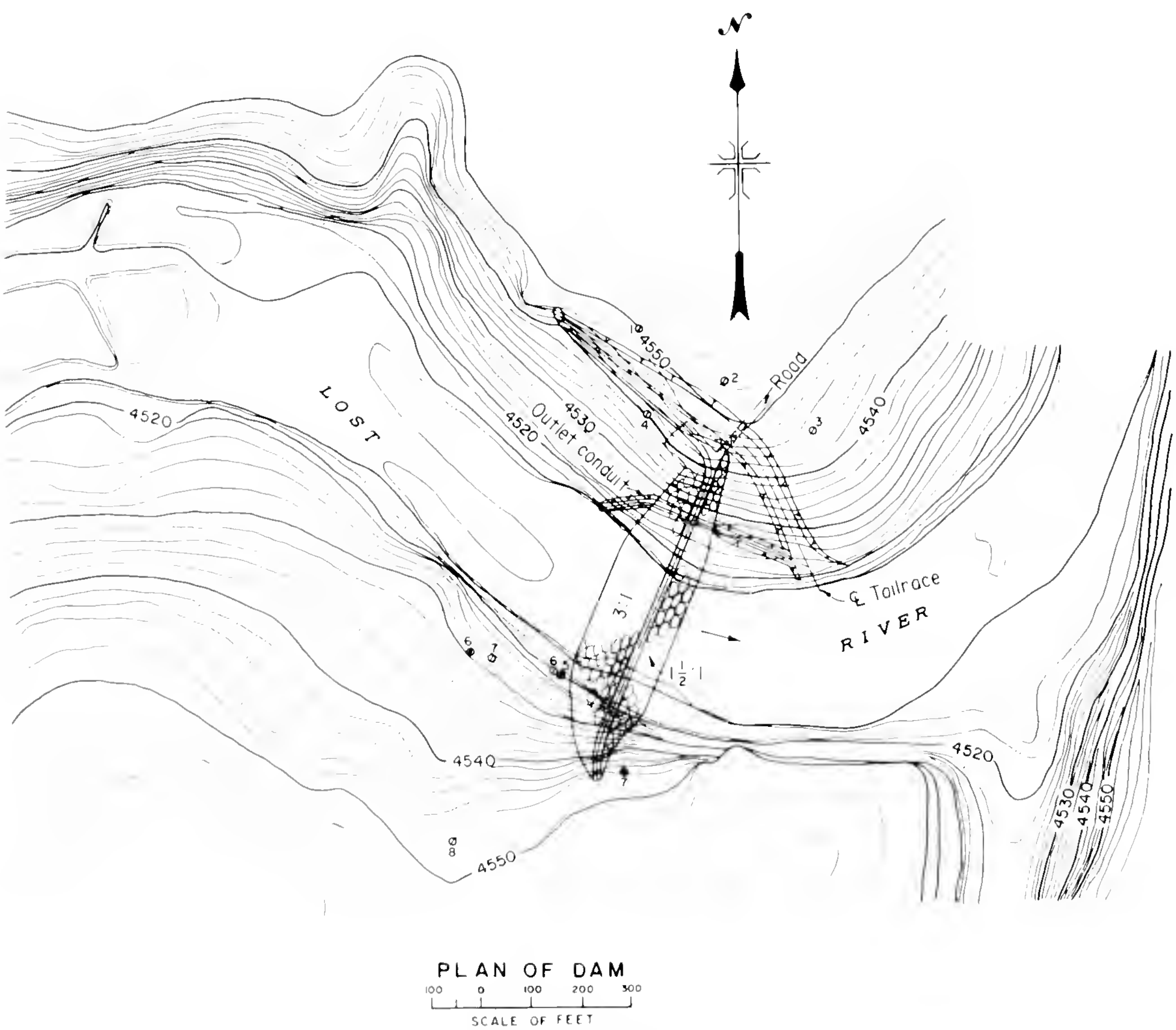
Construction period: 1940-41

Length	6,600 ft
Capacity	250 ft³/s
Cross section: Horseshoe	
Diameter	5.75 ft
Lining: Concrete	
Thickness	3-7 in

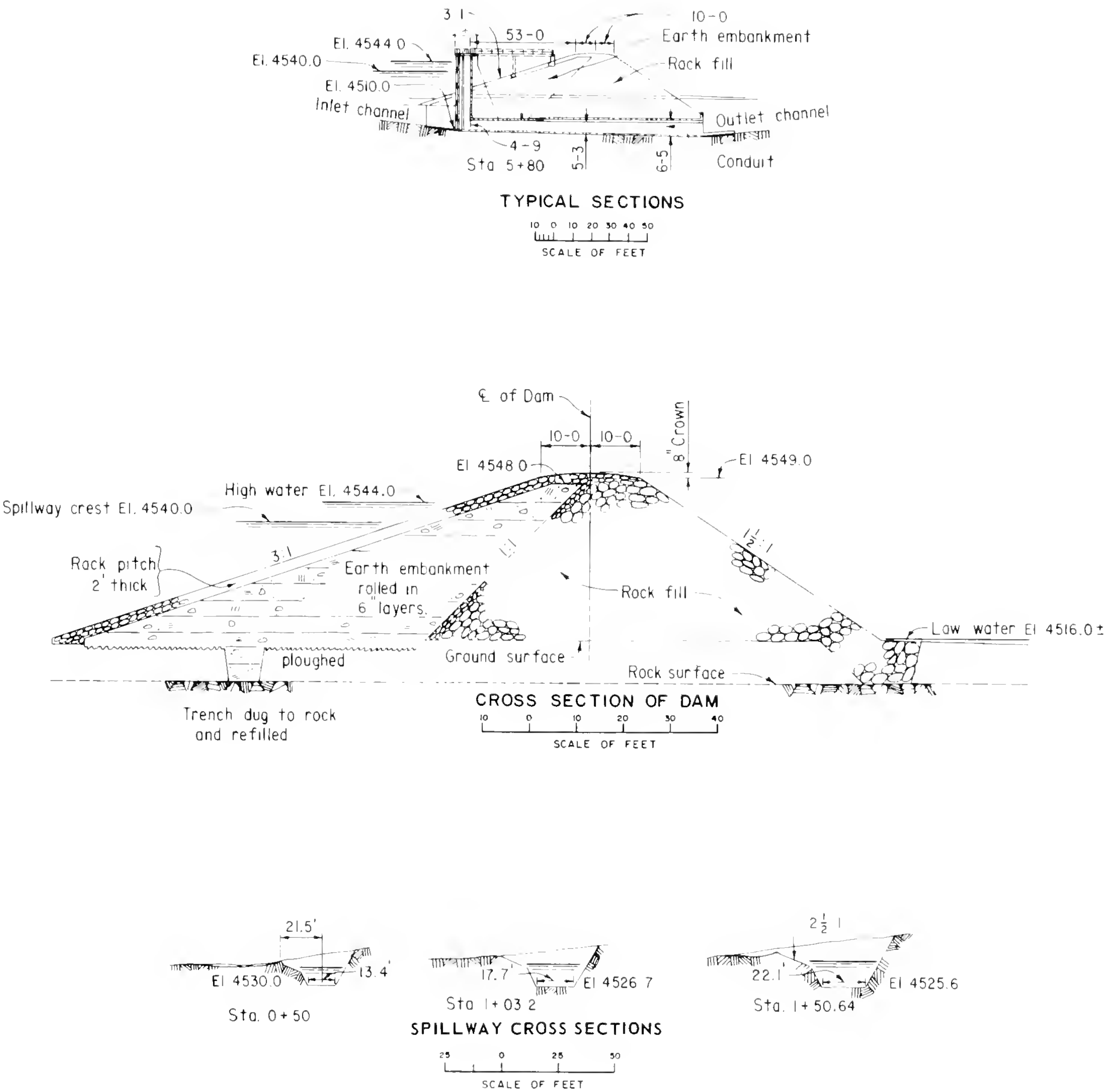
Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Pumping Plant D	5	388	78	3,650
Booster Pumping Plant	7	60	125	1,120
Main Pumping Plant	7	75	327	3,400

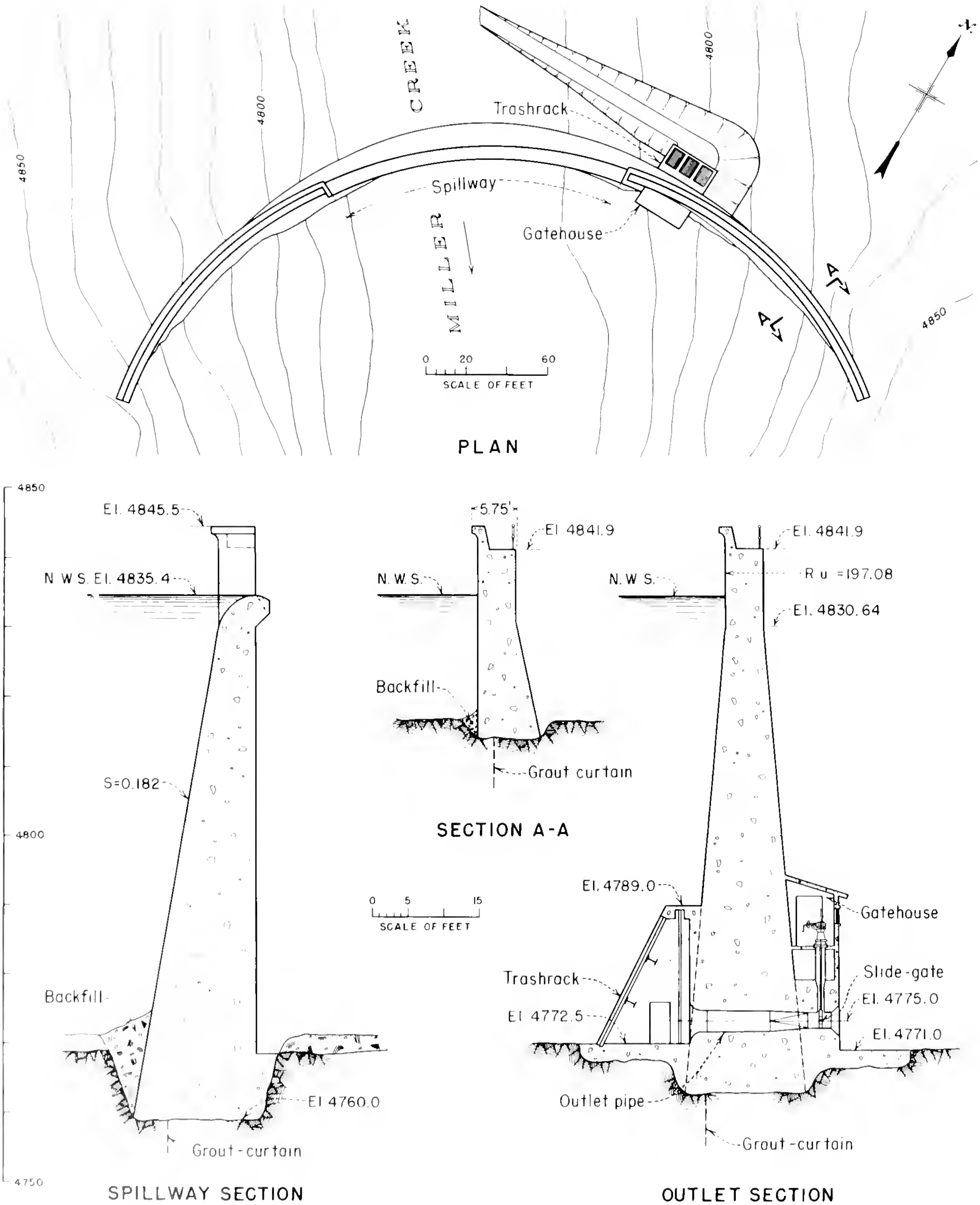




Clear Lake Dam, Plans



Clear Lake Dam, Sections

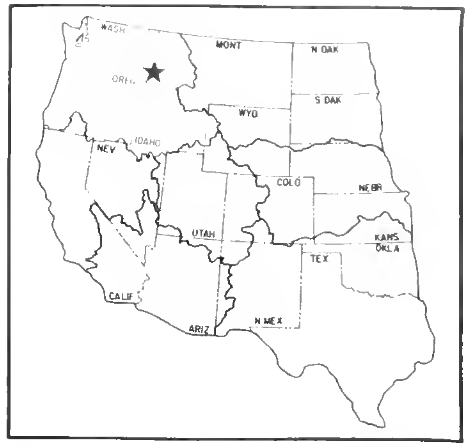


Gerber Dam, Plan and Sections

Lewiston Orchards Project

Idaho: Nez Perce County

Pacific Northwest Region
Water and Power Resources Service



The Lewiston Orchards Project was originally constructed by private interests, beginning in 1906. Most of the project features have been rehabilitated or rebuilt by the Bureau of Reclamation. The project facilities include the Webb Creek Diversion Dam, Sweetwater Diversion Dam, feeder canals, three small storage reservoirs, a domestic water-treatment plant, a domestic water system, and a system for distribution of irrigation water. A full irrigation water supply is delivered to project lands totaling 3,792 acres, and a dependable domestic water system is provided for 13,920 residents.

PLAN

Soldiers Meadow Reservoir stores water from Webb Creek and from upper Captain John Creek via the Captain John Canal. This water is released, when needed, and diverted into Sweetwater Creek by the Webb Creek Diversion Dam and Webb Creek Canal. Water from the West Fork of Sweetwater Creek is stored in the offstream Lake Waha, which is fed by Lake Waha Feeder Canal. The stored water is pumped from Lake Waha back into the creek during the irrigation season. Sweetwater Diversion Dam diverts the releases into Sweetwater Canal, which empties into Reservoir "A". Water for irrigation and domestic use is taken from Reservoir "A." Irrigation water is carried from the reservoir by pipeline.

Storage Reservoirs

Reservoir "A" is an offstream reservoir about 7 miles southeast of Lewiston, Idaho, that has an active capacity of 3,000 acre-feet. Lake Waha, a natural lake, also serves as an offstream reservoir. This lake is about 1 mile southwest of the village of Waha and has a capacity of 6,900 acre-feet. The Soldiers Meadow Reservoir is located on Webb Creek about 6 miles southeast of Waha and has a storage capacity of 2,400 acre-feet.

Diversion Dams

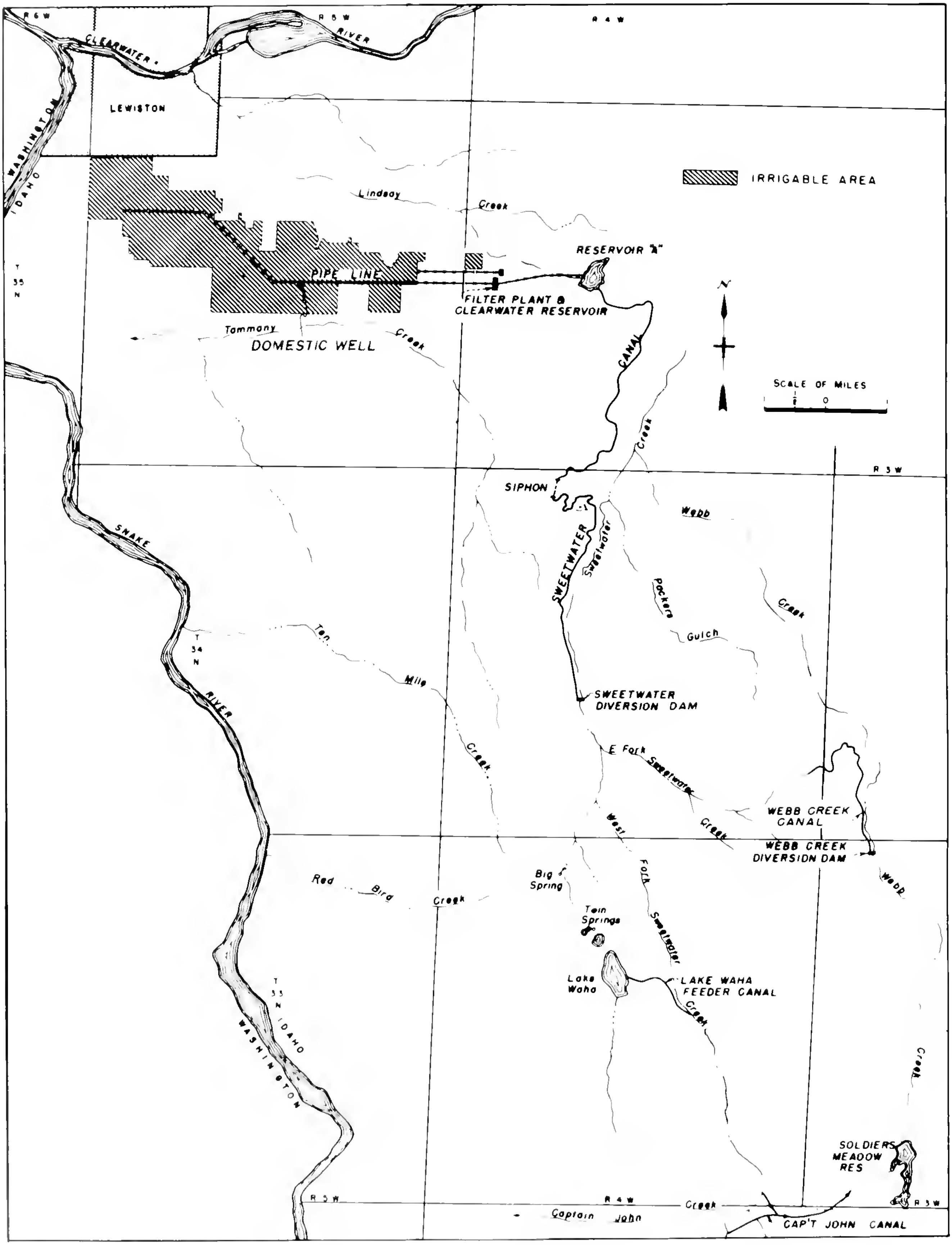
Webb Creek Diversion Dam is on Webb Creek about 5 miles northeast of Waha. It is of the rockfill weir type, and has a structural height of 20 feet.

Sweetwater Diversion Dam is on Sweetwater Creek about 4 miles north of Waha. It is also of the rockfill weir type, 12 feet high.

Domestic Water System

The water treatment plant is about 1 mile west of Reservoir "A." The plant, as originally constructed, had a

Sweetwater Diversion Dam



Lewiston Orchards Project

capacity of 1.5 million gallons per day. In 1977-78, the district, primarily through work done by its own forces, increased the capacity to 2.3 million gallons per day by installing a rapid flow sand filter system. A 1.5-million-gallon, ground-level concrete domestic storage reservoir is located at the treatment plant. The distribution system has 58 miles of domestic pipe ranging from 0.75 to 14 inches in diameter. Forty-seven of these miles were constructed by the Bureau of Reclamation and 11 miles of extensions were installed later by the district. The 8- to 14-inch supply mains are asbestos-cement, the 4- and 6-inch distribution lines are either asbestos-cement or PVC, and all the lines from 0.75 to 3 inches are galvanized pipe.

In 1978, the district, with funds granted by the Economic Development Administration, drilled a 1,520-foot well within the project area to provide added capacity to the domestic system. The top 1,003 feet of the well is 16 inches in diameter and steel cased; the bottom 517 feet is 8 inches in diameter and perforated steel cased. The well is equipped with a 300-horsepower pump that pumps 600 gallons per minute. The well capability is 1,000 gallons per minute. The well is connected to the domesti distribution system by 6,200 feet of 8-inch PVC pipe.

The district's domestic water system is intertied with that of the city of Lewiston. This provides for an interchange of domestic water supply when the need arises.

Irrigation Distribution System

The irrigation distribution system comprises about 88 miles of irrigation pipe ranging from 1 to 36 inches in diameter. Several flumes, siphons, and feeder canals are also included in the system.

DEVELOPMENT

Early History

The project is located near the confluence of the Clearwater and Snake Rivers in Idaho. In early days, it was a natural hunting and fishing ground for Indians. Early settlers found the climate delightful, as the elevation at Lewiston is only 738 feet. These settlers made their living by dry farming, mining, and lumbering. In 1906, a private company initiated irrigation in the project area.

Investigations

The initial irrigation system provided a timber flume and a canal to carry water from Sweetwater Creek to Reservoir "A." From Reservoir "A," water was distributed through a system of wood-stave pressure pipelines to project lands. The water supply was augmented in 1915, 1922, 1934, and 1939 by making new diversions and by increasing the storage capacity. However, the wood-stave

Webb Creek Diversion Dam

pipe system had a limited economic life and when the pipes were 30 years old and the flume 20 years old, the water distribution system had become unreliable. System losses ranged from 12 to 85 percent from section to section with the result that pressures were inadequate for satisfactory delivery of domestic water to many homes. In addition, portions of farm units were left dry because of the inadequate water supply. In 1939, the Irrigation District, aided by the Works Projects Administration, launched a program for replacing the wooden flumes with concrete bench flumes. This program continued in 1940-41 but was not completed. Following these years, extensive maintenance and repair were necessary to keep the Webb Creek diversion in operation as the timber-crib diversion dam was in dire need of replacement. Water delivered through the single-pipe system was unsafe for domestic use, which caused a number of residents in the area to transport drinking water from the city of Lewiston.

Studies carried on during the 1970's considered the possibility of additional facilities to develop firm domestic water supplies. Included in these studies were a pumping plant on the Clearwater River with a design capacity of 30 cubic feet per second to deliver water to Reservoir "A," the relining of Sweetwater Canal to reduce losses and restore full capacity, and the addition of a 2 million gallon domestic water reservoir.

Authorization

The Lewiston Orchards Project was found to be feasible by the Acting Secretary of the Interior on May 31, 1946, pursuant to the Reclamation Project Act of 1939. However, before the Secretary's report was submitted to the Congress, the act of July 31, 1946 (60 Stat. 717), specifically authorized construction of the project.

Construction

Following a full investigation by the Bureau of Reclamation and authorization by the Congress, construction and rehabilitation was started on September 15, 1947. All construction was completed on March 15, 1951.

Operating Agency

The Lewiston Orchards Irrigation District operates the project.

BENEFITS

Irrigation

When originally developed, the project area consisted primarily of fruit orchards. Residential subdivision has since increased to the point where over 50 percent of the land is in ownerships of less than 2 acres with an average of 0.55 acre each. The remainder of ownerships average less than 5 acres. Subdividing is expected to continue. At present, hay, grain, pasture, potatoes, and some fruits are the principal crops within the irrigated areas. Metered irrigation hookups total 4,631.

Domestic Water Supply

Domestic water supply is furnished for a population of 13,920. The demand for domestic water is continuing to increase as the area is developed into suburban residences. Metered domestic hookups total about 5,500 and continue to increase.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	3,792	acres
Number of irrigated farms	54	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,858	326,478
1969	1,880	330,642
1970	550	137,620
1971	500	111,163
1972	500	124,221
1973	500	151,428
1974	576	186,276
1975	533	174,920
1976	532	170,008
1977	464	206,733

Facilities in Operation

Storage dams[1]	2	
Diversion dams	4	
Canals (irrigation)	19	mi
Pumping plants (irrigation)	1	
Laterals (irrigation, pipeline)	88	mi
Domestic pipelines	58	mi
Wells (domestic)	1	

[1]Non-Reclamation.

Climatic Conditions

Annual precipitation	12.7	in
Temperature:		
Maximum	110	°F
Minimum	−22	°F
Mean	53	°F
Growing season	213	days
Elevation of irrigable area	1000-1700.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	170
Other water service[2]	13,750
Total	13,920

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

SWEETWATER AND WEBB CREEKS

Drainage area	52	mi^2
Average annual discharge (estimated)	16,500	acre-ft
Average annual diversions[3]	7,475	acre-ft

[3]Includes 715 acre-feet domestic water.

Storage Facilities

RESERVOIR "A" DAM

Type: Earthfill
Location: Offstream, about 7 mi southeast of Lewiston, Idaho.
Construction period: Privately constructed in 1907, and enlarged to present capacity in 1922. Reclamation installed 405 ft of 30.5-in steel outlet pipe and a regulating valve in 1950-51 to provide direct connection from reservoir to main pipeline.
Reservoir, "A":

Total capacity at El. 1810.3	3,300	acre-ft
Active capacity at El. 1808.2	3,000	acre-ft
Surface area at El. 1808.2	139	acres
Dimensions:		
Structural height	60	ft
Crest length	2,200	ft
Crest elevation	1812.8	ft

Outlet works: A 36.5-in welded-plate steel pipe in concrete conduit through base of dam, controlled by a 36-in gate valve at downstream end.

SOLDIERS MEADOW DAM

Type: Earthfill
Location: On Webb Creek, about 6 mi southeast of Waha.
Construction period: Privately constructed in 1923.
Reservoir, Soldiers Meadow:

Active capacity	2,400	acre-ft
Surface area	121	acres
Dimensions:		
Structural height	57	ft
Crest length	535	ft
Crest elevation	4522.1	ft

Outlet works: Steel gate on upstream side of dam with stem control on upper face of dam.

LAKE WAHA

Natural reservoir formed by a landslide; has no surface outlet. Maximum capacity when filled is 6,900 acre-ft. It is estimated that 40 percent of the stored water passes through subsurface pervious strata into Sweetwater Creek. The remainder of the supply can be pumped (a 170-ft lift is necessary) over a ridge that drains to the West Fork of Sweetwater Creek, then diverted into Sweetwater Canal.

Diversion Facilities

WEBB CREEK DIVERSION DAM

Type: Rockfill weir, concrete crest wall
Location: On Webb Creek, about 15 mi southeast of Lewiston, Idaho.
Year completed: 1948
Dimensions:

Structural height	20	ft
Hydraulic height	10	ft
Crest length	75	ft
Crest elevation	3599.0	ft
Volume	1,300	yd^3

Headworks: 30-in concrete pipe and 30-in concrete sluice pipe, controlled by 30-in intake and sluice gates, respectively.

Diversion capacity	20	ft^3/s

SWEETWATER DIVERSION DAM

Type: Rockfill weir, concrete crest wall.
Location: On Sweetwater Creek, about 12 mi southeast of Lewiston, Idaho.
Year completed: 1948
Dimensions:

Structural height	12	ft
Hydraulic height	8	ft
Crest length	80	ft
Crest elevation (approximate)	2075.0	ft
Volume	7,500	yd^3

Headworks: 5- by 4-ft slide gate, concrete flume, and sand trap.

Diversion capacity	77	ft^3/s

OTHER DIVERSION STRUCTURES

Captain John Diversion Dam, at the head of Captain John Feeder Canal, supplements the water supply for Soldiers Meadow Reservoir. This dam was built by the Irrigation District in 1934 out of log cribs following a simple standard design. The dam is about 50 mi south of Lewiston, Idaho, and is still in use.
The diversion dam at the head of Lake Waha Feeder Canal was constructed by the Irrigation District in 1912 and replaced by a concrete structure about 1941. The dam is on the West Fork of Sweetwater Creek, about 23 mi southeast of Lewiston.

Carriage Facilities

WEBB CREEK DIVERSION CONDUIT AND CANAL

Location: From Webb Creek Diversion Dam, about 15 mi southeast of Lewiston, Idaho, generally northwest to East Fork of Sweetwater Creek.
Construction period: Work by Reclamation consisted of replacing sections of deteriorated wooden flume with 7,800 ft of 30-in precast concrete pipe, and constructing about 500 ft of earth-lined canal in 1947-48.

Length	2.5	mi
Capacity	20	ft^3/s
Typical maximum section, earth lined canal:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	1.9	ft
Lining thickness	6	in

SWEETWATER CANAL

Location: From Sweetwater Diversion Dam on Sweetwater Creek about 12 mi southeast of Lewiston, Idaho, generally north to Reservoir "A."

Length	9	mi
Capacity	50	ft^3/s

Typical maximum section (flume):

Width	5 ft
Water depth	3.5 ft
Wall thickness	6 in

Typical maximum section (canal):

Bottom width	8 ft
Side slopes	1.5:1
Water depth	3.2 ft

Main Pipeline (Reservoir "A")

Location: From Reservoir "A" outlet works west to Lewiston Orchards distribution system.

Construction period: 1948-49

Length ... 4.4 mi

Description: 4,450 ft of 36.5-in outside-diameter enameled welded steel pipe to water treatment plant; 18,900 ft of 30.5-in pipe to end of line.

Irrigation Distribution System

In addition to 4.4 mi of large steel supply lines, 71.2 mi of pressure pipe ranging from 1 to 30 inches in diameter were installed by Reclamation. Extensions installed by the Irrigation District totaled 12 mi.

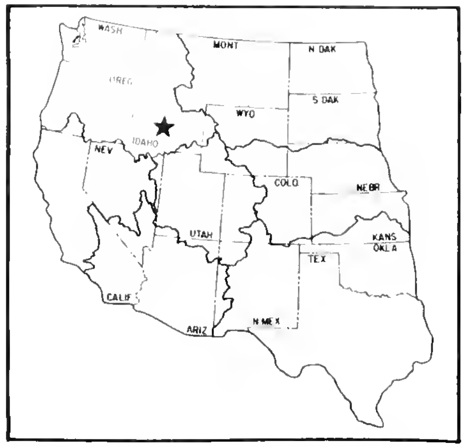
Domestic Distribution System

The domestic distribution system consists of 47 mi of pipeline ranging in diameter from 0.75 to 14 in installed by Reclamation and 11 mi of extension installed by the Irrigation District.

Little Wood River Project

Idaho: Blaine County

Pacific Northwest Region
Water and Power Resources Service



Little Wood River Project includes lands within an area 2 miles wide and 12 miles long upstream and downstream from Carey, Idaho, in the south-central section of the State. The project provides a supplemental irrigation water supply for 9,549 acres of land. The principal construction feature is the enlarged Little Wood River Dam and Reservoir that serve previously constructed diversion and distribution works. Flood control is provided by operation of the reservoir on a forecast basis.

PLAN

An increased water supply to meet the need of water users in the project area was provided by increasing the height of Little Wood River Dam from 77 to 129 feet. This increased the reservoir capacity from 12,100 to 30,000 acre-feet. The diversion and carriage facilities on the project remained unchanged.

Little Wood River Dam

Rehabilitation work included raising the dam crest 52 feet, extending the outlet tunnel downstream 150 feet, and relocating the spillway. The completed structure is 129 feet high, with a zoned earthfill embankment containing about 959,000 cubic yards of material. Outlet works reconstruction included enlargement of the entrance channel to the existing intake structure, construction of a gate chamber with a connecting 6-foot-diameter access shaft and shaft house in the existing tunnel approximately 250 feet downstream from the intake structure, extension of the existing tunnel with a 150-foot-long, 6- by 8-foot conduit and a 60-foot-long, 6- by 10-foot chute, and excavation of a stilling basin in the outlet channel. The spillway consists of an inlet channel, a concrete spillway structure with uncontrolled crest, an outlet channel, and a training wall on the right side of the outlet channel beginning approximately 1,000 feet downstream from the spillway crest.

Little Wood River Dam and Reservoir

DEVELOPMENT

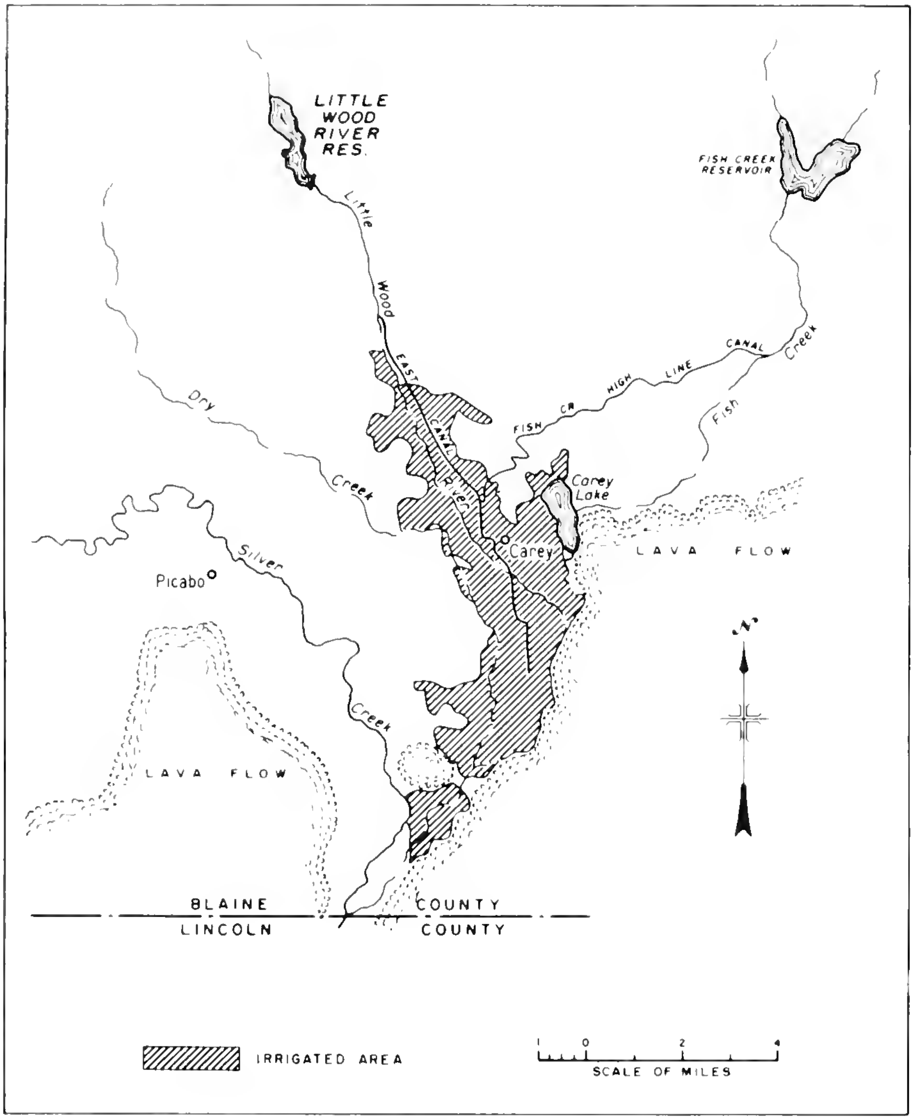
Early History

Settlement of the project area took place in the late 1800's, principally by people interested in raising livestock. Surrounding foothills and mountains to the north furnished summer grazing.

Earliest water rights have a priority date of 1880 and were granted to meet the individual needs of the early farmers. In 1893, the settlers formed a mutual association and constructed canals on both sides of the river to meet water requirements for new irrigable lands. Carey Lake Reservoir Company was formed in 1912 and obtained a license to divert and store water in Carey Lake for 2,051 acres east of Carey, Idaho. By 1923 or 1924, no water was available for storage, and since that time there has been no irrigation storage in Carey Lake. The lake was purchased by the Idaho Fish and Game Department in 1949.

Investigations

Investigation of means for regulating the flow of Little Wood River by storage was begun in the spring of 1904



Little Wood River Project

by the Reclamation Service. A reconnaissance survey for reservoir sites on the Little Wood River and tributaries led to the conclusion that costs of storing water would be excessive. The requirement for storage of late-season supplemental water was continuously evident to Little Wood River Valley irrigators after 1940. Several proposals and sites were investigated, but financial difficulties prevented further development until 1936 when construction of the Little Wood River Dam was started by the Works Projects Administration. In 1947, the board of directors of the Little Wood River Irrigation District employed a private engineering firm to investigate the feasibility of raising the dam an additional 35 feet. Although plans and estimates were made, the enlargement proposal was defeated because some individuals were unwilling to obligate their holdings as required by the proposed financial arrangements. However, interest in the project continued and a complete investigation was made by the Bureau of Reclamation beginning in April 1954. A report dated June 1955 was the basis for project authorization.

Authorization

The project was authorized on August 6, 1956, by Public Law 993, 84th Congress, 2d session (70 Stat. 1059).

Construction

The contract for the enlargement of Little Wood River Dam was awarded August 22, 1958, and work was completed in July 1960.

Operating Agency

The project is maintained and operated by the Little Wood River Irrigation District.

BENEFITS

Irrigation

Principal crops are grain, hay, pasture, and potatoes.

Flood Control

Historically, the area had never been free from the threat of flood damage from periodic floodings. Flood control benefits are being achieved by operating the reservoir on a forecast basis. Flooding, except for an extremely high flood discharge, has been eliminated in the community of Carey and immediate surrounding area.

Recreation and Fish and Wildlife

Impoundment of the Little Wood River has increased opportunities for boating and lake fishing. Located far from large population centers, the reservoir has proved to be popular for camping and fishing. The Bureau of Reclamation operates a small campground, picnic area, and boat ramp near the dam. Trout and kokanee salmon are the anglers' primary catch.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	9,549	acres
Number of irrigated farms	54	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,824	447,510
1969	6,747	446,580
1970	7,706	562,629
1971	7,686	637,144
1972	7,745	599,689
1973	7,774	940,600
1974	7,800	968,278
1975	7,873	1,063,404
1976	7,194	1,185,705
1977	6,877	627,718

Facilities in Operation

Storage dams	1	
Diversion dams[1]	1	
Canals[1]	50	mi
Laterals[1]	10	mi

[1]Non-Reclamation construction.

Climatic Conditions

Annual precipitation	14	in
Temperature:		
Maximum	98	°F
Minimum	−28	°F
Mean	42	°F
Growing season	123	days
Elevation of irrigable area	4800.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	174
Other water service[2]	45
Total	219

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

LITTLE WOOD RIVER

Drainage area at Little Wood River Reservoir	279	mi²
Annual discharge:		
Maximum (1965)	257,700	acre-ft
Minimum (1977)	46,100	acre-ft
Average	141,200	acre-ft
Average annual diversions	59,000	acre-ft

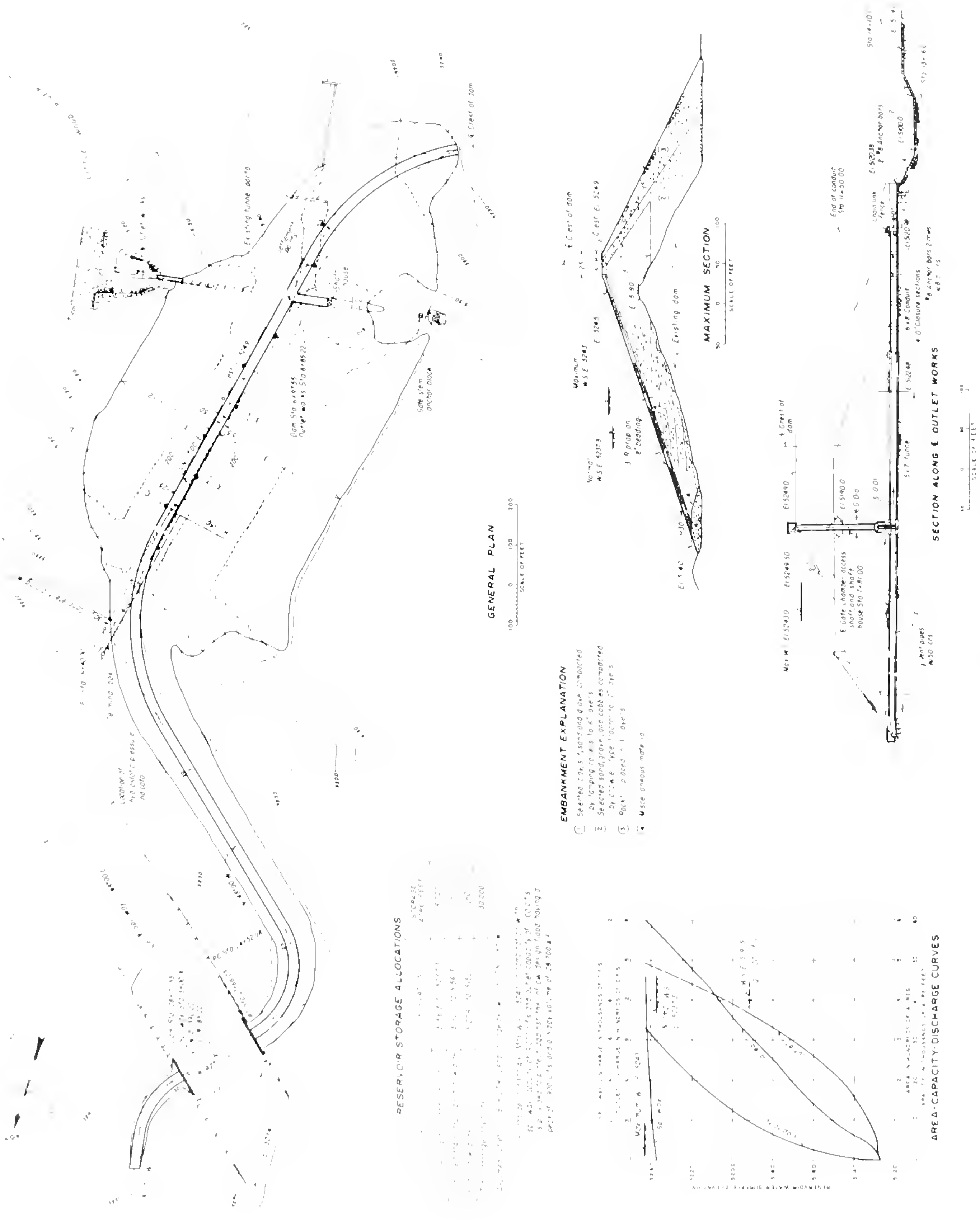
Storage Facilities

LITTLE WOOD RIVER DAM

Type: Zoned earthfill
Location: On the Little Wood River, 11 mi northwest of Carey, Idaho.
Construction period: 1958-60
(Originally constructed in 1936 to about 77 ft above streambed by the Works Projects Administration.)

Reservoir, Little Wood River:		
Total capacity at El. 5237.3	30,000	acre-ft
Active capacity at El. 5237.3	30,000	acre-ft
Surface area	572	acres
Dimensions:		
Structural height	129	ft
Hydraulic height	116	ft
Top width	25	ft
Maximum base width	635	ft
Crest length	3,100	ft
Crest elevation	5249.0	ft
Volume	959,000	yd³

Spillway: Concrete structure on left abutment uncontrolled.
Outlets: Tunnel and concrete conduit through right abutment, controlled by two 6- by 4-ft gates.

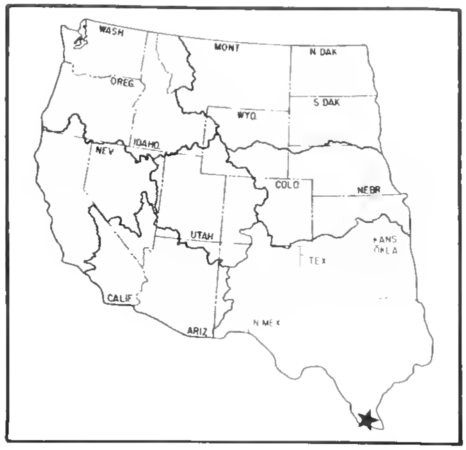


Little Wood River Dam, Plan and Sections

Lower Rio Grande Rehabilitation Project

Texas: Hidalgo and Cameron Counties

Southwest Region
Water and Power Resources Service



The Lower Rio Grande Rehabilitation Project has rehabilitated the diversion, distribution, and drainage systems of La Feria and Mercedes Divisions to permit more efficient operation and maintenance of works. Rehabilitation work also was done to reduce seepage losses from the canals and laterals and to provide drainage relief from a design storm that would produce 2.6 inches of runoff.

PLAN

La Feria Division

La Feria Division has about 35,000 irrigable acres of land in the extreme western half of Cameron County, Texas. The lands are on the Rio Grande deltaic plain about 25 miles inland from the gulf coast.

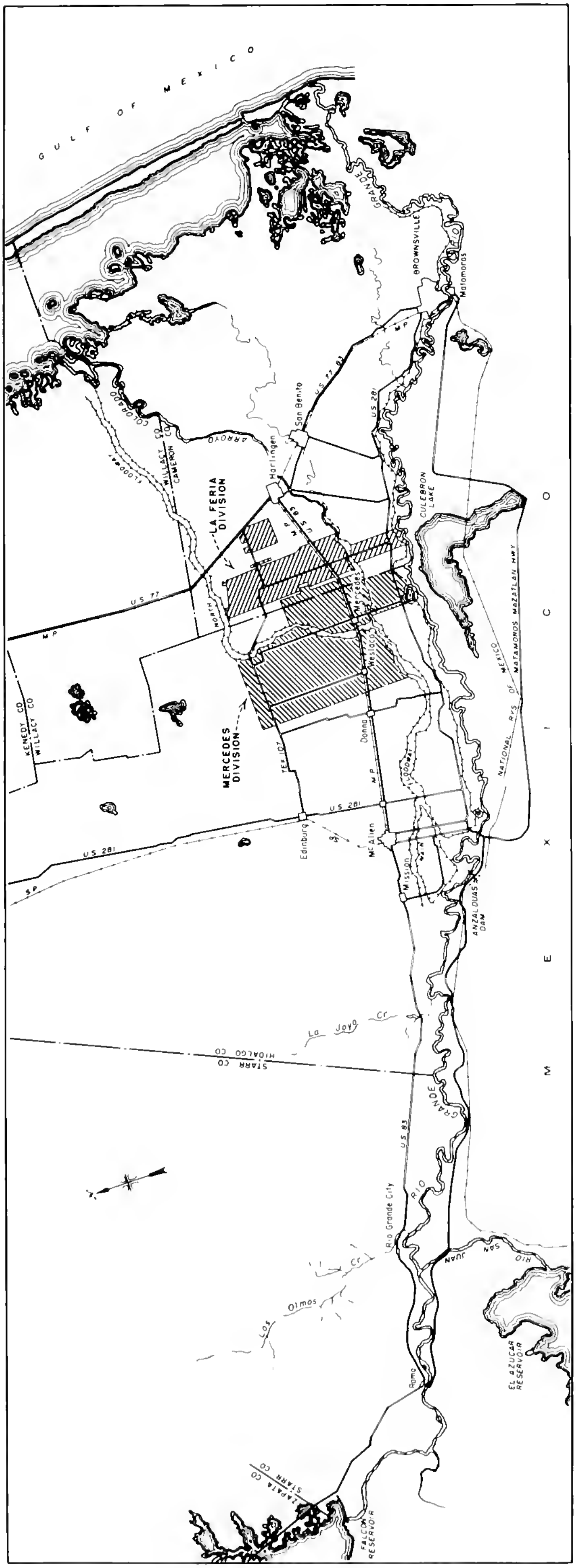
Rehabilitation of the diversion and distribution facilities involved lining 21 miles of canals and laterals; repairing 35.1 miles of formerly unlined canals and laterals; placing 54.5 miles of pipeline, including replacing 9.6 miles of lined laterals in poor condition with pipeline; repairing or replacing structures; repairing or replacing pumping installations; enlarging the existing storage basin to 2,000 acre-feet capacity; cleaning vegetative growth from all unlined canals and laterals; and providing maintenance roads. Drainage system work included reconstructing the drainage pumping plant, cleaning and clearing all drains and ditches, enlarging or replacing some drainage structures, and providing maintenance roads along 153 miles of drainage system. Providing maintenance roads permits use of mechanical maintenance equipment instead of manual labor.

The irrigation works include an inlet channel from the Rio Grande about 7 miles south of La Feria, Tex., a riverside pumping plant, one large and several small relift pumping plants, and approximately 161 miles of canals and laterals. The river pumping plant receives diverted river flows through an inlet channel 1,000 feet in length and about 80 feet in average width. All water diverted from the Rio Grande is lifted an average of 20 feet at the main pumping plant from the inlet channel to the distribution system. Following the first lift, the irrigation system involves one large relift pumping plant located on the main canal at the northeast corner of the storage basin and two small relift pumping plants on the lateral system.

A diked area on the north bank of the Arroyo Colorado 5.5 miles north of the main pumping plant serves as a storage and desilting basin. The main canal functions as a supply canal to the storage basin, the second lift pumping plant, and to the laterals serving the gravity-fed lands of the division. The main canal has a total length of 17.6 miles.

From the river pumping plant, the canal extends northward 5.3 miles to a siphon crossing of the Arroyo Colorado and the storage basin and then extends 12.2 miles to the north boundary of the division. The siphon crossing of the Arroyo Colorado is the only major structure on the main canal and consists of a monolithic concrete box 450 feet long, 7- by 7-feet inside dimensions, with inlet and outlet transitions about 15 feet long.

Rehabilitated "F" Lateral



Lower Rio Grande Rehabilitation Project

The system of laterals is laid out to conform to the water-service units created by topographic features of the area. About 68 percent of the lands are served through the second lift pumping plant near the storage basin. After water passes through the plant, service is by gravity. The lateral system consists of 144 miles of laterals and pipeline. A network of 153 miles of drainage ditches and the Tio Cano drainage pumps serve the district land.

Mercedes Division

The Mercedes Division occupies the southeast corner of Hidalgo County, Texas, and a strip 7 miles long in the western part of Cameron County. It includes the towns of Mercedes, Weslaco, Elsa, Edcouch, several suburban areas, and rural centers of population. The division encompasses 90,000 acres of land, including about 72,000 irrigable acres.

Rehabilitation of the diversion and distribution system involved lining 136 miles of canals and laterals, repairing 94 miles of presently lined canals and laterals, placing 21 miles of pipeline, repairing or replacing structures as required, repairing or replacing pumping installations, enlarging the existing storage and desilting basin capacity of 4,500 acre-feet, cleaning vegetative growth from all unlined canals and laterals, and providing maintenance roads. Drainage system work included clearing and cleaning of all drains and ditches, enlarging or replacing drainage structures, and providing maintenance roads along 250 miles of drainage system.

Water to serve the division's land is diverted from the Rio Grande about 7 miles south of Mercedes, Tex., to the pumping plant through an inlet channel 1,200 feet long and 100 feet in average width. All of the water diverted from the river is lifted at the main pumping plant approximately 20 feet from the inlet channel to the distribution system. Several relift pumping plants serve the higher lands. The distribution system consists of 13.5 miles of canals, 6.5 miles of unlined laterals, 53.8 miles of concrete lined laterals, and 248.9 miles of concrete pipelines.

A diked area just north of the river pumping plant serves the division as a storage and desilting basin. Releases to the main canal are made through a gated control structure. The main canal serves the laterals on the gravity-fed lands and the North Weslaco Relift Pumping Plant.

There are three major structures on the main canal. At the crossing of the main floodway, there are two separate reaches of siphon with a 1,000-foot earth canal section intervening. Both of these siphons are of monolithic four-barrel construction; each barrel is 7 feet 9 inches in diameter. The Anacuitas Arroyo is crossed by a 416-foot continuous concrete U-section flume 6 feet in depth and partitioned into three channels, each of which is 5 feet 10 inches in width. A 750-foot-long, 12-foot-diameter concrete pipe conveys the main canal across Lake Campacuas and the north floodway.

The division's drainage system consists of a 250-mile network of drainage ditches connected with outflow channels to the main and north floodways. Six drain pumps lift the collected drainage flows to the floodways.

DEVELOPMENT

Early History

First permanent settlements in the Lower Rio Grande Valley were established by the Spanish Crown in 1749 to secure its claim to the territory. Early agriculture was restricted to subsistence crops since transportation to outside markets was not available. Livestock raised on the open range were driven overland or to ports for marketing outside the valley. Land grants followed in a few years and settlement expanded, although limited to scattered small farms and ranches. Construction of a railroad southward into the valley in 1904 opened a market for agricultural products and initiated a period of intense land development and agricultural expansion. Settlement of the present La Feria area was started about 1908 by La Feria Mutual Canal Company. Small tracts of land were sold by the company to farmers with the agreement that they would purchase their water at an annual rental. Three years earlier a similar sales program had been started by the American Rio Grande Land and Irrigation Company in what is now the Mercedes Division area.

Investigations

Since 1896, various groups have made numerous investigations of the water supply, soils, drainage (surface and subsurface), and flood-control problems of the Lower Rio Grande Valley. Necessarily, the more recent studies have been primarily concerned with problems of ensuring the availability of an adequate water supply to the valley, delivery of that supply to the land, and removal of excess water to assure continued productivity.

The boards of directors of La Feria and Mercedes Divisions recognized that the irrigation systems were almost a half century old, that operation and maintenance costs were mounting rapidly, that the flow of the Rio Grande had been overappropriated, and that the then-existing facilities were not making the most effective use of the water available, and requested that the Bureau of Reclamation make a general investigation.

In accordance with the request and under a program jointly financed by those interests and the Bureau of Reclamation, four alternative diversion plans to deliver

Rio Grande flows to existing distribution systems were studied. A report on the investigations, dated May 21, 1954, found all plans feasible and recognized the need for rehabilitation of the existing distribution systems and for construction of main drain outlets.

A plan of rehabilitation for the Mercedes Division was completed in January 1956, and for La Feria Division in January 1957. Definite plan reports for both divisions were prepared in April 1959 and July 1960, respectively.

Authorization

The Mercedes Division was authorized by Public Law 85-370 (72 Stat. 82), approved April 7, 1958. La Feria Division was authorized by Public Law 86-357 (73 Stat. 641), approved September 22, 1959.

BENEFITS

The reduction in distribution system loss and waste resulting from the rehabilitation has a significant effect on the economy of the two divisions. The water conserved is available to minimize water shortages.

PROJECT DATA

Land Areas (1977)

La Feria Division:

Total irrigable area	34,499	acres
Number of irrigated farms	400	

Mercedes Division:

Total irrigable area	72,082	acres
Number of irrigated farms	496	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1969	94,030	16,498,130
1970	92,732	12,481,524
1971	92,576	14,914,269
1972	91,743	14,373,459
1973	95,059	19,747,486
1974	96,329	26,177,978
1975	95,793	28,141,760
1976	94,791	29,684,823
1977	93,423	30,038,863

Facilities in Operation

La Feria Division

Storage basin	1	
Pumping plants	3	
Main canal	17.6	mi
Laterals[1]	144	mi
Drains	153	mi

Mercedes Division

Storage basin	1	
Pumping plants	5	
Main canal	13.5	mi
Laterals[1]	309.2	mi
Drains	250	mi

[1]Includes pipelines.

Climatic Conditions

Average annual precipitation	26	in
Temperature:		
Maximum	110	°F
Minimum	18	°F
Mean	74	°F
Growing season	362	days

ENGINEERING DATA

Water Supply

Water available for irrigation releases from Falcon Dam (U.S. share)	1,348,000	acre-ft
Water available for diversion in the Rio Grande Valley	1,300,000	acre-ft
Typical historic diversion by La Feria Division	65,600	acre-ft
Typical historic diversion by Mercedes Division	137,000	acre-ft

Carriage Facilities

Pumping Plants

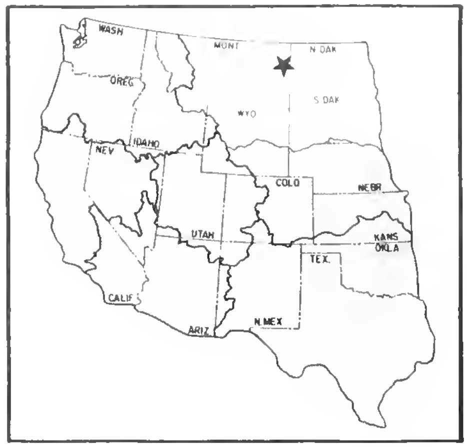
Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
La Feria Division:				
River	5	335	21	1,950
Second Lift	3	285	11	601
Tio Cano	2	50	17	120
Mercedes Division:[2]				
River	3	750	22	2,700
Relift No. 4	6	336	18	1,000
Relift No. 5	2	24	15	60

[2]In addition to those listed, two smaller relift pumping plants serve project needs.

Lower Yellowstone Project

Montana: Richland and Dawson Counties
North Dakota: McKenzie County

Upper Missouri Region
Water and Power Resources Service



The Lower Yellowstone Project in east-central Montana and western North Dakota includes the Lower Yellowstone Diversion Dam, Thomas Point Pumping Plant, the Main Canal, 225 miles of laterals, and 118 miles of drains. The purpose of the project is to furnish a dependable supply of irrigation water for 52,133 acres of fertile land along the west bank of the Yellowstone River. About one-third of the project lands are in North Dakota and two-thirds in Montana.

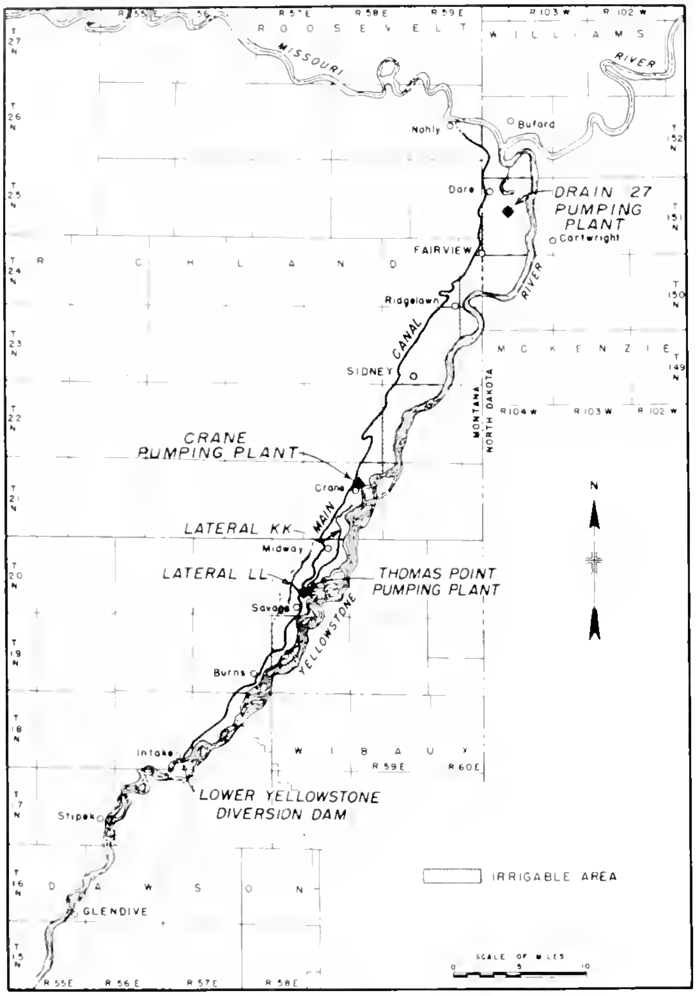
PLAN

Water is diverted from the Yellowstone River into the Main Canal by the Lower Yellowstone Diversion Dam near Intake, Mont. It is carried by gravity to the greater portion of the project lands. About 2,300 acres of benchland are irrigated by water pumped from the canal by the Thomas Point Pumping Plant.

Lower Yellowstone Diversion Dam

The Lower Yellowstone Diversion Dam, on the Yellowstone River about 18 miles below Glendive, Mont., is a rockfilled timber crib weir about 12 feet high. The dam contains 23,000 cubic yards of material.

Lower Yellowstone Diversion Dam



Lower Yellowstone Project

Pumping Plants

There are three pumping plants on the project; one at Thomas Point on the Main Canal, one at Crane on the Main Canal, and one on Drain 27.

The Thomas Point Pumping Plant is on the Main Canal about 19 miles below the headworks. The plant has two units directly connected to hydraulic turbines and one motor-driven unit. The energy derived from 80 cubic feet per second of water falling 28 feet from the Main Canal to Lateral KK is utilized by the two hydraulic turbine-driven centrifugal pumps to lift 45 cubic feet per second of water 31 feet to Lateral LL for irrigation of 2,300 acres of benchland north of Savage, Mont. The motor-driven unit pumps 20 cubic feet per second of water from the Main Canal into Lateral LL.

The Crane Pumping Plant has two motor-driven units, each of which pumps 5 cubic feet per second of water from the Main Canal into Lateral BP-1.

The pumping plant at Drain 27 has one motor-driven unit which pumps 15 cubic feet per second of water from the drain into Lateral N.

Main Canal and Distribution System

The Main Canal diverts to the west side of the Yellowstone River at Intake and extends down the valley to the confluence of the Yellowstone and Missouri Rivers. The canal is 71.6 miles long and has an initial capacity of 1,200 cubic feet per second. A lateral system of 225 miles serves the project lands. A total of 118 miles of drains has been constructed.

DEVELOPMENT

Early History

About 1883, following the completion of the Northern Pacific Railroad, cattlemen settled in the project area. Limited irrigation of meadowland was accomplished by a few of the settlers prior to the construction of the irrigation project.

Investigations

The Reclamation Service began investigating the project in 1903. A report by a board of consulting engineers, dated April 23, 1904, served as a basis for authorization of the project.

Authorization

The project was authorized by the Secretary of the Interior on May 10, 1904, under the Reclamation Act of June 17, 1902.

Construction

Construction began on July 22, 1905. Water was available for irrigation during the season of 1909.

Operating Agency

The project is operated by the Board of Control of the Lower Yellowstone Project.

BENEFITS

Irrigation

The principal crops grown include small grains, alfalfa and other hay crops, pasture, silage, beans, and sugar beets.

Municipal Water

The town of Savage is supplied with Lower Yellowstone Project water.

Recreation

In 1977, the project provided 10,500 visitor days.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	52,133	acres
Number of farms	411	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	45,499	6,303,368
1969	44,334	6,410,206
1970	43,670	5,938,725
1971	43,781	7,085,648
1972	42,884	7,243,715
1973	45,110	11,590,431
1974	45,384	20,492,344
1975	45,248	17,978,762
1976	45,483	12,187,500
1977	45,485	11,231,160

Facilities in Operation

Diversion dams	1	
Canals	71.6	mi
Laterals	225	mi
Pumping plants	3	
Drains	118	mi

Climatic Conditions

Annual precipitation	14	in
Temperature:		
Maximum	111	°F
Minimum	−53	°F
Mean	45	°F
Growing season	129	days
Elevation of irrigable area	1900.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,547
Municipal and industrial use	275

ENGINEERING DATA

Water Supply

YELLOWSTONE RIVER

Drainage area above Lower Yellowstone Diversion Dam	66,800	mi²
Annual discharge at Intake, Mont.:		
Maximum (1943)	13,336,200	acre-ft
Minimum (1934)	4,209,000	acre-ft
Average	8,869,500	acre-ft
Average annual diversion, 1966-77	338,800	acre-ft

Diversion Facilities

LOWER YELLOWSTONE DIVERSION DAM

Type: Rockfilled timber-crib weir, embankment wing
Location: On the Yellowstone River near Intake, Mont.
Year completed: 1910
Dimensions:

Structural height	12	ft
Hydraulic height	4	ft
Crest length	700	ft
Crest elevation	1981.0	ft
Volume	23,000	yd³

Spillway: Ogee
Headworks: Concrete, 11 circular sluice gates, each 5 ft in diameter.

Diversion capacity	1,100	ft³/s

Carriage Facilities

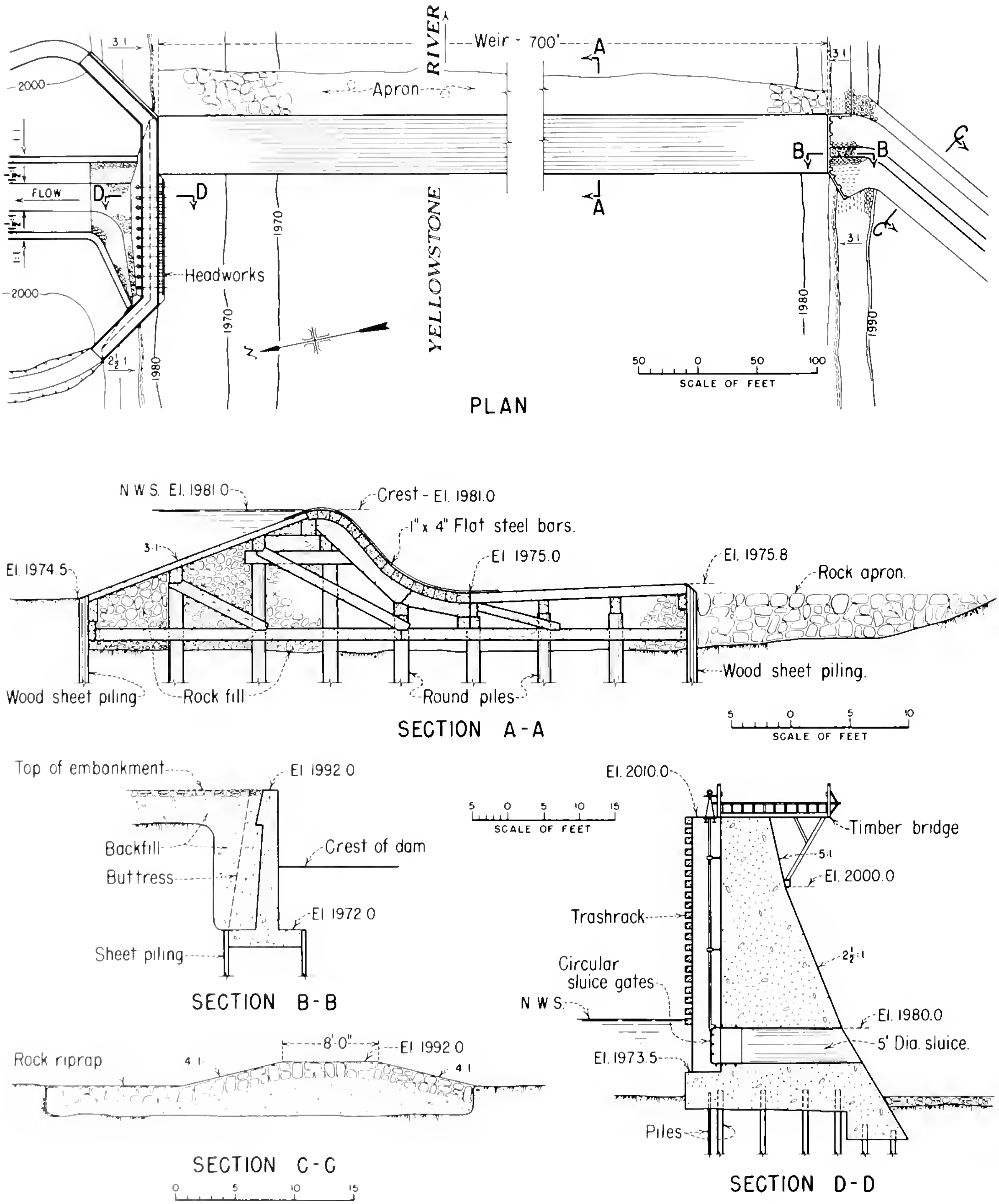
MAIN CANAL

Location: From Lower Yellowstone Diversion Dam near Intake, Mont., generally northeast along west side of Yellowstone River to vicinity of Nohly, Mont.
Construction: 1905-09

Length	71.6	mi
Diversion capacity	1,200	ft³/s
Typical maximum section in earth:		
Bottom width	30	ft
Side slopes	1.5:1	
Water depth	9.8	ft

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Thomas Point				
Turbine-driven	2	45	32.5	---
Motor-driven	1	20	32.5	---
Crane	2	10	---	40
Drain 27	1	15	---	75

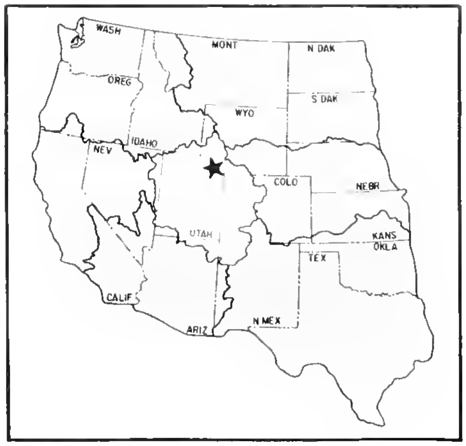


Lower Yellowstone Diversion Dam, Plan and Sections

Lyman Project
(Under Construction)

Wyoming: Uintah County

Upper Colorado Region
Water and Power Resources Service



The Lyman Project lands are in southwestern Wyoming; however, much of the drainage area and one storage feature are in Utah, just across the State line. The project will regulate the flows of Blacks Fork and the East Fork of Smiths Fork for irrigation, municipal and industrial use, fish and wildlife conservation, and recreation.

PLAN

The flows of Blacks Fork are regulated by Meeks Cabin Dam and Reservoir. Since 1971, the reservoir has made available a supplemental irrigation supply for 32,474 acres of land. Construction started in 1977 on Stateline Dam, located on the east fork of Smiths Fork as a replacement for the originally proposed China Meadows Reservoir which was not approved because of potentially adverse environmental impacts. Water stored in Stateline Reservoir will provide supplemental irrigation service for an additional 10,200 acres. Water stored in the two reservoirs will be released as needed for irrigation, and distributed along with return flows through existing canal systems. The project will provide municipal and industrial water for Lyman, Mountain View, Wyo., and surrounding rural areas, as well as enhance fishing and recreation opportunities, and wildlife conservation. Incidental flood control benefits also will be realized from the project.

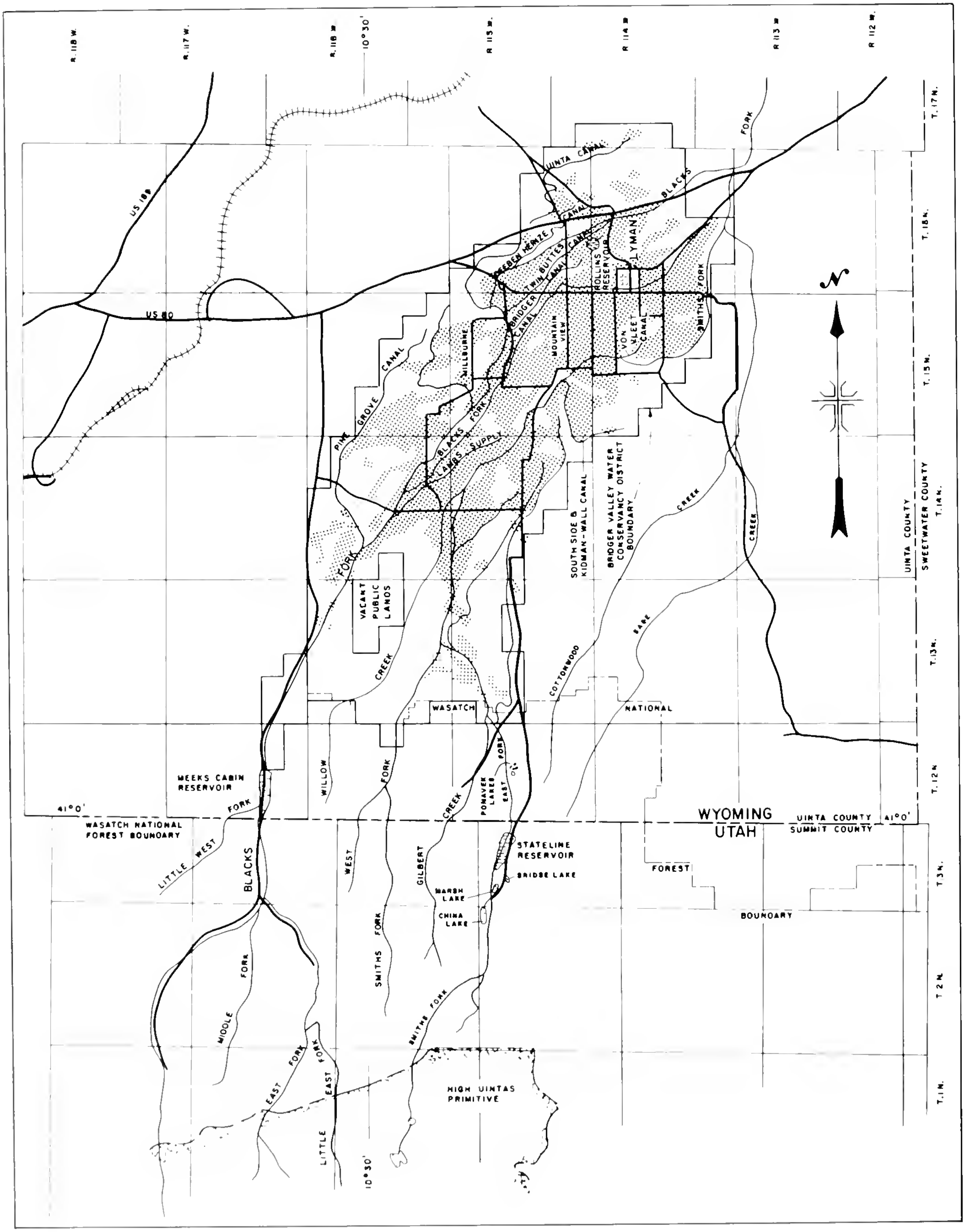
Meeks Cabin Dam and Reservoir

Meeks Cabin Dam and Reservoir

Meeks Cabin Dam, located in Uinta County, about 2 miles north of the Utah-Wyoming State line and 22 miles southwest of Fort Bridger, is a rolled earth and rockfill structure with a height of 184.5 feet above streambed and a crest 3,162 feet long and 30 feet wide. The embankment contains 3,587,000 cubic yards of material. The spillway, with a discharge capacity of 6,250 cubic feet per second, has an uncontrolled concrete overflow crest with a 30-foot-wide by 15-foot-high rectangular conduit through the dam along the left abutment and a stilling basin at river level. The outlet works is located under the dam along the right abutment and has a maximum discharge capacity of 1,070 cubic feet per second at the maximum water surface elevation of 8699.5. Meeks Cabin Reservoir has a total capacity of 32,470 acre-feet, covering an area of 473 acres.

Stateline Dam and Reservoir

Stateline Dam, on the east fork of Smiths Fork within the Wasatch National Forest in Utah, is about 0.5 mile south of the Utah-Wyoming State line. The dam has a height of 134 feet above streambed and a crest length of 2,900 feet. The spillway has a discharge capacity of 5,850 cubic feet per second, an uncontrolled concrete morning-glory drop inlet, and a 14.5-foot-diameter concrete conduit through the dam along the right abutment with a stilling basin at river level. The outlet works is located under the center of the dam along the stream channel and has a discharge capacity of approximately 400 cubic feet per second. Structures along the outlet works include an intake structure, a gate chamber, control house, and stilling basin. Two small earthfill dikes, constructed



Lyman Project

along the west side of the reservoir basin, have crest lengths of 70 and 130 feet. Each dike is about 10 feet high. Stateline Reservoir has a capacity of 14,000 acre-feet. At maximum water surface elevation, it extends about 1.8 miles upstream from the dam and covers an area of about 300 acres.

DEVELOPMENT

Early History

Fort Bridger was established in Wyoming in 1843, on Blacks Fork where the old Oregon and California Trails joined. This fort was operated as a small post for trade with western immigrants, and became one of the first public inns and stores west of the Missouri River. Landholdings for cattle raising were acquired by settlers around the fort after it was garrisoned as a military outpost in 1858. In 1862, production of grass hay through small irrigation diversions from Blacks Fork began so feed could be supplied to garrisoned livestock and stock moving with the wagon trains.

The livestock industry expanded rapidly after 1862 as new settlements were established along Blacks Fork and Smiths Fork, and it soon became necessary for livestock feed to be grown for winter use to supplement the open range. Cooperative irrigation organization began with the formation of the Fort Bridger and Blacks Fork Canal Companies in 1891, soon followed by other canal companies. Irrigation farming increased until about 1920, when it became apparent that the dependable summer streamflows had been overappropriated. Several land tracts irrigated before 1920 were later abandoned because of insufficient irrigation water. The relatively small populations of Lyman, Mountain View, Fort Bridger, and adjoining areas remained stable from about 1940 to 1973. However, population increased about 75 percent in 1973-75, primarily as a result of mining and construction activity in Sweetwater County.

INVESTIGATIONS

The undeveloped irrigation possibilities of the Green River Basin, including the Lyman area, were the subject of intermittent study for more than 40 years. The Bureau of Reclamation studied the area in 1919, 1933, and 1944. The results of the 1944 study were incorporated in a report on the Colorado River in 1946. The basin development report was followed by studies in 1950; the latest study, in 1962, outlined the project for development.

Preconstruction activities for China Meadows Reservoir were essentially completed in January 1970, when it became necessary to postpone further work on the reservoir because of environmental concerns. After distribution of the draft environmental statement in January 1972 and a public hearing in April 1972, the Bureau of Reclamation, in cooperation with other Federal and State agencies, evaluated all practicable alternative sites on the basis of economic and environmental effects. The Stateline site was found to be the most attractive from both standpoints. The final environmental impact statement was filed with the Council on Environmental Quality on December 8, 1975.

Authorization

The project was authorized as one of the initial participating projects of the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

Construction on Meeks Cabin Dam began in 1966 with award of contract for building the dam and access road. The dam was completed early in 1971 and water storage was initiated in 1971. Construction on Stateline Dam commenced in 1977.

Operating Agency

The Bridger Valley Water Conservancy District signed contracts with the United States in April 1964 and in October 1976 providing for project operation.

BENEFITS

Irrigation

The additional late-season irrigation water provided by the project will increase yields of forage and grain crops to bolster the local livestock industry. The water supply to the area served by Meeks Cabin Reservoir has made possible a regrowth of pasture after haying and the production of feed grains on the same land that previously yielded only native grass. Hay and pasture, alfalfa, barley, and oats are the principal crops.

Municipal and Industrial Water

A municipal and industrial water supply of 1,500 acre-feet a year will be made available from Stateline Reservoir for the towns of Lyman and Mountain View and surrounding rural areas.

Recreation and Fish and Wildlife

Facilities to enhance recreation and fishing opportunities are provided at both Meeks Cabin and Stateline Reservoirs. The existing Marsh Lake is to be stabilized by transfer of its irrigation storage to Stateline Reservoir and by rehabilitation of the dike that forms the lake.

Measures for fishery enhancement are provided in the streams below the reservoirs. Provisions have been made to mitigate losses to fish and wildlife from the reservoir developments. Recreational activities at Meeks Cabin Reservoir are administered by the Forest Service. Visitor days in the area during 1977 totaled almost 1,000.

Flood Control

Incidental flood protection will be realized at both reservoirs.

PROJECT DATA

Land Areas (1977)

Supplemental irrigation service:		
Blacks Fork area	32,474	acres
Smiths Fork area	10,200	acres
Total	42,674	acres

Area Irrigated and Crop Value

Year	(Blacks Fork) Area irrigated, acres	Crop value, dollars
1972	15,520	856,019
1973	15,165	466,090
1974	24,484	1,094,628
1975	7,971	433,084
1976	24,513	778,631
1977	25,944	1,036,970

Facilities in Operation

Storage dams	2

Climatic Conditions

Annual precipitation	10.5	in
Temperature:		
Maximum	102	°F
Minimum	−37	°F
Mean	41	°F
Growing season	92	days
Elevation of irrigable area	6500-8000.0	ft

ENGINEERING DATA

Water Supply

BLACKS FORK

Drainage area near Meeks Cabin damsite	156	mi²
Annual discharge:		
Maximum (1965)	163,800	acre-ft
Minimum (1934)	38,500	acre-ft
Average	109,500	acre-ft

EAST FORK OF SMITH FORK

Drainage area near Stateline damsite	48	mi²
Annual discharge:		
Maximum (1952)	49,400	acre-ft
Minimum (1934)	10,900	acre-ft
Average	29,900	acre-ft

Storage Facilities

MEEKS CABIN DAM

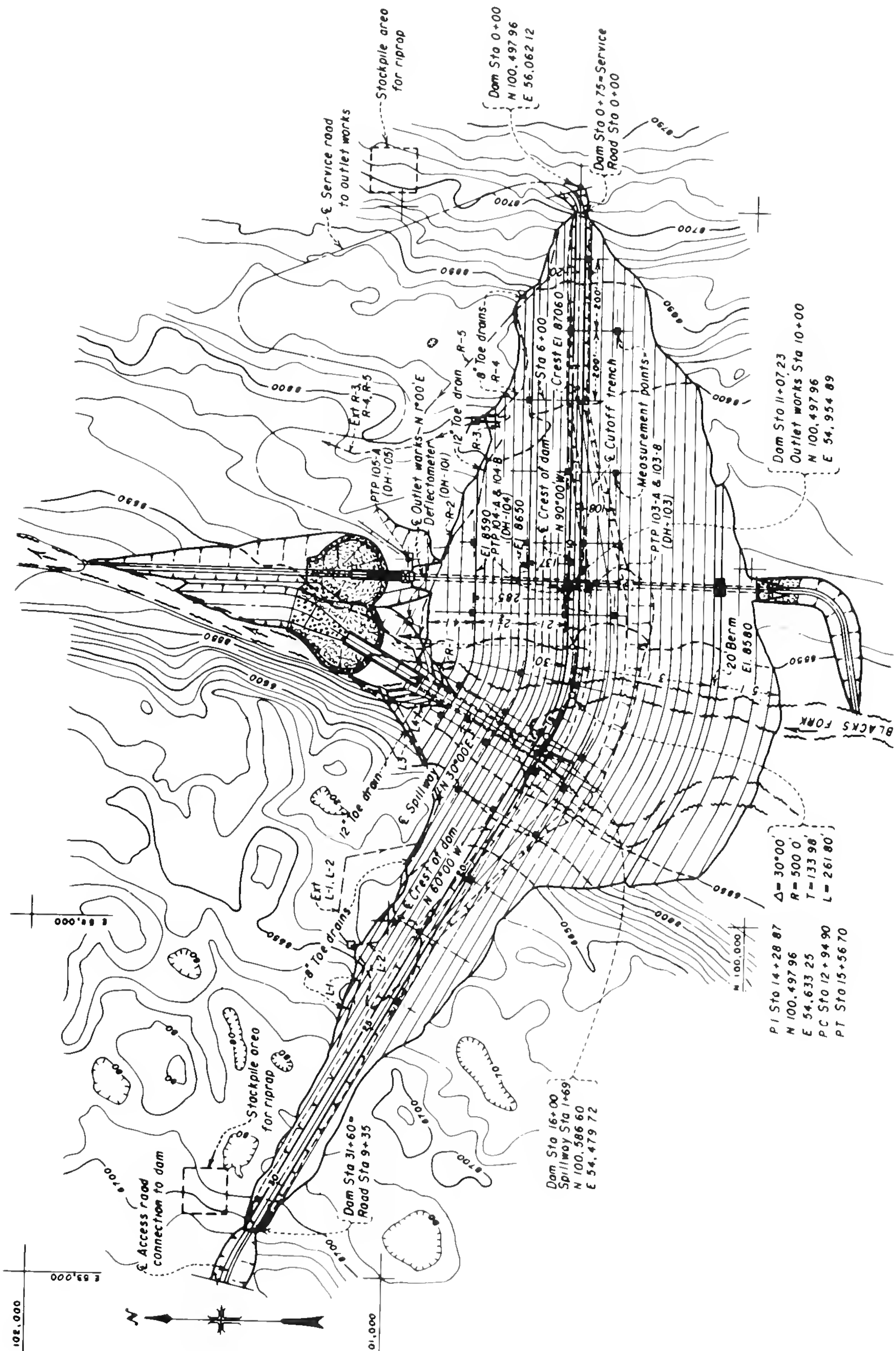
Type: Zoned earth and rockfill
Location: Blacks Fork, Uinta County, Wyoming, about 2 mi north (downstream) of the Wyoming-Utah State line and about 22 mi southwest of Fort Bridger, Wyo.
Construction: 1966-71
Reservoir, Meeks Cabin:

Capacity:		
Active	29,480	acre-ft
Total	32,470	acre-ft
Surface area	473	acres
Dimensions:		
Structural height	184.5	ft
Crest length	3,162	ft
Width	30	ft
Crest elevation	8706.0	ft
Volume	3,587,000	yd³
Spillway: Uncontrolled concrete overflow crest with 30- by 45-ft rectangular conduit through dam along left abutment and stilling basin at river level.		
Discharge capacity	6,250	ft³/s
Outlet works: Includes an 8-ft-diameter conduit gate chamber, a 9.5-ft-diameter horseshoe conduit housing 62- and 48-in steel outlet pipes, and a stilling basin.		
Discharge capacity	1,070	ft³/s

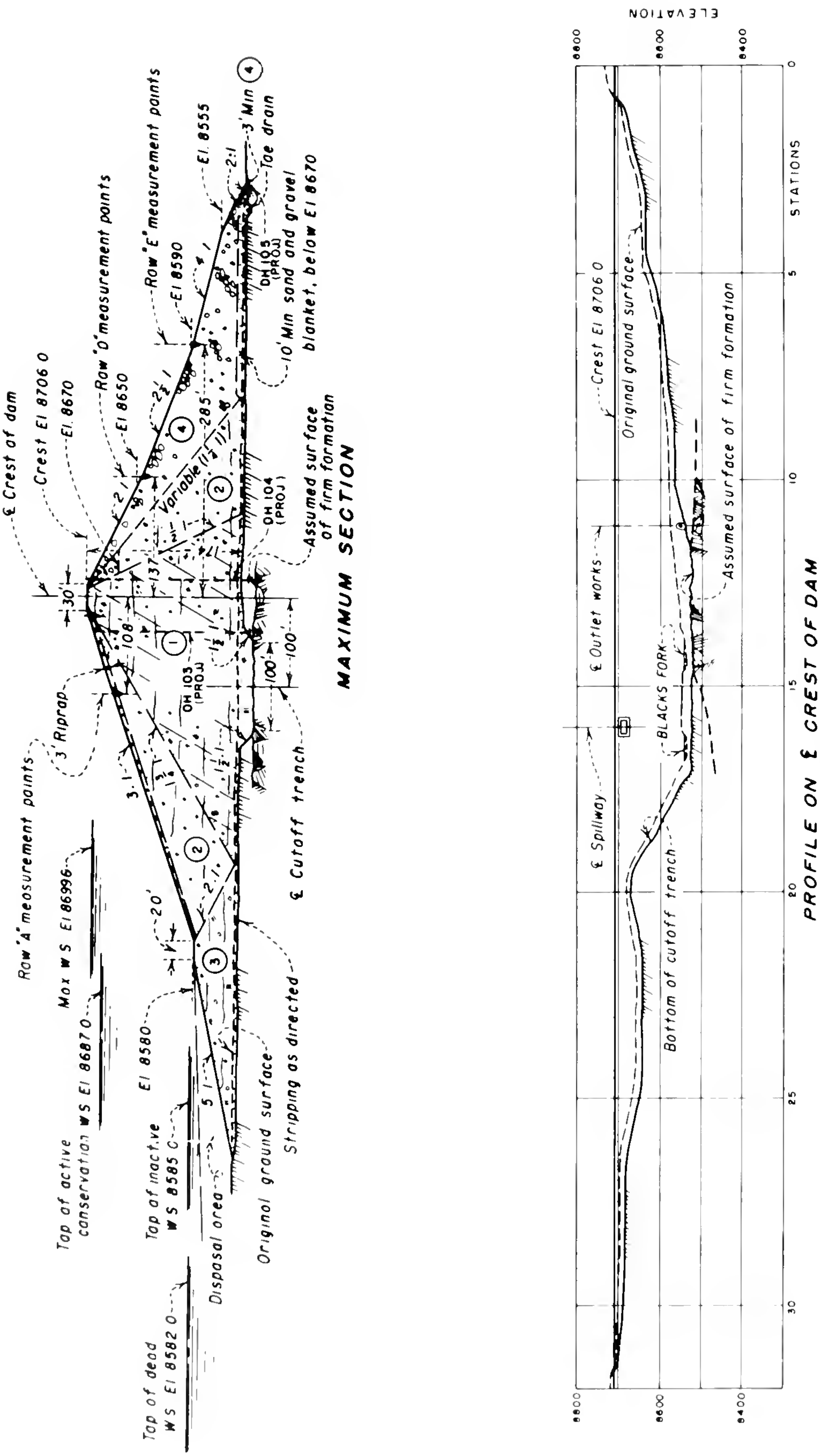
STATELINE DAM

Type: Earthfill
Location: East Fork of Smiths Fork, Summit County, Utah, about 0.5 mi south of Utah-Wyoming State line, and about 28 mi south of Fort Bridger, Wyo.
Construction period: 1977-79
Reservoir, Stateline:

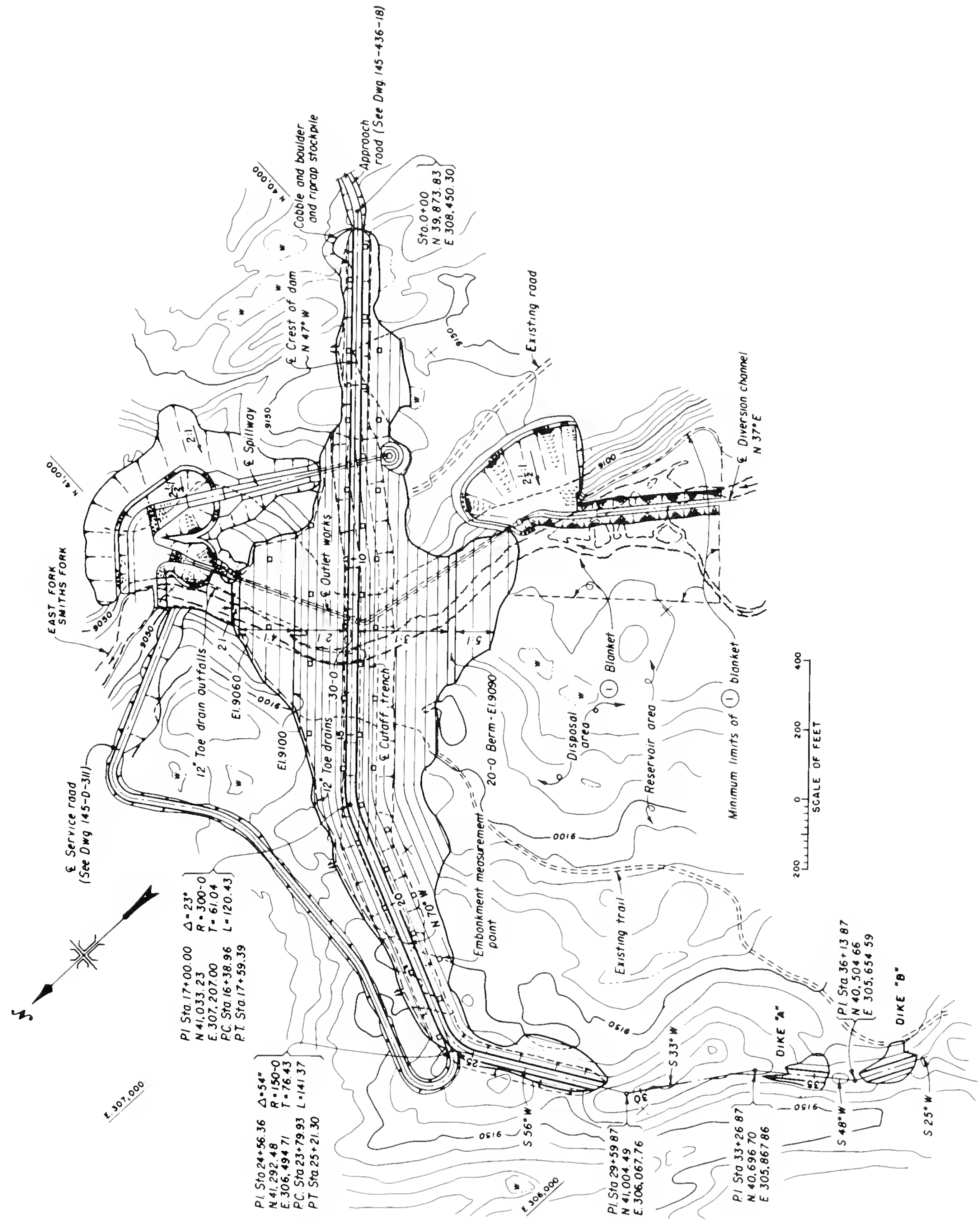
Capacity:		
Active	12,000	acre-ft
Total	14,000	acre-ft
Surface area	300	acres
Dimensions:		
Structural height	134	ft
Crest length	2,900	ft
Width	30	ft
Crest elevation	9176.0	ft
Volume	1,456,000	yd³
Spillway: Uncontrolled concrete morning-glory drop inlet with 14.5-ft-diameter concrete conduit through dam along right abutment and stilling basin at river level.		
Discharge capacity	5,850	ft³/s
Outlet works: Structures include a gate chamber, control house, and stilling basin.		
Discharge capacity	100	ft³/s



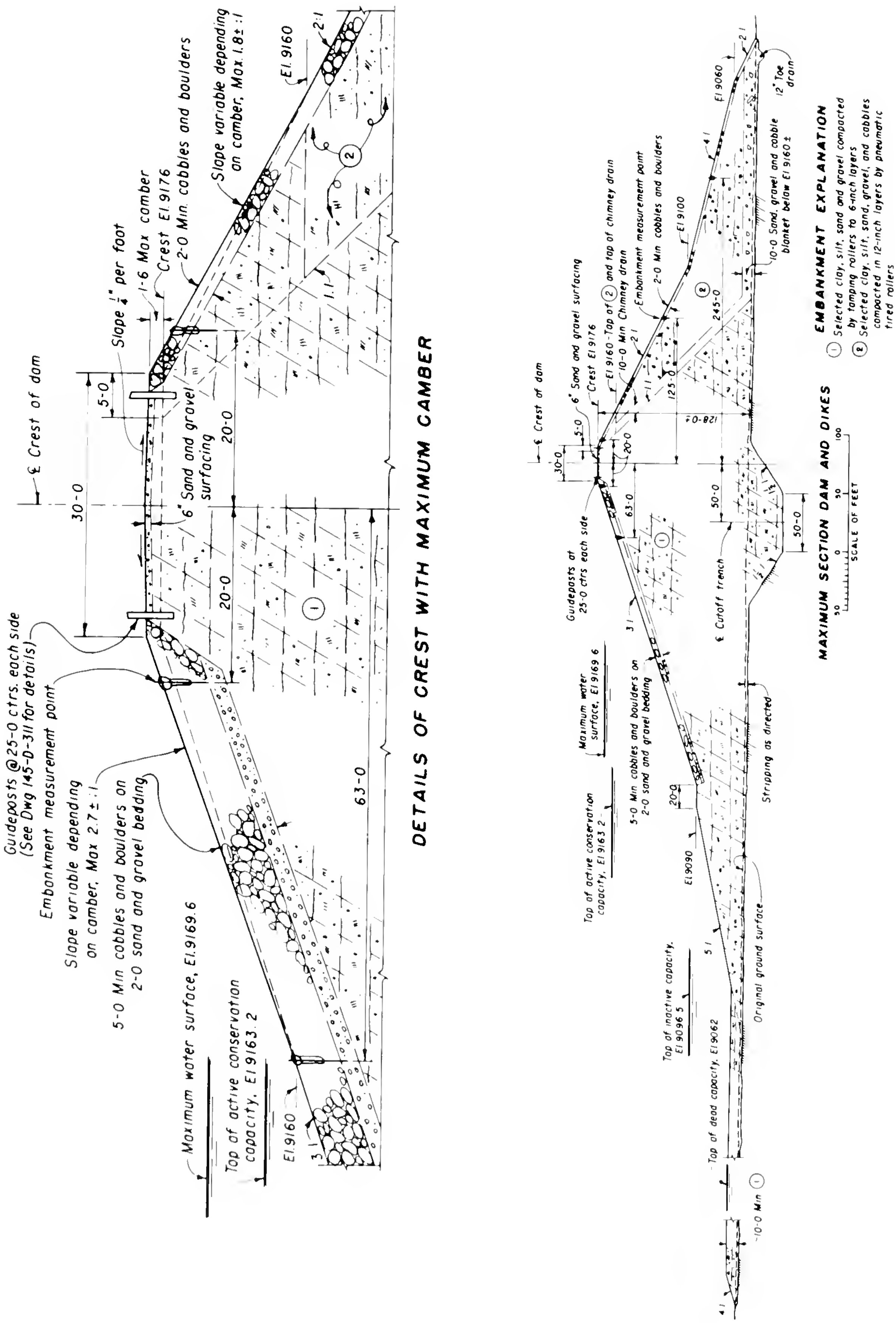
Meeks Cabin Dam, Plan



Meeks Cabin Dam. Section and Profile



Stateline Dam, Plan

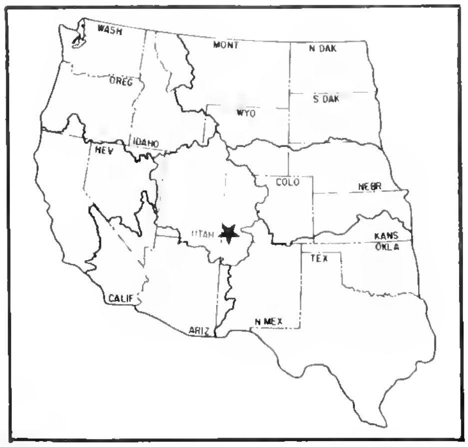


Stateline Dam, Sections

Mancos Project

Colorado: Montezuma County

Upper Colorado Region
Water and Power Resources Service



The Mancos Project in the southwest corner of Colorado consists of the Jackson Gulch Dam and Reservoir, the Inlet Canal, and the Outlet Canal. Project lands extend downstream about 10 miles. The project can furnish a supplemental water supply to approximately 8,650 acres.

PLAN

The offstream reservoir is fed by a 2.6-mile canal from the West Mancos River. Water from the reservoir is returned to the original streambed at a point higher than the project lands through the 2.2-mile-long Outlet Canal. The greater part of the distribution system was constructed by local interests prior to 1900. Facilities constructed by the Bureau of Reclamation furnish supplemental water to an established agricultural area and provide a domestic water supply for the Mesa Verde National Park.

Jackson Gulch Dam and Inlet Canal

Jackson Gulch Dam is a rock-faced earthfill structure 180 feet high with a concrete cutoff wall. The reservoir is offstream on Jackson Gulch, 5 miles north of Mancos, and has a total capacity of almost 10,000 acre-feet. The dam does not have a spillway. The 280-cubic-foot-per-second-capacity outlet works is a concrete pressure conduit from trashrack to gate chamber, and a steel pipe from gate chamber to two hollow jet valves. The Inlet Canal extends from the West Mancos River to the reservoir.

Jackson Gulch Dam

DEVELOPMENT

Early History

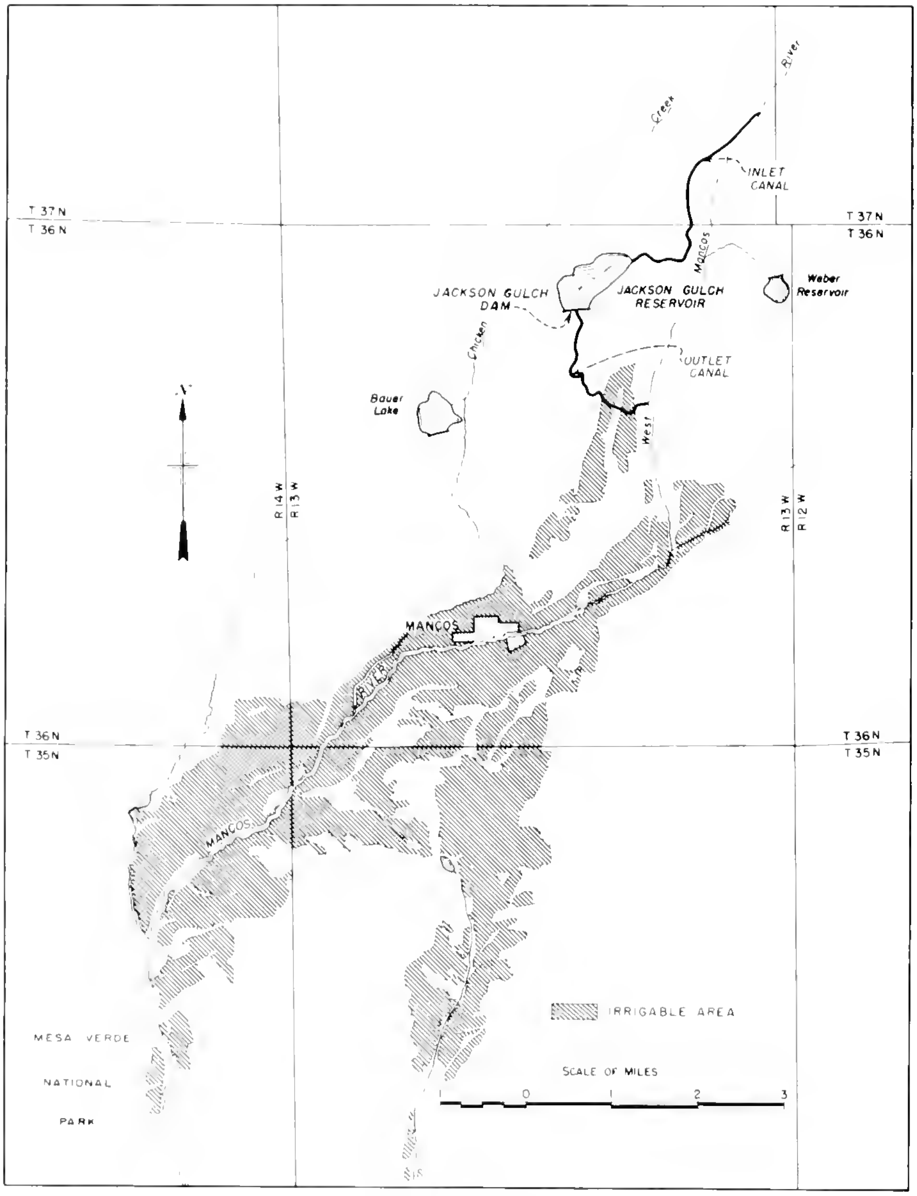
Settlement and irrigation of the Mancos Valley began about 1876. The natural flow of the Mancos River during the months of July, August, and September is very low, and the irrigation water supply for these months was inadequate. By 1893, when a State adjudication of water was made, late summer demands for irrigation water far exceeded the supply. To alleviate the shortage, three small reservoirs storing approximately 1,500 acre-feet of water were built by local irrigation organizations.

Investigations

In 1937, Bureau of Reclamation investigations led to the conclusion that the Jackson Gulch Reservoir site, an offstream storage basin, was the only site of sufficient size to furnish an adequate project water supply. At that time, the project did not appear economically feasible but it received further consideration under the Water Conservation and Utilization Act of August 11, 1939. Detailed project investigations, initiated in November 1940, followed approval of the project.

Authorization

The project was approved by the President on October 21, 1940, under the Water Conservation and Utilization Program Act of August 11, 1939 (53 Stat. 1418), as amended October 14, 1940 (54 Stat. 1119).



Mancos Project

Construction

Construction was started on July 24, 1941, and completed on May 18, 1950. The first water from Jackson Gulch Reservoir was delivered to the water users in 1949. Construction for this project was delayed by World War II. The Civilian Conservation Corps (CCC) started to build the dam under Bureau of Reclamation supervision. In March 1942, the CCC organization was disbanded and a group of Civilian Public Service assignees resumed the construction work by contract after the war ended. The major project works were completed between May 1947 and December 1948.

Operating Agency

Operation and maintenance of the project was transferred to the Mancos Water Conservancy District on January 1, 1963.

BENEFITS

Irrigation

A dependable supplemental water supply for project land adds to the economy of the area. Principal crops are alfalfa, grass hay, irrigated pasture, wheat, oats, barley, and corn silage.

Municipal and Industrial Water

The community of Mancos has subscribed for 600 acre-feet of the reservoir storage, thus ensuring a permanent source of domestic water for the future growth of Mancos Valley. The reservoir also provides water for Mesa Verde National Park.

Recreation and Fish and Wildlife

Jackson Gulch Reservoir has a surface area of almost 220 acres at total capacity. It is stocked with trout by the Colorado Department of Natural Resources, Division of Wildlife. There are many good sites for camping and picnicking. Hunting is permitted in season, and deer and elk are plentiful. Visitor days totaled an estimated 21,900 in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service (approx.)	8,650	acres
Number of irrigated farms	67	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,813	165,481
1969	7,961	158,919
1970	8,009	161,171
1971	8,079	190,229
1972	8,107	526,367
1973	8,239	585,870
1974	8,197	401,318
1975	8,144	477,130
1976	8,277	809,982
1977	[1]6,975	[1]185,115

[1]Colorado River runoff was the lowest in 61 years of record and in most areas of Colorado precipitation for the year was considerably below average.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	97	mi
Laterals	40	mi
Drains	2	mi

Climatic Conditions

Annual precipitation	15.9	in
Temperature:		
Maximum	96	°F
Minimum	−26	°F
Mean	46	°F
Growing season	123	days
Elevation of irrigable area	6400-7700.0	ft

ENGINEERING DATA

Water Supply

West Mancos River

Drainage area at gaging station 1 mi downstream from diversion dam	42	mi²
Annual discharge:		
Maximum (1941)	56,300	acre-ft
Minimum (1951)	12,220	acre-ft
Average	27,490	acre-ft

Storage Facilities

Jackson Gulch Dam

Type: Zoned earthfill
Location: Offstream in Jackson Gulch about 5 mi north of Mancos, Colo.
Construction period: 1941-50
Date of first storage: March 18, 1949.
Reservoir. (Inflow is from the West Mancos River through the inlet canal.)

Average annual inflow, 1949-72	7,400	acre-ft
Total capacity to El. 7825	10,000	acre-ft
Active capacity	9,950.5	acre-ft
Surface area	216.93	acres
Dimensions:		
Structural height	180	ft
Hydraulic height	160	ft
Top width	35	ft
Maximum base width	920	ft
Crest length	1,900	ft
Crest elevation	7831.0	ft
Volume	1,710,000	yd³
Spillway	None	

Outlet works: Concrete conduit through base of dam to emergency gate chamber, a 36-in steel pipe controlled by two 24-in hollow-jet valves at downstream end.

Capacity at El. 7825	280	ft³/s

Foundation: Sound Dakota sandstones near the abutments ranging through sandy shales to soft shale near bottom of gulch.
Special treatment: Grout curtain beneath cutoff wall; supplementary grouting at left abutment and around outlet works gate chamber.

Carriage Facilities

Inlet Canal

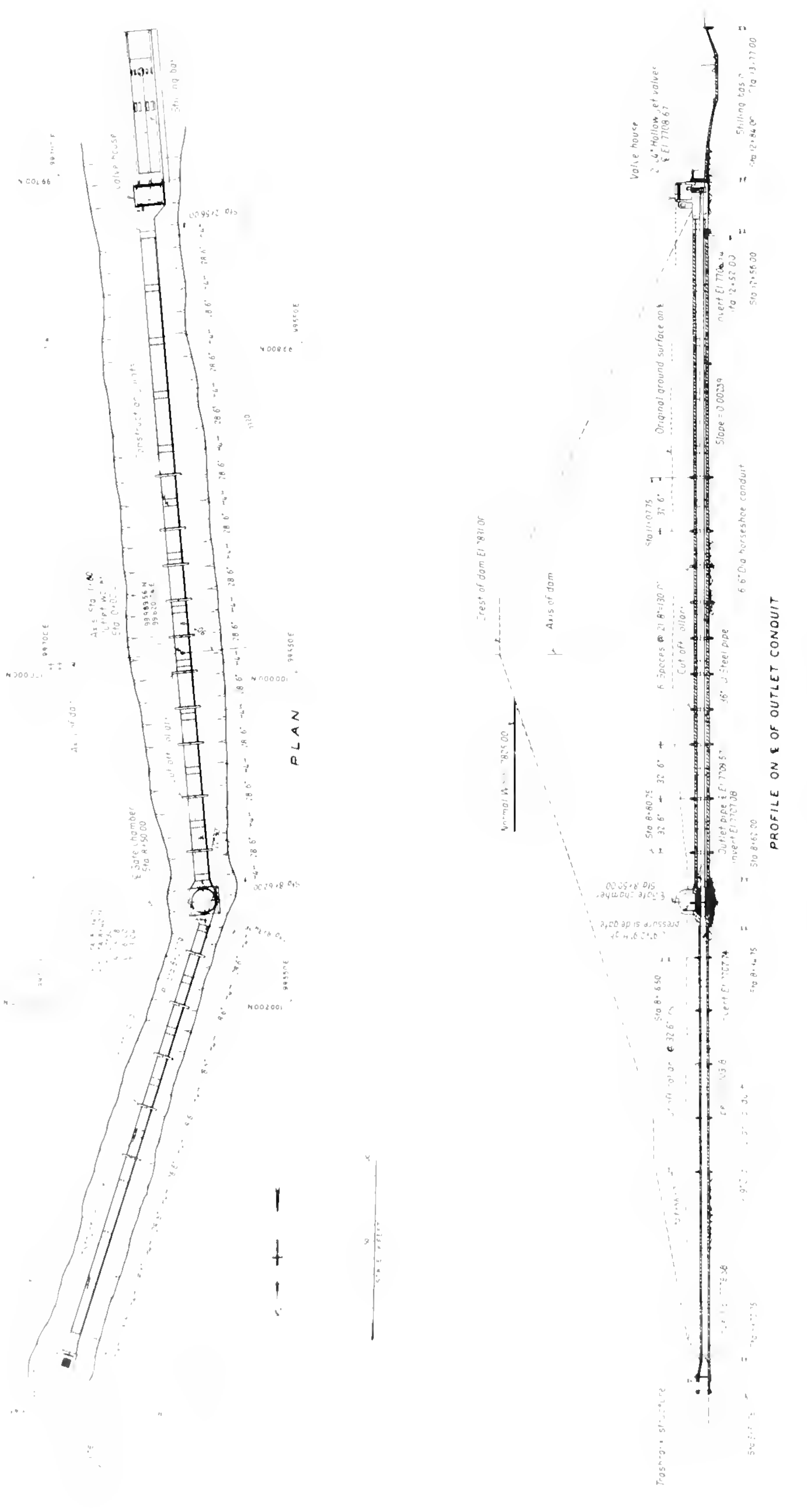
Location: From point on the West Mancos River about 7 mi northeast of Mancos, Colo., generally southwest to Jackson Gulch Reservoir.
Construction period: 1944-49

Length	2.6	mi
Capacity	258	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4.5	ft
Typical maximum section, bench flume:		
Bottom width	10	ft
Side slopes: Vertical		
Water depth	4.83	ft
Lining thickness	7	in

Outlet Canal

Location: From Jackson Gulch Dam generally southeast to the West Mancos River.
Construction period: 1943-50

Length	2.2	mi
Diversion capacity	207	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4	ft
Typical maximum section, bench flume:		
Bottom width	10	ft
Side slopes: Vertical		
Water depth	4	ft
Lining thickness	7	in

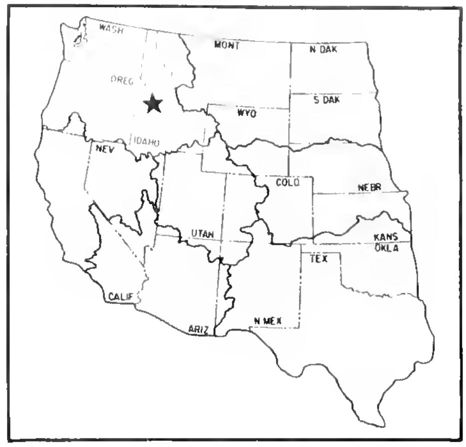


Jackson Gulch Dam, Plan and Profile

Mann Creek Project

Idaho: Washington County

Pacific Northwest Region
Water and Power Resources Service



The Mann Creek Project in west-central Idaho consists of 5,085 irrigable acres utilizing an existing distribution system in the narrow valleys of Mann and Monroe Creeks, both tributaries of the Weiser River. The natural flow of Mann Creek historically has been near its lowest point during the growing season when the demand for irrigation water is at its highest. Project development provides for storage of winter and spring flows of Mann Creek for use later in the irrigation season.

PLAN

Development of the Mann Creek Project consists of the Mann Creek Dam and Reservoir, control structures on the Joslyn Ditch and Mann Creek Ditch, and rehabilitation of 4.1 miles of the Lolley Ditch. Basically, the existing diversion, distribution, and drainage systems within the project areas are used. Mann Creek Reservoir furnishes a supplemental irrigation water supply for the 5,085 irrigable acres within the Mann Creek and Monroe Creek areas of the project. At the request of the water users, the name of Mann Creek Dam and Reservoir was approved August 26, 1967. Prior to that, it was called Spangler Dam and Reservoir. In addition to irrigation, recreation, and fish and wildlife benefits, flood control benefits are being realized through the operation of Mann Creek Reservoir.

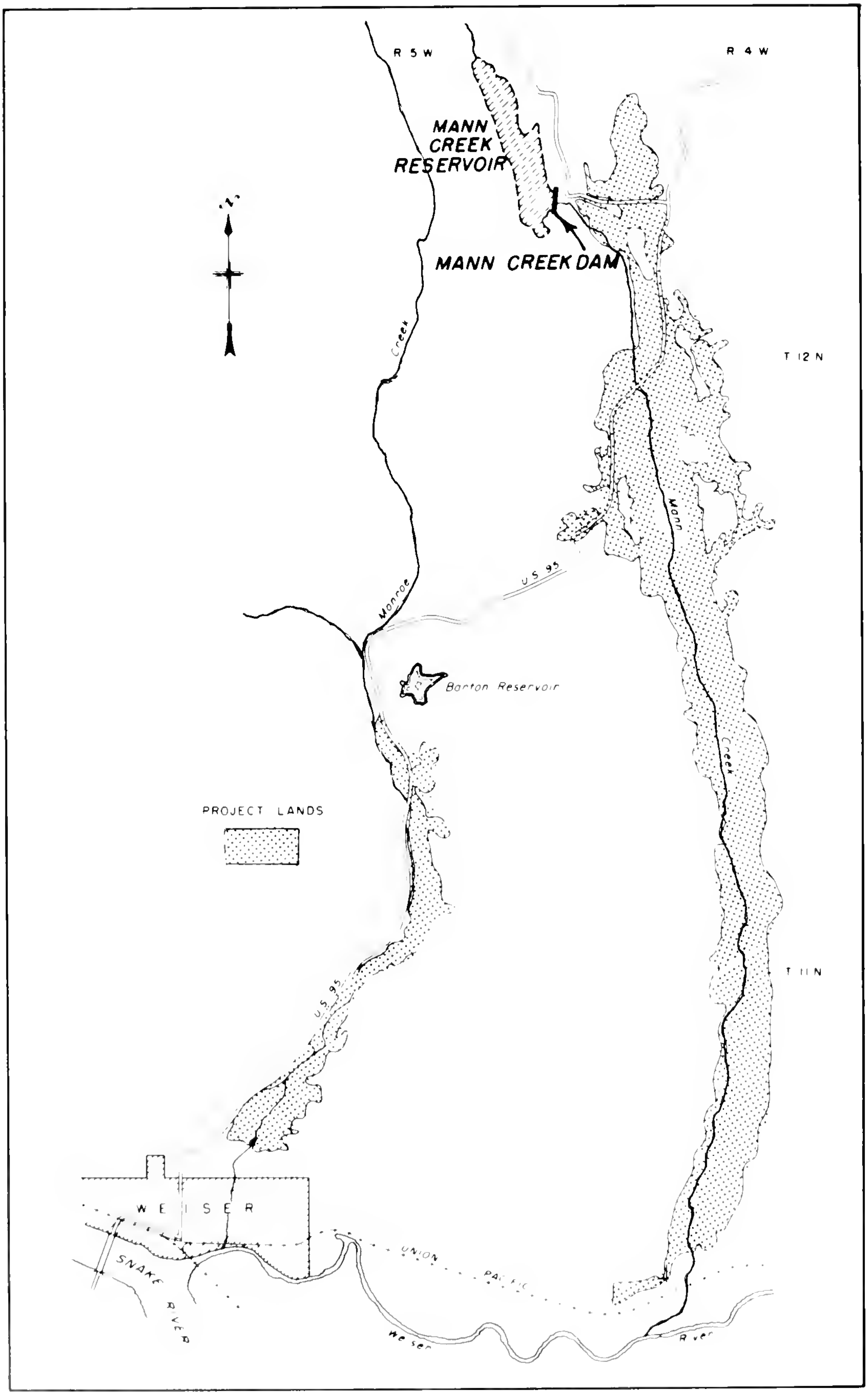
Mann Creek Dam

Mann Creek Dam and Reservoir

Mann Creek Dam, on Mann Creek about 13 miles northeast of Weiser, Idaho, is a zoned earth and rockfill structure with a crest length of 1,176 feet at elevation 2903.0, and height of 148 feet above bedrock. The crest width of 30 feet with guardrails along each shoulder provides a crossing for the relocated Monroe Creek road. A reinforced concrete morning-glory spillway inlet that connects to a reinforced concrete conduit, 13 feet in diameter, terminates in a concrete stilling basin located along the right abutment. The outlet works located along the left abutment is also of reinforced concrete. The flow of water is controlled by two 2.25-foot-square high-pressure gates located in the control house and one 2.75-foot-square high-pressure gate located in the gate chamber for emergency. Mann Creek Reservoir, at normal water surface elevation 2889.0, is 1.8 miles long, has a surface area of 282 acres, and impounds 12,950 acre-feet of water, of which 11,100 acre-feet are active storage.

Distribution System

Both the Mann and Monroe Creek areas have operating distribution systems which are being used in conjunction with Mann Creek Reservoir. These systems consist of several diversion structures across the two creeks, and ditches to serve the farmlands. The only work performed on these facilities was construction of headwork control structures on the Joslyn Ditch and Mann Creek Ditch, and rehabilitation of 4.1 miles of the Lolley Ditch. Existing Barton Reservoir, with a storage right of 2,000 acre-feet, is filled from Monroe Creek diversions through the Monroe Creek feeder canal and by water diverted from Mann Creek during times of high runoff or during the nonirrigation season.



Mann Creek Project

DEVELOPMENT

Early History

First settlers in the area were attracted in the early 1860's by rich bottom lands. Most of them engaged in stock-raising. The creation of Olds Ferry across the Snake River and the location of three forts in the vicinity of Weiser stimulated early development. Completion of the Union Pacific Railroad through Weiser and a branch line north to New Meadows in the 1890's gave further impetus to agricultural settlement of the area.

Early development of the project lands for irrigation was by direct diversions from Monroe and Mann Creeks. Ditches were constructed to meet the individual needs of the early farms.

The Mann Creek decree of July 17, 1919, established the water rights for the various ditches diverting from Mann Creek and the water rights for Barton Reservoir.

Investigations

The Bureau of Reclamation began the investigation of Mann Creek at the Spangler Reservoir site in 1938. A storage application was made in 1940 by the United States for 10,000 acre-feet of water. Results of the investigation were presented in a report on the Mann Creek Project dated October 1940. The project was approved for construction in July 1941 under the terms of the Water Conservation and Utilization Act. The landowners of the Mann Creek area failed to approve the proposed repayment contract by a narrow margin, and the project was not constructed. One of the principal reasons given for rejection of the proposed plan was that the landowners below the Joslyn Ditch would not receive storage water at low reservoir stages.

An alternative reservoir site about 1 mile upstream from the Spangler site that permitted diversion to the Joslyn Ditch at all times was investigated. Reauthorization of the Mann Creek Project, with development of storage at the Yoder site, was recommended with a number of other projects for construction in a basin-pooling plan under which irrigation projects would receive financial assistance from power projects in the Columbia River Basin. The proposals were not adopted by the Congress.

A new study was prepared on the Spangler site in 1958, followed by authorization and development of a definite plan.

Authorization

The Mann Creek Project was authorized for construction under the provisions of Public Law 87-589, approved August 16, 1962 (76 Stat. 388).

Construction

Construction of Mann Creek Dam and Reservoir began in 1965 and was completed in 1967.

Operating Agency

Mann Creek Dam and Reservoir and all other project facilities are operated by the Mann Creek Irrigation District.

BENEFITS

Irrigation

Principal crops raised are grain, hay, pasture, and fruit.

Flood Control

Before construction of Mann Creek Dam, the lands along Mann Creek were threatened each year with flood damages. Operation of Mann Creek Reservoir in regulating peak flows of Mann Creek has been helpful in flood prevention. Inflow to Mann Creek Reservoir is forecast on a monthly basis for use in an informal flood control operation.

Recreation and Fish and Wildlife

Mann Creek Reservoir lies in the rolling foothills of the Hitt Mountains in southwestern Idaho. The reservoir area encompasses a total of 936 acres, with 282 acres of water surface providing almost 5 miles of shoreline. Facilities have been constructed for camping, picnicking, and boat launching and mooring. A major north-south route for Idaho, U.S. Highway 95, passes about 1 mile from the reservoir but recreational use is light, mostly limited to picnicking and fishing, and the majority of the visitors are local residents. There is good fishing for trout at the reservoir, which is stocked annually. Migrating waterfowl use the reservoir for a resting area, and both waterfowl and upland game birds are hunted in season.

Low reservoir level during drought

Flooding of Weiser and Snake Rivers in 1964

PROJECT DATA

Land Areas (1977)

Irrigable area:
Supplemental irrigation service .... 5,085 acres
Number of irrigated farms 100

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	5,027	403,741
1969	4,690	335,752
1970	4,636	324,501
1971	4,566	452,965
1972	4,583	400,612
1973	4,655	627,778
1974	4,751	702,293
1975	4,720	720,573
1976	4,693	729,482
1977	4,512	380,892

Climatic Conditions

Annual precipitation .... 11.5 in
Temperature:
Maximum .... 105 °F
Minimum .... −25 °F
Mean .... 50 °F
Growing season .... 155 days
Elevation of irrigable area .... 2150-2750.0 ft

Settlement

Number of persons served with project water (1977):
Farm irrigation service 278
Other water service[1] 5
Total 283

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

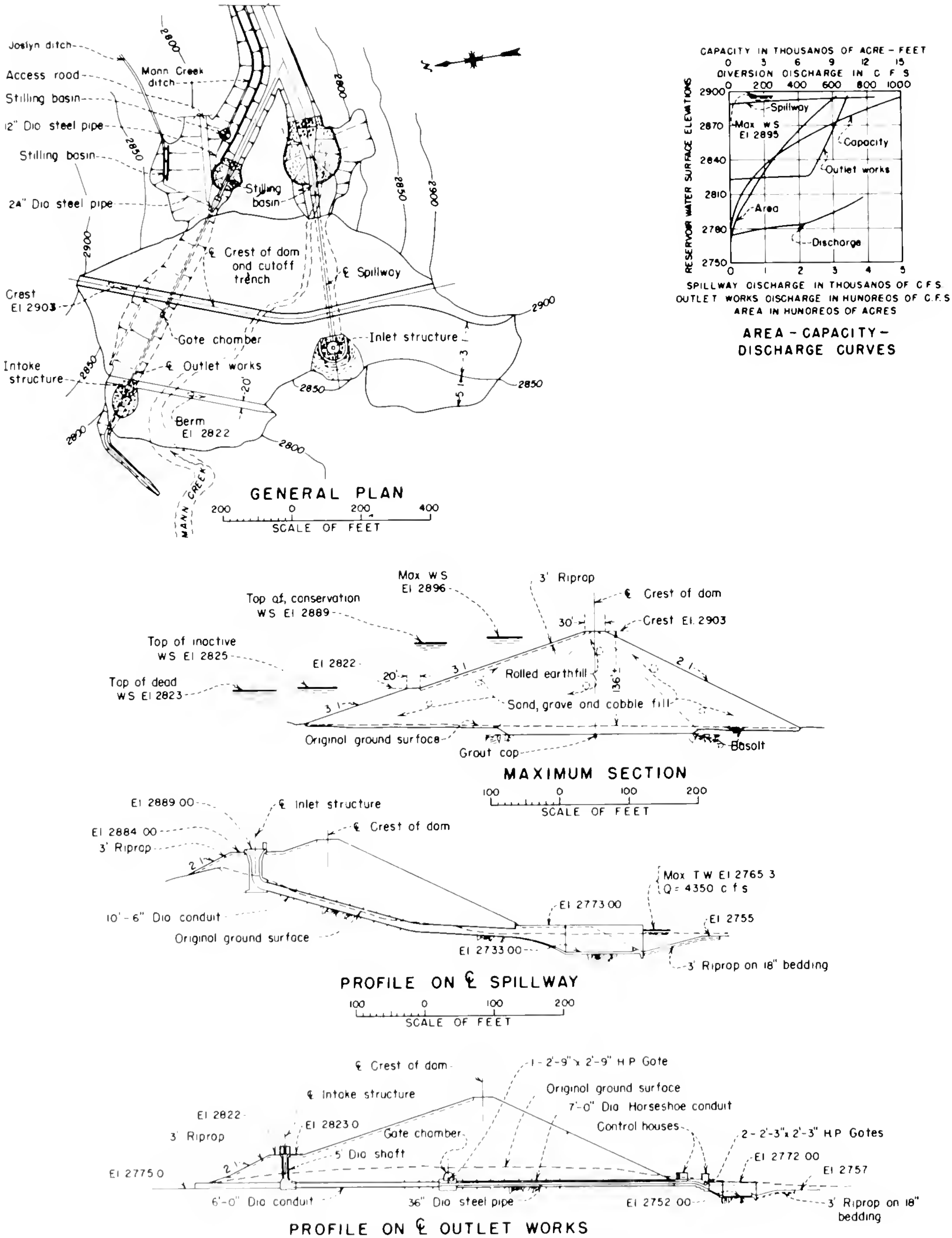
MANN CREEK

Drainage area near Weiser, Idaho .... 56 mi²
Annual discharge:
Maximum (1971) .... 51,800 acre-ft
Minimum (1977) .... 2,800 acre-ft
Average .... 28,000 acre-ft
Average annual diversions .... 26,100 acre-ft

Storage Facilities

MANN CREEK DAM

Type: Zoned earthfill
Location: On Mann Creek about 13 miles northeast of Weiser, Idaho.
Construction period: 1965-67
Reservoir, Mann Creek:
Total capacity to El. 2889 .... 12,950 acre-ft
Active capacity .... 11,100 acre-ft
Surface area .... 282 acres
Dimensions:
Structural height .... 148 ft
Hydraulic height .... 132 ft
Crest width .... 30 ft
Maximum base width .... 700 ft
Crest length .... 1,176 ft
Crest elevation .... 2903.0 ft
Volume .... 1,121,588 yd³
Spillway: Morning glory connected to a reinforced concrete conduit 13 ft in diameter, terminates in a concrete stilling basin and is located along right abutment.
Capacity .... 3,840 ft³/s
Outlet works: Reinforced concrete, located along left abutment. Waterflow controlled by two high-pressure gates located in control house and one high-pressure gate located in the gate chamber for emergency.
Capacity .... 300 ft³/s

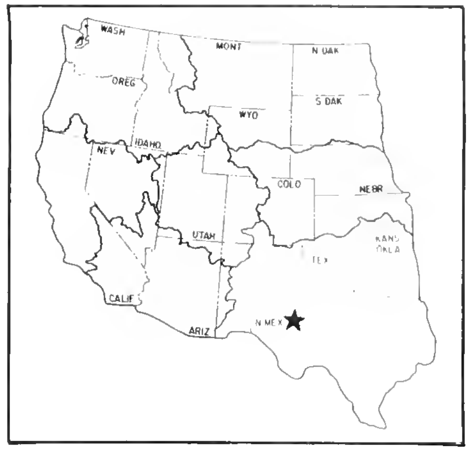


Mann Creek Dam. Plan and Sections

McMillan Delta Project

New Mexico: Eddy County

Southwest Region
Water and Power Resources Service



The McMillan Delta is a broad, almost flat plain of sediment formed by the Pecos River entrance to McMillan Reservoir. It varies in width from 1.5 to 3 miles.

McMillan Dam, about 14 miles north of Carlsbad, was constructed in 1893 by private interests and rehabilitated by the Bureau of Reclamation in 1908. Several embankment modifications and enlargements have been made since that time.

PLAN

The project plan is essentially for water salvage and salinity control. The project, through its first phase or Channelization Division, contemplates the salvage of an annual average of about 24,500 acre-feet of water presently being lost through nonbeneficial consumptive use. Salt cedars were first observed in the delta area in 1914, and in the following year about 600 acres were reported. In 1950, the delta area contained about 13,500 acres lost to water consumption by salt cedars, tules and marsh grass, salt grass, trapped lakes, and minor other causes. The plan was advanced by the Pecos River Commission through the joint efforts of the Commission, the Bureau of Reclamation, the New Mexico Interstate Stream Commission, and various other governmental agencies. Principal features of the Channelization Division consist of a channel heading structure, a water salvage channel, a levee, and a cleared floodway through the delta to the McMillan Reservoir. The second section of the authorizing act included Malaga Bend Division, consisting of the construction of works for the alleviation of salinity in the Pecos River Basin by means of well pumping brine into an evaporation basin. These measures are to improve the quality and quantity of the inadequate water supply in the Pecos River Basin.

DEVELOPMENT

Authorization

The project was authorized February 20, 1958, by Public Law 85-333 (72 Stat. 17).

Construction

Construction of the Malaga Bend Division salinity alleviation works began in 1962 and was completed in 1963. Construction included the enlargement of a Geological Survey test well drilled in 1939 near the edge of the Pecos River at Malaga Bend, installation of a pump, construction of an 8-inch-diameter disposal pipeline to a natural depression 1.3 miles southeast of the brine well, and compaction of earth materials in the depression to minimize brine seepage losses from the depression.

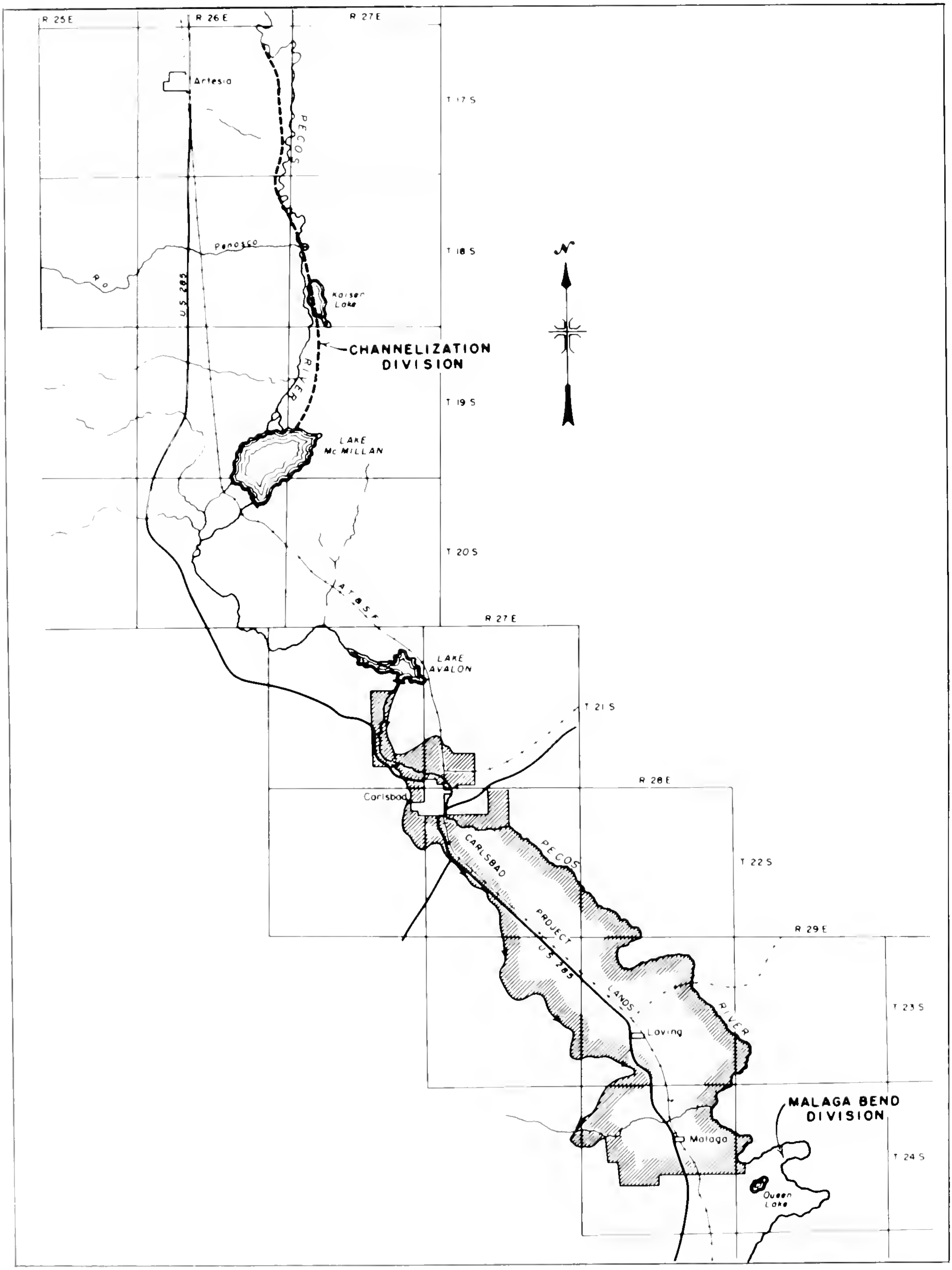
Construction of the Channelization Division water salvage channel, levee, and cleared floodway has not been initiated because the authorizing act requires that no work shall be commenced on clearing the floodway unless provisions shall have been made to replace any Carlsbad Irrigation District terminal storage (McMillan Reservoir) which might be lost by clearing the floodway, and further pending the negotiation of repayment contracts with the Carlsbad Irrigation District, New Mexico, and the Red Bluff Water Power Control District, Texas.

During the 1960's, the Carlsbad Irrigation District excavated several miles of channel between Lake McMillan and the Artesia bridge. The channel has been effective in minimizing conveyance losses through the delta area.

Operating Agency

The Malaga Bend Division (salinity alleviation works) is operated and maintained by the Red Bluff Water Power Control District. Operation and maintenance responsibility was transferred to the district on July 1, 1963.

Collection of data and evaluation of the effectiveness of the salinity alleviation works is the cooperative responsibility of the Geological Survey and the Pecos River Commission.

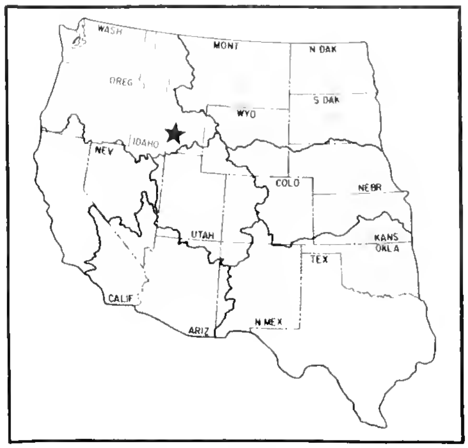


McMillan Delta Project

Michaud Flats Project

Idaho: Power County

Pacific Northwest Region
Water and Power Resources Service



The Michaud Flats Project provides irrigation for 11,275 acres along the Snake River adjacent to the town of American Falls in southeastern Idaho. Surface flow of the Snake River, stored in space allotted to the project in American Falls (Minidoka Project) and Palisades (Palisades Project) Reservoirs, is pumped from below American Falls Reservoir into canals that serve 69 percent of the land. Return flow is used on as much of the land as it will serve, and ground water is pumped from wells to serve the remainder. The project area is part of 65 square miles of flat rolling land south of the Snake River between Pocatello and Eagle Rock known as the Michaud Flats. Irrigable land on the flats is divided by the western boundary of the Fort Hall Indian Reservation into a Michaud Flats extension of the Fort Hall Indian Project and the Michaud Flats Project.

Main Canal East

PLAN

The engineering plan selected for the Michaud Flats Project provides for serving 7,790 acres with surface water, and 3,485 acres with ground water pumped from strategically located wells. Distribution of water to 95 percent of the total acreage is now by sprinkler irrigation. Distribution of the surface or storage water on the project required the construction of a main pumping plant, three small booster pumping plants, canals, and laterals. The ground-water service area includes 25 deep wells.

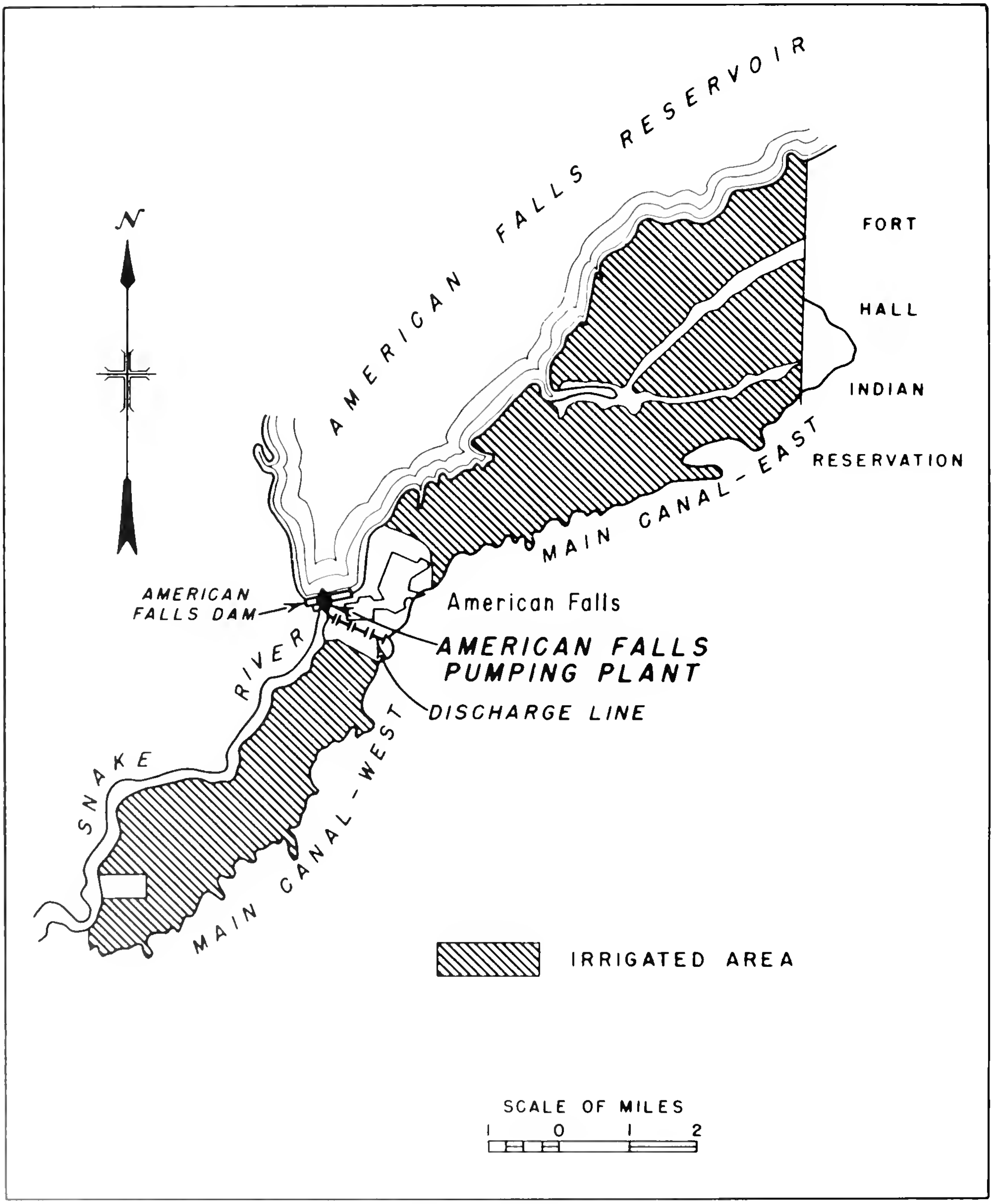
American Falls Pumping Plant

The American Falls Pumping Plant is on the left bank of the Snake River immediately below American Falls Dam. The plant has four pumping units with a total capacity of 126 cubic feet per second. The maximum head under which the pumps operate is 195 feet.

Canal System

The discharge line from the American Falls Pumping Plant delivers water to both the Main Canal West and Main Canal East. The Main Canal West, serving 2,422 irrigable acres southwest of town, is unlined and has an initial capacity of 38 cubic feet per second. It is approximately 9.5 miles long. The Main Canal East serves 5,368 irrigable acres northwest of town. This canal also is unlined, has an initial capacity of 88 cubic feet per second, and is about 10 miles long.

There are 25 deep wells equipped with pumps that furnish water for 3,485 irrigable acres. Seven are on the west side of the project and 18 on the east. On the west side, two wells discharge into the main canal, two into open laterals, and three wells are directly connected to piped laterals. All 18 wells on the east side are directly connected to piped laterals. The project has 35 miles of



Michaud Flats Project

laterals, of which 18.5 miles are unlined and 16.5 miles are piped.

DEVELOPMENT

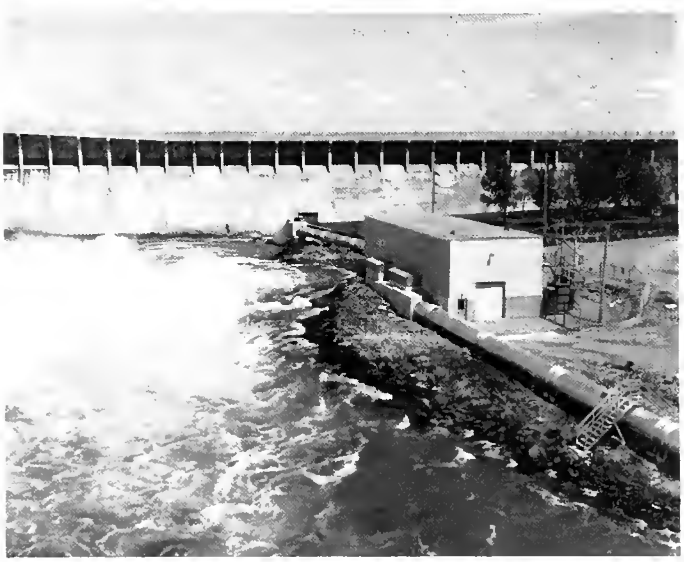
Early History

Named from American Falls on the Snake River, the town of American Falls grew from a campsite on the old Oregon Trail. Placer mining brought the first settlement; stockraising and farming followed and have continued to increase. Michaud Flats was named after a French scout who traded furs with the Indians in the area in the 1840's. Early settlement of the general area began in the 1860's on the bottomlands along the Snake River and its tributaries where the plentiful native hay and pasture encouraged stockraising. Establishment of the Fort Hall military post on Lincoln Creek in 1870 afforded protection and a trading center, and agriculture began to expand to the surrounding benchlands.

Irrigation of areas upstream from American Falls was first practiced in the 1870's by simple diversion to bottomlands that are now largely covered by American Falls Reservoir. Irrigation was expanded to the higher terraces when Carey Act companies were organized to build the larger facilities required. Most of this development took place from 1884 to 1905, fostered by completion of the Utah and Northern Railroad in 1881 and the Union Pacific Railroad shortly thereafter. Construction of the American Falls Dam during the mid-1920's required moving the town but brought new population to the area.

Investigations

Reclamation studies were started in 1926 with the Bureau of Reclamation's investigations of the Neeley Project, instituted because of a petition by the Power County Irrigation District that was organized in 1920. The landowers originally expected to obtain a water supply from Snake River through extension of the Fort Hall Indian Project and Canal, but the short water years in 1924 and 1926 indicated the need for additional storage before further development was undertaken. It was assumed that after completion of the American Falls Dam and Reservoir in 1927, the Michaud area would be developed. However, another series of short water years in 1930-34 showed that even with that reservoir the water supply was inadequate for the land development. As a result of the drought, all irrigation interests in the Snake River Basin began seeking construction of additional storage capacity to ensure supply for existing developments and to provide water for development of new lands. This movement gave rise to proposals to construct Palisades Dam and Reservoir. Continuing interest of the landowners, reflected in the organization of the Falls Irrigation District of 22,000 acres in 1949, led to a detailed investigation of the Michaud Flats Project.



American Falls Pumping Plant

Irrigation possibilities in the Michaud Flats and adjacent areas have been the subject of various investigations, the first of them by the Bureau of Indian Affairs, beginning in about 1890. The Bureau of Reclamation made a full investigation of water use and requirements in the Upper Snake River Valley after the Palisades Project was authorized. The report on that investigation recommended the construction of the Michaud Flats Project. A detailed investigation of the project was renewed in 1948, and the Bureau of Reclamation published a feasibility report in October 1953.

Authorization

The project was authorized on August 31, 1954, by Public Law 741, 83d Congress, 2d session (68 Stat. 1026).

Construction

Construction began in 1955, and was completed in 1958.

Operating Agency

The Bureau of Reclamation operated the project in the early development stages. Beginning January 1, 1961, the Falls Irrigation District assumed operations.

BENEFITS

Irrigation

In an area of proven value when irrigated, the project has enhanced the economy of the American Falls community. Principal crops are potatoes, sugar beets, grain alfalfa, and pasture. Since high yields and ready markets characterize other irrigated areas in the Snake River Valley, the Michaud Flats Project is another successful unit in southeastern Idaho.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	11,275	acres
Number of irrigated farms	92	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	9,500	1,889,799
1969	10,462	1,933,096
1970	10,667	2,187,025
1971	10,763	2,094,200
1972	9,920	3,082,613
1973	10,639	4,729,513
1974	10,494	4,120,913
1975	10,495	4,057,976
1976	10,733	3,491,841
1977	10,298	2,997,309

Facilities in Operation

Storage dams	0	
Canals[1]	24	mi
Laterals	35	mi
Pumping plants	1	
Drains	8	mi
Deep wells (irrigation)	25	

[1]Includes a 1-mile discharge line from American Falls Pumping Plant.

Climatic Conditions

Annual precipitation	11.7	in
Temperature:		
Maximum	102	°F
Minimum	−24	°F
Mean	47	°F
Growing season	153	days
Elevation of irrigable area	4240-4478.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	304
Other water service[2]	94
Total	398

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

SOURCE

The project water comes from American Falls (23,300 acre-ft) and Palisades Reservoirs (40,900 acre-ft), and pumping from deep wells. Diversion is by pumping from the Snake River directly downstream of American Falls Dam. (See Minidoka and Palisades Projects for streamflow data.)

Average annual diversions[3]	30,740	acre-ft

[3]Includes 6,938 acre-ft from ground-water pumping.

Carriage Facilities

MAIN CANAL WEST

Location: From American Falls Pumping Plant, southwest about 9.5 mi.
Construction period: 1956-58

Length	9.5	mi
Diversion capacity	38	ft³/s
Typical maximum section in earth:		
Bottom width	7	ft
Side slopes	1.5:1	
Water depth	3.9	ft

MAIN CANAL EAST

Location: From American Falls Pumping Plant, northeast about 10 mi.
Construction period: 1957-58

Length	10	mi
Diversion capacity	88	ft³/s
Typical maximum section:		
Bottom width	10	ft
Side slopes	2:1	
Water depth	3.3	ft

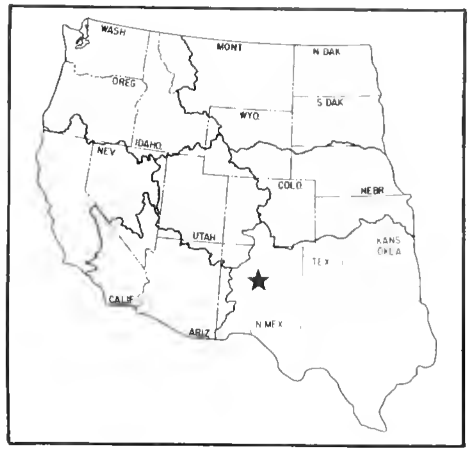
AMERICAN FALLS PUMPING PLANT

Number of units	4	
Total capacity	126	ft³/s
Total dynamic head	195	ft
Total horsepower	3,700	

Middle Rio Grande Project

New Mexico: Rio Arriba, Taos, Santa Fe, Sandoval, Bernalillo, Valencia, Socorro, and Sierra Counties

Southwest Region
Water and Power Resources Service



The Middle Rio Grande Project was authorized by the Congress to improve and stabilize the economy of the Middle Rio Grande Valley by rehabilitation of the Middle Rio Grande Conservancy District facilities and by controlling sedimentation and flooding in the Rio Grande. The Bureau of Reclamation and the Corps of Engineers jointly planned the comprehensive development of the project. Reclamation undertook the rehabilitation of El Vado Dam, rehabilitation of project irrigation and drainage works, and channel realignment. The Corps of Engineers was assigned the construction of flood control reservoirs and levees for flood protection.

The Reclamation project extends along the Middle Rio Grande Valley from the Colorado-New Mexico boundary south to the backwaters of Elephant Butte Reservoir. It includes realignment of the Rio Grande in the vicinity of Truth or Consequences, N. Mex. Built originally by the conservancy district, the irrigation features of the project divert water from the river to irrigate 89,711 acres of irrigable land. There are 21,664 acres of Indian water-right lands within the project. Construction features rehabilitated by Reclamation in addition to El Vado Dam are Angostura, Isleta, and San Acacia Diversion Dams.

El Vado Dam

PLAN

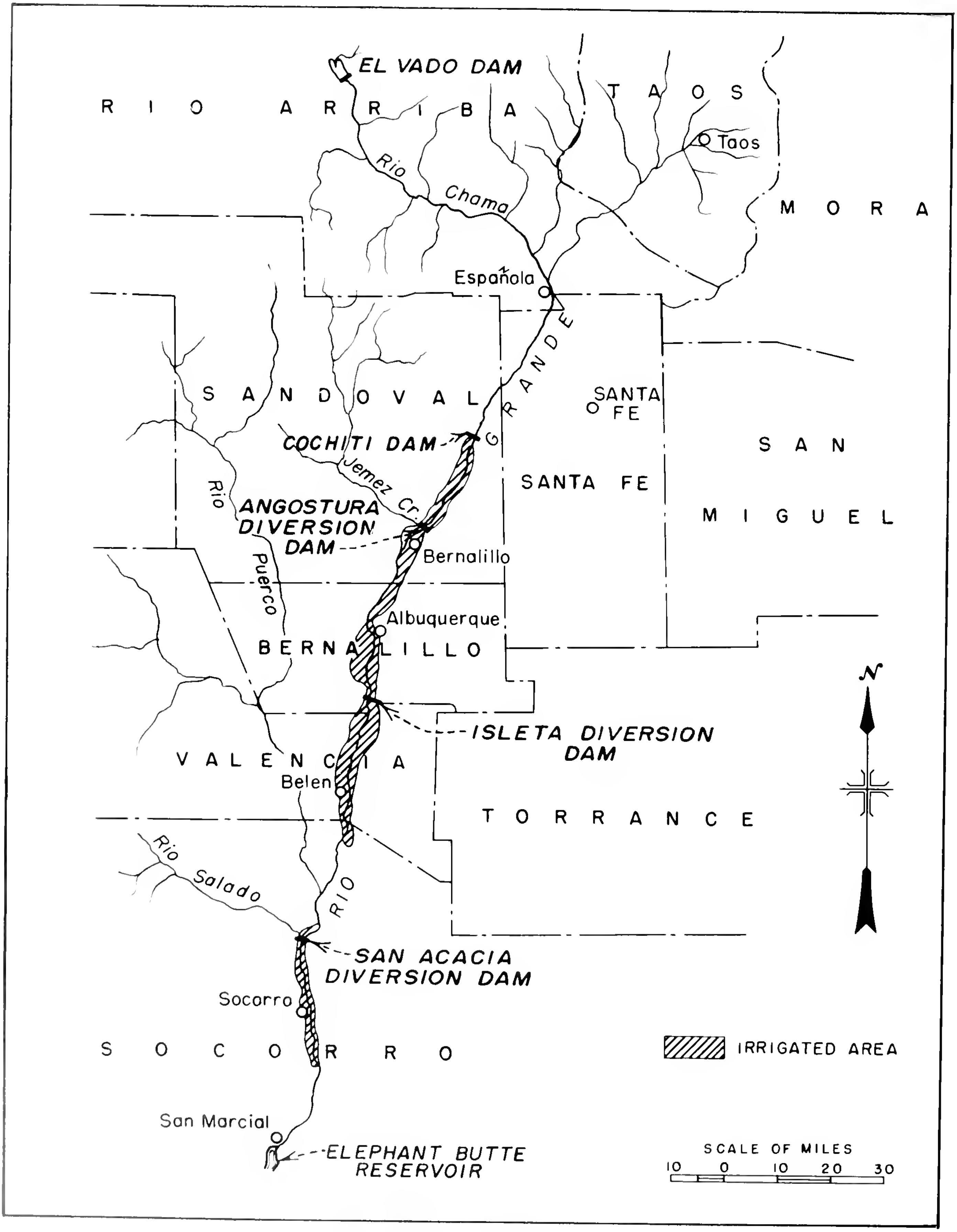
El Vado Reservoir provides supplemental storage for the project. Diversions into the district irrigation system are made at Cochiti Dam and at Angostura, Isleta, and San Acacia Diversion Dams. To effect water savings which help to meet water commitments of the Rio Grande Compact, a permanent conveyance channel was constructed and is maintained between San Acacia Diversion Dam and the Narrows of Elephant Butte Reservoir. River channelization north of San Acacia Diversion Dam to Velarde, N. Mex. also is carried on as part of the river maintenance program.

El Vado Dam

El Vado Dam, located on the Rio Chama about 160 miles north of Albuquerque, was built by the conservancy district in 1934-35 and was rehabilitated by the Bureau of Reclamation in 1954-55. A new outlet works was built by Reclamation in 1965-66 to accommodate the additional water from the San Juan-Chama Project. The dam embankment is of rolled gravel fill with a steel membrane on the upstream face. It is 175 feet high, 1,326 feet long, and impounds a reservoir that has a total capacity of 196,500 acre-feet.

Diversion Dams

There are three diversion dams, all of which have been rehabilitated. Angostura Diversion Dam, serving the Albuquerque division, consists of a concrete weir section 4.5 feet high and 800 feet long; Isleta Diversion Dam, serving the Belen division, is a reinforced concrete structure 5 feet high and 674 feet long with 30 radial gates; and the San Acacia Diversion Dam, serving the Socorro division, is 7.5 feet high and 700 feet long with 29 radial gates. Lands in the Cochiti division, previously served by the Cochiti Diversion Dam, now receive their supply directly from Cochiti Dam, a Corps of Engineers flood control dam. The Cochiti Diversion Dam was inundated by construction of Cochiti Dam.



Middle Rio Grande Project

Distribution, Drainage, and Channelization

The distribution and drainage system is made up of 202 miles of canals, of which about 6 miles are concrete lined; 579 miles of laterals, of which about 4 miles are concrete lined; and 399 miles of open and concrete pipe drains, most of which are open section.

A major portion of the work is channelization of the Rio Grande for a distance of 149 miles to reduce the nonbeneficial use of water. This channelization is necessary because of the aggradation in the channel and resulting loss of water by evaporation and transpiration from heavy growths of salt cedar and other plants. Of the 149 miles of channeling and flood control improvements in the project, there are 18 miles in the Espanola area, 8 miles in the Cochiti, 24 miles in the Albuquerque, 28 miles in the Belen, 37 miles in the Socorro, 33 miles in the San Marcial, and 1 mile in the Truth or Consequences areas. These improvements include clearing, pilot channeling, jetty installation, and the low-flow channel.

DEVELOPMENT

Early History

The land between Taos Pueblo and Socorro is the oldest continually settled section of the United States. For centuries, the Pueblo Indians diverted water from the Rio Grande into a system of open ditches known as *acequias*. Corn, beans, and squash cultivated by primitive methods were the chief support of several thousand people. The area was ceded to the United States by Mexico in 1848, but it was not until shortly after the Civil War that all the land capable of being irrigated had been claimed and was being developed. In 1880, a record total of 124,800 acres was irrigated between Cochiti and San Marcial. During the next 40 years, increased water depletion accompanied by increasing sediment loads, floods, and a rising water table forced acreage out of production.

San Acacia Diversion Dam

Investigations

After 1900, the irrigation system became a combination of ancient *acequias* and modern canals. As more water was applied to the land, and because the riverbed continued to aggrade, drainage became an acute problem. Deterioration of the irrigated area led to the formation of the Middle Rio Grande Conservancy District in 1925. The district has been in operation since about 1936, but developed financial problems which led to negotiations with the Bureau of Reclamation for investigation and rehabilitation of the project.

Authorization

The comprehensive plan for the Middle Rio Grande Project was approved by the Flood Control Act of June 30, 1948 (Public Law 858, 80th Cong., 2d sess.). Completion of the approved plan was authorized by the Flood Control Act of May 17, 1950 (Public Law 516, 81st Cong., 2d sess.).

In addition to the authorized construction, the Flood Control Act of 1948 directed that studies be made to determine feasible ways and means of reducing nonbeneficial consumptive use of water by phreatic vegetation in the flood plains of the Rio Grande and its principal tributaries above Caballo Reservoir.

Construction

El Vado Dam was rehabilitated by the Bureau of Reclamation in 1954-55. In 1966, the spillway and outlet works were modified to bypass San Juan-Chama water.

Isleta Diversion Dam was rehabilitated in 1955; San Acacia Diversion Dam in 1957; Angostura and Cochiti Diversion Dams in 1958. In 1974-75, Cochiti Dam was constructed by the Corps of Engineers.

Considerable rehabilitation work on canals, laterals, drains, and *acequias* throughout the project was performed by Reclamation between 1953-61.

Construction of the low-flow conveyance channel between San Acacia Diversion Dam and the Narrows of Elephant Butte began in 1951 and was completed in 1959.

Modification of the headworks for the Socorro Main Canal north at San Acacia Diversion Dam was completed in 1961. The canal was tied into Drain Unit No. 7 Extension and, in turn, to Drain Unit No. 7 system in 1975.

River realignment and improvement work by the Bureau of Reclamation between Velarde and the mouth of the Rio Puerco was begun in 1954 and completed in 1962.

Operating Agencies

El Vado Dam and channelization of the Rio Grande from Velarde to the Narrows of Elephant Butte Reservoir are operated and maintained by the Bureau of Reclamation. Irrigation facilities, including the three diversion dams, are operated by the Middle Rio Grande Conservancy District. Cochiti Dam is operated and maintained by the Corps of Engineers.

BENEFITS

Irrigation

The type of soil, and the climate, markets, crop varieties, and irrigation facilities make intensive, diversified farming practices attractive and profitable. Alfalfa, barley, wheat, oats, corn, fruits, and vegetables are the principal crops grown. Rehabilitation of the irrigation system throughout the project has resulted in a more stable water supply.

Flood Control

The system of levees and river channel improvements furnish protection from floods originating in the headwaters and local tributaries, or reservoir spills. These improvements consist primarily of jetty fields, pilot channels, and a cleared floodway from Velarde south to Elephant Butte Reservoir. The cleared floodway is discontinuous, especially north of Albuquerque, as some narrow sections were never cleared and others have not been maintained for various reasons including environmental considerations.

Water Salvage

A low-flow conveyance channel with a 2,000-cubic-foot-per-second capacity, a 32-foot bottom width, and side slopes of 2:1 is maintained by Reclamation between San Acacia Diversion Dam and the Narrows of Elephant Butte Reservoir. This, with the other river channelization improvements, is greatly increasing the irrigation water supply through reduction in loss because of seepage and evaporation.

Environment

The stabilization of the river channel through clearing, pilot channels, and jetty fields has resulted in the establishment of large wooded areas. Previously, large stands of trees were destroyed during heavy runoff years because the river meandered back and forth across the channel from levee to levee. The areas between the cleared floodway and the riverside levees are now filled with a permanent stand of large trees and other dense growths of vegetation. Fish and wildlife habitat has been improved, and use of safety systems and measures has mitigated many losses.

Isleta Diversion Dam

PROJECT DATA

Land Areas (1977)

Irrigable area:[1]		
Full irrigation service	89,711	acres
Number of irrigated farms	6,208	

[1]Includes 8,101 acres of Class 6 and 6W administratively classified as irrigable and 81,610 acres of Class 1 through 4. In addition, there are 31,969 acres of Class 6W lands which have water rights but are not classed as irrigable by Bureau of Reclamation standards.

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1973	57,999	10,515,721
1974	58,814	12,313,101
1975	58,299	11,561,673
1976	59,180	13,809,168
1977	60,231	17,419,135

Facilities in Operation

Storage dams	1	
Diversion dams	3	
Canals	202	mi
Laterals	579	mi
Drains	399	mi

Climatic Conditions

Annual precipitation	9	in
Temperature:		
Maximum	108	°F
Minimum	−20	°F
Mean	56	°F
Growing season	196	days
Elevation of irrigable area	5200.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	24,800
Other water service[2]	89,200
Total	114,000

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

Rio Grande

Drainage area at Otowi gaging station	11,400	mi²
Annual discharge at Otowi, 1936-76:		
Maximum (1941)	2,593,000	acre-ft
Minimum (1956)	359,500	acre-ft
Average[3]	947,650	acre-ft

[3]Includes San Juan-Chama diverted water for years 1973-76.

Storage Facilities

El Vado Dam

Type: Random fill, earth, steel membrane on upstream face
Location: On the Rio Chama near El Vado, N. Mex.
Construction period: Non-Reclamation construction (1935). Rehabilitated by Reclamation in 1954-55.

Reservoir, El Vado:		
Average annual inflow, 1936-76[4]	271,550	acre-ft
Active capacity to El. 6902	195,440	acre-ft
Surface area	3,220	acres
Dimensions:		
Structural height	175	ft
Hydraulic height	156.5	ft
Top width	20	ft
Maximum base width	642	ft
Crest length	1,326	ft
Crest elevation	6914.5	ft
Volume	608,000	yd³
Spillway:		
Crest length	36	ft
Crest elevation	6879.0	ft
Capacity at El. 6908.6	17,800	ft³/s
Outlet works: Capacity at El. 6908.6	6,850	ft³/s

Foundation: Special treatment: Grouting of left abutment

[4]1972 to 1976, includes San Juan-Chama water released from Heron Reservoir.

Diversion Facilities

Angostura Diversion Dam

Type: Concrete, wall weir
Location: On the Rio Grande, about 5 mi northeast of Bernalillo, N. Mex.
Year completed: 1934[5]

Dimensions:		
Structural height	17	ft
Hydraulic height	4.5	ft
Crest length	800	ft
Crest elevation	5083.0	ft
Volume	1,500	yd³

Headworks: Albuquerque Main Canal. Concrete, four 20- by 4-ft top seal radial gates.

Diversion capacity	650	ft³/s

Isleta Diversion Dam

Type: Concrete, gate structure
Location: On the Rio Grande about 13 mi south of Albuquerque, N. Mex.
Year completed: 1934[5]

Dimensions:		
Structural height	21	ft
Hydraulic height	5	ft
Crest length	674	ft
Crest elevation	4886.0	ft
Volume	3,900	yd³

Gate structure: Concrete, thirty 20- by 5-ft radial gates.
Headworks: Peralta Main Canal. Concrete, three 15- by 3.75-ft top seal radial gates. Belen Highline Canal. Concrete, four 20- by 3.75-ft top seal radial gates.

Diversion capacity	1,070	ft³/s

San Acacia Diversion Dam

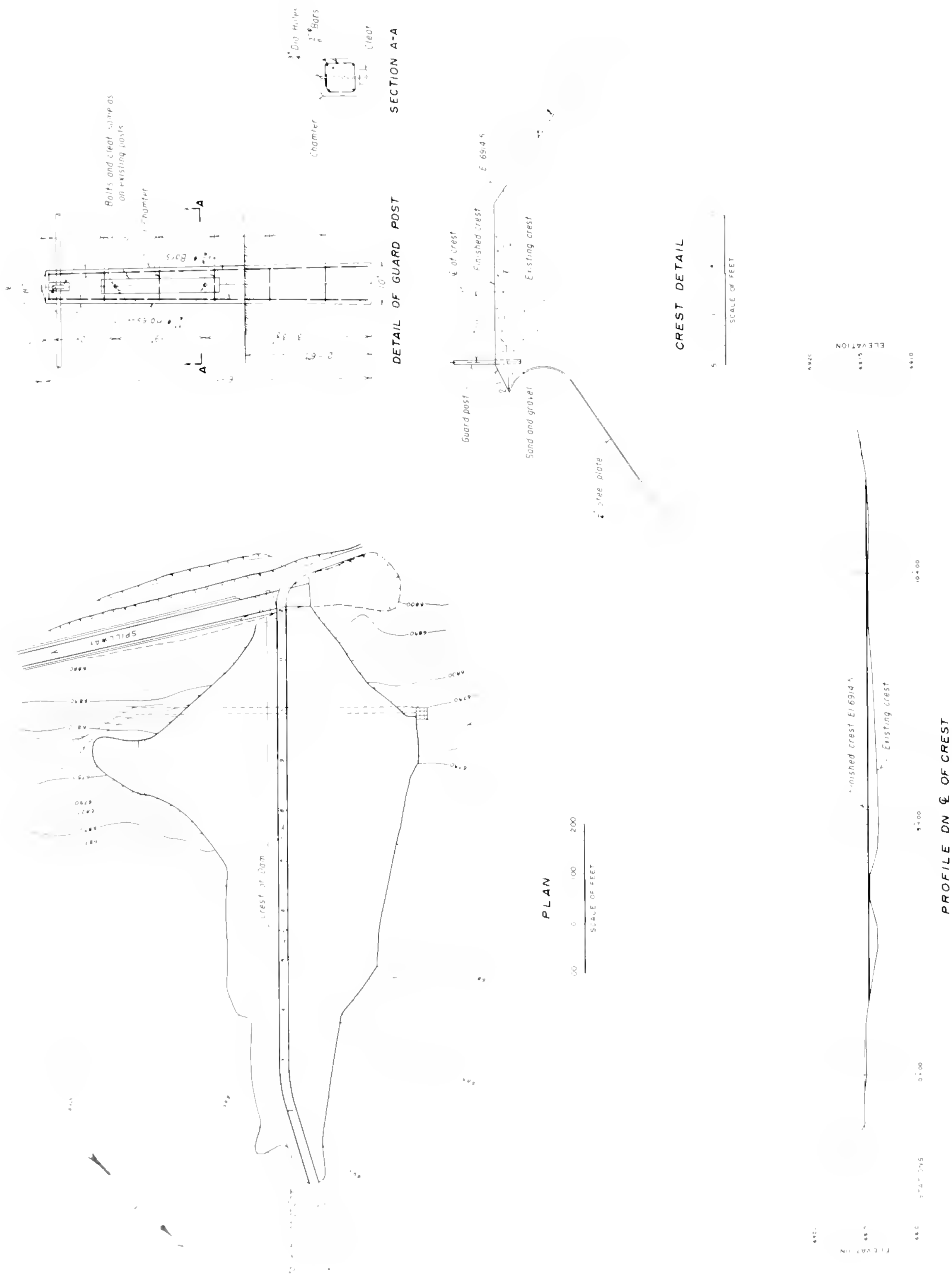
Type: Concrete, gate structure
Location: On the Rio Grande at San Acacia, N. Mex.
Year completed: 1934[5]

Dimensions:		
Structural height	17	ft
Hydraulic height	7.5	ft
Crest length	700	ft
Crest elevation	4668.5	ft
Volume	2,700	yd³

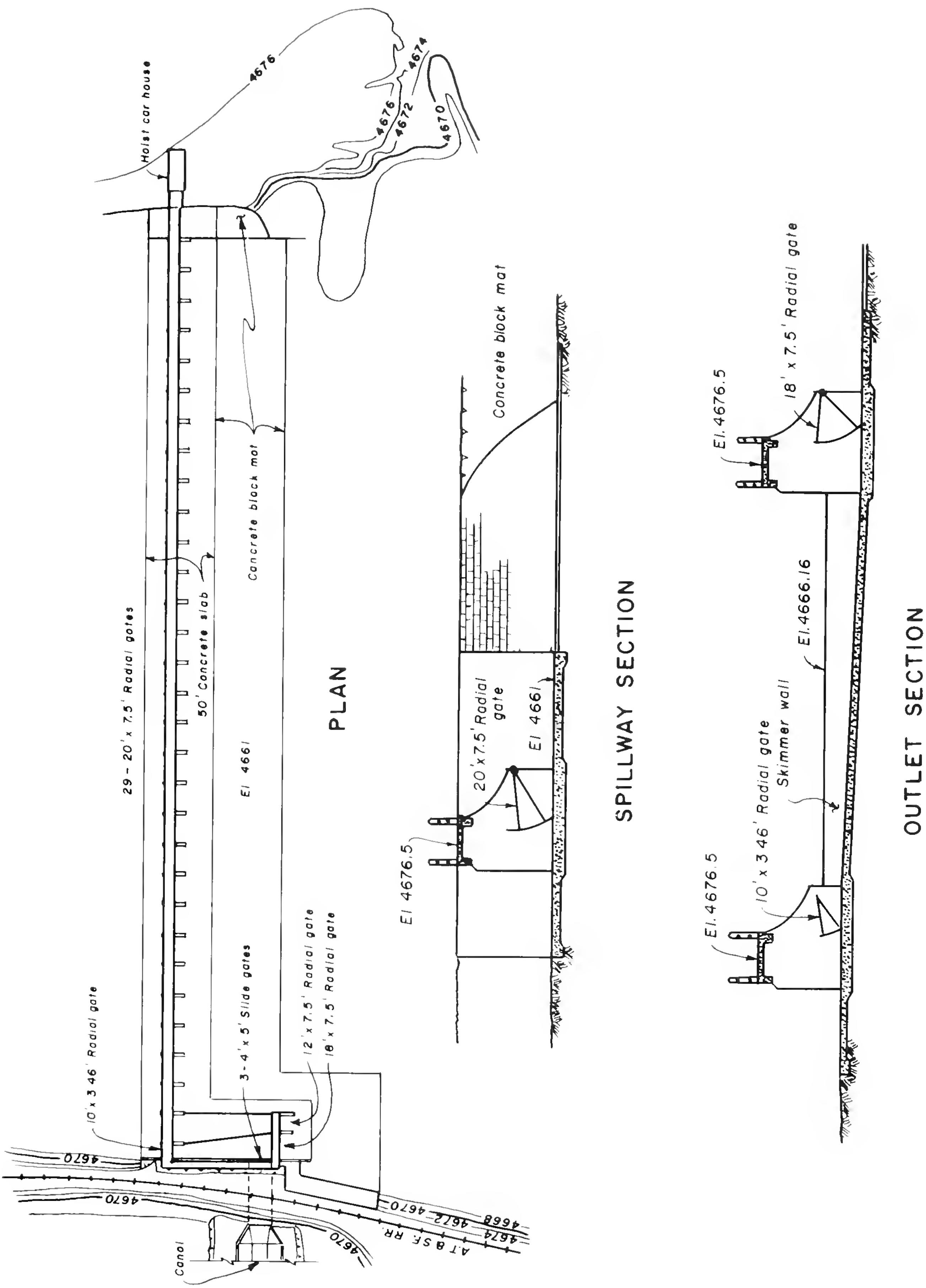
Headworks: Concrete, three 4- by 5-ft slide gates.

Diversion capacity	283	ft³/s

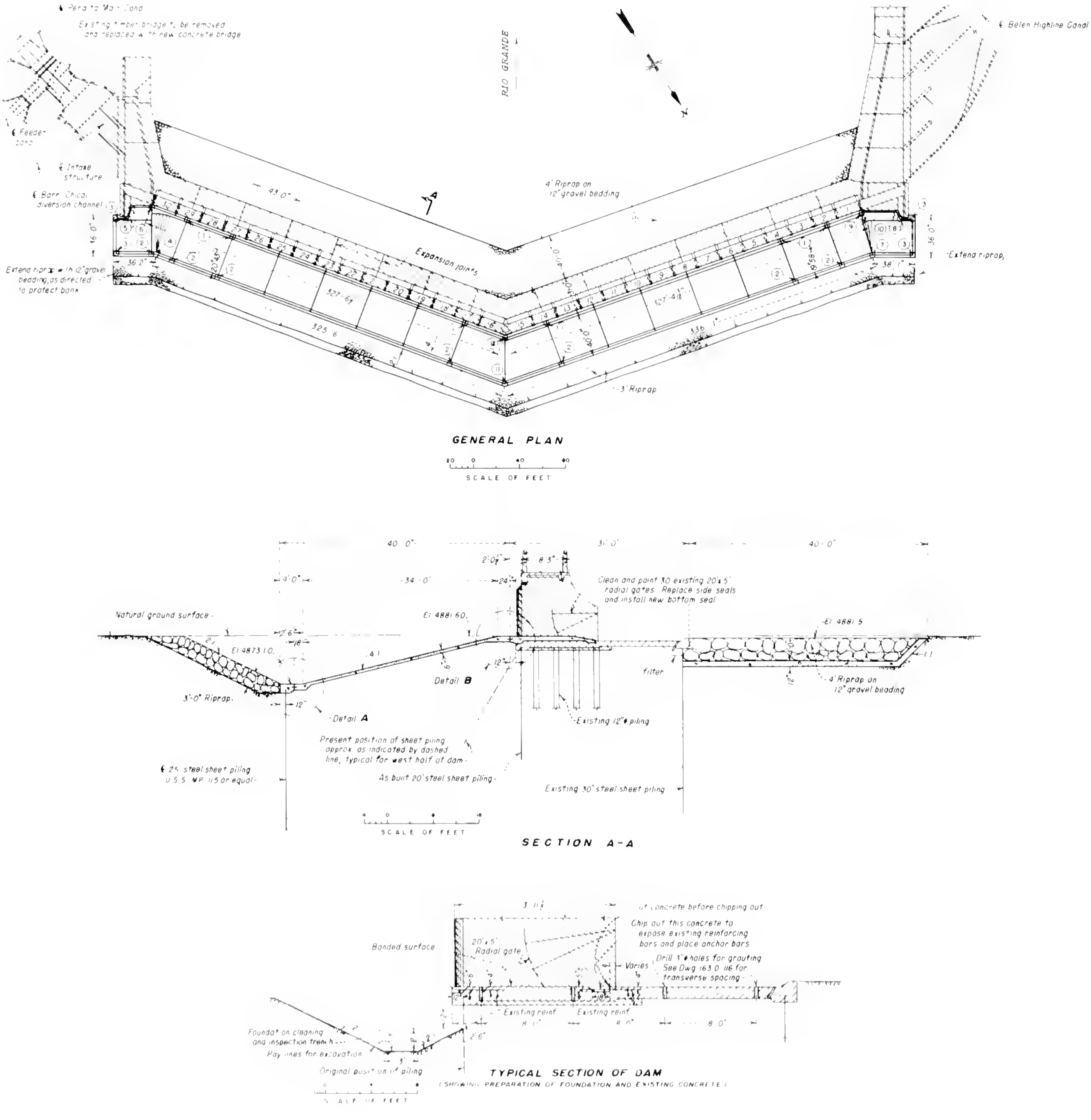
[5]Non-Reclamation construction. Rehabilitated by the Bureau of Reclamation: Isleta in 1955; San Acacia and Angostura in 1958.



El Vado Dam. Plan and Sections



San Acacia Diversion Dam, Plan and Sections

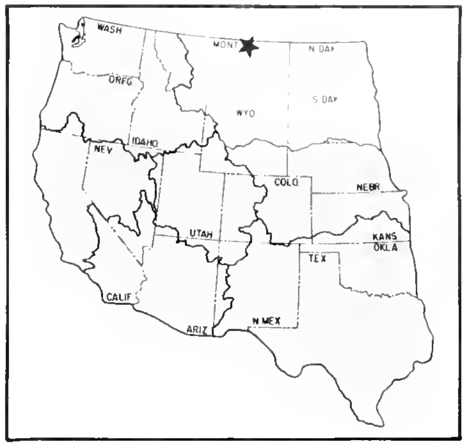


Isleta Diversion Dam, Plan and Sections

Milk River Project

Montana: Blaine, Glacier, Phillips, and Valley Counties

Upper Missouri Region
Water and Power Resources Service



The Milk River Project in north-central Montana furnishes water for irrigation of 120,816 acres of land. Project features are Lake Sherburne, Nelson and the Fresno Storage Dams; Dodson, Vandalia, St. Mary, Paradise, and Swift Current Diversion Dams; and Dodson Pumping Plant, 200 miles of canals, 219 miles of laterals, and 293.2 miles of drains. A water supply is furnished to project lands which are divided into the Chinook, Malta, and Glasgow Divisions and the Dodson Pumping Unit. The lands extend approximately 165 miles along the river from near Havre to a point 6 miles below Nashua, Mont.

PLAN

The project provides storage of water from St. Mary River in Lake Sherburne behind Lake Sherburne Dam and its diversion through a 29-mile canal discharging into the North Fork Milk River. The water then flows through Canada for 216 miles before returning to the United States. Milk River water is stored in Fresno Reservoir, located 14 miles west of Havre, and in Nelson Reservoir, 19 miles northeast of Malta. The water is diverted from the Milk River near Chinook and Harlem into private canals on each side of the river for lands in the Chinook Division. Except for storage facilities, all water supply and distribution works have been constructed. They are operated and maintained by the five irrigation districts which constitute the Chinook Division.

Fresno Dam

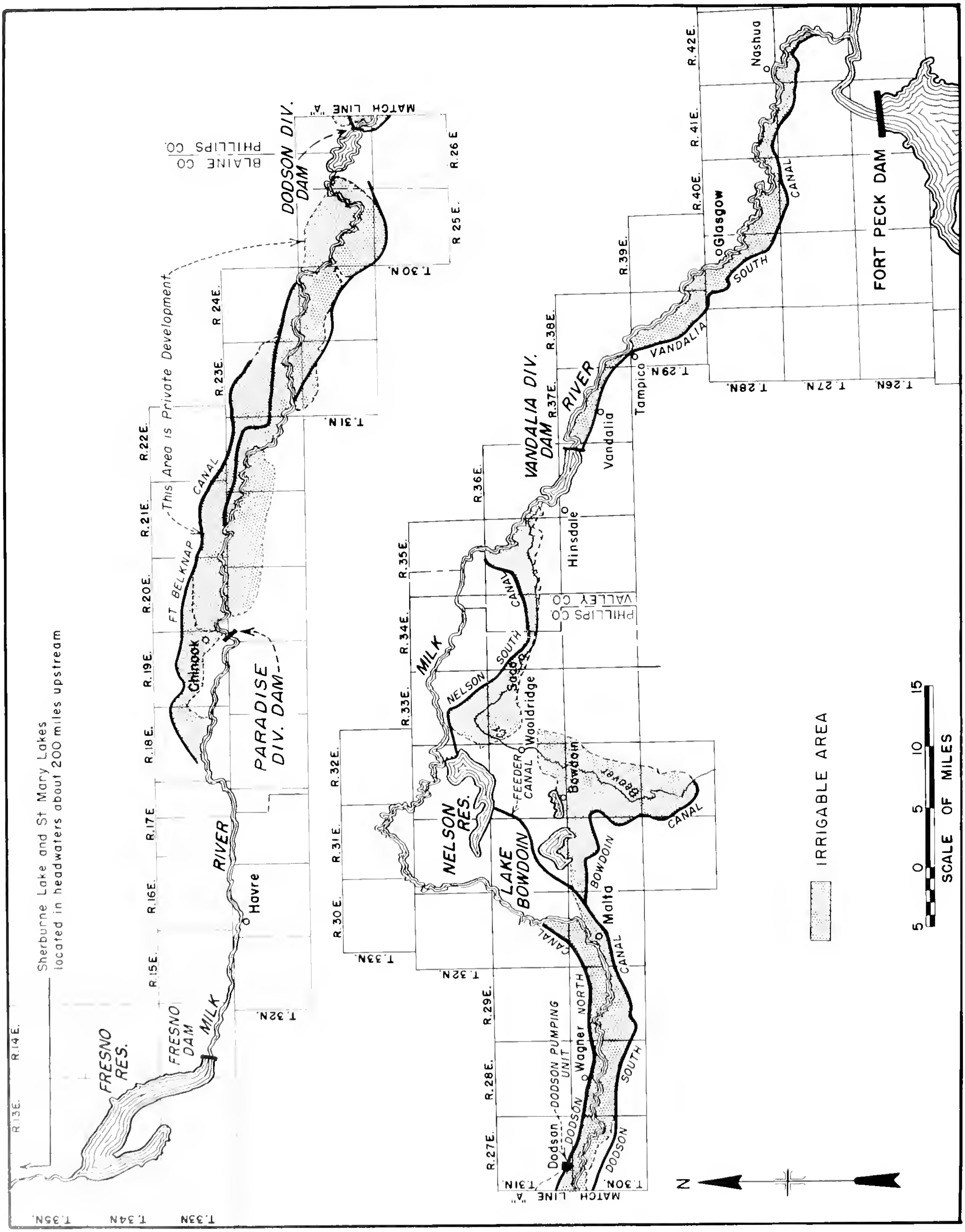
Two canals divert water for irrigation of land near Dodson, Wagner, Malta, and Bowdoin. The South Canal conveys water into Nelson Reservoir. From this storage, land is irrigated on the south side of Milk River and Beaver Creek near Saco and Hinsdale, constituting the Malta Division.

At Vandalia Diversion Dam, a canal on the south side of Milk River carries water for irrigation of land near Tampico, Glasgow, and Nashua, constituting the Glasgow Division.

The Dodson Pumping Plant lifts water from Dodson North Canal to irrigate lands above the gravity system.

Lake Sherburne Dam

Lake Sherburne Dam is a compacted earthfill structure 94 feet in height above foundation with a crest length of 1,086 feet. The total volume of material in the dam is 228,000 cubic yards. In 1960, the intake tower structure was modified by adding a circumferential overflow spillway crest, and the weir-type overflow spillway at the left abutment of the dam was filled with compacted earth material extending the crest of the dam at elevation 4801.8 to the left abutment. Reservoir water surfaces are controlled by operation of the two 4- by 5-foot high-pressure gates, which permit a discharge of 2,100 cubic feet per second at elevation 4788.0. At water surface elevations above 4788, water flows over the crest of the overflow spillway and the discharge through the outlet works is then comprised of the water flowing over the spillway crest and through the 4- by 5-foot gates. Maximum discharge through the outlet works conduit at elevation 4793.0 is 4,000 cubic feet per second. A total storage capacity of 67,604 acre-feet is provided in Lake Sherburne.



Milk River Project

Nelson Dikes and Reservoir

Swift Current Dike

The Swift Current Dike is an earth and rock structure with a timber crib core. It is 13 feet high, 4,800 feet long at the crest, and contains 98,000 cubic yards of material.

St. Mary Diversion Dam and Canal

The St. Mary Diversion Works, located on the St. Mary River 0.75 mile downstream from Lower St. Mary Lake, is a 6-foot-high concrete weir and sluiceway with a length of 198 feet, and a total volume of 1,200 cubic yards.

The St. Mary Canal begins at St. Mary Diversion Dam on the west side of St. Mary River and crosses the river 9.5 miles below the diversion through a two-barrel steel-plate siphon 90 inches in diameter and 3,600 feet in length. Eight miles below the St. Mary crossing a second two-barrel steelplate siphon, 78 inches in diameter and 1,405 feet long, conveys the water across Hall's Coulee. A series of five large concrete drops at the lower end of the 29-mile canal provide a total fall of 214 feet to the point where the water is discharged into North Fork Milk River. Design capacity of the canal is 850 cubic feet per second.

Fresno Dam

The Fresno Dam, located on the Milk River 14 miles west of Havre, Mont., is a compacted earthfill dam with a structural height of 110 feet and a crest length of 2,070 feet. It contains 2,105,000 cubic yards of material. An overflow-type spillway at the north end of the dam provides for a flow of 51,360 cubic feet per second through the concrete-lined channel. The outlet works discharge a maximum of 2,180 cubic feet per second through two 72-inch steel pipe outlet tubes. A conservation storage of 127,200 acre-feet is impounded in Fresno Reservoir. Provision also is made for flood control benefits.

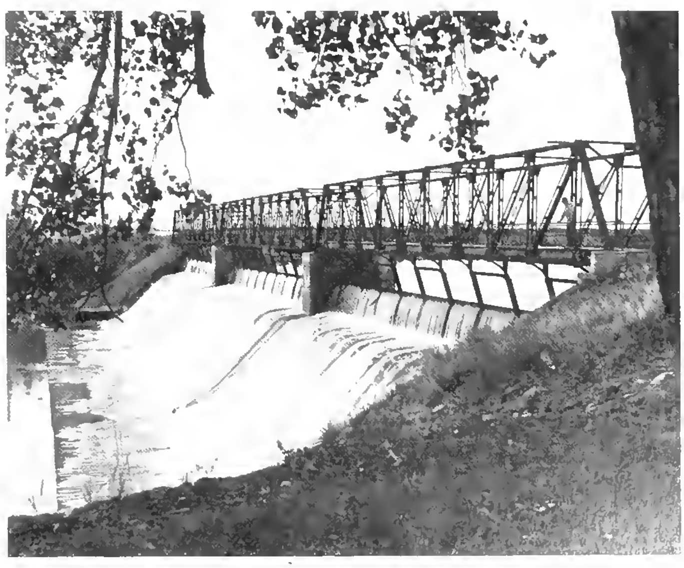
Paradise Diversion Dam

Paradise Diversion Dam was constructed by the Bureau of Reclamation to replace a rock, log, and brush dam destroyed by floodwaters in June 1965. The dam, located on the Milk River near Chinook, Mont., diverts water for irrigation of the Paradise Valley Irrigation District.

The 200-foot-long concrete diversion structure includes a 100-foot ogee spillway section provided with 5-foot-high removable flashboard supports at 5-foot centers along the crest, abutment walls, wingwalls, and cutoff walls, and a sluiceway equipped with a manually operated 5- by 6-foot cast-iron slide gate. Crest elevation of the spillway is 2390.5. Extending from the right abutment of this concrete structure is a compacted earthfill dike, 20 feet wide at the crest, constructed to elevation 2401.5. A cableway with winch-operated cable car, used for maintenance and for placement of flashboards when required, spans the spillway section of the dam.

Dodson Diversion Dam and Canals

The Dodson Diversion Dam on Milk River 5 miles west of Dodson, Mont., is a timber crib, weir-type structure with movable crest gates. The structural height is 26 feet; the crest length is 8,154 feet. The Dodson North Canal, diverting on the north side of the river just above Dodson Dam, has an initial capacity of 200 cubic feet per second and conveys water to Malta Division lands north of Milk River. The Dodson South Canal has a capacity of 500 cubic feet per second, conveys water for irrigation of Malta Division lands south of Milk River, and also conveys water for storage in Nelson Reservoir.



Dodson Diversion Dam

Nelson Reservoir

The Nelson Reservoir, located 19 miles northeast of Malta, Mont., provides offstream storage for irrigation of Malta Division lands in the Saco and Hinsdale areas. A series of dikes, with a maximum structural height of 28 feet, crest length of 9,900 feet, and total volume of 233,000 cubic yards, provide for storage of 79,200 acre-feet of water. The reservoir does not have a spillway. Slide gates installed in the Nelson North Canal outlet works permit releases of water to Milk River for use in the Glasgow Division. Slide gates installed in the Nelson South Canal outlet works permit releases of water for irrigation of project lands.

Vandalia Diversion Dam and Canal

The Vandalia Diversion Dam on Milk River, 3 miles west of Vandalia, Mont., is a reinforced concrete slab and buttress weir-type structure with movable crest gates and auxiliary overflow crest. The hydraulic height is 27 feet; the crest length is 2,350 feet. The auxiliary crest, 1,200 feet in length, is located north of Milk River opposite the dam to provide adequate channel for extreme floodflows. The Vandalia Canal diverts on the south side of the river at the dam and conveys water to the land in the Glasgow Division. The canal has a design capacity of 300 cubic feet per second.

Dodson Pumping Plant

The Dodson Pumping Plant, located 2.5 miles northwest of Dodson, Mont., lifts water from the Dodson North Canal 20.5 feet to the Dodson Pump Canal which serves 1,147 acres of land in the vicinity of Dodson. Two impeller pumps of 15 cubic feet per second capacity each, driven by 50-horsepower electric motors, provide 30 cubic feet per second of water.

DEVELOPMENT

Early History

During the 1880's, settlers built small individual irrigation systems, and in 1890 constructed a community diversion dam in the vicinity of the present Fort Belknap Diversion Dam. Lack of facilities to store the early spring runoff prompted an investigation in 1891 to find means of supplementing the low summer flow of the river.

Investigations

The most feasible plan for developing a large irrigation project involved the diversion of St. Mary River into the headwaters of Milk River. Since both rivers flow through Canada, it was necessary to execute a water-right agreement with Canada before the plan could be completed. Increasing irrigation activities in the valley brought urgent requests for development. Investigation of the Milk River Project led to conditional authorization of the project in 1903.

Authorization

The project was conditionally approved by the Secretary of the Interior on March 14, 1903. The St. Mary Storage Unit was authorized March 25, 1905.

Fresno Dam, constructed under the National Industrial Recovery Act, was approved by the President in

Lake Sherburne Dam

August 1935, pursuant to the acts of June 25, 1910, and December 5, 1924.

The Dodson Pumping Unit was approved by the President on March 17, 1944, under the Water Conservation and Utilization Act of August 11, 1939.

Construction

Construction of the St. Mary Storage Unit began on July 27, 1906. A treaty with Great Britain relating to the distribution between Canada and the United States of the waters of the St. Mary and Milk Rivers was signed on January 11, 1909. The Dodson Diversion Dam was completed in January 1910, and the first water delivered for irrigation in 1911. In 1915, the Nelson and Swift Current Dikes, and St. Mary Diversion Dam were completed. In 1917, the Vandalia Diversion Dam was put into operation, Lake Sherburne Dam was completed in 1921, and the Fresno Dam in 1939. The Dodson Pumping Plant was completed in 1946.

Operating Agencies

The storage works are operated by the Bureau of Reclamation. The systems serving the Malta, Glasgow, and Dodson Irrigation Districts, and the systems serving the Chinook Division, are operated by the Fort Belknap, Zurich, Harlem, Paradise Valley, and Alfalfa Valley Irrigation Districts.

BENEFITS

Irrigation

The land is divided into 693 farms on which the principal crops produced are alfalfa, native hay, oats, wheat, barley, and sugar beets.

Recreation and Fish and Wildlife

Fresno Reservoir provides swimming, boating, and fishing in season for walleyed pike and trout. Nelson Reservoir provides excellent fishing, primarily for walleyed pike and trout and excellent duck and goose hunting. Practically all of Lake Sherburne is located in Glacier National Park, and fishing is permitted in season. The project provided 230,400 visitor days in 1977.

Flood Control

Fresno Reservoir has 40,400 acre-feet allocated to joint-use storage which is used for flood control as well as irrigation and other conservation uses.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	120,816	acres
Number of irrigated farms	693	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	97,220	3,684,858
1969	99,133	4,117,738
1970	96,487	3,679,123
1971	91,656	5,702,480
1972	100,314	5,165,801
1973	101,486	8,716,955
1974	105,625	8,305,112
1975	98,085	7,502,153
1976	102,723	7,765,206
1977	101,242	7,986,640

Facilities in Operation

Storage dams	3	
Diversion dams	5	
Canals	200	mi
Laterals	219	mi
Pumping plants	3	
Drains	293	mi

Climatic Conditions

Annual precipitation	13	in
Temperature:		
Maximum	109	°F
Minimum	−56	°F
Mean	42	°F
Growing season	138	days
Elevation of irrigable area	2200.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	2,116
Municipal water service	16,501
Total	18,617

ENGINEERING DATA

Water Supply

MILK RIVER

Drainage area at Havre, Mont.	5,844	mi²
Annual discharge at Havre:		
Maximum (1965)	526,700	acre-ft
Minimum (1977)	195,300	acre-ft
Average	326,600	acre-ft

Storage Facilities

LAKE SHERBURNE DAM

Type: Homogeneous earthfill
Location: On Swiftcurrent Creek in Glacier National Park about 6 mi west of Babb, Mont.
Construction period: 1914-21
Date of closure (first storage): 1919

Reservoir, Lake Sherburne:	
Total storage to El. 4788	67,604 acre-ft
Active storage El. 4729.3-4788	64,280 acre-ft
Surface area	1,601 acres
Dimensions:	
Structural height	94 ft
Hydraulic height at El. 4801.8	86 ft
Top width	22 ft
Maximum base width	460 ft
Crest length	1,086 ft
Crest elevation	4801.8 ft
Total volume	228,000 yd³
Spillway: Overflow crest (morning-glory type)	
Crest elevation	4788.0 ft
Outlet works: Twin section concrete conduit through base of dam controlled by two 4-by 5-ft high-pressure gates in tower at upper stream end.	
Capacity at El. 4788	2,100 ft³/s
Maximum discharge through outlet works conduit (El. 4793)	4,000 ft³/s

NELSON DIKES

Type: Homogeneous earthfill	
Location: Five dikes located offstream about 19 mi northeast of Malta, Mont.	
Construction period: 1914-15. Enlarged 1921-22.	
Date of first storage: 1916	
Reservoir, inflow from the Milk River through Dodson South Canal:	
Total storage to El. 2221.6	79,224 acre-ft
Active storage, El. 2200-2221.6	60,574 acre-ft
Surface area	4,320 acres
Dimensions:	
Structural height	28 ft
Hydraulic height	20 ft
Top width	18 ft
Maximum base width	166 ft
Crest length	9,900 ft
Crest elevation	2228.0 ft
Total volume	233,000 yd³
Outlet works:	
Nelson North Canal: Two 66- by 78-in slide gates. Capacity	250 ft³/s
Nelson South Canal: Two 78-in-square slide gates. Capacity	500 ft³/s

FRESNO DAM

Type: Homogeneous earthfill	
Location: On the Milk River 14 mi west of Havre, Mont.	
Construction period: 1937-39	
Crest raised 2 ft in 1943. Parapet wall constructed in 1950-51.	
Date of closure (first storage): 1939	
Reservoir, Fresno:	
Total storage to El. 2575	129,062 acre-ft
Active storage, El. 2530-2567	86,700 acre-ft
Surface area	5,760 acres
Dimensions:	
Structural height	110 ft
Hydraulic height at El. 2596.1	78 ft
Top width	22 ft
Maximum base width	726 ft
Crest length	2,070 ft
Crest elevation	2596.1 ft
Total volume	2,105,000 yd³
Spillway: Uncontrolled concrete-lined open channel in left abutment:	
Crest length	210 ft
Crest elevation	2575.0 ft
Capacity at El. 2591	51,360 ft³/s
Outlet works: Concrete-lined tunnel through left abutment controlled by two 5- by 6-ft-high pressure slide gates:	
Capacity at El. 2575	2,180 ft³/s
Foundation: River silts and gravel in riverbed, irregularly cemented, leaky Fresno sandstone in right abutment; sandstone underlain by impervious and fairly stable Sprague shale in left abutment.	
Special treatment: Cement-grout curtain beneath cutoff walls, supplemental grouting of abutments.	

Diversion Facilities

DODSON DIVERSION DAM

Type: Concrete capped timber crib weir, movable crest, embankment wings. (Concrete slab placed over crest and ogee section, 1952.)	
Location: On the Milk River, 5 mi west of Dodson, Mont.	
Year completed: 1910	
Dimensions:	
Structural height	26 ft
Hydraulic height	23 ft
Crest length	8,154 ft
Crest elevation	2280.0 ft
Volume	87,400 yd³
Spillway: Movable overflow crest	
Headworks:	
Dodson South Canal: Concrete, eleven 4- by 5-ft slide gates	
Dodson North Canal: Concrete, four 4-ft-square slide gates	
Diversion capacity:	
South Canal	500 ft³/s
North Canal	200 ft³/s

VANDALIA DIVERSION DAM

Type: Reinforced concrete slab and buttress weir, movable crest embankment wing	
Location: On the Milk River, 3 mi west of Vandalia, Mont.	
Year completed: 1917	
Dimensions:	
Structural height	32 ft
Hydraulic height	27 ft
Crest length	2,350 ft
Crest elevation	2116.0 ft
Volume	15,200 yd³
Spillway: Movable overflow crest. Auxiliary crest.	
Headworks: Concrete, four 4- by 5-ft headgates.	
Diversion capacity, Vandalia South Canal	300 ft³/s

PARADISE DIVERSION DAM

Type: Concrete ogee spillway and sluiceway and compacted earthfill dike	
Location: On the Milk River, 4 mi southeast of Chinook, Mont.	
Year completed: 1966	
Dimensions:	
Structural height	20 ft
Hydraulic height	14 ft
Crest length (including spillway)	570 ft
Crest elevation	2401.5 ft
Spillway crest elevation (100 ft long)	2390.5 ft
Volume	5,000 yd³
Spillway: Overflow crest	

St. Mary Diversion Dam

Type: Concrete weir and sluiceway
Location: On the St. Mary River, 2 mi southeast of Babb, Mont.
Year completed: 1915
Dimensions:

Structural height	6 ft
Hydraulic height	6 ft
Crest length	198 ft
Crest elevation	4457.5 ft
Volume	1,200 yd³

Spillway: Overflow crest
Headworks: 8 headgates, 5 by 5.5 ft.

Diversion capacity	850 ft³/s

Swift Current Dike

Type: Earth and rock, timber-crib core, nonoverflow
Location: On Swiftcurrent Creek, 3 mi southwest of Babb, Mont.
Year completed: 1915
Dimensions:

Structural height	13 ft
Hydraulic height	13 ft
Crest length	4,800 ft
Crest elevation	4485-4548.0 ft
Volume	98,000 yd³

Spillway[1]
Headworks[1]

[1]Swift Current Dike is a nonoverflow earth dike requiring neither spillway nor headworks in diverting the flow of Swiftcurrent Creek, including the controlled releases from Lake Sherburne Dam, into St. Mary River above St. Mary Diversion Dam. Diversion capacity is the maximum release from Lake Sherburne Dam, including flow from Swiftcurrent Creek.

Carriage Facilities

St. Mary Canal

Location: From St. Mary Diversion Dam to the North Fork Milk River.
Construction period: 1907-15

Length	29 mi
Capacity	850 ft³/s
Typical maximum section in earth:	
Bottom width	26 ft
Side slopes	2:1
Water depth	9 ft

Dodson North Canal

Location: From Dodson Diversion Dam about 4 mi west of Dodson, Mont., generally east along Milk River.
Construction period: 1912-14

Length	28 mi
Capacity	200 ft³/s
Typical maximum section in earth:	
Bottom width	12.4 ft
Side slopes	2:1
Water depth	5 ft

Dodson South Canal

Location: From Dodson Diversion Dam about 4 mi west of Dodson, Mont., generally east along Milk River to vicinity of Malta, Mont., then northeast to Nelson Reservoir.
Construction period: 1914-15

Length	43 mi
Capacity	500 ft³/s
Typical maximum section in earth:	
Bottom width	42 ft
Side slopes	2:1
Water depth	4.8 ft

Nelson North Canal

Location: From Nelson Reservoir north to Milk River.
Construction period: 1915

Length	1 mi
Capacity	250 ft³/s
Typical maximum section in earth:	
Bottom width	40 ft
Side slopes	2:1
Water depth	5.2 ft

Nelson South Canal

Location: From Nelson Reservoir near Milk River generally southeast.
Construction period: 1915-17

Length	27 mi
Capacity	500 ft³/s
Typical maximum section in earth:	
Bottom width	18 ft
Side slopes	1.5:1
Water depth	3.2 ft

Vandalia South Canal

Location: From Vandalia Diversion Dam on Milk River near Vandalia, generally southeast to vicinity of Nashua, Mont.
Construction period: 1915-17

Length	46 mi
Capacity	300 ft³/s
Typical maximum section, concrete lined:	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	5 ft
Lining thickness	6 in

Bowdoin Canal

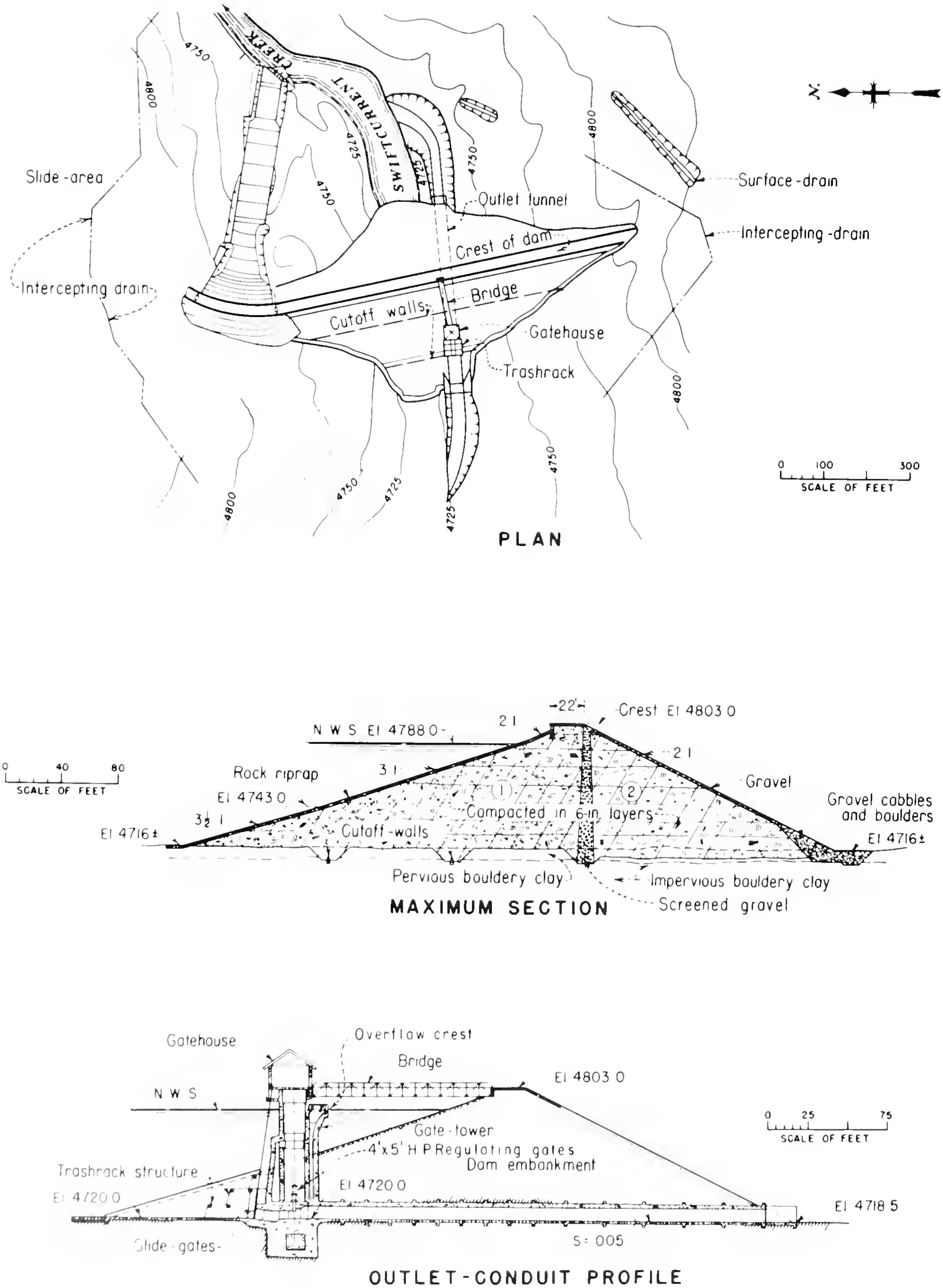
Location: From end of Dodson South Canal near Malta, Mont., east about 8 mi, then generally south about 5 mi.
Construction period: 1915-17

Length	18 mi
Capacity	175 ft³/s
Typical maximum section in earth:	
Bottom width	10 ft
Side slopes	2:1
Water depth	2.5 ft

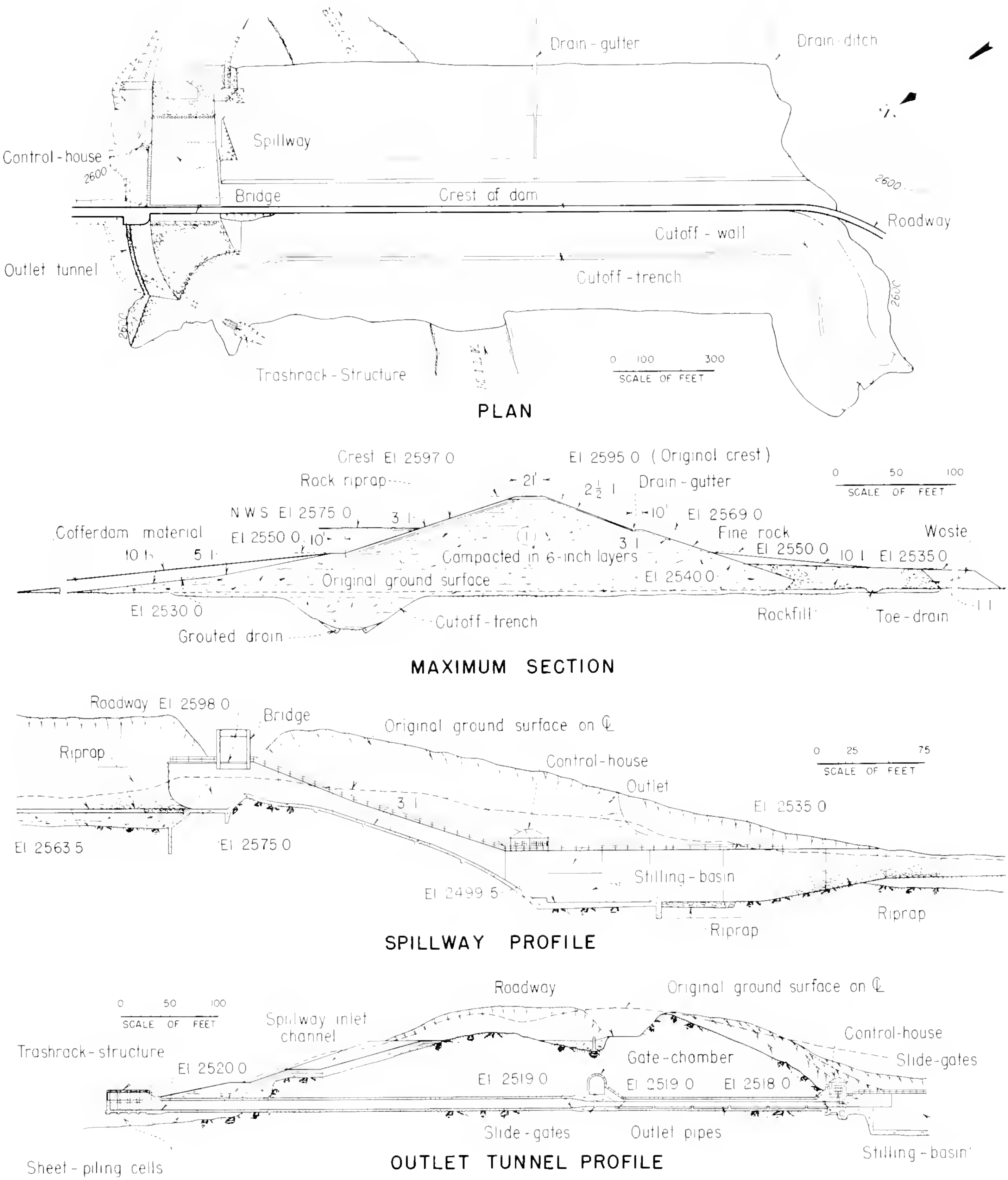
Dodson Pump Canal

Location: From Dodson North Canal upstream of Dodson, Mont., to Dodson Pumping Plant. Then to Dodson North Canal downstream of Dodson.
Construction period: 1946

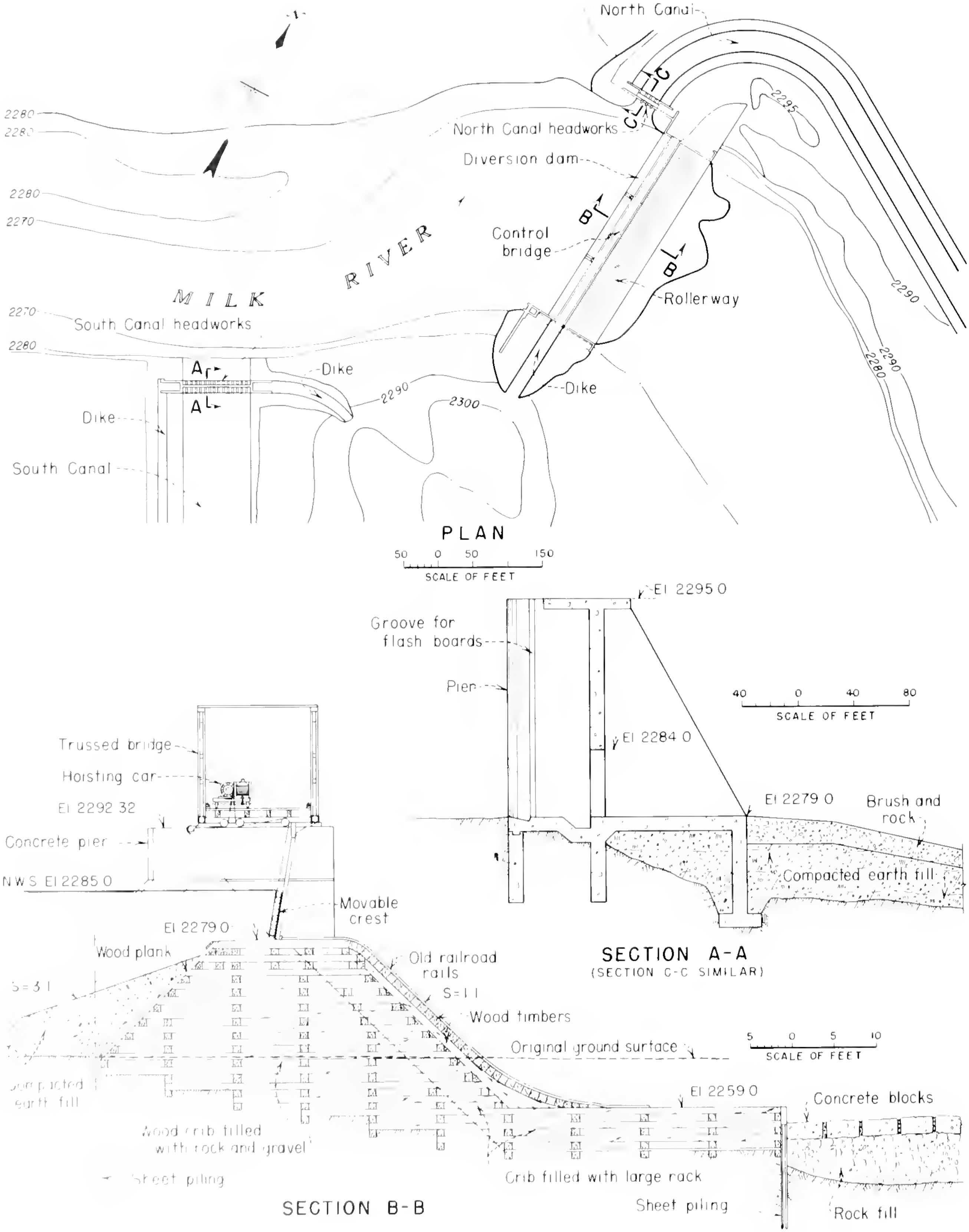
Length	7.5 mi
Capacity	30 ft³/s
Typical maximum section in earth:	
Bottom width	5 ft
Side slopes	1.5:1
Water depth	2.8 ft



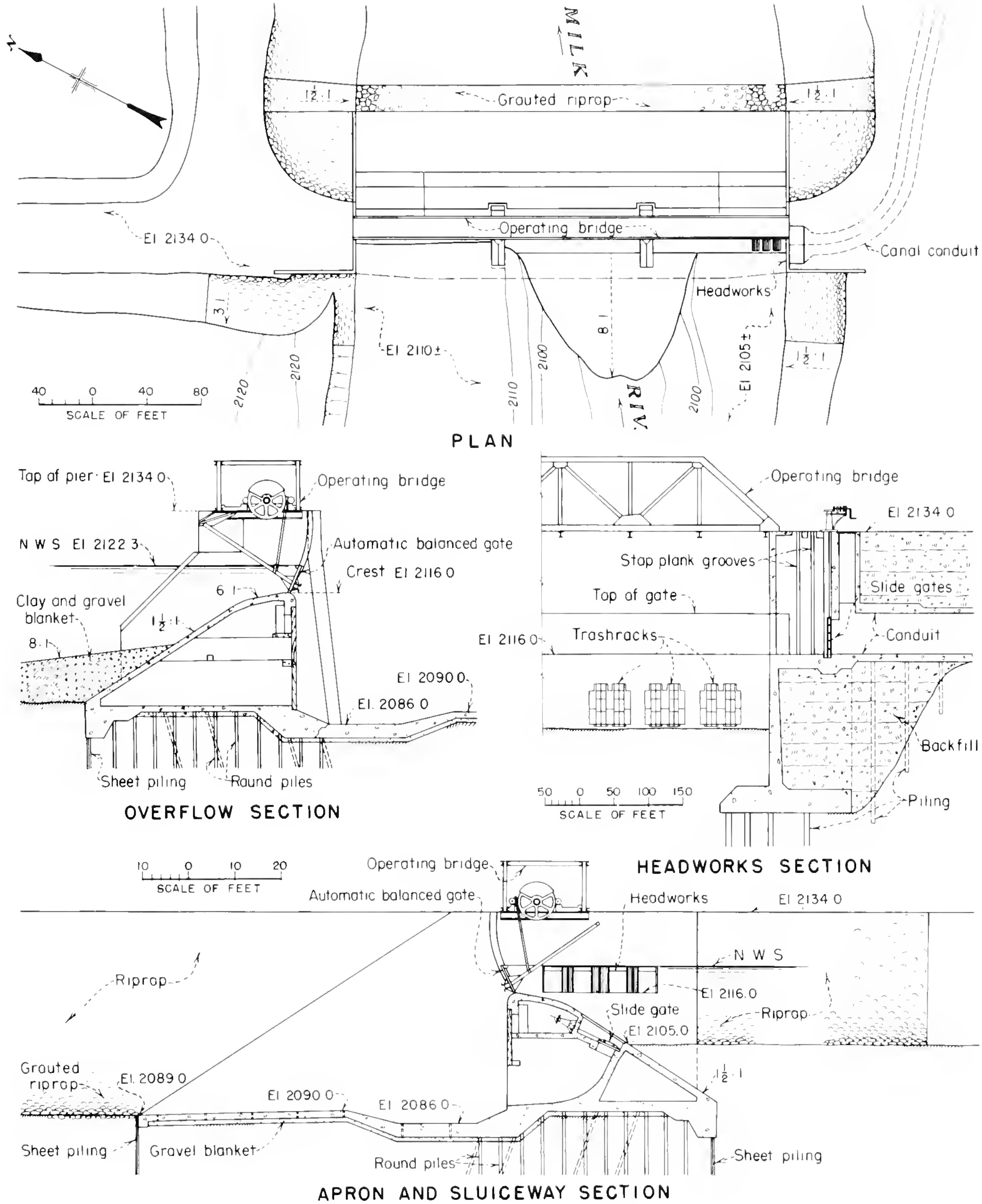
Lake Sherburne Dam, Plan and Sections



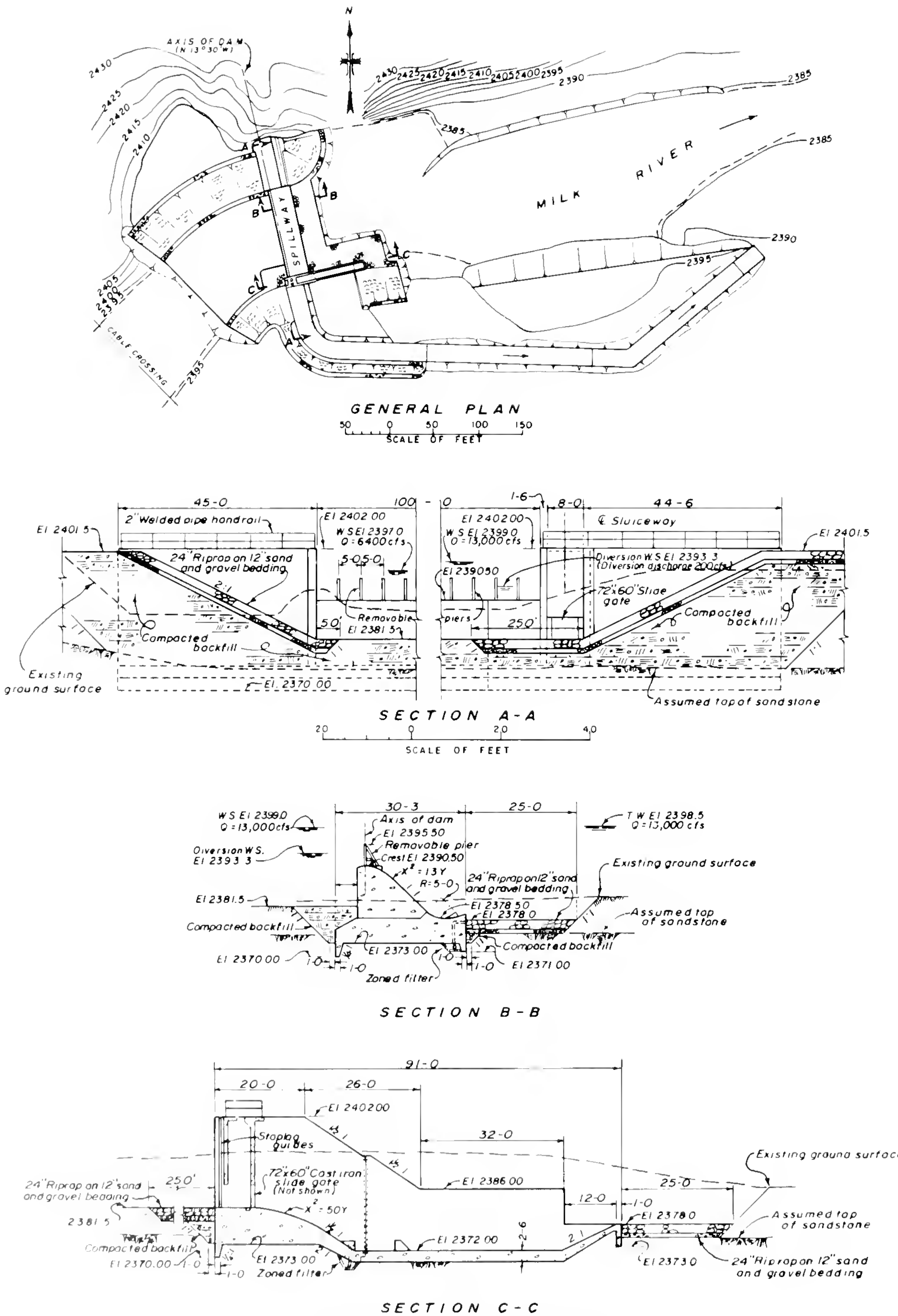
Fresno Dam, Plan and Sections



Dodson Diversion Dam, Plan and Sections



Vandalia Diversion Dam, Plan and Sections

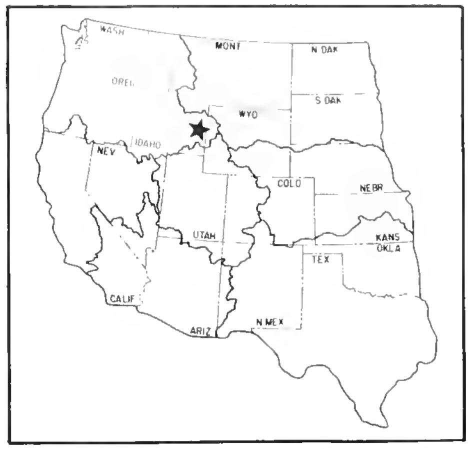


Paradise Diversion Dam, Plan and Sections

Minidoka Project

Idaho and Wyoming: 16 Counties[1]

Pacific Northwest Region
Water and Power Resources Service



Minidoka Project lands extend discontinuously from the town of Ashton in eastern Idaho along the Snake River, approximately 300 miles downstream to the town of Bliss in south-central Idaho. The project furnishes a full or supplemental water supply to more than 1 million acres of land from five reservoirs that have a combined active storage capacity of 2,784,600 acre-feet.

The project works consist of Minidoka Dam and Powerplant and Lake Walcott, Jackson Lake Dam and Jackson Lake, American Falls Dam and Reservoir, Island Park Dam and Reservoir, Grassy Lake Dam and Grassy Lake, two diversion dams, 1,662 miles of canals, 3,929 miles of laterals, 1,249 miles of drains, and 177 water supply wells.

PLAN

Natural flow of the Snake River and some of its tributaries, and water stored in the reservoirs at Jackson Lake, Grassy Lake, Island Park, American Falls, and Lake Walcott are delivered at numerous diversion points to the Fremont-Madison, Burley, and Minidoka Irrigation Districts, American Falls Reservoir District No. 2, and Warren Act contractors.

A full water supply is furnished to 216,796 acres and a supplemental supply to 946,846 acres. Water from Palisades Reservoir on the Palisades Project is instrumental in helping meet the Minidoka Project water requirements.

Much of the power developed on the project is used for pumping water to lands lying above the gravity canals and for pumping drainage water. Power also is furnished to several small communities in the area.

Minidoka Dam and Powerplant

Minidoka Dam is a combined diversion, storage, and power structure located just south of Minidoka, Idaho. A key structure in the initial development of the project, the zoned earthfill dam is 86 feet high. The reservoir, Lake Walcott, has a storage capacity of 95,200 acre-feet. Water is diverted at the dam into a canal on each side of the river. The concrete powerplant, which forms a section of the dam, has seven generating units with a combined capacity of 13,400 kilowatts.

North Side Canal

Water is diverted on the north side of Minidoka Dam into the North Side Canal, a gravity canal and lateral system serving 72,000 acres of land called the Gravity Division, in the vicinity of Rupert, Idaho. The 8-mile canal has an initial capacity of 1,700 cubic feet per second.

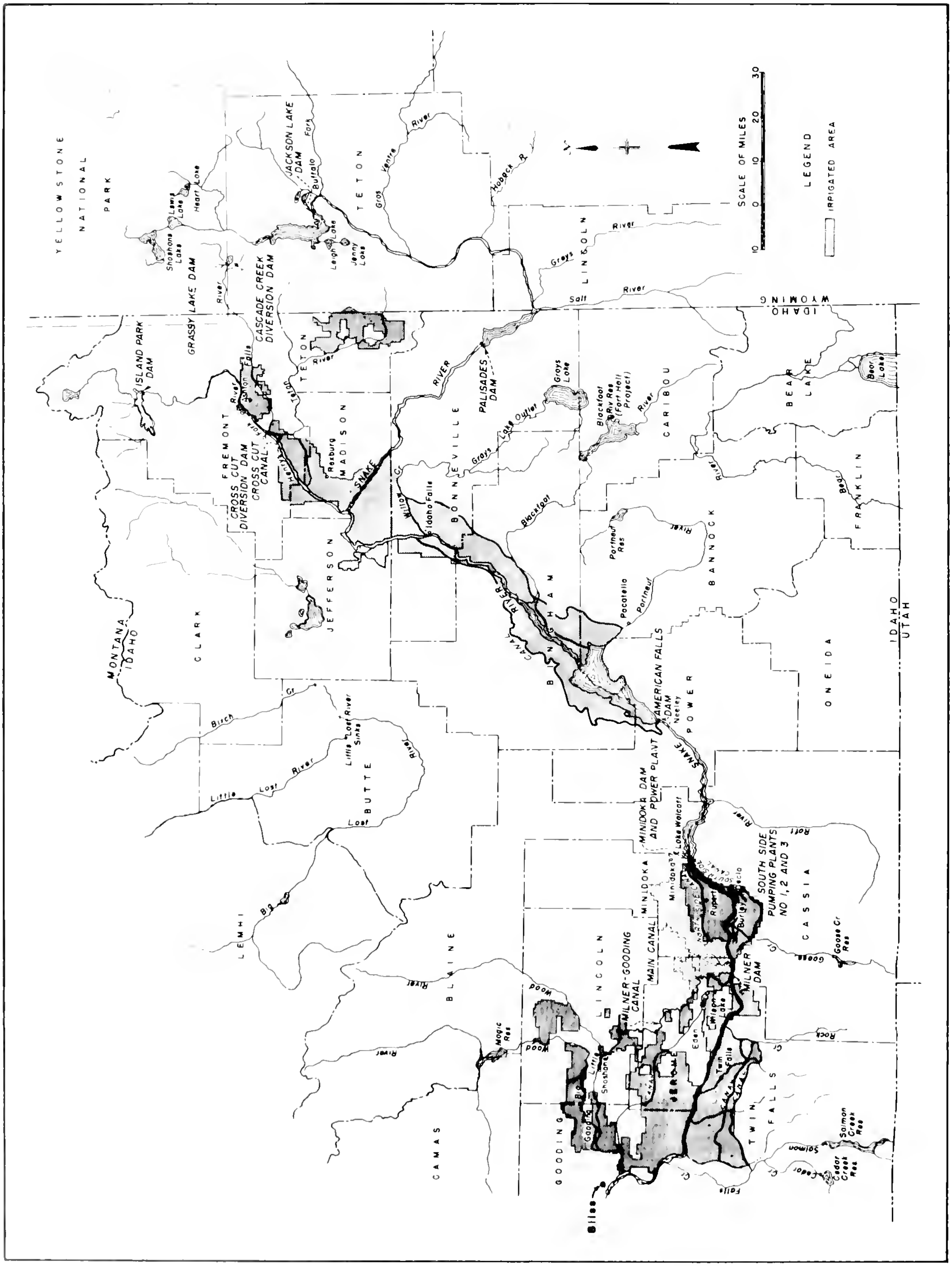
South Side Canal

Water is diverted on the south side of Minidoka Dam into the South Side Canal, a canal system which includes three large pumping plants. Each plant lifts the water about 30 feet, for a total lift of about 90 feet. The system, known as the South Side Pumping Division, serves 48,000 acres adjacent to Burley and Declo. The canal is 13 miles long and has an initial capacity of 1,325 cubic feet per second.

Jackson Lake Dam

A temporary rockfilled crib dam was completed in 1907 by the Bureau of Reclamation at Jackson Lake to store 200,000 acre-feet for the Minidoka Project until the storage requirements could be determined. A portion of this dam failed in 1910, and in 1911 a concrete gravity structure with earth embankment wings was built at the site. The new dam increased storage capacity to 380,000 acre-feet. In 1916, further construction raised the dam 17 feet to a structural height of 65.5 feet and increased the storage capacity to 847,000 acre-feet.

[1]Idaho: Bannock, Bingham, Blaine, Bonneville, Cassia, Fremont, Gooding, Jefferson, Jerome, Lincoln, Madison, Minidoka, Power, Teton, and Twin Falls. Wyoming: Teton.



Minidoka Project

American Falls Dam and Reservoir

American Falls Dam

Project storage was increased by 1,700,000 acre-feet in 1927 upon the completion of American Falls Dam, a 94-foot-high composite concrete and earth structure on the Snake River near American Falls, Idaho. A core-drilling program in the early 1960's revealed that the concrete in portions of the dam was in a relatively advanced stage of deterioration due to a chemical reaction between alkalis in the cement and the aggregate. This type of reaction, unknown at the time of construction, resulted in a significant loss in strength and durability, threatening the competence of the dam. In the early 1970's, storage was limited to 11.3 feet below full pool, which reduced the reservoir storage capacity to 1,125,000 acre-feet, about 66 percent of maximum design capacity.

By congressional act of December 28, 1973, the American Falls Reservoir District, acting as the constructing agency representing the storage spaceholders, was authorized to finance and contract for the replacement of American Falls Dam. The new dam replaces the concrete portion of the original structure and was built immediately downstream from the old dam. Reservoir storage capacity was restored to 1,700,000 acre-feet upon completion of the replacement dam in 1978.

Island Park Dam

The Upper Snake River Division of the project comprises Island Park Dam, Cross Cut Canal and Diversion Dam, and Grassy Lake Dam.

Island Park Dam is located 38 miles north of Ashton, Idaho, on Henrys Fork. The dam is a zoned earthfill

North Side Canal

structure 91 feet high. Water stored at Island Park and Grassy Lake Reservoirs is used in Fremont and Madison Counties in northeastern Idaho, and Teton County in Wyoming.

Cross Cut Diversion Dam and Canal

Water for irrigation in the Upper Snake River Division is diverted from Henrys Fork into the Cross Cut Canal by the Cross Cut Diversion Dam. The dam is a concrete weir which raises the water 10 feet above the streambed.

Cross Cut Canal extends southwest from the diversion dam 6.6 miles to the Teton River. The canal furnishes irrigation water for 112,000 acres of land in Fremont and Madison Counties.

Grassy Lake Dam

This 118-foot-high zoned earthfill storage dam is on Grassy Creek in Wyoming near the southern boundary of Yellowstone National Park. The reservoir capacity of 15,200 acre-feet supplements the storage at Island Park. Storage at Grassy Lake Dam is augmented by a 0.7-mile canal from Cascade Creek which is fed from the Cascade Creek Diversion Dam, a rockfilled log crib weir that is 14 feet high.

Milner-Gooding Canal

In 1928, construction began on the Gooding Division of the Minidoka Project. The work consisted primarily of building the Milner-Gooding Canal which heads at Milner Dam on the Snake River 12 miles west of Burley, Idaho. This 70-mile canal extends to the North Gooding Main Canal northwest of Shoshone, Idaho. The Milner-Gooding Canal and its connecting laterals furnish a full water supply for 20,000 acres and a supplemental supply for 78,667 acres. The initial capacity of the canal is 2,700 cubic feet per second.

North Side Pumping Division

The North Side Pumping Division consists of 76,796 acres of irrigable public land that have been withdrawn from entry, of which 62,159 acres (Unit B) are irrigated by pumping ground water from deep wells, and 14,637 acres (Unit A) by pumping from the Snake River. A portion of the storage space in American Falls Reservoir, augmented by storage from Palisades Reservoir, is used to supply irrigation water to Unit A lands.

Water for Unit A is pumped from the Snake River by a pumping plant located about 8 miles west of Burley. The plant capacity is 240 cubic feet per second and the dynamic head is 168 feet. The pumping plant delivers water to a 4.4-mile-long unlined canal that has the same capacity.

Seven groups of deep wells, totaling 177 wells that are from 12 to 24 inches in diameter, supply water for Unit B. The average pumping head is 211 feet and the average discharge is 6.4 cubic feet per second.

Grassy Lake Dam and Reservoir

A distribution system consisting principally of unlined ditches is used to distribute the water in both units.

DEVELOPMENT

Early History

In 1904, the lower Minidoka Project area around the present cities of Burley and Rupert was a nearly uninhabited sagebrush desert with only a few scattered ranches. After construction of the initial phases of the project brought water to the land, giving opportunity for expansion, it became a prosperous, highly developed farm area. By 1919, 2,208 farms were in operation, there were 6 towns, and the total population was about 17,000.

Investigations

Early investigations of irrigation possibilities in Idaho were made under the direction of the Geological Survey in 1889-90. These surveys included a preliminary examination of the Minidoka Project, when survey lines were run from 15 to 35 miles westward on both sides of the Snake River from the Minidoka Dam site. Additional surveys were made in 1895. Private organizations became interested in developing the area at various times after 1887.

At the time of passage of the Reclamation Act of June 1902, considerable data relative to the area were available for use by the State Engineer, who was responsible for cooperating with the Reclamation Service in Idaho. During 1902, information obtained about the storage potential in the headwaters of the Snake River indicated that suitable capacities could be developed at reasonable cost. On November 17, 1902, the Secretary of the Interior withdrew from public entry a large body of land embracing the proposed irrigable area of the Minidoka tract, rendering it subject to filing under the terms of the Reclamation Act.

Island Park Dam and Reservoir

Studies were in progress during the middle and late 1970's in connection with facilities at Minidoka Dam. These studies are incomplete and no final report has been made. Primary consideration is being given to increasing the generating capacity at the powerplant from 13.4 to 20-40 megawatts. This would be accomplished by retaining the present Unit 7 and installing two additional units of 8 to 18 megawatts each. The first six units and powerplant housing are now listed in the *National Register of Historic Places.* Unit 7 is separately housed and two additional units would require new housing adjacent to and south of the Unit 1-6 powerhouse. Also being considered are additional recreation facilities, and rehabilitation and betterment of the dam, spillway, and canal headworks.

Authorization

The Minidoka Project was authorized by the Secretary of the Interior on April 23, 1904. Investigation and construction funds for the Gravity Extension Unit (Gooding Division) were provided by act of Congress January 12, 1927 (44 Stat. 934), and the Secretary's finding of feasibility July 2, 1928, was approved by the President on July 3, 1928. The Upper Snake River storage was authorized by a finding of feasibility by the Secretary of Interior, and approved by the President on September 20, 1935. The North Side Pumping Division was authorized for construction by the act of September 30, 1950 (64 Stat. 1083, Public Law 864, 81st Congress). Replacement of American Falls Dam was authorized by act of December 28, 1973 (87 Stat. 904, Public Law 93-206).

Construction

Construction activities on the project began in 1904 at Minidoka Dam which, with its associated diversions and canals, formed the nucleus of the present development. Headwaters storage began with the erection of the temporary Jackson Lake Dam in 1905.

Later major developments were the enlargement of Jackson Lake in 1911 and 1916, the original construction of American Falls Dam in 1925-27, construction of Grassy Lake and Island Park Dam in 1935-39, and American Falls Replacement Dam in 1976-78.

The first power came from the Minidoka Powerplant in 1909; the last generator was installed in 1942.

Construction on the last project land area to be developed, North Side Pumping Division, began in 1948 and was completed in 1959.

The Palisades Reservoir, while not a part of the Minidoka Project, contributes greatly to the project's success by storing excess flows for later release and by increasing the available power supply.

Operating Agencies

The Gravity Division has been operated by the Minidoka Irrigation District since January 1, 1917; the South Side Pumping Division by the Burley Irrigation District since April 1, 1926; Gooding Division by American Falls Reservoir District No. 2 since May 1, 1933; and the Upper Snake River Division by Fremont-Madison Irrigation District since November 15, 1940. The North Side Pumping Division, last to be developed, was turned over to the A&B Irrigation District for operation on March 1, 1966. All storage and power facilities are operated by the Bureau of Reclamation.

BENEFITS

Irrigation

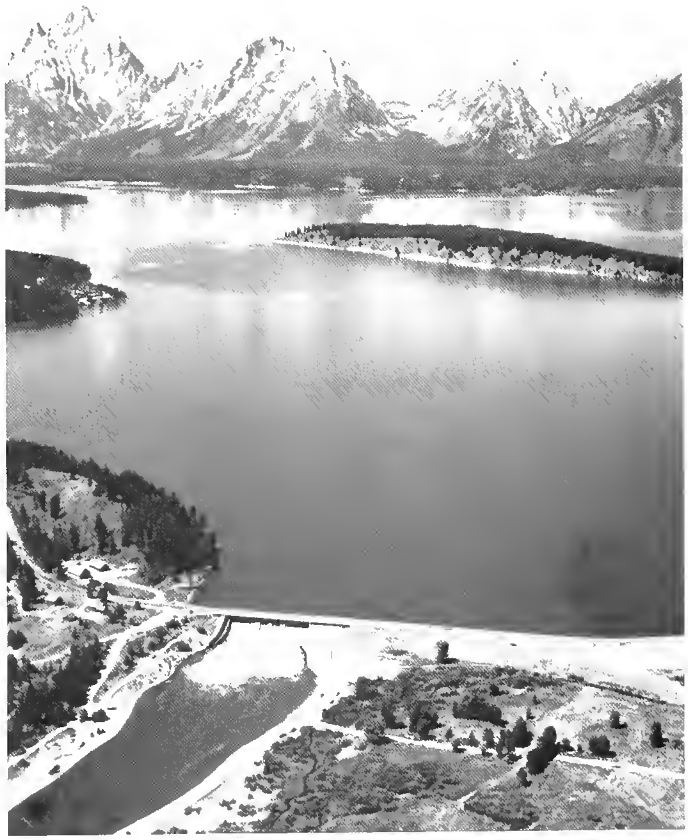
There are over a million irrigated acres in the arid Snake River valley of southern Idaho. Much of the famed Idaho potato crop is grown in this valley, and sugar beets, dry beans, sweet corn, field grains, alfalfa hay, and irrigated pasture diversify the land use. Cattle raising and dairying are important industries.

Flood Control

The reservoirs of the Minidoka Project were designed originally to provide for distribution of spring runoff through the irrigation season, rather than to provide for carryover storage for years of low streamflows. The addition of Palisades Reservoir provides not only holdover storage, but also an increased measure of flood control over the river. Sufficient vacant space is maintained in Jackson Lake and Palisades Reservoir on a forecast basis to prevent flows on the Snake River near Heise from exceeding 20,000 cubic feet per second. The flood control operation is carried out under formal agreement with the Corps of Engineers.

Recreation and Fish and Wildlife

The five project reservoirs provide 36,194 acres of land and 101,554 acres of water surface, with 319 miles of shoreline for recreational use. American Falls Reservoir is the largest with a total land and water area of over 68,000 acres. The Bureau of Reclamation administers



Jackson Lake Dam and Reservoir

recreation at the reservoir and has leased out three areas for recreation development. The reservoir offers fishing for both salmonoid and spiny ray species, and millions of waterfowl use the area annually. Jackson Lake is located within Grand Teton National Park and recreation is administered by the National Park Service. With the Teton Mountains as a background, excellent facilities, and Yellowstone National Park only a few miles away, the reservoir attracts many vacationers.

The Minidoka National Wildlife Refuge, consisting of a major portion of the Lake Walcott area, is administered by the Fish and Wildlife Service. Part of the area is open to public hunting, and fishing is provided in the reservoir. Several million waterfowl use the area each year. Both Island Park Reservoir and Grassy Lake are administered by the Forest Service. Many recreation facilities have been constructed at Island Park Reservoir. There is good fishing for rainbow trout and coho and kokanee salmon at the reservoir, and it is used by large numbers of waterfowl during their migrations. Snowmobiling is a very popular activity in this area. Grassy Lake is a small reservoir located just outside the southern boundary of Yellowstone National Park. Visitation is light but there is some trout fishing.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	216,796	acres
Supplemental irrigation service	945,354	acres
Temporary irrigation service	1,492	acres
Total	1,163,642	acres
Number of irrigated farms	19,181	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,102,450	140,144,635
1969	1,101,877	139,634,179
1970	1,102,724	149,988,101
1971	1,102,548	153,687,140
1972	1,099,985	201,895,257
1973	1,102,554	363,292,048
1974	1,087,839	425,943,339
1975	1,072,630	319,034,384
1976	1,072,863	260,363,770
1977	1,062,992	283,123,553

Facilities in Operation

Storage dams	5	
Diversion dams	2	
Canals	1,662	mi
Laterals	3,979	mi
Pumping plants	4	
Irrigation wells	177	
Drains	1,249	mi
Powerplants	1	
Transmission lines	3.4	mi
Substations	184	

Climatic Conditions

Annual precipitation	10.3	in
Temperature:		
Maximum	102	°F
Minimum	−23	°F
Mean	48	°F
Growing season	154	days
Elevation of irrigable area	4225-5000.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	70,766
Other water service[1]	99,487
Total	170,253

[1]Urban and suburban, residential, commercial, and industrial lands.

Power Generation

Fiscal year	Minidoka Powerplant, kWh	Fiscal year	Minidoka Powerplant, kWh
1968	103,075,200	1973	115,604,800
1969	113,924,000	1974	107,835,500
1970	82,284,000	1975	123,566,300
1971	124,000,800	1976	[2]159,702,100
1972	114,412,000	1977	106,329,700

[2]15-month period. Transitional quarter July-September 1976 included. Fiscal year changed from July-June to October-September.

ENGINEERING DATA

Water Supply

SNAKE RIVER:

JACKSON LAKE

Drainage area	824	mi²
Annual discharge:		
Maximum (1971)	1,500,300	acre-ft
Minimum (1977)	452,600	acre-ft
Average	1,091,900	acre-ft

SNAKE RIVER NEAR HEISE

Drainage area	5,752	mi²
Annual discharge:		
Maximum (1971)	7,443,000	acre-ft
Minimum (1977)	2,561,000	acre-ft
Average	5,377,000	acre-ft

ISLAND PARK

Drainage area	481	mi²
Annual discharge:		
Maximum (1971)	605,400	acre-ft
Minimum (1977)	416,400	acre-ft
Average	513,600	acre-ft

GRASSY LAKE

Drainage area	10	mi²
Estimated average annual runoff	8,100	acre-ft

AMERICAN FALLS[3]

Drainage area	13,580	mi²
Annual discharge:		
Maximum (1971)	13,191,900	acre-ft
Minimum (1977)	6,435,300	acre-ft
Average	10,398,100	acre-ft

MILNER

Drainage area	17,180	mi²
Average annual discharge (1963-77)	10,787,600	acre-ft
Average annual diversions by project (1963-77)	7,284,100	acre-ft

[3]Adjusted for diversions and storage above Neeley.

Storage Facilities

MINIDOKA DAM

Type: Zoned earthfill with concrete-gravity powerhouse, spillway, and headgate sections.
Location: On the Snake River about 6 mi south of Minidoka, Idaho.
Construction period: 1904-06
Spillway modified in 1913; right abutment cutoff wall extended in 1943.

Reservoir, Lake Walcott:		
Total capacity to El. 4245	210,000	acre-ft
Active capacity, El. 4236-4245	95,200	acre-ft
Surface area	11,850	acres
Length	26	mi
Shoreline	80	mi
Dimensions:		
Structural height	86	ft
Hydraulic height	74	ft
Top width	25	ft
Maximum base width	412	ft

Crest length ... 4,475 ft
Crest elevation ... 4250.0 ft
Total volume ... 257,300 yd^3
Spillway: Uncontrolled overflow weir section with 5-ft flashboards, and controlled section with four 10- by 12-ft top-seal radial gates.
Crest length ... 2,385 ft
Crest elevation, controlled section ... 4228.0 ft
Elevation, top of gates ... 4240.0 ft
Capacity at El. 4245 ... 89,000 ft^3/s
Outlet works:
River: Five tunnels through base of concrete powerhouse section controlled by 8- by 12-ft slide gates at upstream openings.
Capacity at El. 4245 ... 16,100 ft^3/s
Power: Five 10-ft-diameter steel penstocks and one steel-lined concrete penstock of variable circular section. Two steel-lined 9.625- by 11.25-ft concrete penstocks in concrete powerhouse section.
Capacity at El. 4245 ... 5,000 ft^3/s
Diversion works: Separate structures for the North and South Canals controlled by nine 5- by 7-ft and by twelve 5- by 6-ft slide gates, respectively.
Capacity at El. 4245 ... 3,025 ft^3/s
Foundation: Entire site underlain by basaltic lava flows ranging from porous and soft on the left abutment to uniformly firm and hard under the main body of the dam.
Special treatment: Right abutment grouted.

American Falls Dam

Type: Concrete gravity with embankment wings
Location: On the Snake River at American Falls, Idaho.
Construction period: Original 1925-27; replaced in 1976-78 by American Falls Reservoir District.
Reservoir, American Falls:
Active capacity, El. 4354.5 ... 1,700,000 acre-ft
Surface area ... 58,076 acres
Length ... 22 mi
Shoreline ... 100 mi
Dimensions:
Structural height ... 103.5 ft
Hydraulic height ... 77.5 ft
Top width ... 42.5 ft
Crest length ... 5,277 ft
Crest elevation ... 4366.5 ft
Total volume ... 1,374,300 yd^3
Spillway: Concrete overflow weir controlled by five 44- by 25-ft radial gates.
Length including four 8-ft-thick piers ... 252 ft
Crest elevation ... 4333.0 ft
Elevation, top of gates ... 4356.5 ft
Capacity at El. 4354.5 ... 87,000 ft^3/s
Outlet works: Nine 7.17-ft-square low-level outlets at El. 4285 in the spillway blocks, each with two 7-ft-square slide gates.
Capacity at El. 4354.5 ... 19,400 ft^3/s
Power outlet works: Three 18-ft-diameter outlet tubes in the powerhouse intake and abutment section on the west that furnish water to a private company for power generation.
Capacity of three tubes ... 13,500 ft^3/s
Foundation: Massive, columnar basalt underlain by a bed of obsidian.

Jackson Lake Dam[1]

Type: Concrete gravity dam with embankment wings
Location: On the Snake River near Moran, Wyo.
Construction period: 1910-11
Crest raised 17 ft and concrete gravity section reconstructed in 1916; 2,400 ft of left embankment raised 3 ft in 1932.
Reservoir, Jackson Lake:
Active capacity, El. 6728-6769 ... 847,000 acre-ft
Surface area ... 25,500 acres
Length ... 16 mi
Shoreline ... 70 mi
Dimensions:
Structural height ... 65.5 ft
Hydraulic height ... 42 ft
Top width ... 20 ft
Maximum base width ... 72 ft
Crest length ... 4,920 ft
Crest elevation ... 6777.0 ft
Total volume ... 491,700 yd^3
Spillway: Concrete overflow section with incorporated logway controlled by 17 8- by 7.83-ft and two 10- by 7.83-ft radial gates.
Crest elevation ... 6762.5 ft
Elevation, top of gates ... 6769.0 ft
Capacity at El. 6769 ... 8,690 ft^3/s
Outlet works: Fifteen conduits through base of dam controlled by 8- by 6.5-ft slide gates.
Capacity at El. 6769.5 ... 24,000 ft^3/s
Foundation: Rock ledge about 30 ft thick underlain by a 10-ft layer of stiff, blue clay overlying second rock formation. Embankment wings lie on alluvial clay, sand, and well-graded gravel.

Island Park Dam

Type: Zoned earthfill dam and dike
Location: On Henrys Fork about 38 mi north of Ashton, Idaho.
Construction period: 1935-38
Reservoir, Island Park:
Total capacity to El. 6302 ... 127,600 acre-ft
Active capacity above El. 6230 ... 127,200 acre-ft
Surface area ... 7,794 acres
Length ... 11 mi
Shoreline ... 64 mi
Dimensions:
Structural height ... 91 ft
Hydraulic height ... 81 ft
Top width ... 35 ft
Maximum base width ... 585 ft
Crest length ... 9,450 ft
Crest elevation ... 6309.0 ft
Total volume ... 564,000 yd^3
Spillway: Horseshoe-shaped inclined tunnel in right abutment with uncontrolled U-shaped concrete weir at inlet end. At its lower end, the spillway tunnel joins outlet tunnel passing under right abutment.
Crest length ... 257 ft
Crest elevation ... 6302.0 ft
Capacity at El. 6305 ... 5,000 ft^3/s
Outlet works: Concrete-lined tunnel through right abutment controlled by four 5- by 6-ft high-pressure gates.
Capacity at El. 6302 ... 3,400 ft^3/s

---

[1]Jackson Lake has been restricted to a normal water surface elevation of 6760.0 to assure safety of dam until modifications are made for earthquake stability.

Foundation: Rhyolite tuff ranging from porous and comparatively weak in right abutment to moderately sound beneath streambed.
Special treatment: Grout curtain beneath cutoff walls, supplemental grouting of abutments, and concrete filling and grouting of numerous springs.

GRASSY LAKE DAM

Type: Zoned earthfill
Location: On Grassy Creek about 25 mi northwest of Moran, Wyo.
Construction period: 1937-39
Reservoir, Grassy Lake:
(Storage is supplemented through feeder canal from a diversion on Cascade Creek.)

Total capacity to El. 7210	15,500	acre-ft
Active capacity above El. 7135	15,200	acre-ft
Surface area	310	acres
Length	3	mi
Shoreline	5	mi

Dimensions:

Structural height	118	ft
Hydraulic height	103	ft
Top width	30	ft
Maximum base width	738	ft
Crest length	1,170	ft
Crest elevation	7218.0	ft
Total volume	539,000	yd³

Spillway: Uncontrolled, concrete-lined closed channel in left abutment with side-channel overflow weir at inlet end and stilling basin at outlet end.

Crest length	115	ft
Crest elevation	7210.0	ft
Capacity at El. 7212	1,200	ft³/s

Outlet works: Concrete conduit through base of dam controlled by 30-in needle valve at outlet end.

Capacity at El. 7210	230	ft³/s

Foundation: Rhyolitic lava grading downward from much altered and soft decomposed layers to firm hard flows; overlain with clays, silts, sands, and gravels.
Special treatment: Cement grout curtain beneath cutoff walls; grouting in abutments of upstream foundation area and springs in downstream foundation area.

Diversion Facilities

CROSS CUT DIVERSION DAM

Type: Concrete gravity weir, ogee overflow
Location: On Henrys Fork near Chester, Idaho.
Year completed: 1938
Dimensions:

Structural height	17	ft
Hydraulic height	10	ft
Weir crest length	355	ft
Total length	457	ft
Crest elevation	5040.5	ft
Volume	7,400	yd³
Diversion capacity	591	ft³/s

CASCADE CREEK DIVERSION DAM

Type: Rockfilled log crib weir
Location: On Cascade Creek, 25 mi northwest of Moran, Wyo.
Year completed: 1937
Dimensions:

Structural height	14	ft
Hydraulic height	6	ft
Weir crest length	140	ft
Total length	217	ft
Crest elevation	7315.0	ft
Weir crest elevation	7310.0	ft
Volume	3,000	yd³
Diversion capacity	220	ft³/s

Carriage Facilities

MILNER-GOODING CANAL

Location: From Milner Diversion Dam on the Snake River northwest about 50 mi to vicinity of Gooding, Idaho.
Construction period: 1928-32

Length	70	mi
Diversion capacity	2,700	ft³/s

Typical maximum section, concrete lined:

Bottom width	20	ft
Side slopes	0.25:1	
Water depth	13.8	ft

Typical maximum section in earth:

Bottom width	50	ft
Side slopes	1.25:1	
Water depth	12.6	ft

CROSS CUT CANAL

Location: From Cross Cut Diversion Dam south about 6 mi to Teton River.
Construction period: 1936-38

Total length	6.6	mi
Diversion capacity	591	ft³/s

Typical maximum section in earth:

Bottom width	26	ft
Side slopes	1.5:1	
Water depth	5.7	ft

DIVERSION CANAL

Location: From Cascade Creek Diversion Dam to natural channel leading to Grassy Lake Reservoir.
Construction period: 1937

Total length	0.7	mi
Diversion capacity	220	ft³/s

Typical maximum section in earth:

Bottom width	10	ft
Side slopes	1.5:1	
Water depth	5	ft

SOUTH SIDE CANAL

Location: From Minidoka Dam south-southwest about 12 mi to first lift pumping plant.
Construction period: 1905-07

Total length	13	mi
Diversion capacity	1,325	ft³/s

Typical maximum section, concrete lined:

Bottom width	57	ft
Side slopes	1.25:1	
Water depth	7.5	ft

NORTH SIDE CANAL

Location: From Minidoka Dam west-southwest to a point about 5 mi north of Snake River.
Construction period: 1905-07

Total length	8	mi
Diversion capacity	1,700	ft³/s

Unit "A" Main Canal (North Side Pumping Division)

Location: Extends northeast from a point on the Snake River to about 8 mi west of Burley, Idaho.
Construction period: 1954-55

Total length	4.4 mi
Diversion capacity	240 ft³/s
Typical maximum section, earth lined:	
Bottom width	14 ft
Side slopes	2:1
Water depth	4.5 ft
Typical maximum section, unlined:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	5 ft

Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
South Side Pumping Division:				
Lift No. 1	6	1,011	31	4,040
Lift No. 2	6	891	34	3,590
Lift No. 3	3	453	31	2,340
North Side Pumping Division:				
Unit A[5]	5	240	168	6,000
Unit B[6]	177	[7]1,128	129 - 345	[8]38,000

[5]Unit A has six small relift pumping plants with a total capacity of 20.8 ft³/s, total dynamic heads varying from 10 to 39 ft, and motor horsepower varying from 3 to 75 hp for a total of 148 hp.
[6]Unit B has eight small relift pumping plants with a total capacity of 30.8 ft³/s, total dynamic heads varying from 18 to 44 ft, and motor horsepower varying from 7.5 to 40 hp for a total of 172.5 hp.
[7]Capacity in 1977 through rectification; design capacity was 1,009 ft³/s.
[8]Units 50 to 400.

Power Facilities

Minidoka Powerplant

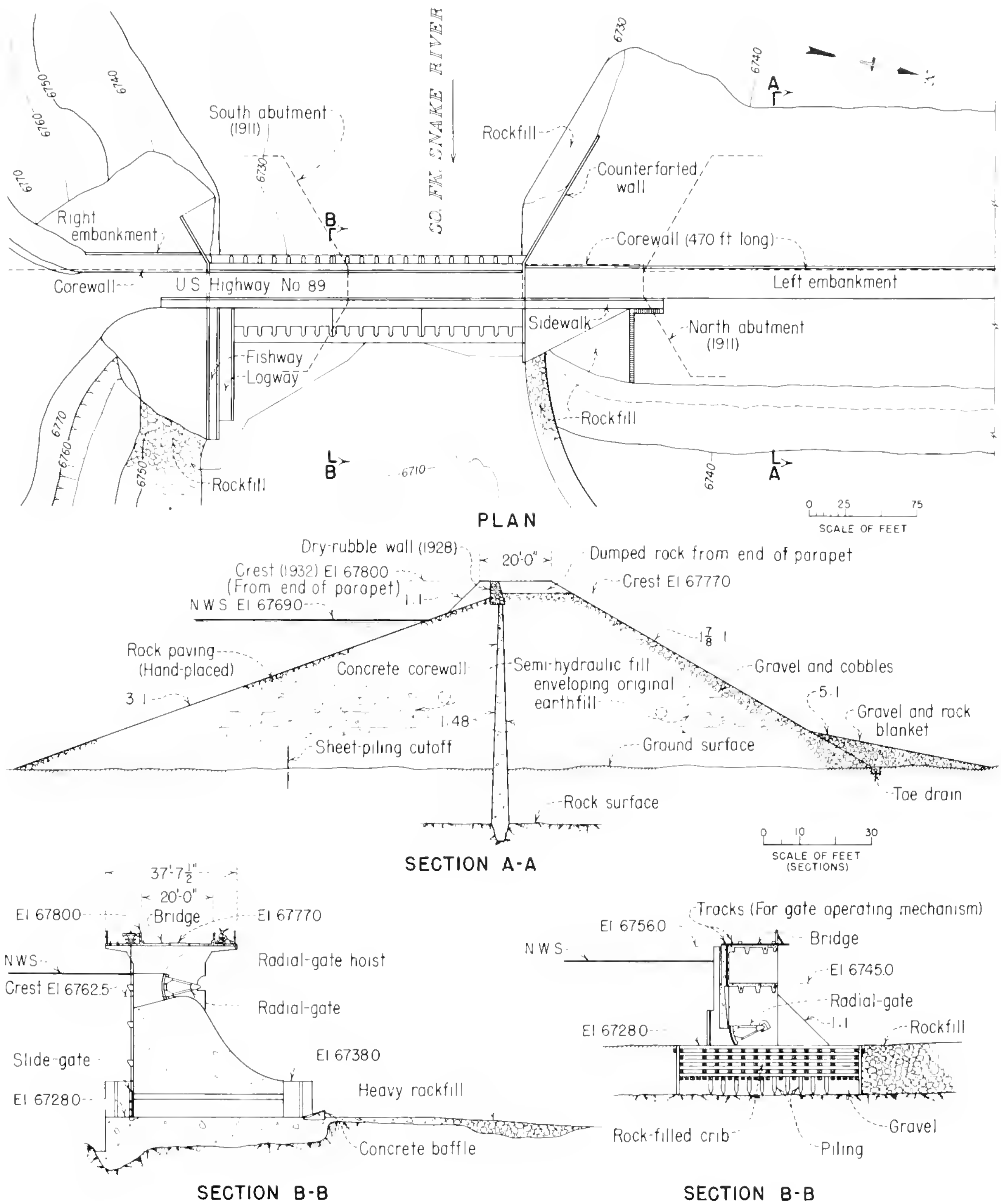
Location: Minidoka Dam
Year of initial operation: 1909
Year last generator placed in operation: 1942

Nameplate capacity	13,400 kW
Capacity of generators:	
Units 1-5 (1,200 kW each)	6,000 kW
Unit 6	2,400 kW
Unit 7	5,000 kW

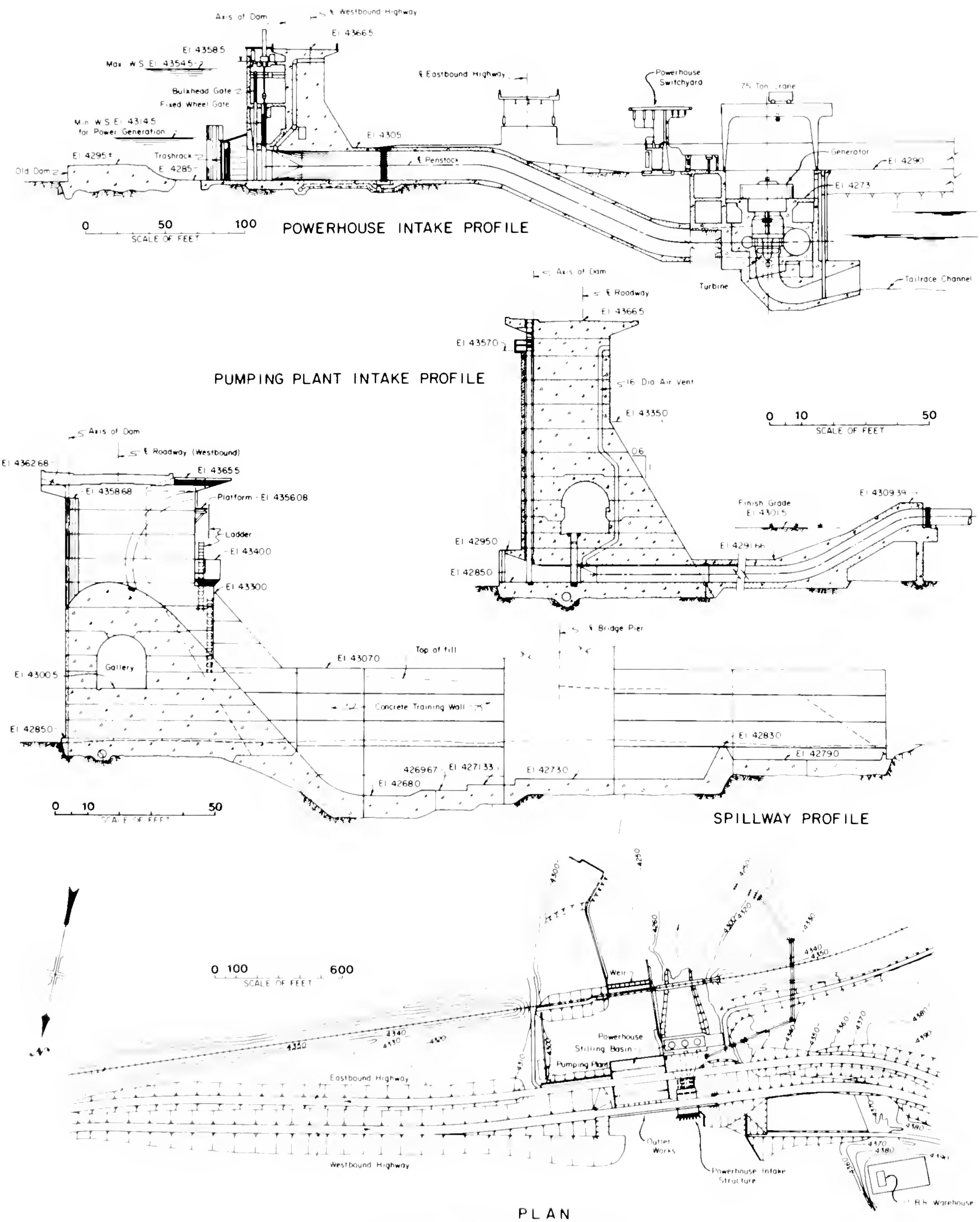
Transmission Lines

Total number of lines	[illegible]
Total circuit miles	3.[illegible]

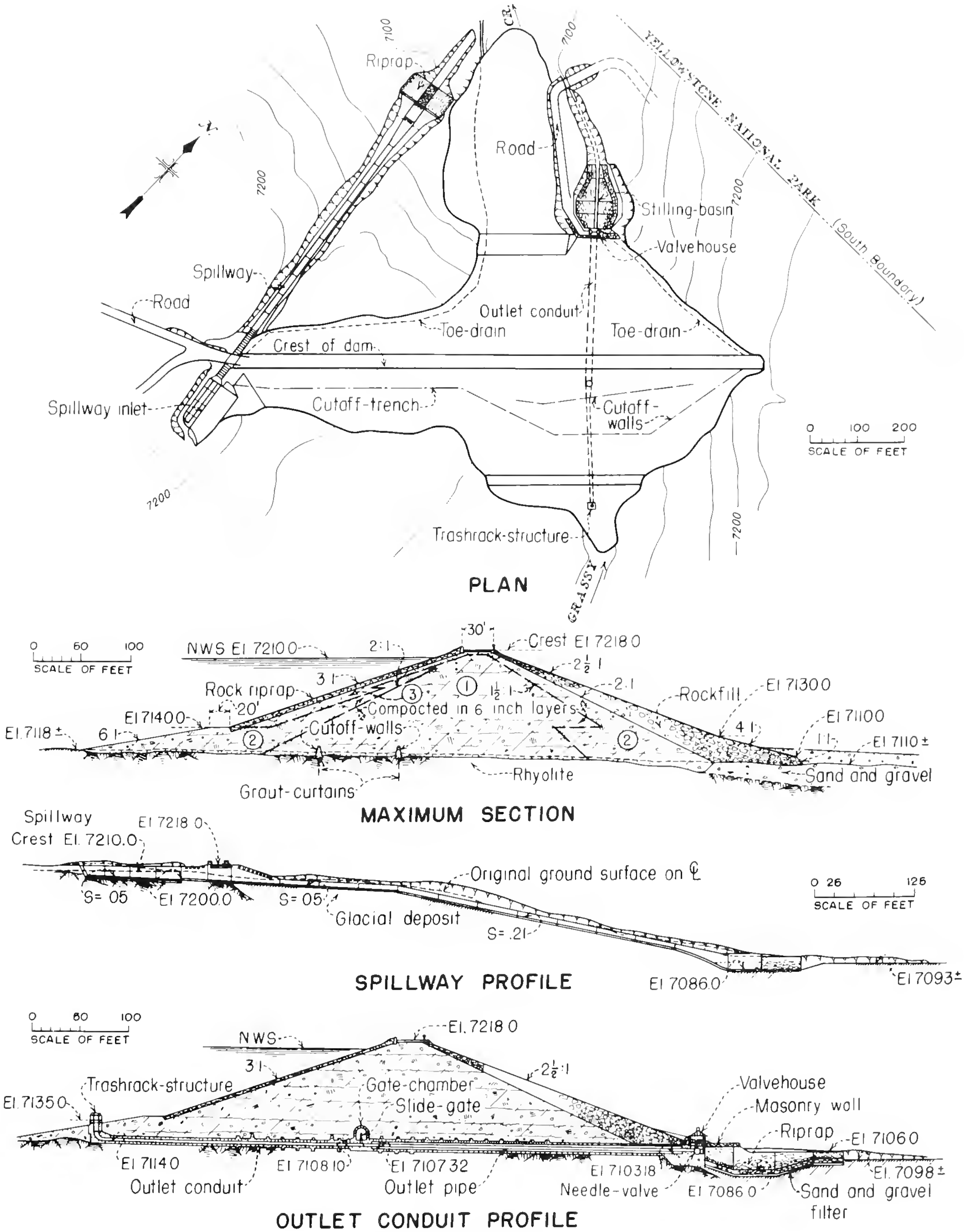
Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Minikoka Powerplant—Government Camp	2.3	25	1.00	1910
Burley Irrigation District First Lift—Second Lift	2.3	50	1.65	1910
Burley Irrigation District Second Lift—Third Lift	2.3	50	0.75	1910



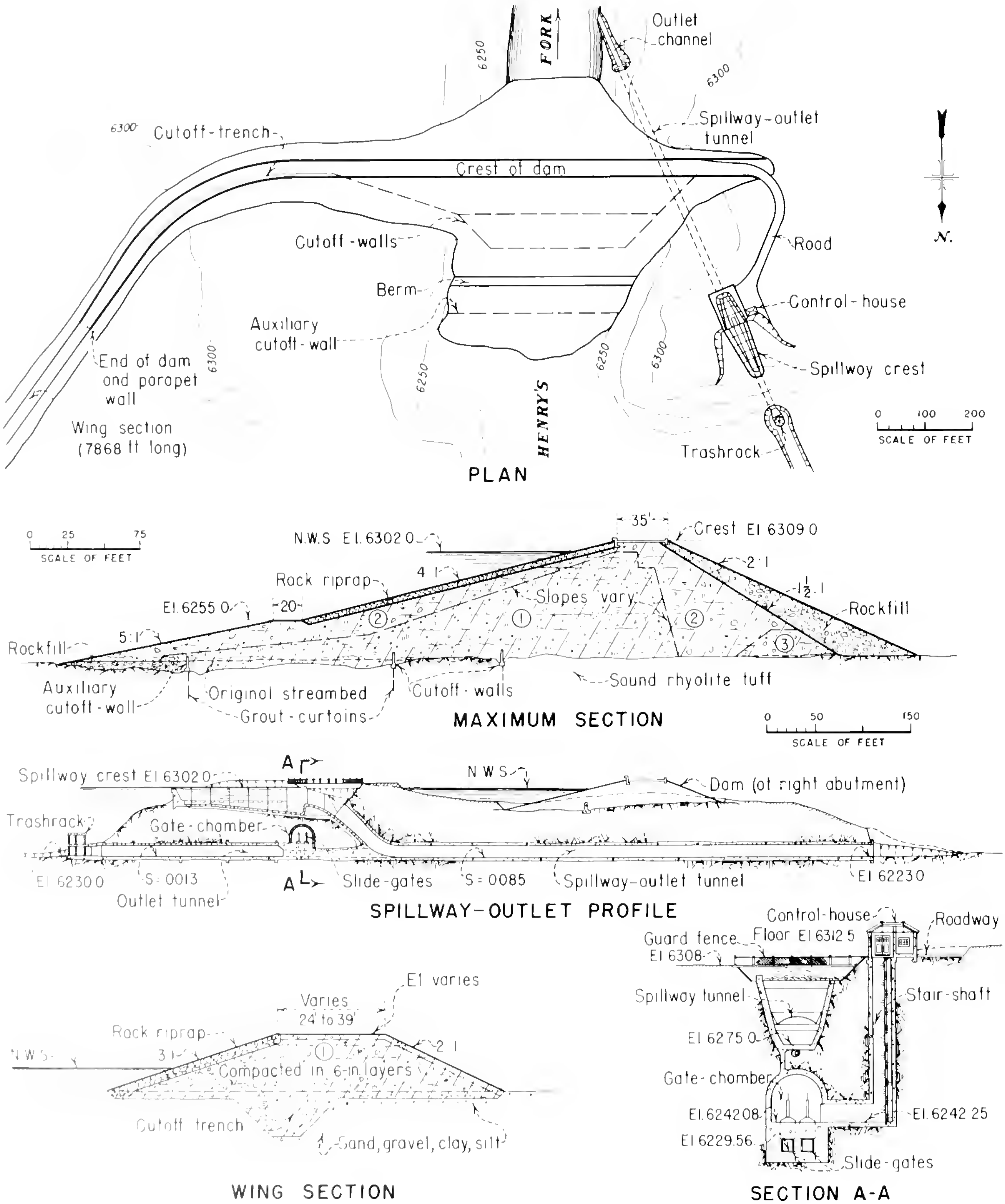
Jackson Lake Dam, Plan and Sections



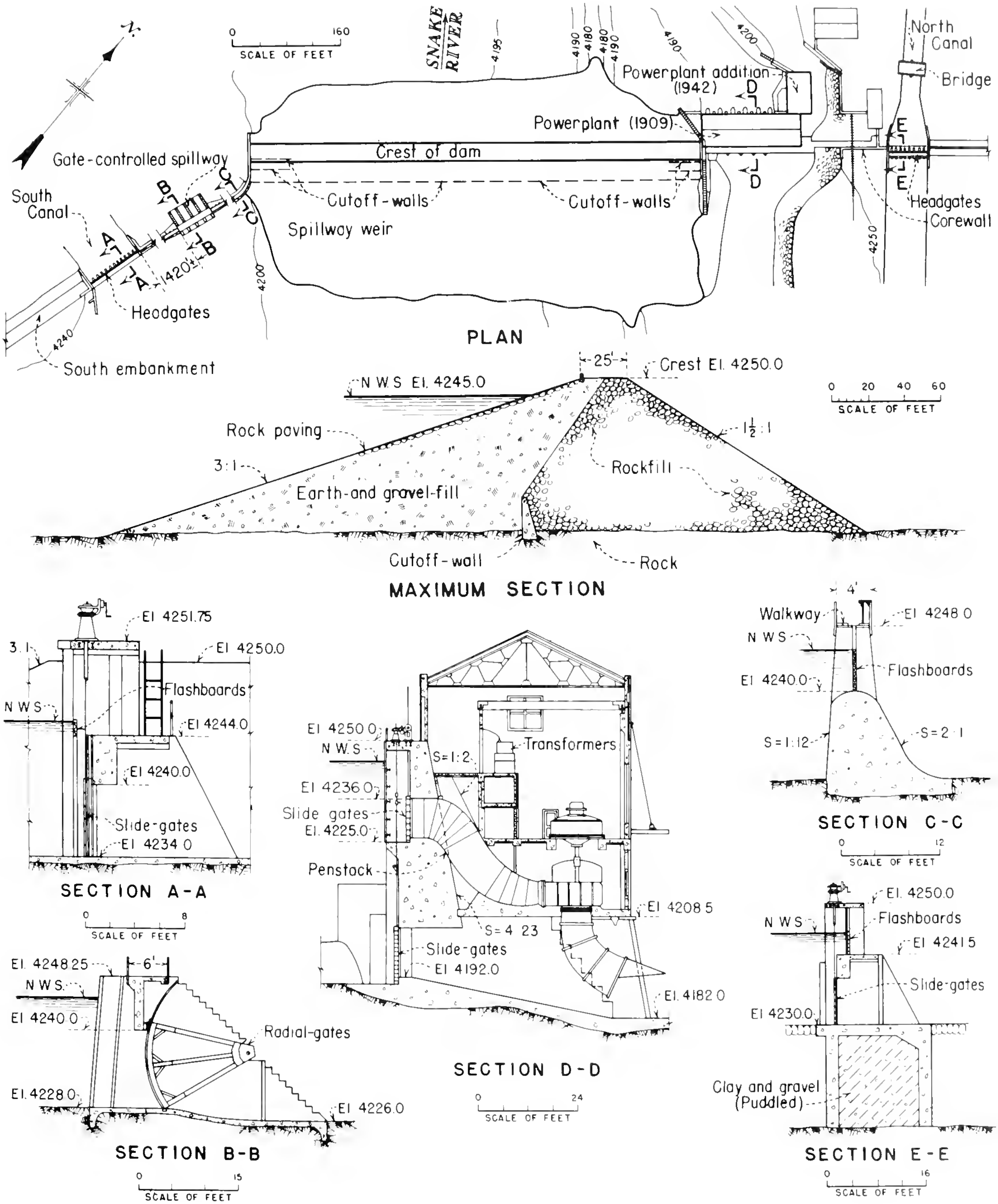
American Falls Dam, Plan and Sections



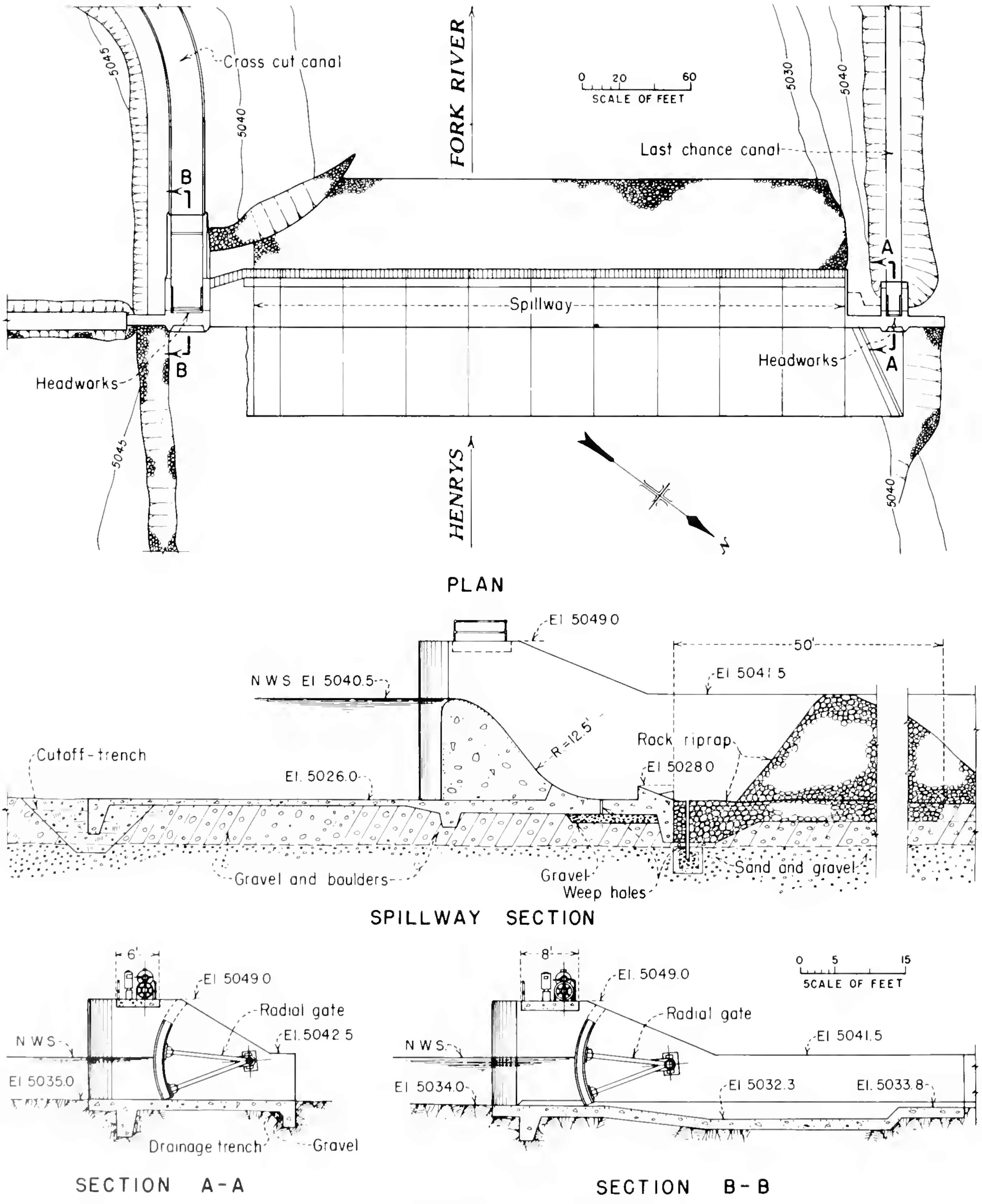
Grassy Lake Dam, Plan and Sections



Island Park Dam, Plan and Sections



Minidoka Dam, Plan and Sections

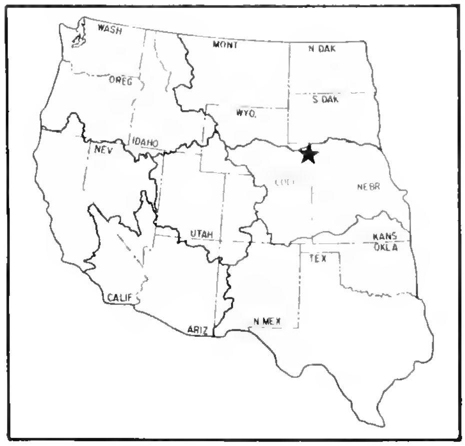


Cross Cut Diversion Dam, Plan and Sections

Mirage Flats Project

Nebraska: Dawes and Sheridan Counties

Lower Missouri Region
Water and Power Resources Service



The Mirage Flats Project is in northwestern Nebraska on the Niobrara River. It includes Box Butte Dam and Reservoir, Dunlap Diversion Dam, Mirage Flats Canal, and distribution and drainage systems. Water is diverted from the Niobrara River to irrigate approximately 11,670 acres of fertile land on the north bank of the Niobrara River about 12 miles south of Hay Springs. No power is developed on the project.

PLAN

Water is stored in Box Butte Reservoir, on the Niobrara River about 10 miles north of Hemingford. The reservoir also controls the floodflows of the river. About 8 miles downstream from the Box Butte Dam, Dunlap Diversion Dam diverts water into the Mirage Flats Canal for irrigation. Water flows by gravity to project lands, about 12 miles east of the diversion dam.

Box Butte Dam

Box Butte Dam, a rock-faced zoned earthfill structure, is 87 feet high and contains 1,422,000 cubic yards of material. The spillway, located at the left abutment, is a reinforced concrete structure with a capacity of 2,700 cubic feet per second. The total capacity of the reservoir is 31,060 acre-feet.

Box Butte Dam and Reservoir

Dunlap Diversion Dam

Dunlap Diversion Dam is located on the Niobrara River 8 miles downstream from Box Butte Dam. This structure has a reinforced concrete weir with a crest 80 feet long and a structural height of 12.6 feet.

Mirage Flats Canal, Distribution, and Drainage System

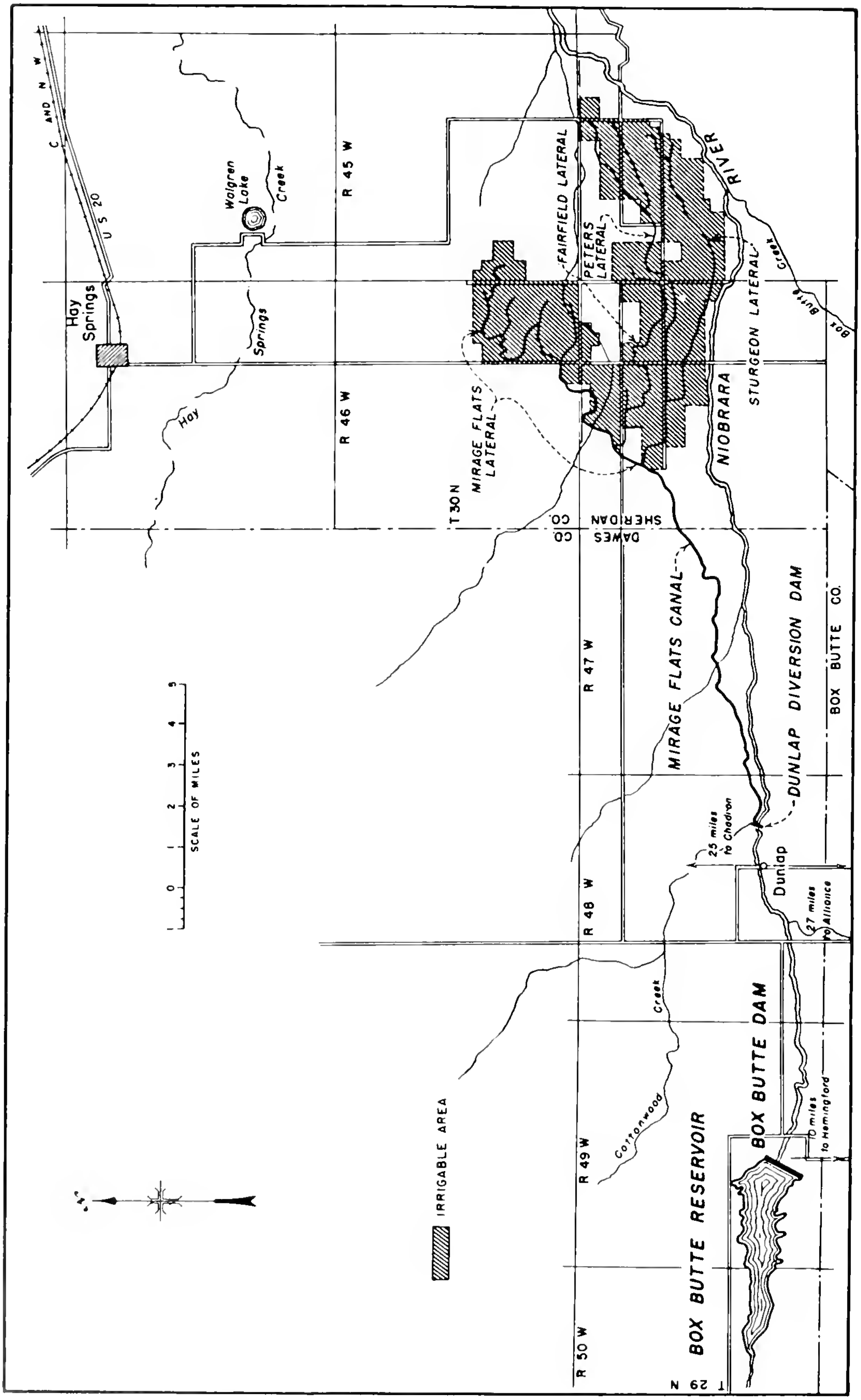
The Mirage Flats Canal extends from the diversion dam to the beginning of the irrigable land, a distance of approximately 13.2 miles, where the first large lateral, the Sturgeon, diverts water from the canal. The canal continues for 1.2 miles. Design capacity of the first 12 miles of the canal is 220 cubic feet per second. Major structures on the canal include five concrete siphons, a Parshall flume, spillway structures, bridges, and turnouts. There are four main laterals in the distribution system, totaling approximately 47.2 miles in length. Three drains, totaling 14 miles in length, carry floodwater and farm wastewater from the project area; the longest is 6.5 miles, and has a capacity of 400 cubic feet per second.

DEVELOPMENT

Early History

The Dakota Indians were in possession of the area until 1877. At that time, the gold rush to the Black Hills began and the Federal Government placed the Indians on the Pine Ridge Reserve in South Dakota. Cattlemen started establishing large ranches on the open range in 1878. Operations of the early cattlemen were reduced by settlers seeking homesteads in 1883.

The early homesteaders experienced a few years of good crops and immigration was greatly stimulated. By 1885,



Mirage Flats Project

there was a homesteader on nearly every quarter section. The period of rapid settlement and good crops was followed by a severe drought, culminating in extremely dry years in 1893-94. Total failure of all crops resulted and there was a general abandonment of homesteads and decline of population.

Until 1920, the Mirage Flats area was almost entirely in one ownership. About 1920, the owners began a campaign to bring settlers into the area and to divide the land into small farm units.

Investigations

The 1930-36 drought resulted in crop failures and a revival of interest in irrigation. The Bureau of Reclamation was requested to investigate the area to determine the feasibility of constructing an irrigation project. Detailed investigations were conducted and a report issued in 1939, which served as the basis for authorization of the project.

Authorization

The project was authorized by the President on April 26, 1940, under the terms of the Water Conservation and Utilization Program (act of May 10, 1939, 53 Stat. 685). Completion of the project under the act of August 11, 1939, was approved by the President on July 13, 1944.

Construction

Construction of the dam and reservoir was started in January 1941, using Works Projects Administration labor. All construction was suspended by the War Production Board order of December 1942. Construction was resumed in 1944 by approval of the President and was completed in 1946. Construction of the distribution system was completed in late 1948.

Operating Agency

The Mirage Flats Irrigation District operates and maintains the project.

BENEFITS

Irrigation

Development of the project has stabilized the agricultural economy of the area, resulting in larger farm populations and increased employment in related industries.

Recreation

The lake created by the Box Butte Dam is ideal for aquatic and outdoor sports. The high temperatures that

Dunlap Diversion Dam

prevail during summer, and the cleanliness of the fresh water in the reservoir combine to make the lake an attractive spot for swimming, boating, aquaplaning, and similar water sports. Many varieties of game fish abound in the lake, such as large-mouth bass, Great Northern pike, rainbow trout, walleyed pike, and crappie. There are locations suitable for picnicking around the lakeshore.

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service .... 11,662 acres
Number of irrigated farms 54

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value,[1] dollars
1968	10,876	845,693
1969	10,795	912,534
1970	10,740	947,502
1971	10,621	1,108,769
1972	10,188	781,032
1973	10,852	1,824,867
1974	10,977	2,791,900
1975	10,950	2,619,736
1976	11,072	1,874,932
1977	11,197	2,347,972

[1]Includes additional revenue.

Facilities in Operation

Storage dams 1
Diversion dams 1
Canals .... 13.2 mi
Laterals .... 47.2 mi
Drains .... 14 mi

Climatic Conditions

Annual precipitation	15.1	in
Temperature:		
Maximum	104	°F
Minimum	−32	°F
Mean	47	°F
Growing season	129	days
Elevation of irrigable area	3800.0	ft

Settlement

Number of persons served with project water (1977):		
Farm irrigation service	216	

ENGINEERING DATA

Water Supply

NIOBRARA RIVER

Drainage area above Box Butte Dam	1,260	mi²
Annual discharge at Box Butte Dam:		
Maximum (1949)	27,780	acre-ft
Minimum (1947)	10,040	acre-ft
Average	19,230	acre-ft
Average annual diversion	16,800	acre-ft

Storage Facilities

BOX BUTTE DAM

Type: Zoned earthfill
Location: On Niobrara River about 10 mi north of Hemingford, Nebr.
Construction period: 1941-46
Date of closure (first storage): April 3, 1942

Reservoir, Box Butte:		
Average annual inflow	22,145	acre-ft
Total capacity to El. 4007	31,060	acre-ft
Active capacity, El. 3969 to 4007	28,785	acre-ft
Surface area	1,600	acres
Dimensions:		
Structural height	87	ft
Hydraulic height	52	ft
Top width	24	ft
Maximum base width	410	ft
Crest length	5,508	ft
Crest elevation	4024.0	ft
Total volume	1,422,000	yd³
Spillway: For service, uncontrolled concrete crest, conduit and chute at left abutment; for emergency, open cut with earth plug next to service spillway in left abutment.		
Crest length	75	ft
Crest elevation	4007.0	ft
Capacity at El. 4015	2,700	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by one 39-in-square high-pressure slide gate.		
Capacity at El. 4007	420	ft³/s

Diversion Facilities

DUNLAP DIVERSION DAM

Type: Concrete weir, embankment wing
Location: On the Niobrara River, near Dunlap, Nebr.
Year completed: 1945

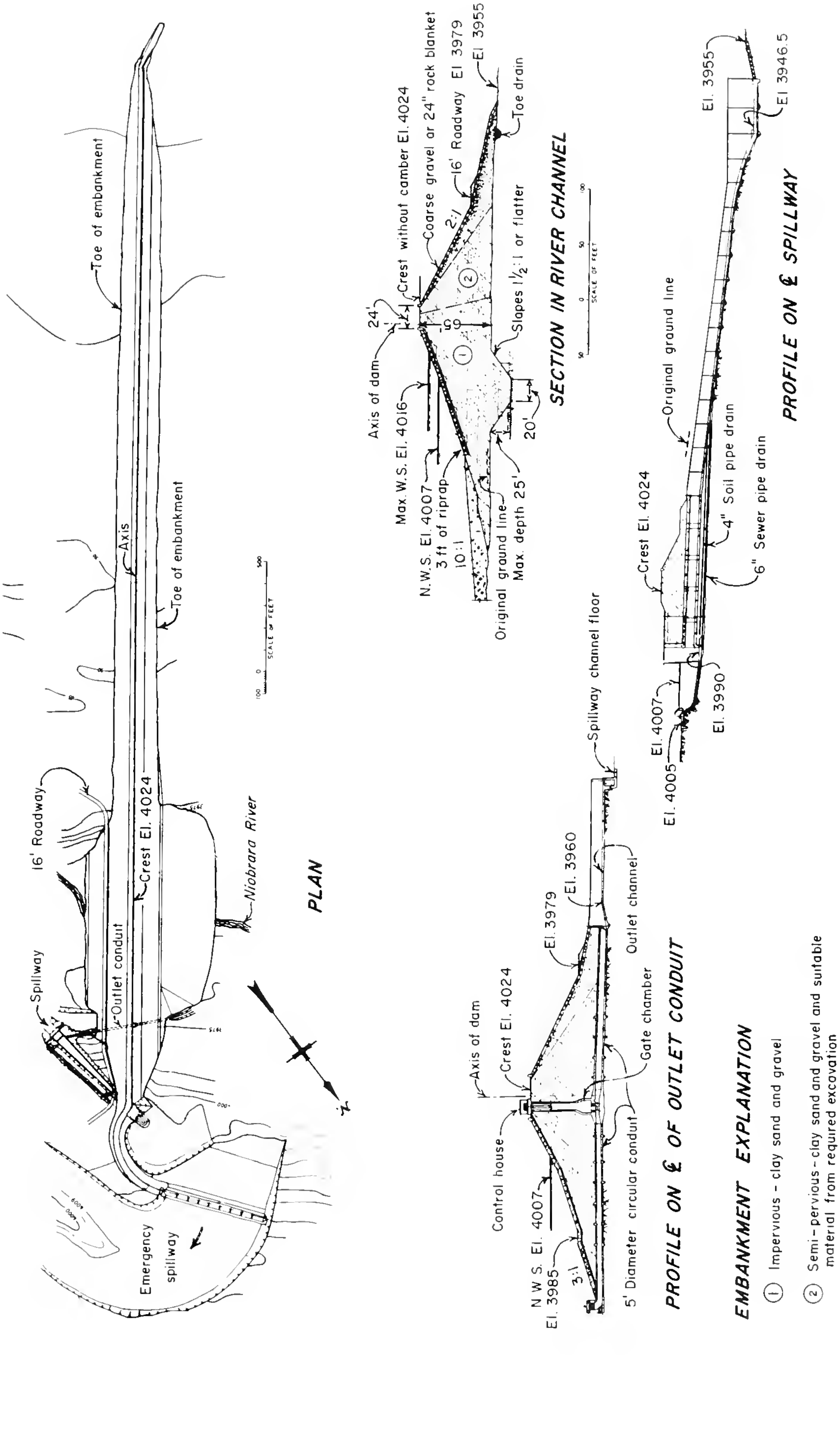
Dimensions:		
Structural height	12.6	ft
Weir height above streambed	6	ft
Weir crest length	80	ft
Crest elevation	3873.3	ft
Volume:		
Earth	5,100	yd³
Concrete	1,300	yd³
Spillway: Overflow weir		
Capacity at water surface El. 3877	2,500	ft³/s
Headworks: At left end of dam on centerline of Mirage Flats Canal. Two 10-ft-square radial gates (one for sluiceway)		
Diversion capacity	220	ft³/s

Carriage Facilities

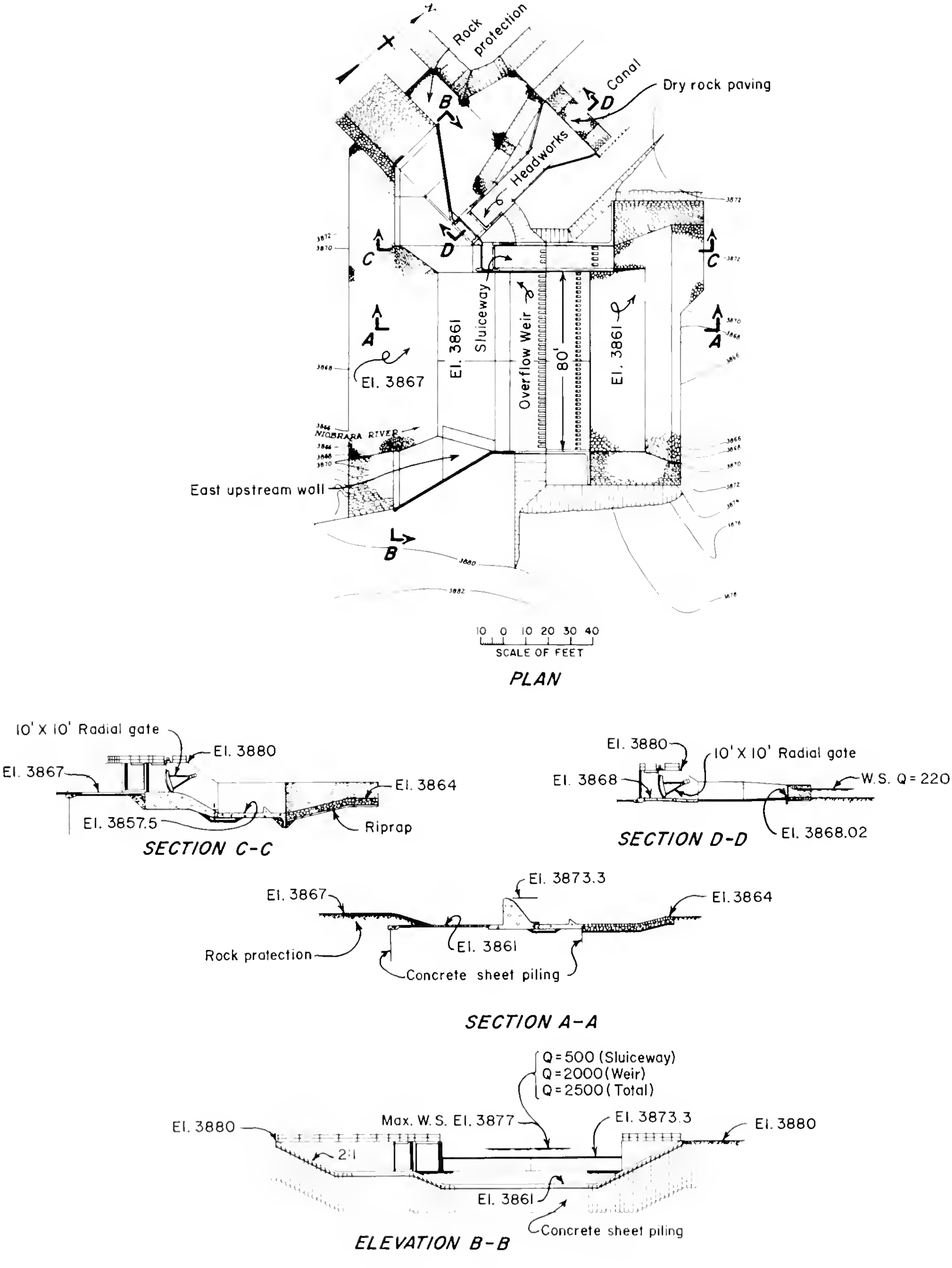
MIRAGE FLATS CANAL

Location: From Dunlap Diversion Dam near Dunlap, Nebr., generally east along the Niobrara River.

Length	13.2	mi
Capacity	220	ft³/s



Box Butte Dam, Plan and Sections

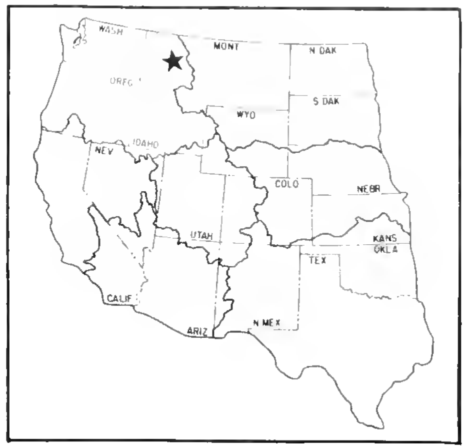


Dunlap Diversion Dam, Plan and Sections

Missoula Valley Project

Montana: Missoula County

Pacific Northwest Region
Water and Power Resources Service



The Big Flat Unit of the Missoula Valley Project is in west-central Montana about 7 miles west of the city of Missoula. The unit lands are parallel and adjacent to Clark Fork River, which is known locally as the Missoula River.

The project furnishes irrigation water from the Bitterroot River for 780 acres of land. The principal project feature is Big Flat Canal and headworks.

PLAN

Water is diverted from the Bitterroot River at a point 5 miles southwest of Missoula into the Big Flat Canal, which conveys the water to the project lands. The canal headworks are located on the canal about 450 feet below the point of diversion.

Big Flat Canal and Distribution System

The Big Flat Canal is 9.3 miles long and extends about 5 miles to the upper end of the irrigable area and about 4 miles within the irrigable area. One mile of concrete bench flume has been constructed on the upper 5 miles of the canal. The canal has an initial capacity of 39 cubic feet per second to the headworks and 25 cubic feet per second below the headworks. Two miles of laterals complete the distribution system.

DEVELOPMENT

Early History

Irrigation has been practiced in the Missoula Valley since the founding of the city of Missoula in 1864. Many years ago, a canal diverted water from the south bank of the Clark Fork River, about 3 miles above the present dam of the Montana Power Company at Bonner. The canal followed down the south side of the canyon, and around the southeast corner of Missoula. When the Chicago, Milwaukee, St. Paul, and Pacific Railroad was built into the valley in 1909, this canal was purchased and the right-of-way was used for a roadbed. Another canal diverted from Rattlesnake Creek and crossed through the center of Missoula to irrigate the area west of the city. As the city grew, the canal had to be abandoned. Other canals diverted from Grant Creek and Butler Creek to irrigate parts of the valley; however, recent dry years and increased diversion of water from the headwaters has made use of these creeks impracticable for farming.

Investigations

Investigation of the Big Flat Unit was started in 1939 at the request of local interests. Surveys were made by the Works Progress Administration, assisted by the Montana State Water Conservation Board. The Bureau of Reclamation classified the lands and prepared cost estimates.

Authorization

Construction of the Missoula Valley Project in Missoula County, Montana, was approved by the President on May 10, 1944, under authority of the Water Conservation and Utilization Act of August 11, 1939 (53 Stat. 1418), as amended, particularly by the act of July 16, 1943.

Construction

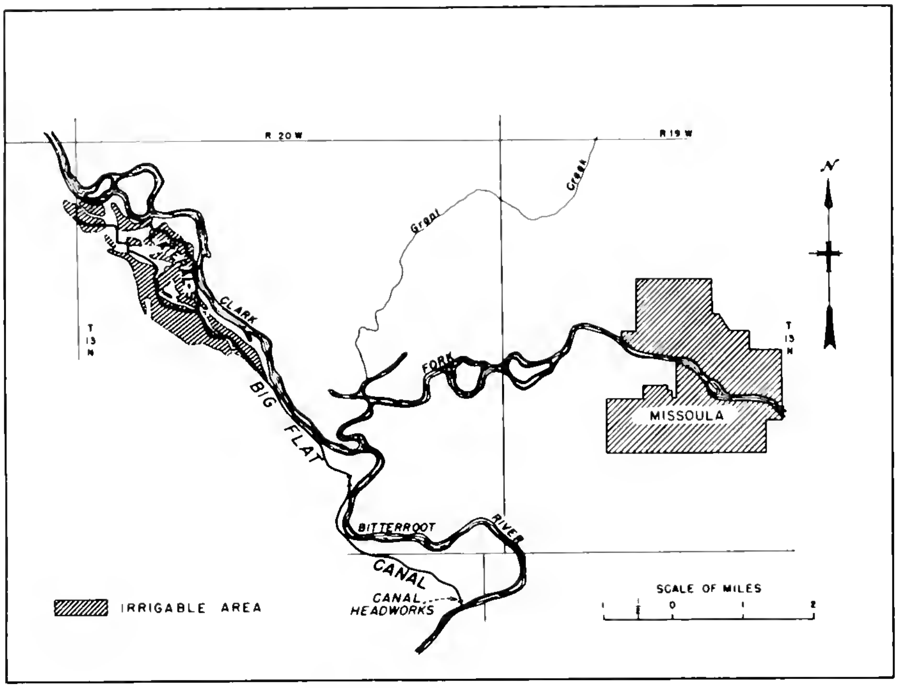
Construction of the project began on June 7, 1945, and was completed in 1949.

Operating Agency

The Big Flat Irrigation District operates and maintains the project.

BENEFITS

Suburban development for rural homesites in the northern portion of the project area has increased in recent years. Subdividing is expected to continue. Hay, grain, and pasture are the principal crops within the irrigated areas.



Missoula Valley Project

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service . . . . 780 acres
Number of irrigated farms 4

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	300	15,405
1969	300	15,316
1970	331	16,398
1971	325	16,787
1972	325	20,348
1973	325	31,860
1974	325	28,440
1975	325	29,407
1976	230	23,438
1977	230	23,520

Facilities in Operation

Canals . . . . 9 mi
Laterals . . . . 2 mi

Climatic Conditions

Annual precipitation . . . . 13.1 in
Temperature:
Maximum . . . . 103 °F
Minimum . . . . −30 °F
Mean . . . . 44 °F
Growing season . . . . 142 days
Elevation of irrigable area . . . . 3100.0 ft

Settlement

Number of persons served with project water (1977):
Farm irrigation service 18
Other water service[1] 150
Total 168

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

BITTERROOT RIVER

Drainage area above diversion point for Big Flat Canal . . . . 2,950 mi²
Annual discharge above confluence with Clark Fork:
Maximum (1976) . . . . 2,730,000 acre-ft
Minimum (1937) . . . . 834,000 acre-ft
Average . . . . 1,794,000 acre-ft
Average annual diversion, 1963-77 . . . . 2,734 acre-ft

Carriage Facilities

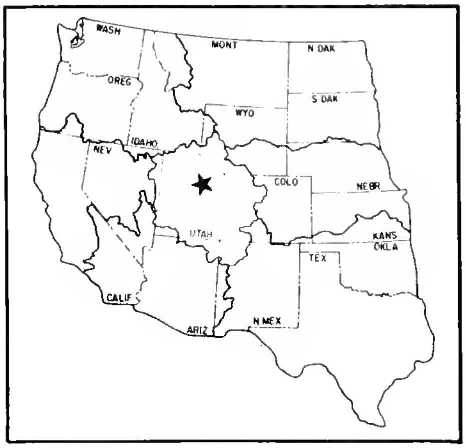
BIG FLAT CANAL

Location: From intake on Bitterroot River about 5 mi southwest of Missoula, Mont., generally northwest along west side of Bitterroot and Clark Fork Rivers.
Construction period: 1945-49
Length . . . . 9.3 mi
Diversion capacity . . . . 25 ft³/s
Typical maximum section in earth:
Bottom width . . . . 5 ft
Side slopes 1.5:1
Water depth . . . . 2.2 ft
Typical maximum section, concrete bench flume:
Bottom width . . . . 4 ft
Side slopes: Vertical
Water depth . . . . 2.2 ft
Lining thickness . . . . 5 in

Moon Lake Project

Utah: Duchesne and Uintah Counties

Upper Colorado Region
Water and Power Resources Service



The Moon Lake Project is in northeastern Utah on the north side of the Duchesne River about 140 miles east of Salt Lake City, Utah. The facilities of the project include Moon Lake Dam on the West Fork of the Lake Fork River; Yellowstone Feeder Canal extending from the East Fork of Lake Fork easterly to Cottonwood Creek, a tributary of the Uinta River; Midview Dam and Dike which form an offstream reservoir; Midview Lateral which connects Midview Reservoir with the Lake Fork; and the Duchesne Feeder Canal which carries water to Midview Reservoir and the Lake Fork River. The project provides supplemental irrigation water for 75,256 acres of land in Duchesne and Uintah Counties.

PLAN

The project stores water in Moon Lake and Midview Reservoirs to supplement the water supply for land along the Lake Fork and Uinta Rivers. The Duchesne Feeder Canal conveys water to the Midview Reservoir, and other canals and laterals deliver water to natural channels to improve the water supply at strategic points throughout the irrigable area.

Moon Lake Dam and Reservoir

Moon Lake Dam and Reservoir

Moon Lake Dam is an earthfill, rock-faced dam with a structural height of 101 feet and a volume of 513,000 cubic yards. Moon Lake Reservoir, on the West Fork of the Lake Fork of the Duchesne River, has a total capacity of 49,500 acre-feet.

Yellowstone Feeder Canal

The Yellowstone Feeder Canal conveys water from the East Fork of the Lake Fork to the west branch of Cottonwood Creek. The canal has a capacity of 88 cubic feet per second and a length of 22.5 miles, which includes 2 miles of natural channel.

Midview Dam, Dike, and Reservoir

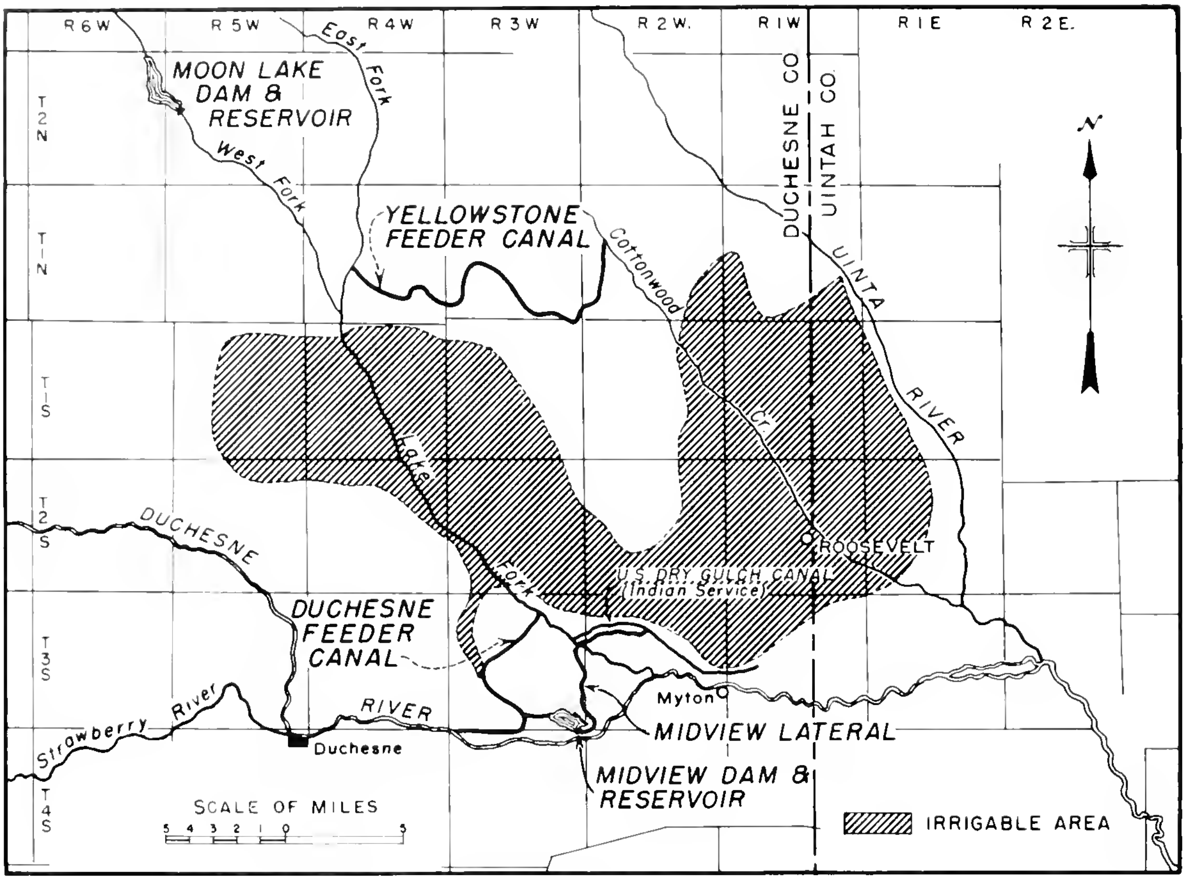
Midview Dam and Dike form a 5,800-acre-foot-capacity, offstream reservoir about 12 miles east of Duchesne, Utah. The dam is an earthfill, rock-faced structure, 54 feet high, with a volume of 139,000 cubic yards. The dike has a volume of 86,000 cubic yards.

Duchesne Feeder Canal

Duchesne Feeder Canal conveys surplus water from the Duchesne River to Midview Reservoir and to lands along the Lake Fork River. The canal has a diversion capacity of 200 cubic feet per second and a length of 15 miles.

Midview Lateral

Midview Lateral conveys water released from Midview Reservoir to the U.S. Dry Gulch (Bureau of Indian Affairs) Canal for exchange purposes. The lateral has a diversion capacity of 80 cubic feet per second and a length of 9 miles.



Moon Lake Project

DEVELOPMENT

Early History

Prior to the arrival of pioneers in 1905, Indian inhabitants had established water rights for the irrigation of their lands throughout the Uinta and Duchesne River Basins. As the settlers began to irrigate, it became apparent that the flow of the streams was insufficient to satisfy the existing Indian rights and also to irrigate some 70,000 acres owned by the settlers.

Investigations

Local interests made some investigations during 1922-25. In June 1927, the Utah Water Storage Commission entered into a cooperative contract with the Bureau of Reclamation for the investigation and planning of the Moon Lake Project. A report of this cooperative investigation was submitted by the Utah Water Storage Commission to the Federal Emergency Administration of Public Works in 1933, with the result that an allotment was made available for construction.

Authorization

Moon Lake Project was approved by the President on November 6, 1935. The project was initiated under provisions of the National Industrial Recovery Act of 1933 and an allotment of funds for construction was made on November 29, 1933.

Construction

On June 22, 1934, a contract was executed with the Moon Lake Water Users' Association providing for construction, repayment of cost, and operation and maintenance of Moon Lake Dam and appurtenant works. On December 7, 1935, the contract was amended to include Midview Dam, Duchesne Feeder Canal, and Yellowstone Feeder Canal. Construction was initiated on Moon Lake Dam on May 7, 1935, and was substantially completed on May 29, 1938. Midview Dam, Duchesne Feeder Canal, and Yellowstone Feeder Canal (except for 2.5 miles of the Yellowstone Feeder Canal constructed by the association) were constructed by Civilian Conservation Corps during 1935-41. The project has been in operation since 1938.

Operating Agencies

Operation and maintenance of Moon Lake Reservoir and Yellowstone Feeder Canal and conveyance canals were assumed in 1938 by the Moon Lake Water Users Association. Operation of the Duchesne Diversion Dam and

Feeder Canal and the Midview Reservoir and Lateral was assumed by the Bureau of Indian Affairs in 1967.

BENEFITS

Irrigation

Principal crops produced are wheat, alfalfa, oats, barley, and pasture. These crops are used as feed for livestock, primarily beef cattle, sheep, and dairy cattle. Project water furnishes a late season supply, adding stability to farming operations.

Recreation and Fish and Wildlife

Moon Lake Reservoir, high in the Uinta Mountains in the Ashley National Forest, is probably the most picturesque of Utah's manmade lakes. Overnight lodging accommodations are available at a privately operated lodge with cabins. Camping, picnicking, and boating facilities are available. There is trout fishing and seasonal big game hunting on the adjacent area.

Midview Reservoir is used locally for picnicking, swimming, boating, and fishing. The area had 91,550 visitor days during 1977.

Midview Dam

Midview Reservoir

PROJECT DATA

Land Areas (1977)

Irrigable area:

Supplemental irrigation service	75,256 acres
Number of irrigated farms	450

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	66,585	2,308,633
1969	65,059	2,745,685
1970	66,443	3,156,625
1971	66,058	3,572,192
1972	66,066	4,484,522
1973	66,596	9,221,995
1974	61,307	3,609,803
1975	62,460	5,002,042
1976	63,690	4,844,687
1977	[1]52,583	[1]4,844,784

[1]Area irrigated and crop value reduced because of 1976-77 drought.

Facilities in Operation

Storage dams	2
Diversion dams	1
Canals	37.5 mi
Laterals	9 mi

Climatic Conditions

Annual precipitation	7.2 in
Temperature:	
Maximum	103 °F
Minimum	−39 °F
Mean	46 °F
Growing season	135 days
Elevation of irrigable area	5000-7000.0 ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	1,574
Urban, suburban, and industrial service	5,460
Total	7,034

ENGINEERING DATA

Water Supply

Duchesne River

Drainage area at Duchesne	660 mi²
Annual discharge:	
Maximum (1952)	416,100 acre-ft
Minimum (1948)	197,900 acre-ft
Average	284,600 acre-ft

West Fork of the Lake Fork River

Drainage area at Moon Lake Reservoir	110 mi²
Annual discharge:	
Maximum (1965)	135,200 acre-ft
Minimum (1977)	13,715 acre-ft
Average	86,800 acre-ft

East Fork of the Lake Fork (Yellowstone Creek)

Drainage area near Altona	131 mi²
Annual discharge:	
Maximum (1952)	149,300 acre-ft
Minimum (1946)	75,950 acre-ft
Average	99,980 acre-ft

Uinta River

Drainage area near Neola	181 mi²
Annual discharge:	
Maximum (1952)	183,100 acre-ft
Minimum (1946)	91,060 acre-ft
Average	129,700 acre-ft

Storage Facilities

Moon Lake Dam

Type: Zoned earthfill
Location: About 28 mi north of Duchesne, Utah, on the West Fork of Lake Fork, Duchesne River.
Construction period: 1935-38
Curb and parapet added 1940-41
Reservoir, Moon Lake:

Average annual inflow	90,100 acre-ft
Total capacity to El. 8137	49,500 acre-ft
Active capacity, El. 8137-8072	35,800 acre-ft
Surface area	770 acres
Dimensions:	
Structural height	101 ft
Hydraulic height	79 ft
Top width	35 ft
Maximum base width	745 ft
Crest length	1,108 ft
Crest elevation	8145.0 ft
Volume	513,000 yd³

Spillway: Concrete-lined open channel in right abutment, controlled by two 24- by 16-ft radial gates.

Elevation top of gates	8137.0 ft
Crest elevation	8121.0 ft
Capacity at El. 8137	10,000 ft³/s

Outlet works: Tunnel through right abutment, controlled by two 36-in needle valves.

Capacity at El. 8137	610 ft³/s

Midview Dam and Dike

Type: Zoned earthfill
Location: Offstream, about 12 mi east of Duchesne, Utah. The dike closes a low area on the northeast side of the reservoir.
Construction period: 1935-37
Reservoir, Midview:

Average annual inflow	16,300 acre-ft
Total capacity to El. 5260	5,800 acre-ft
Active capacity, El. 5260-5222.5	5,800 acre-ft
Surface area	405 acres

Dimensions:	*Dam*	*Dike*
Structural height	54 ft	21 ft
Hydraulic height	40 ft	15 ft
Top width	30 ft	27 ft
Maximum base width	280 ft	132 ft
Crest length	663 ft	2,575 ft
Crest elevation	5268.0 ft	5266.0 ft
Volume	139,000 yd³	86,000 yd³

Spillway: Emergency spillway only, located west of the left end of the dike.
Outlet works: Concrete conduit through base of dam, controlled by 2.1- by 3-ft slide gate. Capacity is limited by capacity of outlet canal.

Capacity	80 ft³/s

Diversion Facilities

Duchesne Feeder Canal Diversion Dam

Type: Concrete weir, embankment wings

Location: On the Duchesne River, about 5 mi east of Duchesne, Utah.

Year completed: 1939

Dimensions:

Hydraulic height	6 ft
Weir length	220 ft
Crest elevation	5375.5 ft
Volume	4,000 yd^3
Diversion capacity	200 ft^3/s

Headworks: One 12-ft-square radial gate in canal headworks. Two 10- by 6-ft radial gates in sluiceway.

Carriage Facilities

Duchesne Feeder Canal

Location: From the Duchesne River about 6 mi from Duchesne, Utah, to Midview Reservoir, then generally northeast to Lake Fork of Duchesne River.

Construction period: 1934-35

Length	15 mi
Diversion capacity	200 ft^3/s

Typical maximum section in earth:

Bottom width	14 ft
Side slopes	1.5:1
Water depth	3.4 ft

Yellowstone Feeder Canal

Location: From point on the East Fork of Lake Fork generally east about 20 mi to the Uinta River.

Construction period: 1938-40

Length	22.5 mi
Diversion capacity	88 ft^3/s

Typical maximum section in earth:

Bottom width	7 ft
Side slopes	1.5:1
Water depth	3 ft

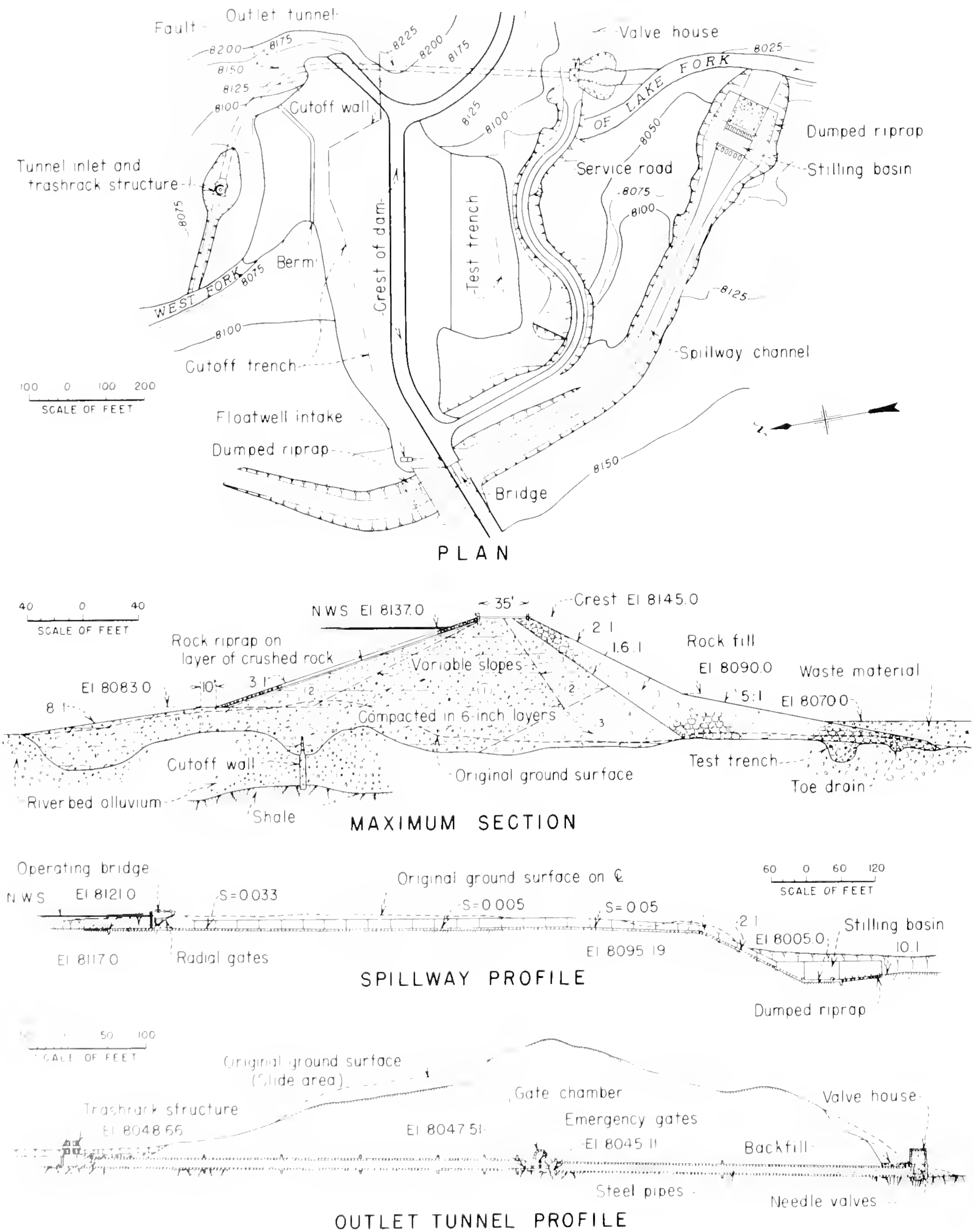
Midview Lateral Canal

Location: From Midview Reservoir north past the Lake Fork of Duchesne River.

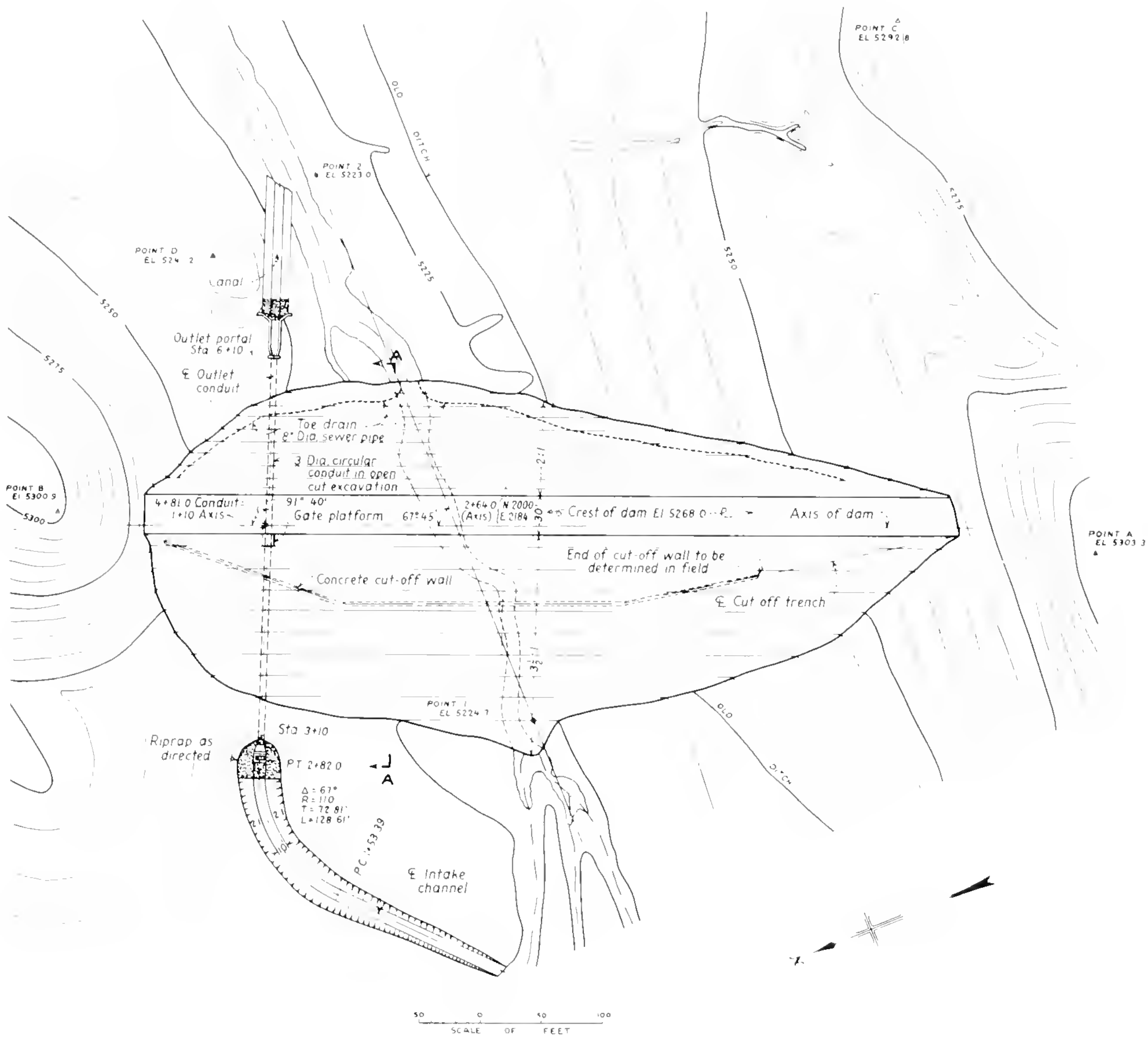
Length	9 mi
Diversion capacity	80 ft^3/s

Typical maximum section in earth:

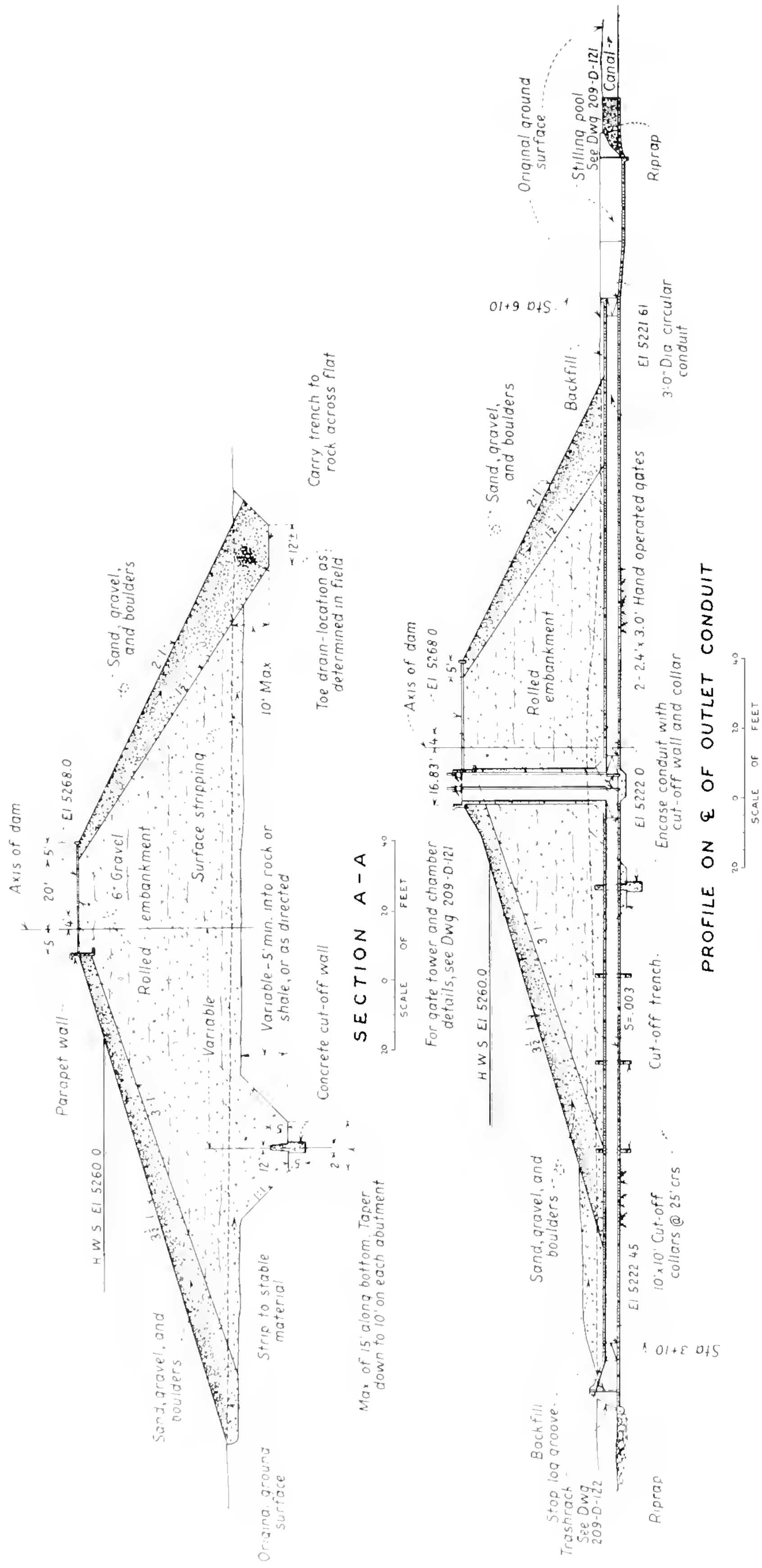
Bottom width	7 ft
Side slopes	1.5:1
Water depth	3 ft



Moon Lake Dam, Plan and Sections



Midview Dam, Plan

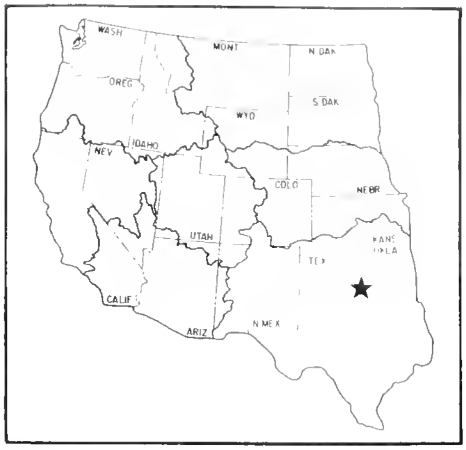


Midview Dam. Sections

Mountain Park Project

Oklahoma: Jackson, Kiowa, and Tillman Counties

Southwest Region
Water and Power Resources Service



The Mountain Park Project provides a supplemental municipal and industrial water supply to the Oklahoma cities of Altus, Snyder, and Frederick. The project also provides flood control, recreation, and fish and wildlife benefits. Principal features are Mountain Park Dam, on West Otter Creek in Kiowa County about 6 miles northwest of Snyder, Okla., two pumping plants, and an aqueduct system to service the three cities. Project facilities include Bretch Diversion Dam on Elk Creek in Kiowa County and Bretch Diversion Canal, which divert and convey Elk Creek flow into the watershed upstream from Mountain Park Dam to supplement the natural flow of West Otter Creek into Tom Steed Reservoir.

PLAN

Mountain Park Dam forms Tom Steed Reservoir, and regulates natural flows of West Otter Creek and diverted flows from Elk Creek to provide municipal and industrial water supplies for the cities of Altus, Snyder, and Frederick, Okla. The water is conveyed from the reservoir to the project cities through an aqueduct system that consists of 40 miles of pipeline, two pumping plants, a chlorination station, and other appurtenant facilities.

Mountain Park Dam

Mountain Park Dam is located just upstream of Snyder Dam, on Otter Creek near Mountain Park, Okla. Snyder Lake was drained to accommodate construction of Mountain Park Dam, then restored upon completion of construction. The lake is maintained at sufficient elevation to provide tailwater to stilling water released or spilled from the dam.

A thin double-curvature concrete arch flanked by concrete thrust blocks, Mountain Park Dam is 535 feet in length with a maximum structural height of 133 feet. This dam and the rolled earth East and West Dike embankments, which extend 10,630 feet and 13,233 feet, respectively, form the Tom Steed Reservoir. The reservoir has a total capacity of 117,825 acre-feet, an active capacity of 109,276 acre-feet, and a surface area at the top of conservation pool of approximately 6,400 acres.

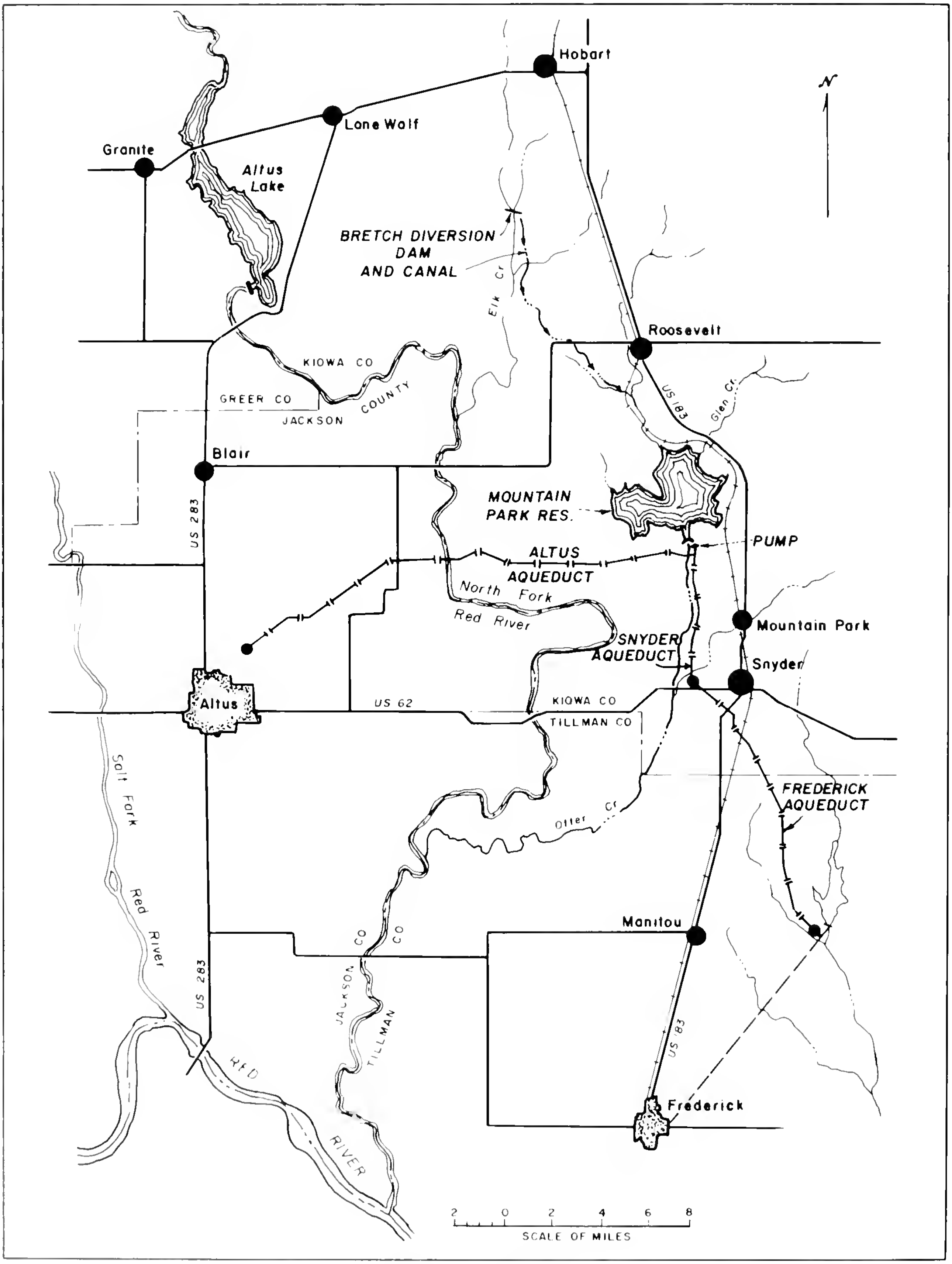
The outlet works for Mountain Park Dam is in the left thrust block and includes three outlet pipes, trashracks, fish screens, emergency and operating slide gates, and motor-operated gate hoists. A 42-inch-diameter, joint-use outlet pipe is provided to release water into the aqueduct system; an 84-inch-diameter flood outlet pipe and a 15-inch-diameter river outlet pipe are provided to release floodwater and small streamflows. The joint-use outlet to the aqueduct system contains two gated intakes at elevations 1382.0 and 1401.0 to permit selection of the level of the reservoir from which water is to be withdrawn; water from both levels may be mixed. This outlet also is provided with fish screens.

The concrete arch portion of Mountain Park Dam functions as an uncontrolled, overflow spillway. The crest is at the top of the exclusive flood control pool at elevation 1414.0, and is 320 feet long measured along the axis of the dam. Concrete piers and training walls at each end of the spillway direct floodwater into and over the crest. Floodwaters fall into a plunge pool energy dissipator at the toe of the dam. The spillway is designed for a maximum discharge of 38,300 cubic feet per second with the reservoir at elevation 1423.6.

Bretch Diversion Dam

Bretch Diversion Dam is located on Elk Creek in Kiowa County about 24 miles northeast of Altus, Okla., and about 15 miles northwest of Mountain Park Dam. The dam diverts flows from Elk Creek into Bretch Canal for conveyance into Tom Steed Reservoir by way of Noname Creek and West Otter Creek.

This concrete diversion structure has canal headworks and a concrete wing wall on the left abutment, stream control gates in the center section, and a rolled earthfill dike extending from the concrete structure across the flood plain 5,200 feet to the right abutment. The canal headworks include trashracks at the five-bay intake, and



Mountain Park Project

an 18-foot-square radial gate for controlling flows into Bretch Canal, which is designed for a flow of 1,000 cubic feet per second.

The stream control gates include two 27- by 21-foot spillway radial gates, one 10- by 21-foot sluiceway radial gate, and one 24-inch-diameter bypass gate.

The rolled earthfill dike across the flood plain to the right abutment contains a low grass-covered section which provides an overflow spillway with a crest length of 3,620 feet.

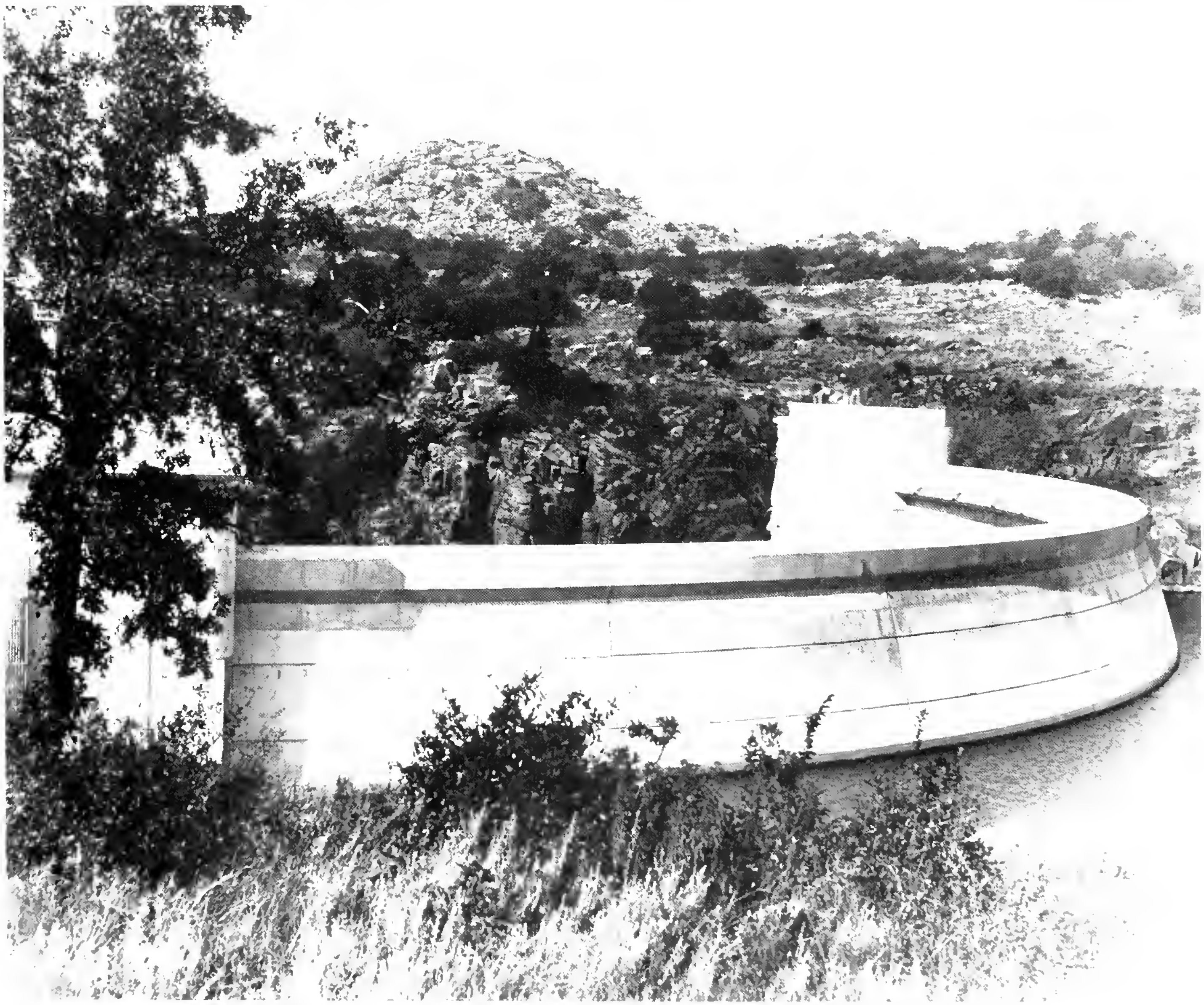
Bretch Diversion Canal

Bretch Diversion Canal begins at Bretch Diversion Dam and runs generally south and southeast to Noname Creek. The concrete-lined canal is 9.48 miles long and has a capacity of 1,000 cubic feet per second. Safety ladders are provided at 750-foot intervals; a safety net and cable are provided at each siphon inlet.

Aqueduct System

The aqueduct system is designed to convey water from Tom Steed Reservoir to the cities of Altus, Snyder, and Frederick, Okla., for municipal and industrial use.

The Altus and Snyder Aqueducts are supplied water from Tom Steed Reservoir through a joint-use pipeline that is approximately 0.5 mile in length, and has a design capacity of 37.9 cubic feet per second. The pipeline conveys water by gravity to the Mountain Park rate-of-flow control station, where it receives primary chlorination and enters the Mountain Park forebay tank. Flow divides at the forebay tank; the water continues by gravity flow through the Snyder Aqueduct to the Snyder Ter-



Mountain Park Dam

minal. The Snyder Aqueduct includes 16-, 24-, and 27-inch pipe extending approximately 5.6 miles to the terminal. The design capacity of Snyder Aqueduct is 9.8 cubic feet per second of water to the Snyder-Frederick Regulating Tank, at which point the capacity is reduced to 1.7 cubic feet per second, and the water is conveyed to Snyder. The Frederick Aqueduct receives 8.1 cubic feet per second from the regulating tank at this point and conveys the flow through 16- to 27-inch pipe about 12 miles to the Frederick Terminal. Water for the city of Altus flows from the forebay tank to the adjacent Altus Pumping Plant, where it is lifted to the Altus Regulating Tank. The water then flows from the regulating tank by gravity to the Altus Terminal, which includes a rate-of-flow structure and a terminal storage tank. The 22-mile-long Altus Aqueduct includes 36- and 39-inch-diameter concrete cylinder pipe and has a design capacity of 24.3 cubic feet per second.

Appurtenances to the aqueduct system include a chlorination station, rate-of-flow control stations, regulating tanks, telemetering systems, air valve and blowoff structures, and cathodic protection test stations at selected locations along the pipelines.

Altus Pumping Plant

The Altus Pumping Plant consists of four horizontal centrifugal-type pumps, three units plus one standby, driven by electric motors. The pumping plant building, constructed of precast concrete tees on a concrete foundation, also houses the electrical control center for automatic operation of the plant, and includes a chlorination room and chlorine storage room at one end of the building. Each of the pumps is designed for a unit capacity of 8.5 cubic feet per second against a rated head of 140 feet.

The Altus Pumping Plant is unattended. A telemeter receives water level data from the Altus Regulating Tank and starts and stops pumping units automatically according to demand.

Frederick Pumping Plant

The Frederick Pumping Plant consists of four horizontal centrifugal-type pumps, three units plus one standby, driven by electric motors. The structure is similar to the Altus Pumping Plant except that chlorination facilities are not provided. Each of the pumps is designed for a rated capacity of 2.85 cubic feet per second against a rated head of 104 feet.

The Frederick Pumping Plant is unattended. A telemeter receives water level data from the upstream Snyder-Frederick Regulating Tank and from the downstream Frederick Regulating Tank. The pumps start and stop automatically to satisfy downstream demand as long as sufficient water is available in the upstream Snyder-Frederick Regulating Tank.

Investigations

Potential for development of the water resources of Otter Creek were recognized as early as 1903 when the Bureau of Reclamation mapped the Mountain Park damsite. In 1924, Reclamation investigated possibilities of developing Otter Creek for irrigation and reported adversely because of insufficient water supply from Otter Creek and excessive costs. A Corps of Engineers survey of the Red River Basin and tributaries was published in 1936 as House Document 378, 74th Congress, 2d session. No specific projects in the Elk or Otter Creek Basin were recommended for construction in that report. An unpublished report on the North Fork of Red River, dated July 1940, by the Corps of Engineers found that improvements necessary to alleviate flooding were not economically justified; that further irrigation studies should be deferred until such time as results of the W. C. Austin Project had been determined; that there was no need for stream pollution control, or for water supply facilities in addition to those existing or planned; and that improvements for hydro power and navigation were not warranted.

An inventory of land and water resources, needs and problems of the Red River Basin was initiated by the Bureau of Reclamation in fiscal year 1948. While these studies were underway, the Arkansas-White-Red Basin Interagency Committee was authorized by the Flood Control Act of 1950 to formulate a comprehensive long-range plan for development of the land, water, and other resources in those basins. Following establishment of the interagency committee, the investigation of the potential Mountain Park Project by the Bureau of Reclamation was carried out as a part of the overall basin study. The cooperative investigations undertaken by the various agencies resulted in a tentative plan which included the Mountain Park Reservoir on Otter Creek, a diversion dam on Elk Creek, a diversion canal between Elk and Otter Creeks, and distribution works to irrigate suitable lands near Tipton. The evaluated plan was found to be economically unjustified for for inclusion in the overall basin plan.

In late 1954 and early 1955, expressions of interest in the water resources of Otter and Elk Creeks as a source of municipal and industrial water supply were received from the cities of Altus, Frederick, and Tipton, Okla. As a result, a reconnaissance investigation of the Mountain Park Project was initiated early in 1955. The report did not advance a final plan for utilization of the water supplies that would be provided by reservoir construction.

Bretch Diversion Dam and Canal

In 1958, the cities of Altus, Frederick, Snyder, and Roosevelt expressed interest in a plan to obtain water from the Mountain Park Project. Detailed investigations of the project were initiated early in 1959.

In June 1961, a summary statement was prepared in advance of completing the feasibility report to provide a basis for the interested communities to participate in the project; the city of Roosevelt withdrew. The city of Frederick later withdrew from participation in the project because the long aqueduct system required would result in high water costs. The plan of development was therefore modified to exclude Roosevelt and Frederick, with identified users being limited to the cities of Altus and Snyder.

On August 24, 1962, a feasibility report was submitted. The Secretary's report on the project was transmitted to the President on May 12, 1964, and authorized on May 11, 1966.

On August 20, 1969, the decree forming the Mountain Park Master Conservancy District was amended to include the city of Frederick, Okla., and the plan of development was amended to include the Bretch Diversion Dam and Canal in the initial construction.

The final environmental statement was submitted to the Commissioner of Reclamation on April 13, 1971, and approval of the definite plan report was received June 22, 1971.

Authorization

The Mountain Park Project was authorized by Public Law 90-503, September 21, 1968 (82 Stat. 853). This authorization included aqueducts to serve the cities of Altus and Snyder, Okla. The authorization was amended to include an aqueduct to the city of Frederick, Okla., by Public Law 93-493 (88 Stat. 1492).

Construction

Construction began on Mountain Park Project in 1971 with the award of contracts for exploratory drilling, breaching Snyder Dam, warehouse and shop buildings, and minor contracts. Relocation contracts for power lines, highways, county roads, and railroads were initiated in 1972. Construction of Mountain Park Dam began with award of contract July 26, 1973, and was completed on June 20, 1975. Construction of Bretch Diversion Dam and Canal started with award of contract on September 12, 1975, and the work was essentially complete October 28, 1977.

Construction of the aqueduct system began with the award of contract for Altus Aqueduct and Pumping Plant on April 25, 1974; the contract was completed on May 26, 1976. The contract for the Frederick Aqueduct and Pumping Plant was awarded August 5, 1976, and is scheduled for completion in 1979.

Operating Agencies

The agency responsible for operation and maintenance of the project diversion, storage, and aqueduct system is the Mountain Park Master Conservancy District. The Oklahoma Tourism and Recreation Department administers the recreation areas and the Oklahoma Department of Wildlife Conservation administers the wildlife management areas.

BENEFITS

Municipal Water

Municipal water is furnished to the cities of Altus, Snyder, and Frederick, Okla.

Irrigation

No irrigation development is contemplated as part of the project.

Flood Control

Tom Steed Reservoir will effectively control all floods of record at Mountain Park damsite and will protect areas downstream to the mouth of East Otter Creek.

Recreation and Fish and Wildlife

The Oklahoma Tourism and Recreation Department administers 6,400 acres on the east and south shores of the reservoir. Public recreation facilities on the east side include shelters, tables, grills, a comfort station, a boat launching ramp, and a swimming beach. Proposed development includes a road around the east side of the reservoir connecting the east and south recreation areas. The area south of the dam along Otter Creek offers picnic facilities and a bridge across the creek which leads to a nature trail through large cottonwood, ash, elm, walnut, and pecan trees.

The Oklahoma Department of Wildlife Conservation administers 5,150 acres of the west and north side of the reservoir area. Waterfowl and dove are plentiful, and other upland game species are increasing as more food and cover are developed. An extensive tree and shrub planting program continues to increase wildlife habitat. The reservoir is one of the best fishing areas in southwest Oklahoma, offering catfish, crappie, largemouth black bass, and other varieties.

PROJECT DATA

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Pipelines	40	mi
Pumping plants	2	

Climatic Conditions

Average annual precipitation	26.5	in
Temperature:		
Maximum	120	°F
Minimum	−11	°F

Settlement

Number of persons served with project water (1977):	
Municipal and industrial	38,000

ENGINEERING DATA

Water Supply

Otter Creek

Drainage area	132	mi²
Annual discharge:		
Maximum	43,400	acre-ft
Minimum	0	acre-ft
Average	15,040	acre-ft

Elk Creek

Drainage area, above Hobart gage	549	mi²
Annual discharge:		
Maximum	107,100	acre-ft
Minimum	8,300	acre-ft
Average	47,870	acre-ft

Storage Facilities

Mountain Park Dam

Type: Thin, double-curvature concrete arch flanked by concrete thrust blocks
Location: On West Otter Creek in Kiowa County, southwestern Oklahoma, about 6 mi northwest of Snyder, Okla.
Construction period: 1973-75
Date of closure: June 20, 1975

Reservoir, Tom Steed:

Average annual inflow[1]	40,000	acre-ft
Storage space in the reservoir is allocated as follows:		
Dead capacity—Streambed to El. 1376.5	1,800	acre-ft
Inactive capacity—El. 1376.5-1386.3	6,749	acre-ft
Active conservation capacity—El. 1386.3-1411	88,971	acre-ft
Exclusive flood control capacity—El. 1411-1414	20,305	acre-ft
Surcharge capacity—El. 1414-1423.6	79,741	acre-ft
Surface area, El. 1411	6,402	acres
Dimensions:		
Structural height	133	ft
Hydraulic height	59	ft
Top width	6	ft
Maximum base width	17	ft
Crest length:		
Arch dam	320	ft
Thrust blocks	215	ft
Crest elevation	1423.6	ft
Total volume	17,750	yd^3
Spillway: Uncontrolled, overflow over the arch portion of the dam, free fall into a plunge pool energy dissipator at toe of dam.		
Crest elevation	1414.0	ft
Crest length	320	ft
Capacity at El. 1423.6	38,300	ft^3/s

Outlet works:

The outlet works consists of a stream outlet, flood outlet, joint-use outlet, and an intake structure in the left abutment thrust block. The intake structure consists of a concrete-walled structure with regulating and emergency gates for the outlets, fish screens, and trashracks. The stream outlet consists of a 30-in-square emergency slide gate and lift and a 20-in-diameter regulating slide gate and lift at the upper end of a 15-in-diameter steel outlet pipe. The flood outlet consists of a 108-in-square emergency slide gate and lift, and 84-in-diameter regulating slide gate and lift at the upper end of an 84-in-diameter outlet pipe. The joint-use outlet consists of a 60-in-square slide gate and lift and a 36- by 72-in slide gate and lift mounted on the face of the outlet works at El. 1382 and 1401. A 48-in-diameter slide gate and lift are mounted at the upper end of the 42-in-diameter joint-use pipeline.

[1]Varies with reservoir operation and water quality.

Diversion Facilities

Bretch Diversion Dam

Type: Concrete river control structure with canal headworks and a rolled earthfill dike extending across the flood plain		
Location: On Elk Creek, about 24 mi northeast of Altus, Okla.		
Construction period: 1975-77		
Dimensions:		
Structural height	35.5	ft
Hydraulic height	26.7	ft
Total crest length	5,192	ft
Crest elevation	1471.0	ft
Spillway: Low section in rolled earthfill dike seeded to grass, with a crest length of 3,620 ft. Two 27- by 21-ft radial gates in stream control structure and one 10- by 21-ft sluiceway radial gate. A 24-in-diameter bypass gate is provided to release small flows downstream.		
Headworks: In left abutment with one 18-ft-square radial gate.		
Diversion capacity	1,000	ft^3/s

Carriage Facilities

Bretch Diversion Canal

Location: From Bretch Diversion Dam generally south and southeast to Noname Creek.		
Construction period: 1975-77		
Length	9.5	mi
Capacity	1,000	ft^3/s
Typical maximum section (concrete lined):		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	9.63	ft
Lining thickness	3	in

Joint Use Pipeline

(Steel pipe encased in concrete and steel pipe with cement mortar coating)

Length	0.5	mi
Diameter	42	in

Altus Aqueduct

(Pretensioned concrete cylinder pipe)

Length	21.8	mi
Diameter	36 and 39	in

Snyder Aqueduct

(Pretensioned concrete cylinder pipe)

Length	5.5	mi
Diameter	16, 24, and 27	in

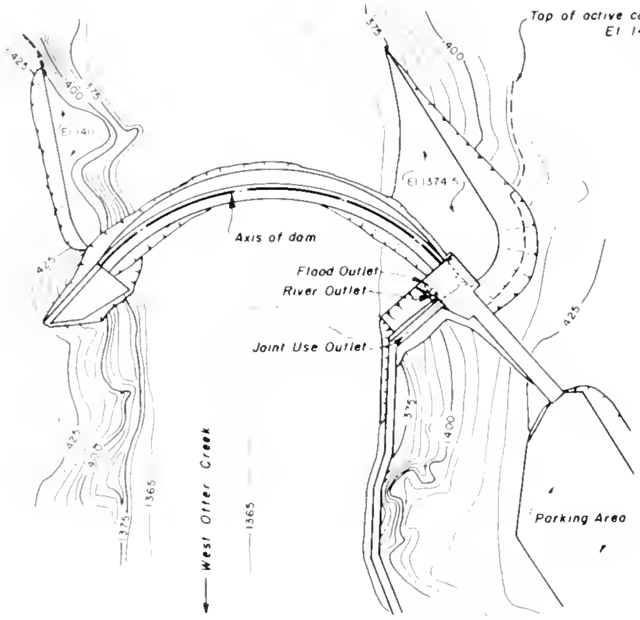
Frederick Aqueduct

(Asbestos cement pipe)

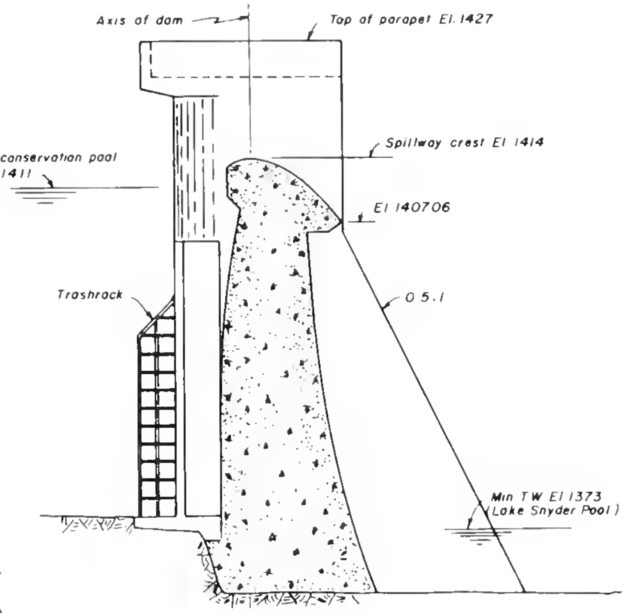
Length	12.2	mi
Diameter	16, 18, 24, and 27	in

Pumping Plants

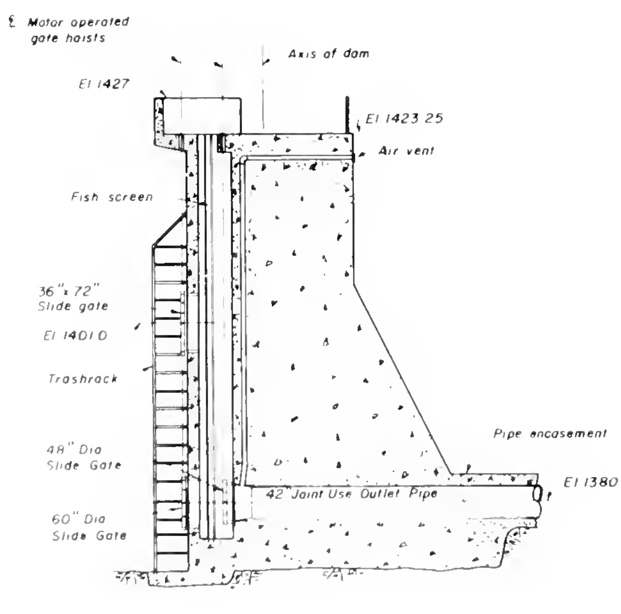
Designation	Number of units	Total capacity, ft^3/s	Rated head, ft	Total horsepower
Altus	3 (plus 1 standby)	25.3	140	800
Frederick	3 (plus 1 standby)	8.1	104	200



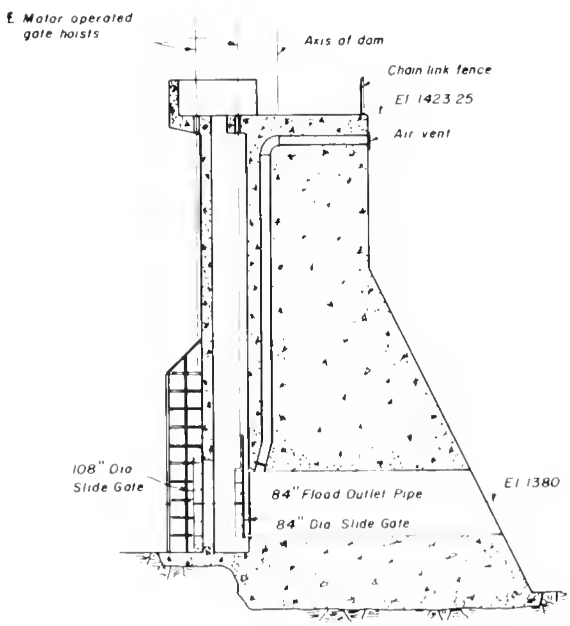
PLAN



SECTION
SPILLWAY AT LEFT ABUTMENT



SECTION - JOINT USE OUTLET



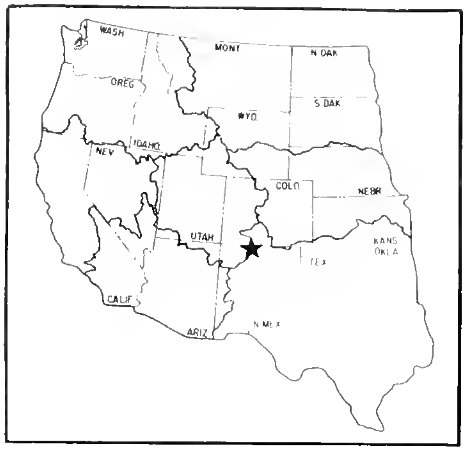
SECTION - FLOOD OUTLET

Mountain Park Dam, Plan and Sections

Navajo Indian Irrigation Project

New Mexico: San Juan County

Southwest Region
Water and Power Resources Service



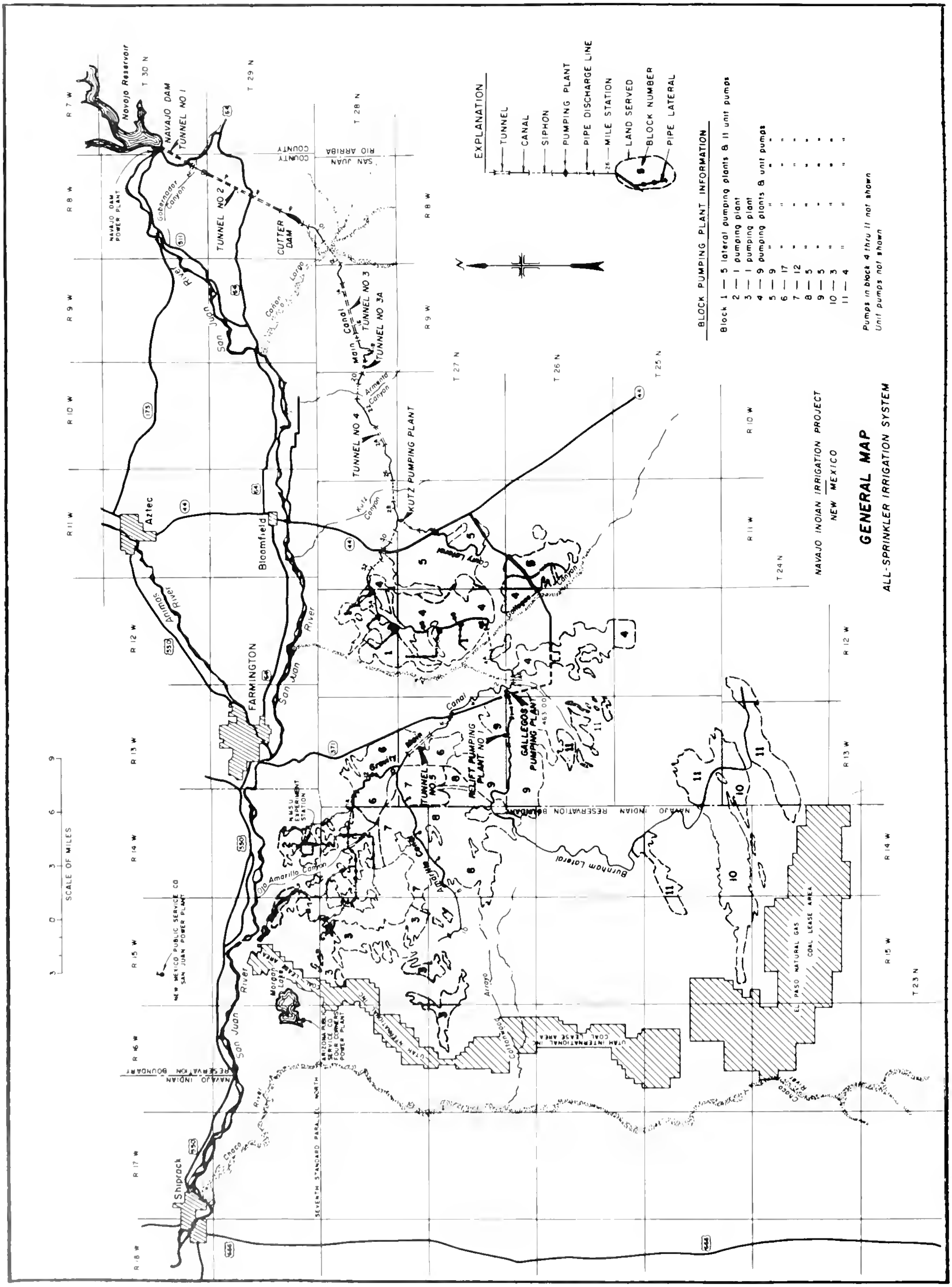
The Navajo Indian Irrigation Project is on an elevated plain south of the San Juan River, in San Juan County in northwestern New Mexico. It is bordered by New Mexico State Highway 44 on the east and the Chaco River on the west.

The project is being developed exclusively for Indian use on lands that lie on or adjacent to the Navajo Reservation. The Bureau of Reclamation is responsible for the design and construction of irrigation facilities through the turnouts at the individual farm units. The Bureau of Indian Affairs, in cooperation with the Navajo Tribe, will develop the farm units, farm distribution systems, drainage, and farm-to-market roads.

Based on an economic analysis made in 1973, the entire project is designed for full-sprinkler irrigation. Eleven blocks of approximately 10,000 acres each are being developed for irrigation.

This development will create a large municipal and industrial water use in the San Juan Basin. Therefore, the authorization provides for these uses in addition to irrigation, but stipulates that separate contracts for such uses must first be executed and approved by the Congress.

Cutter Dam and Reservoir



Navajo Indian Irrigation Project

PLAN

Irrigation water is released at Navajo Dam through a diversion headworks. When the project has been completed, the water will travel through a series of approximately 50.6 miles of open canals, 7 tunnels totaling 12.8 miles in length, 15 siphons totaling 7.1 miles in length, and a 1.5-mile-long in-line earth channel and reservoir behind Cutter Dam. Three pumping plants will lift water to lined laterals. At full capacity, the system will carry up to 1,800 cubic feet per second. Two lateral systems, totaling 40.6 miles in length, will convey water to the southern and eastern parts of the development.

Distribution of water on the lands is by underground pipe lateral systems. Estimates are that there will be a total of 340 miles of underground pipe laterals ranging in diameter from 6 to 84 inches.

Project plans include construction of a 23-megawatt powerplant and switchyard at Navajo Dam to furnish a part of the energy required by the project. Other electrical facilities include two substations and 164 miles of transmission and distribution lines which will have a capacity ranging from 2.4 to 115 kilovolts.

The drain system includes 200 miles of collector drains to handle 10- and 25-year frequency storm runoff and irrigation return flow.

Canal System

The Main Canal carries water to Blocks 1 and 4. In addition, it is designed to supply water to the Gravity Main Canal, the Amarillo Canal, and Burnham and Coury Laterals. When complete, Kutz Pumping Plant will lift water from the Main Canal east of New Mexico State Highway 44 to Coury Lateral which flows southward through Block 5. The Gravity Main Canal originates at the termination of the Main Canal at West Gallegos Wash and flows northwest approximately 14.5 miles where it services Blocks 2 and 6 with irrigation water. Amarillo Canal branches off the Gravity Main Canal at Amarillo Canyon and extends westward 11.2 miles to Blocks 3, 7, and 8. When constructed, Burnham Lateral will begin at West Gallegos Canyon, where the Gallegos Pumping Plant is designed to feed the lateral with water from the Gravity Main Canal; the water will be raised at Relift Pumping Plant No. 1. The lateral continues southward to supply Blocks 8, 9, 10, and 11. Its total length will be approximately 35 miles.

DEVELOPMENT

Early History

In the 14th or 15th century, the Navajo Indians spread southward into the "Navajo Nation." This has become the largest Indian reservation in the United States, encompassing about 24,000 square miles in Arizona, New Mexico, and Utah.

In the early 1600's, the Navajos had acquired sheep and horses from the Spaniards and developed skills in weaving and metalcraft. They remained nomadic, moving the sheep to new pastures when forage became scarce.

Federal troops which attempted to confine the Indians to definite living areas met with resistance. Treaties signed by representatives of the Navajos were not understood since those who signed them represented only a small segment of the Navajo people. After a number of years and misunderstandings, many of the Indians were sent about 700 miles south to Fort Sumner, N. Mex., although some small bands eluded their would-be captors. Those who were captured were allowed to return to their homes 3 years later, after the treaty of 1868 was ratified. The treaty provided that the Navajo Tribe could return to its homeland, and defined the lands on which the Navajos could live. The lands were fertile but required water to make them productive.

Investigations

In the early 1900's, a survey party studied the rugged terrain around the Pine and San Juan Rivers in the area of the present Navajo Dam for possible development of an irrigation system. In 1909, the party reported that the project was feasible, but the report failed to arouse interest. In 1925, the Bureau of Indian Affairs reinvestigated and determined that the project was not practical under existing economic conditions.

In 1953, the Governor of New Mexico asked the Federal Government to develop a project that would use waters of the San Juan River to irrigate lands adjacent to and within the Navajo Indian Reservation. The Secretary of the Interior promptly directed the Bureau of Reclamation and the Bureau of Indian Affairs to cooperate in an investigation of such a project. Through the cooperative efforts of the two bureaus, a feasibility report dated January 1955 was prepared. This study was supplemented in 1957 and was followed by authorization of the project.

The Navajo Indian Irrigation Project, as originally authorized, provided for the development of 77,543 acres of land east of the Chaco River and 33,087 acres west of the Chaco. In 1966, a complete reevaluation of the project was conducted. The reevaluation report, approved by the Secretary of the Interior on December 20, 1966, established a plan for development of 110,630 acres east of Chaco Wash, excluding all project lands lying west of Chaco Wash. This plan of development was subsequently authorized by the amendment of September 23, 1970, Public Law 91-416.

In 1973, a joint study was made by the Bureau of Indian Affairs and the Bureau of Reclamation to determine the feasibility of sprinkler irrigation. The resulting report recommended that an all-sprinkler system would be economically advantageous and more efficient since the lands were predominantly sandy and rolling. The report further pointed out that a gravity system would require diversion of 508,000 acre-feet of water annually, whereas a sprinkler system would require only 330,000 acre-feet. The remaining 178,000 acre-feet would be available to generate electric energy to operate project pumping plants.

Authorization

On June 13, 1962, the Congress authorized construction of the project under provisions of Public Law 87-483. The authorization was amended September 23, 1970, by Public Law 91-416.

Construction

Construction on the project began in 1964 with the Main Canal headworks and Tunnel No. 1. By the end of 1977, construction was completed on the 46.3-mile Main Canal, the 14.5-mile Gravity Main Canal, the underground pipe lateral distribution systems for Blocks 1 and 2, and the Block 1 drains. Construction of the Navajo Dam Powerplant and Switchyard began in 1977. It was terminated in the same year by court order pending further environmental impact studies. Remaining project features and blocks are being completed over the succeeding years to allow for orderly progress and development of the lands.

Operating Agency

Operations and maintenance are the responsibilities of the Bureau of Reclamation until the Navajo Indian Irrigation Project is completed.

BENEFITS

Irrigation

When the project was first authorized, project lands provided very poor grazing for livestock. These lands are considered irrigable and well suited for cultivation and production of certain crops. With irrigation, the type of soil would produce small grains, hay, forage, vegetables, and fruits.

Economic projections indicate that the project could create new industry and stimulate trade in related business. More than 6,550 farm and related industry jobs are expected to result, which would provide a higher standard of living for more than 33,000 Navajo Indians.

Recreation and Fish and Wildlife

Wildlife and recreational benefits will increase on the irrigated lands and in the wooded and hilly areas to the east of the area. Fishing and picnicking around Cutter Reservoir are attractions.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full service	110,630	acres

Facilities in Operation[1]

Canals	72	mi
Siphons	15	
Tunnels	7	
Regulating dam on reservoir	1	
Laterals (open)	40.6	mi
Laterals (closed pipe distribution system)	340	mi
Powerplant (23 MW)	1	
Switchyards	3	
Substations	2	
Power transmission lines	162	mi
Pumping plants (project)	3	

[1]When the project is completed.

Climatic Conditions

Annual precipitation	8.2	in
Temperature:		
Maximum	107	°F
Minimum	−37	°F
Mean	51	°F
Growing season	160	days
Elevation of irrigable land	5372-6236.0	ft

ENGINEERING DATA

Water Supply

Annual allocation	508,000	acre-ft
Diversion facilities (completed in 1967)		
Canal headworks (at Navajo Dam)		
Concrete structure—diversion is controlled by two 9- by 12-ft fixed-wheel gates and two 9- by 12-ft radial gates.		
Capacity	1,800	ft³/s

Storage Facilities

CUTTER DAM

Type: Zoned earthfill
Location: Cutter Canyon (mileposts 8.0-8.9 of the Main Canal).
Construction period: 1970-72
Date of closure (first storage): April 1976
Reservoir, Cutter:

Active conservation capacity, El. 5950-5963.9	808	acre-ft
Inactive capacity, El. 5915-5950	942	acre-ft
Dead capacity, streambed - El. 5915	50	acre-ft
Total capacity	1,800	acre-ft
Surface area	63.5	acres

Dimensions:

Structural height	158 ft
Hydraulic height	95 ft
Top width	30 ft
Maximum base width	478 ft
Crest length	950 ft
Crest elevation	5980 ft
Total volume	722,000 yd^3

Spillway: Uncontrolled concrete crest and concrete-lined chute at left abutment.

Crest elevation	5963.9 ft
Capacity	2,460 ft^3/s

Outlet works:

Canal: On left side near the spillway controlled by 24- by 14-ft radial gate.

Capacity	1,800 ft^3/s

River: Intake on left side, one conduit (27-in dia. upstream and a 30-in dia. downstream) controlled by two 2-ft square slide gates

Carriage Facilities

Canal System[2]

Concrete-lined canals	49.4 mi
Plastic-lined canals	1.2 mi
Tunnels	12.8 mi
Siphons	7.1 mi
Channel and inline reservoir behind Cutter Dam	1.5 mi

Main Canal

Location: Originates at Navajo Dam and terminates at the west fork of Gallegos Canyon.

Construction period: 1967-77

Length	46.3 mi
Capacity:	
Initial	1,800 ft^3/s
At termination	1,355 ft^3/s
Type: Trapezodial section side slope	1.5:1
Lining: Concrete	
Bottom width (initial)	23 ft
Water depth (initial)	11.8 ft

Gravity Main Canal

Location: Begins at West Fork of Gallegos Canyon and terminates at Block 2.

Construction period: 1976-77

Length	14.5 mi
Capacity (initial)	1,285 ft^3/s
Type: Trapezodial section side slope	1.5:1
Lining: Concrete	
Bottom width (initial)	18 ft
Water depth (initial)	10.9 ft

Amarillo Canal

Location: Branches off the Gravity Main Canal at Amarillo Canyon and terminates in Block 3.

Construction period: 1977- (Under construction)

Length	11.2 mi
Capacity:	
Initial	610 ft^3/s
At termination	170 ft^3/s
Type: Trapezodial section side slope	1.5:1
Lining: Primarily concrete	
Polyvinyl chloride membrane (approx.)	3,400 ft
Polyethylene membrane (approx.)	3,200 ft
Slope for plastic lining	2:1
Bottom width (initial)	10 ft
Water depth (initial)	9 ft

Burnham Lateral

Location: Begins at Gallegos Pumping Plant at the Gravity Main Canal at West Gallegos Canyon and terminates in Block 11.

Construction period: Stage 1 scheduled for 1981. Stage 2 scheduled for 1982.

Length	36.8 mi
Capacity (initial)	615 ft^3/s
Type: Trapezodial section side slope	1.5:1
Lining: Concrete	
Base width (initial)	10 ft
Water depth (initial)	9 ft

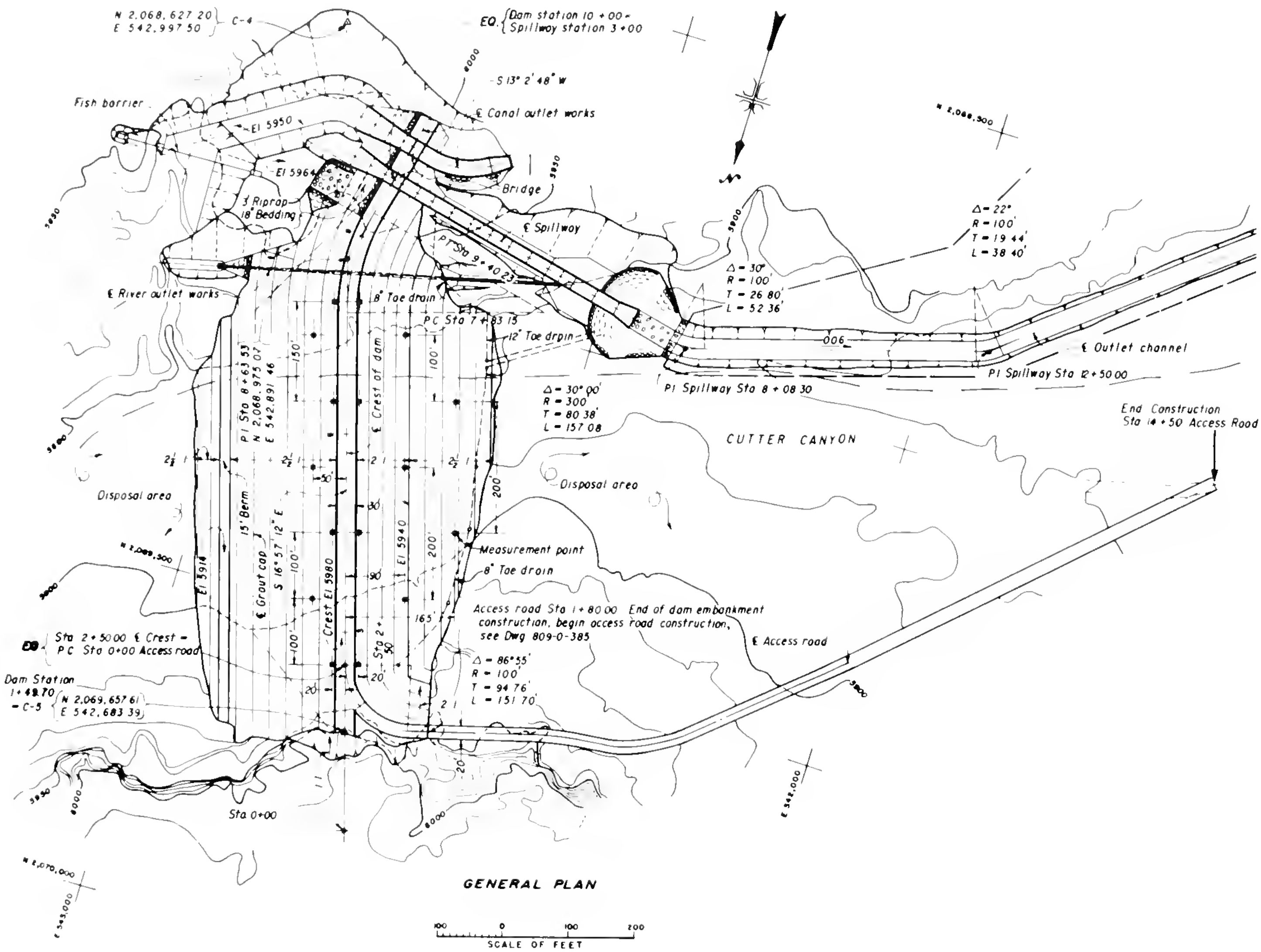
Coury Lateral

Location: Begins at Kutz Pumping Plant on the Main Canal and ends in Block 5.

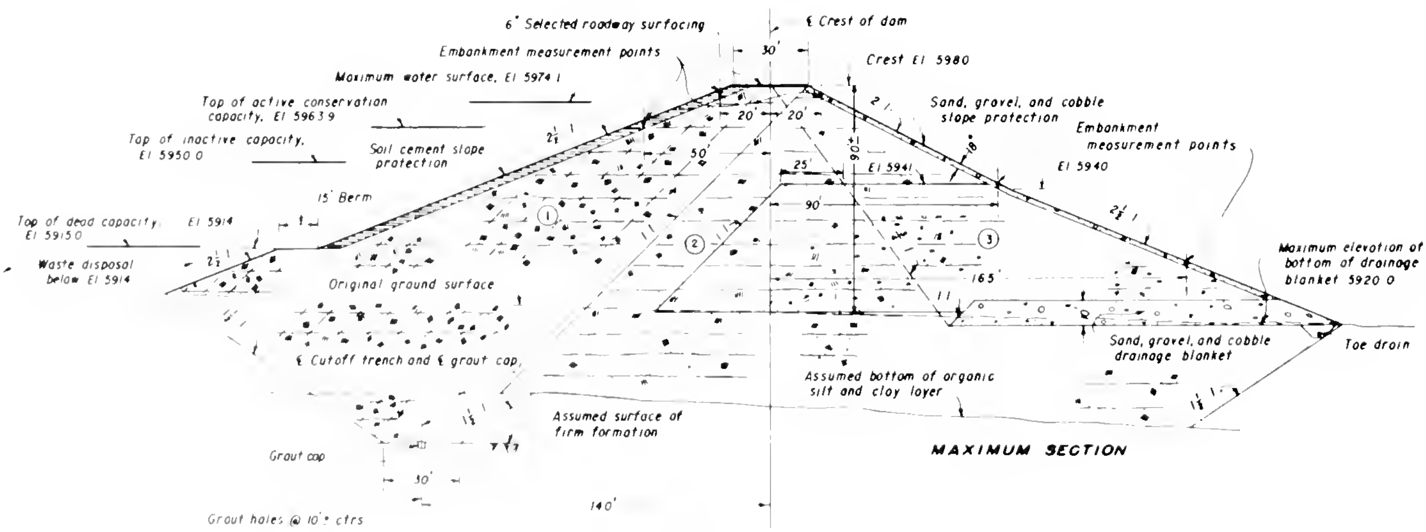
Construction period: Scheduled for 1979

Length	4.1 mi
Capacity (initial)	195 ft^3/s
Type: Trapezodial section side slope	1.5:1
Lining: Concrete	
Base width (initial)	6 ft
Water depth (initial)	5.8 ft

[2]The system is comprised of the Main, Gravity Main, and Amarillo Canals.



GENERAL PLAN



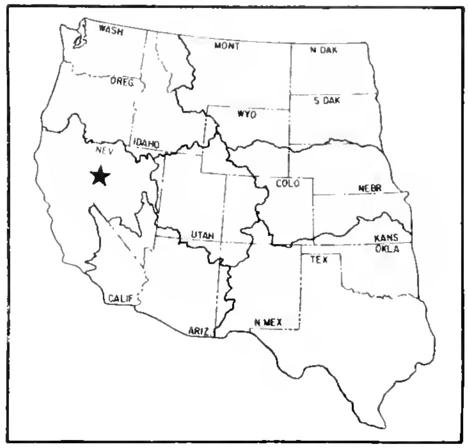
MAXIMUM SECTION

Cutter Dam, Plan and Section

Newlands Project

Nevada: Churchill, Lyon, Storey, and Washoe Counties

Mid-Pacific Region
Water and Power Resources Service



The Newlands Project, formerly the Truckee-Carson Project, was one of the first Bureau of Reclamation projects. It provides irrigation water from the Truckee and Carson Rivers for the lower Carson Valley near Fallon in western Nevada. The drainage basins contain nearly 3,400 square miles with a combined average annual runoff of about 850,000 acre-feet of water. Construction began in 1903 on Derby Diversion Dam and the Truckee Canal. Other features include Lahontan Dam and Reservoir, Lake Tahoe Dam, Carson River Diversion Dam, and Lahontan Powerplant.

PLAN

Boca Reservoir, the major feature of the Truckee Storage Project, was constructed by the United States and is operated by the Washoe County Water Conservation District. Storage of water in Boca and Lake Tahoe is regulated in accordance with the provisions of the Truckee River Agreement, to which the United States, the Truckee-Carson Irrigation District, the Washoe County Water Conservation District, and the Sierra Pacific Power Company are parties. This agreement was made to stabilize and supplement the natural flow of the Truckee River, for which Donner Lake storage also is available. The Truckee-Carson Irrigation District and the Sierra Pacific Power Company have acquired storage rights in Donner Lake for joint use and Truckee River regulation. Donner Lake on Donner Creek has a capacity of about 9,500 acre-feet.

Lahontan Dam and Reservoir

Water for the Newlands Project is diverted from the Truckee River into the Truckee Canal for irrigation of the Truckee Division and for conveyance to Lahontan Reservoir for storage. Water stored in Lahontan Reservoir or conveyed by the Truckee Canal is released into the Carson River either directly or through Lahontan Powerplant, and is diverted into the "V" and "T" Canals at the Carson Diversion Dam for irrigation of the Carson Division.

Lahontan Dam and Reservoir

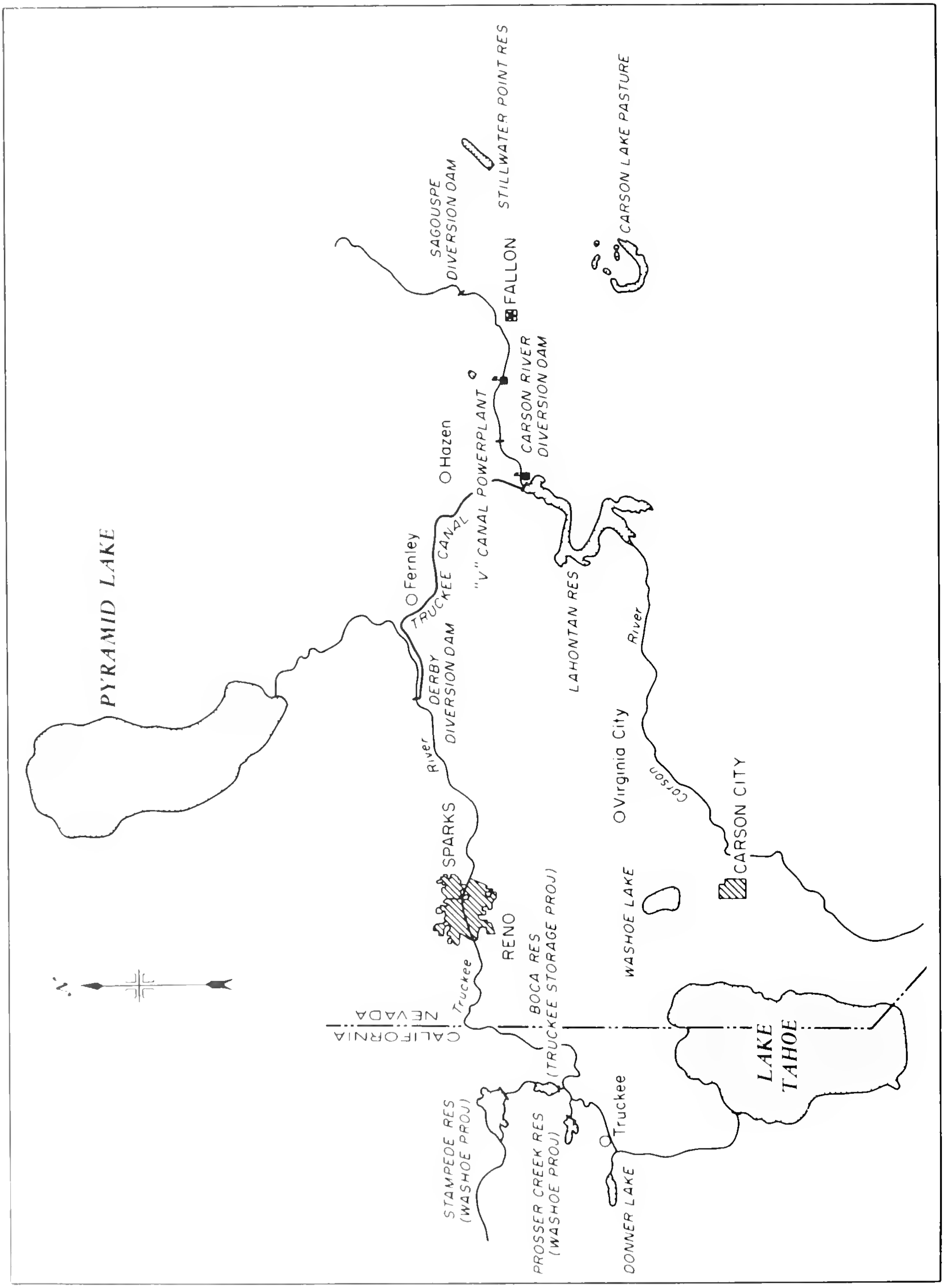
Lahontan Dam and Reservoir on the Carson River store the natural flow of the Carson River along with water diverted from the Truckee River. The reservoir has a storage capacity of 314,000 acre-feet. The dam, completed in 1915, is a zoned earthfill structure 162 feet high.

Lake Tahoe Dam

Completed in 1913, Lake Tahoe Dam is an 18-foot-high concrete slab and buttress structure with 17 vertical gates. By controlling the top 6 feet of Lake Tahoe, the dam creates a reservoir of 732,000-acre-feet capacity and regulates the lake outflow into the Truckee River.

Carson River Diversion Dam

Located on the Carson River 5 miles below Lahontan Dam, the Carson River Diversion Dam diverts water into two main canals for irrigation of the Carson Division lands. The dam is a concrete gate structure 23 feet high.



Newlands Project

Derby Diversion Dam

Derby Diversion Dam, on the Truckee River about 20 miles below Reno, diverts water into the Truckee Canal for conveyance to Lahontan Reservoir and for irrigation of the Truckee Division lands. The dam is a concrete structure 31 feet high.

Lahontan Powerplant

Lahontan Powerplant, immediately below Lahontan Dam, has a capacity of 1,920 kilowatts, and facilities to utilize water from either Lahontan Reservoir or the Truckee Canal. In 1949, the Truckee-Carson Irrigation District installed diesel equipment adjoining this plant to generate 2,000 kilowatts.

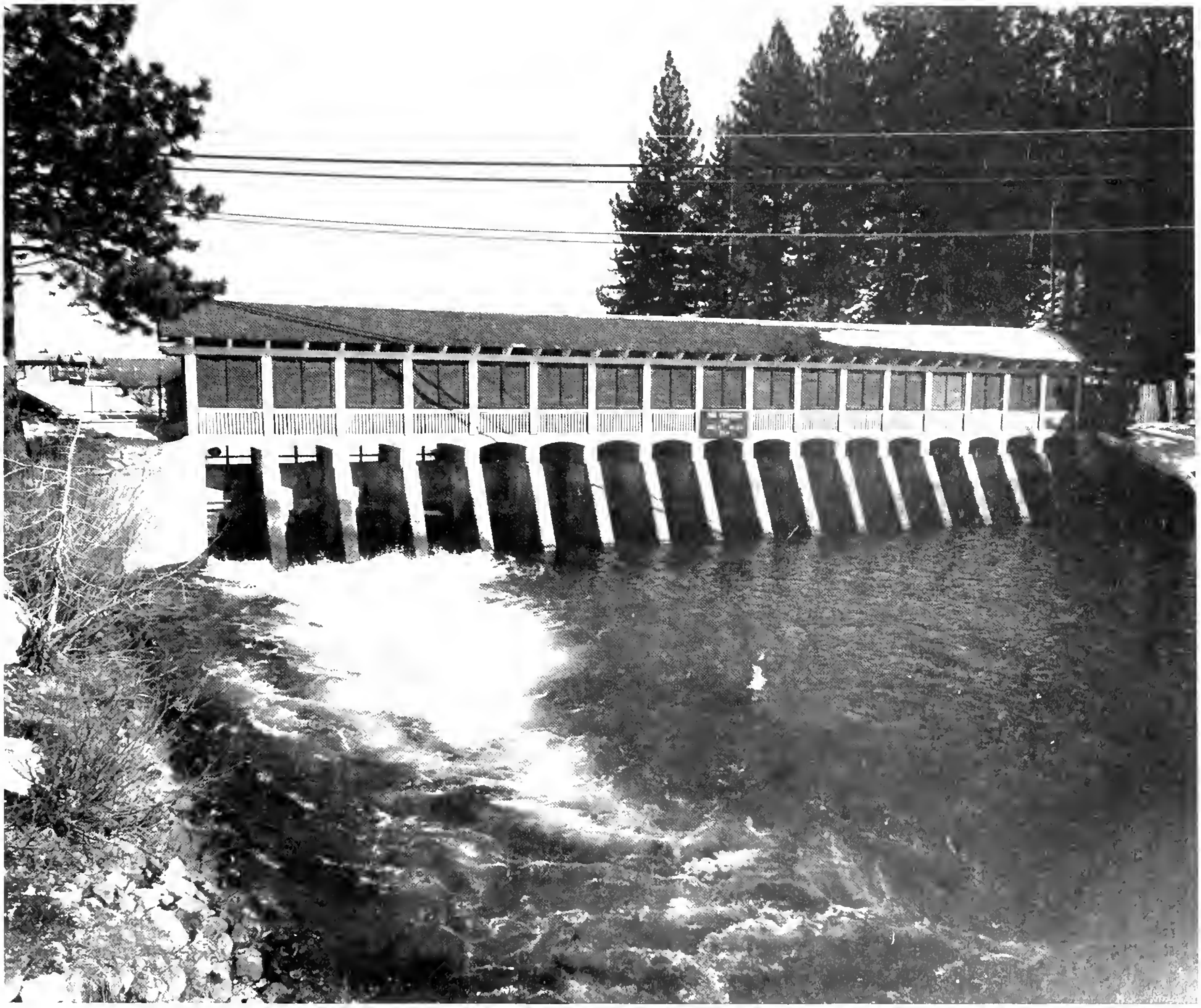
Canal, Distribution, and Drainage System

The project has 68.5 miles of main canals with a combined diversion capacity of 2,000 cubic feet per second. There are 312 miles of laterals and a drainage system of about 345 miles of deep, open drains which were constructed by the United States and the district.

DEVELOPMENT

Early History

The early settlers of the project area irrigated by simple diversions, relying on natural flow for their water supply. Prior to the authorization of the project in 1903, there were 20,000 acres of land under cultivation that had natural-flow water rights.



Lake Tahoe Dam

Investigations

The first investigations in the Truckee and Carson River Basins were started by the Geological Survey in 1889 and were continued intermittently until the newly organized Reclamation Service commenced investigations in the summer of 1902. The Reclamation investigations consisted of surveys for storage reservoirs, including the Lake Tahoe storage and the present Lahontan Reservoir, and the canal system. Truckee-Carson was among the first five projects to be recommended by the Reclamation Service.

Authorization

The project was authorized by the Secretary of the Interior on March 14, 1903. The Omnibus Adjustment Act of May 25, 1926, contained provisions to reduce the original scope of the Newlands Project and to establish specific repayment obligations.

Construction

Construction began in 1903, the same year the project was authorized. The first construction specification issued by the Bureau of Reclamation was for the Truckee River Diversion Dam, now the Derby Diversion Dam, which was completed by June 1905. By September 1905, the Carson River Diversion Dam and main distributing canals for the Carson Division had been completed. The Truckee Canal and a timber chute to the Carson River (the chute was later replaced by one of concrete which discharges into Lahontan Reservoir) were completed in November 1906. This permitted the diversion of Truckee River water for use in the Carson Division for the first time in 1907. Construction of Lake Tahoe Dam was completed in 1913. The United States assumed control of the dam at the outlet of Lake Tahoe along with appurtenant lands on July 1, 1915, pursuant to a decree of the United States District Court dated June 4, 1915.

Operating Agency

Under terms of the contract of December 18, 1926, the operation and maintenance of the project were transferred to the Truckee-Carson Irrigation District on December 31, 1926.

BENEFITS

Irrigation

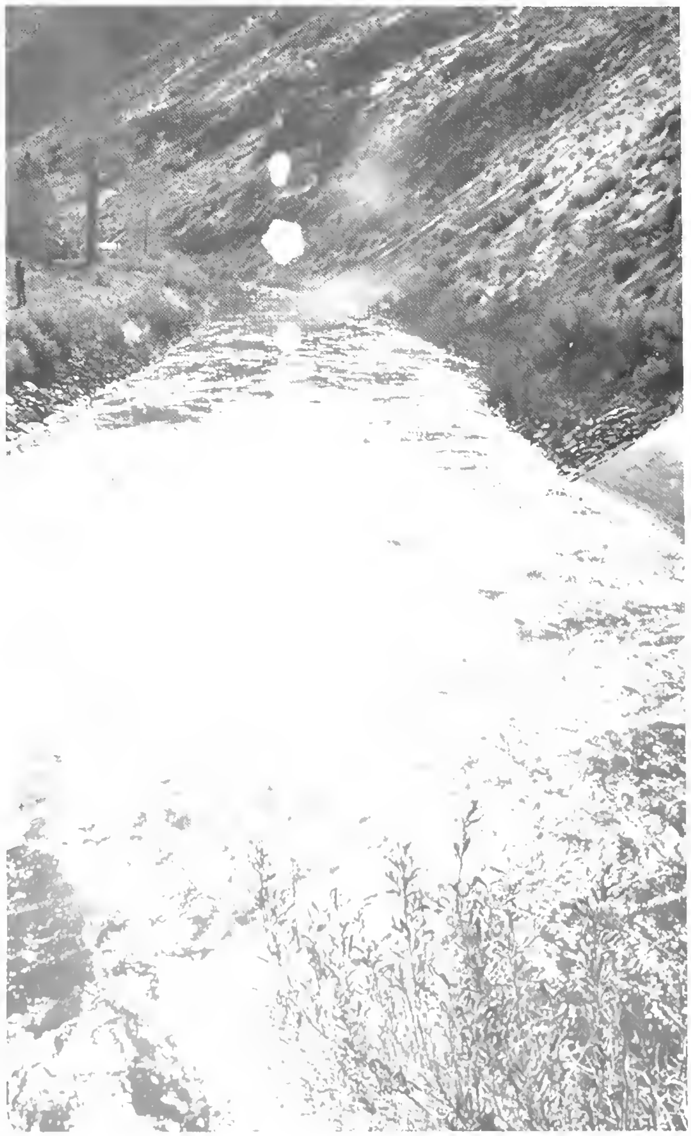
Principal irrigated crops are alfalfa hay, irrigated pasture, barley, and sorghum.

Hydroelectric Power

Truckee-Carson Irrigation District has built 73 miles of 33-kilovolt transmission lines to convey power from Lahontan Powerplant to the city of Fallon; towns of Fernley, Wadsworth, Hazen, and Stillwater; Indian reservations; and most of the rural areas of the project. Distribution facilities were constructed by the district and local improvement districts. The Lahontan plant and distribution system is interconnected to the Sierra Pacific Power Company system and operated by the power company.

Recreation

The Lahontan Reservoir area offers swimming, picnicking, camping, boating facilities, and fishing for trout and warm water fish. Overnight lodging accommodations are located nearby. Recreation facilities are administered by the Nevada State Parks System.



Truckee Canal

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	73,002	acres
Number of irrigated farms	1,200	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	61,697	4,321,134
1969	62,158	4,903,655
1970	62,350	5,051,524
1971	62,863	6,875,262
1972	61,876	7,196,810
1973	62,475	10,041,404
1974	62,744	12,266,452
1975	64,598	14,432,434
1976	64,043	12,784,883
1977	57,530	9,163,886

Facilities in Operation

Storage dams	2	
Diversion dams	2	
Canals	68.5	mi
Laterals	312.1	mi
Drains	345	mi
Powerplants	1	
Transmission lines	73	mi
Tunnels	0.5	mi

Climatic Conditions

Annual precipitation	4.16	in
Temperature:		
Maximum	110	°F
Minimum	−17	°F
Mean	54	°F
Growing season	132	days
Elevation of irrigable area	3965.0	ft

Settlement

Number of persons served with project water (1977):		
Farm irrigation service	8,000	

ENGINEERING DATA

Water Supply

CARSON RIVER

Drainage area at Ft. Churchill	1,450	mi²
Annual discharge at Ft. Churchill:		
Maximum (1914)	617,000	acre-ft
Minimum (1961)	44,400	acre-ft
Average	263,700	acre-ft
Average annual diversion	234,400	acre-ft

TRUCKEE RIVER

Drainage area at Vista	1,429	mi²
Annual discharge at Vista:		
Maximum (1907)	1,660,000	acre-ft
Minimum (1933)	162,000	acre-ft
Average	585,400	acre-ft
Average annual diversion	154,100	acre-ft

Storage Facilities

LAHONTAN DAM

Type: Zoned earthfill
Location: On the Carson River about 18 mi west of Fallon, Nev.
Construction period: 1911-15
Reservoir, Lahontan:

Average annual inflow, 1918-68	321,200	acre-ft
Total capacity to El. 4168	314,000	acre-ft
Active capacity, El. 4168	314,000	acre-ft
Surface area	11,200	acres
Shoreline	69	mi
Dimensions:		
Structural height	162	ft
Hydraulic height	110	ft
Top width	20	ft
Maximum base width	660	ft
Crest length	5,400	ft
Crest elevation	4174.0	ft
Total volume	733,000	yd³

Spillway: Two concrete, uncontrolled open channel structures near each end of the dam curving into a common stilling pool at the base of the dam.

Crest elevation	4162.0	ft
Capacity, El. 4168	26,200	ft³/s

Outlet works: Two conduits through base of dam controlled by slide gates in gate tower and two 8.5-ft cylindrical valves in base of gate tower, and one 5-ft needle valve in valvehouse at stilling basin. Two 3-ft-square slide gates at base of gate tower provide for sluicing.

Capacity at El. 4055	2,000	ft³/s

Power: 6-ft steel penstock, 500 ft long from Truckee Canal; 6.5-ft steel penstock in left outlet conduit.
Foundation: Seamy, badly broken sandstones, mudstones, and shales; sand, gravel, and lake silts in strata intensely faulted and variously inclined. Artesian ground water.
Special treatment: Cement grout curtain 30 to 50 ft deep beneath cutoff wall.

LAKE TAHOE DAM

Type: Concrete slab and buttress
Location: On the Truckee River about 10 mi south of Truckee, Calif.
Construction period: 1909-13
Reservoir, Lake Tahoe:[1]

Average annual inflow, 1917-68	137.2	acre-ft
Total capacity to El. 6229.1[2]	732,000	acre-ft
Active capacity, El. 6229.1	732,000	acre-ft
Surface area	120,000	acres
Dimensions:		
Structural height	18	ft
Hydraulic height	10	ft
Top width	11	ft
Maximum base width	19	ft
Crest length	109	ft
Crest elevation	6233.2	ft

Outlet works: Seventeen 5- by 4-ft gates.

[1]Natural lake, controlled additional storage.
[2]Dead storage not evaluated.

Diversion Facilities

Carson River Diversion Dam

Type: Concrete gate structure
Location: On the Carson River, 5 mi northeast of Lahontan Dam.
Year completed: 1905
Dimensions:

Structural height	23 ft
Hydraulic height	14 ft
Crest length	241 ft
Crest elevation[3]	4024.0 ft
Volume	3,000 yd³
Diversion capacity	1,950 ft³/s

Derby Diversion Dam

Type: Concrete gate structure, embankment wing
Location: On the Truckee River, 5 mi west of Derby, Nev.
Year completed: 1905
Dimensions:

Structural height	31 ft
Hydraulic height	15 ft
Crest length	1,331 ft
Volume	37,000 yd³
Diversion capacity	1,500 ft³/s

[3]Spillway.

Carriage Facilities

"T" Canal

Location: East from Carson River Diversion Dam and north of Carson River to vicinity of Fallon, Nev.
Construction period: 1904-05

Length	9 mi
Capacity	450 ft³/s
Section (initial reach):	
Bottom width	10 ft
Side slopes	2:1
Water depth	6 ft

Truckee Canal

Location: From Derby Diversion Dam southeast to Lahontan Dam.
Construction period: 1903-06

Length	32.5 mi
Capacity	1,500 ft³/s
Section (initial reach):	
Bottom width	20 ft
Side slopes	0.5:1
Water depth	13 ft

"V" Canal

Location: East from Carson River Diversion Dam and south of Carson River to vicinity of Fallon, Nev.
Construction period: 1904-05

Length	27 mi
Capacity	1,500 ft³/s
Section (initial reach):	
Bottom width	22 ft
Side slopes	2:1
Water depth	12 ft

Tunnel No. 1, Truckee Canal

Construction period: 1903-06

Length	905 ft
Capacity	1,500 ft³/s
Cross section: Horseshoe	
Diameter	15.3 ft

Tunnel No. 2, Truckee Canal

Construction period: 1903-06

Length	309 ft
Capacity	1,500 ft³/s
Cross section: Horseshoe	
Diameter	15.3 ft
Lining thickness	8 in

Tunnel No. 3, Truckee Canal

Construction period: 1903-06. Rehabilitated in 1976.

Length	1,521 ft
Capacity	1,500 ft³/s
Cross section: Horseshoe	
Diameter	15.3 ft

Power Facilities

Lahontan Powerplant

Location: Immediately below Lahontan Dam on the Carson River about 18 mi west of Fallon, Nev.
Year of initial operation: 1911
Year last generator placed in operation: 1915

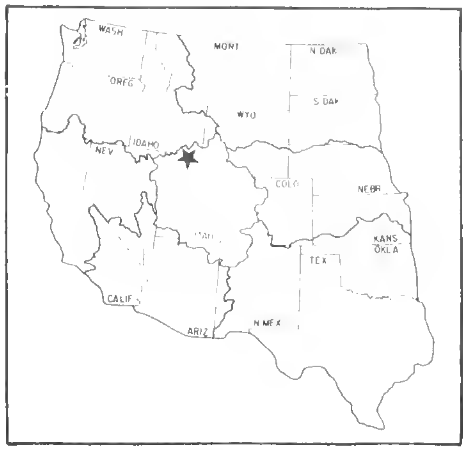
Nameplate capacity	1,920 kW
Number and capacity of generators (3)	640 kW
Maximum head	125 ft

Power distribution facilities, built by the district, and generation facilities are operated under contract by Sierra Pacific Power Company as part of the company system.

Newton Project

Utah: Cache County

Upper Colorado Region
Water and Power Resources Service



The Newton Project is in northern Utah in the vicinity of the town of Newton. Supplemental irrigation water is furnished to 2,861 acres of land from storage in the Newton Reservoir. Approximately 10 miles of main canals carry the water to the distribution system.

PLAN

The project rehabilitated and stabilized an established agricultural area by storing supplemental irrigation water in Newton Reservoir on Clarkston Creek. The Reclamation-constructed reservoir replaced an older privately constructed reservoir of inadequate capacity which had been formed by a dam 1.5 miles upstream from the present Newton Dam.

Releases from the reservoir flow 0.6 mile through the Main Canal and then divide into the East and Highline Canals. The East Canal serves lands on the east side of Clarkston Creek; the Highline Canal serves farmlands on the west side of the creek.

Newton Dam

Newton Dam is an earthfill structure on Clarkston Creek approximately 2 miles north of Newton. It is 101 feet high and has a volume of 410,000 cubic yards. The reservoir has a capacity of 5,600 acre-feet. The service spillway is controlled by a radial gate. An emergency spillway with an uncontrolled crest 1,000 feet long is located near the west end of the dam. A horseshoe conduit, 4 feet in diameter, controlled by a slide gate, serves as outlet works.

DEVELOPMENT

Early History

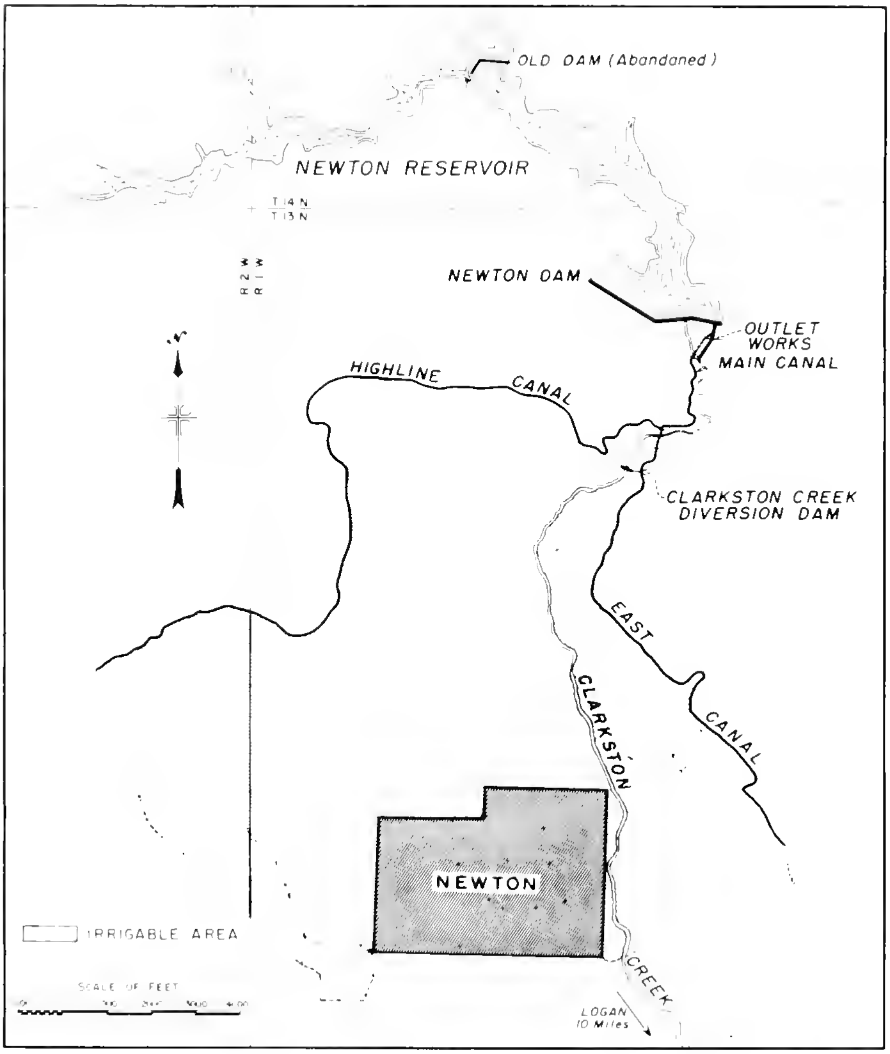
Trappers following the Bear River entered "Willow Valley," later named Cache Valley, in the fall of 1824. This group established a camp in the center of the valley. Mormon colonists settled near the present town of Wellsville in September 1856. Clarkston, a town adjacent to the project, was settled in 1864. Because of Indian troubles, some of the residents moved to "New Town," or "Newton," as it was later called.

A serious shortage of water in Newton during 1870 was disastrous to that farming community. At a public meeting in March 1871, the settlers voted to construct a dam on Clarkston Creek. It was built in 1871 with ox- and horse-drawn scrapers, and impounded 1,566 acre-feet of water. This reservoir was the first large body of irrigation storage water in the State of Utah, and possibly the first in the United States. In August 1972, the project was listed in the *National Register of Historic Places.*

Investigations

From 1918 to 1938, studies were undertaken to increase the storage facilities. The data acquired were turned over to the Bureau of Reclamation for further investigation in 1938. Because the number of farms requiring irrigation continued to increase and local interests could not finance a more elaborate project, the new dam was authorized for construction.

Newton Dam and Reservoir



Newton Project

Authorization

Construction was approved by the President on October 17, 1940, under the terms of the Water Conservation and Utilization Act of August 11, 1939, as amended. A supplemental funding for completion of the project pursuant to the July 16, 1943, amendment to the act was approved by the President on August 31, 1943.

Construction

Construction by the Bureau of Reclamation started in the spring of 1941 with Works Projects Administration labor and funds. Work was suspended by the WPA in November 1942, and the War Production Board issued a stop order in December 1942. Construction was resumed in the fall of 1943, using the balance of WPA funds and an allotment of reimbursable funds made available by the Bureau of Reclamation. The dam was completed in June 1946.

Operating Agency

Operation and maintenance of the project works was transferred to the Newton Water Users Association on January 1, 1948, at the conclusion of the 2-year development period.

BENEFITS

Irrigation

New storage facilities have provided 2,861 acres of land with additional water to ensure crop maturity, thus stabilizing an established agricultural area previously inadequately irrigated. Principal crops are wheat, sugar beets, alfalfa, grains, and vegetables.

Recreation

Recreation on Newton Reservoir is administered by Cache County. Main activities are picnicking, swimming, boating, and fishing. In 1977, visitor days totaled 3,860.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	2,861	acres
Number of irrigated farms	30	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	2,247	185,147
1969	2,434	210,448
1970	2,346	190,463
1971	2,446	268,294
1972	2,523	304,741
1973	2,792	461,834
1974	2,773	462,226
1975	2,773	394,666
1976	2,811	366,960
1977	2,811	354,561

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	7.4	mi
Laterals	7.8	mi
Drains	2	mi

Climatic Conditions

Annual precipitation	16	in
Temperature:		
Maximum	102	°F
Minimum	−25	°F
Mean	48	°F
Growing season	150	days
Elevation of irrigable area	4600.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	211

ENGINEERING DATA

Water Supply

Clarkston Creek

Drainage area at Newton Dam	23.3	mi²
Annual discharge at Newton Dam:		
Maximum (1946)	10,760	acre-ft
Minimum (1963)	2,100	acre-ft
Average	5,578	acre-ft
Average annual diversion, 1948-56	4,628	acre-ft

Storage Facilities

Newton Dam

Type: Zoned earthfill
Location: On Clarkston Creek about 2 mi north of Newton, Utah.
Construction period: 1941-46
Service spillway constructed in 1948-49.
Date of closure (first storage): 1945

Reservoir, Newton:		
Average annual inflow, 1940-47	6,290	acre-ft
Total capacity to El. 4774.5	5,600	acre-ft
Active capacity, El. 4725-4774.5	5,400	acre-ft
Surface area	297	acres
Dimensions:		
Structural height	101	ft
Hydraulic height	74	ft
Top width	30	ft
Maximum base width	465	ft
Crest length	3,340	ft
Crest elevation	4781.0	ft
Volume	410,000	yd³

Spillways: Concrete-lined chute at left abutment, controlled by one 14- by 7.5-ft radial gate, serves as service spillway. Uncontrolled concrete overflow crest 1,000 ft long near right end of dam acts as emergency spillway.

Service spillway:		
Elevation top of gate	4774.5	ft
Crest elevation	4767.0	ft
Capacity at El. 4776.7	1,260	ft³/s
Emergency spillway:		
Crest elevation	4776.0	ft
Capacity at El. 4776.7	1,240	ft³/s

Outlet works: Concrete conduit through base of dam near left abutment controlled by one 2.33-ft-square slide gate.

Capacity at El. 4774.5	240	ft³/s

Special foundation treatment: Cutoff trench to zone that is slowly pervious.

Carriage Facilities

Main Canal

Location: Generally south from Newton Dam along west side of Clarkston Creek.
Construction period: 1946-47

Length	0.6	mi
Diversion capacity	25	ft³/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.8	ft

East Canal

Location: From end of Main Canal generally south to a point about 1 mi east of Newton, Utah.
Construction period: 1946-47

Length	2	mi
Diversion capacity	9	ft³/s
Typical maximum section in earth:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1	ft

Highline Canal

Location: From end of Main Canal generally southwest to a point about 1.5 mi west of Newton, Utah.
Construction period: 1946-47

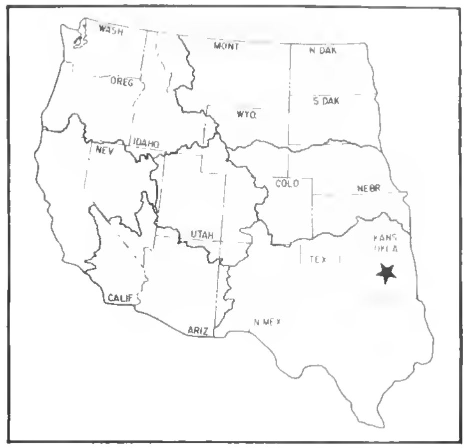
Length	4	mi
Diversion capacity	18	ft³/s
Typical maximum section in earth:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1	ft

Newton Dam, Plan and Section

Norman Project

Oklahoma: Cleveland and Oklahoma Counties

Southwest Region
Water and Power Resources Service



The Norman Project provides a supplemental municipal water supply for the cities of Norman, Del City, and Midwest City, Okla., flood protection to lands south and east of the project area, and significant recreation benefits. Principal features are Norman Dam on Little River about 13 miles east of Norman, two pumping plants, and a pressure pipeline to serve the three cities. No irrigation features or power development are included in the project.

PLAN

Water stored in Lake Thunderbird, the reservoir produced by the construction of Norman Dam, is pumped into two pipelines, one serving the city of Norman directly and the other leading to the relift pumping plant, where separate pipelines serve the communities of Del City and Midwest City, both suburbs of Oklahoma City. The reservoir adds greatly to recreation facilities in the vicinity since it is the largest body of water within a 100-mile radius.

Norman Dam

Norman Dam is located at the confluence of Hog Creek and Little River about 13 miles east of Norman, and about 30 miles southeast of Oklahoma City, Okla. The dam is a zoned earthfill embankment containing approximately 3,111,400 cubic yards of embankment. The crest of the dam is 30 feet wide, 7,260 feet long, and approximately 144 feet high. The spillway is located in the left abutment and has a morning-glory inlet with an ungated crest of 22-feet 4-inch diameter.

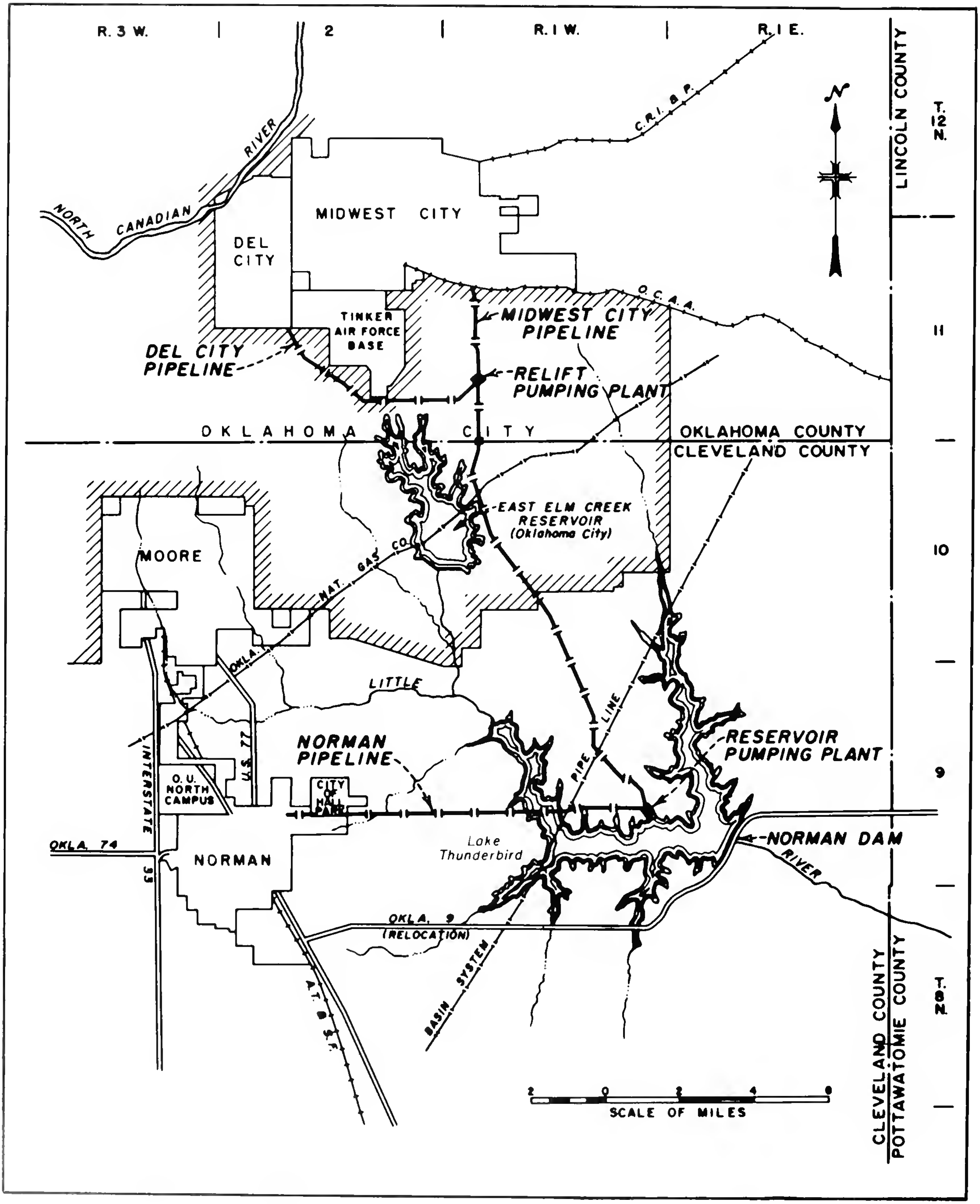
Pipeline System

From the reservoir pumping plant on the north shore of Lake Thunderbird, two pipelines serve the communities in the project. One of the lines extends westward 8.4 miles to the city of Norman; the other northwest 12.5 miles to a relift pumping plant within the city limits of Oklahoma City.

Pumping Plants

The reservoir pumping plant has eight vertical shaft, turbine-type pumps. Four pumps, driven by four 200-horsepower motors, have a capacity of 5.72 cubic feet per second at 228 feet of total head. These pumps provide 22.8 cubic feet per second capacity in the Norman pipeline. The other four pumps, driven by 350-horsepower motors, have a capacity of 7.35 cubic feet per second at 320 feet of total head. These pumps provide the capacity through the Midwest City-Del City line to the relift pumping plant.

Norman Dam


R. 3 W.
2
R. 1 W.
R. 1 E.
LINCOLN COUNTY
T. 12 N.
11
10
9
T. 8 N.
C.R.I. & P.
NORTH CANADIAN RIVER
MIDWEST CITY
DEL CITY
TINKER AIR FORCE BASE
O.C.A.A.
MIDWEST CITY PIPELINE
DEL CITY PIPELINE
RELIFT PUMPING PLANT
OKLAHOMA CITY
OKLAHOMA COUNTY
CLEVELAND COUNTY
EAST ELM CREEK RESERVOIR (Oklahoma City)
MOORE
NAT. GAS CO.
OKLA.
LITTLE
NORMAN PIPELINE
RESERVOIR PUMPING PLANT
PIPE LINE
O. U. NORTH CAMPUS
U.S. 77
INTERSTATE 35
CITY HALL PARK
OKLA. 74
NORMAN
Lake Thunderbird
NORMAN DAM
RIVER
OKLA. 9 (RELOCATION)
BASIN SYSTEM
A.T. & S.F.
SCALE OF MILES
2 0 2 4 6
CLEVELAND COUNTY
POTTAWATOMIE COUNTY

The Midwest City-Del City design capacity is 28 cubic feet per second to the relift pumping plant, at which point the capacity is divided into 20.1 cubic feet per second to Midwest City and 7.9 cubic feet per second to Del City.

The relift pumping plant has eight horizontal centrifugal pumps. Four of these units, driven by 100-horsepower motors, provide water to Midwest City. Each has a capacity of 5.27 cubic feet per second at a total head of 138 feet. The four remaining pumps provide water to Del City. Two pumping units, driven by 40-horsepower motors, have a capacity of 2.49 cubic feet per second each, and two units, driven by 25-horsepower motors, have a capacity of 1.66 cubic feet per second each. Total head is 104 feet.

DEVELOPMENT

Early History

Settlement of the public lands in the former Indian Territory progressed rapidly once they were opened to entry. The cattle ranches of the early days soon converted to a crop-based economy. The relatively high rainfall—33 to 35 inches—in the project area inhibited demand for irrigation water supplies, and the abundance of ground water available in aquifers beneath the land in the vicinity of Oklahoma City slowed development of surface water resources. However, discovery of oil and natural gas led to a rapidly expanding population, with consequent heavier demands on the underground water supply. A progressive lowering of the water table and deterioration in the quality of water withdrawn from wells encouraged the local communities to seek supplemental water resources.

Investigations

In the course of normal investigations of flood potentials of the rivers of the United States, the Corps of Engineers submitted a report on the Little River that appeared as House Document No. 308, 74th Congress, 1st session, in 1936. This was followed in 1947 by a report by the Tulsa District, Corps of Engineers. Both reports concluded that improvements to Little River for flood control and allied water uses were not economically justified. Following a public hearing on the reports, in 1948 a Board of Engineers for Rivers and Harbors recommended to the Chief of Engineers that the unfavorable opinion expressed in the District Engineer's report and concurred in by the Division Engineer be upheld.

Local interests continued their endeavor to enlist support for development of surface water resources, and the Bureau of Reclamation was asked to include studies of the Little River Basin—looking to development of a water supply for the city of Norman, flood control, and other benefits—with the studies of the Arkansas-White-Red Basin begun in 1946. As a result of this request, a reconnaissance study of a reservoir at the Upper Norman site was made in 1949.

In June 1953, Oklahoma City joined with Norman, Midwest City, Del City, Moore, and Tinker Air Force Base to request that they be included in studies of a project at a site downstream on Little River from the Upper Norman site. It was concluded from this study that during early years of the proposed development, a surplus of water would be available for use by Oklahoma City, but that within a 25- to 30-year period, the other beneficiaries would require all available water. In 1953, the Central Oklahoma Water Users Association was formed, excluding Tinker Air Force Base and the town of Moore.

Reports of the Bureau of Reclamation studies appeared successively as a feasibility report in December 1954, issued as House Document 420, 85th Congress, 2d session, in 1959; a reappraisal report in May 1959; and the definite plan report in May 1961.

The Central Oklahoma Master Conservancy District for Norman Project was formed by decree of the District Court of Cleveland County, Oklahoma, on September 10, 1959, and validated on January 31, 1961.

Authorization

The Norman Project was authorized by act of Congress, Public Law 86-529, 86th Congress, June 27, 1960 (74 Stat. 225).

Construction

Construction began on Norman Dam in 1962 and was completed in 1965. Construction began on the pipelines and pumping facilities in 1963 and was completed in 1965.

BENEFITS

Irrigation

No irrigation development is contemplated as part of the project. About 750 acres of land in areas previously subject to flooding can be irrigated since the dam has been constructed, but the tracts are discontinuous and can best be served by individual or small group developments.

Municipal Water

As the primary purpose of the project, municipal water is furnished to the communities of Norman, Midwest City, and Del City by pumping from Lake Thunderbird. Norman Dam regulates runoff on Little River which, when integrated with existing ground-water sources, satisfies the municipal water needs of the three communities.

Recreation and Fish and Wildlife

A major secondary benefit of the project is recreation. Lake Thunderbird, situated in central Oklahoma near Oklahoma City, Norman, and several other cities, hosts thousands of visitors each year. The State of Oklahoma has established Little River State Park on the shores of the 6,070-acre lake, which is framed by rolling, oak-covered hills and sandy shores with some 86 miles of shoreline at top of active conservation capacity elevation 1039.0.

Fishing is excellent with largemouth bass, catfish, and walleye being sought-after species. A large public hunting area offers such game as ducks, geese, rabbit, deer, squirrel, and quail in season.

The recreation areas of Lake Thunderbird are administered by the Oklahoma Tourism and Recreation Department and the wildlife management areas are administered by the Oklahoma Department of Wildlife Conservation.

Visitation to Lake Thunderbird recreation areas and wildlife management areas has exceeded 1.5 million visitor days annually for activities which include fishing, hunting, boating, water skiing, picnicking, swimming, camping, and sightseeing.

Flood Control

Reservoir storage in Lake Thunderbird includes exclusive flood control capacity of 76,600 acre-feet (elevation 1039.0 to 1049.4) and surcharge capacity of 171,300 acre-feet (elevation 1049.4 to 1064.7).

The Little River Basin is long and narrow, with streamflow generally in a southeast direction. Runoff from the upper portions of the basin is rapid during storm periods and the duration of flooding varies from a few hours to several days. Releases from the flood-control pool are made in accordance with regulations prepared by the Corps of Engineers, dated January 1965, in concurrence with the Bureau of Reclamation, and in close cooperation with the Central Oklahoma Master Conservancy District, the entity which has assumed operation and maintenance responsibility for the project facilities.

Construction of Norman Dam has reduced the flood hazards on Little River to its confluence with the Canadian River, and flood control operation will continue to provide benefits to the downstream areas.

PROJECT DATA

Facilities in Operation

Storage dams	1	
Pipelines	30.9	mi
Pumping plants	2	

Climatic Conditions

Average annual precipitation	33	in
Temperature:		
Maximum	115	°F
Minimum	−12	°F
Mean	61	°F
Growing season	213	days

Settlement

Number of persons served with project water (1977):	
Municipal and industrial[1]	163,800

[1]Urban and suburban, residential, commercial, and industrial.

ENGINEERING DATA

Water Supply

LITTLE RIVER

Drainage area	256	mi²
Annual discharge:		
Maximum (1945)	190,000	acre-ft
Minimum (1943)	2,000	acre-ft
Average	57,300	acre-ft

Storage Facilities

NORMAN DAM

Type: Zoned earthfill
Location: On Little River about 13 mi east of Norman, Okla.
Construction period: 1962-65
Reservoir, Lake Thunderbird:
Storage space in the reservoir is allocated as follows:

Dead capacity—Streambed, El. 970 to 997	1,200	ace-ft
Inactive capacity—El. 997 to 1010	12,500	acre-ft
Active conservation capacity—El. 1010 to 1039	105,900	acre-ft
Exclusive flood control capacity—El. 1039 to 1049.4	76,600	acre-ft
Surcharge capacity—El. 1049.4 to 1064.7	171,300	acre-ft
Total capacity to El. 1049.4	196,200	acre-ft
Surface area at El. 1049.4	8,788	acres

Capacity of 196,200 acre-ft between streambed and El. 1049.4 includes an allowance of 35,000 acre-ft for sediment accumulation.

Dimensions:		
Structural height	144	ft
Top width	30	ft
Maximum base width	950	ft
Crest length	7,260	ft
Crest elevation	1071.0	ft
Total volume	3,111,400	yd³

Spillway: Uncontrolled morning-glory inlet structure having a diameter of 22.33 ft leading into a 9.5-ft diameter circular concrete conduit with transition, chute, and stilling basin at downstream end.

Capacity at El. 1064.7	2,840	ft³/s
Crest elevation	1049.4	ft

Outlet works: Approach channel, trashrack protected intake structure, a 13-ft-diameter upstream pressure conduit, a gate chamber enclosing two 6.5- by 10-ft high-pressure emergency gates and two 6.5- by 10-ft high-pressure regulating gates, an access shaft and shaft house for the gate controls, a downstream 17-ft-diameter flat-bottom free-flow conduit, a chute, stilling basin and outlet channel.

Capacity at El. 1064.7	6,950	ft^3/s
Capacity at El. 1039	5,410	ft^3/s

Carriage Facilities

Norman pipeline (precast reinforced concrete pressure pipe and cylinder prestressed concrete pipe)

Length	8.4	mi
Diameter	33 and 30	in
Capacity	21.8	ft^3/s

Midwest City pipeline (precast reinforced concrete pressure pipe and cylinder prestressed concrete pipe)

Reservoir pumping plant to relift pumping plant:

Length	12.5	mi
Diameter	36, 33 and 30	in
Capacity	28.0	ft^3/s

Midwest City pipeline (precast reinforced concrete pressure pipe and cylinder prestressed concrete pipe)

Relift pumping plant to Midwest City terminal meter structure:

Length	3.6	mi
Diameter	30	in
Capacity	20.1	ft^3/s

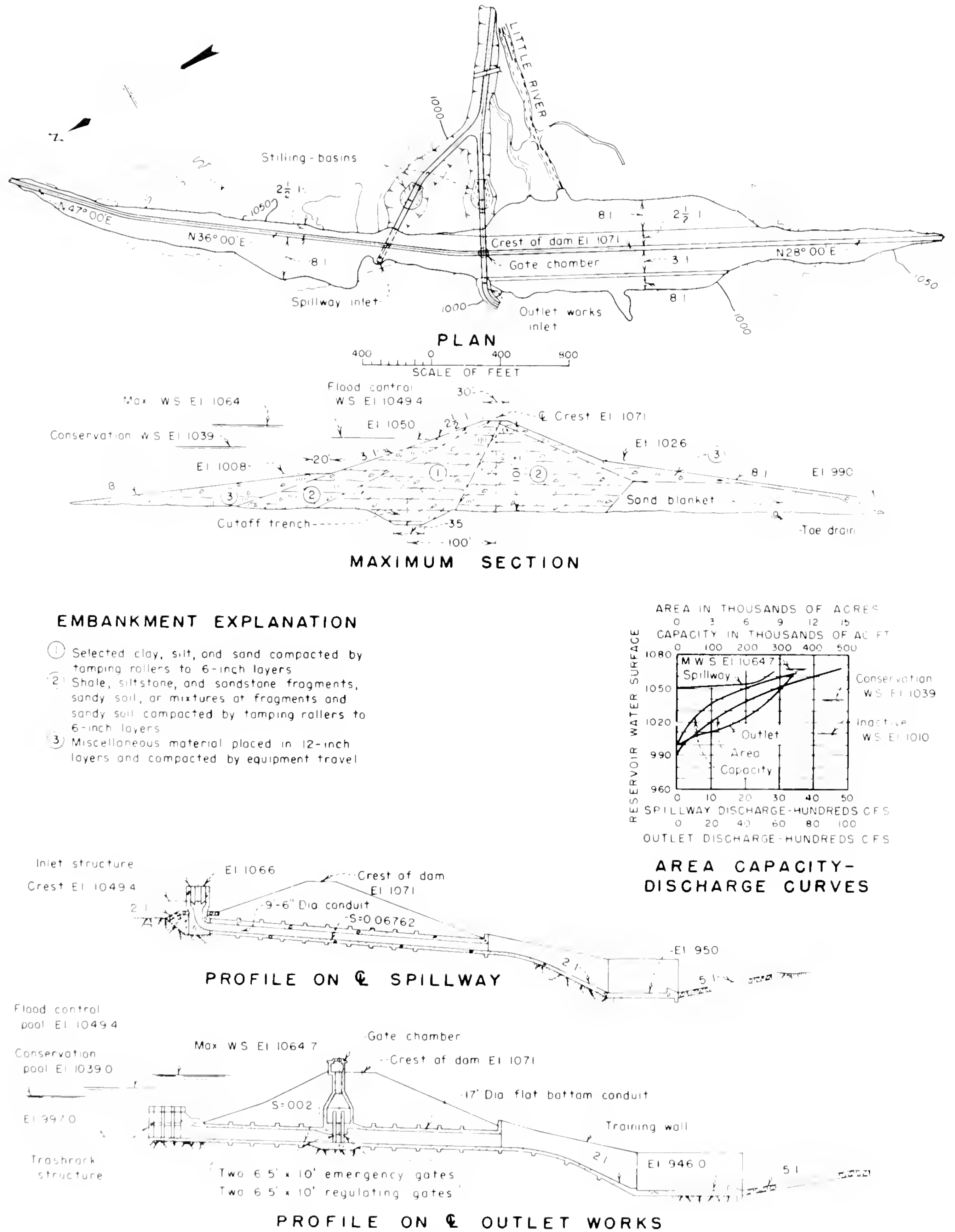
Del City pipeline (precast reinforced concrete pressure pipe and cylinder prestressed concrete pipe)

Relift pumping plant to Del City terminal meter structure:

Length	6.4	mi
Diameter	21 and 18	in
Capacity	7.9	ft^3/s

PUMPING PLANTS

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horsepower
Reservoir	4	5.72	228	800
(Vertical turbine pumps)	4	7.35	320	1,400
Relift	4	5.27	138	400
(Horizontal centrifugal	2	2.49	104	80
pumps)	2	1.66	104	50



Norman Dam, Plan and Sections

North Platte Project

Nebraska: Morrill, Sioux, and Scotts Bluff Counties
Wyoming: Carbon, Goshen, Natrona, and Platte Counties

Lower Missouri Region
Water and Power Resources Service

The North Platte Project extends 111 miles along the river valley from near Guernsey, Wyo., to below Bridgeport, Nebr. The city of Scottsbluff is near the center of the development. The project provides water for irrigation of approximately 390,000 acres that are divided into four irrigation districts. A supplemental supply is furnished to eight water-user associations serving a combined area of about 109,000 acres. Electric power is supplied to the project area.

Project features are the Pathfinder Dam and Reservoir; Guernsey Dam, Reservoir, and Powerplant; Whalen Diversion Dam; Lake Alice, Lake Minatare, and two other regulating reservoirs; over 2,000 miles of canals, laterals, and drains; and about 160 miles of electric power transmission lines.

PLAN

The North Platte River, fed by many mountain streams rising in the Rocky Mountains of Colorado and Wyoming, is the most important river in southeastern Wyoming and western Nebraska. Its waters are stored and used for irrigation and power development for the North Platte Project, the Kendrick Project, and the Kortes and Glendo Units of the Pick-Sloan Missouri Basin Program. Storage structures for these projects are interspersed along the North Platte River and require close coordination of operations.

Project operation is further complicated by agreements and laws governing water rights. The use and quantity of water are allocated for certain defined purposes—some on a priority basis, some on a proportionate share basis, and some on a geographical source basis.

Pathfinder Dam and Reservoir

Waters of the North Platte River must pass the Seminoe and Kortes Dams before entering the reservoir at Pathfinder Dam, which impounds the flow from Sweetwater River. Pathfinder Reservoir has a storage capacity of 1,016,000 acre-feet and holds much of the North Platte Project water. During the nonirrigation season, a small amount of water is released to satisfy other water rights, enhance fish and wildlife, and operate powerplants downstream. During the irrigation season, water is released as required, including water flowing from Seminoe Reservoir to be diverted at Alcova Dam for irrigation on the Kendrick Project.

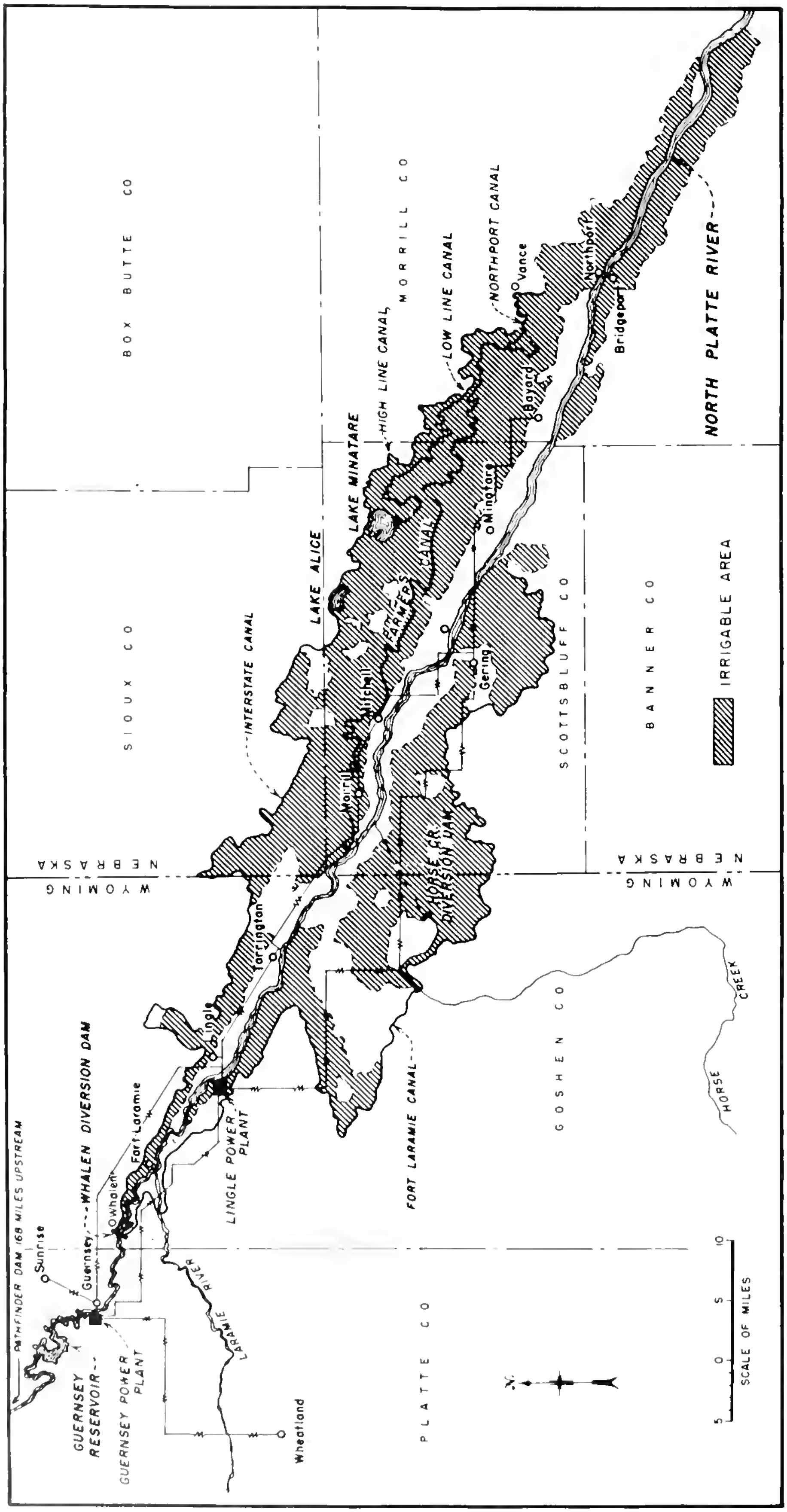
Pathfinder Dam is one of the first constructed by the Reclamation Service. The dam is in a granite canyon on the North Platte River about 3 miles below its junction with the Sweetwater River and about 47 miles southwest of Casper, Wyo. It is made of granite quarried from nearby hills and is faced with large rectangular blocks laid in horizontal courses. It is an arch dam with a gravity-type section, and has a structural height of 214 feet.

Pathfinder Dike fills a depression in the natural ground surface about 0.25 mile south of the dam. It is an earthfill structure, 38 feet high, with a concrete corewall.

Guernsey Dam and Powerplant

One hundred and eighty miles below Alcova Dam and 25 miles below Glendo Dam, the Guernsey Dam controls river flow. Water released from Pathfinder Reservoir can be stored and released to fit varying irrigation demands. Water is released through the Guernsey Powerplant.

Guernsey Dam is in a rocky canyon 2 miles upstream from Guernsey, Wyo. It is a diaphragm-type embankment of sluiced clay, sand, and gravel that forms an impervious core. Its slopes are protected by a thick layer of rock riprap. The structural height of the dam is 135 feet. The original capacity of the reservoir was 73,810 acre-feet, but this has been greatly reduced by silt deposits. The powerplant is on the right bank below the dam and has two 2,400-kilowatt generators. Power is transmitted to towns and industries down the valley over project and other interconnected transmission system lines.



North Platte Project

Pathfinder Dam

Guernsey Dam and Reservoir

Whalen Diversion Dam

Since 1909, water for the North Platte Project has been diverted from the river by the Whalen Diversion Dam. Water is diverted on the south side of the river into the Fort Laramie Canal and on the north side of the river into the Interstate Canal. The dam is a gravity, concrete ogee weir with an embankment wing which spans the river about 8 miles below Guernsey Dam.

Fort Laramie Canal

This canal has an initial capacity of 1,500 cubic feet per second and winds its way for 130 miles to an area south of Gering, Nebr., delivering water to farms all along its course. It also originally carried water for operating the Lingle Powerplant, which was retired in April 1956. The canal was constructed during 1915-24.

Interstate Canal and Reservoir System

The Interstate Canal has an initial capacity of 2,200 cubic feet per second. Constructed during 1905-15, it follows the contour of the land for 95 miles to Lake Alice and Lake Minatare Reservoirs northeast of Scottsbluff, Nebr.

The 37-mile High-Line Canal extends from Lake Alice to the southwest. The diversion capacity is 160 cubic feet per second. The construction period was 1910-13.

The Low-Line Canal extends from Lake Minatare southwest. It is 44 miles long and has a diversion capacity of 343 cubic feet per second.

Lake Alice, Lake Minatare, Lake Winters Creek, and Reservoir No. 2 are offstream equalizing reservoirs. The reservoirs are fed from water diverted at Whalen Diversion Dam through the Interstate Canal, which ends at Lake Alice. The Reservoir Supply Canal carries water to the other reservoirs, which are usually filled each year before the start of the irrigation season. Natural depressions were made into important reservoirs by building the Upper and Lower Dams at Lake Alice and Minatare Dams. The combined storage capacity is about 75,000 acre-feet.

Northport Canal

Water for the Northport Canal is conveyed 80 miles through the Tri-State Canal of the Farmers Irrigation District.

The Northport Canal, a continuation of the privately constructed Tri-State Canal, was designed to irrigate 16,170 acres in the Northport Division. The canal is 28 miles long and has a diversion capacity of 250 cubic feet per second.

The Tri-State Canal diverts water, stored in project reservoirs, from the North Platte River in Nebraska.

DEVELOPMENT

Early History

In the early days the trade route to the west beyond the Rocky Mountains followed the North Platte River. Many historic trails wound their way from the east along the North Platte and Sweetwater Rivers to cross the Continental Divide at South Pass. Stage stations, trading posts, and army forts were scattered along the trails but, with the advent of the railroad in the late 1860's, the trails began to disappear. Two old forts, Fort Laramie and Fort Caspar, have been restored for their historical value.

Settlement of the North Platte Valley in western Nebraska began in the early 1880's. Rainfall was scarce when needed, and small private irrigation systems were built without storage reservoirs. The lack of facilities to hold the early spring runoff meant that the river could not supply sufficient water during the growing season and some of the projects failed.

Investigations

In 1895, Nebraska enacted an irrigation district law permitting the formation of districts with power to assess lands for irrigation improvements. Shortly after the Federal Reclamation Act was passed in 1902, the Reclamation Service began studying the North Platte Project. The project was authorized in 1903, and surveys were started to determine the location of irrigable lands. As the work proceeded, it became apparent that storage must be provided to reclaim any considerable area. Further investigations led to the selection of the Pathfinder Dam site as the most favorable storage location.

Authorization

The project, originally called Sweetwater Project, was authorized by the Secretary of the Interior on March 14, 1903. Guernsey Dam and Powerplant were approved by the President on April 30, 1925.

Construction

Construction started in 1905 on Pathfinder Dam and the Interstate Canal. By 1915, work on the Interstate Canal and Reservoirs was completed and work had started on Fort Laramie Canal. Lingle Powerplant and the Northport Canal system were started in 1918. All canal construction was completed by 1925. Guernsey Dam was started on June 1, 1925, and completed in July 1927.

Operating Agency

The Pathfinder and Guernsey Reservoirs, Whalen Diversion Dam, and Guernsey Powerplant are operated and maintained by the Bureau of Reclamation. The water distribution systems are operated by the districts which they serve.

BENEFITS

Irrigation

Over 335,000 acres of sagebrush and rangeland were transformed into productive farmland. Agriculture is the basic income-producing activity. From the first irrigation, the project has produced alfalfa, corn, potatoes, and sugar beets steadily and abundantly. Dry beans also have become an important crop.

Hydroelectric Power

Electricity is supplied to many towns, rural cooperatives, and industries in the project area.

Flood Control

Project reservoirs have been effective in reducing damage to property and loss of life from floods. A direct result of flood control is the increased utilization of river valley lands made safe and productive by the regulation of riverflows.

Recreation

Guernsey Reservoir area has camp and picnic grounds with fireplace grates, garbage disposal units, and water supply. It also provides swimming and boating. Pathfinder Reservoir is used for boating and fishing, primarily for German brown and Mackinaw trout. Picnic grounds, a swimming beach, and boat docks are available at Lake Minatare, and fishing is good for trout, perch, and pike.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	226,237	acres
Supplemental irrigation service	108,715	acres
Total	334,952	acres
Number of irrigated farms	2,773	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value,[1] dollars
1968	335,038	41,229,749
1969	335,038	44,661,070
1970	334,952	46,350,354
1971	334,952	49,282,381
1972	334,952	62,507,512
1973	334,952	84,825,992
1974	334,952	130,521,523
1975	334,952	113,196,095
1976	320,054	82,801,974
1977	319,575	84,675,518

[1]Includes additional revenue.

Facilities in Operation

Storage dams	5	
Diversion dams	4	
Canals	337	mi
Laterals	1,261	mi
Pumping plants	1	
Drains	373	mi
Powerplants	1	
Transmission lines	162.5	mi
Substations	4	

Climatic Conditions

Annual precipitation	13.6	in
Temperature:		
Maximum	106	°F
Minimum	−22	°F
Mean	51	°F
Growing season	150	days
Elevation of irrigable area	4000.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	10,553

Power Generation

Fiscal year	Guernsey Powerplant,[2] kWh	Total, kWh
1968	26,719,000	26,719,000
1969	26,327,000	26,327,000
1970	25,021,000	25,021,000
1971	27,202,000	27,202,000
1972	32,725,000	32,725,000
1973	27,158,000	27,158,000
1974	32,557,000	32,557,000
1975	23,927,000	23,927,000
1976	25,374,000	25,374,000
1977	21,330,000	21,330,000

[2]Operation of Lingle Powerplant discontinued after May 1, 1956.

ENGINEERING DATA

Water Supply

North Platte River

Drainage area at Whalen	16,300	mi²
Annual discharge at Whalen:		
Maximum (1917)	2,170,000	acre-ft
Minimum (1940)	183,700	acre-ft
Average	693,600	acre-ft

North Platte River

Drainage area at Pathfinder	10,700	mi²
Annual discharge at Pathfinder:		
Maximum (1909)	2,230,000	acre-ft
Minimum (1934)	485,400	acre-ft
Average	1,168,400	acre-ft

Storage Facilities

Pathfinder Dam and Dike

Type: Masonry arch. Dike is a homogeneous earthfill structure.
Location: On North Platte River, 47 mi southwest of Casper, Wyo. Dike is about 0.25 mile south of dam.
Construction period: 1905-09. South outlet constructed in 1910-12; north outlet reconstructed in 1919-21.

Reservoir, Pathfinder:		
Average annual inflow	1,153,100	acre-ft
Total capacity	1,016,000	acre-ft
Active capacity, El. 5850.1	984,668	acre-ft
Inactive capacity, El. 5725	5,000	acre-ft
Surface area at El. 5850.1	22,012	acres

Dimensions	Dam	Dike
Structural height	214 ft	38 ft
Hydraulic height	192 ft	20 ft
Top width	10.9 ft	20 ft
Maximum base width	97 ft	210 ft
Crest length	432 ft	1,650 ft
Crest elevation	5858.1 ft	5868.1 ft
Volume	65,700 yd³	152,000 yd³

Spillway: Uncontrolled, flat-crested weir in left abutment of dam.

Crest length	583	ft
Crest elevation	5850.1	ft
Capacity at El. 5858.1	65,000	ft³/s

Outlet works: Tunnels through abutment. North outlet is controlled by two 58-in needle valves; sluicing outlet is provided.

Capacity:		
North outlet at El. 5818	2,000	ft³/s

Foundation: Coarse-grained, massive granite; local vertical crush zone at left abutment; some flat mud seams in canyon floor.

Guernsey Dam

Type: Diaphragm type earthfill
Location: On North Platte River near Guernsey, Wyo.
Construction period: 1925-27

Reservoir, Guernsey:		
Average annual inflow	1,101,200	acre-ft
Total capacity	45,228	acre-ft
Active capacity, El. 4420	45,228	acre-ft
Inactive storage below El. 4370	105	acre-ft
Surface area at El. 4420	2,380	acres
Dimensions:		
Structural height	135	ft
Hydraulic height	92	ft
Top width	25.3	ft
Maximum base width	940	ft
Crest length	560	ft
Crest elevation	4430.0	ft
Total volume	586,000	yd³

Spillways: Concrete-lined open channel in north abutment, controlled by a 50-ft-square Stoney gate; morning-glory inlet and vertical shaft in south abutment leading to concrete-lined combination spillway and outlet tunnel, controlled by two 64- by 14.5-ft drum gates.

	North	South
Elevation top of gates	4420.0 ft	4420.0 ft
Crest elevation	4370.0 ft	4405.5 ft
Capacity at El. 4420	50,000 ft³/s	25,800 ft³/s

Outlet works: Vertical shaft from 20- by 26-ft Stoney intake gate, controlled by three 5-ft-square high-pressure slide gates for sluicing in spillway-outlet tunnel; for power, 12-ft concrete-lined tunnel 662 ft long branching from spillway-outlet tunnel, controlled by the intake gate.

Minatare Dam

Type: Zoned earthfill, concrete paving on upstream slope
Location: Offstream about 11 mi northeast of Gering, Nebr.
Construction period: 1912-15
Reservoir, Lake Minatare: Inflows are from canal, controlled by releases from Guernsey Reservoir.

Total capacity	62,200	acre-ft
Active capacity, El. 4125[3]	60,800	acre-ft

[3]Includes 2,000 acre-ft of storage capacity in Lake Winters Creek.

Dead storage below El. 4085.3	5,000	acre-ft
Surface area at El. 4125	2,160	acres
Dimensions:		
Structural height	114	ft
Hydraulic height	48	ft
Top width	20	ft
Maximum base width	304	ft
Crest length	3,760	ft
Crest elevation	4140.0	ft
Volume	696,000	yd³
Spillway: Uncontrolled overflow concrete weir in open channel in right abutment		
Crest length	100	ft
Crest elevation	4125.0	ft
Outlet works: Two 4-ft concrete pipes in concrete conduit through base of dam. Each pipe is controlled by three 2-ft needle valves.		
Capacity at El. 4125	435	ft³/s

Foundation: Generally fissured and somewhat porous brule clay overlain by gravel and loam 10- to 30-ft deep.
Special treatment: Foundation grouted.

Lake Alice Dams

Type: Homogeneous earthfill
Location: Offstream, 9 mi north of Scottsbluff, Nebr. Upper dam is at west end of Lake Alice; lower dam at east end.
Construction period: Upper, 1911-13; lower, 1911-12.
Reservoir, Lake Alice:

Total capacity	11,020	acre-ft
Active capacity, El. 4182	11,020	acre-ft
Surface area at El. 4182	776	acres

Dimensions:	*Upper*	*Lower*
Structural height	37 ft	24 ft
Hydraulic height	20 ft	13 ft
Top width	31 ft	30 ft
Maximum base width	196 ft	168 ft
Crest length	3,100 ft	2,550 ft
Crest elevation	4192.0 ft	4192.0 ft
Volume	241,000 yd³	119,000 yd³

Spillway: Concrete-lined chute in right abutment of upper dam. None in lower dam.

Crest length	100	ft
Crest elevation	4182.0	ft

Outlet works: Three 3- by 4-ft conduits controlled by vertical rectangular gates in upper dam; conduit controlled by 6-ft-square slide gate in lower dam.

Diversion Facilities

Whalen Diversion Dam

Type: Concrete ogee weir, embankment wing
Location: North Platte River, near Whalen, Wyo.
Year completed: 1909[4]
Dimensions:

Structural height	35	ft
Hydraulic height	11	ft
Crest length	2,460	ft
Crest elevation	4279.0	ft
Volume	81,700	yd³
Diversion capacity:		
Interstate Canal	2,200	ft³/s
Fort Laramie Canal	1,500	ft³/s

[4]Supplemental construction performed in 1918, 1921, and 1923.

Horse Creek Diversion Dam

Type: Concrete weir, embankment wing
Location: Horse Creek, 12 mi southeast of Torrington, Wyo.
Year completed: 1923
Dimensions:

Structural height	17	ft
Hydraulic height	6	ft
Crest length	720	ft
Crest elevation	4130.0	ft
Volume	5,300	yd³
Diversion capacity	430	ft³/s

Dry Spotted Tail Diversion Dam

Type: Steel sheet pile and earth
Location: Dry Spotted Tail Creek, 3 mi north of Mitchell, Nebr.
Year completed: 1954
Dimensions:

Structural height	14.5	ft
Crest length	255	ft
Crest elevation	3996.0	ft
Volume	700	yd³

Tub Springs Creek Diversion Dam

Type: Steel sheet pile and earth
Location: Tub Springs Creek, about 6 mi east of Mitchell, Nebr.
Year completed: 1954
Dimensions:

Structural height	11	ft
Crest length	205	ft
Crest elevation	4000.0	ft
Volume	2,600	yd³

Carriage Facilities

Interstate Canal

Location: From Whalen Diversion Dam near Whalen, Wyo., southeast 55 mi along the North Platte River to Lake Alice.
Construction period: 1905-15

Length	95	mi
Diversion capacity	2,200	ft³/s
Typical maximum section in earth:		
Bottom width	44	ft
Side slopes	1.5:1	
Water depth	10	ft

High-Line Canal (Interstate System)

Location: From Lake Alice generally southeast about 25 mi.
Construction period: 1910-13

Length	37	mi
Diversion capacity	160	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	4.5	ft

Low-Line Canal (Interstate System)

Location: From Lake Minatare generally southeast about 25 mi.
Construction period: 1913-14

Length	44 mi
Diversion capacity	343 ft³/s
Typical maximum section in earth:	
Bottom width	16 ft
Side slopes	2:1
Water depth	6 ft

RESERVOIR SUPPLY CANAL (INTERSTATE SYSTEM)

Location: From Lake Alice to Lake Minatare.
Construction period: 1910-13

Length	4.6 mi
Capacity	492 ft³/s
Typical maximum section in earth:	
Bottom width	22 ft
Side slopes	2:1
Water depth	6 ft

FORT LARAMIE CANAL

Location: From Whalen Diversion Dam generally southwest about 60 mi to vicinity of Gering, Nebr.
Construction period: 1915-24

Length	130 mi
Diversion capacity	1,500 ft³/s
Typical maximum section in earth:	
Bottom width	45 ft
Side slopes	2:1
Bank height	12 ft

NORTHPORT CANAL

Location: Vicinity of Vance, Nebr.
Construction period: 1919-23

Length	28 mi
Diversion capacity	250 ft³/s
Typical maximum section in earth:	
Bottom width	20 ft
Side slopes	2:1
Water depth	5.2 ft

DUTCH FLATS DRAINAGE PUMPING PLANT

Number of units	3
Total capacity	8 ft³/s
Total dynamic head	30-52 ft
Total horsepower	70

Power Facilities

GUERNSEY POWERPLANT

Location: At toe of Guernsey Dam.
Year of initial operation: 1927
Year last generator placed in operation: 1928

Nameplate capacity	4,800 kW
Number and capacity of generators (2)	2,400 kW
Maximum head	90 ft

SUBSTATIONS

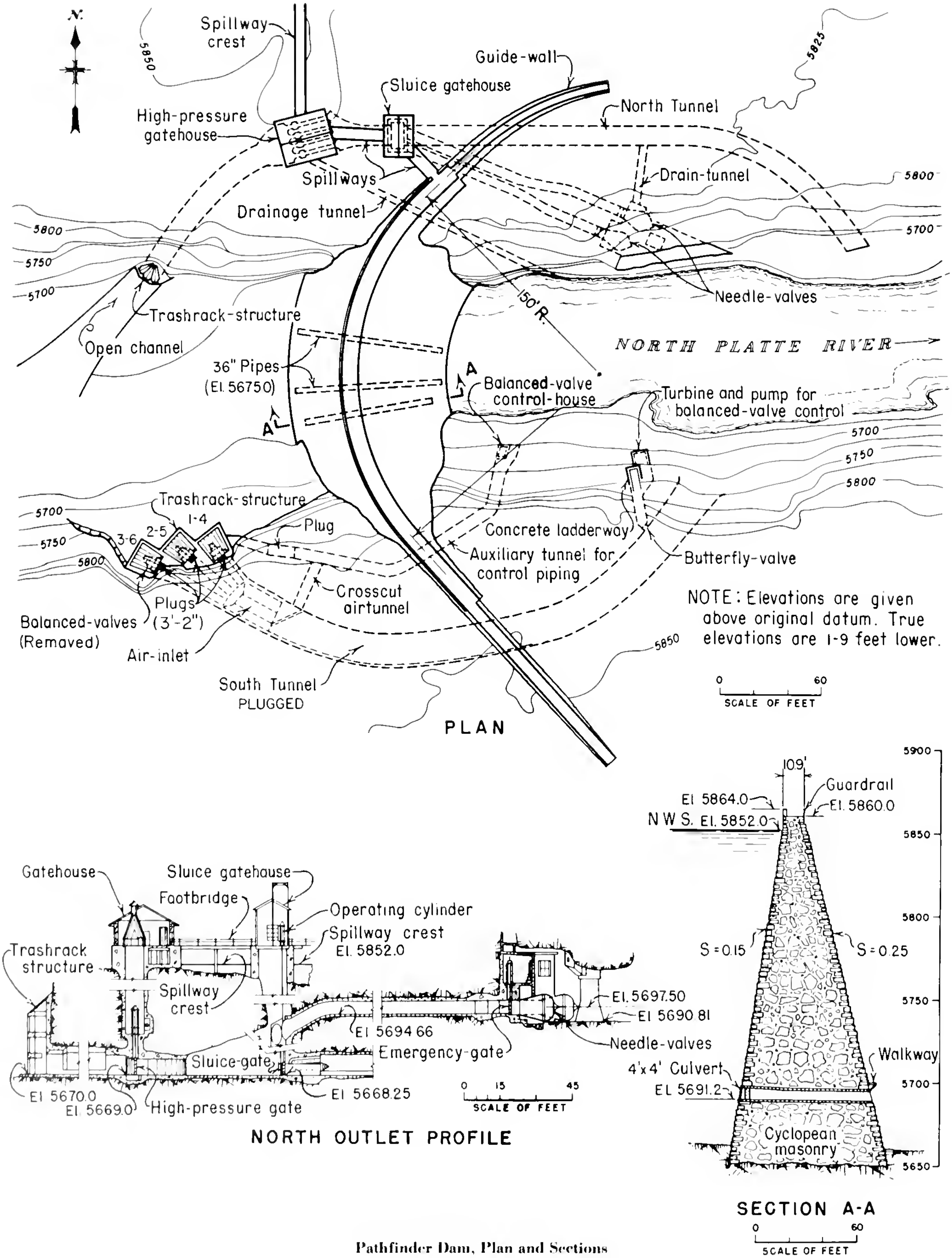
Number in operation	3
Capacity of transformers	7,545 kVA

TRANSMISSION LINES

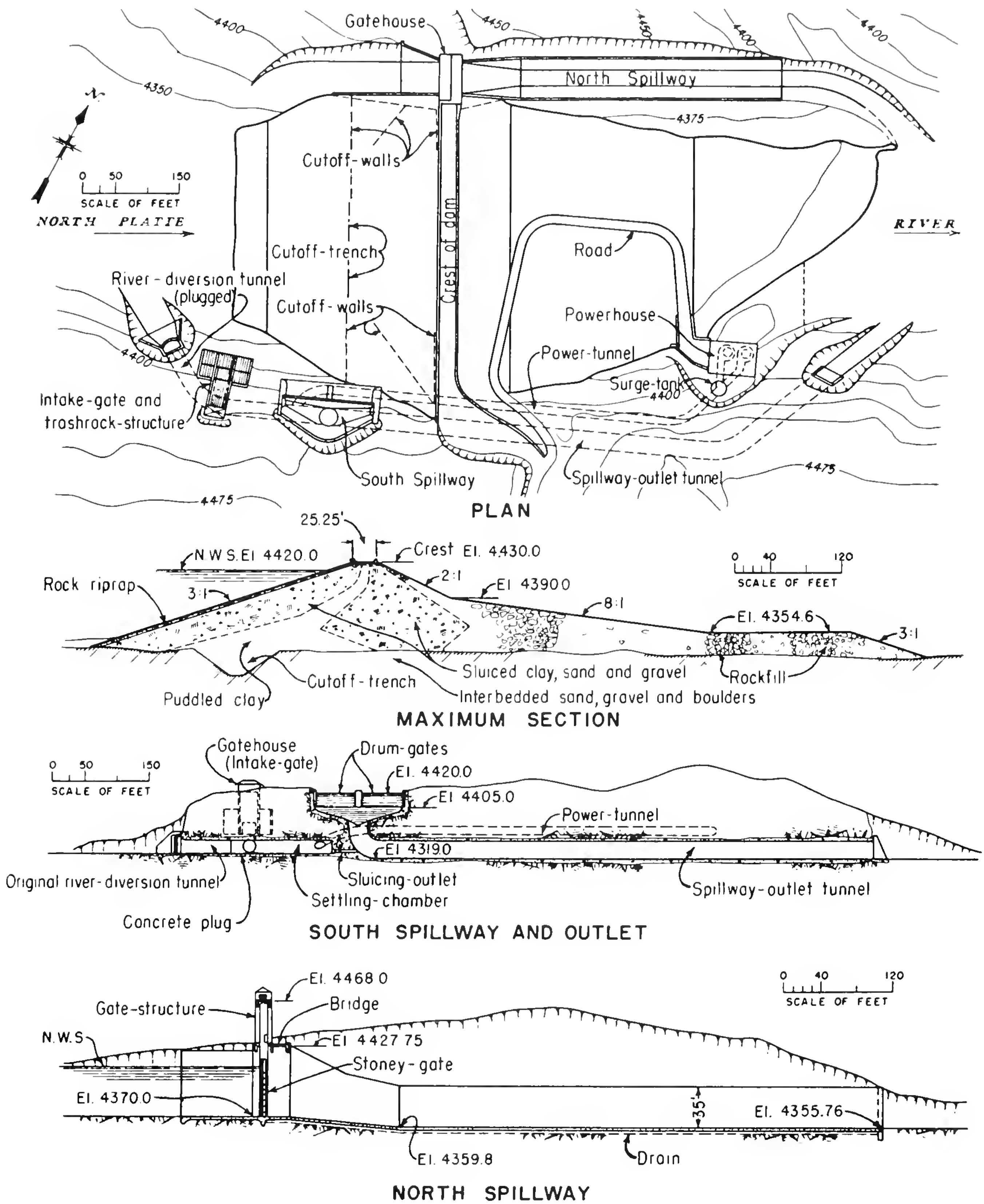
Total number of lines	9
Total circuit miles	158.7

Designation	Capacity kV	Circuit miles	Year placed in service
Gering-Bayard & Northport Tap			
Gering-CRPPD Minatare Tap	34.5	6.00	1937
CRPPD Minatare Tap-CRPPD Bayard Tap	34.5	13.30	1940
CRPPD Bayard Tap-Bayard	34.5	4.00	1940
Guernsey-Ft. Laramie Tap			
Guernsey-WYRULEC Guernsey Tap	34.5	1.50	1936
WYRULEC Guernsey Tap-Whalen Dam Tap	34.5	5.70	1936
Whalen Dam Tap-Ft. Laramie Tap	34.5	7.50	1936
Whalen Dam Tap-Whalen Dam	34.5	0.50	1950
Ft. Laramie Tap-Lingle			
Ft. Laramie Tap-WYRULEC Ft. Laramie Tap	34.5	0.40	1936
WYRLC Ft. Lar. Tap.-WYRLC Lingle & Lingle Tap	34.5	10.14	1936
WYRULEC Lingle & Lingle Tap-Laramie	34.5	1.90	1936
Ft. Laramie Tap-Ft. Laramie	34.5	0.20	1957
WYRULEC Ft. Laramie Tap-WYRULEC Ft. Laramie	34.5	0.68	1952
WYRLC Lingle & Lingle Tap-WYRLC Lingle & Lin	34.5	0.75	1949
Guernsey-Wheatland (South)			
Guernsey Rural-Wheatland (North)*	69	18.29	1976
Wheatland North-Wheatland South*	69	2.02	1976
Guernsey-Wheatland REA Guernsey			
Guernsey-Guernsey Tap	34.5	1.48	1953
Guernsey Tap-WYRULEC Guernsey Stone Tap	34.5	0.42	1953
WYRULEC Guernsey Stone Tap-Wheatland REA Guernsey	34.5	4.32	1953
Guernsey Tap-Guernsey (town)	34.5	0.71	1955
Lingle-Torrington			
Lingle-Torrington Tap (WYRULEC)	34.5	5.00	1934
Torrington Tap (WYRULEC) - Torrington	34.5	5.43	1934
Torrington-Gering			
Torrington-RPPD Henry Tap	34.5	8.60	1934
RPPD Henry Tap-Morrill Tap	34.5	7.05	1934
Morrill Tap-West Mitchell Tap	34.5	7.51	1934
West Mitchell Tap-East Mitchell Tap	34.5	0.02	1934
East Mitchell Tap-RPPD Mitchell Tap	34.5	2.30	1934
RPPD Mitchell Tap-RPPD Sievers Tap	34.5	3.1	1934 & 1955
RPPD Sievera Tap-Gering	34.5	6.8	1934 & 1955
Lyman-Lyman Nebraska Tap			
Lyman Jct-Lyman Nebraska Tap	34.5	8.10	1919
Lyman Nebraska Tap-Gering			
Lyman Nebraska Tap-RPPD Lyman Tap	34.5	3.70	1919
RPPD Lyman Tap-WYRULEC	34.5	14.30	1919
WYRULEC-Roosevelt PPD Tap	34.5	5.74	1919
Roosevelt PPD Tap-Gering	34.5	1.26	1919

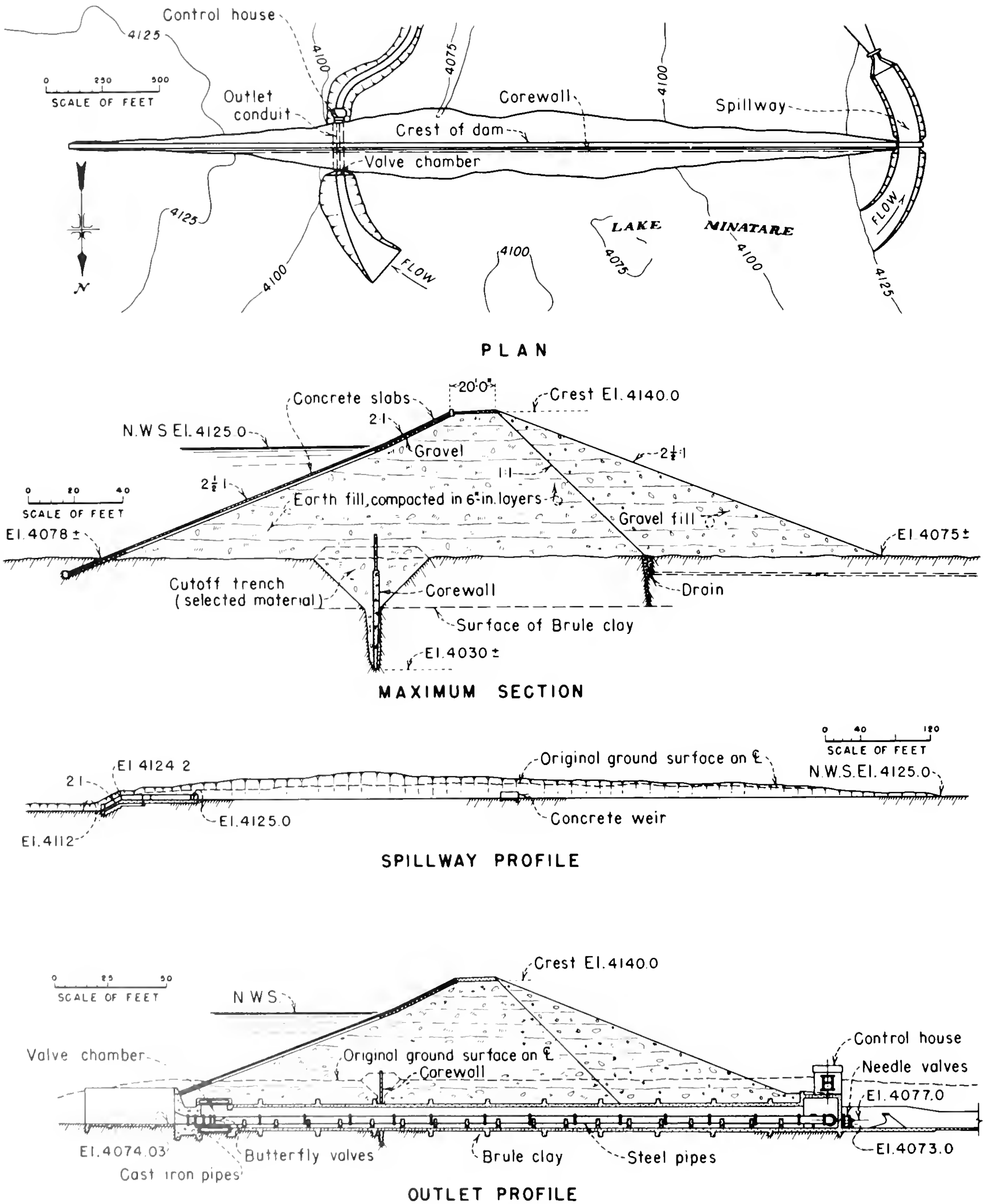
*Both lines were reconductored and reinsulated (1970-76) and their capacities increased in 1976.



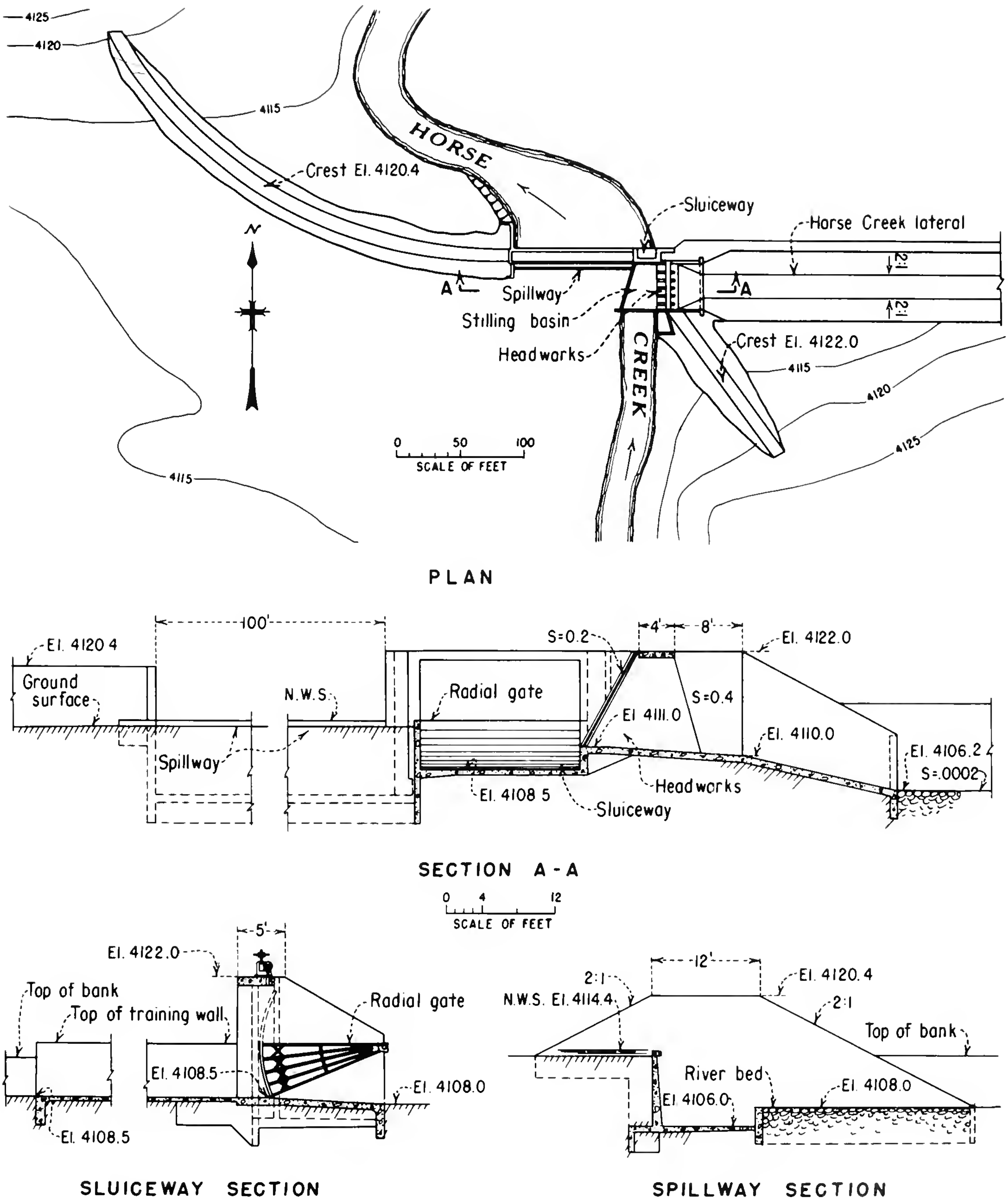
Pathfinder Dam, Plan and Sections



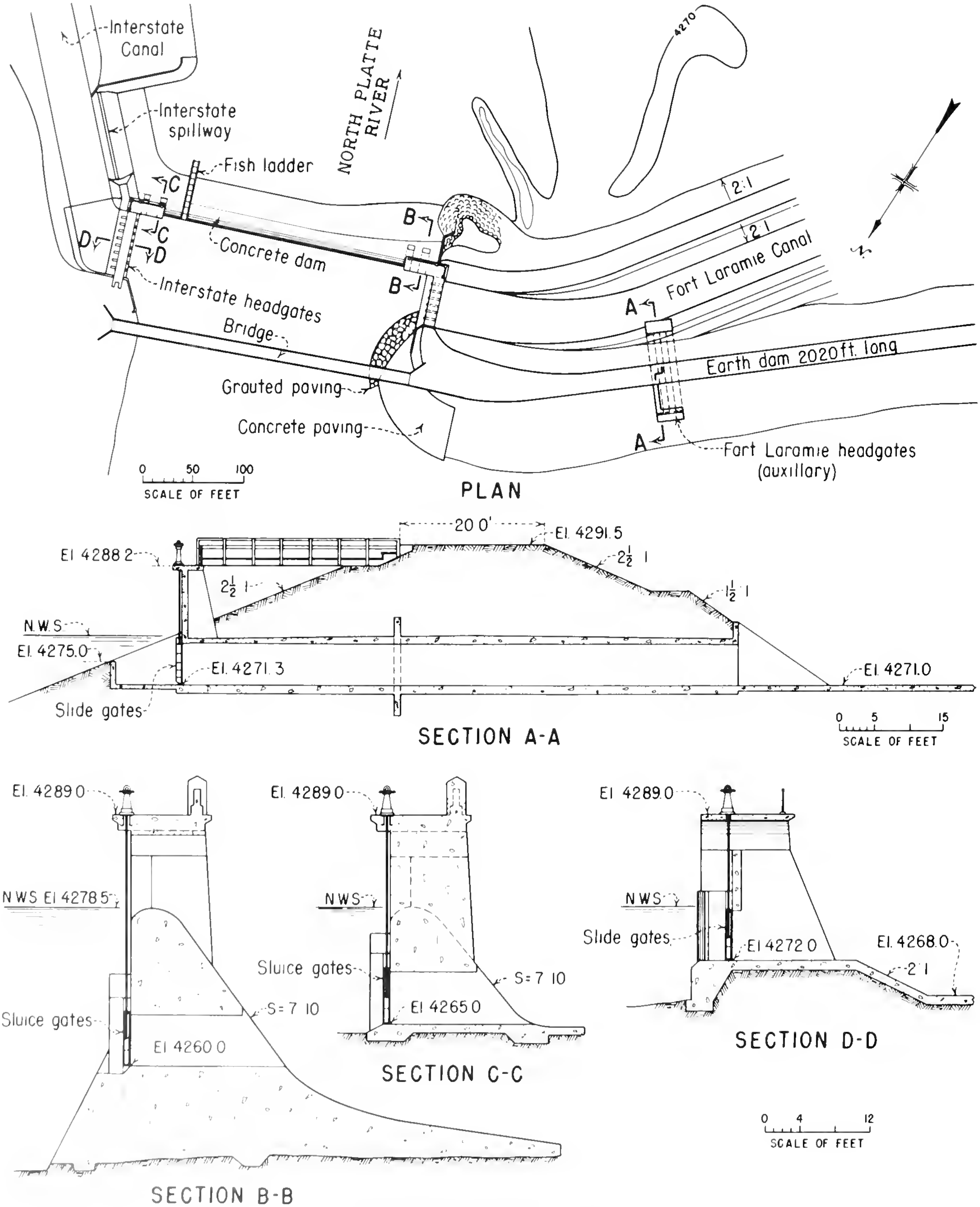
Guernsey Dam, Plan and Sections



Minatare Dam, Plan and Sections



Horse Creek Diversion Dam, Plan and Sections

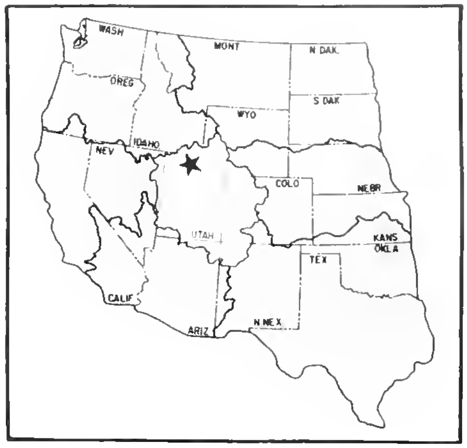


Whalen Diversion Dam, Plan and Sections

Ogden River Project

Utah: Weber and Box Elder Counties

Upper Colorado Region
Water and Power Resources Service



The Ogden River Project, in north-central Utah near Ogden and Brigham City, can furnish an irrigation supply to almost 25,000 acres of land lying between the Wasatch Mountains and the Great Salt Lake, and a supplemental municipal water supply for the city of Ogden. Project features include the Pineview Dam and Reservoir, the reconstructed Ogden Canyon Conduit, the Ogden-Brigham Canal, the South Ogden Highline Canal, and the high-pressure distribution system constructed for the South Ogden Conservation District.

PLAN

Water for project use is stored in the Pineview Reservoir. Irrigation releases are made through one of the dam outlets into the Ogden Canyon Conduit. At a point 4.7 miles below the reservoir, 35 cubic feet per second of the conduit's flow is diverted across the canyon through a suspended siphon to the head of the South Ogden Highline Canal. This canal conveys water to a 2,687-acre area lying within and adjacent to the east and south boundaries of Ogden.

Approximately 0.25 mile north of the Ogden Canyon siphon diversion, the wood-stave pipeline terminates in a concrete and steel surge tank where the remaining 245 cubic feet per second of water is divided between the valley and bench lands. Water for irrigation of valley lands first is used in the turbines of the Utah Power and Light Company's Pioneer Plant. The Ogden-Brigham Canal, extending from the surge tank to Brigham City, serves the higher lands adjacent to and below the canal. Distribution from the Ogden-Brigham Canal is made through privately constructed ditches.

Forty-seven artesian wells of the city of Ogden's domestic water supply system are submerged by Pineview Reservoir. Protection of this water supply required a pipe collection system through the reservoir and dam where it connects to the existing city main.

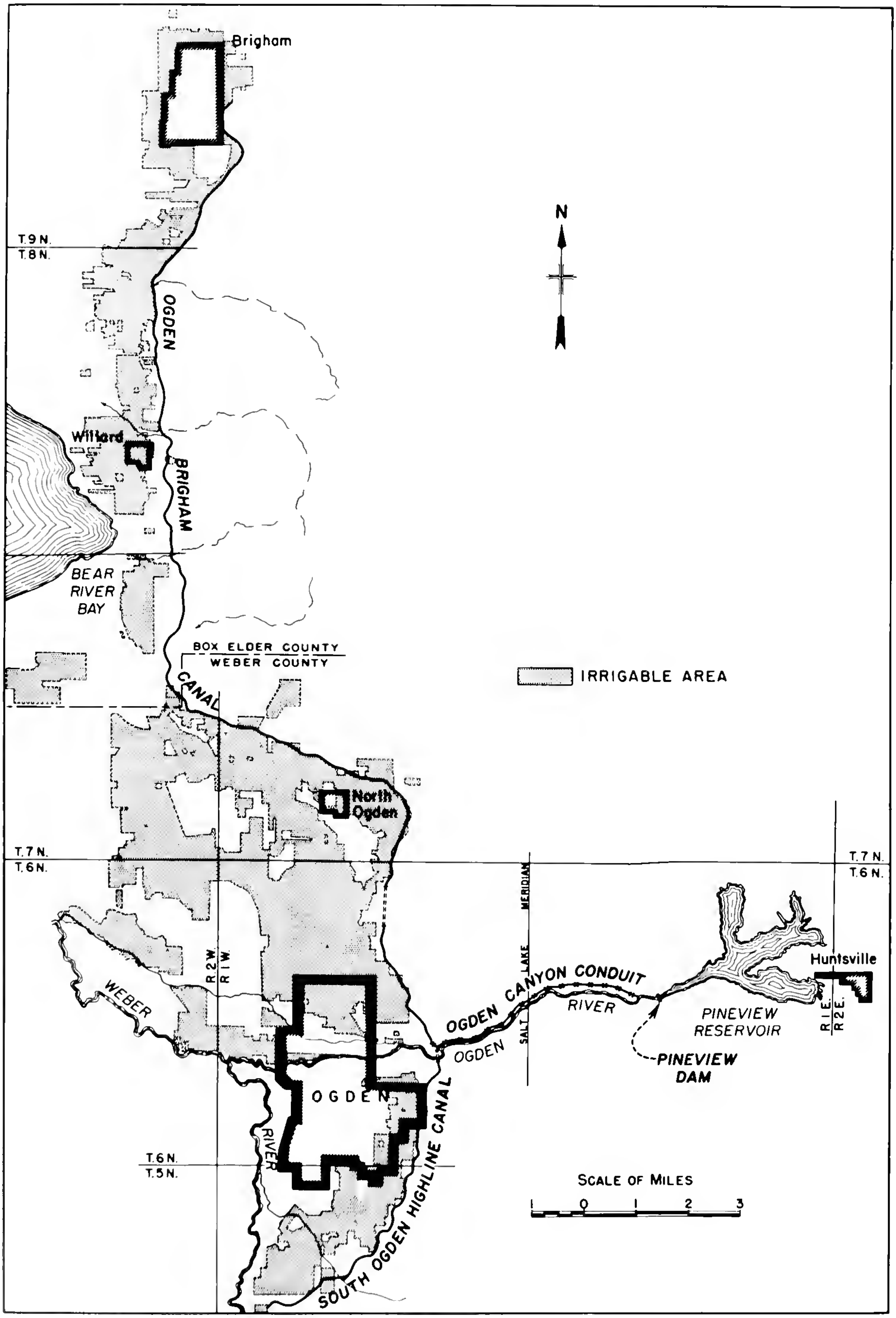
Pineview Dam

Pineview Dam is in the Ogden River Canyon about 7 miles east of Ogden, Utah. The dam is a zoned earthfill structure. It was originally constructed to a structural height of 103 feet, forming a reservoir of 44,170 acre-feet capacity. The capacity of the reservoir was later enlarged to 110,150 acre-feet by increasing the structural height of the dam to 137 feet as a part of the Weber Basin Project. The overflow, channel-type spillway, controlled by radial gates, has a capacity of 10,000 cubic feet per second.

A 2,300-cubic-foot-per-second-capacity outlet works is located in a tunnel in the right abutment. It consists of a 72-inch pipe which leads into the 75-inch Ogden Canyon Conduit, and a 60-inch pipe which discharges into the spillway stilling basin. A wye was added to the 72-inch line to permit additional discharges into the stilling basin, and a 42-inch pipe was connected to the 60-inch line to serve a new Ogden City filtration plant located downstream from the dam.

Canal System

From Pineview Dam, the water is transported westward 4.7 miles through the 75-inch Utah Power and Light Company conduit to the two canals for distribution. Water for the South Ogden Highline Canal is conveyed across the canyon in a 360-foot-long, 36-inch-diameter steel siphon suspended from the canyon wall. The South Ogden Highline Canal has an initial capacity of 35 cubic feet per second and extends south 5.2 miles from the intersection. It is a high-pressure distribution system, constructed for the delivery of water under pressure and on demand from the South Ogden Highline Canal. The Ogden-Brigham Canal has an initial capacity of 120 cubic feet per second and extends north on the east side of the project lands. These two canals convey water to



Ogden River Project

Pineview Dam and Reservoir

the water users through privately owned laterals under the Ogden-Brigham Canal and through project laterals under the South Ogden Highline Canal.

DEVELOPMENT

Early History

In 1850, three years after the settlement of Salt Lake City, Utah, the first diversions of water were made from the Ogden River to irrigate crops. Prior to 1900, 3,000 acres of land were irrigated from the Ogden River, either partially or fully. The fertile soil and the favorable climate made it possible to raise fruit and vegetables of excellent quality to supply the local market. However, as the diversions increased, the late summer natural flow was not sufficient to irrigate all of the developed land.

Investigations

Stream gaging stations were established on the Ogden River by the Geological Survey in 1921. Shortly thereafter, an investigation for a storage reservoir was made by the Bureau of Reclamation, in cooperation with the Utah Water Storage Commission, which continued intermittently through 1932. This resulted in adopting the Pineview Reservoir site for the storage of approximately 38,000 acre-feet of water. Plans were later revised for a storage of 44,170 acre-feet. The present reservoir has a total capacity of 110,150 acre-feet.

Authorization

The project was approved by the President on November 16, 1935, under terms of section 4 of the act of June 25, 1910 (36 Stat. 835) and subsection B, section 4, act of December 5, 1924 (43 Stat. 701). An allotment of funds for construction was made on August 24, 1933, under the National Industrial Recovery Act of June 16, 1933, section 203 (Public Law 57, 73rd Congress).

Construction

Construction by contract was started on September 29, 1934. Construction of the Pineview Dam and Ogden-Brigham Canal was completed in June 1937. The South Ogden Highline Canal and a distribution system consisting of 5.2 miles of concrete-lined canal and a 35-mile pressure pipe system were built during 1938-41. Pineview Dam was enlarged to provide storage of 110,150 acre-feet as part of the Weber Basin Project.

Operating Agencies

The project is operated by the Ogden River Water Users Association, except for the South Ogden distribution system, which is operated by the South Ogden Conservation District.

BENEFITS

Irrigation

A full supply for irrigation can be furnished to 24,801 acres of land. The water supply has improved economic conditions in the area and has brought fertile land under cultivation. Principal crops are peaches, apples, apricots, vegetables, sugar beets, small grains, corn, and hay.

Recreation

Pineview Reservoir area is used extensively for camping, picnicking, swimming, boating, boat racing, water skiing, and fishing for trout, bass, and walleyed pike. Recreation facilities, greatly expanded under the Weber Basin Project development, are administered by the Forest Service. Recreation visitors in 1977 totaled 328,800.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	24,801	acres
Number of irrigated farms	600	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	15,812	3,206,707
1969	15,812	2,879,727
1970	15,407	2,428,842
1971	15,291	3,571,278
1972	15,236	2,391,514
1973	15,205	4,576,109
1974	14,895	5,817,786
1975	14,875	5,663,138
1976	14,875	7,015,224
1977	14,855	6,962,210

Facilities in Operation

Storage dams	1	
Canals	30	mi
Laterals	66	mi

Climatic Conditions

Annual precipitation	17.6	in
Temperature:		
Maximum	105	°F
Minimum	−23	°F
Mean	50	°F
Growing season	150	days
Elevation of irrigable area	4700.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	2,400
Municipal water service	56,000
Other water service[1]	62,000
Total	120,400

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

OGDEN RIVER

Drainage area above Pineview Dam	298	mi²
Annual discharge at Pineview Dam:		
Maximum (1936)	263,500	acre-ft
Minimum (1934)	25,800	acre-ft
Average	161,000	acre-ft

Storage Facilities

PINEVIEW DAM

Type: Zoned earthfill
Location: On Ogden River 5 mi east of Ogden, Utah.
Construction period: 1934-37
Enlarged under the Weber Basin Project: 1955-57
Date of closure (first storage): November 1936

Reservoir, Pineview (enlarged):		
Average annual inflow, 1928-55	154,900	acre-ft
Total capacity to El. 4900	110,150	acre-ft
Active capacity	110,149	acre-ft
Surface area	2,874	acres

Dimensions (enlarged dam):

Structural height	137	ft
Hydraulic height	95	ft
Top width	30	ft
Maximum base width	480	ft
Crest length	600	ft
Crest elevation	4908.0	ft
Volume	418,000	yd^3

Spillway: Concrete-lined open channel in right abutment, controlled by two 12- by 22-ft radial gates.

Elevation top of gates	4900.0	ft
Crest elevation	4878.0	ft
Capacity at El. 4902	10,000	ft^3/s

Outlet works: Concrete-lined tunnel through right abutment, branching into 5- and 6-ft-diameter steel pipes, controlled by one 4- by 5-ft and one 5- by 6-ft gate, respectively, discharges into spillway stilling basin. The 5-ft pipe branches into a 3.5-ft steel pipe, controlled by a butterfly valve, leading to city of Ogden filtration plant. The 6-ft pipe has a 6-ft branch, without a gate, that leads into the 75-in Ogden Canyon Conduit, which branches into the Ogden-Brigham Canal, the South Ogden Highline Canal, and to Utah Power and Light Co.'s Pioneer Powerplant at the mouth of Ogden Canyon.

Capacity, all outlets at El. 4902	2,300	ft^3/s

City of Ogden water supply: 3-ft-diameter steel conduit beneath invert of outlet tunnel provides direct connection from city's artesian well collection system in reservoir area to city supply line.

Foundation: River sands, clays, and silts from 40 to 120 ft deep lying over limestone.

Special treatment: Cement grout curtain beneath cutoff walls and special grouting of springs in foundation.

Carriage Facilities

Ogden River Crossing (South Ogden Highline Canal)

Location: At Ogden River near Ogden, Utah.
Description: Circular steel siphon
Construction period: 1936-37

Length	360	ft
Capacity	35	ft^3/s
Diameter	36	in

South Ogden Highline Canal

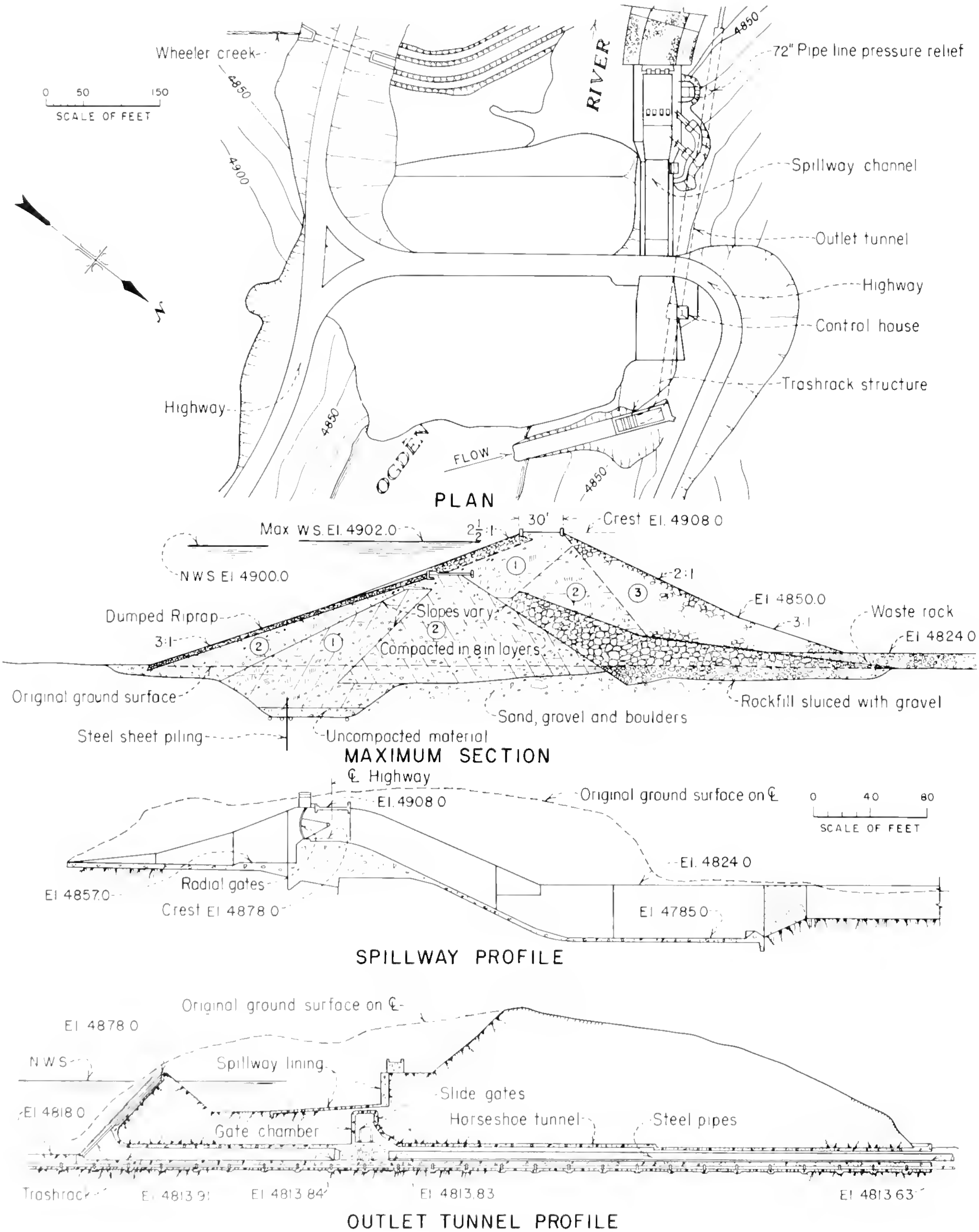
Location: From end of Ogden Canyon Conduit generally southwest. Entire canal is concrete lined.
Construction period: 1938-41

Length	5.2	mi
Diversion capacity	35	ft^3/s
Typical maximum section, concrete lined:		
Bottom width	1.94	ft
Side slopes	1.25:1	
Water depth	2	ft
Lining thickness	3	in

Ogden-Brigham Canal

Location: From end of Ogden-Brigham Conduit near Ogden, Utah, generally north to Brigham, Utah.
Type: Concrete
Construction period: 1935-37

Length	24.2	mi
Diversion capacity	120	ft^3/s
Typical maximum section, concrete lined:		
Bottom width	4	ft
Side slopes	1.25:1	
Water depth	3.1	ft
Lining thickness	3	in

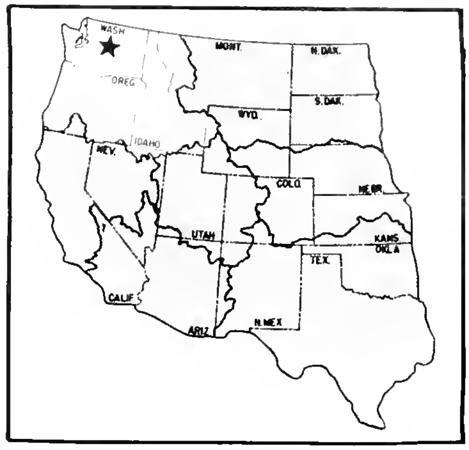


Pineview Dam, Plan and Sections

Okanogan Project

Washington: Okanogan County

Pacific Northwest Region
Water and Power Resources Service



Project facilities include Conconully Dam and Reservoir, Salmon Lake Dam and Conconully Lake, Salmon Creek Diversion Dam, 20 miles of main canals, and 43 miles of laterals to serve 5,038 acres of irrigable lands along the Okanogan River in the vicinity of Okanogan, Wash.

PLAN

Water is stored in Conconully Lake, a natural lake in which additional storage was developed by the construction of Salmon Lake Dam and a feeder canal diverting water from Salmon Creek, and in Conconully Reservoir, formed by the construction of Conconully Dam on Salmon Creek. Both reservoirs are near the town of Conconully, about 17 miles northwest of Okanogan. Water released from the reservoirs is conveyed through the channel of Salmon Creek for about 12 miles to the diversion dam and main canal heading. Two pumping plants provide water to about 1,500 acres of the project lands that are not served by the gravity canal system. Shell Rock Point Pumping Plant lifts water from the Okanogan River, and Duck Lake Pumping Plant lifts water from Duck Lake.

Conconully Dam and Reservoir

Salmon Lake Dam and Conconully Lake

Salmon Lake Dam is an earthfill structure 54 feet high, and has a volume of 195,000 cubic yards. The active reservoir capacity of Conconully Lake is 10,500 acre-feet. The spillway is a siphon type with a capacity of 400 cubic feet per second. The outlet works is a conduit controlled by two gates. A small diversion headworks structure on Salmon Creek diverts the flow into the reservoir through a short feeder canal.

Conconully Dam and Reservoir

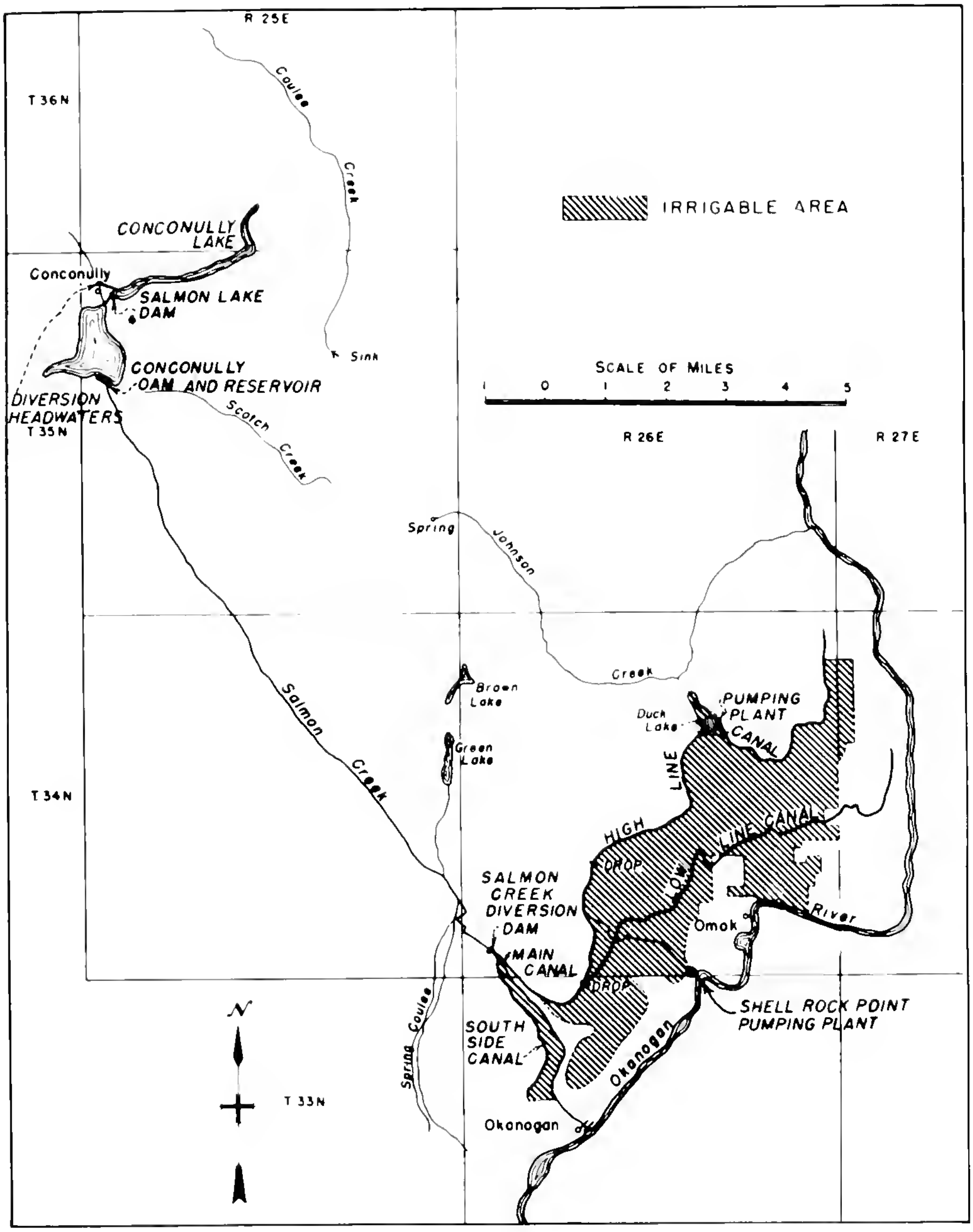
Conconully Dam is a hydraulic earthfill structure that was originally completed in 1910, was 70 feet high, and contained 359,000 cubic yards of fill. In 1920, the dam was raised 2.5 feet. Active capacity of the reservoir is 13,000 acre-feet. During 1968-69, the crest of the dam was repaired with new embankment materials and riprap. The old open-chute concrete spillway that had an inadequate capacity of 6,000 cubic feet per second was replaced with a concrete-baffled apron spillway that has a capacity of 11,580 cubic feet per second.

Salmon Creek Diversion Dam

About 12 miles downstream from Conconully Dam is the concrete diversion weir, 6 feet high, and 140 feet across the crest, with a 300-cubic-foot-per-second overflow capacity. The dam diverts Salmon Creek releases to the Main Canal, which is 2 miles long and has a capacity of 100 cubic feet per second. The High Line and Low Line Canals are 12 and 6 miles long, respectively.

Shell Rock Point Pumping Plant

The Shell Rock Point Pumping Plant was built on the Okanogan River in 1977-78 to replace two smaller pumping plants. The new plant has four pumps, each with a capacity of 8.3 cubic feet per second against a total head of 620 feet that discharge into the High Line Canal. Each drive motor is rated at 800 horsepower.



Okanogan Project

The Duck Lake Pumping Plant lifts water from Duck Lake and discharges into the High Line Canal; it has one unit with a capacity of 10 cubic feet per second driven by a 125-horsepower motor.

DEVELOPMENT

Early History

In 1886, the lands west of the Okanogan River were separated from the Colville Indian Reservation and thrown open to settlement. Settlers soon began to arrive and commenced irrigating forage crops for winter stock feed.

In 1897, because of the popularity of irrigation and the increasing demand for water from Salmon Creek, or Salmon River as it was shown on early maps, the Conconully Reservoir Company was organized to manage storage of some 1,500 acre-feet of water in Salmon Lake. By 1902, about 1,500 acres of land with water-right appropriations of 57 cubic feet per second from the Salmon River had been developed.

Investigations

In 1902, a preliminary investigation was undertaken by the Reclamation Service. The investigations were continued in 1903 and eventually the project was declared infeasible. In the first investigation, five reservoir sites were considered: the present Conconully and Salmon

Lakes, the Scotch Coulee, and Green and Brown Lakes. In 1904, investigations of feasibility were again undertaken, and in December 1905 the project was declared feasible. Immediately following this declaration, the Okanogan Water Users Association was formed, representing some 10,000 acres.

Authorization

The construction of the Okanogan Project was authorized by the Secretary of the Interior on December 2, 1905, under authority of the Reclamation Project Act of 1902. Shell Rock Point Pumping Plant was built under authority of the Emergency Drought Act of April 7, 1977, Public Law 95-18 (91 Stat. 36).

Construction

Conconully Dam was built during 1907-10, increased in height in 1920, and a new spillway completed in 1969; Salmon Lake Dam, 1919-21; Salmon Creek Diversion, 1906; North Fork Salmon Creek Diversion, originally completed in 1920, but rebuilt in 1948; Main, High Line, and Low Line Canals, 1911-17; Shell Rock Point Pumping Plant, 1977-78.

Operating Agency

Operation and maintenance of the irrigation system was assumed by the Okanogan Irrigation District on December 31, 1928.

BENEFITS

Irrigation

Full development of the project depended on reliable irrigation facilities. Although apples always have been the principal crop, other fruits, hay, and forage crops also are grown.

Recreation

Both Conconully Reservoir and Conconully Lake are located in an area of steep-sided hills that have open forests of coniferous and deciduous trees. Conconully is the smaller of the two reservoirs in the area; it has 5 miles of shoreline. Four roads provide good access. There are three campgrounds but the reservoir area is used predominantly by picnickers. The reservoir offers good fishing for trout and perch. Washington State Parks and Recreation Commission administers recreation at Conconully Reservoir.

Conconully Lake has 8 miles of shoreline and is served by one access road. There are two campgrounds on the lake, and two concessions provide lodging and rental boats. There is excellent trout fishing. Some of the upper reservoir area lies within the boundaries of the Okanogan National Forest which administers recreation for that portion. Recreation administration of the remaining reservoir area is by the Okanogan Irrigation District.

PROJECT DATA

Land Areas (1977)

Irrigable area:	
Full irrigation service	5,038 acres
Number of irrigated farms	365

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	3,963	1,575,442
1969	3,947	684,747
1970	4,018	1,363,001
1971	4,003	1,560,916
1972	3,985	1,991,886
1973	3,992	3,589,788
1974	3,992	1,886,338
1975	3,992	2,289,118
1976	3,992	1,789,248
1977	4,177	3,013,203

Facilities in Operation

Storage dams	2
Diversion dams	1
Canals	20 mi
Laterals	43 mi
Pumping plants	2

Climatic Conditions

Annual precipitation	11.8 in
Temperature:	
Maximum	101 °F
Minimum	−16 °F
Mean	47 °F
Growing season	168 days
Elevation of irrigable area	1000.0 ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,035
Other water service[1]	550
Total	1,585

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

SALMON CREEK

Drainage area	119 mi²
Annual discharge:	
Maximum (1974)	61,600 acre-ft
Minimum (1966)	8,800 acre-ft
Average[2]	23,000 acre-ft
Average annual diversions (1963-77)	21,257 acre-ft

[2]This is also the average annual inflow to both Conconully Reservoir and Conconully Lake.

Storage Facilities

Conconully Dam

Type: Hydraulic earthfill
Location: On Salmon Creek near Conconully, Wash.
Construction period: 1910. Repairs and new spillway: 1968-69.
Reservoir, Conconully:

Active capacity to El. 2287	13,000	acre-ft
Surface area	450	acres
Dimensions:		
Structural height	72	ft
Hydraulic height	63	ft
Top width	16	ft
Maximum base width	360	ft
Crest length	1,075	ft
Crest elevation	2301.0	ft
Volume	359,000	yd^3
Spillway: Uncontrolled, concrete-lined baffled apron at right abutment.		
Crest length	149	ft
Crest elevation	2287.0	ft
Capacity at El. 2295.3	11,580	ft^3/s
Outlet works: Concrete conduit through left abutment controlled by two 3-ft gate valves.		
Capacity at El. 2287	724	ft^3/s

Salmon Lake Dam

Type: Zoned earthfill
Location: Offstream near Conconully, Wash.
Construction period: 1919-21
Date of closure (first storage): 1921
Reservoir, Conconully Lake:

Active capacity to El. 2324.25	10,500	acre-ft
Surface area	310	acres
Dimensions:		
Structural height	54	ft
Hydraulic height	40	ft
Top width	18	ft
Maximum base width	263	ft
Crest length	1,250	ft
Crest elevation	2330.25	ft
Volume	195,000	yd^3
Spillway: Siphon spillway in dam above outlet works conduit. Vertical shaft passes through dam to outlet works conduit.		
Crest length	4.5	ft
Crest elevation	2324.25	ft
Capacity at El. 2325	400	ft^3/s
Outlet works: Concrete conduit through base of dam controlled by two 3- by 4.5-ft slide gates.		
Capacity at El. 2324	500	ft^3/s

Diversion Facilities

Salmon Creek Diversion Dam

Type: Concrete ogee weir, embankment wing
Year completed: 1906
Location: On Salmon Creek about 4 mi northwest of Okanogan, Wash.
Dimensions:

Structural height	6	ft
Hydraulic height	5	ft
Weir crest length	50	ft
Crest length	140	ft
Crest elevation	1376.0	ft
Volume	800	yd^3
Spillway: Overflow weir		
Capacity	300	ft^3/s
Headworks: 6-ft-wide concrete with hand-operated wooden control gate.		
Diversion capacity	100	ft^3/s

Carriage Facilities

Main Canal

Location: From Salmon Creek Diversion Dam southeasterly.
Construction period: 1911-17. Partially relined in 1936, 1947, and 1950.

Length	2	mi
Diversion capacity	100	ft^3/s
Typical maximum section in earth:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	3	ft
Typical maximum section, concrete lined:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	3	ft
Lining thickness	1.5	in

High Line Canal

Location: From end of Main Canal 2 mi north of Okanogan, then northeasterly.
Construction period: 1911-17. Partially relined 1935-40.

Length	12	mi
Typical maximum section in earth:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	2.5	ft
Typical maximum section, concrete lined:		
Bottom width	3	ft
Side slopes	1.25:1	
Water depth	2	ft
Lining thickness	3	in

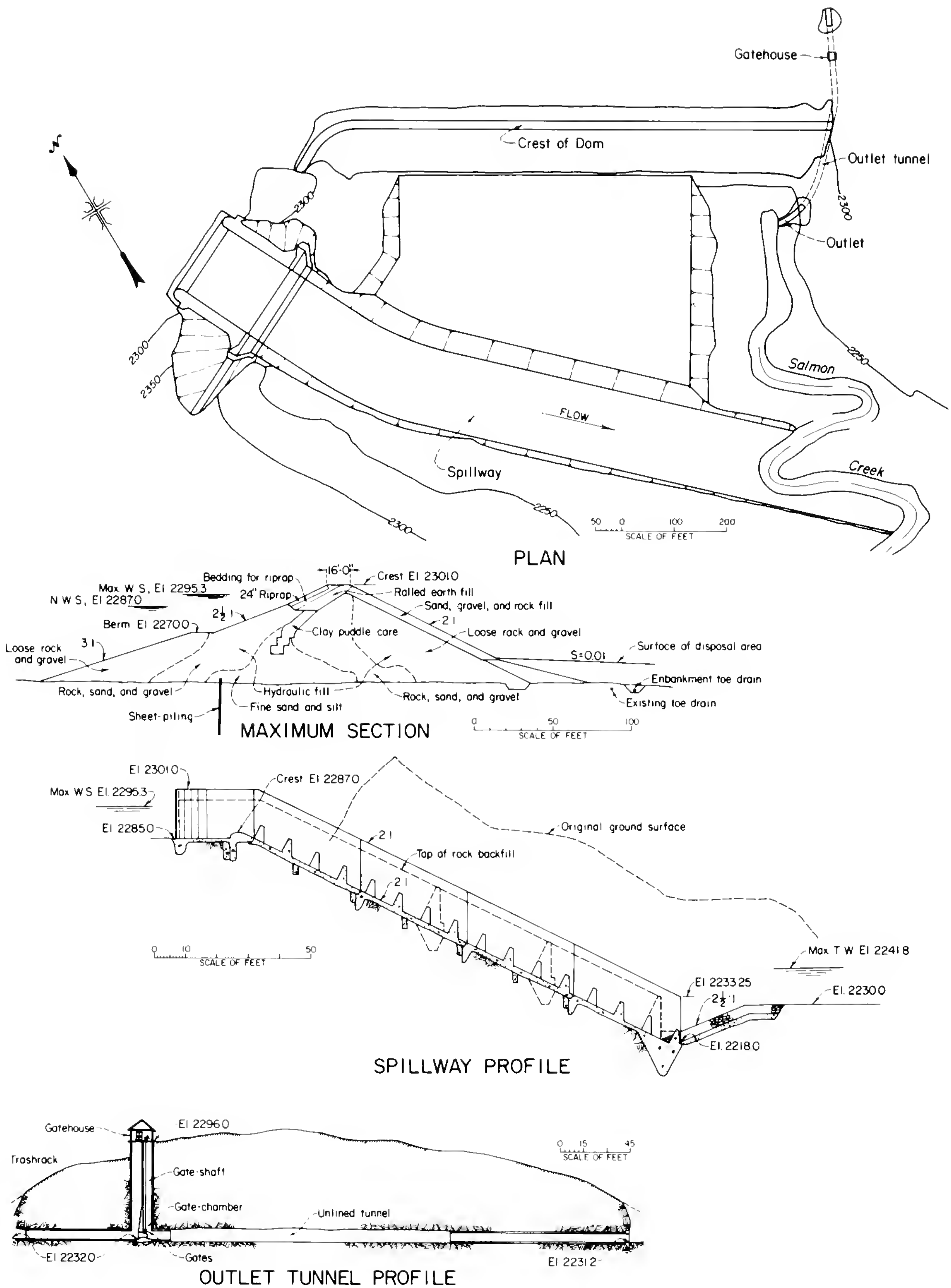
Low Line Canal

Location: From end of Main Canal 2 mi north of Okanogan, northeasterly.
Construction period: 1911-17

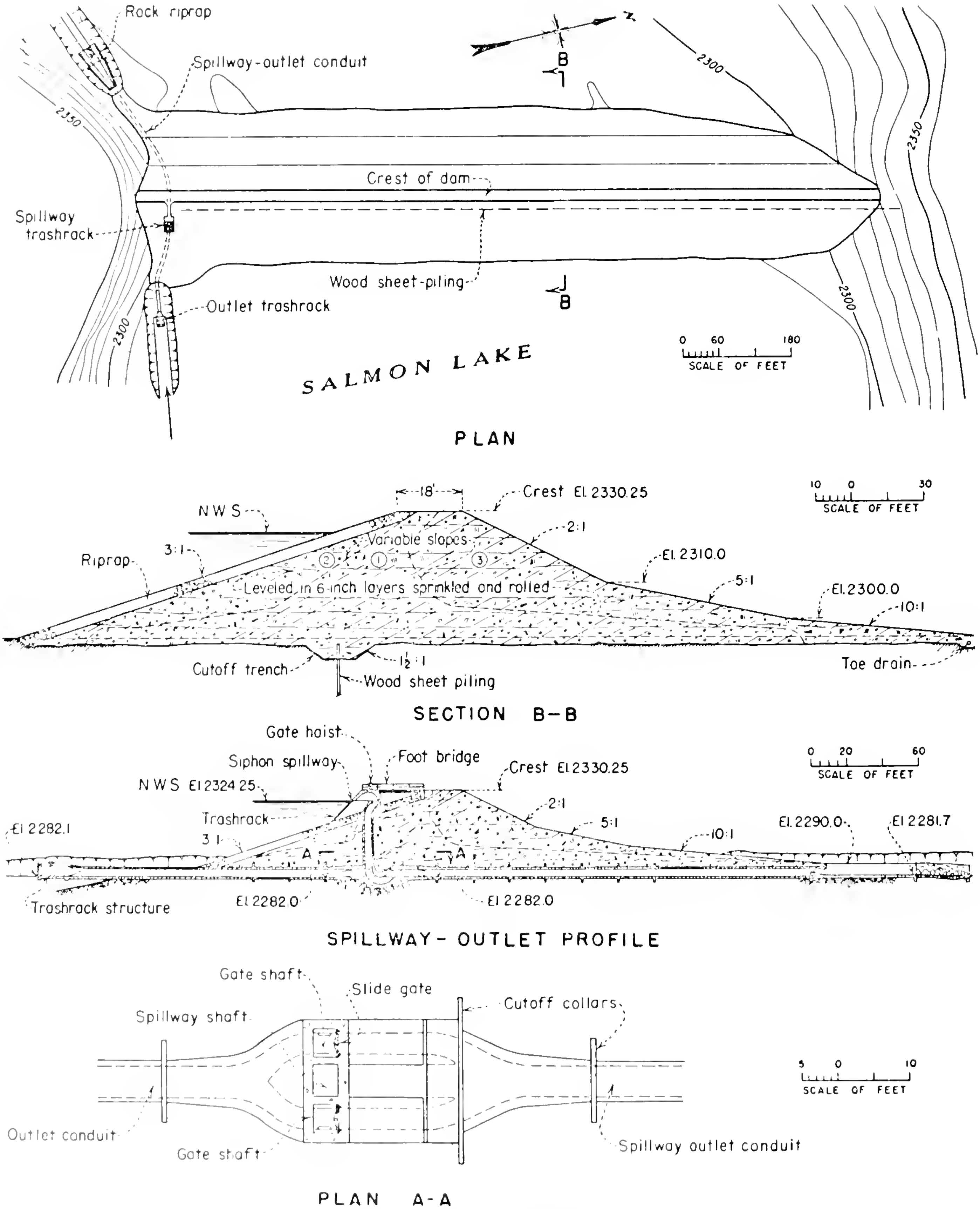
Length	6	mi
Typical maximum section, concrete lined:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1.5	ft
Lining thickness	1.5	in

Pumping Plants

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horsepower
Shell Rock Point	4	33	620	3,200
Duck Lake	1	10	15-40	125



Conconully Dam, Plan and Sections

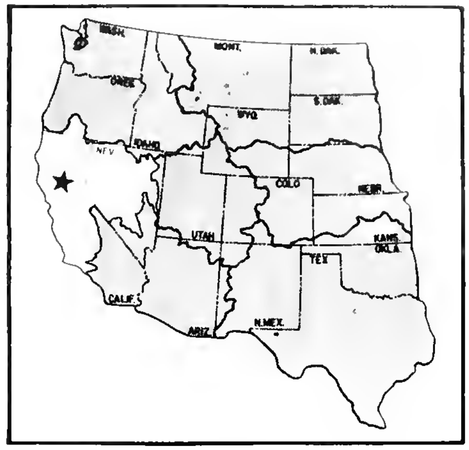


Salmon Lake Dam, Plan and Sections

Orland Project

California: Colusa, Glenn, and Tehama Counties

Mid-Pacific Region
Water and Power Resources Service



The Orland Project in north-central California is located in the Sacramento Valley about 100 miles north of Sacramento. The project, one of the oldest Federal reclamation projects in the country and one of the first undertaken in California, was authorized by the Secretary of the Interior in October 1907 after a finding of feasibility by a board of engineers. Water was delivered to the first farm units at the beginning of the 1910 growing season. The project comprises water storage facilities at two reservoirs and a distribution system servicing approximately 20,000 acres of irrigable land surrounding the town of Orland in Glenn County.

PLAN

The project plan provides for storage of water in East Park and Stony Gorge Reservoirs. The Rainbow Diversion Dam and the Northside Diversion Dam are the main diversion structures of the project. The Rainbow Diversion Dam diverts water from Stony Creek through the East Park Feed Canal to East Park Reservoir to furnish a supplemental water supply for that reservoir. The Northside Diversion Dam diverts water from Stony Creek into the North Canal for lands lying on the north side of the creek in the vicinity of Orland. Originally a Southside Diversion Dam, located at the site of the present Black Butte Dam, diverted water into the South Canal for lands south of the creek. Since Black Butte Dam and Reservoir were completed in 1963, this diversion has been made directly from the reservoir.[1]

East Park Dam and Reservoir

East Park Dam and Reservoir

East Park Dam, on Little Stony Creek about 33 miles southwest of the town of Orland, was completed in 1910. The reservoir has a storage capacity of 51,000 acre-feet and stores surplus water for irrigation purposes. Releases and spills from the reservoir flow down Stony Creek 18 miles for restorage in Stony Gorge Reservoir. The dam is a concrete thick-arch structure with a height of 139 feet and a crest length of 266 feet.

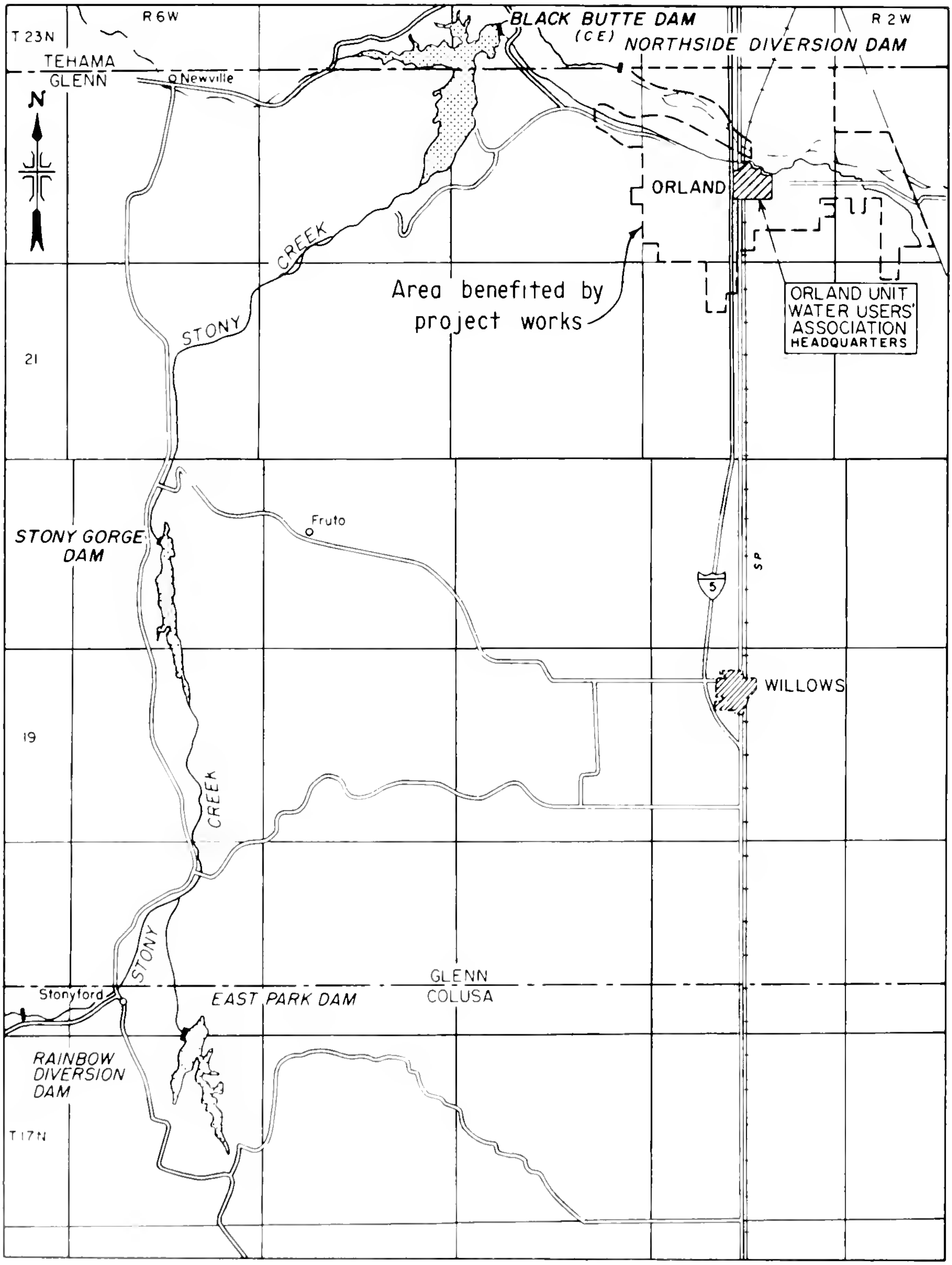
Stony Gorge Dam and Reservoir

Stony Gorge Dam, completed in 1928, is on Stony Creek about 18 miles downstream from East Park Dam and 5 miles west of Fruto in western Glenn County. The dam is a concrete slab and buttress structure with a height of 139 feet and a crest length of 868 feet. The reservoir, which has a storage capacity of 50,000 acre-feet, regulates flows along the lower reaches of Stony Creek and stores surplus water for irrigation purposes. Releases from the reservoir travel 22 miles down Stony Creek to the project's diversion points.

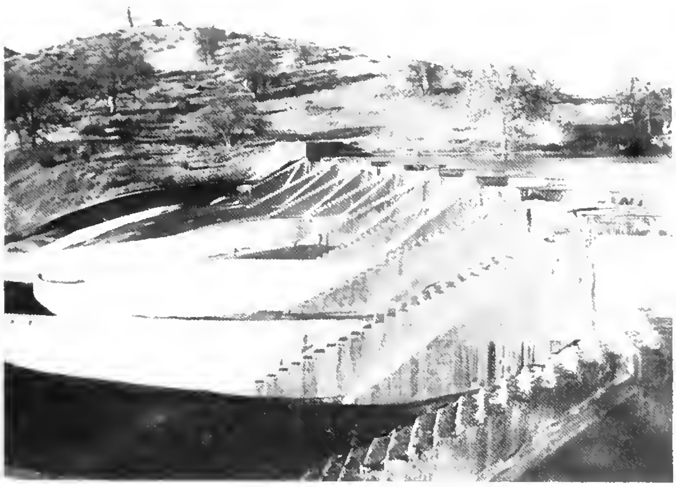
Rainbow Diversion Dam and Feeder Canal

Rainbow Diversion Dam is on Stony Creek about 3 miles west of the town of Stonyford. Its function is to divert

[1]Black Butte Dam and Reservoir are not a part of the Orland Project. They were constructed by the Corps of Engineers primarily for flood control purposes in 1960-63. By Public Law 91-502, October 23, 1970 (84 Stat. 1097), Black Butte is financially integrated and operationally coordinated with the Central Valley Project by the Bureau of Reclamation. Physical operation and maintenance of Black Butte Dam and Reservoir are retained by the Corps of Engineers.



Orland Project



Spillway at East Park Dam

part of the high flows of Stony Creek into the 7-mile-long East Park Feed Canal and then into East Park Reservoir to supplement the natural inflow to that reservoir. The dam, completed in 1914, is a concrete arch structure with a height of 44 feet and a crest length of 271 feet.

Northside Diversion Dam

Northside Diversion Dam is on Stony Creek about 5 miles northwest of Orland. Its function is to divert water into the headworks of the North Canal. The dam is a concrete gravity structure with a height of 15 feet and a crest length of 375 feet. It was completed in 1913 and partially replaced in 1954.

Canal and Distribution System

The canal and distribution system contains 16.9 miles of canals, including the East Park Feed Canal, and 139 miles of laterals. The system was designed to deliver water directly to each 40-acre unit in the project. Concrete lines 120 miles of the canals and laterals, and 5.6 miles of the laterals are in pipe.

DEVELOPMENT

Early History

The rapid development of the Central Valley in California began in 1849 after the discovery of gold. Cattle raising was the primary activity for the next decade, but at the same time various forms of agriculture were being established.

Investigations

The Reclamation Service began investigations in the Sacramento Valley in 1902. Included in these investigations was an area involving 40,000 to 50,000 acres located on Stony Creek on the west side of the Sacramento Valley close to the town of Orland. Three reservoir sites for water storage were considered; the East Park site was the most promising for development. The proposed dam was to be 115 feet high, capable of storing 26,000 acre-feet of water.

A committee of citizens took the initiative of obtaining signatures on a petition to the Secretary of the Interior. The petition was presented in May 1906 and an engineering board was appointed to present a detailed report. This report favored building a dam at the East Park site which would be 139 feet high and provide a storage capacity of 46,000 acre-feet.

As early as 1909, preliminary surveys had been made on the Stony Gorge Dam site. Supplemental surveys made in 1918 confirmed that an additional water supply for the project might be expected at this site. A vote of the water users, following a dry season in 1924 when there was considerable agricultural loss, resulted in unanimous approval of the dam.

Authorization

The project was authorized by the Secretary of the Interior on October 5, 1907.

Stony Gorge Dam and Reservoir

Northside Diversion Dam

Construction

Construction of the East Park Dam was started on August 27, 1908, and completed in 1910. The Northside Diversion Dam was built during the same period. The Rainbow Diversion Dam and East Park Feed Canal were constructed in 1913-15 when it was determined that insufficient water was being stored for project use.

The original canal system was unlined, but a supplemental agreement with the water users signed in 1918 provided for concrete lining. Under the resulting program, 1.5-inch unreinforced concrete lining in varying lengths was placed throughout the summer of 1924. Since then, additional lining has been placed as required where heavy transit and maintenance costs were encountered.

Stony Gorge Dam was started in 1926 and finished in October 1928. In April 1954, the Northside Diversion Dam failed. Temporary repairs permitted water service during the 1954 irrigation season, and permanent replacement was made during the following fall and winter.

Operating Agency

The Orland Unit Water Users' Association has operated the project since October 1, 1954.

BENEFITS

Irrigation

The principal crops are irrigated pasture, wheat, alfalfa hay, sorghum, olives, nuts, and citrus fruits. Dairying is an important business due to the mild climate, good market, and feed conditions. The hills and mountains west of the project are used extensively for grazing of sheep and cattle.

Recreation

East Park and Stony Gorge Reservoir areas provide campgrounds, including trailer space, picnicking areas, swimming, boating, and fishing, primarily for bluegill and largemouth bass. Management of the recreation facilities is under the jurisdiction of the Bureau of Reclamation.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	19,870	acres
Number of irrigated farms	849	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	16,823	2,306,089
1969	16,855	1,896,156
1970	16,778	2,106,091
1971	16,648	2,388,357
1972	16,317	2,826,109
1973	16,761	2,828,000
1974	17,128	3,480,763
1975	17,288	3,717,138
1976	16,734	2,611,919
1977	10,030	1,573,149

Facilities in Operation

Storage dams	2	
Diversion dams	2	
Canals	16.9	mi
Laterals	139	mi
Pumping plants	1	

Climatic Conditions

Annual precipitation	19.8	in
Temperature:		
Maximum	112	°F
Minimum	3	°F
Mean	62	°F
Growing season	220	days
Elevation of irrigable area	255.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	2,360
Municipal and other water service	250
Total	2,610

ENGINEERING DATA

Water Supply

STONY CREEK

Drainage area at Stony Gorge Reservoir	735	mi²
Annual discharge at Stony Gorge Reservoir:		
Maximum (1974)	422,000	acre-ft
Minimum (1977)	10,000	acre-ft
Average	220,000	acre-ft
Average annual diversion	125,000	acre-ft

Storage Facilities

EAST PARK DAM

Type: Concrete thick arch
Location: On Little Stony Creek about 33 mi southwest of Orland, Calif.
Construction period: 1908-10

Reservoir, East Park:		
Average annual inflow, 1920-70	63,900	acre-ft
Total capacity to El. 1198.2	51,000	acre-ft
Active capacity, El. 1198.2	51,000	acre-ft
Surface area	1,800	acres
Dimensions:		
Structural height	139	ft
Hydraulic height	90	ft
Top width	10	ft
Maximum base width	86	ft
Crest length	266	ft
Crest elevation	1198.7	ft
Total volume	16,000	yd³

Spillway: Concrete, multiple-arch uncontrolled overflow structure 2,000 ft south of dam.

Crest elevation, without flashboards	1198.2	ft

Outlet works: For service, conduit through dam controlled by a 4- by 5-ft slide gate. For sluicing, 2-ft conduit through base of dam.

Capacity at El. 1198.2	750	ft³/s

Foundation: Hard, tight, well-cemented conglomerate.

Mass concrete: Aggregate from natural sand and gravel deposits along Little Stony Creek near dam; standard portland cement. To decrease permeability, 12 percent fine sand was used in upstream face concrete.

Volume	12,200	yd³
Aggregate size (maximum)	3	in
Cement content	1	bbl/yd³

Temperature control: Concrete placed between 7 p.m. and 7 a.m. during summer months; aggregate cooled by sprinkling.

STONY GORGE DAM

Type: Concrete slab and buttress
Location: On Stony Creek about 40 mi southwest of Orland, Calif.
Construction period: 1926-28

Reservoir, Stony Gorge:		
Average annual inflow, 1929-70	219,700	acre-ft
Total capacity to El. 1852.7	50,000	acre-ft
Active capacity, El. 1852.7	50,000	acre-ft
Surface area	1,300	acres
Dimensions:		
Structural height	139	ft
Hydraulic height	113	ft
Top width, including parapet	9.75	ft
Maximum base width	168	ft
Crest length	868	ft
Crest elevation	1858.7	ft
Total volume	43,000	yd³

Spillway: Gate controlled section near center of dam overflows onto noncontinuous deck slabs spanning buttresses between training walls; concrete apron extends 75 ft downstream. Three 30-ft-square crawler gates open downward onto face of dam.

Elevation, top of gates	1852.7	ft
Crest elevation	1833.1	ft
Capacity, El. 1856.2	38,000	ft³/s

Outlet works: Two 50-in steel pipes through dam at the base controlled by 42-in needle valves.

Capacity at El. 1852.7	1,010	ft³/s

Foundation: Steeply tilted sedimentary rocks consisting of thick, massive sandstone with interbedded strata of conglomerate and shale. Inactive fault crosses dam axis in streambed.

Special treatment: Cement grout curtain beneath cutoff trench; secondary fault seams grouted.

Mass concrete: Natural aggregate from river-bed near dam, oversized crushed, maximum size 2, 3, and 6 in for various parts of the structure; standard portland cement used; natural temperature control.

Volume	43,100	yd^3
Aggregate size (maximum)	2, 3, 6	in
Cement content	1.85, 1.30, 1.23	bbl/yd^3

Diversion Facilities

Northside Diversion Dam

Type: Concrete weir, removable crest

Location: On Stony Creek about 5 mi northwest of Orland.

Year completed: 1913. Partially replaced in 1954.

Dimensions:

Structural height	15	ft
Hydraulic height	3	ft
Crest length	375	ft
Crest elevation	1329.9	ft
Volume	1,000	yd^3
Diversion capacity	125	ft^3/s

Rainbow Diversion Dam

Type: Concrete arch weir

Location: On Stony Creek about 3 mi west of the town of Stonyford.

Year completed: 1914

Dimensions:

Structural height	44	ft
Hydraulic height	29	ft
Crest length	271	ft
Crest elevation	1288.7	ft
Volume	2,000	yd^3
Diversion capacity	200	ft^3/s

Carriage Facilities

East Park Feed Canal

Location: From Rainbow Diversion Dam southeast to East Park Reservoir.

Construction period: 1913-15

Length	7	mi
Capacity	250	ft^3/s
Typical maximum section:		
Bottom width	6	ft
Side slopes	1:1	
Water depth	6	ft
Lining thickness	4	in

North Canal

Location: From Northside Diversion Dam southeast along Stony Creek.

Construction period: 1913

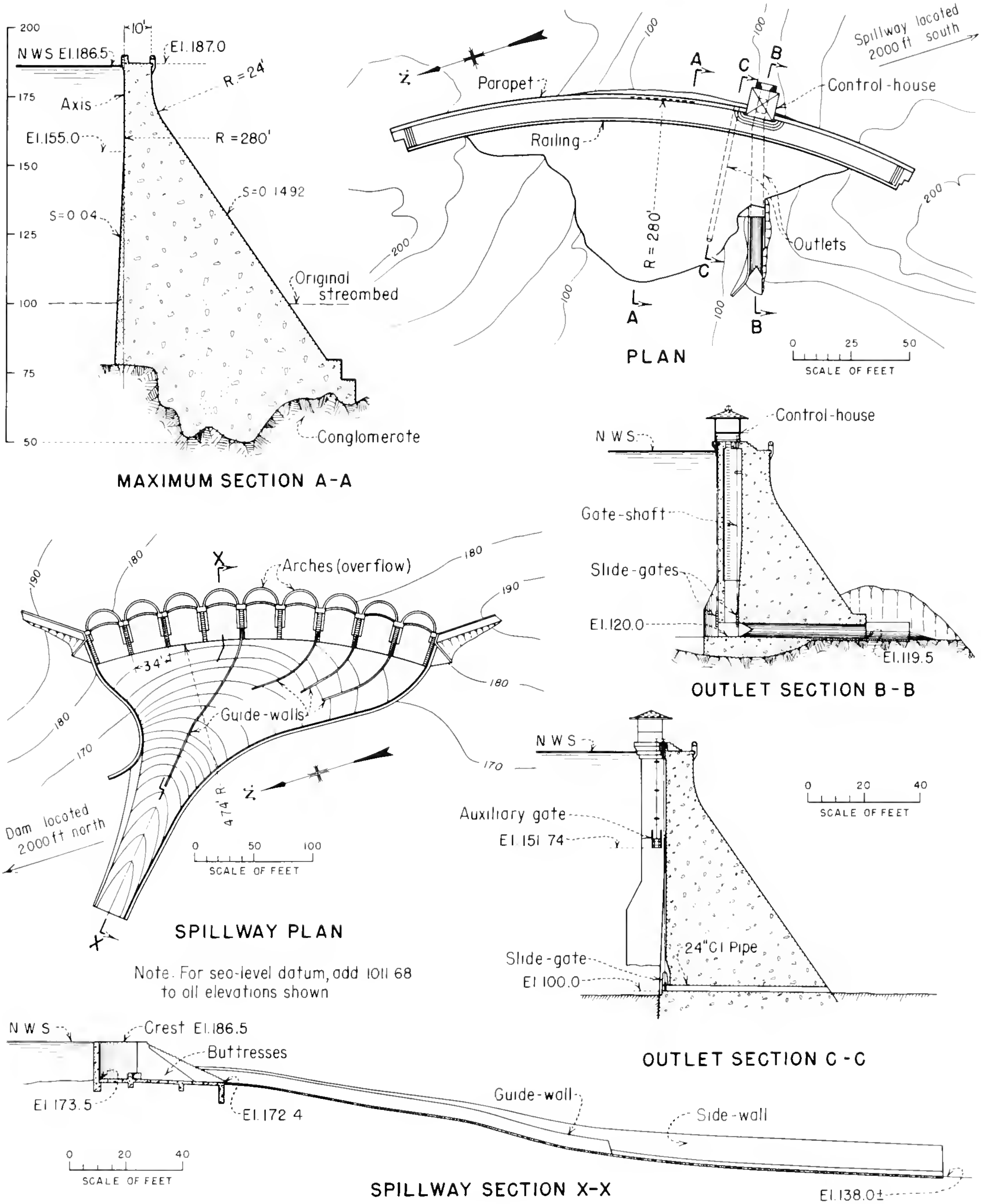
Length	0.3	mi
Capacity	125	ft^3/s
Typical maximum section:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth	4.1	ft

South Canal

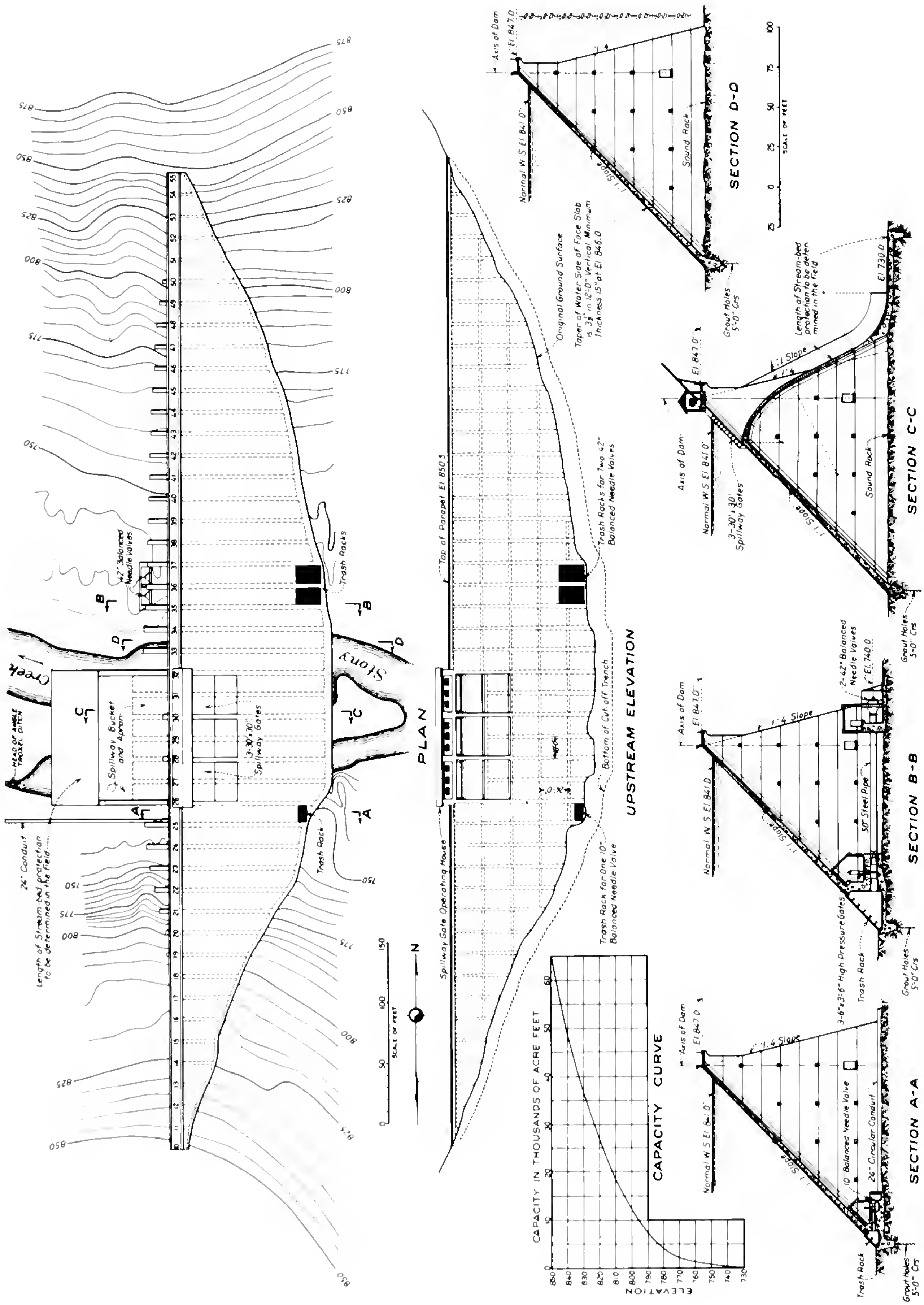
Location: Along Stony Creek southeast to Orland.

Construction period: 1912-16

Length	9.6	mi
Capacity	260	ft^3/s
Typical maximum section:		
Bottom width	18	ft
Side slopes	1.5:1	
Water depth	3.8	ft



East Park Dam, Plan and Sections

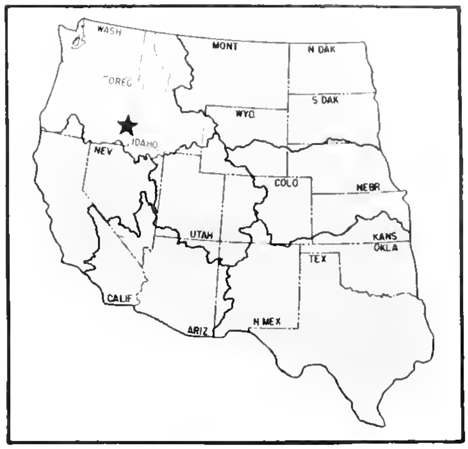


Stony Gorge Dam, Plan and Sections

Owyhee Project

Idaho: Owyhee County
Oregon: Malheur County

Pacific Northwest Region
Water and Power Resources Service



PLAN

The Owyhee Project lies west of the Snake River in Malheur County, Oregon, and Owyhee County, Idaho. Principal towns in the area are Homedale, Idaho, and Adrian, Nyssa, and Ontario, Oreg. The project furnishes irrigation water for 105,249 acres of land lying along the west side of the Snake River in eastern Oregon and southwestern Idaho. An additional 13,000 acres are furnished supplemental water. Approximately 72 percent of the lands are in Oregon, and 28 percent in Idaho. Irrigable lands are divided into the Mitchell Butte, Dead Ox Flat, and Succor Creek Divisions. The key feature of the project is Owyhee Dam, on the Owyhee River about 11 miles southwest of Adrian, Oreg., which acts as both a storage and diversion structure. Project works also include 172 miles of canals, 543 miles of laterals, 9 pumping plants, and 227 miles of drains.

Owyhee Dam

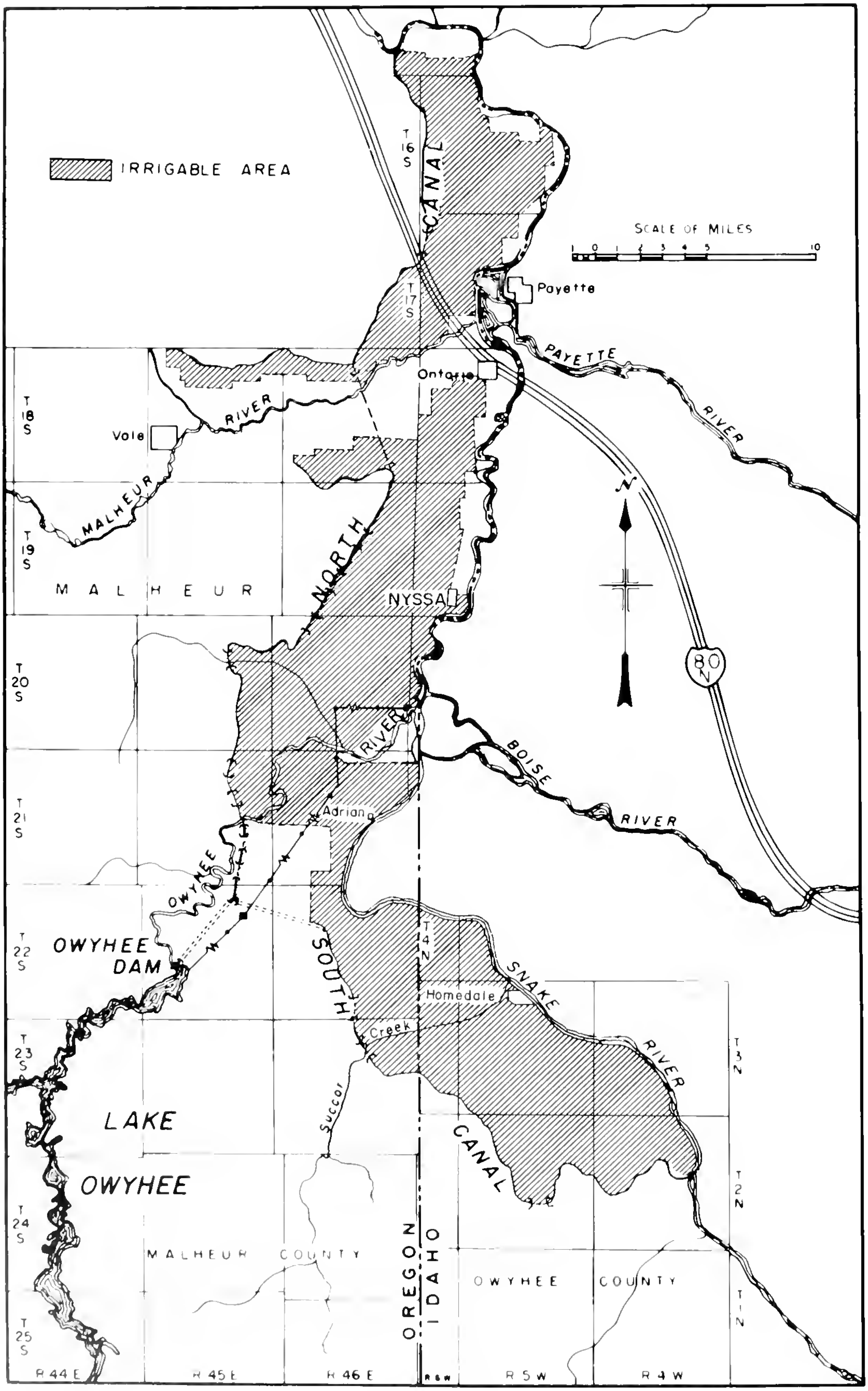
The Owyhee River Basin above Owyhee Dam contains 11,160 square miles and has an average runoff of about 760,000 acre-feet. Water for irrigation of project lands is both stored in Lake Owyhee and pumped directly from the Snake River. The water is released from Lake Owyhee through a 3.5-mile tunnel to Tunnel Canyon where the North and South Canals have their headings. The North Canal distributes water to the Mitchell Butte and Dead Ox Flat Divisions. The South Canal distributes water south to the Succor Creek Division.

Originally, the irrigation works were designed to supply water to the entire project by gravity from Lake Owyhee. Because of the irregular flow of the Owyhee River, storage of a 2-year water supply is advisable. Pumping water from the Snake River for lower lying lands makes this possible. A contract executed in 1936 provides for the operation of existing pumping plants to irrigate from 30,000 to 35,000 acres. Power is supplied from Boise Project powerplants.

Owyhee Dam and Lake Owyhee

Owyhee Dam is a concrete, thick-arch structure which was designed to carry about three-fourths of the water load by arch action, and the remainder by gravity action. The dam rises 417 feet above foundation in the river section, and 530 feet above the low point of the excavated fault zone. At the time of its construction, Owyhee ranked as the world's highest dam. The arch section is 623 feet long, and a gravity tangent extends 210 feet to the right abutment. The capacity of Lake Owyhee is 1,120,000 acre-feet.

Owyhee Dam became a proving ground for theories being developed to assist with the design and construction of Hoover Dam, whose unprecedented size—it would tower more than 300 feet higher than Owyhee—required totally new construction methods. The trial-load method of design, developed first for Pathfinder and Buffalo Bill Dams, was refined in the design of Owyhee Dam, and



Owyhee Project

later Hoover Dam. Cooling methods, necessary to remove excess heat of cement hydration from mass concrete and bring a dam to stable temperatures, were carefully studied. A 28-foot-square section extending through the dam was cooled artificially by circulating river water through 1-inch pipes spaced at 4-foot intervals.

Water for irrigation is diverted through a horseshoe-type tunnel 16 feet 7 inches in diameter and 3.5 miles long. This tunnel heads in the reservoir 80 feet below normal maximum water surface.

North Canal

This canal extends from the diversion works, 3.5 miles from Owyhee Dam, northward 61.5 miles to the Snake River near Weiser, Idaho. The diversion capacity is 1,190 cubic feet per second. The canal contains several siphons and tunnels. The most noteworthy structure is the Malheur River Siphon, which carries water from the Mitchell Butte Division across the Malheur Valley to the Dead Ox Flat Division. It is an 80-inch steel pipe siphon approximately 4.5 miles long with a monolithic concrete pipe section at each end. The design capacity of the siphon is 325 cubic feet per second.

South Canal

The South Canal extends from the diversion works near Owyhee Dam through a 5-mile tunnel and then southward 37 miles to the Snake River south of Marsing, Idaho. The diversion capacity of the canal is 490 cubic feet per second.

Pumping Plants

Dead Ox Pumping Plant, on the Snake River about 5 miles north of Payette, pumps water to several irrigation districts in the Dead Ox Flat Division. The plant has five pump units with a total capacity of 176 cubic feet per second.

Owyhee Ditch and Ontario-Nyssa Pumping Plants, on the Snake River 5 miles south of Nyssa, pump water to the Ontario-Nyssa Irrigation District and the Owyhee Ditch Company in the Mitchell Butte Division. The Owyhee Ditch Pumping Plant has a capacity of 222 cubic feet per second and the Ontario-Nyssa Pumping Plant a capacity of 130 cubic feet per second.

Gem Pumping Plant, 2 miles south of Marsing, Idaho, pumps water from the Snake River to the Gem Irrigation District in the Succor Creek Division. It has a capacity of 334 cubic feet per second.

Power Distribution System

Power from the Boise Project is transmitted over lines of a private power company to various points on the Owyhee Project. A 69-kilovolt project transmission line of 2,500-kilowatt capacity extends 19.4 miles from Ontario-Nyssa substation at Dunaway, Oreg., to Owyhee Dam.

DEVELOPMENT

Early History

Scouts, trappers, and traders visited the project lands in the early part of the 19th century. Permanent settlers arrived about 60 years later. At the beginning of the 20th century, irrigation in the project area was limited to about 6,000 acres from Owyhee Ditch, diverted from the Owyhee River, and to smaller acreages from Wilson Ditch, the Snake, and individual diversions from Succor Creek. Later, private organizations became interested in developing storage to provide adequate late-season water and to irrigate additional lands at higher elevations. Several damsites were investigated and various irrigation plans considered, but the inaccessibility of the sites made construction costs prohibitive.

Investigations

From 1903 to 1905, the Reclamation Service made topographic surveys of the irrigable lands in the Owyhee River Basin and of possible reservoir sites. During the following years several reports were made by Government engineers, State cooperative boards, and private companies. After studying various plans and making intensive investigations, the Bureau of Reclamation issued a feasibility report in January 1925 that recommended construction of the project substantially as it has been developed. On the basis of this report, the project was recommended by the Secretary of the Interior on October 9, 1926.

Authorization

Construction of the project was approved by the President on October 12, 1926.

Construction

Contracts were awarded and work started on the storage dam and canal system in 1928. The first water from constructed works was delivered to the project lands in 1935, and the lateral system was extended to the last irrigation area in 1939.

Operating Agency

Project works, except Owyhee Dam and related works which were retained and operated by the United States, were transferred to the water users (represented by the

North and South Boards of Control) in 1952 for operation and maintenance. Two years later, Owyhee Dam and related works also were transferred to the water users for operation and maintenance.

BENEFITS

Irrigation

The fertile lands and favorable climate, combined with a good supply of irrigation water, make possible the production of abundant crops on the Owyhee Project, principally grain, hay, pasture, sugar beets, potatoes, onions, sweet corn, and alfalfa seed. Livestock and dairy products contribute to the returns from the land.

Recreation and Fish and Wildlife

Lake Owyhee is a long, narrow reservoir with about 150 miles of shoreline, located in a canyon of rugged and spectacular beauty. The lake is in a remote area with only two areas of access but, because of an excellent warm-water fishery, it experiences heavy recreational use. Public facilities have been constructed a few miles above the dam and include two campgrounds, a day-use area, and a resort and marina complex. Fifty-six private cabins have been built at two boat-in areas under lease from the Bureau of Reclamation. The lake also provides excellent waterfowl hunting, and the surrounding hills and canyons offer many opportunities for the pursuit of upland game birds. A variety of wildlife may be observed in the reservoir area, including wild horses, bighorn sheep, golden eagles, pelicans, and cormorants.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	105,249	acres
Supplemental irrigation service	13,000	acres
Total	118,249	acres
Number of irrigated farms	1,826	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	111,293	19,832,880
1969	110,249	24,360,538
1970	110,267	23,264,237
1971	109,532	24,968,891
1972	109,912	30,568,925
1973	111,043	39,265,174
1974	111,136	55,985,480
1975	112,279	51,922,410
1976	112,249	40,043,359
1977	[1]112,492	47,639,978

[1]Idaho, 32,373; Oregon, 80,119.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	172	mi
Laterals	543	mi
Pumping plants	9	
Drains	227	mi
Transmission lines	19.4	mi
Substations	7	

Climatic Conditions

Annual precipitation	9.8	in
Temperature:		
Maximum	105	°F
Minimum	−18	°F
Mean	51	°F
Growing season	188	days
Elevation of irrigable area	2250-2500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	5,413
Other water service[2]	3,832
Total	9,245

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

OWYHEE RIVER

Drainage area	11,160	mi²
Annual inflow, Lake Owyhee:		
Maximum (1971)	1,328,000	acre-ft
Minimum (1977)	203,000	acre-ft
Average	760,000	acre-ft
Annual pumping from Snake River:[3]		
Maximum (1977)	186,608	acre-ft
Minimum (1972)	131,814	acre-ft
Average	144,045	acre-ft
Average annual diversions including pumping (1963-77)	652,900	acre-ft

[3]Supply available in Snake River for pumping limited only by pump capacity. Actual pumpage varies inversely with Owyhee River supply including holdover.

Storage Facilities

OWYHEE DAM

Type: Concrete thick-arch
Location: On Owyhee River about 11 mi southwest of Adrian, Oreg.
Construction period: 1928-32
Reservoir, Lake Owyhee:

Average annual inflow, 1963-77	760,000	acre-ft
Total capacity to El. 2670	1,120,000	acre-ft
Active capacity, El. 2590.2-2670	715,000	acre-ft
Surface area	12,742	acres
Dimensions:		
Structural height	417	ft
Hydraulic height	325	ft
Top width	30	ft

Maximum base width	265	ft
Crest length	833	ft
Crest elevation	2675.0	ft
Total volume	537,500	yd^3

Spillway: Morning-glory type controlled by 60- by 12-ft ring gate at entrance to 309-ft vertical shaft 60 to 22.5 ft in diameter, and a 760-ft-long tunnel through right abutment.

Crest elevation	2658.0	ft
Elevation top of gates (fully raised)	2670.0	ft
Capacity at El. 2670	30,560	ft^3/s

Outlet works: For service, three conduits through dam controlled by 4-ft needle valves at downstream face. Dam also has three sluicing outlets and two blind conduits for future power installation.

Capacity of needle valves at El. 2670	2,800	ft^3/s

Diversion works: Tunnel (North Canal Tunnel No. 1) with inlet about 80 ft below normal water surface about 0.5 mi from dam on right side of reservoir, controlled by eight 4.75- by 12-ft slide gates. (See Carriage Facilities tunnel characteristics.)

Foundation: Felsite volcanic plug flanked by rhyolitic flows of broken and glassy lava overlying tuff, shale, and pitchstone agglomerate. Fault zone in streambed parallel to canyon.

Special treatment: Fault zone excavated to firm rock and backfilled with concrete; all cracks and crevices pressure grouted, abutments grouted.

Mass concrete: Natural aggregate from Dunaway pit 24 mi from damsite, oversize crushed; standard portland cement; natural temperature control.

Volume	488,000	yd^3
Aggregate maximum size	8	in
Cement content	1	bbl/yd^3
Average water-cement ratio (by weight)	0.67	

Contraction joints: Radial spacing at upstream face on 50-ft centers. Surfaces painted with watergas tar; pressure grouted through embedded pipe system.

Carriage Facilities

NORTH CANAL

Location: From Lake Owyhee north about 65 mi to the Snake River across from Weiser, Idaho.
Construction period: 1930-36

Total length (excluding pipelines and tunnels)	61.5	mi
Diversion capacity	1,190	ft^3/s
Typical maximum section in earth:		
Bottom width	24	ft
Side slopes	1.5:1	
Water depth	10.9	ft
Typical maximum section, concrete lined:		
Bottom width	10.2	ft
Side slopes	1.25:1	
Water depth	10	ft
Thickness of lining	4	in

NORTH CANAL TUNNEL NO. 1

Location: From Lake Owyhee near the dam, 3.5 mi northeast to Tunnel Canyon.
Construction period: 1930-32

Length	3.5	mi
Capacity	1,840	ft^3/s
Diameter	16.58	ft
Cross section: Horseshoe		
Concrete lining	8-16	in

MALHEUR RIVER SIPHON (NORTH CANAL)

Location: Valley of the Malheur River near Ontario, Oreg.
Construction period: 1935

Length	4.3	mi
Capacity	325	ft^3/s
Diameter (inside)	6.67	ft
Maximum head	283	ft

Material: Plate steel

SOUTH CANAL

Location: From end of North Canal Tunnel No. 1 to Snake River opposite Marsing, Idaho.
Construction period: 1930-36

Total length	37	mi
Diversion capacity	490	ft^3/s
Typical maximum section in earth:		
Bottom width	16	ft
Side slopes	1.5:1	
Water depth	7	ft

SOUTH CANAL TUNNEL NO. 5

Location: From end of North Canal Tunnel No. 1, southeast.
Construction period: 1930-32

Length	4.2	mi
Capacity	650	ft^3/s
Diameter:		
Horseshoe section	9.25	ft
Circular section	9.5	ft
Lining	6-10	in

PUMPING PLANTS

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horse-power
Mitchell Butte Division:				
Ontario-Nyssa	4	130	120	2,250
Owyhee Ditch	3	222	50	1,500
Dead Ox Flat Division:				
Dead Ox	5	176	50-111	2,675
Succor Creek Division:				
Succor Creek No. 1[4]	1	15	61	--
Succor Creek No. 2[4]	1	15	66	--
Gem District: Gem Advancement District:	9	334	76-180	7,610
South	1	13	20	40
North	1	5.5	33	30
Kingman Colony District:				
Kingman Colony	1	6	44	40

[4]Succor Creeks No. 1 and No. 2 are direct-connected hydraulic powered units. Other plants are supplied power from Boise Project powerplants.

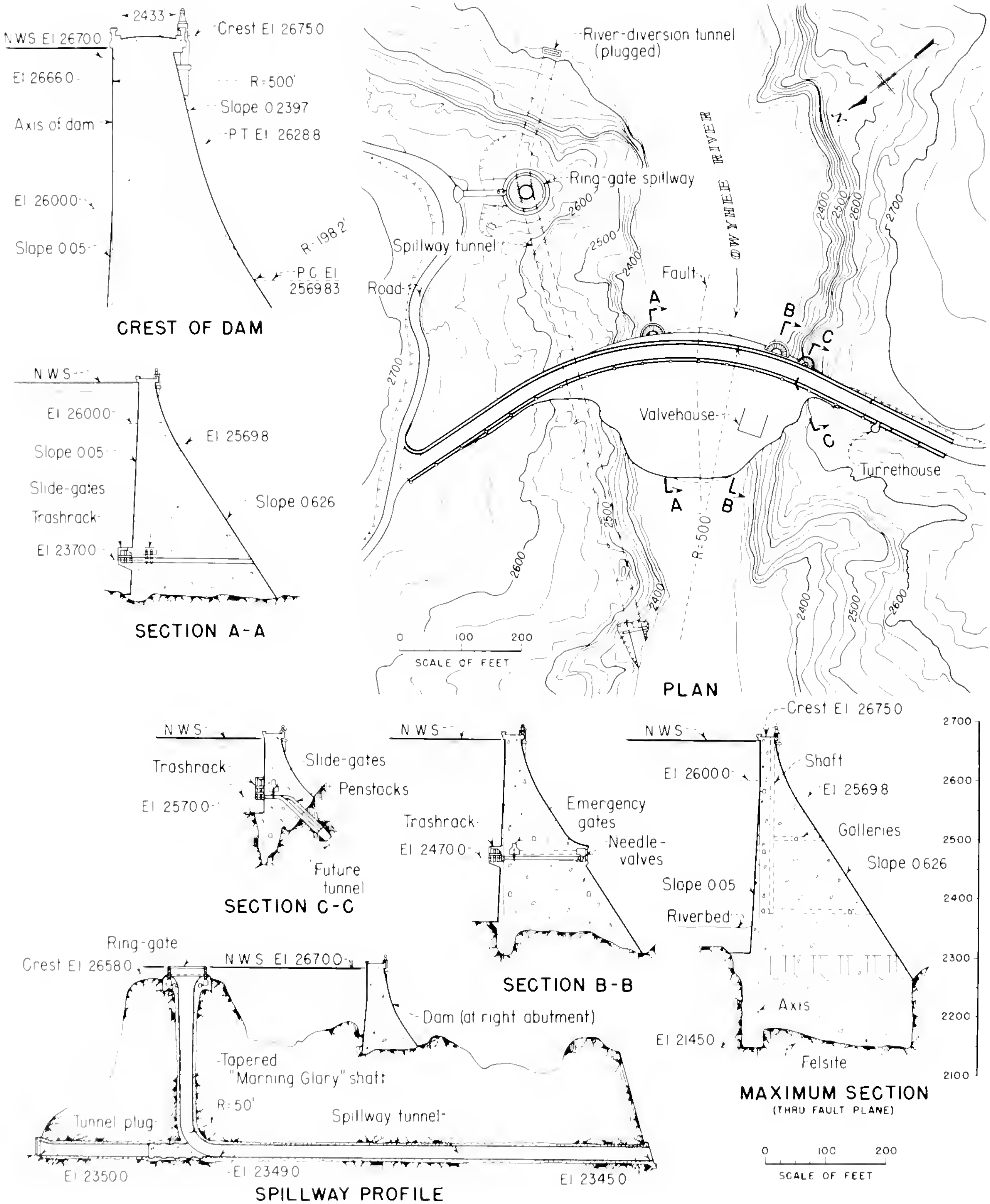
Power Facilities

TRANSMISSION LINES

Total number of lines	1	
Total circuit miles	19.4	
Capacity	69	kV

SUBSTATIONS

Number in operation	7	
Total capacity of transformers	5,670	kVA

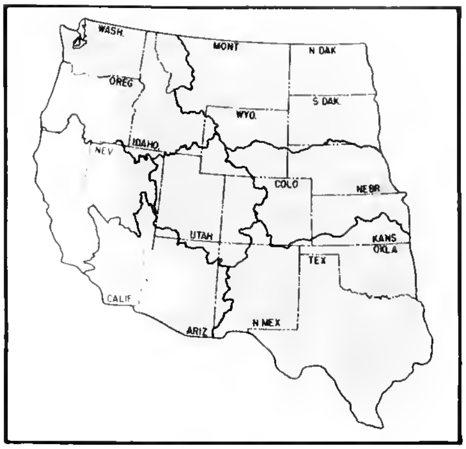


Owyhee Dam, Plan and Sections

Pacific Northwest-Pacific Southwest Intertie
(Under Construction)

Arizona, California, Nevada, and Oregon

Pacific Northwest, Mid-Pacific, and Lower Colorado Regions
Water and Power Resources Service



The Bureau of Reclamation had an important role in the planning and early development of the Pacific Northwest-Pacific Southwest Intertie. It is the largest single electrical transmission program ever undertaken in the United States.

The intertie system, when fully installed, will directly and indirectly interconnect the major Federal, public, and private electrical systems in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The transmission system will extend from Vancouver, British Columbia, through Seattle, Wash., to Phoenix, Ariz., and include points in California and Nevada.

By integrating Federal, publicly owned non-Federal, and privately owned electric utility systems, the intertie will permit exchange of loads and fuller utilization of generating capacity. The system will indirectly benefit the customers of many small electric cooperatives, municipal systems, and other public agencies.

On October 1, 1977, in conformance with Public Law 95-91 (the Department of Energy Organization Act of August 4, 1977), the power marketing function, including the construction, operation, and maintenance of transmission lines and attendant facilities of the Bureau of Reclamation, was transferred to the Department of Energy. As a result, the Bureau of Reclamation is no longer involved in the Pacific Northwest-Pacific Southwest Intertie.

PLAN

Four major transmission lines and several shorter interconnecting lines comprise the full intertie. Two of the extra high voltage (EHV) lines will transmit direct current (d.c.). The constructed 800-kilovolt (kV) d-c line interconnects the northern converter station at Celilo, Oreg., with the Sylmar Terminal Station near Los Angeles, Calif. This line was energized in 1968. A proposed 1,000-kV d-c transmission line will interconnect the Celilo Converter Station with a southern converter station near Phoenix, Ariz.

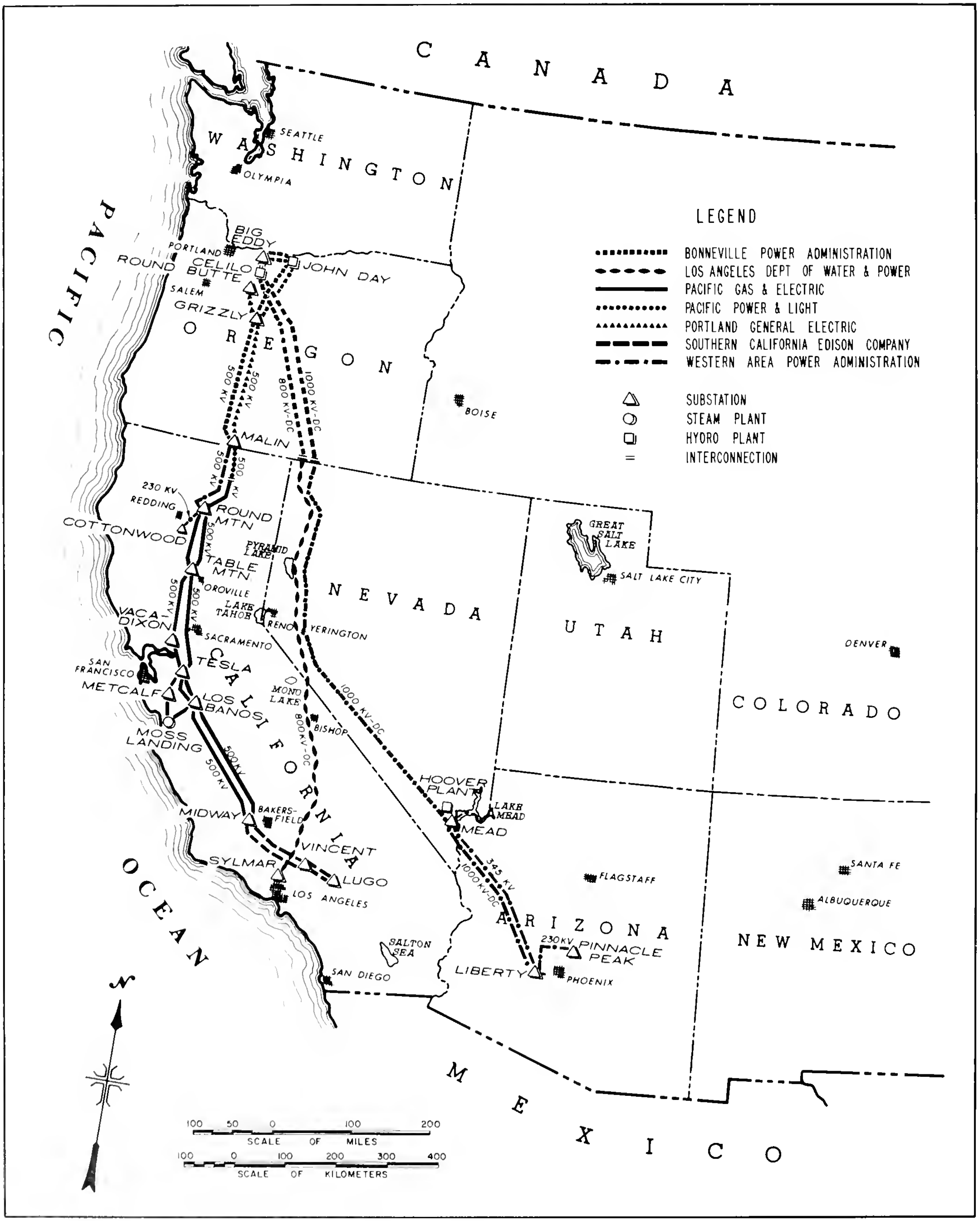
The two constructed 500-kV alternating current (a-c) transmission lines were placed in service in late 1960. These two a-c lines extend from the John Day Substation on the Columbia River near The Dalles, Oreg., to the Lugo Substation in southern California.

A 345-kV a-c line and associated facilities were constructed from the Mead Substation near Hoover Dam to the Liberty Substation near Phoenix, with a connecting 230-kV a-c line to Pinnacle Peak Substation north of Phoenix. These facilities were placed in service in 1968.

In 1967, contracts were awarded for construction of the Mead Substation and installation of two d-c terminals. Surveys and right-of-way acquisitions were completed for The Dalles-Hoover Intertie. In 1969, construction of this intertie was postponed.

Task forces were appointed in 1975 to evaluate future needs for the Northwest-Southwest Intertie. These task forces concluded that an EHV transmission system between the Pacific Northwest and Pacific Southwest would be most effective with a $\pm$500-kV bipolar overhead high-voltage d-c transmission line. The task forces further

Mead Substation



Pacific Northwest-Pacific Southwest Intertie concluded that the best location for the northern terminal would be the Celilo Converter Station in Oregon and that the location for the southern terminal should be in the Phoenix area. The recommended 1,054-mile-long transmission line would have a rating of 1,000-kV d.c.

Celilo—Sylmar, 800-kV d-c Transmission Line

This line runs about 845 miles from the Celilo Converter Station, the northern d-c terminal of the NW-SW Intertie on the Columbia River near The Dalles, Oreg., via Nevada to the Sylmar Station. This bipolar overhead transmission line, with an operating voltage of 800 kV (±400 kV) and a power rating of 1,440 megawatts (MW), was constructed and placed in service in 1970.

Celilo—Phoenix, 1,000-kV d-c Transmission Line (Proposed)

The Celilo Converter Station will be the northern terminal of this proposed 1,000-kV (±500-kV), 1,440-MW system. The Liberty Substation near Phoenix is being considered, along with two other potential sites, as the southern terminal. This high-voltage d-c transmission line was formerly known as The Dalles-Hoover or Celilo-Mead Transmission Line.

John Day—Lugo, 500-kV a-c Transmission Line

These two 500-kV, 1,000-MW capacity, a-c transmission lines extend from the John Day Substation near The Dalles on the Columbia River, via Round Mountain Substation and the Central Valley of California to Lugo Substation near Los Angeles.

The 500-kV lines were constructed by a combination of Federal and private power companies over a period of about 6 years. The Bureau of Reclamation constructed the section of the second line from the Oregon-California border to Round Mountain Substation. This section was energized in 1968. The Bureau of Reclamation section of the 500-kV a-c transmission line was constructed on single circuit steel towers with two 1780-kcmil ACSR conductors per phase. The total length of this section is about 94 miles.

Round Mountain—Cottonwood, 230-kV a-c Transmission Line

This 230-kV transmission line, constructed by the Bureau of Reclamation, was energized in 1968. It is a single circuit steel tower line with 795-kcmil ACSR conductors and is about 34 miles long.

Mead—Liberty—Pinnacle Peak, 345-230-kV a-c Transmission Line and Terminal Facilities

A 345-kV line and associated facilities were constructed from Mead Substation near Hoover Dam to Liberty Substation, and a 230-kV line was constructed from Liberty Substation to Pinnacle Peak Substation.

Under contract with the Salt River Project Agricultural Improvement and Power District, the Bureau of Reclamation constructed a double circuit line from Liberty Substation to the Salt River Project's Estrella Substation. This line was built in 1968 in connection with Liberty Substation. The contract also provided for the construction, by the Salt River Project, of a double circuit 230-kV line from Estrella to Pinnacle Peak Substation. This section was completed in 1968.

Interconnections with Mead Substation, in addition to other interconnections, include the Southern California Edison Company's four 220-kV transmission lines from Hoover Dam to Mead and from Eldorado to Mead; Western Area Power Administration's (WAPA's) 230-kV transmission line from Hoover Dam to Mead and its 230-kV transmission line from Mead to Basic Substation; Nevada Power Company's 230-kV transmission line from Mead to its Decatur Substation; and the Metropolitan Water District's four 230-kV transmission lines from Hoover Dam to Mead and from Mead to Camino.

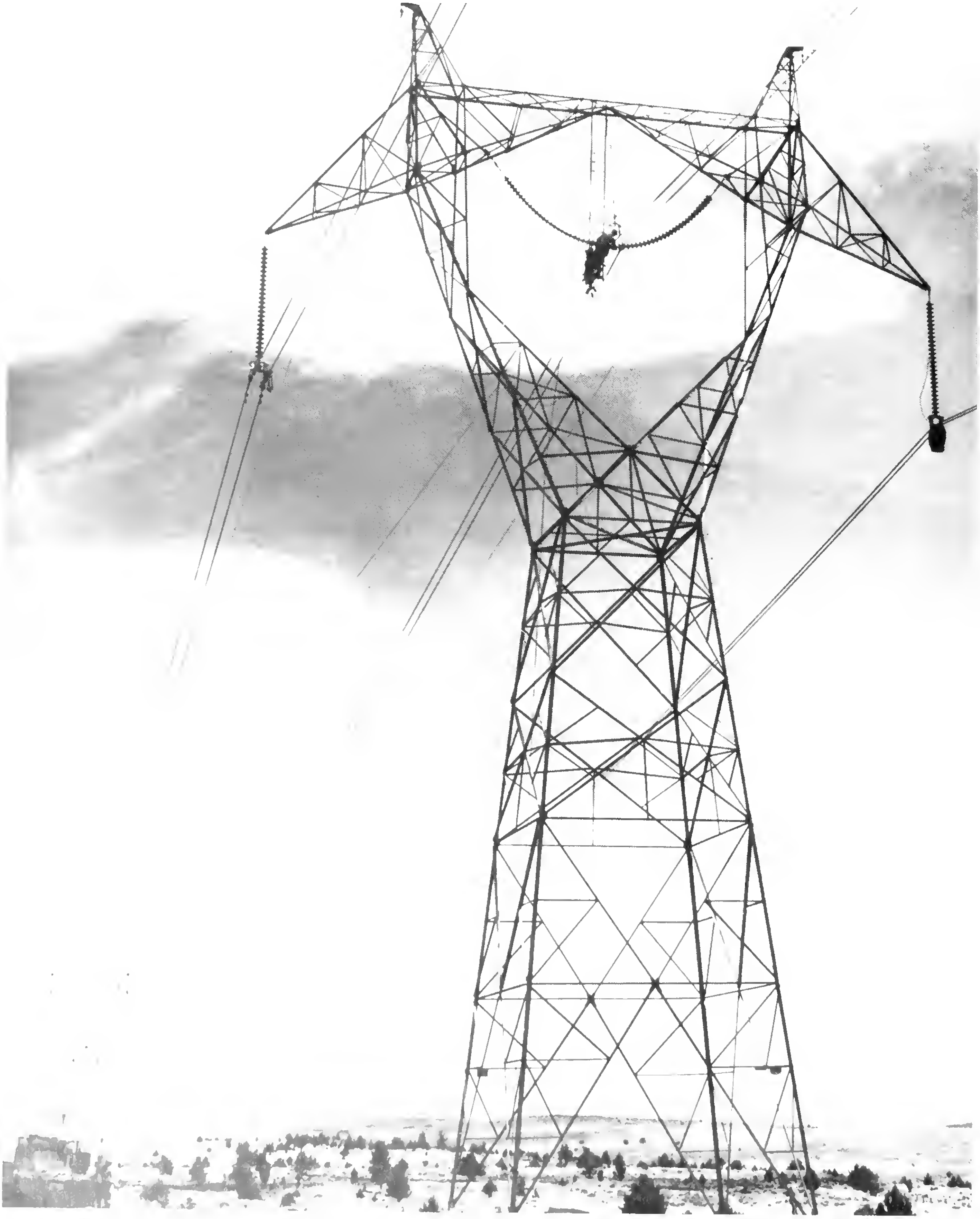
DEVELOPMENT

Early History

For many years there had been general agreement on the need for a vast new power tieline in the Far West. However, conflicts over controlling and sharing benefits delayed progress. The primary purpose of the Pacific Intertie was to coordinate operation of all utility systems in the area.

The intertie program is the culmination of, and the enlargement of, an idea first suggested in 1935, when the Pacific Northwest Regional Planning Commission, a Federal agency, issued a report which envisioned the eventual interconnection of the power resources.

In 1959-60, a 230-kV interconnection was proposed by the Pacific Gas and Electric Company. However, the Senate Interior Committee requested deferral of the proposal pending enactment of legislation to assure each region that power consumers would have first call on Federal hydroelectric power generated in their respective regions. Legislation was enacted in August 1964 authorizing the Pacific Northwest-Pacific Southwest Intertie.



Tower on Malin-Round Mountain Transmission Line

Investigations

The first investigation of a possible intertie between the Bonneville Power Administration (BPA) system and the Central Valley Project was released by the Bureau of Reclamation in 1949. The investigation found that a 217-mile interconnection between Roseburg, Oreg., and the switchyard at Shasta Dam was economically feasible and desirable. The intertie would close the 217-mile gap which at that time separated the two systems.

In April 1959, the Secretary of the Interior was requested to direct BPA and the Bureau of Reclamation to make a study of the California Intertie for the disposal of surplus secondary energy. Interior's report of February 1960 indicated that the intertie was feasible. A request for further studies was made by the States of California and Washington.

The Secretary of the Interior's Special Task Force, in its report of December 15, 1961, recommended construction of the Pacific Northwest-Pacific Southwest Intertie and specified the features, use, and purpose of the development. A version of Senate Bill S1007, passed by the Congress in 1964, cleared the way for construction of the Pacific Northwest-Pacific Southwest Intertie and guaranteed the electric power consumers of the Northwest first call on electrical energy generated at Federal hydroelectric plants in that region. Reciprocal priority was given to the consumers in the Southwest.

In October 1964, a favorable feasibility report on The Dalles-Hoover d-c intertie was submitted to the Appropriations Committees. The Bonneville Power Administration and the Bureau of Reclamation were directed to proceed with construction of the Federal portion of the intertie.

By 1969, as a result of several delays in appropriation of funds, the proposed inservice date of The Dalles-Hoover Intertie had been delayed to the extent that the involved entities were forced to make other arrangements for a power supply. In May 1969, construction of the Hoover d-c line was postponed.

As a result of a review initiated in August 1975, three task forces were established. Evaluation by the task forces found that the Celilo-Phoenix area 1,000-kV d-c Intertie was feasible.

Authorization

The Pacific Northwest-Pacific Southwest Intertie was authorized by Public Law 88-552 (78 Stat. 756), dated August 31, 1964.

Construction

The first 264.4-mile section of the 800-kV Celilo-Sylmar d-c Transmission Line was constructed by the Bonneville Power Administration. The 580.5-mile Nevada-California section was built by the city of Los Angeles. Construction was started in 1966 and transferred to operation and maintenance in 1969.

The 500-kV a-c line from John Day Substation, near the John Day Dam on the Columbia River via Round Mountain Substation and California's Central Valley, to the Lugo Substation near Los Angeles was energized in the late 1960's. The 267-mile Oregon section was built by BPA. The 94-mile section from the Oregon border to Round Mountain was constructed by the Bureau of Reclamation. The balance of the line from Round Mountain south, about 650 miles over a zigzag route, was constructed by the California Power Pool, consisting of the Pacific Gas and Electric Company, the Southern California Edison Company, and the San Diego Gas and Electric Company. The Federal portions of this 500 kV a-c line and the 230 kV a-c tap will provide an all-Federal interconnection between the Federal Columbia River Power System and the Federal Central Valley System in California.

A second 500-kV a-c line was constructed from John Day Substation to Indian Springs Tower in northern California, where it interconnects with a 500-kV a-c line constructed by the California Power Pool. This line, completed in the late 1960's, extends to Lugo. The 88.4-mile portion from John Day to Grizzly Substation in Oregon was built by BPA. The 178.5-mile section from Grizzly to the Oregon border was built by the Portland General Electric Company. A 47-mile section from the Oregon border south to Round Mountain was built by the Pacific Power and Light Company. The balance, about 700 miles, was built by companies in the California Power Pool.

The 34-mile 230-kV a-c transmission line from Round Mountain Substation in California to Cottonwood Substation was built by the Bureau of Reclamation. This transmission line was energized in 1968.

The 238-mile 345-kV a-c line from Mead Substation, near Hoover Dam, to Liberty Substation was constructed by the Bureau of Reclamation and placed in service in 1968. Also, a 230-kV transmission line was constructed from Liberty Substation to Pinnacle Peak Substation in 1968.

Operating Agencies

The Celilo-Sylmar 800-kV d-c Transmission Line is operated by the Bonneville Power Administration of the Department of Energy from the Celilo Converter Station to the Oregon-Nevada State line and by the city of Los Angeles from the Oregon border to Sylmar Station.

The John Day-Lugo 500-kV a-c Transmission Line No. 2 is operated by BPA from John Day Substation to Round Butte interconnection. Portland General Electric operates the transmission line from Round Butte to the Oregon-California State line. The California Power Pool operates the remaining section of the line to Lugo Substation.

The No. 1 500-kV a-c Transmission Line from the John Day Substation to Lugo Substation is operated by BPA from John Day to the Oregon border. The section from the Oregon border to Lugo is operated by the California Power Pool.

The Round Mountain-Cottonwood 230-kV a-c Transmission Line is operated by WAPA, which also operates the Mead-Liberty 345-kV a-c line and the 230-kV a-c line from Liberty to Pinnacle Peak.

The proposed 1,000-kV d-c Celilo-Phoenix Transmission Line will be constructed and operated by BPA from the Celilo Converter Station to the Oregon-Nevada State line, and WAPA will construct and operate the section of the transmission line from the Oregon border to its southern terminal near Phoenix, Ariz.

BENEFITS

Benefits to be derived by the installation of the Northwest-Southwest Intertie will include (1) exchange of summer-winter surplus peaking capacity between the Northwest and the Southwest to reduce capital expenditures for new generating capacity, (2) sale of Northwest secondary energy to the Southwest, and (3) sale of Southwest energy to the Northwest to firm peaking hydroelectric sources during critical water years. The intertie also will provide a means for conservation of significant amounts of fuel by use of surplus hydroelectric energy, and on increased efficiency in the operation of hydro and thermal resources.

PROJECT DATA

Facilities in Operation

Transmission lines (Federal circuit miles)	2,106.5
Substations (Federal)	7

ENGINEERING DATA[1]

Power Facilities

SUBSTATIONS

Number of substations in operation	7	
Total capacity of transformers	3,156	MVA

TRANSMISSION LINES

Total number of major interconnecting lines ..	4
Total circuit miles	2,106.5

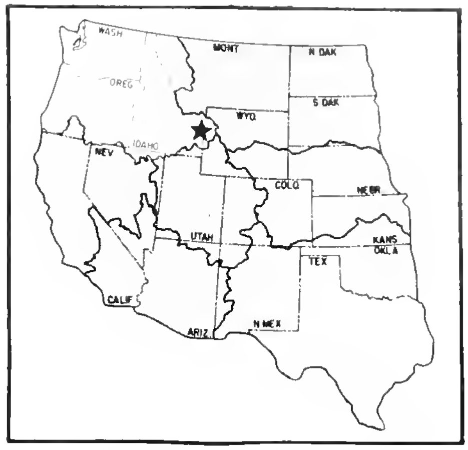
Designation	Voltage, kV	Conductors and supporting structures, kcmil Steel	Circuit miles	Year placed in operation
Celilo-Sylmar d.c.[2]	800	2-2312	844.9	1969
Celilo-Phoenix d.c.	1,000		1,054	Proposed
John Day-Grizzly No. 1 a.c.	500	2-1780	88.4	1967
John Day-Grizzly No. 2 a.c.	500	2-1780	88.4	1967
Grizzly-Malin No. 1 a.c.	500	2-1780	178.5	1967
Malin-Round Mtn. No. 1 a.c.	500	2-1780	94.3	1968
Round Mtn.-Cottonwood No. 1 a.c.	230	795	33.6	1968
Mead-Liberty a.c.	345	2-1033 2-167	238.0	1968
Liberty-Estrella a.c.	230	2-954	10.9	1968
Liberty-Westwing a.c.	230	2-954	33.9	1968
Westwing-Pinnacle Peak a.c.	230	2-954	22.1	1968

[1]Federal system only.
[2]BPA's section of the line from Celilo to the Oregon border is 264.4 circuit miles.

Palisades Project

Idaho: Bonneville County
Wyoming: Lincoln County

Pacific Northwest Region
Water and Power Resources Service



The Palisades Project is a multiple-purpose development involving irrigation, power, flood control, recreation, and fish and wildlife conservation. Palisades Dam is on the South Fork of the Snake River at Calamity Point in eastern Idaho about 11 miles west of the Idaho-Wyoming boundary. The project provides a supplemental water supply to about 670,000 acres of irrigated land in the Minidoka and Michaud Flats Projects. The 118,750-kilowatt hydroelectric powerplant furnishes energy needed in the upper valley to serve irrigation pumping units, municipalities, rural cooperatives, and other power users. The principal features of the project are Palisades Dam, Reservoir, and Powerplant.

PLAN

The project, in addition to providing needed holdover storage, helps control floods, develops a substantial block of power, and permits the annual storage of about 135,000 acre-feet of water saved by shutting off canals in the upper valley during the winter. This water is stored to the credit of and delivered to the water users who make the savings possible.

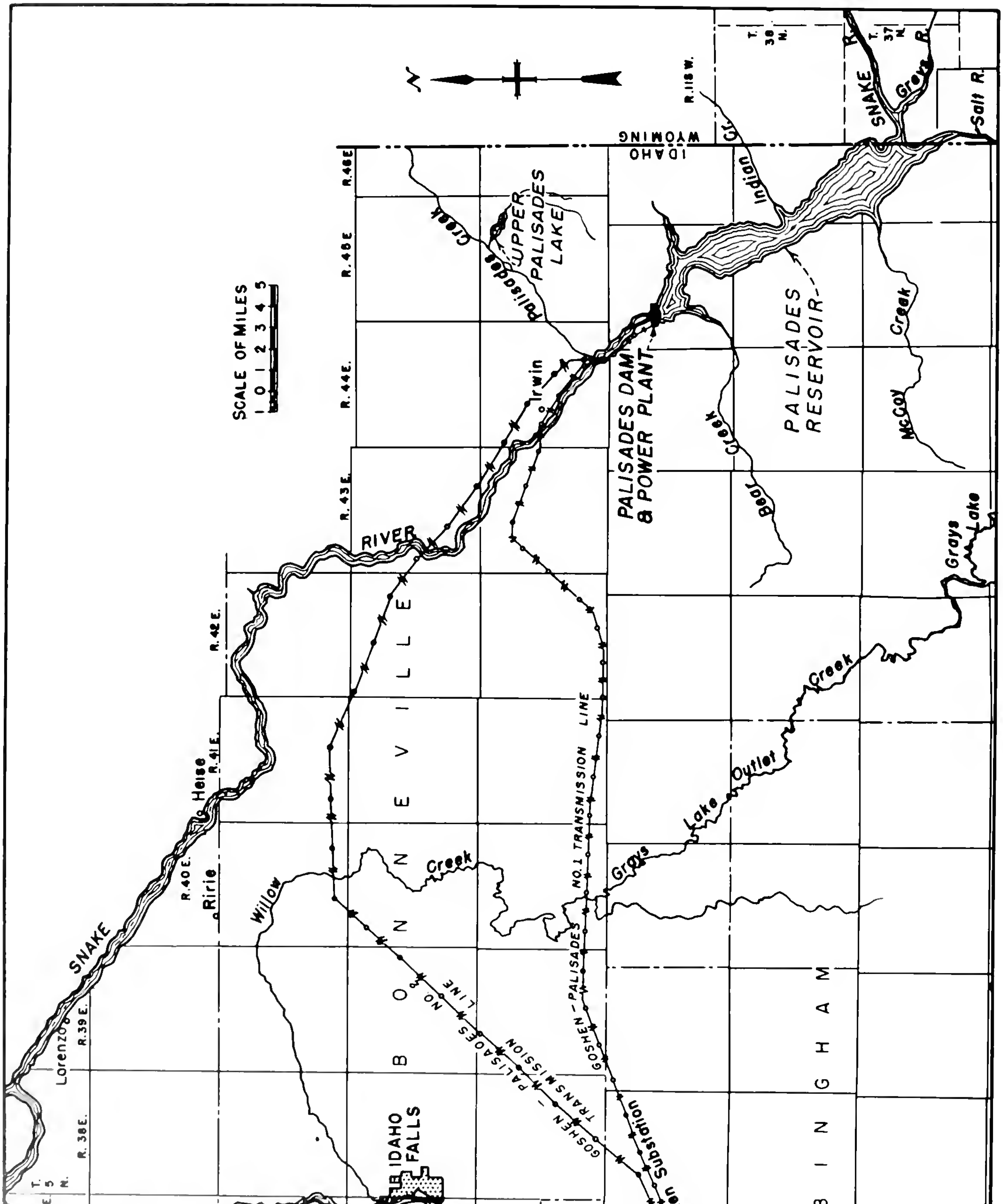
Releases from Palisades Reservoir are diverted and carried to the land by previously constructed facilities.

Palisades Dam and Powerplant

Located on the Snake River about 55 miles southeast of Idaho Falls, Idaho, Palisades Dam is a large zoned earthfill structure 270 feet high, has a crest length of 2,100 feet, and contains 13,571,000 cubic yards of material. At the time of construction, this was the largest volume of material placed in a dam by the Bureau of Reclamation. The spillway is a 28-foot-diameter tunnel through the left abutment, with a capacity of 48,500 cubic feet per second. The outlet works and power inlet structures are controlled by a fixed-wheel gate at the entrances of the inclined shafts leading to 26-foot-diameter tunnels. The outlet tunnel conveys the water to the steel manifold transition section, where it is released to the stilling basin by regulating gates. At the lower end of the power tunnel, the water may be released to the stilling basin or to four penstocks and conveyed to the turbines for power generation. The capacity of the outlet works is

Palisades Dam and Reservoir

Jackson Lake, Wyoming



Palisades Project

33,000 cubic feet per second. The dam creates a reservoir of 1,401,000 acre-feet capacity.

The powerplant is on the downstream toe of the dam on the west side of the river and has a total capacity of 118,750 kilowatts.

DEVELOPMENT

Investigations

Following the drought period of the early 1930's, a need was recognized for additional storage for lands already under irrigation in the Minidoka Project and in private developments, and investigations of various reservoir sites were made upstream from American Falls Dam. The Palisades site was selected for the construction of the dam and reservoir to provide holdover storage to supplement the water supply for existing irrigated lands, to develop a limited acreage of new lands, to provide flood control, and to generate electrical power. Intensive investigations at the location as now developed were started by the Bureau of Reclamation in 1934.

In February 1978, a study was completed that could add 90,000 kilowatts of power. Present penstock capacity could be tapped and two generating units of 45,000 kilowatts each added, accommodated by an extension to the existing powerhouse. Further studies are underway, with anticipated completion in the early 1980's, that would tap the present outlet works with power facilities to add another 135,000 kilowatts. This would require a new powerplant building and probably downstream reregulating facilities.

Authorization

The project was initially authorized by the Secretary of the Interior on December 9, 1941, under the provisions of section 9 of the Reclamation Project Act of 1939 (53 Stat. 1187). Reauthorization of the project by the Congress was granted on September 30, 1950 (Public Law 864, 81st Cong.), substantially in accordance with a supplemental report approved by the Secretary of the Interior in 1949.

Construction

The preconstruction phase of the project was started early in 1945. Construction was delayed until the close of World War II and until local interests gave satisfactory assurance to the Bureau of Reclamation that they would eliminate the wasteful use of water in the area to be served by the project. Actual construction of the project was initiated in 1951 and completed in 1957. All generating units of the powerplant were in operation by May 1958.

Operating Agency

Reclamation operates and maintains the project.

BENEFITS

Irrigation

Palisades Dam provides holdover storage during years of average or above average precipitation for release in ensuing dry years to lands of the Upper Snake River Valley, the area served by diversions from the river above Milner Dam. This holdover storage assures an adequate supply of supplemental water for over 670,000 acres of irrigated lands in the valley. Principal crops are grain, alfalfa, pasture, dry beans, potatoes, sugar beets, other vegetables, and seeds.

Hydroelectric Power

The Palisades Powerplant has four generators, two rated at 30,875 kilowatts each and two rated at 28,500 kilowatts each, making the total capacity of the powerplant 118,750 kilowatts. It serves large irrigation pumping power requirements on and near the Minidoka Project in southern Idaho. The plant is connected with the Pacific Northwest Power Pool.

Flood Control

The project also provides substantial flood control benefits. A flood control operating plan has been established with the Corps of Engineers and several local interests. The plan provides for the joint use of storage capacity during flood seasons for irrigation and flood control on the basis of periodic runoff forecasts. Flood control space is held in Jackson Lake and Palisades Reservoir on a forecast basis to control the Snake River near Heise to no more than 20,000 cubic feet per second.

Recreation

Palisades Reservoir is in a scenic river valley with forested hillsides rising from the water to the towering snowcapped mountains which form the background. Since the reservoir is paralleled by U.S. Highway 26, much of the recreational use is by tourists. The reservoir has about 70 miles of shoreline and six access roads have been built. Recreation at Palisades Reservoir is administered by the Targhee National Forest headquartered in St. Anthony, Idaho. Public use facilities include six campgrounds, five picnic areas, and six boat ramps. Two boat clubs have facilities on the reservoir and 74 private cabins have been constructed under lease from the Forest Service. The Bureau of Reclamation has developed a day-use area and campground below the dam to provide fishing and boat launching on the Snake River.

PROJECT DATA

Land Areas (1977)

Irrigable area:
Supplemental irrigation service[1] .... 670,000 acres

[1]Land areas are under the Minidoka and Michaud Flats Projects.

Facilities in Operation

Storage dams	1	
Powerplants	1	
Transmission lines	0.44	mi
Substations	1	

Power Generation

Fiscal year	Palisades Powerplant, kWh	Fiscal year	Palisades Powerplant, kWh
1968	663,702,000	1973	731,438,000
1969	611,407,000	1974	645,435,000
1970	563,954,000	1975	773,119,000
1971	651,019,000	1976	[2]1,081,240,000
1972	754,984,000	1977	585,141,000

[2]15-month period. Transitional quarter July-September 1976 included. Fiscal year changed from July-June to October-September.

ENGINEERING DATA

Water Supply

South Fork, Snake River

Drainage area above Palisades Dam	5,208	mi²
Annual discharge at Heise, Idaho:		
Maximum (1971)	7,443,000	acre-ft
Minimum (1977)	2,561,000	acre-ft
Average[3]	5,377,000	acre-ft

[3]Runoff at Heise is 9.12 percent higher than at Palisades Dam.

Storage Facilities

Palisades Dam

Type: Zoned earthfill
Location: On the South Fork of Snake River 7.5 mi southeast of Irwin, Idaho.
Construction period: 1951-57
Date of closure (first storage): November 1956
Reservoir, Palisades:

Average annual inflow, 1963-77	4,929,000	acre-ft
Total capacity to El. 5620	1,401,000	acre-ft
Active capacity	1,200,000	acre-ft
Surface area	16,150	acres

Dimensions:

Structural height	270	ft
Hydraulic height	249	ft
Top width	40	ft
Maximum base width	2,100	ft
Crest length	2,100	ft
Crest elevation	5630.0	ft
Total volume	13,571,000	yd³

Spillway: Concrete crest and concrete-lined tunnel through left abutment controlled by two 20- by 50-ft radial gates.

Elevation, top of gates	5620.0	ft
Crest elevation	5570.0	ft
Capacity at El. 5621	48,500	ft³/s

Outlet works:
River: Concrete-lined tunnel through left abutment controlled by four 7.5- by 9-ft slide gates and two 96-in hollow-jet valves.
Capacity at El. 5621 .... 33,000 ft³/s
Power: Concrete-lined tunnel through left abutment terminating in four penstock branches to powerhouse. Two penstock bypass branches to outlet works control house are each controlled by a 7.5- by 9-ft slide gate.
Capacity at El. 5621 (bypass) .... 14,500 ft³/s
Foundation: Highly compacted, generally impermeable alternating layers of clayey silt, sandstone, clayey sand and gravel, and conglomerate in the riverbed and right abutment; left abutment is a hard, exceedingly sound andesite intrusion.

Power Facilities

Palisades Powerplant

Location: Palisades Dam
Year of initial operation: 1957
Year last unit placed in operation: 1958

Nameplate capacity		118,750	kW
Number and capacity of generators	(2)	28,500	kW
	(2)	30,875	kW
Maximum head		244	ft

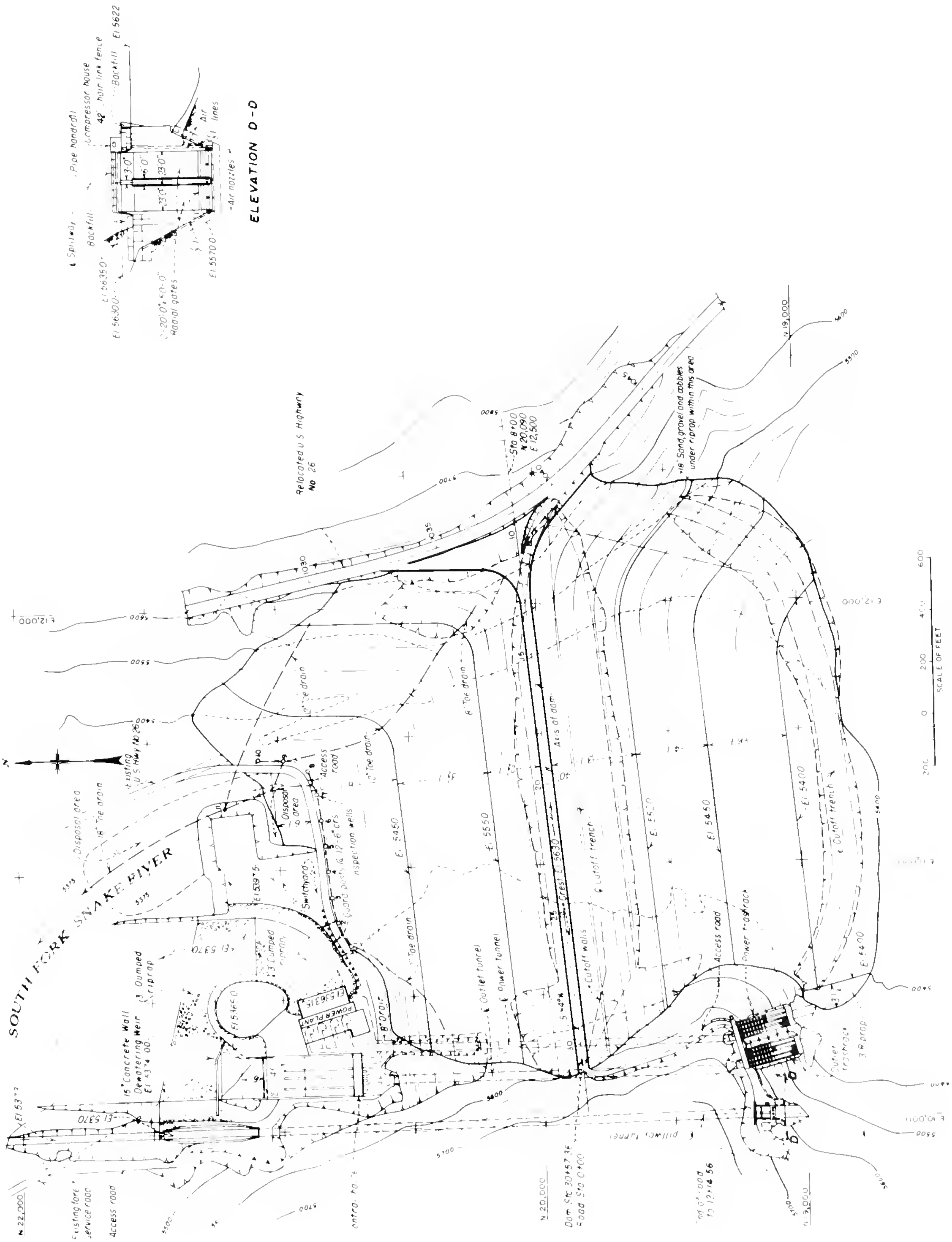
Substations

Number in operation	1	
Capacity of transformers	152,500	kVA

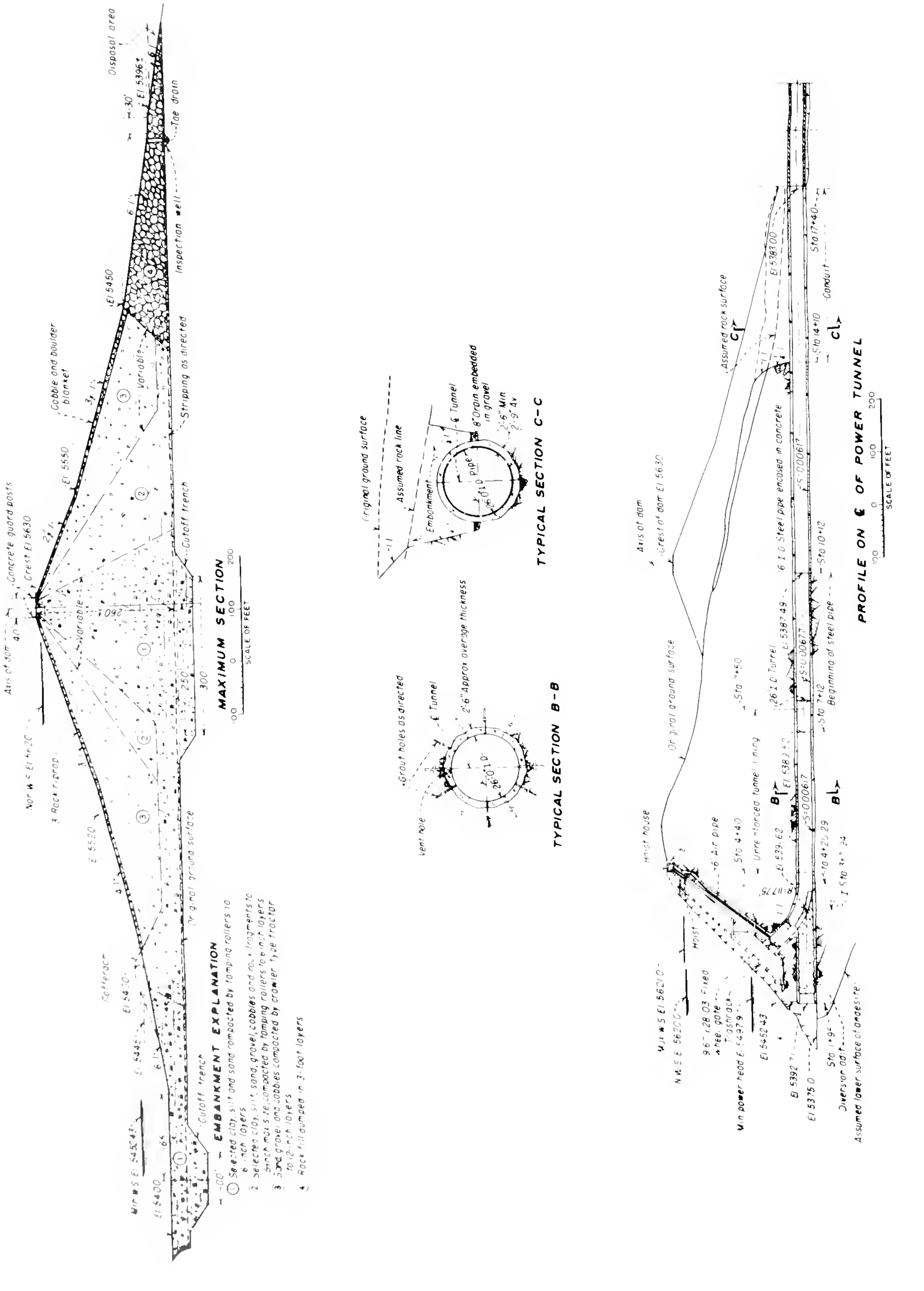
Transmission Lines

Total number of lines	4
Total circuit miles	0.44

Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Palisades Powerplant—				
Switchyard (Y1)	115	35,000	0.11	1957
Switchyard (Y2)	115	35,000	.11	1957
Switchyard (Y3)	115	35,000	.11	1957
Switchyard (Y4)	115	35,000	.11	1958



Palisades Dam, Plan

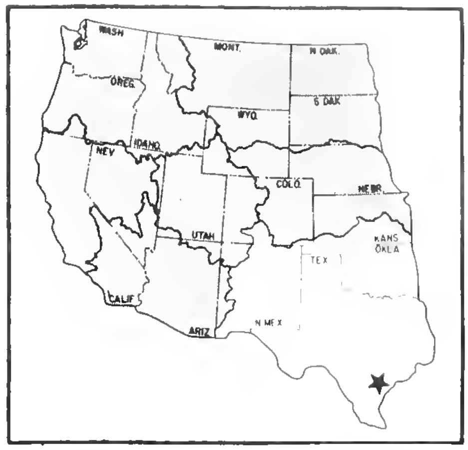


Palisades Dam, Sections

Palmetto Bend Project
(Under Construction)

Texas: Jackson County

Southwest Region
Water and Power Resources Service



The Palmetto Bend Project is in Jackson County, Texas. The project authorization permits construction of Palmetto Bend Dam and Reservoir on the Navidad River near Edna, Tex., and recreation facilities. Project purposes include storing, regulating, and furnishing water for municipal and industrial use, conserving and developing fish and wildlife resources, and enhancing outdoor recreation opportunities.

PLAN

The original plan of development provided for regulating flows of Lavaca and Navidad Rivers by Palmetto Bend Reservoir to supply municipal and industrial water requirements in Jackson and Calhoun Counties, and also for development of recreation facilities and accomplishment of fish and wildlife conservation measures.

The plan requires stage construction of the project. Stage 1 provides for construction of a dam across the Navidad River for development of the Navidad River arm of Palmetto Bend Reservoir, and construction of recreation facilities and accomplishment of fish and wildlife conservation measures.

Stage 2 requires enlargement of Palmetto Bend Reservoir by extension of the dam across Post Oak Branch and Lavaca River and construction of a channel to connect the Navidad River arm of the reservoir with the Post Oak Branch and Lavaca River arms. Stage 2 will provide additional recreation facilities and fish and wildlife conservation measures similar to those accomplished in Stage 1. Construction of Stage 2 will be deferred until the water supply provided by Stage 1 is completely utilized. The anticipated annual water supply provided by Palmetto Bend Reservoir is 75,000 acre-feet for Stage 1 and 30,000 acre-feet for Stage 2.

DEVELOPMENT

Investigations

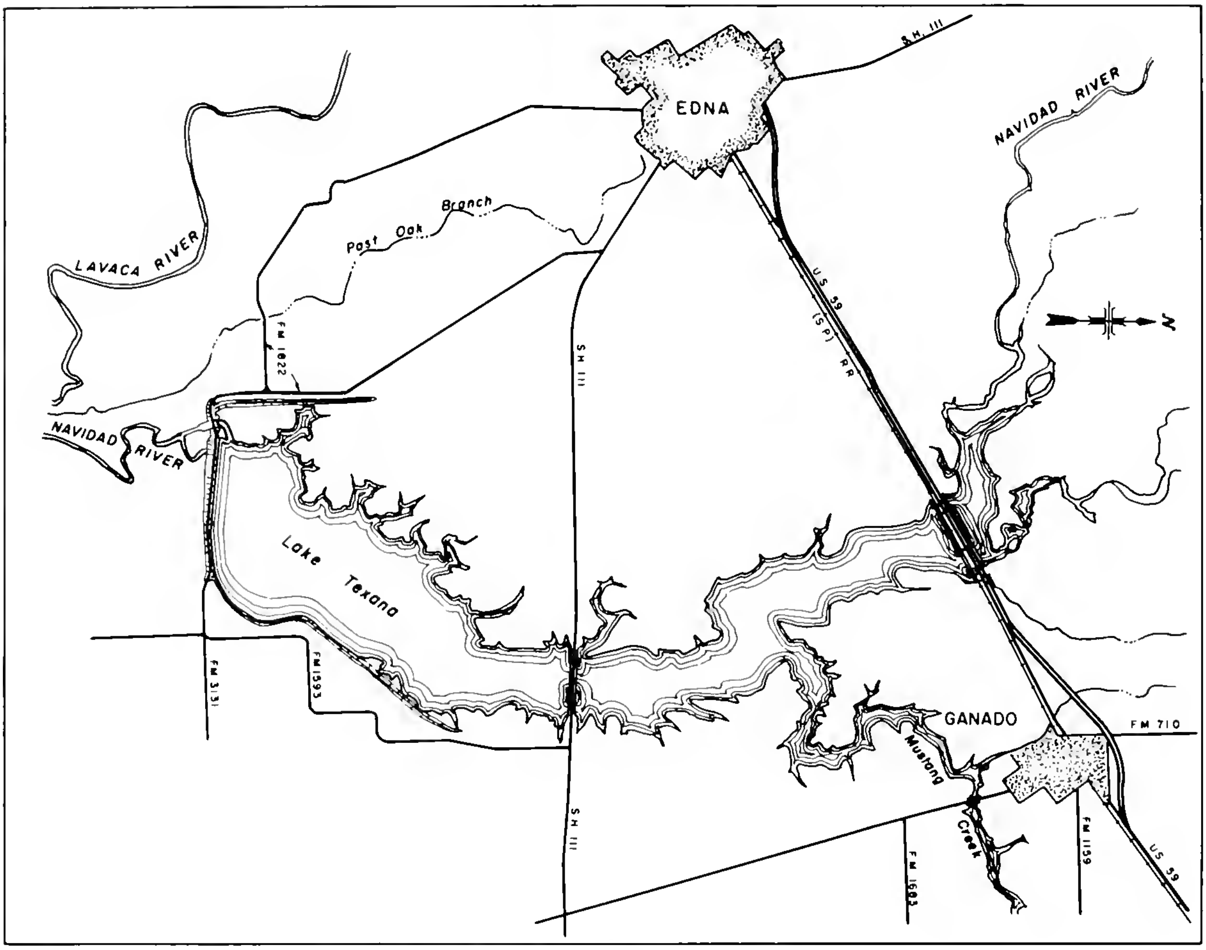
Investigations resulting in formulation of plans for development of the flows of Lavaca and Navidad Rivers have been made by the Jackson County Flood Control District; the Texas Water Commission; the U.S. Study Commission on the Neches, Trinity, Brazos, Colorado, Guadalupe, San Antonio, Nueces, and San Jacinto River Basins and intervening areas; and the Bureau of Reclamation. The Lavaca-Navidad River Authority was created in 1969 as successors to the Jackson County Flood Control District.

Bureau of Reclamation studies and surveys in the Lavaca-Navidad River Basin and adjoining areas have been made as part of the overall Texas Basins Project investigation which was initiated in 1954. The original purpose of this investigation was to formulate an overall plan of water use and control for the portion of Texas lying within basins of streams entering the Gulf of Mexico, from the Sabine River to the Rio Grande, inclusive, and to complete a report on that plan in 1960. In 1958, however, the U.S. Study Commission was created and directed to formulate and report on such a plan for all of the area covered by the Texas Basins Project investigation except the Texas portions of the Sabine River and Rio Grande Basins. Under these circumstances, it was necessary to modify the purpose of Reclamation's investigation.

Results of U.S. Study Commission-Texas studies are presented in a report which was transmitted on May 28, 1962, to the President, and to the Congress on August 1, 1962. Texas Water Commission studies pertaining to the area are presented in a report dated May 1961.

At the same time the U.S. Study Commission was preparing its report, the Jackson County Flood Control District also was investigating the area. Two reports were prepared that presented detailed analyses of the Texana Reservoir.

Bureau of Reclamation studies showed that it would be desirable to develop Palmetto Bend Reservoir independently of the development of an interbasin canal from the Sabine River to the Rio Grande; however, the project could later be integrated into operation with the canal. It



Palmetto Bend Project

was intended to recommend Palmetto Bend Reservoir for authorization in the report on the Texas Basins Project. However, in 1961 Jackson and Calhoun Counties received heavy hurricane damages and early construction of Palmetto Bend Reservoir would provide invaluable assistance in restoring and expanding the economy of the area. Following conferences with local representatives in December 1961, it was determined that the Palmetto Bend Project should be submitted to the Congress for authorization in advance of completion of Reclamation's report on the overall Texas Basins Project.

The report and a reevaluation statement were submitted to the House of Representatives on August 24, 1965, and were included in House Document 279, 89th Congress, 1st session. Another reevaluation statement, dated April 1967, updated the report and was used as a basis for final authorization.

Authorization

The construction and operation of Stage 1 of the project and the purchase of lands for Stage 2 were authorized by Public Law 90-562, approved October 12, 1968 (82 Stat. 999).

Construction

The construction office was opened in Edna, Tex., on March 13, 1972. Collection of design data and the relocation of highways, railroads, gas lines, electric transmission lines, and city utility lines were initiated prior to award of the contract for Palmetto Bend Dam on January 16, 1976.

Operating Agency

Upon completion of the Federal project works, the care, operation, and maintenance of the project will be transferred to the Lavaca-Navidad River Authority.

BENEFITS

Municipal and Industrial Water

Stage 1 of the Palmetto Bend Project will provide a dependable municipal and industrial water supply of 75,000 acre-feet annually to the Jackson-Calhoun County area. The area has the factors needed for industrial development except for an adequate water supply. Stage 1 of the project will provide a firm water supply adequate to meet the estimated demands of the area in the early years of the project. Stage 2 of the project will supply an additional 30,000 acre-feet annually to meet demand requirements for future anticipated growth.

Recreation and Fish and Wildlife

Stage 1 of the Palmetto Bend Project will provide an 11,000-acre reservoir for recreation and for fish and wildlife habitat, resulting in an estimated annual gain of 221,000 reservoir fisherman days, 18,000 waterfowl-hunter days, and 5,000 wildlife-oriented days.

PROJECT DATA

Facilities in Operation

There are no facilities in operation; Stage 1 of the project is under construction. Stage 2 of Palmetto Bend Project has been deferred until a demonstrated need has been established for its development.

Climatic Conditions

Annual precipitation:		
Western edge of area	35	in
Eastern edge of area	40	in
Average annual temperature	70	°F
Average frost-free period:		
Upper basin	260	days
Coast area	300	days

ENGINEERING DATA

Water Supply

Drainage area:		
Navidad River, Stage 1	1,402	mi²
Annual discharge[1]:		
Maximum (1941)	1,038,000	acre-ft
Minimum (1954)	13,000	acre-ft
Average	411,000	acre-ft

Storage Facilities

PALMETTO BEND DAM

Type: Zoned embankment
Location: On the Navidad River about 7 mi southeast of Edna, Tex.
Construction period: 1976-79 (scheduled completion)

Reservoir, Palmetto Bend:		
Average annual inflow[1]	411,000	acre-ft
Total capacity to El. 44	170,300	acre-ft
Active capacity, El. 15 to 44	161,120	acre-ft
Surface area, El. 44	11,000	acres
Dimensions:		
Structural height	69	ft
Hydraulic height	50	ft
Top width:		
Typical flood plain section	42	ft
Typical abutment section	30	ft
Maximum base width	820	ft
Crest length	7.9	mi
Crest elevation	55.0	ft
Total volume	5,600,000	yd³

Spillway: Concrete overflow weir with concrete chute and stilling basin controlled by twelve 22.61- by 35-ft radial gates, hoist operated.

Crest elevation	23.0	ft
Capacity at El. 44	157,000	ft³/s
Capacity at El. 47	190,000	ft³/s

Outlet works:

Municipal and industrial outlet works: Structures located on the east and west sides of the spillway are identical. The structures include intake structures with dual level (Invert El. 7.5 and 33) intake openings controlled by 48- by 60-in slide gates with motor operated lifts; a flat bottom horseshoe concrete conduit through a dam embankment with a terminal structure for connecting the future delivery system to the outlet works. Each municipal and industrial outlet works is designed for 127 ft³/s.

River outlet works: Multiple level outlets are provided for control of quality of water to be released from the Palmetto Bend Reservoir if thermal, chemical, or nutrient stratification should occur. Outlet gates include a 96-in-square slide gate with sill El. 8 and two 48-in-square slide gates with sill El. 20 and 35 ft mounted on the intake tower structure. The lower level gate size was increased to provide sufficient capacity to evacuate the reservoir below the spillway crest in a reasonable time, in addition to discharging the base flow of the river. The upper level gates are designed for a minimum flow of 150 ft³/s with the reservoir at top of conservation pool, El. 44. The lower level outlet has a design capacity of 1,800 ft³/s with the reservoir at top of conservation pool.

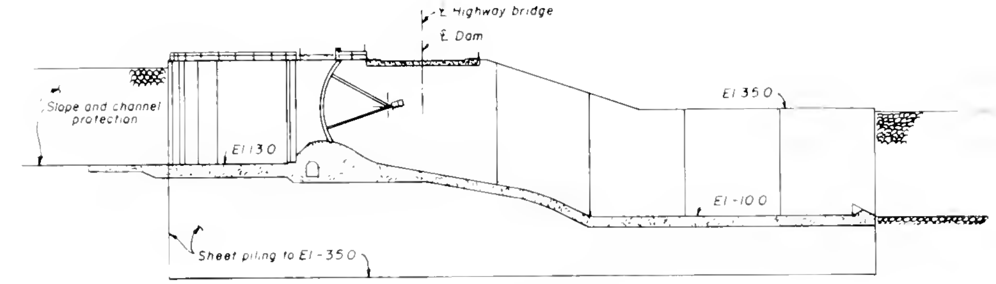
An 8-ft-square concrete conduit connects the intake structure to the gate structure located in the dam embankment just upstream of the crest. The gate structure contains a 96-in-square slide gate controlling flows into the downstream, 8- by 10-ft rectangular concrete conduit which leads in the concrete chute and stilling basin at the downstream toe of the dam.

Foundation: The concrete spillway chute and stilling basin flow (invert elevation minus 10.0) is constructed upon a foundation of steel piles located at 8-ft centers with a minimum penetration of 30 ft below the structure to ensure stability against uplift pressure.

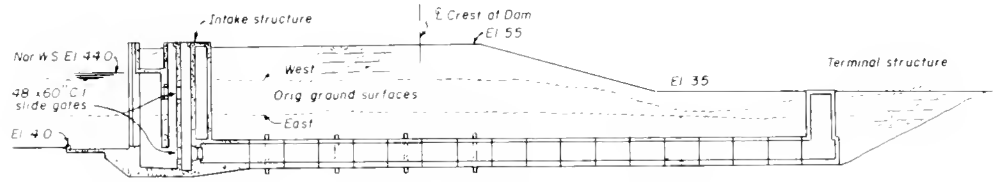
Carriage Facilities

No carriage facilities are provided by the Bureau of Reclamation other than the municipal and industrial outlet works at the dam. Construction of future pipelines and pumping plants is the responsibility of the Lavaca-Navidad River Authority or the Texas Department of Water Resources.

[1]Estimated flow with future upstream conservation measures.

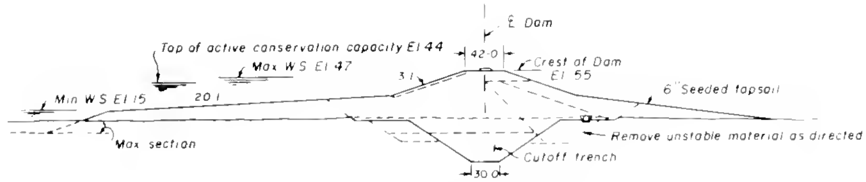


SPILLWAY SECTION



SECTION - M & I OUTLET WORKS

SCALE OF FEET

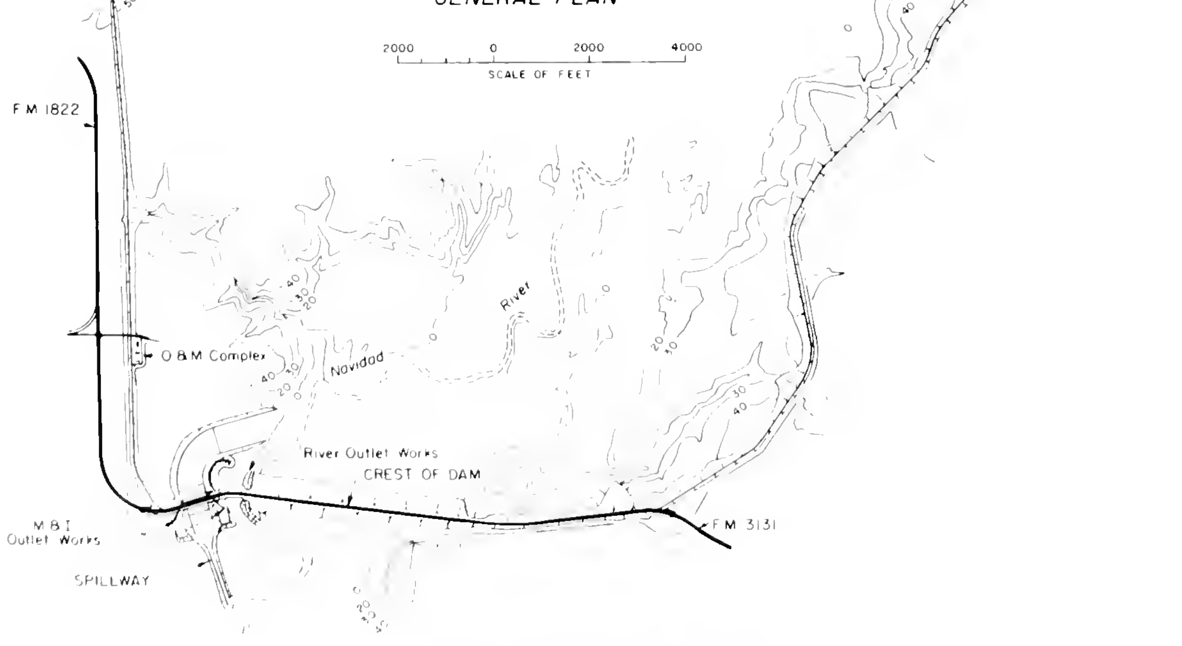


TYPICAL EMBANKMENT SECTION

SCALE OF FEET

GENERAL PLAN

SCALE OF FEET

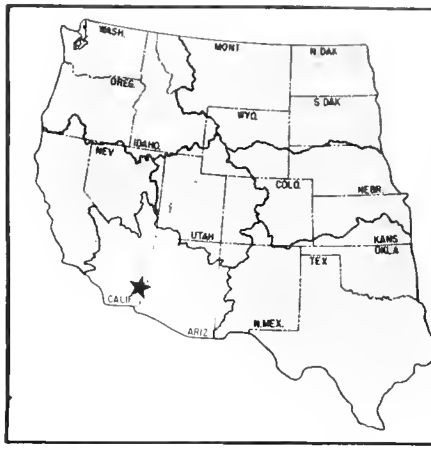


Palmetto Bend Dam, Plan and Sections

Palo Verde Diversion Project

California: Riverside County
Arizona: Yuma County

Lower Colorado Region
Water and Power Resources Service



The Palo Verde Diversion Project includes the Palo Verde Diversion Dam on the Colorado River, and a spillway and canal headworks to serve the Palo Verde Irrigation District. A levee system and drain were built to protect portions of the Colorado River Indian Reservation. The dam was constructed to replace a temporary rock weir built by the Bureau of Reclamation during World War II. The rock weir was an emergency structure replacing other diversion structures previously built by the Palo Verde Irrigation District.

The Palo Verde Irrigation District is on the west side of the Colorado River in the vicinity of Blythe, Calif. The district includes 120,000 acres of valley and mesa lands.

PLAN

The diversion dam maintains a constant water surface elevation at the canal intake during periods of normal riverflow. Except during periods of high river discharge, this forebay elevation is maintained at 283.5 feet.

The diversion facilities were designed to discharge 1,800 cubic feet per second into the Palo Verde desilting basin when the river is at the established forebay elevation.

The district diverts its water from the Colorado River on the basis of rights dating back to 1877. The water rights and water supply are adequate for valley lands. Diversion, however, has always been attended by difficulties, primarily those of maintaining satisfactory diversion conditions at the district intake.

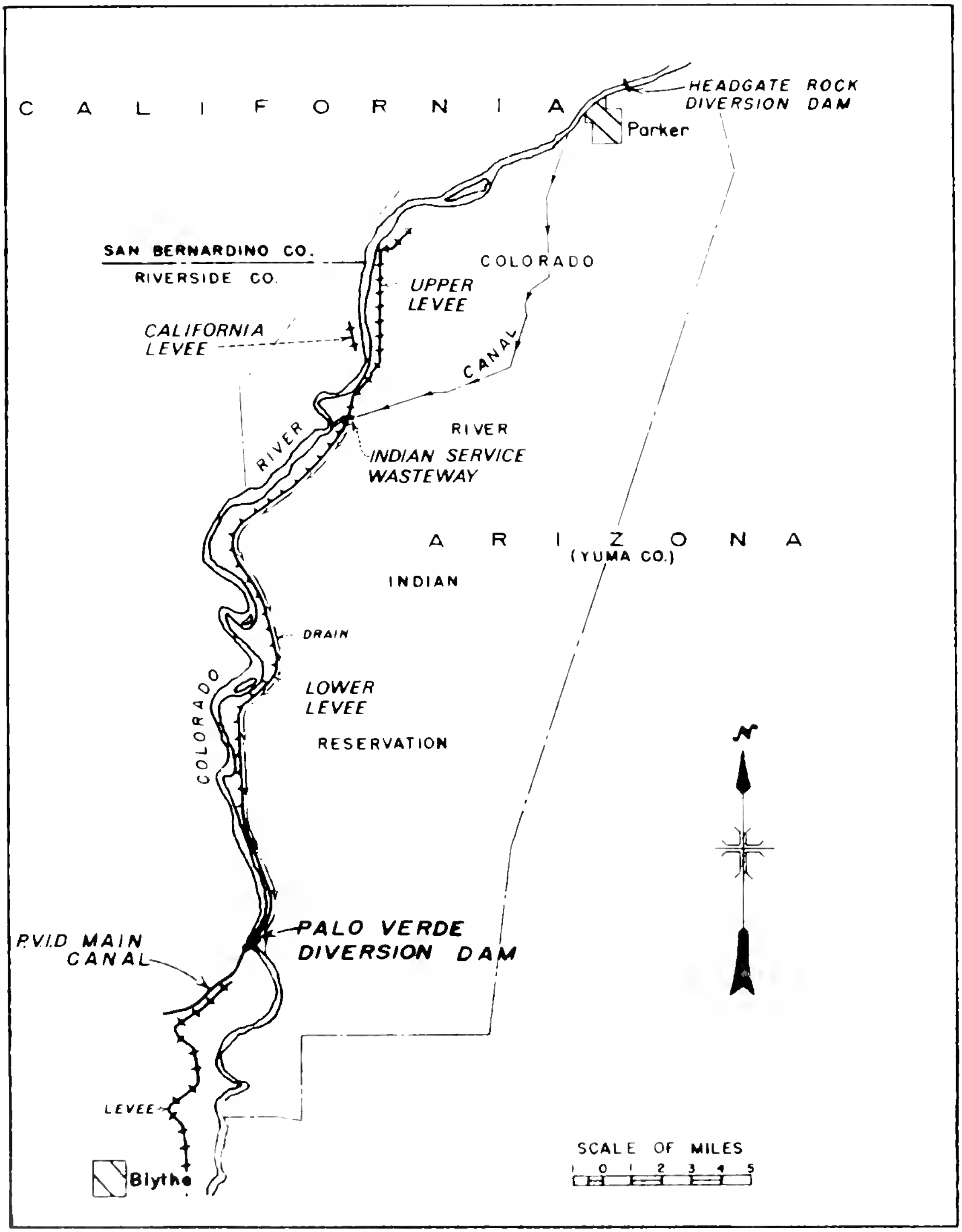
The dam, spillway, and canal headworks were built by the Bureau of Reclamation. The canals serving the irrigation district were constructed by private interests.

Palo Verde Diversion Dam

The Palo Verde Diversion Dam, located on the Colorado River 9 miles northeast of Blythe, is a semipervious barrier of sand, gravel, and rockfill, with a crest width of 20 feet, a length of 1,300 feet, and a maximum height of 46 feet above the streambed. The embankment, consisting of two zones, contains 157,000 cubic yards of material. Both the upstream and downstream slopes of the embankment are 4:1 from crest elevation to riverbed. The upstream zone consists of sand, gravel, and cobble fill, which is protected with 24 inches of riprap to elevation 280.0 feet. The downstream zone is rockfill taken from structure excavation and quarry. The spillway control structure is founded on rock at the right abutment of the dam. It is a gated structure consisting of three 50-foot bays, separated by two 8-foot-thick intermediate piers. The piers and gravity wall abutments support a bridge structure on which is mounted the hoist for operating the spillway radial gates. The headworks structure is designed to direct 1,800 cubic feet per second from the river into the settling basin of the Palo Verde Irrigation District canal system with diversion water at elevation 283.5 feet. The structure includes four 12- by 8-foot conduit barrels with a downstream transition and training channel.

A control house is located immediately upstream of the headworks. In it are housed the panels for the power

Palo Verde Diversion Dam



Palo Verde Diversion Project

distribution and control system, forebay stilling wells and probe units, emergency power units, and recording equipment. Emergency power is supplied by a 30-kilowatt, 230-volt, 3-phase, 60-hertz gas engine generator set for use during failure of the local power supply.

Levee System

The 30-mile levee system is divided into the Lower Arizona Levee, Upper Arizona Levee, and the California Levee. At the request of the Tribal Council of the Colorado River Indian Reservation at Parker, Ariz., the levees were located about 1,300 feet from the river channel so the shoreline would not be encroached upon and would, in the future, be made available for recreation development. The tops of the levees were surfaced with 6 inches of selected gravel to provide a roadway for maintenance purposes and access to various points on the river. The design flood for the levees is 75,000 cubic feet per second. The levees are provided with a 20-foot top, landside slope of 1.5:1, riverside slope of 2:1, and 4 feet of freeboard. The amount of riprap placed varies within different sections of the levees.

Drain

A 21-mile-long intercepting drain was constructed parallel to and 300 feet from the landward side of the lower levee; the outfall is downstream of the dam. The drain was designed for a capacity of 30 cubic feet per second at the upstream end, increasing to 128 cubic feet per second at the outfall below the dam.

DEVELOPMENT

Early History

In the late 1870's, Thomas Blythe secured title to a block of land comprising roughly the northern third of the Palo Verde Valley. Blythe cultivated some land with water that was diverted from the Colorado River by gravity. In 1923, the California State legislature passed a special act creating the Palo Verde Irrigation District. The act combined the duties and functions of the existing levee and drainage districts into one organization and authorized the newly created district to acquire the properties and water rights of the Mutual Water Company.

Investigations

Before the construction of Hoover Dam, the heavy siltload of the Colorado River constituted a serious problem to the district at the diversion point.

Upon the closure of Hoover Dam early in 1935, diversion conditions at the Palo Verde intake improved considerably. The clear water released from Hoover Dam materially reduced the district's silt problem. However, about 2 years after closure of Hoover Dam, retrogression of the riverbed started in the vicinity of the Palo Verde intake. By 1942, it had become difficult for the irrigation district to divert water under normal riverflow conditions.

In 1943 and 1944, the problem became serious since it seemed probable that the Palo Verde Valley crops might be lost. To alleviate this problem temporarily, one of the provisions of the First Deficiency Appropriations Act, approved on April 1, 1944, authorized the Bureau of Reclamation to build a temporary weir for raising the river level to an elevation that would provide satisfactory diversion at the Palo Verde intake.

Construction began immediately after passage of the act, and a temporary rock weir was completed in 1945. Investigations for a permanent structure continued intermittently from 1944 until construction of the permanent works was authorized.

Authorization

The project was authorized by the Congress by act of August 31, 1954 (68 Stat. 1045).

Construction

Construction began in 1956 on Palo Verde Diversion Dam, levees, and drain. The first water was diverted into the Palo Verde Irrigation District's canal system on October 28, 1957. Construction of the dam was completed on December 17, 1957.

The contract for the construction of the levees and drain was awarded February 2, 1956. The work was completed and accepted by the Government on August 4, 1958.

Operating Agencies

The Palo Verde Diversion Dam and diversion works were turned over to the Palo Verde Irrigation District for operation and maintenance on December 17, 1957. Operation and maintenance of the levees and drain were transferred to the Bureau of Indian Affairs on August 20, 1958.

BENEFITS

Completion of the Palo Verde Diversion Dam ensured adequate diversion of irrigation water to the fertile and highly productive land in the Palo Verde Irrigation District. The principal crops are alfalfa, short cotton, feed grains, truck crops, citrus, and melons.

PROJECT DATA

Facilities in Operation (1977)

Diversion dam	1
Levees	3
Drain	1

Climatic Conditions

Annual precipitation	4.2 in
Temperature:	
Maximum	122 °F
Minimum	5 °F
Mean	70 °F
Growing season	277 days
Elevation of irrigable area	230-285.0 ft

ENGINEERING DATA

Water Supply

COLORADO RIVER

(See Boulder Canyon Project for streamflow data.)

Diversion Facilities

PALO VERDE DIVERSION DAM

Type: Concrete ogee gated weir, embankment wing
Location: On Colorado River, 9 mi north of Blythe, Calif.
Year completed: 1957
Dimensions:

Structural height	50 ft
Hydraulic height	46 ft
Weir crest length	150 ft
Weir crest width	20 ft
Total length[1]	1,300 ft
Weir crest elevation	259.0 ft
Crest elevation	296.0 ft
Volume	157,000 yd³

Spillway: Concrete gate structure, three 50- by 24.91-ft radial gates.
Headworks: Concrete, four 8- by 12-ft radial gates.

Diversion capacity	1,800 ft³/s

[1]Total length of dam and spillway is about 1,850 ft.

Levees

CALIFORNIA LEVEE

Type: Earth embankment[2]
Location: On California side of Colorado River about 2 mi downstream from San Bernardino-Riverside County line.
Construction period: 1958

Length	1.14 mi
Dimensions:	
Top width	20 ft
Side slopes:	
River side	2:1
Land side	1.5:1
Volume of embankment	26,076 yd³

[2]The levee is protected on the river side slope by 2 ft of gravel. The crest is not surfaced.

Volume of gravel blanket	646 yd³

Area protected: Blocks on old river channel to prevent flooding of Colorado River Indian Reservation lands.

Design flood	75,000 ft³/s

UPPER ARIZONA LEVEE

Type: Earth embankment and rock riprap[3]
Location: Extends upstream for about 8 mi from the end of Colorado River Indian Reservation Main Canal.
Construction period: 1956-58

Length	8 mi
Dimensions:	
Top width	20 ft
Side slopes:	
River side	2:1
Land side	1.5:1
Volume of embankment	91,022 yd³
Volume of riprap	14,812 yd³
Selected surfacing	16,859 yd³

Area protected: Colorado River Indian Reservation lands.

Design flood	75,000 ft³/s

LOWER ARIZONA LEVEE

Type: Earth embankment and rock riprap[3]
Location: Extends 21 mi upstream on Arizona side of the river from the left abutment of Palo Verde Diversion Dam to near the end of Main Canal.
Construction period: 1956-58

Length	21 mi
Dimensions:	
Top width	20 ft
Side slopes:	
River side	2:1
Land side	1.5:1
Volume of embankment	1,051,767 yd³
Volume of gravel blanket	1,007 yd³

Area protected: Colorado River Indian Reservation lands.

Design flood	75,000 ft³/s
Volume of riprap	57,066 yd³
Selected surfacing	44,242 yd³
Length of levee road	21 mi

[3]The upper and lower levees include five types of sections which have 0.5 ft of gravel surfacing on the crests. The river side slopes of most sections are protected by 1.3 ft of riprap.

Drain

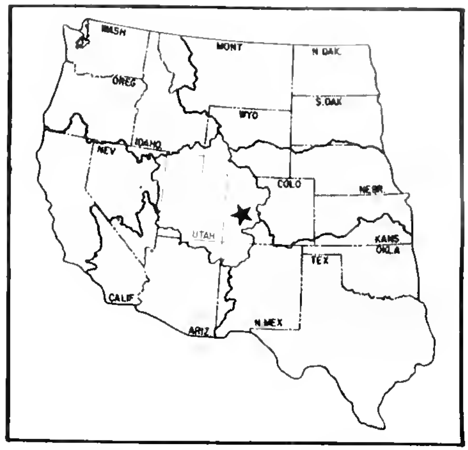
Location: On the land side of the Lower Arizona Levee, parallel to the levee except for the last mile where it diverges and ends at a point in the Colorado River approximately 2,000 ft downstream.
Construction period: 1956

Length	21 mi
Capacity	30-128 ft³/s
Typical maximum section:	
Bottom width, variable	10-20 ft
Side slopes	2:1
Water table slope	0.00076
Depth to water table below average ground surface	5.5 ft
Volume - excavation	1,045,503 yd³
Number of drainage structures	6

Paonia Project

Colorado: Delta and Gunnison Counties

Upper Colorado Region
Water and Power Resources Service



The Paonia Project, in west-central Colorado, provides full and supplemental irrigation water supplies for 15,300 acres of land in the vicinity of Paonia and Hotchkiss.

Project construction includes Paonia Dam and Reservoir and enlargement, and extension of Fire Mountain Canal. Paonia Dam controls and regulates the runoff of Muddy Creek, a tributary of the North Fork of the Gunnison River. No new irrigation laterals have been provided by the project.

PLAN

Paonia Reservoir stores the flows of Muddy Creek upstream of its confluence with the North Fork of the Gunnison River. Downstream, the Fire Mountain Diversion Dam and Canal divert flows from the river for delivery to project lands in the Fire Mountain Division. Leroux Creek Division water, used downstream of the Fire Mountain Canal extension, is exchanged with the Fire Mountain Canal and Reservoir Company. These shares are used as project water by the Leroux Creek Water Users Association for irrigation of Leroux Division lands above the Fire Mountain Canal. Fire Mountain Division water is then used by the Leroux Division lands on Rogers Mesa downstream of the Fire Mountain Canal system. Improvement of existing small reservoirs in the Leroux Creek Division was accomplished independently by water users.

Paonia Dam

Paonia Dam and Reservoir

Paonia Dam is on Muddy Creek about 1 mile upstream of its junction with Anthracite Creek, which in turn forms the North Fork of the Gunnison River. The dam is an earthfill structure containing 1,302,000 cubic yards of embankment with an interior impervious zone, blanketed upstream and downstream by zones of sand, gravel, and cobbles. The upstream face is protected by a layer of riprap and the downstream face by a layer of rockfill. The crest of the dam is 35 feet wide and 770 feet long; the structure stands 199 feet above foundation.

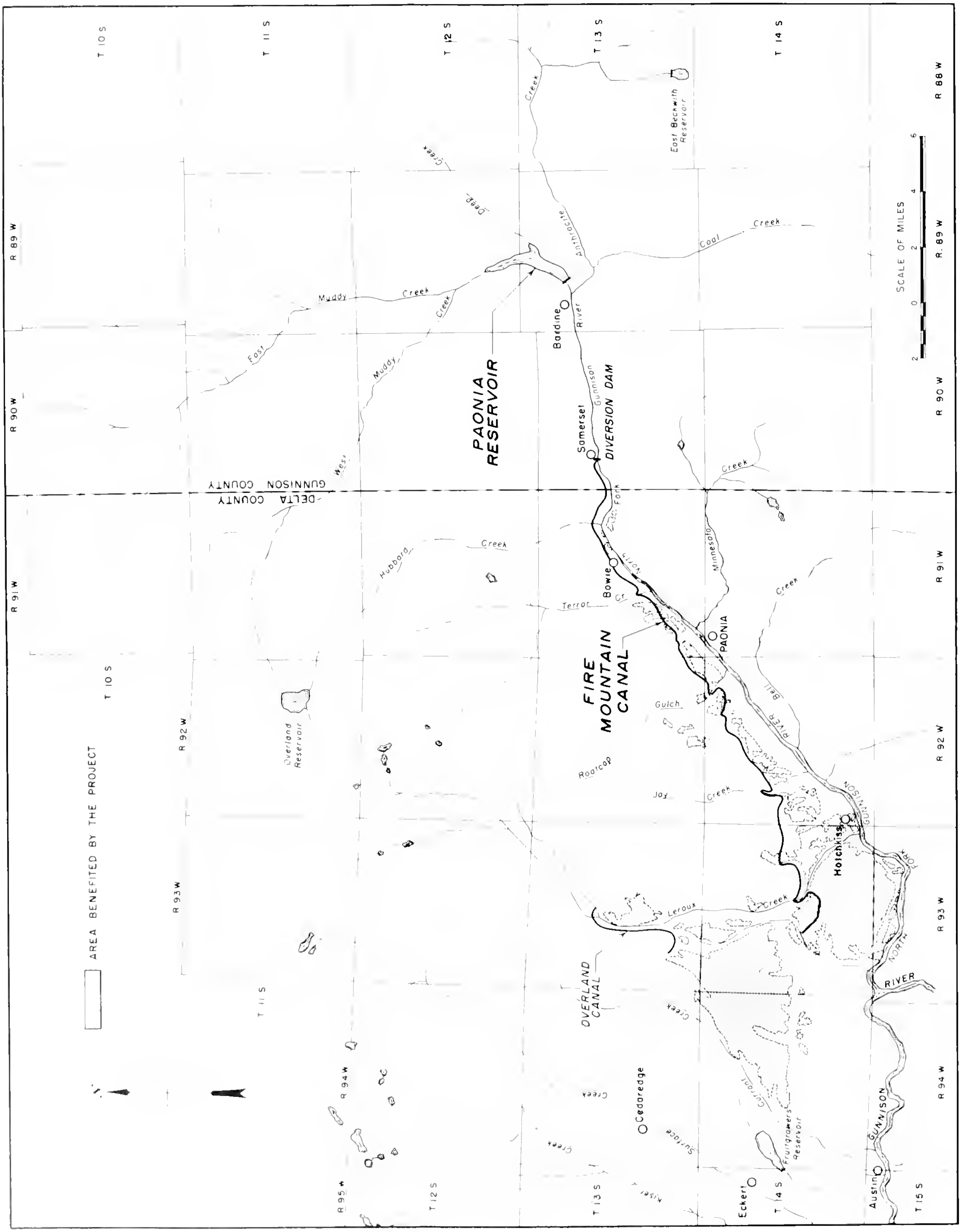
The outlet works on the right abutment of the dam consists of a concrete intake tower, concrete-lined tunnel, gate chamber near the dam axis, and a combination stilling basin for both the outlet works and spillway. The outlet works also includes a concrete shaft house and concrete-lined shaft and adit between the gate chamber and access shaft. The capacity of the outlet works is 1,130 cubic feet per second at maximum water surface elevation.

The spillway, also on the right abutment, consists of an uncontrolled ogee crest and open chute having a design capacity of 12,600 cubic feet per second. The chute joins the combined outlet works-spillway stilling basin.

Paonia Reservoir has a surface area of 334 acres with a total capacity of 20,950 acre-feet and an active capacity of 18,150 acre-feet.

Fire Mountain Diversion Dam and Canal

Fire Mountain Diversion Dam, located on the North Fork of the Gunnison River near Somerset, Colo., is a timber sheet-piling, rockfill structure. It has a height



Paonia Project

above streambed of 11 feet. Fire Mountain Canal extends 34.7 miles along the north side of the valley. It has an initial capacity of 180 cubic feet per second, reducing to 100 cubic feet per second at the Leroux Creek crossing.

DEVELOPMENT

Early History

Mining led to the early settlement of western Colorado and brought the area's first railroad service. The Ute Indians originally occupied west-central Colorado, including the valley of the North Fork of the Gunnison River. Early efforts to penetrate the area were resisted by the Indians until a compromise agreement with the Government was reached on September 4, 1881, and the Indians removed to the Uintah Reservation in the Territory of Utah.

Water rights in the valley date from 1882. The development of irrigation facilities proceeded rapidly until, by the turn of the century, the late summer natural flow of the river had become heavily appropriated. Rate of settlement and population growth were rapid in early years, but development of the area slowed by 1920. Agricultural settlement has remained more or less static since that time, although the population has increased slightly during recent years.

Investigations

In 1934, the State of Colorado began investigating a number of reservoir sites, including five in the North Fork watershed. As a result of these investigations and activities of the local water users, the Bureau of Reclamation commenced investigation of storage possibilities in the North Fork Valley in 1936.

A report issued by the Bureau of Reclamation in August 1938 suggested development of a reservoir at the Horse Ranch site on Anthracite Creek to serve lands of the Fire Mountain Canal and also of a reservoir at the Beaver damsite on the East Fork of Minnesota Creek to supplement the water supply for ditches diverting from Minnesota Creek. Anthracite Creek and Minnesota Creek are tributaries of the North Fork of the Gunnison River. On the strength of this report, the Paonia Project was authorized on March 18, 1939, by Presidential approval of the findings of feasibility of the Secretary of the Interior, dated March 16, 1939.

Subsequent findings prompted issuance of a revised report in 1940 dealing only with the Fire Mountain Division. This report proposed that the Spring Creek Reservoir site on East Muddy Creek, another tributary of the North Fork, be developed by the Bureau of Reclamation and that the Fire Mountain Canal be enlarged by the

Paonia Dam and Reservoir

water users in a 10-year development period during which no payments would be required for the storage dam. Funds for the canal enlargement were to be derived from charges made for the use of Spring Creek Reservoir water and from revenues from the sale of Leroux Creek water rights in the area to be served by an extension of the Fire Mountain Canal. This plan, however, was not favored by water users and authorization was not requested.

In 1946, the project plan was further revised to include a total of 14,750 acres of land to be benefited, to provide 4,000 acre-feet of surplus reservoir capacity, to provide for enlargement and improvement of the Overland and Fire Mountain Canals, and to provide for transfer of the use of water to upstream lands on Leroux Creek under two alternative plans. The project was authorized on June 25, 1947, by the 80th Congress. When bids for construction of Spring Creek Dam were opened on August 3, 1948, the low bid was 54 percent above the engineer's estimate and exceeded the total expenditure authorized for all features. No justification could be found for such high bids, and all bids were rejected. It was determined, however, that enlargement and extension of the Fire Mountain and Overland Canals were feasible undertakings independent of the storage feature. As repayment contracts had been executed between the Government

Spillway inlet structure

and the water users, construction of the Fire Mountain Canal was commenced.

In a February 1951 report, the project plan was revised to include an 18,000 acre-foot reservoir at the Paonia site, additional extension of the Fire Mountain Canal, enlargement of Overland Ditch, and construction of a siphon and pumping plant to convey irrigation water from the Fire Mountain Canal to 2,010 acres of land along Minnesota Creek. This plan would have provided irrigation service for 14,830 acres of irrigated land and 2,210 acres of unirrigated land. Development was authorized in 1956 as a participating project with the Colorado River Storage Project.

Since the 1956 authorization, water users in the Minnesota Creek area have withdrawn from the project in favor of private development of a reservoir on that stream. Therefore, the Minnesota Siphon and Pumping Plant and service to the Minnesota Creek lands were eliminated from the plan. It also was determined that existing ditches from Leroux Creek were adequate to convey usable flows of that stream, and enlargement of Overland Ditch was deleted from the plan. In the definite plan studies, it was determined that the total reservoir capacity should be increased to 21,000 acre-feet to provide more space for sediment retention. Irrigable acreages were reduced to 15,300.

Authorization

Construction under the 1938 plan was authorized by the President under Reclamation law on March 18, 1939.

The revised plan was authorized by the Congress on June 25, 1947. The project was reauthorized as a participating project under the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

The contract for the construction of Paonia Dam was awarded January 7, 1959, and work was completed in January 1962. Contracts for extension and lining of Fire Mountain Canal were awarded in 1959 and 1960, and work was completed in 1962.

Operating Agency

Operation and maintenance was assumed by the North Fork Water Conservancy District on June 1, 1962. By contract, the district transferred the physical operation and maintenance of the project to the Fire Mountain Canal and Reservoir Company.

BENEFITS

Irrigation

The project assures a full supply of water for irrigated lands. The general type of farming formerly practiced in the area has been continued with project development, but the additional irrigation supplies make possible more intensive crop production. Livestock feeds and fruit such as apples, peaches, and cherries are the major crops grown. Dairy cows and beef cattle are the principal livestock of the area.

Flood Control

Flood dangers on North Fork River are reduced by emptying the reservoir each year and by reserving storage space through forecasts of snowmelt runoff, and regulation of floodflows.

Recreation and Fish and Wildlife

Fishing, hunting, picnicking, and water sports are available at Paonia Reservoir. Recreation facilities are administered by the Colorado Division of Parks and Outdoor Recreation. Visitor days totaled 15,225 in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	12,928	acres
Full irrigation service	2,372	acres
Total	15,300	acres
Number of irrigated farms	253	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	11,751	1,182,207
1969	11,716	1,211,958
1970	11,781	1,026,871
1971	12,262	1,786,050
1972	12,075	916,663
1973	12,373	3,181,659
1974	12,371	2,632,891
1975	12,019	3,189,656
1976	12,019	3,143,187
1977	11,033	1,757,832

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	31.7	mi

Climatic Conditions

Annual precipitation	15	in
Temperature:		
Maximum	102	°F
Minimum	−28	°F
Mean	18	°F
Growing season	160	days
Elevation of irrigable area	5400-6800.0	ft

Settlement

Number of persons served with project water (1977):	3,635
Farm irrigation service	935
Urban, suburban, and residential service	2,700

ENGINEERING DATA

Water Supply

MUDDY CREEK

Drainage area at Paonia Dam	246	mi²
Annual discharge at Paonia Dam:		
Maximum (1973)	153,202	acre-ft
Minimum (1977)	17,315	acre-ft
Average	90,000	acre-ft

NORTH FORK GUNNISON RIVER

Drainage area at Somerset, Colo.	521	mi²
Annual discharge near Somerset, Colo.:		
Maximum (1952)	474,700	acre-ft
Minimum (1934)	136,500	acre-ft
Average	312,000	acre-ft

LEROUX CREEK

Drainage area at Cedaredge, Colo.	13	mi²
Annual discharge near Cedaredge, Colo.:		
Maximum (1938)	55,600	acre-ft
Minimum (1934, estimated)	16,000	acre-ft
Average	34,600	acre-ft

Storage Facilities

PAONIA DAM

Type: Zoned earthfill
Location: On Muddy Creek about 1 mi upstream of its junction with Anthracite Creek.
Construction period: 1959-62
Reservoir, Paonia:

Total capacity to El. 6447.5	20,950	acre-ft
Active capacity	18,150	acre-ft
Surface area	334	acres

Dimensions:

Structural height	199	ft
Top width	35	ft
Maximum base width	1,115	ft
Crest length	770	ft
Crest elevation	6460.0	ft
Total volume	1,302,000	yd^3

Spillway: Uncontrolled ogee crest and open chute.

Capacity at El. 6454.1	12,600	ft^3/s

Outlet works: Concrete-lined tunnel, 11 ft in diameter, through right abutment, controlled by two 2.75-ft-square high-pressure gates.

Capacity at El. 6454.1	1,130	ft^3/s

Diversion Facilities

FIRE MOUNTAIN DIVERSION DAM

Type: Timber sheet-piling, rockfill
Location: On the North Fork of Gunnison River near Somerset, Colo.
Year completed: 1950
Dimensions:

Height above streambed	11	ft
Weir crest length	187	ft
Total crest length	187	ft
Weir crest elevation	5955.0	ft
Volume	2,000	yd^3

Headworks: Concrete, one 12-ft-square radial gate.

Diversion capacity	180	ft^3/s

Carriage Facilities

FIRE MOUNTAIN CANAL

Location: From the diversion dam on the North Fork of Gunnison River near Somerset, Colo., generally southeast to a point about 4 mi northwest of Hotchkiss, Colo.
Construction period: Privately constructed. Enlarged by Reclamation in 1949-53 and 1959-62.

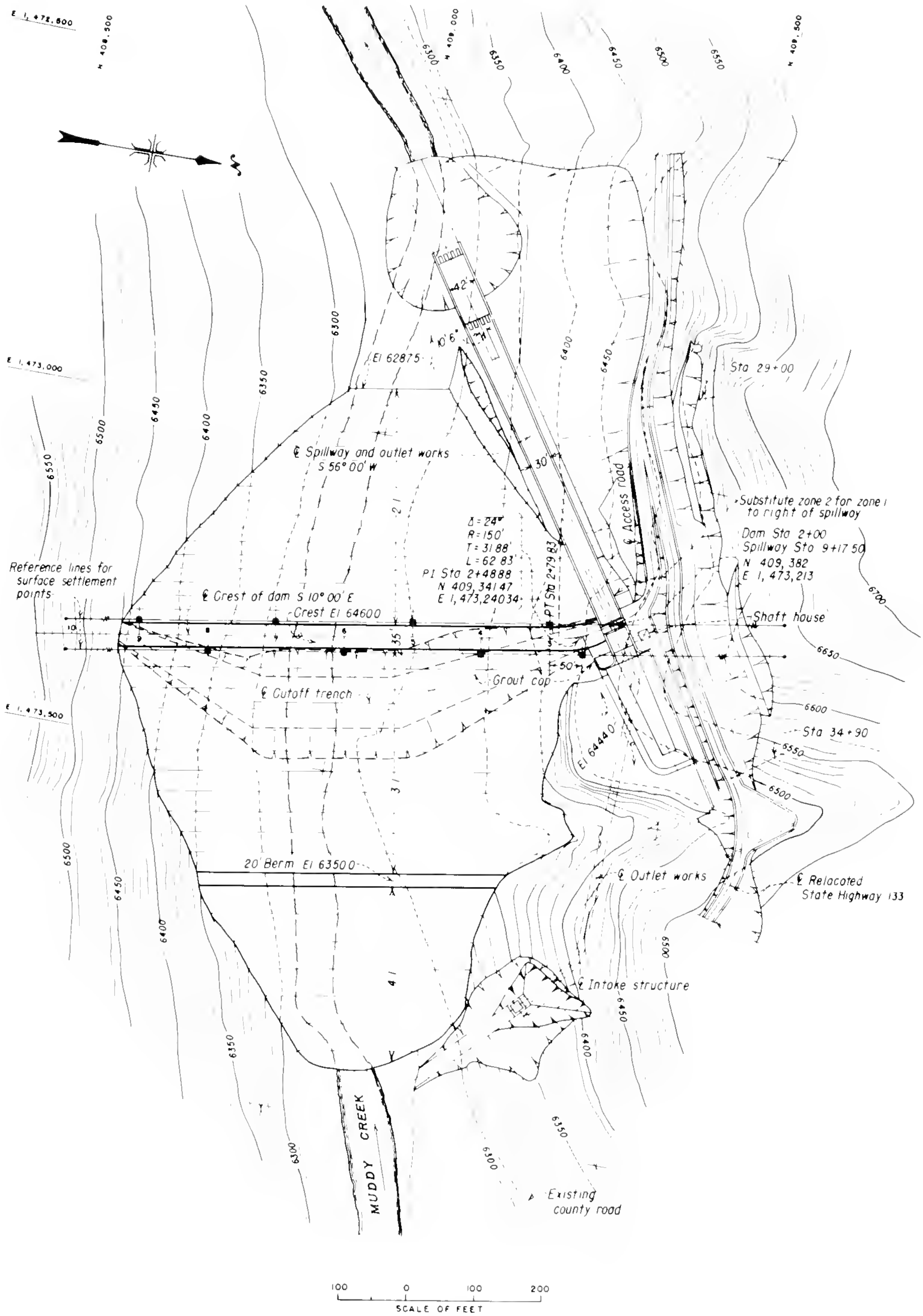
Length	31.7	mi
Initial capacity	200	ft^3/s

Typical maximum section, clay lined:

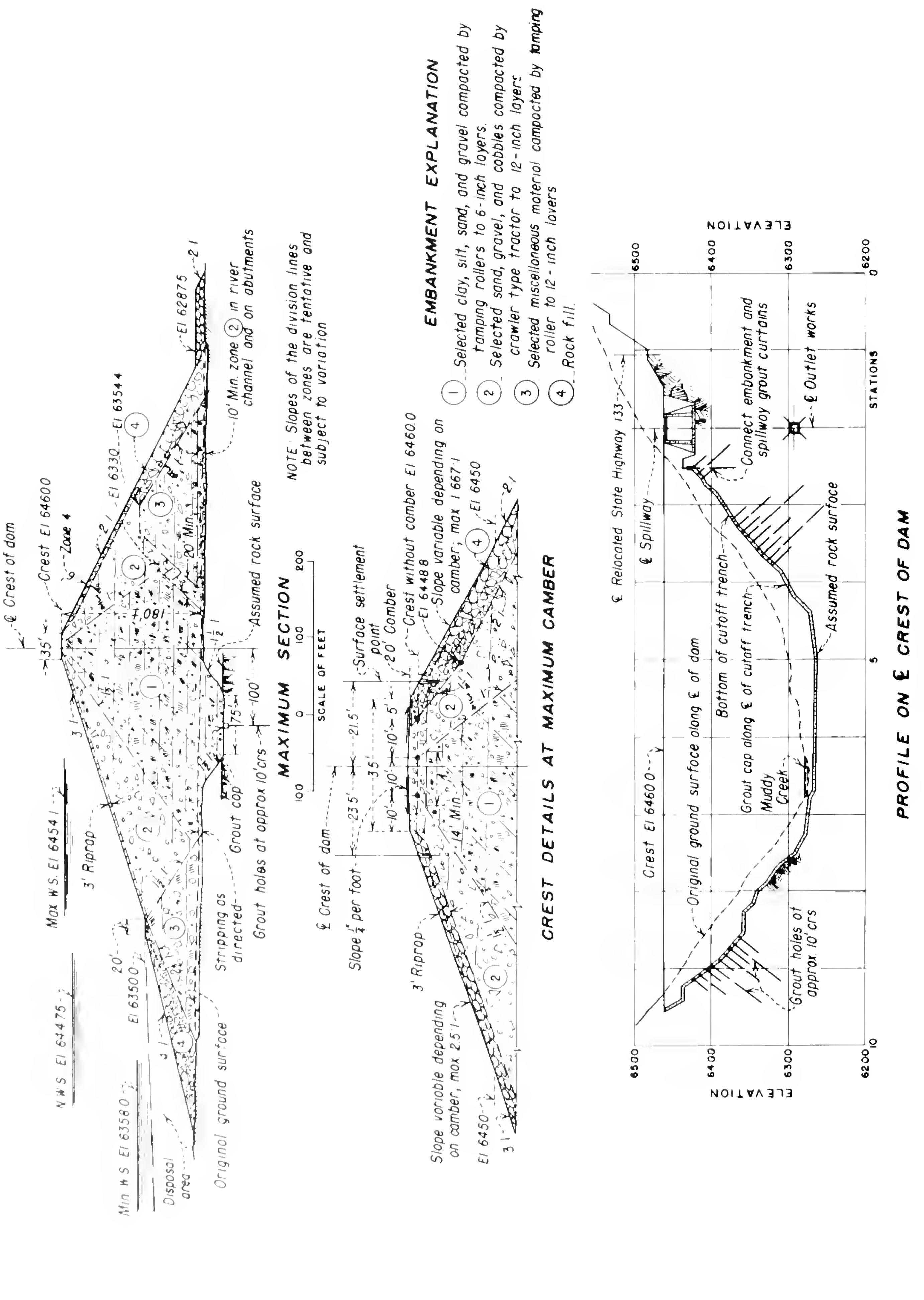
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	4	ft
Lining thickness	4	in

Typical maximum section, concrete lined:

Bottom width	4	ft
Side slopes	1.5:1	
Water depth	3.85	ft
Lining thickness	4	in



Paonia Dam, Plan

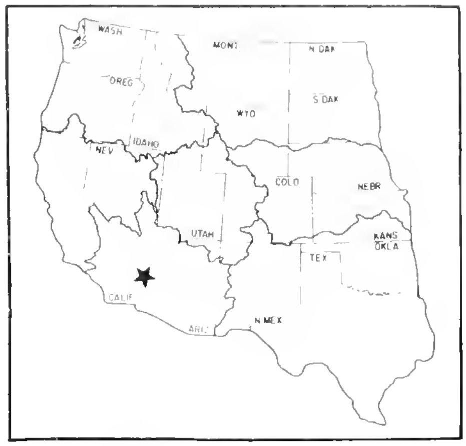


Paonia Dam. Sections

Parker-Davis Project

Arizona: Mohave and Yuma Counties
California: San Bernardino County
Nevada: Clark County

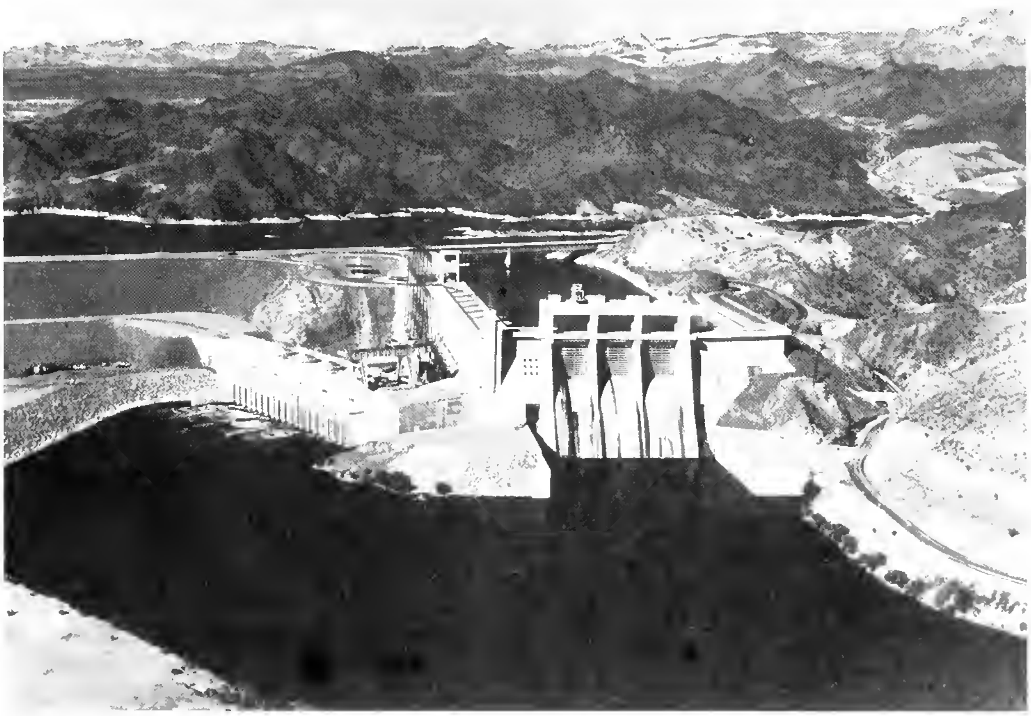
Lower Colorado Region
Water and Power Resources Service



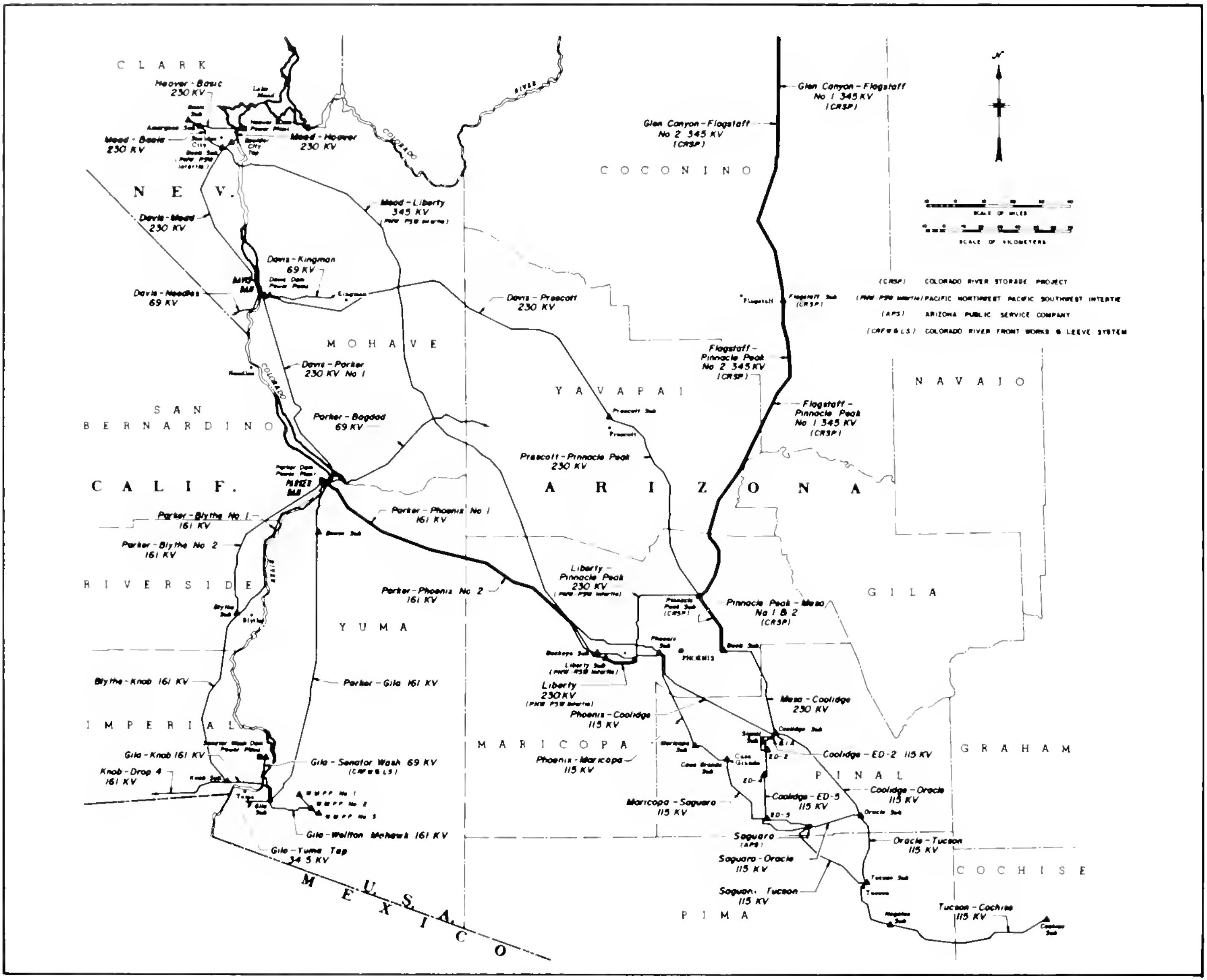
PLAN

In 1954, the Parker Dam Power Project and the Davis Dam Project were consolidated to form the Parker-Davis Project. The major works include Davis (originally named "Bullshead") Dam and Powerplant, Parker Dam and Powerplant, a high-voltage transmission system, and substations which sectionalize the long transmission lines. The original capacity of the Davis Powerplant was 225,000 kilowatts. In 1973, generator replacement of stator windings was initiated. Completed in 1976, the new windings increased the capacity of the powerplant to 240,000 kilowatts. The rated capacity of the Parker plant is 120,000 kilowatts. The transmission system includes 1,609.2 miles of high-voltage transmission lines and 31 substations. Parker Dam and Davis Dam are located on the Colorado River, 155 miles and 67 miles, respectively, downstream of Hoover Dam.

Lake Havasu, formed by Parker Dam, provides a forebay and desilting basin from which the Metropolitan Water District pumps water into its Colorado River Aqueduct. Parker Dam Powerplant was added to provide low-cost electrical energy to Arizona and southern California. Davis Dam provides reregulation of the Colorado River below Hoover Dam and facilitates water delivery beyond the boundary of the United States as required by treaty with Mexico. The Davis Dam portion of the project also provides for production and transmission of electrical energy, contributes to flood control, irrigation and municipal water supplies, navigation improvement, recreation, and wild waterfowl protection and related conservation purposes.



Davis Dam



Parker-Davis Project

Parker Dam, Powerplant, and Reservoir

Parker Dam is a concrete arch structure with a structural height of 320 feet, and a volume of 380,000 cubic yards. At its crest, the dam is 856 feet long and is controlled by five 50-foot-square gates.

Lake Havasu backs up behind the dam for 45 miles and covers over 25,000 acres. The total capacity of the reservoir is 648,000 acre-feet. The Metropolitan Water District's W. P. Whitsett Intake Pumping Plant for the Colorado River Aqueduct is located on the shore of Lake Havasu about 2 miles upstream from the dam. The aqueduct begins at the intake pumping plant and extends 242 miles to its terminus at Lake Mathews near Riverside, Calif. About half of the power generated at the Parker Powerplant is reserved by the district for pumping water along the aqueduct. The Bureau of Reclamation retains the other half of the power output. The contract limits the use of active storage in Lake Havasu to the uppermost 180,000 acre-feet.

The Parker Powerplant includes a penstock gate structure, four penstock tunnels, and a powerplant building housing four hydroelectric generating units. Each of the four tunnels and the penstocks conveying river water from the forebay at the left end of the dam to the turbines is 22 feet in diameter and has a water capacity of 5,575 cubic feet per second.

Davis Dam, Powerplant, and Reservoir

Davis Dam spans the Colorado River in Pyramid Canyon 67 miles downstream from Hoover Dam and 88 miles upstream from Parker Dam. The Mexican Treaty

Parker Dam

of 1944 required the United States to construct Davis Dam for regulation of water to be delivered to Mexico. The reservoir formed by the dam, Lake Mohave, is used for that purpose through integrated operations of Hoover and Davis Powerplants.

Davis Dam, rising 200 feet above the lowest point of the foundation and about 140 feet above the level of the river, is a zoned earthfill structure with concrete spillway, intake structure, and powerplant. It has a crest length of 1,600 feet, and a top width of 50 feet. Its reservoir, Lake Mohave, has a total storage capacity of 1,818,300 acre-feet, and at high-water stages extends 67 miles upstream to the tailrace of the Hoover Powerplant.

Almost 5 million cubic yards of rock and earth were excavated to form the diversion and forebay channel and foundations for the dam, spillway and intake structures, and powerplant. More than 3,642,000 cubic yards of earth and rockfill were required to form the dam, and about 600,000 cubic yards of concrete and 23 million pounds of reinforcing steel were placed in the spillway, powerplant, and other structures.

The semi-outdoor type Davis Powerplant is on the Arizona side of the river immediately downstream from the dam embankment. Water is delivered from the forebay to the powerplant through five 22-foot-diameter penstocks.

Transmission System

The transmission system includes 31 substations with a total capacity of 2,113,083 kilovolt-amperes, and 51 transmission lines with a total length of 1,609.2 miles. The high-voltage switchyards near the powerplants are the takeoff points for a system of transmission lines and substations which interconnect the Davis, Hoover, and Parker Powerplants, and extend to load centers in central and southern Arizona, southern Nevada, and southern California.

DEVELOPMENT

Investigations

Parker Dam. Population growth of municipalities within the greater Los Angeles area in California created a domestic water demand in excess of the supply from the local streams and the more remote Owens Valley source. After intensive investigations, it was determined that sufficient water could be obtained from the Colorado River. The construction of Hoover Dam, by virtue of the resulting river regulation and power generation, made feasible a plan to construct a dam on the Colorado River below the mouth of the Bill Williams River. Surveys initiated by the Bureau of Reclamation on June 25, 1934, established the best site for the location of Parker Dam.

Davis Dam. The Reclamation Service investigated a possible damsite at the lower end of Pyramid Canyon, 67 miles below Hoover Dam, as early as 1902-03. Until Hoover Dam controlled the Colorado River, however, a dam at the Davis site was not practicable.

In 1930, the Bureau of Reclamation made further investigations and explorations of the site in Pyramid Canyon, which led to authorization of the Davis Dam Project.

Authorization

The Parker-Davis Project was formed by the consolidation of the Parker Dam Power Project and the Davis Dam Project under the terms of the act of May 28, 1954 (68 Stat. 143). The Parker Dam Power Project was authorized by the Rivers and Harbors Act of August 30, 1935 (49 Stat. 1028). The Davis Dam Project was found feasible and authorized April 26, 1941, by the Secretary of the Interior under provisions of the Reclamation Project Act of 1939 (53 Stat. 1187).

On October 1, 1977, in conformance with Public Law 95-91, the Department of Energy Organization Act of August 4, 1977, the power marketing function of the Bureau of Reclamation, including operation and maintenance of transmission lines and attendant facilities, were transferred to the Department of Energy.

Construction

With funds advanced by the Metropolitan Water District of southern California, contracts were awarded by the Bureau of Reclamation and excavation for the Parker Dam and Powerplant commenced in October 1934. The dam was substantially completed in September 1938. Construction of the powerplant, consisting of four units, began in July 1939. Concurrently with construction of the powerplant, transmission lines and substations of the project were constructed and put into operation. Because of the onset of World War II, certain features were constructed with temporary materials or were omitted until proper materials could be made available and installed. Postwar work included replacement of temporary wood supporting structures with permanent steel structures in the substations.

A contract for the construction of Davis Dam and appurtenant works was awarded in June 1942. Work was halted after the War Production Board revoked priority ratings required to obtain the necessary materials for construction. Construction resumed in April 1946, and was completed in 1953.

Operating Agencies

The dams, hydroelectric powerplants, and attendant facilities are operated and maintained by the Bureau of Reclamation. The Parker Dam and Davis Dam Field Division of the Parker-Davis Project and the Boulder Canyon Project (Hoover Dam) were combined in a single operating unit administered by the Lower Colorado Dams Project Office located at Hoover Dam. The marketing functions, including the operation and maintenance of the transmission lines and attendant facilities of the Parker-Davis Project, are administered by the Boulder City Area Office of the Western Area Power Administration.

BENEFITS

Municipal and Industrial Water

Parker Dam diverts about 1,080 cubic feet per second of water daily to the Colorado River Aqueduct for use in the metropolitan area of Los Angeles.

Hydroelectric Power

Davis, Hoover, and Parker Powerplants are interconnected. The electrical integration and interconnection of these Bureau of Reclamation powerplants provides maximum generation of power with efficient use of water resources. The highly developed agricultural base and the complex industrialization of the Pacific Southwest benefit greatly from Colorado River hydroelectric energy.

Flood Control

Just above Parker Dam, the Bill Williams River pours flash floods into Lake Havasu. These floods are trapped in the reservoir and the downstream lands are protected. Parker Dam and Davis Dam both reregulate water releases from Lake Mead through the Hoover Powerplant for use downstream.

Recreation and Fish and Wildlife

Lake Havasu and most of the large marsh area extending 10 miles above the reservoir are included in the Havasu National Wildlife Refuge. Cabin sites are available for lease. Principal activities are camping, picnicking, swimming, boating, and year-round fishing—primarily for large-mouth black bass, bluegills, and crappie. Migratory waterfowl hunting is permitted in season.

Lake Mohave is included in and administered as part of the Lake Mead National Recreation Area. Several concessions operate in the area with cabins, camping and trailer parks, and boats for hire. Camping, picnicking, swimming, boating, and excellent year-round fishing are the major activities. From Hoover Dam downstream to Cottonwood Landing, where Lake Mohave begins to widen, rainbow trout fishing is good. Below Cottonwood Landing, bass, catfish, and bluegills predominate.

PROJECT DATA

Facilities in Operation

Storage dams	2	
Powerplants	2	
Transmission lines[1]	1,609.2	mi
Substations	31	

[1]The power marketing function, including the operation and maintenance of transmission lines and attendant facilities, was transferred to Western Area Power Administration, Department of Energy, in 1977.

Power Generation

Fiscal Year	Davis Powerplant (kWh)	Parker Powerplant (kWh)	Total
1968	912,961,000	433,611,000	1,346,572,000
1969	915,507,000	437,581,000	1,353,088,000
1970	926,879,000	434,108,000	1,360,987,000
1971	949,674,000	446,645,724	1,396,319,724
1972	972,116,000	455,856,000	1,427,972,000
1973	914,652,000	435,800,794	1,350,452,794
1974	997,680,000	477,109,291	1,474,789,291
1975	959,710,000	475,751,232	1,435,461,232
1976	961,381,000	478,940,452	1,440,321,452
1977	941,940,000	438,740,000	1,380,680,000

ENGINEERING DATA

Water Supply

Colorado River

(See Boulder Canyon Project for information on drainage area and discharge.)

Annual diversion at Parker Dam[2]

Maximum (1977)	1,280,000	acre-ft
Minimum (1946)	80,100	acre-ft
Average	740,500	acre-ft

[2]Pumped by the Metropolitan Water District of Southern California.

Storage Facilities

Davis Dam

Type: Zoned earthfill
Location: On the Colorado River, 32 mi west of Kingman, Ariz.
Construction period: 1942-50
Date of closure (first storage): January 1950
Reservoir, Lake Mohave:

Total capacity to El. 647	1,818,300	acre-ft
Active capacity, El. 533.39-647	1,810,000	acre-ft
Surface area	28,500	acres

Dimensions:

Structural height	200	ft
Hydraulic height	140	ft
Top width	50	ft
Maximum base width	1,400	ft
Crest length	1,600	ft
Crest elevation	655.0	ft
Total volume	3,642,000	yd³

Spillway: Concrete ogee weir in end of forebay channel at east end of dam, controlled by three 50-ft-square fixed-wheel gates.

Elevation top of gates	647	ft
Crest elevation	597.0	ft
Capacity at El. 647	214,000	ft³/s

Outlet works: Two openings, one on each side of spillway section, each controlled by one 22- by 19-ft radial gate.

Capacity at El. 610	43,400	ft³/s

Foundation: Badly fractured and faulted porphyric granite gneiss overlain by silt, sand, and gravel in river channel.
Special treatment: Cement grout curtain under dam; intensive intermediate-zone grouting under concrete structures.

Parker Dam

Type: Concrete arch
Location: On the Colorado River 12 mi northeast of Parker, Ariz.
Construction period: 1934-38
Power plant constucted in 1939-42
Date of closure (first storage): July 16, 1938
Reservoir, Lake Havasu:

Total capacity to El. 450	648,000	acre-ft
Available capacity, El. 400-450	180,000	acre-ft
Surface area	20,400	acres

Dimensions:

Structural height	320	ft
Hydraulic height	75	ft
Top width	39	ft
Maximum base width	100	ft
Crest length	856	ft
Crest elevation	455.0	ft
Total volume	380,000	yd³

Spillway: Overflow section at center of dam controlled by five 50-ft-square Stoney gates.

Elevation top of gates	450.0	ft
Crest elevation	400.0	ft
Capacity at El. 455	400,000	ft³/s

Outlet works: Four 22-ft-diameter steel penstocks through right abutment, each controlled by one 22- by 35-ft fixed-wheel gate.

Capacity at El. 450	22,300	ft³/s

Foundation: A hard, firm porphyric gneiss with subordinate masses of granite cut by several aplitic dikes; clay seams and fractured rock in right abutment.
Special treatment: Cement grout curtain near axis of dam, supplemental grouting in abutments.
Mass concrete: Natural aggregate from pit on Bill Williams River 3.5 mi from dam; low-heat portland cement; mixing and placing temperatures controlled, artificial cooling through embedded pipe system.

Maximum size aggregate	6	in
Average net water-cement ratio (by weight)	0.58	
Cement content	1.09	bbl/yd³

Power Facilities

Parker Powerplant

Location: Parker Dam
Year of initial operation: 1942
Year last generator placed in operation: 1943

Nameplate capacity	120,000	kW
Number and capacity of generators (4)	30,000	kW
Maximum head	78	ft

Davis Powerplant

Location: Davis Dam
Year of initial operation: 1951
Year last generator placed in operation: 1951

Nameplate capacity[3]	240,000	kW
Number and capacity of generators (5)	48,000	kW
Maximum head	136	ft

Substations[4]

Number in operation	31	
Total capacity of transformers	2,113,083	kVA

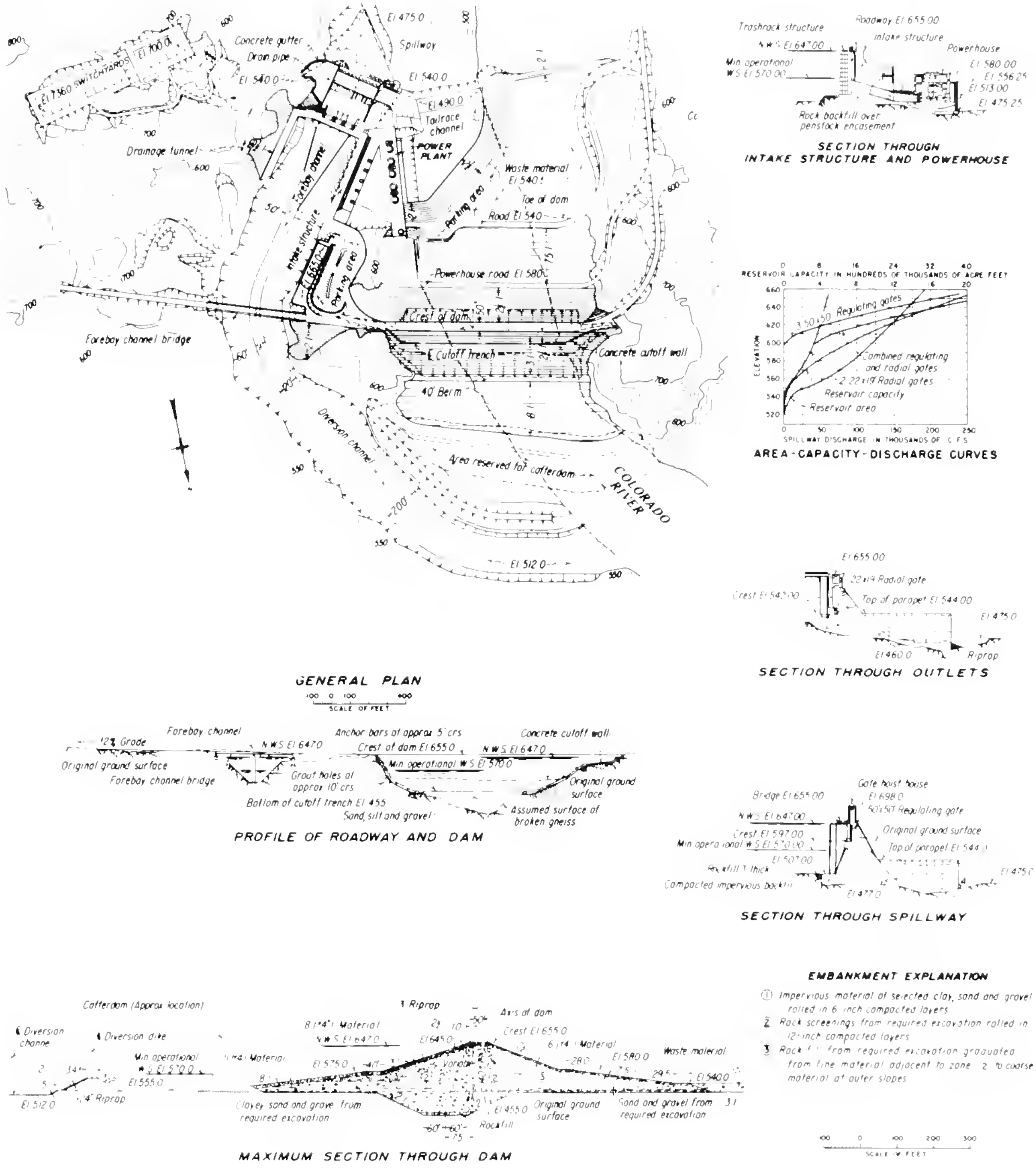
Transmission Lines[4]

Total number of lines	51
Total circuit miles	1,609.2

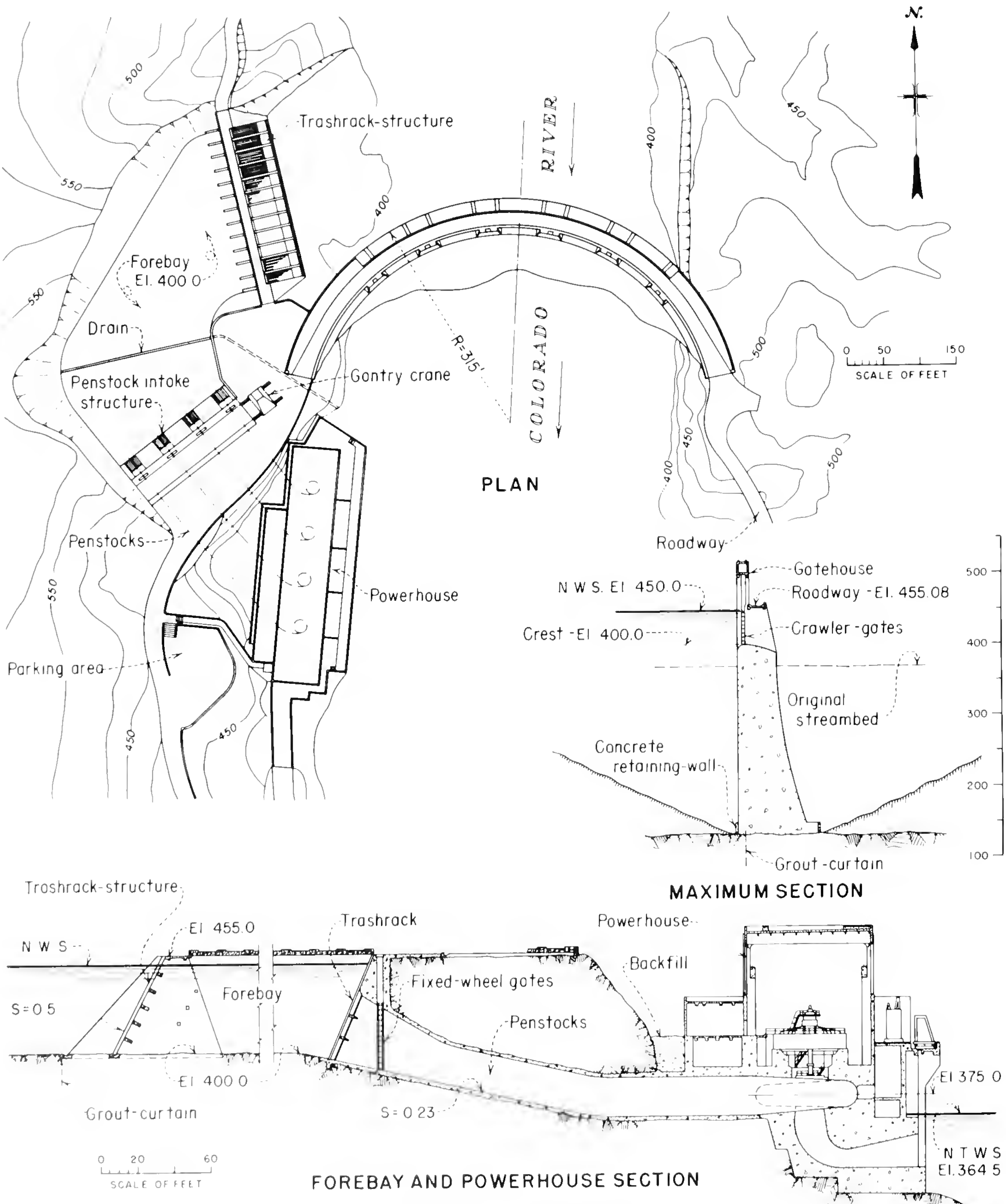
Description	Voltage, kV	Conductors and supporting structures	Circuit miles	Year placed in service
Parker-Davis No. 1	230	795 Steel	69.9	1951
Davis-Mead	230	795 Steel	60.7	1951
Davis-Davis Switchyards 1 through 5	230	CU 500 Steel	1.5	1951
Davis-Prescott	230	795 Steel	142.5	1951
Hoover-Basic (North Basic Line)	230	CU 500 Steel	15.0	1942
Mead-Basic	230	795 Steel	12.8	1942
		CU 500 Steel		
Mead-Hoover States	230	795 Steel	8.5	1942
		CU 500 Steel		
Mesa-Coolidge	230	795 Steel	39.9	1951
Parker-Gene (MWD)	230	795 Steel	1.7	1947
Prescott-Pinnacle Peak	230	795 Steel	74.9	1951
Blythe-Knob	161	477 Wood-H	64.4	1951
Gila-Knob	161	CU 300 Wood-H	20.2	1943
Gila-Wellton-Mohawk (P.P. No. 2)	161	397.5 Wood-H	12.7	1956

Description	Voltage, kV	Conductors and supporting structures	Circuit miles	Year placed in service
Parker Powerplant-Parker 161-kV Switchyard (Nos. 1 through 1)	161	CU 300 Steel	0.5	1942-43
Parker-Blythe No. 1	161	CU 300 Wood-H	64.6	1943-51
		477 Wood-H		
Parker-Blythe No. 2	161	954 Wood-H	63.9	1946
Parker-Gila	161	CU 300 Wood-H	116.5	1943
		477 Wood-H		
Parker 161-kV-Parker 230-kV (Trans. 5 & 6)	161	477 Steel	0.5	1947-54
Parker-Phoenix No. 1[5]	161	CU 300 Wood-H	136.9	1942
Parker-Phoenix No. 2	161	477 Wood-H	139.8	1946
Knob Tap-Drop 1 Tap	161	CU 300 Wood-H	28.6	1943
Coolidge-BIA Coolidge	115	CU 4/0 Wood-H	0.4	1950
Coolidge-Elect. District No. 2 (via Signal)	115	336.4 Wood-H	12.2	1965
Coolidge-Oracle	115	CU 4/0 Wood-H	44.7	1943
Coolidge-Saguaro	115	795 Wood-H	47.1	1948-65
		336.4 Wood-H		
Maricopa-Saguaro	115	336.4 Wood-H	58.5	1948-54
		795 Wood-H		
Oracle-Tucson	115	CU 4/0 Wood-H	25.0	1943
		CU 4/0 Wood-P		
Phoenix-Coolidge	115	CU 4/0 Wood-H	52.5	1943-48
		336.4 Wood H		
Phoenix Maricopa	115	336.4 Wood-H	36.1	1943-48
		CU 4/0 Wood-H		
Saguaro-Oracle	115	795 Wood-H	19.0	1954
Saguaro-Tucson	115	795 Wood-H	35.4	1948-54
		336.4 Wood-H		
Tucson-Cochise	115	336.4 Wood-H	79.7	1952
Davis Powerplant-Davis 69-kV Switchyard	69	3/0 Steel	0.2	1965
Davis-CPU Tap (Needles)[6]	69	2/0 Wood-H	12.2	1946-53
		4/0 Wood-H		
		CU No. 2 Wood-H		
Davis-CUC Tap (Kingman)	69	2/0 Wood-H	27.3	1947
Parker Powerplant-Parker 69-kV (Transf. 3)	69	CU 250 Wood-H	0.1	1943
Parker Powerplant-Parker 69-kV (Transf. 4)	69	CU 250 Wood-H	0.1	1943
Parker-Bagdad[7]	69	CU No. 2 Wood-H	64.3	1943
Gila-Yuma Tap	34.5	CU 2/0 Wood-P	9.8	1943
Parker (Indian Service)-Parker Dam Camp	34.5	CU No. 2 Wood-P	0.2	1943
Wellton-Mohawk-Wellton-Mohawk P.P. No. 1	34.5	266.8 Wood-P	4.9	1951
Wellton-Mohawk-Wellton-Mohawk P.P. No. 3	34.5	336.4 Wood-P	3.5	1951
Parker LV-Colorado (APS)	13.2	795 Wood-P	0.2	1963

[3] In 1976, the new winding of generators increased the capacity from 225,000 to 240,000 kW.
[4] See footnote 1.
[5] To be replaced and upgraded to 230 kV as part of the Granite Reef Aqueduct transmission system of the Central Arizona Project.
[6] To be transferred to the Bureau of Indian Affairs.
[7] Planet Tap to the Cyprus Tap section (57.1 mi) to be sold to the Mohave Electric Cooperative, Inc.



Davis Dam, Plan and Sections

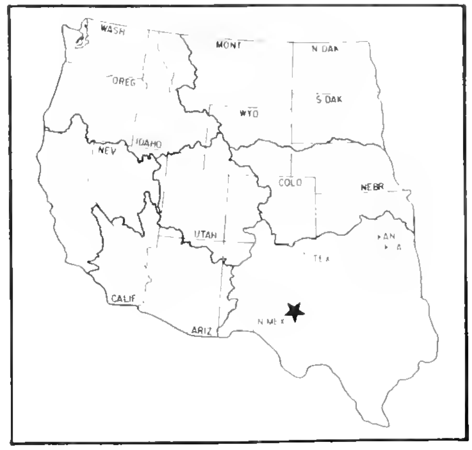


Parker Dam, Plan and Sections

Pecos River Basin Water Salvage Project

New Mexico: Guadalupe, DeBaca, Chaves, and Eddy Counties
Texas: Loving, Reeves, and Ward Counties

Southwest Region
Water and Power Resources Service



The Pecos River Basin Water Salvage Project is a phreatophyte eradication and management program in the flood plain of the Pecos River extending from Santa Rosa, N. Mex., to Girvin, Tex. The consumption of water by phreatophytes is a continuing problem in the arid and semiarid regions of the western United States. It is estimated that phreatophytes cover 15 million acres of bottom lands in the 17 Western States.

Virtually every stream in the Southwest supports growth of salt cedars. This is particularly true in the Pecos River Basin, and the impact is great because of the short supply of water.

Four major earth dams are located within this reach of the Pecos River. They are Sumner Dam, approximately 16 miles north of Fort Sumner, N. Mex.; McMillan Dam, about 18 miles north of Carlsbad, N. Mex.; Avalon Dam, 5 miles north of Carlsbad, N. Mex.; and Red Bluff Dam, 12 miles north of Orla, Tex.

PLAN

Approximately 590 miles of the Pecos River and, before clearing, over 200,000 acres of salt cedars are within the boundaries of the project. The lateral boundaries of about 78,000 acres of land to receive treatment were established on each side of the river where the depth to water table was no more than 10 feet. This relatively high water table provides excellent growing conditions for the salt cedars. A total of 53,950 acres infested with dense growths of salt cedars was selectively cleared; the remaining 24,050 acres were left untouched to reduce the impact on wildlife.

DEVELOPMENT

Early History

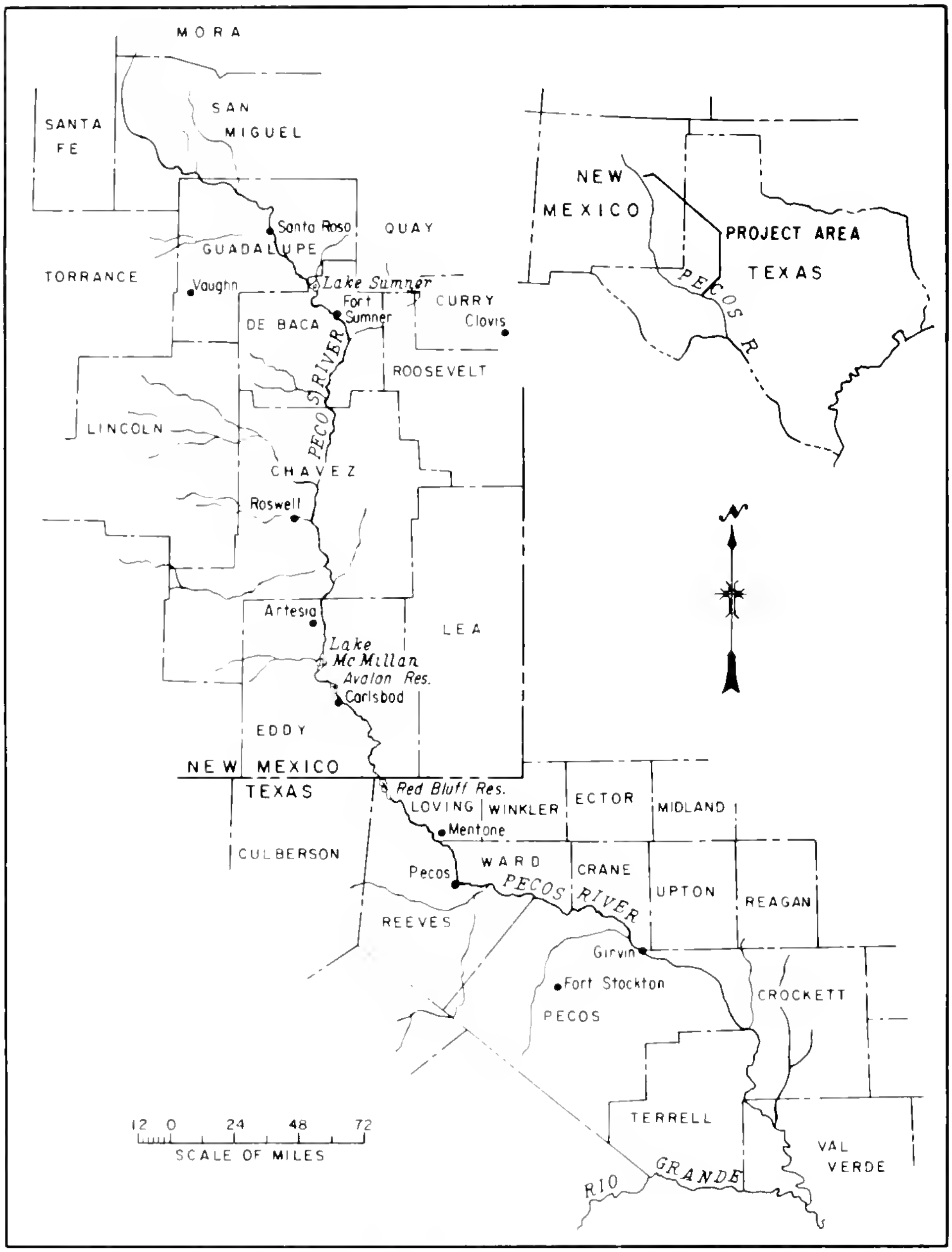
The major phreatophyte species which is a problem in the Southwest is the salt cedar *(Tamarix ssp)*. It was first noted in the McMillan Delta area, Pecos River Basin, between 1912 and 1914. Since that time salt cedar has spread throughout the basin, occupying more than 275,000 acres in 1961.

Salt cedars contribute to the problems of water shortages and flooding within the Pecos River Basin area. It is estimated that the consumptive use of water by salt cedars in some areas of the Pecos River Basin may be as much as 4.15 acre-feet per acre per year. Also, phreatophyte invasion onto farmlands was decreasing crop yield and forage available for pasture grazing.

Authorization

Public Law 88-594, dated September 12, 1964, authorized the Secretary of the Interior, as he deems necessary, to ". . .carry out a continuing program to reduce nonbeneficial consumptive use of water in the basin including that by salt cedars and other phreatophytes."

Uncleared area, Pecos River



Pecos River Basin Water Salvage Project

Construction

Clearing activities conducted by the Bureau of Reclamation began in 1967 and continued until 1971. About 53,950 acres at various locations between Lake Sumner, N. Mex., and Pecos, Tex., a distance of about 370 miles, were within the clearing boundaries. New clearing has not been done since 1971. Maintenance activities on 53,800 acres of cleared areas were initiated in 1968 and are continuing.

There were various methods and equipment used for the initial clearing of the salt cedars, such as plowing, tree crushers, mowing, bulldozing, and chaining. The maintenance of the regrowth is performed by root plowing.

Operating Agency

The operating agency for the Pecos River Basin Water Salvage Project is the Bureau of Reclamation. New Mexico and Texas participated in the project by supplying funds for acquisition of permits and rights-of-way.

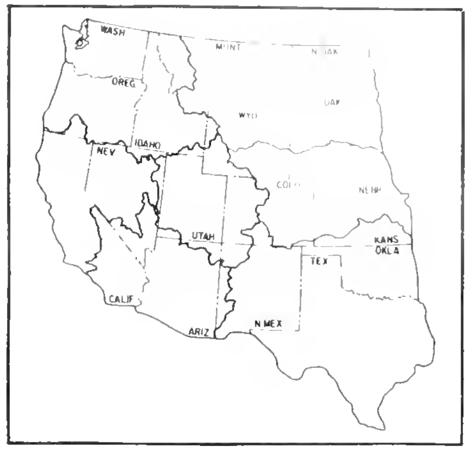
BENEFITS

The purposes of the project are to prevent further decreases in the supply of water in the Pecos River Basin; to enhance the water supply for municipal, industrial, irrigation, and recreational uses; to provide flood protection for the farmlands in the basin; and to provide for the conservation of fish and wildlife.

Pick-Sloan Missouri Basin Program[1]

Ten States: Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming

Upper and Lower Missouri Regions
Water and Power Resources Service



The Pick-Sloan Missouri Basin Program was initially authorized by the Flood Control Act of December 22, 1944, which approved the general comprehensive plan for the conservation, control, and use of water resources in the entire Missouri River Basin. The justifiable and beneficial uses of these water resources include flood control, aids to navigation, irrigation of over 3 million acres of new land, a supplemental water supply to nearly 700,000 acres of land, power generation from plants with a total installed capacity of about 2.5 million kilowatts, municipal and industrial water supplies, stream-pollution abatement, sediment control, preservation and enhancement of fish and wildlife, and creation of recreation opportunities.

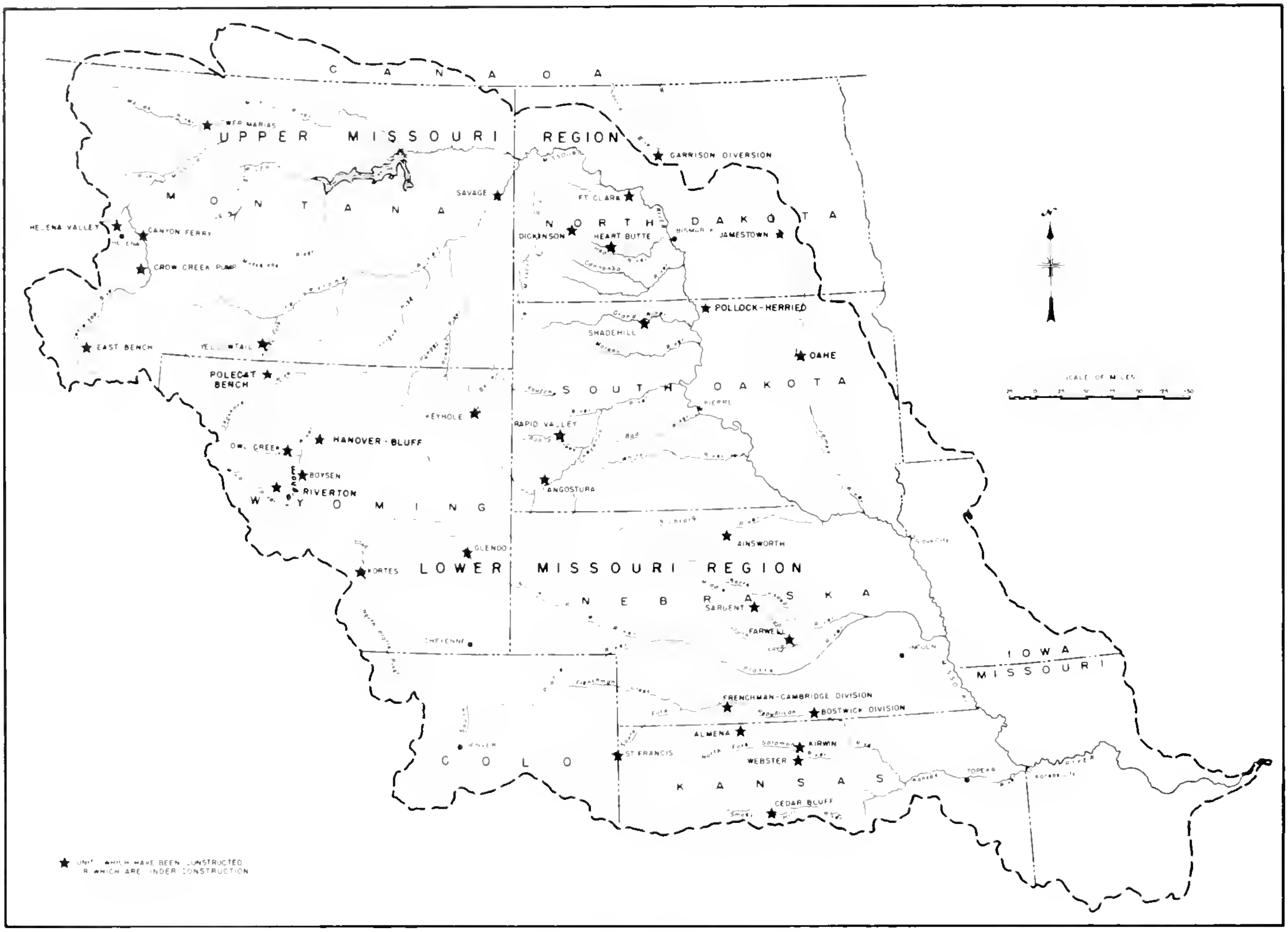
The Missouri Basin Interagency Committee was established by the Federal Interagency River Basin Committee in April 1945 to coordinate the activities of the participating Federal agencies and the 10 Missouri Basin States in developing the water resources of the basin. A revised charter was adopted in 1954 to provide improved facilities and procedures for coordination of the policies, programs, and activities of the various Federal departments and the States in water and related land resources investigation, planning, construction, operation, and maintenance. In March 1972, the Interagency Committee was replaced by establishment of the Missouri River Basin Commission. The commission membership consists of a chairman appointed by the President; the Governors of the 10 States which make up the Missouri Basin States; representatives from 10 Federal agencies—Departments of the Interior, Army, Agriculture, Commerce, Health, Education and Welfare, Housing and Urban Development, and Transportation, and the Energy Research and Development Administration, Environmental Protection Agency, and Federal Energy Regulatory Commission; the interstate commission for the Big Blue River and Yellowstone River Compacts; and the Canadian Government as an observer.

[1]Formerly called the Missouri River Basin Project.

The Bureau of Reclamation program in Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming is composed of approximately 150 units, each of which has been or is being constructed or investigated. Activities under the program include units completed and in operation, units under construction, and units, areas, or subbasins being investigated to meet the continuing water and land-related needs of the Missouri River Basin. The Corps of Engineer's program includes major main-stem reservoirs and flood control projects. The Bureau of Reclamation cooperates with the Corps of Engineers and other agencies in the joint coordinated plan of conservation, control, and use of the basin's water resources. Cooperating agencies within the Department of the Interior, in addition to the Bureau of Reclamation, include: Bureau of Land Management, Bureau of Mines, Fish and Wildlife Service, Geological Survey, National Park Service, Bureau of Indian Affairs, Heritage Conservation and Recreation Service, and Office of Water Resources Research.

The power systems of the Colorado-Big Thompson, Kendrick, Shoshone, and North Platte Projects have been integrated with the Pick-Sloan Missouri Basin Program for the purpose of marketing the power produced from these projects. In return for all the power generated surplus to project needs on the integrated projects, the program returns, to each project, revenues sufficient to cover the annual production operating expenses and a reserve for replacement of facilities and to allow net operating revenue great enough to repay the power and irrigation construction costs obligated for repayment from power revenues.

The Bureau of Reclamation's plan for development of the water resources of the Missouri River Basin was presented to the Congress May 5, 1944, (Senate Document No. 191, 78th Congress, 2d session). A plan sponsored by the Corps of Engineers (House Document No. 475, 78th Congress, 2d session) was submitted to the Congress March 2, 1944. Senate Document No. 247,



Pick-Sloan Missouri Basin Program

coordinating the plans of the Bureau of Reclamation and the Corps of Engineers, was submitted to the Senate November 21, 1944. On December 22, 1944, the President signed the Flood Control Act of 1944, Public Law 534, 78th Congress, 2d session, which approved the coordinated plan and authorized appropriations to each of the two agencies for construction of the initial stages.

The Flood Control Act of 1946, approved July 24, 1946, authorized additional appropriations to the Department of the Interior for the further development of the comprehensive plan adopted by the Flood Control Act of 1944. This act extended the authorization to all units of the plan in addition to the initial stage authorized in the 1944 act. Further appropriations have provided for the continued development of the program.

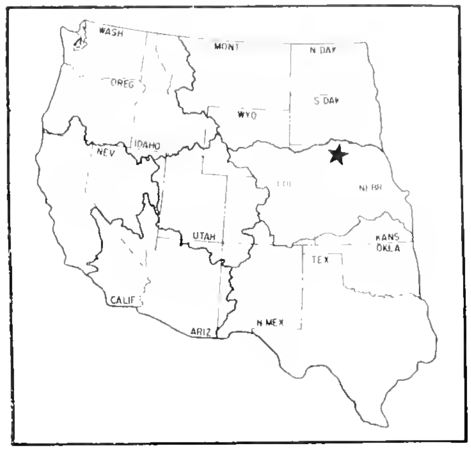
The act of August 14, 1964, Public Law 88-442, requires that any unit of the Pick-Sloan Missouri Basin Program which was not under construction or in operation during August 1964 must be subsequently authorized before construction can be started. Most Bureau of Reclamation projects in the Missouri Basin which were built before 1944 are separate and independent from the Pick-Sloan Missouri Basin Program, although the Congress has integrated a few of them into the program.

Many of the key features of the program have been completed and are in operation. Others are under construction. A large number of the remaining features will require considerable investigation before they can be proposed for authorization. It is necessary to continue investigations of the general plan of development, as well as advance planning on units authorized for construction. This ensures an orderly development of water and related resources for the maximum benefit of the basin's residents and the Nation.

Pick-Sloan Missouri Basin Program
Ainsworth Unit

Nebraska: Brown, Cherry, and Rock Counties

Lower Missouri Region
Water and Power Resources Service



The Ainsworth Unit is located in north-central Nebraska. The storage facilities are on the Snake River approximately 14 miles upstream from its confluence with the Niobrara River, in Cherry County southwest of Valentine. The irrigable lands extend 22 miles from west to east and 14 miles from north to south, beginning near Johnstown and continuing eastward to a point near Long Pine, all in Brown and Rock Counties.

PLAN

The unit provides a full water supply for the irrigation of 33,960 acres of land in the Ainsworth Irrigation District. Project facilities include Merritt Dam and Reservoir, the Ainsworth Canal, a system of laterals, and surface and subsurface drains. Although essentially a single-purpose irrigation development, additional benefits accrue from recreation, fish and wildlife, and water quality control.

The water supply for the unit comes from the Snake River and is stored in Merritt Reservoir for timely release into the Ainsworth Canal, by which it is conveyed to project lands for irrigation. The Snake River originates in the Sandhills region of Nebraska, an area characterized by highly permeable sands and many closed basins. Precipitation falling into these basins seeps into the ground or ponds temporarily, and feeds the streams with a large, steady baseflow. Because of the underground flow, the total drainage area contribution to the Snake River above Merritt Dam is about 600 square miles. Of this, only 83 square miles contribute surface runoff. Average annual runoff was 184,600 acre-feet for the period 1947-62. Average annual irrigation diversion requirement to provide a full supply for the 33,960 irrigable acres is 102,000 acre-feet.

Merritt Dam

Merritt Dam and Reservoir

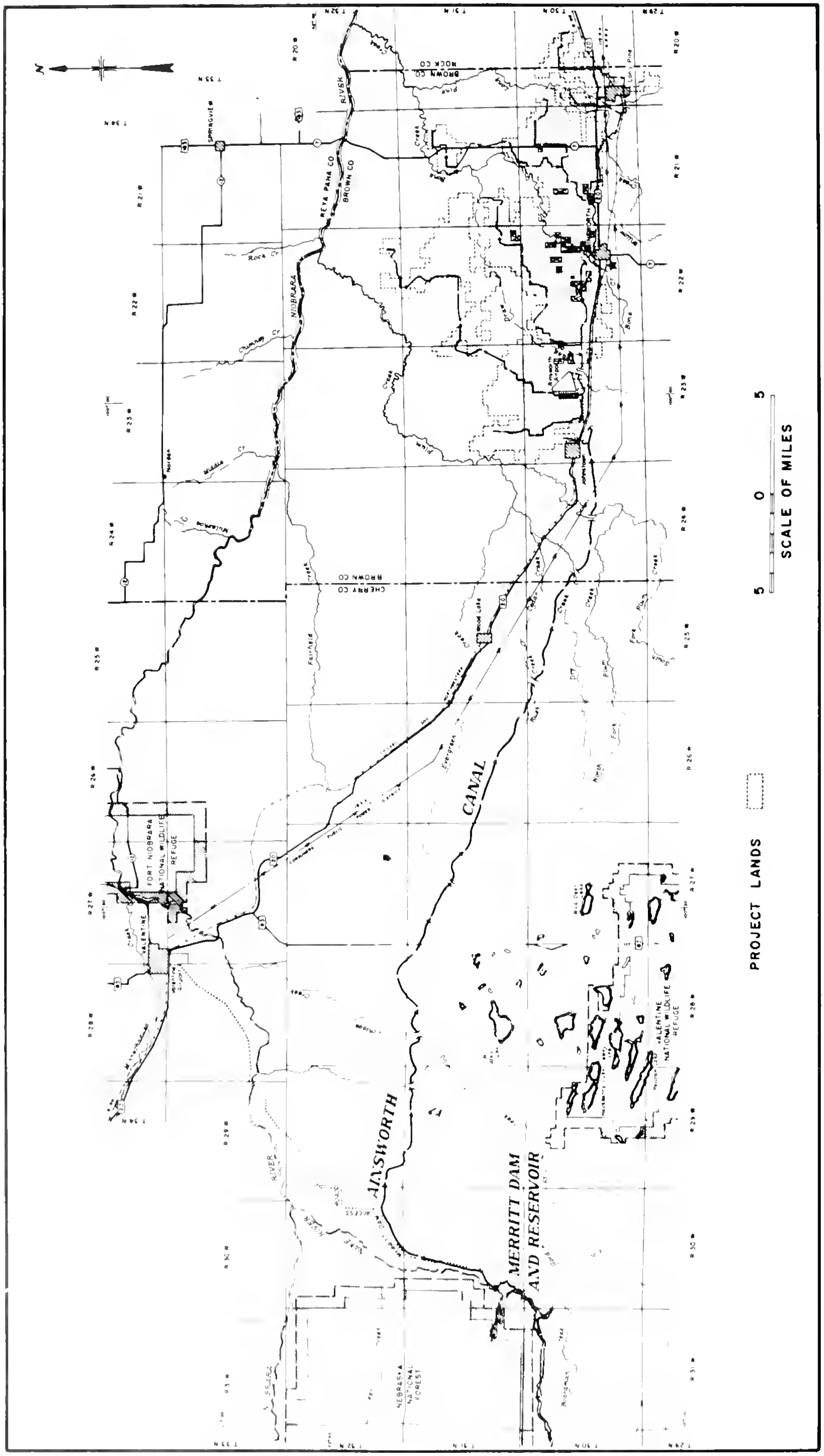
Merritt Dam has a structural height of 126 feet and a crest length of 3,222 feet. The zoned earthfill embankment consists of 1,548,000 cubic yards of material. It is the first Bureau of Reclamation earthfill dam to use soil cement instead of the traditional rock riprap to protect the upstream face.

The morning-glory ungated spillway protects the dam from damage by floods. It consists of a concrete intake structure, concrete conduit, concrete chute and stilling basin, and outlet channel. The spillway has a capacity of 2,080 cubic feet per second at water surface elevation 2949.8 feet.

A branched outlet works in the dam provides for diverting water to the Ainsworth Canal or for controlling releases to the Snake River through the stilling basin.

The canal outlet works consists of a 78-inch-diameter steel pipe, concrete control house for two 4-foot-square high-pressure gates, stilling basin, wave suppressor, gage house, and Parshall flume.

The river outlet works consists of a concrete intake structure, concrete conduit, gate chamber for one 5- by 6-foot high-pressure gate, access shaft and access house, a 54-inch-diameter steel pipe, control house for two 2.75-foot-square high-pressure gates, and a stilling basin.



Ainsworth Unit

Merritt Reservoir has a total capacity of 74,500 acre-feet at elevation 2946.0, an active conservation capacity of 67,686 acre-feet between elevations 2896.0 and 2946.0, and a surface area of 2,906 acres at elevation 2946.0.

Ainsworth Canal and Distribution System

The Ainsworth Canal originates at Merritt Dam outlet works and extends eastward through the Sandhills to the project lands. The canal is concrete lined for its entire length to minimize seepage losses in the sandy soils it traverses, is 52.9 miles long, and has an initial capacity of 580 cubic feet per second.

The lateral system which delivers the water to the project lands has a total length of 169.7 miles and the initial capacities range from 530 to 4 cubic feet per second. Five miles of surface water disposal drains and several disposal ponding areas have been constructed. Other surface water disposal and subsurface drainage facilities will be constructed as necessary.

DEVELOPMENT

Early History

Settlement of the territory was slow until 1860-70, when the Homestead Act of 1862, demobilization of Civil War veterans, establishment of military posts on the frontier, and completion in 1867 of a transcontinental railway running through Nebraska combined to stimulate settlement. By 1890, nearly all of the irrigable lands in the Ainsworth Unit area had been homesteaded.

Early interest in the possibilities of irrigation development in the Ainsworth area is evidenced by the recording of applications for water rights in the 1880's along the Niobrara River and its tributaries. Many of the developments were unsuccessful or did not materialize, mainly because of the inability of the farmers to finance the construction and maintenance.

Investigations

The Bureau of Reclamation began a comprehensive investigation of the land and water resources of the

Ainsworth Canal

Niobrara River Basin in 1946 after local residents attended a public hearing at Valentine, Nebr., to present evidence and discuss possibilities of developments for irrigation, power generation, flood control, and other functions associated with water resource development. At this hearing, the people of the basin appealed to the Federal Government for assistance in investigating the opportunities for future development. A basin report dated June 1953 recommended that four units—Mirage Flats Extension, Lavaca Flats, O'Neill (excluding the proposed Long Pine and Meadville Powerplants), and the Ainsworth Unit—be considered for development. Both engineering and economic reasons prompted the selection of the Ainsworth Unit for early construction.

Authorization

The Ainsworth Unit was authorized as an integral part of the Missouri River Basin Project on August 21, 1954, by Presidential approval of Public Law 612, 83d Congress, 2d session (68 Stat. 757).

Construction

Construction of Merritt Dam and Reservoir began in August 1961, and storage of water was started in February 1964. Construction of the dam was completed in May 1964, and the dam and reservoir were transferred from construction to operation and maintenance status on March 10, 1965.

Construction of the irrigation distribution system began in April 1962, was completed in June 1966, and was transferred to operation and maintenance status on September 1, 1966.

Operating Agencies

Merritt Dam and Reservoir, the Ainsworth Canal, and the laterals and drains are operated and maintained by the Ainsworth Irrigation District. The Nebraska Game and Parks Commission administers the recreation and fish and wildlife aspects of the reservoir.

BENEFITS

Irrigation

The local economy had been almost entirely dependent upon dryland agriculture. After development of the unit, the predominant type of farming became a livestock-general crop pattern in which the major income is derived from livestock and its products. The principal crops being irrigated are feed grains, alfalfa, and small grains.

Recreation and Fish and Wildlife

An all-weather road provides access to Merritt Reservoir as well as picturesque Snake River Falls and to the downstream section of the Snake River.

Improvement of upland game bird habitat has increased the number of game birds in the area and the reservoir water surface attracts great numbers of waterfowl. Several varieties of game fish have been stocked in the reservoir. Opportunities for boating, water skiing, camping, and picnicking are plentiful during the warm summer months at Merritt Reservoir. Picnic and sanitary facilities, parking areas, and boat ramps have been provided to facilitate outdoor recreation.

Bone Lateral

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	31,539	acres
Number of irrigated farms	242	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value,[1] dollars
1968	21,141	2,451,602
1969	22,666	2,585,510
1970	28,175	3,333,430
1971	30,964	4,048,989
1972	28,200	4,467,718
1973	30,200	6,511,561
1974	32,537	9,922,584
1975	33,694	10,277,182
1976	33,934	9,664,380
1977	31,513	6,219,597

[1]Includes additional revenue.

Facilities in Operation

Storage dams	1	
Canals	52.9	mi
Laterals	169.7	mi

Climatic Conditions

Annual precipitation	21	in
Temperature:		
Maximum	112	°F
Minimum	−33	°F
Mean	49	°F
Growing season	157	days
Elevation of irrigable area	2300 to 2600.0	ft

Settlement

Number of persons served with project water (1977):	415

ENGINEERING DATA

Water Supply

SNAKE RIVER

Drainage area above Merritt Dam	600	mi²
Average annual discharge at Merritt Dam	151,658	acre-ft
Maximum (1973)	185,054	acre-ft
Minimum (1970)	96,475	acre-ft
Estimated average annual diversion to project lands	64,488	acre-ft

Storage Facilities

MERRITT DAM

Type: Zoned earthfill
Location: On Snake River 14 mi upstream from the confluence of the Snake and Niobrara Rivers
Construction period: 1961-64
Reservoir, Merritt:

Average annual inflow	166,102	acre-ft
Total capacity to El. 2946	71,186	acre-ft
Active capacity, El. 2896-2946	67,686	acre-ft
Surface area	2,906	acres

Dimensions:

Structural height	126	ft
Hydraulic height	111	ft
Top width	30	ft
Maximum base width	680	ft
Crest length	3,222	ft
Crest elevation	2956.0	ft
Total volume	1,548,000	yd³

Spillway: Uncontrolled morning-glory with concrete conduit, chute, and stilling basin

Crest elevation	2946.0	ft
Capacity at water surface El. 2949.8	2,080	ft³/s

Outlet works: Conduit through base of dam with branches at outlet end to serve the Ainsworth Canal and the river.

River outlet works: A concrete intake structure, concrete conduit, gate chamber for one 5- by 6-ft high-pressure gate, access shaft and access house, a 54-in-diameter steel pipe, control house for two 2.75-ft-square high-pressure gates, and a stilling basin.

Canal outlet works: A 78-in-diameter steel pipe, concrete control house for two 4-ft-square high-pressure gates, stilling basin, wave suppressor, gate house, and Parshall flume.

Capacity at El. 2896	580	ft³/s

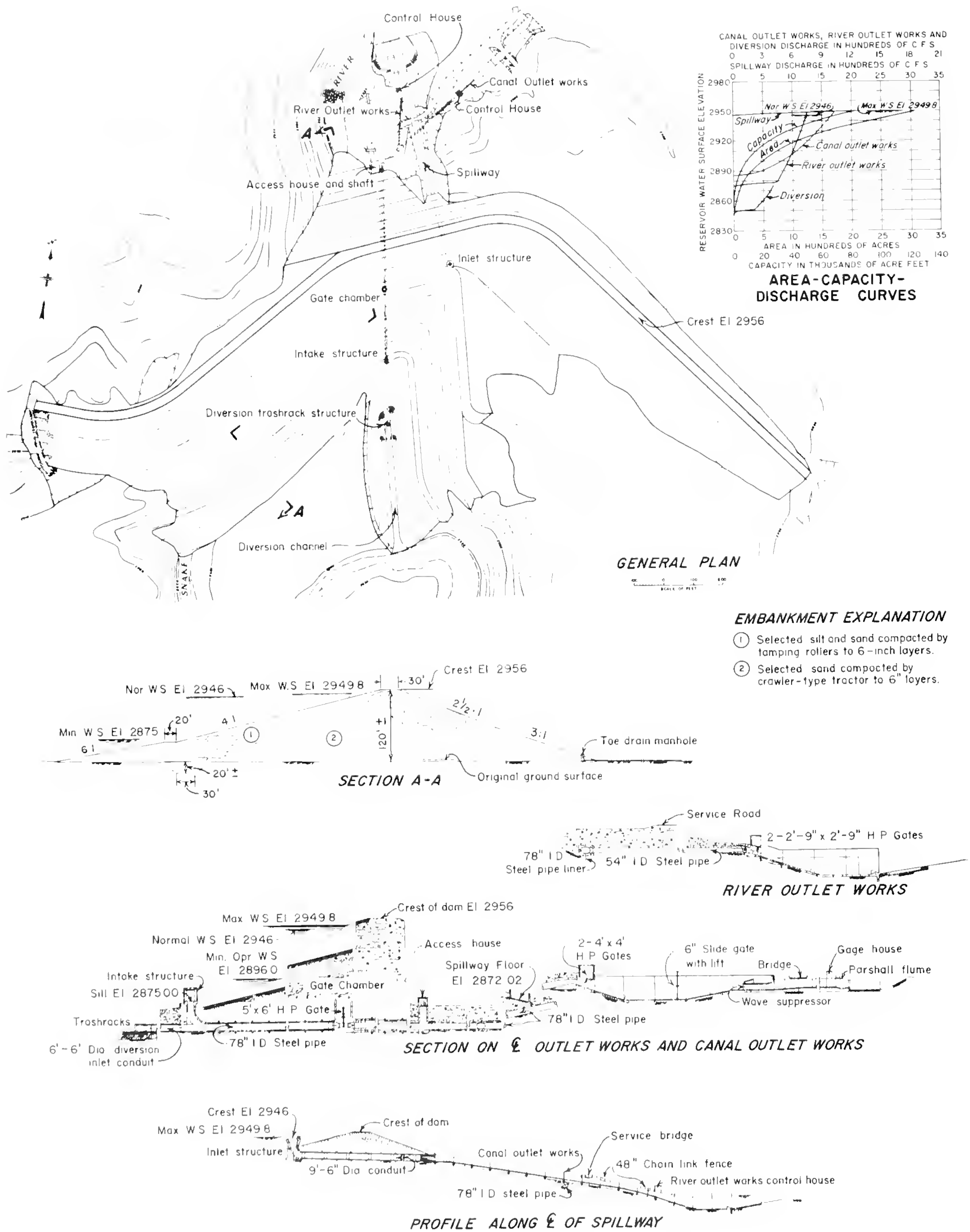
Foundation: The dam is located in a relatively narrow steep-sided valley mantled by alluvial and dune sand deposits which overlie sandy sediments of the Ash Hollow Formation of the Ogallala group. It was necessary to provide a compacted earthfill cutoff trench which penetrated the maximum alluvial and dune sand deposits overlying the dam foundation.

Carriage Facilities

AINSWORTH CANAL

Location: From Merritt Dam outlet works, extends eastward through the Sandhills to the project lands.
Construction period: 1962-66

Length	52.9	mi
Diversion capacity	580	ft³/s
Typical maximum section, concrete lined		
Bottom width	9	ft
Side slopes	2:1	
Water depth	7.22	ft
Lining thickness	3.5	in

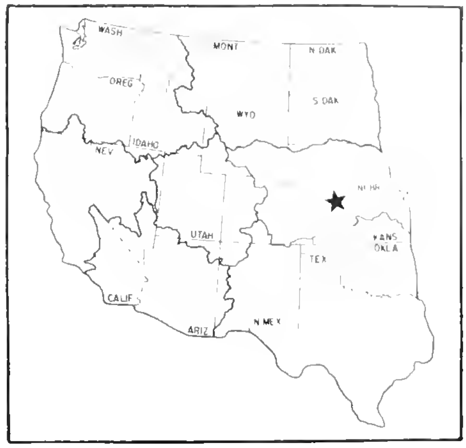


Merritt Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Almena Unit, Kanaska Division

Kansas: Norton and Phillips Counties

Lower Missouri Region
Water and Power Resources Service



The Almena Unit is located along the valley of Prairie Dog Creek in north-central Kansas. The unit consists of Norton Dam and Reservoir, Almena Diversion Dam, Almena Main and South Canals, and a system of laterals and drains to serve 5,350 acres of project lands. In addition to storing water for irrigation, the unit provides water for use in the city of Norton; protects the valley downstream from floods; and offers opportunities for recreation and for conservation and development of fish and wildlife resources.

PLAN

Storage for the Almena Unit is provided by Norton Dam and Reservoir on Prairie Dog Creek. The dam is about 2.5 miles upstream from Norton, Kans. Water is released for the municipal needs of Norton. Releases for irrigation purposes are diverted by the Almena Diversion Dam, about 11 miles downstream from Norton Dam. Water diverted from Prairie Dog Creek by the diversion structure is carried by the Main and South Canals and a system of laterals to the lands of the Almena Irrigation District No. 5. These lands are in Prairie Dog Creek Valley and extend from about 2 miles southwest of Almena to 3 miles east of Long Island.

Norton Dam and Reservoir

Norton Dam is a zoned earthfill structure with rock riprap on its upstream face. Its height above streambed is 101 feet and it has a crest length of 6,450 feet. The volume of the embankment is 3,740,000 cubic yards.

The spillway is located at the right abutment and consists of an approach channel, a concrete inlet structure, a concrete gate structure, concrete chute, concrete stilling basin, and an outlet channel. There are three radial gates in the gate structure. The capacity of the spillway is 94,600 cubic feet per second.

The outlet works is located at the left abutment and consists of a concrete intake structure, concrete conduit, concrete gate chamber, concrete control house, concrete chute and stilling basin, and outlet channel. The intake structure includes a cast iron slide gate used during diversion, the gate chamber which has a high-pressure gate, and the control house which includes a high-pressure gate. The outlet capacity is 330 cubic feet per second. Water is released to the stream and to a 16-inch-diameter steel conduit which serves the city of Norton.

The capacity of Norton Reservoir is 134,740 acre-feet. Of this amount, 2,718 acre-feet are allocated for dead storage, 2,566 acre-feet are inactive capacity, 30,651 acre-feet are allocated for irrigation and municipal supply, and 98,805 acre-feet are for flood control.

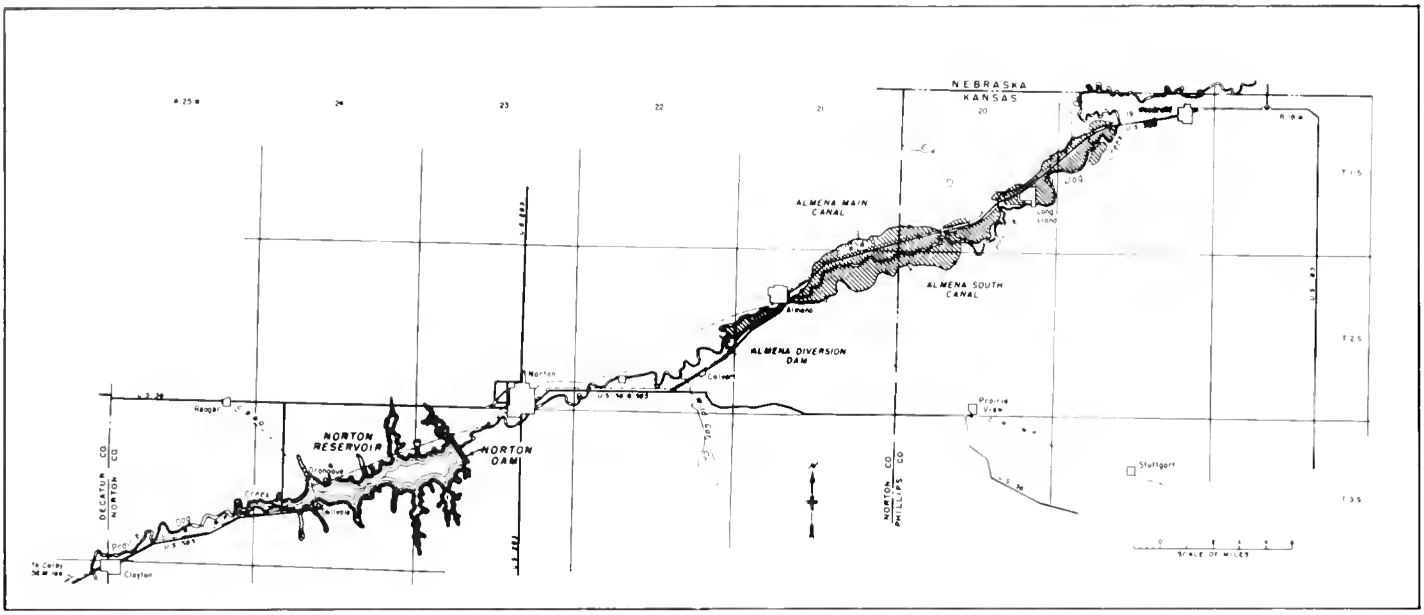
Almena Diversion Dam

Almena Diversion Dam is located 8 miles northeast of Norton and about 11 miles downstream from Norton Dam. The diversion dam consists of a reinforced concrete ogee overflow weir about 150 feet long, 19 feet high above streambed, and includes abutment wing walls, a sluiceway with a 6- by 18-foot radial gate, and constant head orifice-type turnouts to the canals with two 72- by 60-inch orifice gates and two 60- by 48-inch turnout gates. Earth dikes 310 feet long and 31 feet high above streambed were included in the construction of this dam.

Canal and Lateral System

The Almena Main Canal originates at the headwaters of the Almena Diversion Dam on the south side of Prairie Dog Creek. The canal siphons below Almena to serve lands on the north side and terminates just west of Woodruff. The canal has a length of 20 miles, a capacity of 100 cubic feet per second, and serves 3,830 acres of land.

The Almena South Canal originates at the main canal below Almena and serves the south side of the valley. The canal has a length of 8.3 miles, a capacity of 36 cubic feet per second and serves 1,520 acres of land.



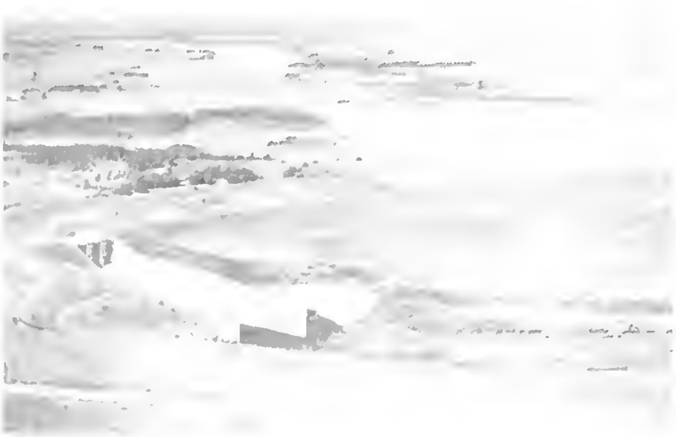
Almena Unit

The lateral system serves 2,450 acres; the remaining 2,900 acres are served by turnouts from the canals. Of the irrigated lands, about 350 acres are served by privately installed canalside pumps. A total of 6.4 miles of collector drains disposes of excess surface runoff and irrigation waste. There are 17 laterals with a total length of 14.3 miles and capacities ranging from 4 to 15 cubic feet per second.

DEVELOPMENT

Early History

A large portion of the land in Norton and Phillips Counties was occupied by settlers in the 1870's. The population increased slowly until the trend was reversed by technological improvement in agricultural practices and later by drought and the depression. In the 1930's, the downtrend in population accelerated so rapidly that the two-county population decreased from 23,860 in 1930 to 18,081 in 1950. This decrease was primarily in the rural areas, as the principal towns gained in population during that period.



Norton Dam

Investigations

The plan for the Almena Unit generally is that presented in Senate Document No. 191. The only significant changes are the inclusion of a municipal water supply for Norton and the provision for controlled storage of floodflows.

Authorization

The unit was approved by the Flood Control Act of 1944 (Public Law 534, 78th Congress, 2d session) as a unit of the Missouri River Basin Project (now Pick-Sloan Missouri Basin Program), published as Senate Document 191, April 1944, and authorized by the Flood Control Act of 1946 (Public Law 526, 79th Congress, 2d session).

Construction

Construction of Norton Dam and Reservoir was started in December 1961 and completed in December 1964. Almena Diversion Dam was begun in August 1965 and completed in February 1967. The canals, laterals, and drains were started in October 1965 and completed in May 1967. Initial storage of water started in October 1964.

Operating Agencies

Norton Dam and Reservoir are operated and maintained by the Bureau of Reclamation. The reservoir operation is integrated with that of other reservoirs in the Kansas River Basin. The Corps of Engineers furnishes the operational procedures for regulation of water stored in the flood control pool.

Almena Diversion Dam and the canals, laterals, and drains are operated and maintained by Almena Irrigation District No. 5.

The Kansas Forestry, Fish and Game Commission administers the reservoir water surface and wildlife lands above the dam, and the recreation areas are administered by the Kansas State Park and Resources Authority. The Kansas Forestry, Fish and Game Commission also assumes responsibility for the administration of the water surface and wildlife lands above Almena Diversion Dam.

BENEFITS

Irrigation

Drought has always been a major menace to the stability of agriculture in this area of Kansas. The fluctuations in the local economy caused by crop failures due to drought have been considerably reduced by the benefits provided by the unit. Principal crops raised on this irrigation unit are corn, milo, alfalfa, wheat, and native pasture.

Municipal Water

The city of Norton receives a full municipal water supply from Norton Reservoir. In 1963, the State of Kansas approved a water right granting the city of Norton a storage limit in Norton Reservoir of 1,600 acre-feet and maximum releases from storage of 1,600 acre-feet per year. A pipeline from the outlet works of Norton Dam to the municipal treatment plant was constructed by the city.

Flood Control

Norton Reservoir protects the valley downstream against flash floods which have damaged or destroyed towns, crops, livestock, bridges, railroads, and other property in the past. To the extent practicable, floodwater is stored in the reservoir for future releases for irrigation and municipal water use.

Recreation and Fish and Wildlife

The water surface of Norton Reservoir and the adjoining project land provides excellent opportunities for outdoor recreation and fish and wildlife activities.

The Kansas State Park and Resources Authority has established a State park on the Prairie Dog Creek arm of the reservoir. There are excellent facilities, including paved roads, boat launching ramps, picnicking, camping, swimming, fishing, day use activities, and modern water and sanitation facilities.

The Kansas Forestry, Fish and Game Commission administers 5,656 acres for fish and wildlife. A Game Management and Public Hunting area has been established. Hunting for quail, pheasant, waterfowl, small game, and big game is available. A small waterfowl refuge has been established. The reservoir provides excellent fishing for a variety of species.

Almena Diversion Dam

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service .... 5,763 acres
Number of irrigated farms 58

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value[1], dollars
1968	5,189	696,957
1969	5,262	753,235
1970	5,233	858,828
1971	5,264	816,755
1972	4,246	931,958
1973	5,118	1,723,329
1974	5,207	2,078,270
1975	5,280	1,837,493
1976	5,274	1,361,468
1977	5,067	1,532,621

[1]Includes additional revenue.

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	28.3	mi
Laterals	14.3	mi
Drains	6.1	mi

Climatic Conditions

Annual precipitation	21	inches
Temperature:		
Maximum	116	°F
Minimum	−27	°F
Mean	53	°F
Growing season	173	days
Elevation of irrigable area	2080-2150.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	106
Municipal water service	3,888
Total	3,994

ENGINEERING DATA

Water Supply

PRAIRIE DOG CREEK

Drainage area above Norton Dam	716	mi²
Annual discharge at Norton:		
Maximum (1951)	106,200	acre-ft
Minimum (1964)	1,500	acre-ft
Average	22,900	acre-ft

Storage Facilities

NORTON DAM

Type: Zoned earthfill
Location: On Prairie Dog Creek about 2.5 mi west of Norton, Kans.
Construction period: 1961-64
Date of closure (first storage): 1964

Reservoir, Norton:		
Total capacity to El. 2331.1	134,740	acre-ft
Active conservation and M&I capacity, El. 2280.1 to 2301.3	30,651	acre-ft
Surface area, El. 2301.3	2,181	acres
Dimensions:		
Structural height	131	ft
Hydraulic height	85	ft
Top width	30	ft
Maximum base width	706	ft
Crest length	6,450	ft
Crest elevation	2347.0	ft
Total volume	3,740,000	yd³

Spillway: Overflow concrete spillway and concrete-lined channel at right abutment controlled by three 30- by 36.35-ft radial gates.

Crest length	106	ft
Crest elevation	2296.0	ft
Capacity at El. 2341	94,600	ft³/s

Outlet works: Gated conduit through base of dam at left abutment provides for releases to river. Outlet conduit tapped upstream from gate chamber for municipal water outlet pipe.

Capacity at El. 2301.3	260	ft³/s
Maximum capacity at El. 2341	330	ft³/s

Foundation: The valley floor in the area of Norton Dam consists of thick deposits of silt, clay, and sand with a few sand lenses. The bedrock floor consists of the Ogallala Formation overlying the Niobrara Formation.

Special treatment: A main cutoff trench across the valley and a secondary cutoff trench around the upstream portion of the left abutment were included in the design for the dam.

Diversion Facilities

ALMENA DIVERSION DAM

Type: Concrete ogee weir, embankment wings.
Location: On Prairie Dog Creek about 8 mi east of Norton, Kans.
Year completed: 1967

Dimensions:		
Height of dikes above streambed	31	ft
Height of weir above streambed	19	ft
Length of dikes	310	ft
Length of weir	150	ft
Diversion capacity	100	ft³/s

Carriage Facilities

ALMENA MAIN CANAL

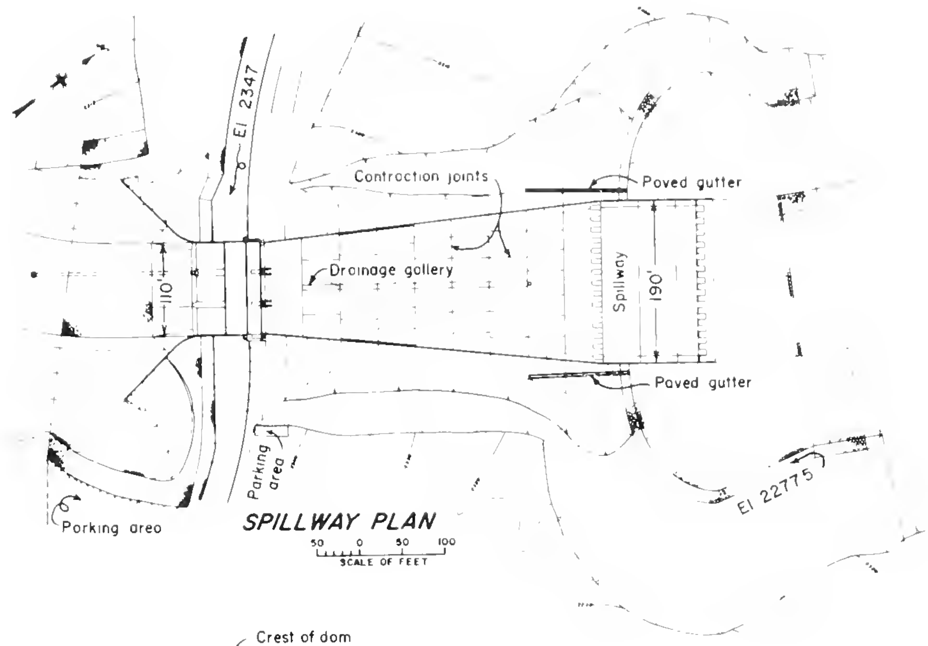
Location: Heads at Almena Diversion Dam and runs easterly along the north side of Prairie Dog Creek.
Construction period: 1965-67

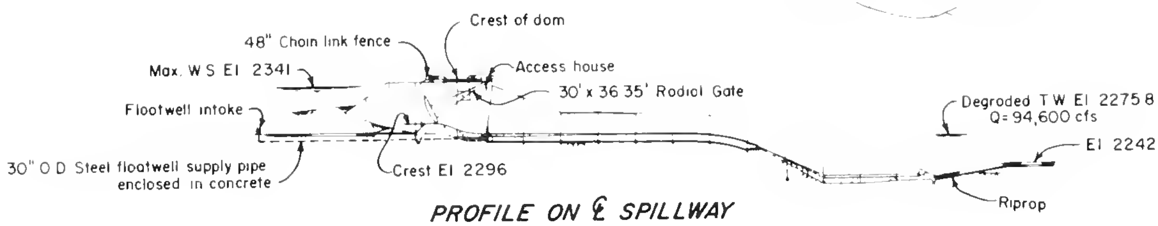
Length	20	mi
Diversion capacity	100	ft³/s
Typical maximum section, earth lined:		
Bottom width	11	ft
Side slopes	1.5:1	
Water depth	3.6	ft

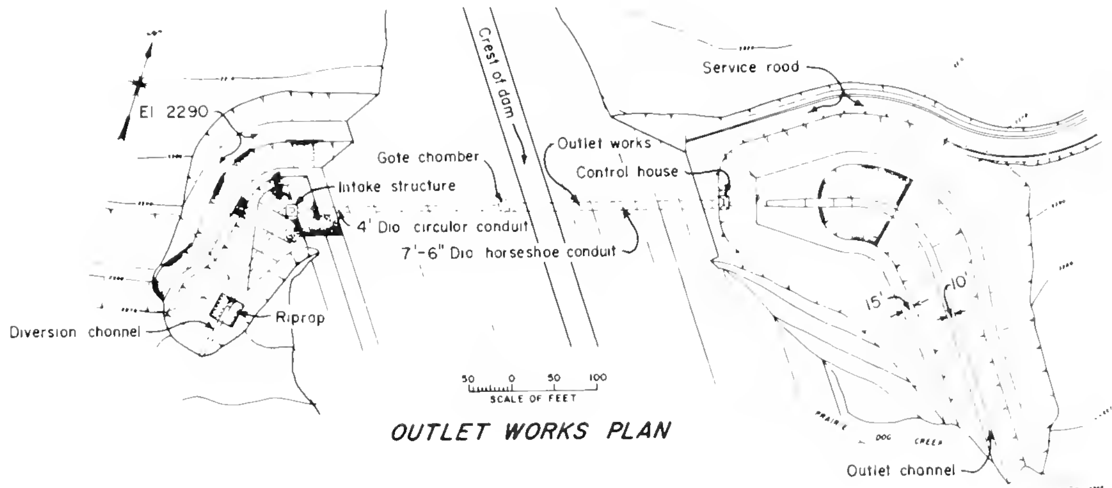
ALMENA SOUTH CANAL

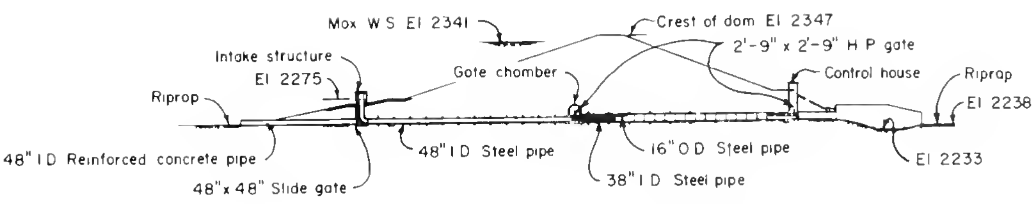
Location: Heads at Almena Diversion Dam and runs easterly along the south side of Prairie Dog Creek.
Construction period: 1965-67

Length	8.3	mi
Diversion capacity	36	ft³/s
Typical maximum section, earth lined:		
Bottom width	7	ft
Side slopes	1.5:1	
Water depth	2.6	ft

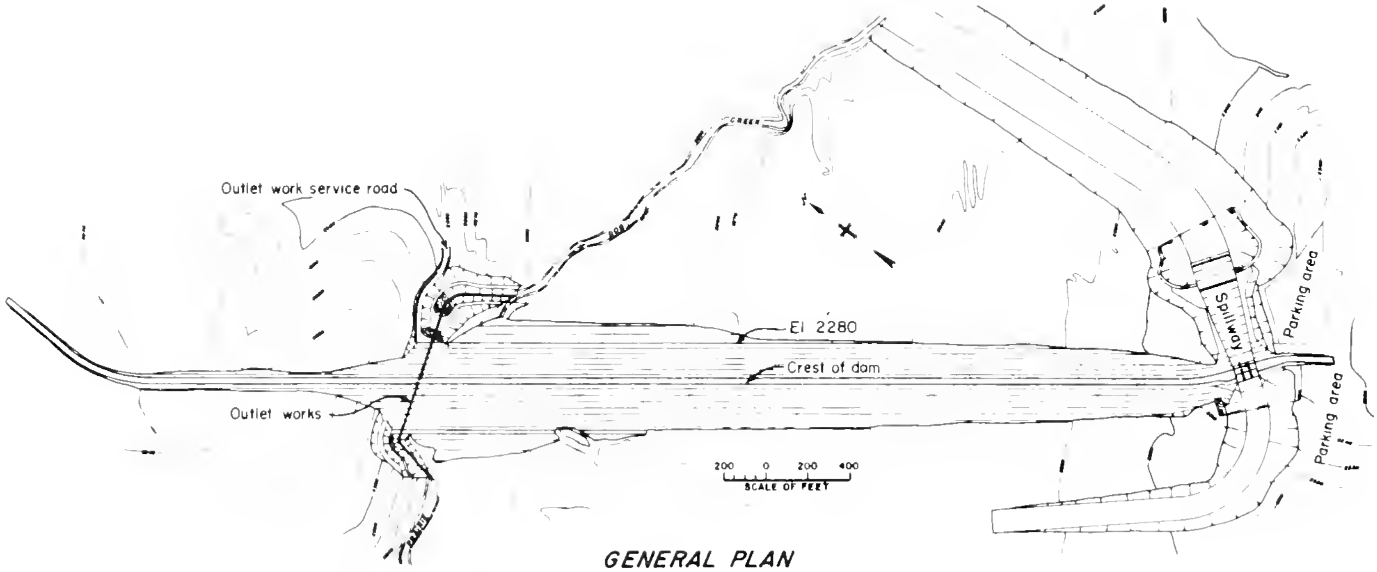




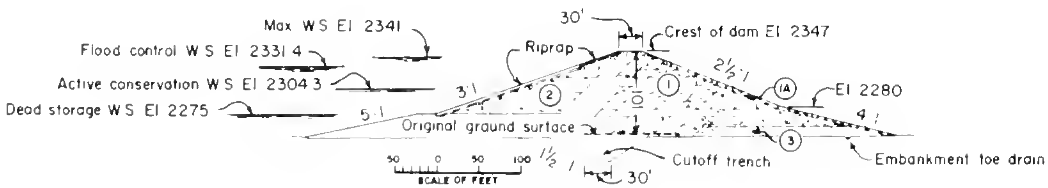




Norton Dam, Spillway and Outlet Works



GENERAL PLAN



MAXIMUM SECTION

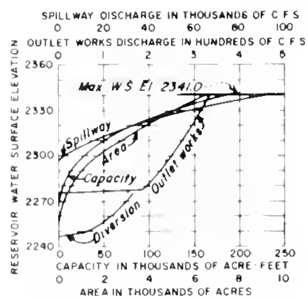
EMBANKMENT EXPLANATION

(1) Selected clay, silt and sand compacted by tamping rollers to 6-inch layers

(1A) Selected topsoil compacted by tamping rollers to 6-inch layers.

(2) Sand, or sand, silt, and clay compacted by crawler type tractor to 6-inch layers

(3) Selected sand compacted to 12-inch layers to 75 % relative density



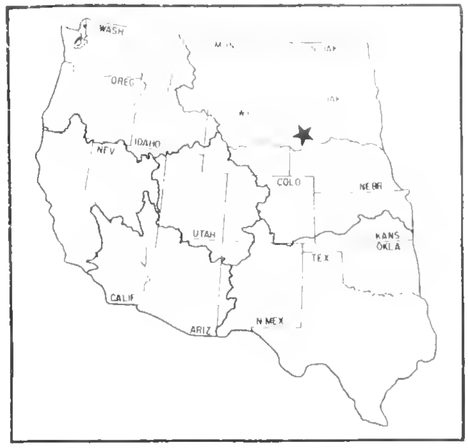
AREA-CAPACITY-DISCHARGE CURVES

Norton Dam, Plan and Section

Pick-Sloan Missouri Basin Program
Angostura Unit

South Dakota: Custer and Fall River Counties

Upper Missouri Region
Water and Power Resources Service



The Angostura Unit is in the Great Plains region at the southeast edge of the Black Hills in southwestern South Dakota. Angostura Dam and Reservoir, located on the Cheyenne River about 9 miles southeast of Hot Springs, S. Dak., provides multipurpose benefits, including irrigation, flood control, fish and wildlife conservation, recreation, and sediment control. The unit lies within Custer and Fall River Counties of South Dakota.

PLAN

The primary function of the Angostura Unit is to impound and deliver a full supply of irrigation water for production of forage and grain crops. The unit lands, consisting of 12,218 acres extending along the Cheyenne River approximately 24 miles downstream from the dam, are served by the Angostura Canal. The canal has a design capacity of 290 cubic feet per second. With a 30.9-mile-long alignment along the southerly edge of the unit lands, the canal crosses the Cheyenne River through a 9,800-foot-long inverted siphon to the north side of the river. Unit lands are served by 39 miles of laterals and 34 miles of open and closed drains.

Angostura Dam and Reservoir

The prime features of the unit are Angostura Dam across the Cheyenne River, and Angostura Reservoir.

The dam is a composite type, consisting of a concrete gravity structure and earth embankment. The concrete portion of the dam comprises of a gated spillway section located in the river channel and two nonoverflow sections, one extending to the left abutment and one abutting the earth embankment extending to the right abutment. The dam has a crest length of 2,030 feet; the concrete section is 970 feet long and the earth embankment 1,060 feet long, with a structural height of 193 feet and a hydraulic height of 136 feet above the riverbed.

The spillway is an overflow section in the concrete portion of the dam, controlled by five 50- by 30-foot radial gates. Discharge capacity is 247,000 cubic feet per second. The river outlet works consists of a 4.5-foot-diameter steel conduit through the concrete dam section, controlled by one 4-foot-square high-pressure slide gate in the valvehouse at the downstream end. Discharge capacity is 590 cubic feet per second. The main canal outlet works for irrigation water delivery consists of a 6-foot-diameter steel conduit through the concrete dam, terminating in a valvehouse, stilling basin, and canal headworks at the downstream end. Releases into the 290-cubic-foot-per-second-capacity canal are controlled by two 3.5-foot-square high-pressure slide gates in the valvehouse.

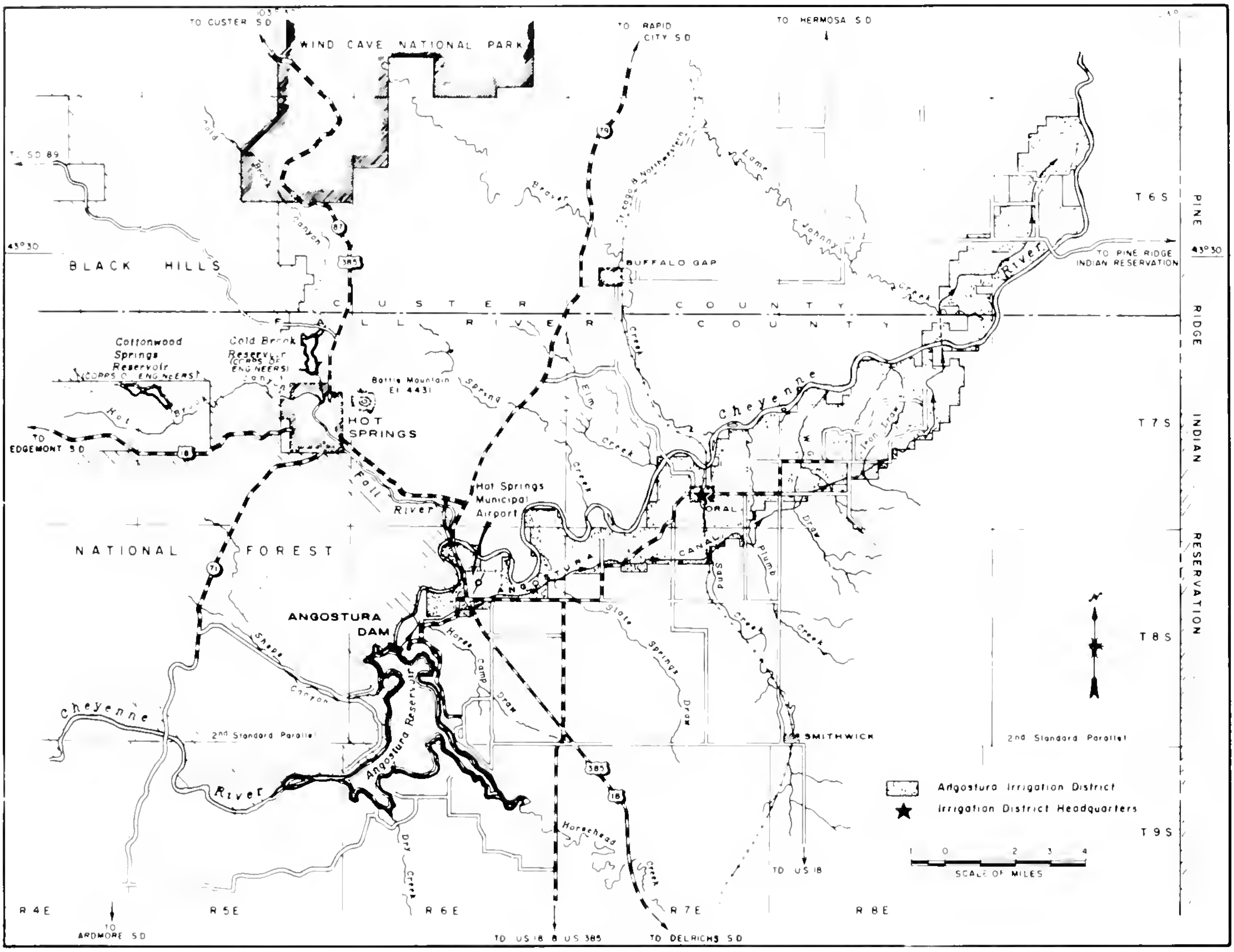
DEVELOPMENT

Early History

Dry farming by settlers in the Angostura Unit area began about 1880. The gold rush to the Black Hills in 1876, followed by several years of adequate precipitation and accompanying good crop production, stimulated development in the area. Severe drought conditions and heavy infestations of grasshoppers in the late 1880's contributed to mortgage foreclosures, resulting in fewer landowners with larger landholdings.

Investigations

Irrigation potential along the Cheyenne River in South Dakota prompted a field reconnaissance of the Angostura Unit by South Dakota in 1913. On the basis of the reconnaissance report and local organizational support, the State legislature appropriated funds for one-half the cost of a survey by the Reclamation Service made in 1917-18. A Bureau of Reclamation report in 1939 cited 16,200 acres of land suitable for irrigation development. Continuing local interest for development of the unit area for resettlement and rehabilitation of distressed farmers prompted authorization of the Angostura Unit under the Water Conservation and Utilization Act of August 11, 1939.



Angostura Unit

Authorization

The Angostura Unit was included in Senate Document 191, 78th Congress, 2nd session, and was reauthorized by the Flood Control Act of 1944, Public Law 534.

Construction

Construction of Angostura Dam began on August 23, 1946, and was completed on December 7, 1949. The first delivery of irrigation water was made in 1953.

Operating Agency

Angostura Unit, including Angostura Dam and Reservoir and the associated project irrigation facilities, has been operated and maintained by the Angostura Irrigation District, since January 1, 1968.

BENEFITS

Irrigation

A full supply of irrigation water is provided to the 12,218 acres of irrigable land. Alfalfa and corn are the principal crops, along with wheat, barley, oats, pasture, and forage.

Flood Control

There is no exclusive flood capacity in Angostura Reservoir; however, flood control benefits are provided by the use of conservation capacity, as available, and the surcharge capacity above the top of the radial spillway gates.

Recreation

Activities associated with outdoor recreation provided at Angostura Reservoir include picnic grounds, campgrounds, boat ramp developments, marinas, swimming beaches, and areas for lease for seasonal use cabins. All recreation areas and facilities, including fishery in the reservoir, are administered by the South Dakota Department of Wildlife, Parks and Forestry. There were 230,500 visitor days at Angostura Reservoir area in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	12,218	acres
Number of irrigated farms	66	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	9,961	739,422
1969	9,765	855,526
1970	10,116	1,017,611
1971	9,900	956,117
1972	9,415	1,053,550
1973	10,155	1,776,070
1974	11,010	2,158,889
1975	11,186	1,938,217
1976	11,194	2,254,252
1977	11,353	1,969,860

Facilities in Operation

Storage dams	1	
Canals	29.8	mi
Laterals	39	mi
Drains	21	mi

Climatic Conditions

Annual precipitation	17.5	in
Temperature:		
Maximum	112	°F
Minimum	−41	°F
Mean	48	°F
Growing season	132	days
Elevation of irrigable area	3100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	166

ENGINEERING DATA

Water Supply

CHEYENNE RIVER

Drainage area above Angostura Dam	9,100	mi²
Annual discharge below Angostura Dam:		
Maximum (1962)	292,800	acre-ft
Minimum (1961)	600	acre-ft
Average	53,700	acre-ft
Annual diversion to Angostura Canal	41,096	acre-ft
Maximum annual diversion (1958)	58,960	acre-ft
Minimum annual diversion (1961)	12,189	acre-ft
Average	41,096	acre-ft

Storage Facilities

ANGOSTURA DAM

Type: Concrete gravity, embankment wing
Location: On the Cheyenne River 9 mi southeast of Hot Springs, S. Dak.
Construction period: 1946-49
Date of closure (first storage): October 3, 1949

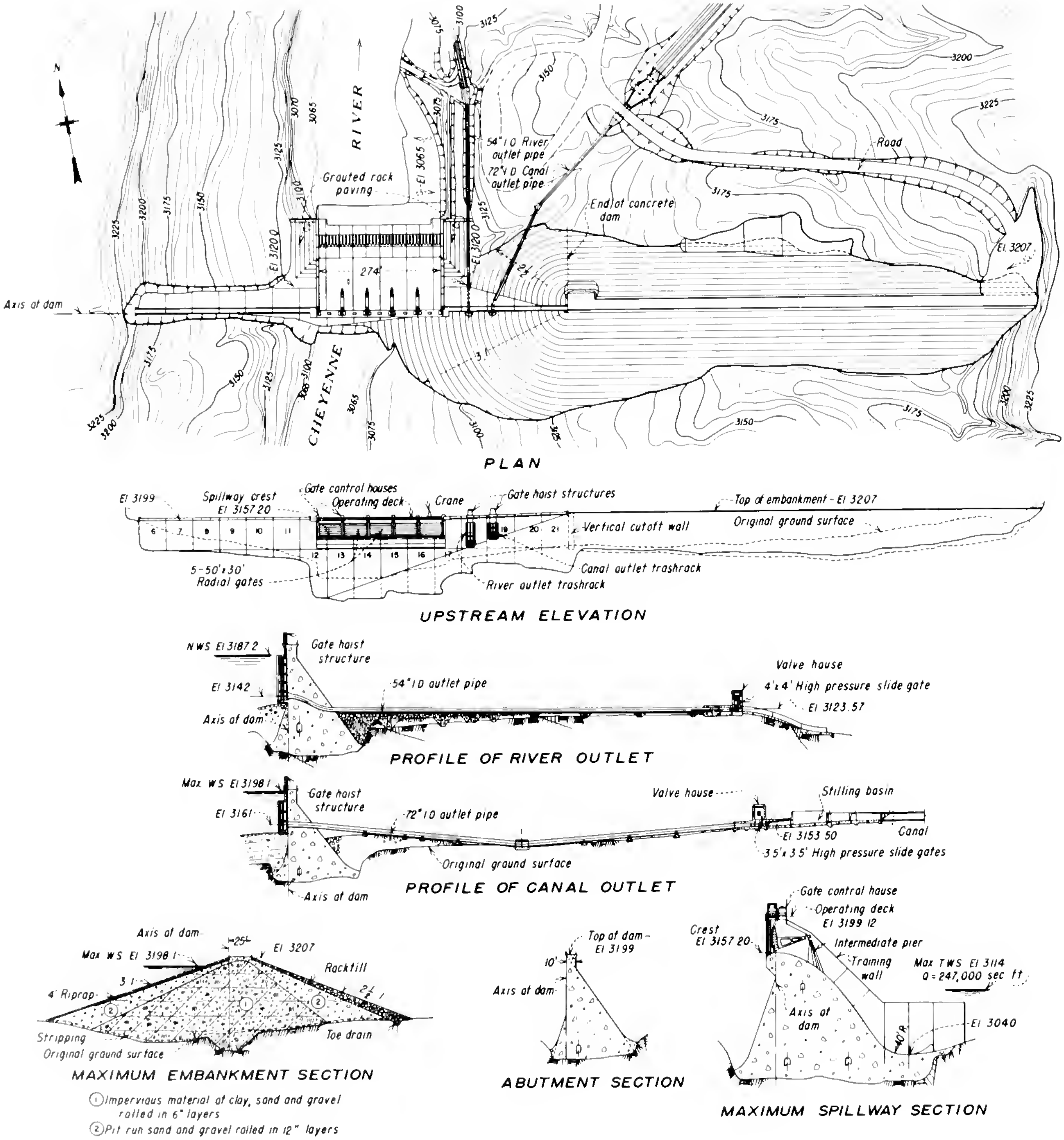
Reservoir, Angostura:		
Total capacity to El. 3187.2	138,761	acre-ft
Active capacity, El. 3163-3187.2	86,160	acre-ft
Surface area	4,706	acres
Dimensions:		
Structural height	193	ft
Hydraulic height	136	ft
Top width	10	ft
Maximum base width	230	ft
Crest length	2,030	ft
Crest elevation:		
Concrete section	3199.0	ft
Earth embankment section	3207.0	ft
Volume	850,000	yd³
Spillway: Overflow section in concrete portion of dam, controlled by five 50- by 30-ft radial gates.		
Elevation top of gates	3187.2	ft
Crest elevation	3157.2	ft
Capacity at elevation 3198.1	247,000	ft³/s
Outlet works:		
River: 4.5-ft-diameter steel conduit through concrete dam section near right abutment, controlled by one 4-ft-square high-pressure slide gate in valvehouse at downstream end.		
Capacity at El. 3198.1	590	ft³/s
Canal: 6-ft-diameter steel conduit through concrete dam section near right abutment, terminating in valvehouse and canal headworks at downstream end. Releases are controlled by two 3.5-ft-square high-pressure slide gates in valvehouse.		
Capacity at El. 3187.2	720	ft³/s
Foundation: Sandstone beds up to 65 ft thick separated by mudstone and limestone seams. Overburden ranges from 0 to 70 ft thick.		
Special treatment: Blanket grouting and grout curtain under upstream toe of dam.		
Mass concrete: Crushed aggregate from quarry 7 mi southwest of dam site; Type II (low-alkali) cement; temperature control through embedded pipe system.		
Volume	238,640	yd³
Maximum size aggregate	7	in
Contraction joints: Transverse joints spaced 60 ft apart, pressure grouted through embedded pipe system.		

Carriage Facilities

ANGOSTURA MAIN CANAL

Location: From Angostura Dam generally northeast.
Construction period: 1951-53

Length	29.8	mi
Diversion capacity	290	ft³/s
Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	2:1	
Water depth	5.2	ft
Typical maximum section, asphalt membrane lined:		
Bottom width	14	ft
Side slopes	2:1	
Water depth	5.51	ft
Lining thickness	0.25	in



Angostura Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Armel Unit, Upper Republican Division

Colorado: Yuma County

Lower Missouri Region
Water and Power Resources Service

The Armel Unit, formerly called the St. Francis Unit, is in eastern Colorado on the South Fork of the Republican River. The principal feature of the unit is Bonny Dam and Reservoir which serves as an important flood control feature and provides benefits for recreation and fish and wildlife conservation and enhancement. Originally, irrigation was to have been a part of the multiple-purpose benefits included in the unit plan; however, investigations have shown that an economically feasible plan for Federal development could not be formulated within the 24,000-acre upland area considered.

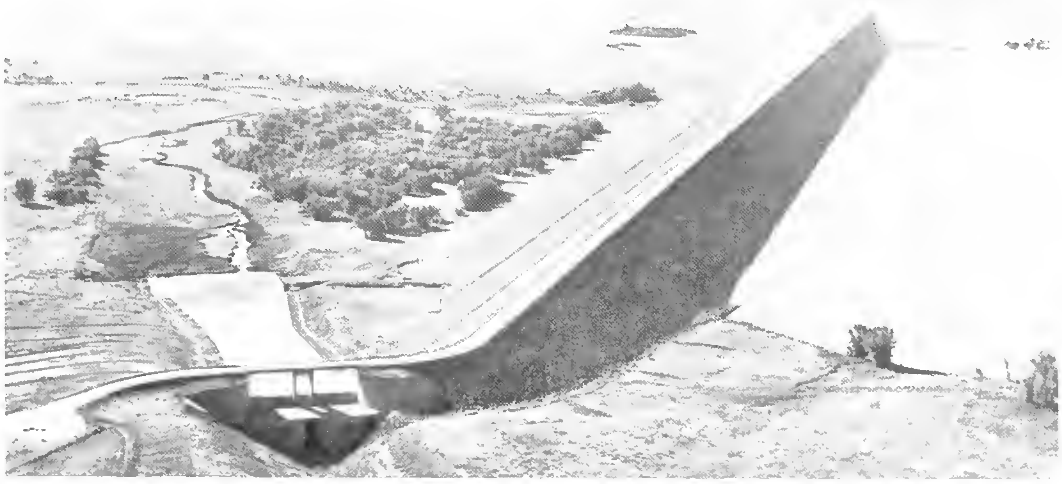
PLAN

The primary purpose of Bonny Dam is the protection of the lower South Fork of the Republican River Valley from recurring floods originating upstream from Hale, Colo. The estimated frequency and magnitude of floods occurring upstream from Bonny Dam which can be wholly or partially controlled make this dam and reservoir one of the most important flood-control features in the Republican River Basin upstream of the Corps of Engineers' Harlan County Dam. The unit also provides regulation of the existing water supply to Hale Ditch, which serves 750 acres, 400 of which are owned by the State of Colorado. The State operates a fish hatchery and wildlife habitat area on these lands. The reservoir and surrounding lands provide excellent recreation opportunities and fish and wildlife conservation.

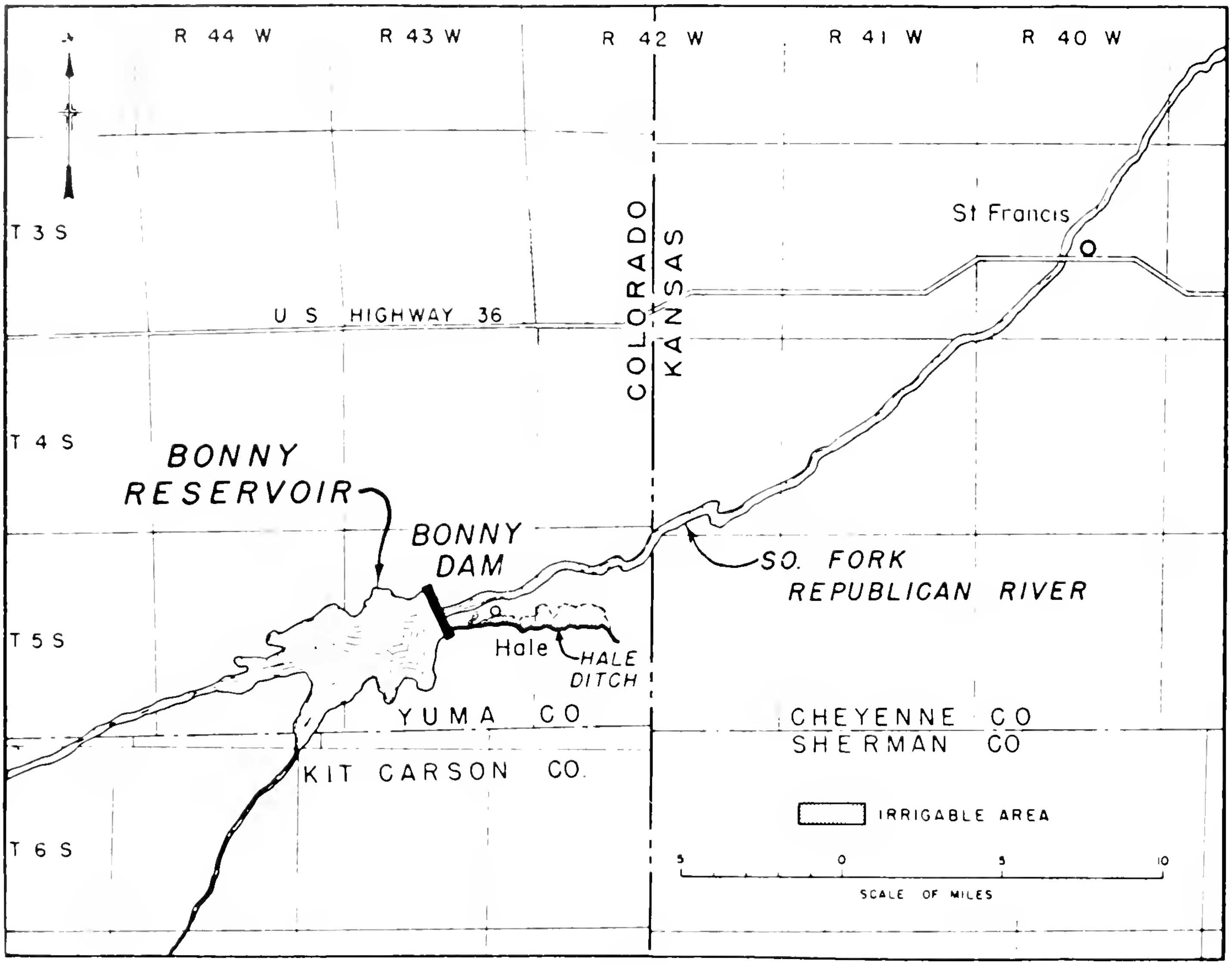
Bonny Dam

Bonny Dam is a modified homogeneous earthfill structure rising 158 feet above foundation. It contains 8,853,000 cubic yards of embankment material.

The spillway is an uncontrolled concrete-lined chute in the left abutment with sluiceway at center and below spillway crest partially controlled by a 16.5- by 10.75-foot fixed-wheel gate. The maximum capacity of the spillway is 73,300 cubic feet per second. The sluiceway was designed to discharge 10,000 cubic feet per second from the reservoir at elevation 3710.0.



Bonny Dam



Armel Unit

The outlet works extending through the dam near the left abutment is a 56-inch-diameter steel pipe designed to provide releases into the stream for downstream purposes. A 40-inch-diameter branch pipe was installed for future use. A 32-inch-diameter branch, constructed across the downstream face of the dam, serves the 750 acres of nonproject land south of the river. The Hale Ditch outlet pipe, which is an integral part of the Bonny Dam outlet works, has been modified to permit regulatory releases during the winter months. This enhances fish spawning in the spring and affords excellent hunting conditions in the fall.

The Bonny Reservoir has 170,160 acre-feet of total capacity below the crest of the spillway at elevation 3710.0.

DEVELOPMENT

In the early 1880's, settlers moved into this region and established claims under the Homestead, Timber Claim, and Preemption Acts. Prior to this time, only a few scattered ranches were located in the area, although cattle were often trailed through from Texas to the Platte River, where they were shipped east by rail.

Recurring droughts throughout the Great Plains and in the Republican River watershed in particular, have stimulated considerable interest in irrigation possibilities in this area during the past 80 years or more. Several attempts were made to irrigate directly from the stream, and a number of canals were built as early as 1889. Most of the projects failed because of destructive floods, sandy soil, lack of water supply, or financial difficulties.

Investigations

Investigations of the Armel Unit on the South Fork of the Republican River were initiated in 1939. These investigations resulted in Bonny Dam and Reservoir being included in Senate Document No. 191. The plan called for construction of the multiple-purpose dam and reservoir as the major feature of the unit.

Subsequent to initiation of investigations for irrigation, Public Law 88-442, August 14, 1964, was enacted which required reauthorization of the irrigation portion of the unit. Accordingly, in December 1969 investigations of the irrigation phase were initiated. The results of these investigations disclosed that an economically feasible plan for Federal development could not be formulated within the 24,000-acre upland area previously investigated. Reclamation is currently working with the State of Colorado to evaluate alternative uses for the developed water supply.

Authorization

The unit was authorized by the Flood Control Acts of December 22, 1944, and July 24, 1946.

Construction

Construction of Bonny Dam began December 8, 1948, and was completed May 4, 1951.

Operating Agencies

Bonny Dam and Reservoir are operated and maintained by the Bureau of Reclamation. The reservoir water surface and reservoir lands upstream from the dam are administered by the Division of Parks and Outdoor Recreation of the Colorado Department of Natural Resources.

BENEFITS

Flood Control

Bonny Dam provides a high degree of flood control in the upper reaches of the Republican River and, together with other dams and reservoirs downstream, furnishes effective control of floods in the Republican River Basin.

Recreation and Fish and Wildlife

The reservoir and surrounding lands, set aside for that purpose, serve as a center for outdoor, water-oriented recreational activities for the immediate locale as well as more distant areas. Recreational use includes picnicking, camping, swimming, water skiing, boating, fishing, and hunting. The reservoir is stocked with fish, and the State of Colorado operates a fish hatchery and manages the surrounding lands for conservation and enhancement of wildlife resources.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service[1]	750	acres

[1]Nonproject lands along Hale Ditch; 400 acres owned by State of Colorado.

Facilities in Operation

Storage dams	1

Climatic Conditions

	Bonny Dam, Colo.	St. Francis, Kans.
Annual precipitation	16 in	18 in
Temperature:		
Maximum	109 °F	111 °F
Minimum	−24 °F	−28 °F
Growing season	157 days	161 days

ENGINEERING DATA

Water Supply

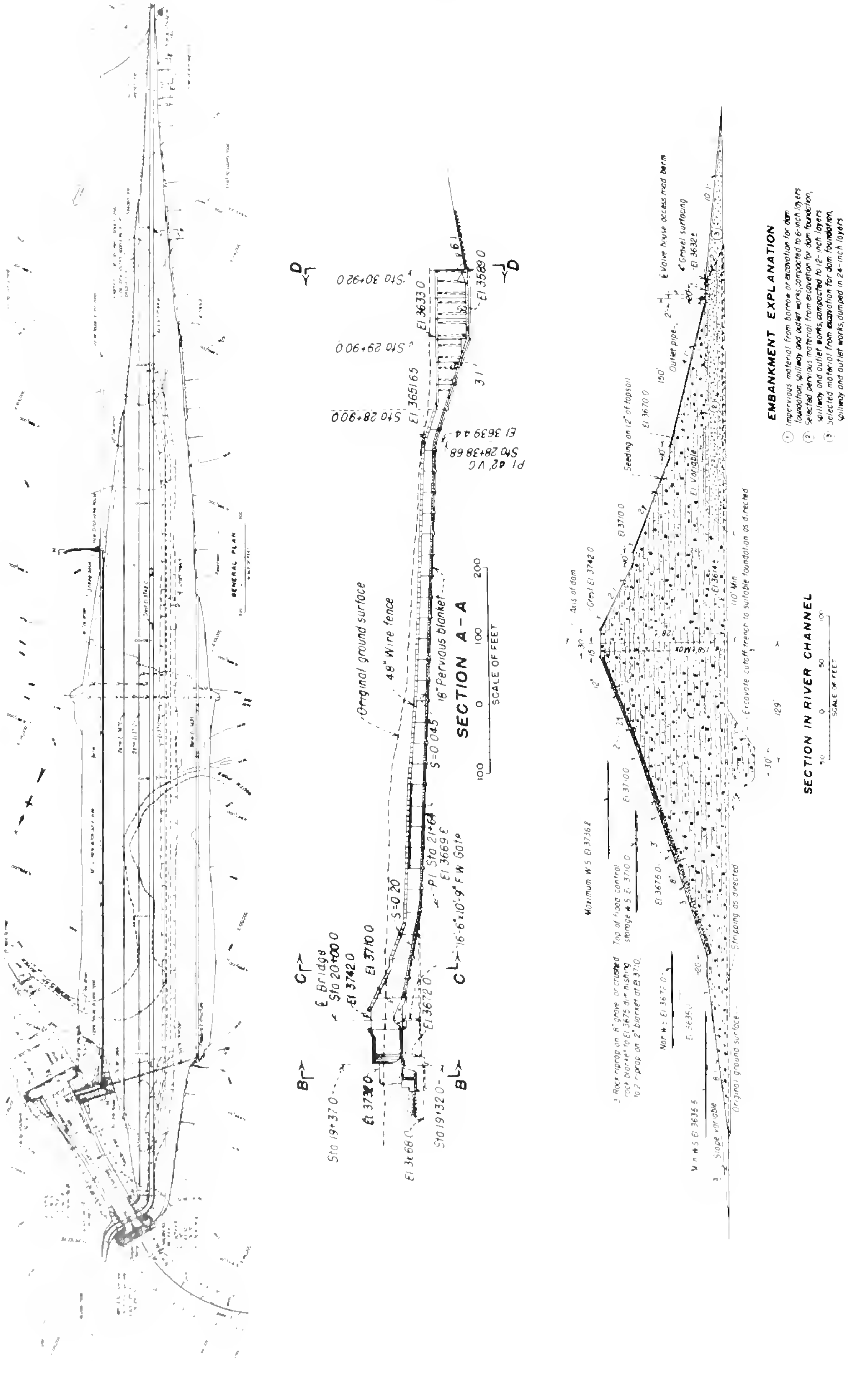
SOUTH FORK, REPUBLICAN RIVER

Drainage area above Bonny Dam	1,495	mi²
Annual discharge at Bonny Dam:		
Maximum (1935)	152,600	acre-ft
Minimum (1976)	15,284	acre-ft
Average	29,850	acre-ft

Storage Facilities

BONNY DAM

Type: Modified homogeneous rolled earthfill		
Location: On the South Fork of the Republican River near Hale, Colo.		
Construction period: 1948-51		
Date of closure (first storage): July 6, 1950		
Reservoir, Bonny:		
Average annual inflow	29,850	acre-ft
Total capacity to El. 3710	170,160	acre-ft
Active capacity, El. 3638-3710	168,026	acre-ft
Surface area at El. 3710	5,036	acres
Dimensions:		
Structural height	158	ft
Hydraulic height	96	ft
Top width	30	ft
Maximum base width	980	ft
Crest length	9,200	ft
Crest elevation	3742.0	ft
Total volume	8,853,000	yd³
Spillway: Uncontrolled, concrete-lined chute in left abutment with sluiceway at center and below spillway crest partially controlled by one 16.5- by 10.75-ft fixed-wheel gate.		
Crest length	121.5	ft
Crest elevation	3710.0	ft
Capacity at El. 3736.2	73,300	ft³/s
Outlet works: 56-in-diameter steel pipe in concrete conduit through base of dam.		
Canal outlets: 32-in-diameter branch from outlet conduit controlled by one 24-in hollow-jet valve for Hale Ditch; 40-in pipe branch provides for originally planned future deliveries to irrigation canal (Armel Canal).		
Capacity, Hale Ditch outlet	10	ft³/s
River outlets: 26-in-diameter branch from outlet pipe controlled by one 24-in hollow-jet valve discharging into stilling basin.		
Capacity, river outlets	150	ft³/s

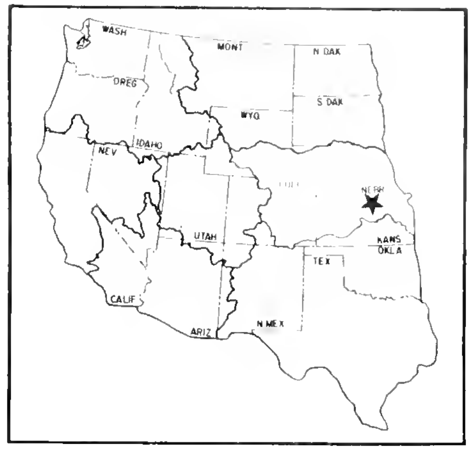


Bonny Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Bostwick Division

Kansas: Jewell, Republic, and Cloud Counties
Nebraska: Harlan, Franklin, Webster, and Nuckolls Counties

Lower Missouri Region
Water and Power Resources Service



The Bostwick Division is in south-central Nebraska and north-central Kansas. It extends from Orleans, Nebr., above Harlan County Lake, to Concordia, Kans., and includes land on both sides of the Republican River. The greater part of the project works has been completed. The Scandia Unit has not been constructed. Features of the Bostwick Division include Harlan County Dam and Lake on the Republican River (constructed by the Corps of Engineers), Lovewell Dam and Reservoir on White Rock Creek, one existing and one proposed diversion dam, six pumping plants, and the canals, laterals, and drains necessary to serve 80,887 irrigable acres (62,887 with available service and an additional 18,000 proposed) in seven counties. The reservoir, lake, and surrounding lands of the division provide benefits for flood control, irrigation, sediment control, fish and wildlife enhancement, and recreation.

PLAN

Water for the Bostwick Division is stored in the Harlan County Lake and the Lovewell Reservoir. The division is divided into two general areas: the Bostwick in Nebraska, and the Kansas-Bostwick.

The Nebraska area contains 22,787 acres divided into two units: Franklin, 14,944 acres; and Superior-Courtland, 7,843 acres. Completed facilities served approximately 21,000 acres of these two units during the 1977 irrigation season.

The Franklin Unit is served by the Franklin and Naponee Canals, which diverts directly from the Harlan County Lake, and by the Franklin South Side Pump Canal, which receives water directly from the river through a pumping plant 17 miles downstream from the dam.

The Superior-Courtland Unit is served by the Superior and Courtland Canals, originating at the Superior-Courtland Diversion Dam on the Republican River. The Courtland Canal also serves the Courtland Unit in Kansas.

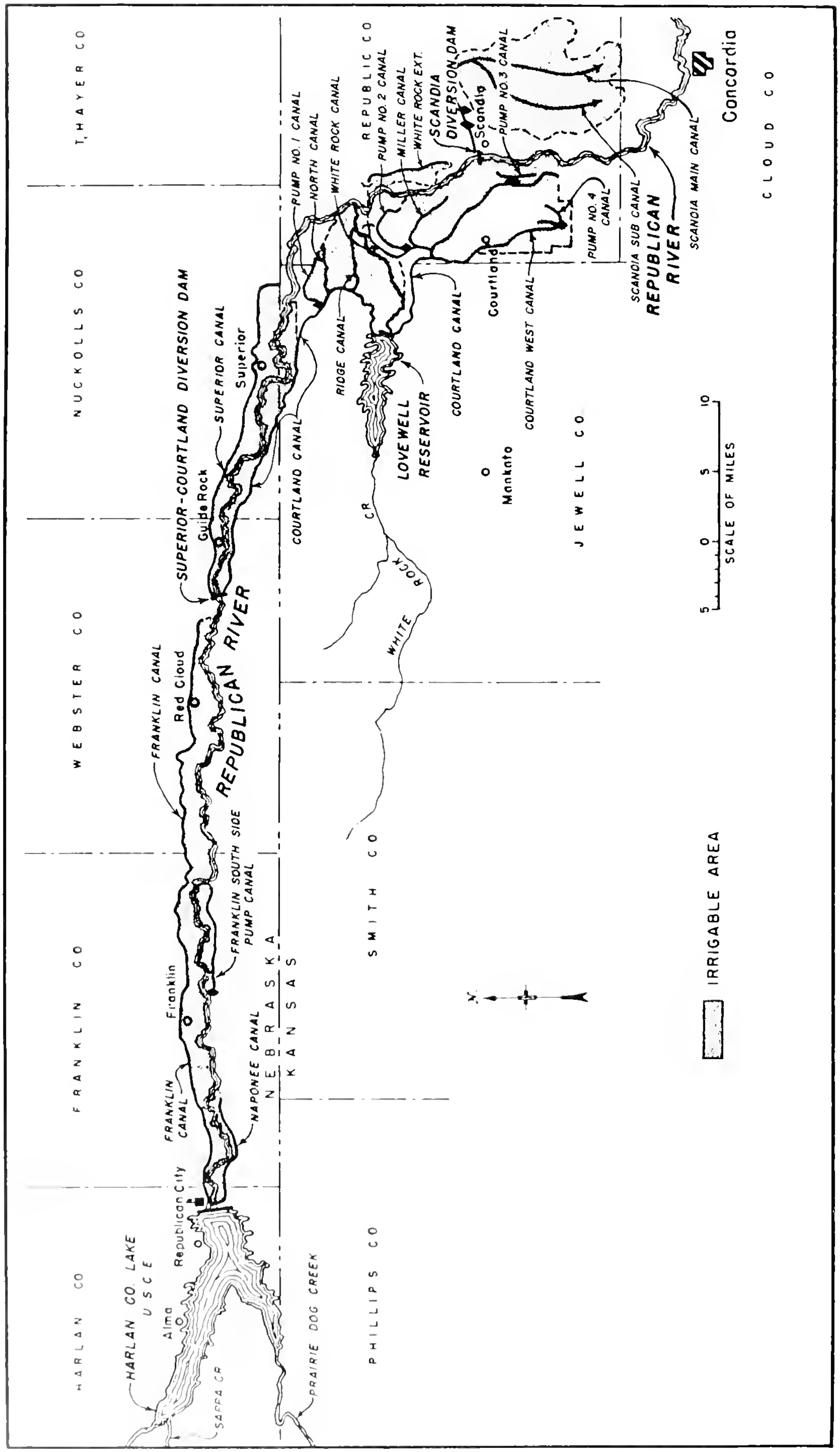
The Kansas-Bostwick area consists of 58,100 irrigable acres: 40,100 acres in the Courtland Unit and 18,000 acres in the potential Scandia Unit. Water for the Courtland Unit is diverted into the Courtland Canal at the Superior-Courtland Diversion Dam. Several other canals branch off from the Courtland Canal for irrigation. The proposed Scandia Unit, to be located east of the river between Scandia and Concordia, will require its own diversion dam and canal. This unit is scheduled for study, and future construction if authorized.

Harlan County Dam

Harlan County Dam, the principal storage feature of the Bostwick Division, was completed by the Corps of Engineers on December 2, 1952, under the authority of the Flood Control Act of 1941, as amended by the act of 1944. The dam is located on the Republican River in Harlan County, Nebraska. It is an earthfill structure 107 feet high and 11,828 feet long. It contains 13,400,000 cubic yards of earth in the embankment and 430,000 cubic yards of concrete in the spillway. During construction, provisions were made for future installation of a power penstock. The lake storage capacity is 828,776 acre-feet, of which 193,060 acre-feet are allocated to irrigation, 508,989 to flood control, and the remainder to inactive and dead capacity.

Franklin Unit

Two diversion outlets are installed in the Harlan County Dam to serve the Franklin Unit: The 230-cubic-foot-per-second Franklin Canal extends 47.9 miles east, paralleling the Republican River to serve the 11,116 acres of the north portion; the 30-cubic-foot-per-second Naponee Canal extends from the dam on the south side of the river eastward and serves 1,737 acres; the 45-cubic-foot-per-second Franklin South Side Pumping Plant, located about 17 miles downstream from the dam, lifts river water 20 feet to a 4.9-mile-long canal to supply 2,091 acres. Laterals and drains complete the facilities for operation of the Franklin Unit.



Bostwick Division

Harlan County Dam

Superior-Courtland Diversion Dam and Canal System

The Superior-Courtland Diversion Dam is located on the Republican River 3 miles west of Guide Rock, Nebr. It is a concrete ogee weir structure with a hydraulic height of 8 feet and a weir crest length of 420 feet. Embankment wings total more than 4,000 feet. The Superior Canal begins at the north side of the dam and extends 30 miles eastward to the State line. The canal has a capacity of 139 cubic feet per second, and supplies water to 5,863 acres north of the river in the Superior-Courtland Unit in Nebraska.

The Courtland Canal system originates at Superior-Courtland Diversion Dam, and serves 1,930 acres in Nebraska and 40,100 acres in Kansas. About midway along its length, the canal discharges into Lovewell Reservoir, which regulates the combined flows of the canal and White Rock Creek. The lower end of the system diverts from Lovewell Reservoir and extends southwestward to the vicinity of Courtland, Kans. The system and its components total 114 miles in length. In addition to the Courtland Canal, some of the more important features are the North, Ridge, White Rock, Miller, White Rock Extension, and Courtland West Canals. Other facilities of importance are the Pump Canals Nos. 1, 2, 3, and 4, and the associated pumping plants.

Lovewell Dam

Lovewell Dam is on the White Rock Creek 3 miles northwest of Lovewell, Kans. The reservoir stores water from White Rock Creek and diversions from the Republican River by way of the Courtland Canal. The dam is a 3-million-cubic-yard earthfill structure, 8,500 feet long, with a height-of-embankment 81 feet above streambed. The total capacity of the reservoir is 92,150 acre-feet, of which 24,930 is allocated for conservation, 50,460 acre-feet for flood control, and the remainder for inactive and dead capacity.

Scandia Unit (Proposed)

The Scandia Diversion Dam would be located on the Republican River near the town of Scandia. Additional facilities would include a system of pumping plants, canals, and laterals to provide a water supply for up to 18,000 acres of land on the east side of the river. The unit also could provide a supplemental water supply for the town of Belleville. Development of the Scandia Unit would permit full utilization of the substantial investment that already has been made in the facilities of the Bostwick Division.

DEVELOPMENT

Early History

The Republican River Basin was acquired from France in 1803, but settlement of the valley and of the Bostwick Division area developed slowly until the end of the Civil War. The postwar period of westward expansion, combined with construction of railroads through the West and peaceful relations with the Indians, brought rapid settlement of the valleys along the principal streams. The adjacent and higher tablelands were homesteaded in the 1880's.

During the early 1900's, the residents of the valley battled flood, drought, and insects. These tribulations and several intervals of economic depression contributed to the difficulty of maintaining an economic and social order based primarily on agriculture. A disastrous flood occurred in 1935 which took the lives of 110 persons and caused over $9 million in property damage and loss. As a result, the residents took the first of a long series of steps to develop, control, and improve the land and water resources.

An organization of landowners, businessmen, and other concerned citizens requested the assistance of the Federal Government. In response to these appeals, the Departments of the Interior, Agriculture, and War conducted comprehensive studies and surveys of the area. The Bureau of Reclamation started its work in 1939. As a result of these studies, construction of the Bostwick Division was authorized by act of Congress on December 22, 1944, and work began in 1948. By 1957, the Nebraska part of the division was essentially complete, and the structures in Kansas were nearing completion.

The Bostwick Irrigation District in Nebraska was formed April 26, 1948, and a repayment contract with the United States was executed February 21, 1949. The Kansas-Bostwick Irrigation District No. 2 was approved by the Chief Engineer, Division of Water Resources of Kansas, on September 25, 1948, and a repayment contract was executed April 20, 1951.

Investigations

The Corps of Engineers released a report in 1931 (H. Doc. 195, 73d Cong., 2d sess.) which included a description of the Lower Republican Project and outlined a plan of development for irrigation in the Bostwick Division area. The unprecedented Republican River flood of 1935 prompted further studies by the Corps of Engineers, and its report of April 1940 included a revised plan for development of the lower project.

The 1931 report included a proposal for the irrigation of 107,000 acres lying in the Republican River Valley and on adjacent lands in Kansas between Harlan County Dam near Republican City, Nebr., and Concordia, Kans. Storage of 200,000 acre-feet was proposed at Harlan County Dam. The Bureau of Reclamation released its preliminary report on the project in 1938 and initiated detailed investigations in 1940. In 1943, Reclamation released a report in which a comprehensive plan for flood control and irrigation development of the entire basin was presented. Results of a detailed investigation of the Bostwick Division were included in that report.

Lovewell Reservoir

Authorization

The division was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Documents 191 and 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of Bureau of Reclamation features began in March 1949, and the existing features were completed in June 1968.

Operating Agencies

Harlan County Dam is operated and maintained by the Corps of Engineers; Lovewell Dam by the Bureau of Reclamation; and the Superior-Courtland Diversion Dam, as well as its distribution system, by the Kansas-Bostwick Irrigation District. The Franklin, Naponee, Franklin Pump, and Superior Canals, with associated laterals and drains, and the laterals from the Courtland Canal in Nebraska, are operated and maintained by the Bostwick Irrigation District in Nebraska.

BENEFITS

Irrigation

Principal crops include corn, alfalfa, silage, and wheat. Beef production is the principal livestock enterprise, with dairy products also serving as an important source of in-

Superior-Courtland Diversion Dam

come. Crop failure from drought on irrigated land has been virtually eliminated as a result of the division construction, and agricultural production has been stabilized. The community is assured of adequate dependable income and purchasing power with a resultant beneficial impact on the local economy.

Flood Control

Harlan County Lake and Lovewell Reservoir provide effective flood control to the valleys immediately downstream of these impoundments as well as to cities, towns, farms, and lands located far downstream.

Recreation and Fish and Wildlife

Lovewell Reservoir and Harlan County Lake provide excellent facilities for outdoor recreation and fish and wildlife activities. Thousands of persons visit the facilities each year. Principal recreational activities include camping, fishing, swimming, boating, and water skiing.

UNIT DATA

Land Areas (1977)

Full irrigation service:		
Kansas Bostwick Irrigation District	40,100	acres
Bostwick Irrigation District in Nebraska	22,787	acres
Scandia Unit, Kans. (potential)	18,000	acres
Total	80,887	acres
Number of irrigated farms (1977):		
Kansas-Bostwick Irrigation District	497	
Bostwick Irrigation District in Nebraska	289	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
	Kansas-Bostwick Irrigation District	
1968	27,652	3,465,975
1969	25,433	3,554,141
1970	27,736	3,882,814
1971	28,634	3,611,574
1972	26,515	5,113,987
1973	30,528	7,006,234
1974	29,452	9,273,479
1975	31,777	8,273,460
1976	30,648	6,846,200
1977	32,247	5,915,317
	Bostwick Irrigation District in Nebraska	
1968	19,609	2,378,470
1969	18,538	2,407,947
1970	18,480	2,726,572
1971	19,708	2,674,615
1972	18,735	3,177,465
1973	20,029	4,983,197
1974	20,760	6,488,573
1975	20,797	5,524,766
1976	20,889	5,181,491
1977	20,997	4,644,042

Facilities in Operation[1]

Storage dam (Lovewell Dam)	1	
Diversion dam	1	
Canals	206	mi
Laterals	201	mi
Pumping plants	6	

[1]Data do not include Corps of Engineers' Harlan County Dam.

Climatic Conditions

	Belleville, Kans.	Franklin, Nebr.
Annual precipitation	29.9 in	24.1 in
Temperature:		
Maximum	113 °F	113 °F
Minimum	−19 °F	−21 °F
Mean	53 °F	52 °F
Growing season	182 days	161 days
Elevation of irrigable area	1640.0 ft	1820.0 ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service:	
Kansas-Bostwick Irrigation District	584
Bostwick Irrigation District in Nebraska	381

ENGINEERING DATA

Water Supply

REPUBLICAN RIVER

Drainage area at gage near Guide Rock, Nebr.	22,040	mi²
Annual discharge at Guide Rock:		
Maximum (1957)	29,200	acre-ft
Minimum (1964)	0.1	acre-ft
Average	112,800	acre-ft
Average annual diversion (Bostwick Division)	97,997	acre-ft

Storage Facilities

Lovewell Dam

Type: Zoned earthfill
Location: On White Rock Creek, about 3 mi northwest of Lovewell, Kans.
Construction period: 1955-57
Reservoir, Lovewell:

Average annual inflow, White Rock Creek only, 1929-77	37,500	acre-ft
Total capacity to El. 1595.3	92,150	acre-ft
Flood control capacity, El. 1582.6-1595.3	50,460	acre-ft
Conservation capacity, El. 1571.7-1582.6	24,930	acre-ft
Surface area (Top of flood control pool)	5,025	acres

Dimensions:

Structural height	93	ft
Hydraulic height	70	ft
Top width	30	ft
Maximum base width	680	ft
Crest length	8,500	ft
Crest elevation	1616.0	ft
Total volume	3,000,000	yd³

Spillway: Concrete-lined chute at right abutment, controlled by two 25- by 20-ft radial gates

Elevation top of gates	1595.3	ft
Crest elevation	1575.3	ft
Capacity at El. 1610.3	35,000	ft³/s

Outlet works: Concrete conduit through right abutment, controlled by one 8- by 10-ft radial gate

Capacity to El. 1610.3[2]	3,200	ft³/s

Harlan County Dam (Constructed by Corps of Engineers)

Reservoir, Harlan County Lake:

Average annual inflow, Harlan Co. Lake. (1953-77)	285,000	acre-ft
Total capacity to El. 1973.5	828,776	acre-ft
Active capacity, El. 1885-1973.5	702,049	acre-ft
Surface area (Top of flood control pool)	22,830	acres

[2]Limited by wasteway capacity of 685 ft³/s and canal capacity 635 ft³/s.

Diversion Facilities

Superior-Courtland Diversion Dam

Type: Concrete ogee weir, embankment wings
Location: On the Republican River about 3 mi west of Guide Rock, Nebr.
Year completed: 1950
Dimensions:

Structural height	42	ft
Hydraulic height	8	ft
Weir crest length	420	ft
Total length	4,000	ft
Weir crest elevation	1639.5	ft
Volume	179,000	yd³
Spillway capacity	42,000	ft³/s

Sluiceways:
North: One 20- by 12-ft radial gate
South: One 20- by 12-ft radial gate
Headworks:
Courtland Canal: Concrete, right abutment. Five 10- by 6-ft radial gates.
Superior Canal: Concrete, left abutment. One 10- by 6-ft radial gate.
Diversion capacity:

Courtland Canal	751	ft³/s
Superior Canal	139	ft³/s

Carriage Facilities

Franklin Canal

Location: From Harlan County Dam eastward along the north side of the Republican River to 5 mi east of Red Cloud, Nebr.
Construction period: 1952-56

Length	47.9	mi
Diversion capacity	230	ft³/s
Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth	4.8	ft
Typical maximum section, earth lined:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth	4.8	ft
Lining thickness	2	ft

Franklin Southside Pump Canal

Location: From Franklin South Side Pumping Plant near Franklin, Nebr., eastward along south side of the Republican River.
Construction period: 1951-53

Length	4.9	mi
Diversion capacity	42	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.6	ft

Naponee Canal

Location: From Harlan County Dam, generally eastward along the south side of the Republican River.
Construction period: 1953-55

Length	8.8	mi
Diversion capacity	30	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2	ft
Typical maximum section, earth lined:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1.9	ft
Lining thickness	2	ft

Superior Canal

Location: From Superior-Courtland Diversion Dam about 15 mi west of Superior, Nebr., generally southeastward along the north side of the Republican River to Nebraska-Kansas line.
Construction period: 1949-52

Length	30	mi
Diversion capacity	139	ft³/s
Typical maximum section in earth:		
Bottom width	13	ft
Side slopes	1.5:1	
Water depth	4	ft
Typical maximum section, earth lined:		
Bottom width	11	ft
Side slopes	1.5:1	
Water depth	3.57	ft
Lining thickness	1.5	ft
Typical maximum section, concrete lined:		
Bottom width	4	ft
Side slopes	1.25:1	
Water depth	3.5	ft
Lining thickness	3	in

Courtland Canal

Location: From Superior-Courtland Diversion Dam about 17 mi west of Superior, Nebr., generally southeastward along west side of the Republican River to vicinity of Scandia, Kans.
Construction period: 1949-59

Length	55.6	mi
Diversion capacity	751	ft³/s
Typical maximum section in earth:		
Bottom width	26	ft
Side slopes	1.5:1	
Water depth	8.5	ft
Typical maximum section, earth lined:		
Bottom width	26	ft
Side slopes	1.5:1	
Water depth	8.5	ft
Lining thickness	1.5	ft
Typical maximum section, concrete lined:		
Bottom width	16	ft
Side slopes	1.5:1	
Water depth	8.44	ft
Lining thickness	3	in
Typical maximum section, asphalt lined:		
Bottom width	29	ft
Side slopes	2:1	
Water depth	8.5	ft
Lining thickness[3]	2	ft

Courtland Pump Canal 3A

Location: On west side of Republican River southwest of Scandia, Kans.
Construction period: 1967-68

Length	1.5	mi
Diversion capacity	15	ft³/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	2	ft

Courtland Pump Canal 3B

Location: On west side of Republican River southwest of Scandia, Kans.
Construction period: 1967-68

Length	0.8	mi
Diversion capacity	9	ft³/s
Typical maximum section in earth:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1.5	ft

Courtland West Canal

Location: On the west side of the Republican River, running north to south and directly west of the town of Courtland, Kans.
Construction period: 1957-58

Length	10.6	mi
Diversion capacity	200	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	5.2	ft
Typical maximum section, earth lined:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	5.2	ft
Lining thickness	2	ft

[3]Membrane with earth cover.

Miller Canal

Location: On the west side of the Republican River, northwest of Scandia, Kans.
Construction period: 1957-58

Length	8.3	mi
Diversion capacity	190	ft³/s
Typical maximum section in earth:		
Bottom width	16	ft
Side slopes	2:1	
Water depth	4.6	ft
Typical maximum section, earth lined:		
Bottom width	16	ft
Side slopes	2:1	
Water depth	4.64	ft
Lining thickness	2	ft

North Canal

Location: On the west side of the Republican River, runs west to east, just northwest of Republic, Kans.
Construction period: 1954-55

Length	6.3	mi
Diversion capacity	50	ft³/s
Typical maximum section in earth:		
Bottom width	8	ft
Side slopes	1.5:1	
Water depth	2.6	ft

Pump No. 1 Canal

Location: On the west side of the Republican River, just south of the Nebraska-Kansas State line and northwest of Republic, Kans.
Construction period: 1960-61

Length	5.3	mi
Diversion capacity	36	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.6	ft

Pump No. 1 South Canal

Location: On the west side of the Republican River, south of the Nebraska-Kansas State line and northwest of Republic, Kans.
Construction period: 1960-61

Length	1.5	mi
Diversion capacity	15	ft³/s
Typical maximum section in earth:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	1.7	ft

Pump No. 4 Canal

Location: On the west side of the Republican River, southwest of Scandia, Kans.
Construction period: 1959-60

Length	2.1	mi
Diversion capacity	24	ft³/s
Typical maximum section in earth:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	2.3	ft

Pump No. 4 West Canal

Location: On the west side of the Republican River, southwest of Scandia, Kans.
Construction period: 1959-60

Length	1	mi
Diversion capacity	15	ft³/s

Typical maximum section in earth:

Bottom width	3 ft
Side slopes	1.5:1
Water depth	2 ft

Ridge Canal

Location: On the west side of the Republican River directly west of Republic, Kans., and runs from west to east.

Construction period: 1954-55

Length	6 mi
Diversion capacity	90 ft³/s

Typical maximum section in earth:

Bottom width	12 ft
Side slopes	1.5:1
Water depth	3.4 ft

Typical maximum section, earth lined:

Bottom width	6 ft
Side slopes	1.5:1
Water depth	2.4 ft
Lining thickness	1.5 ft

White Rock Canal and Extensions

Location: On both west and east sides of the Republican River directly north and slightly west of Scandia, Kans.

Construction period: 1958-61

Length	14.8 mi
Diversion capacity	100 ft³/s

Typical maximum section in earth:

Bottom width	12 ft
Side slopes	1.5:1
Water depth	4 ft

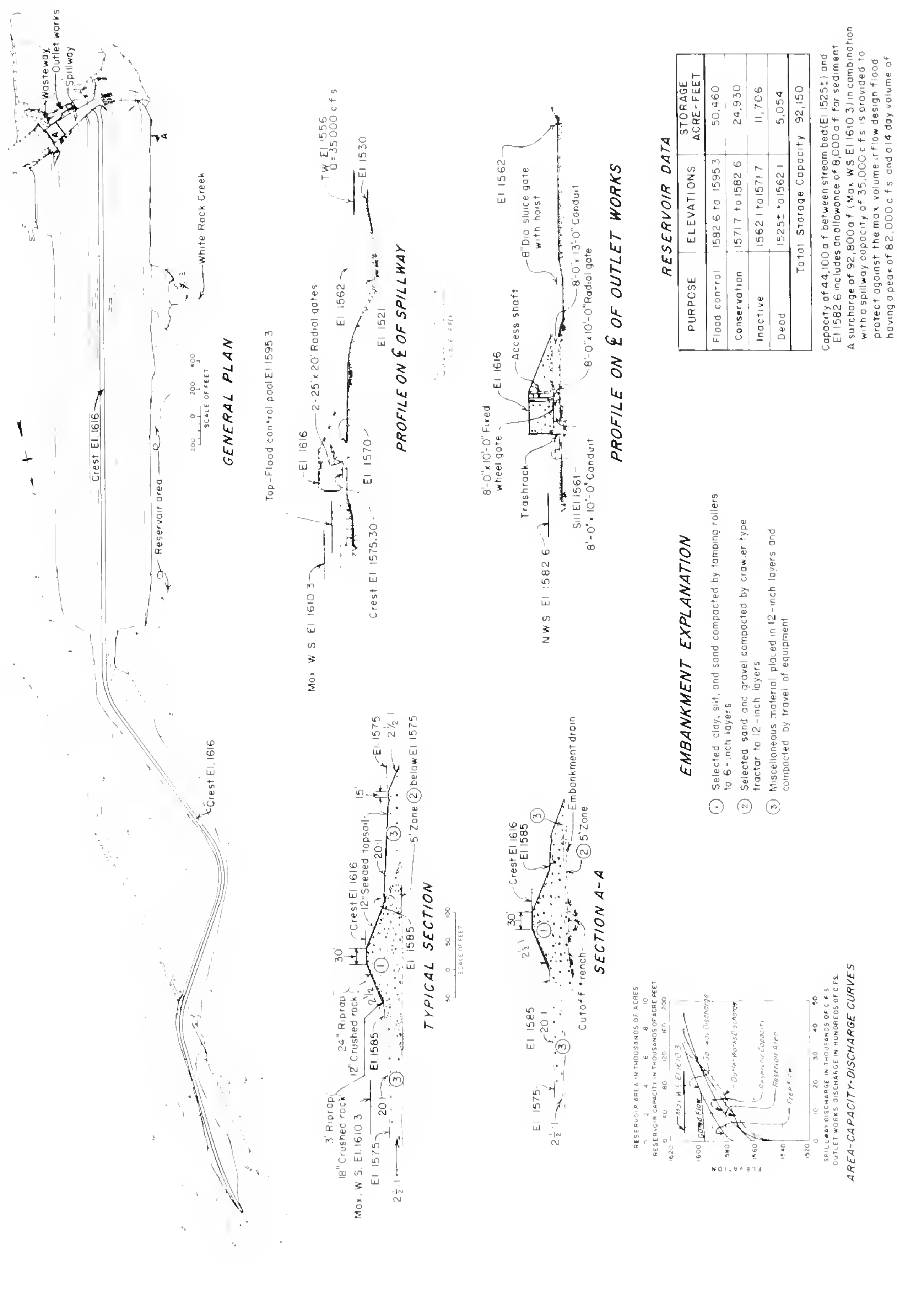
Typical maximum section, earth lined:

Bottom width	8 ft
Side slopes	2:1
Water depth	2.7-2.8 ft
Lining thickness	2 ft

Pumping Plants

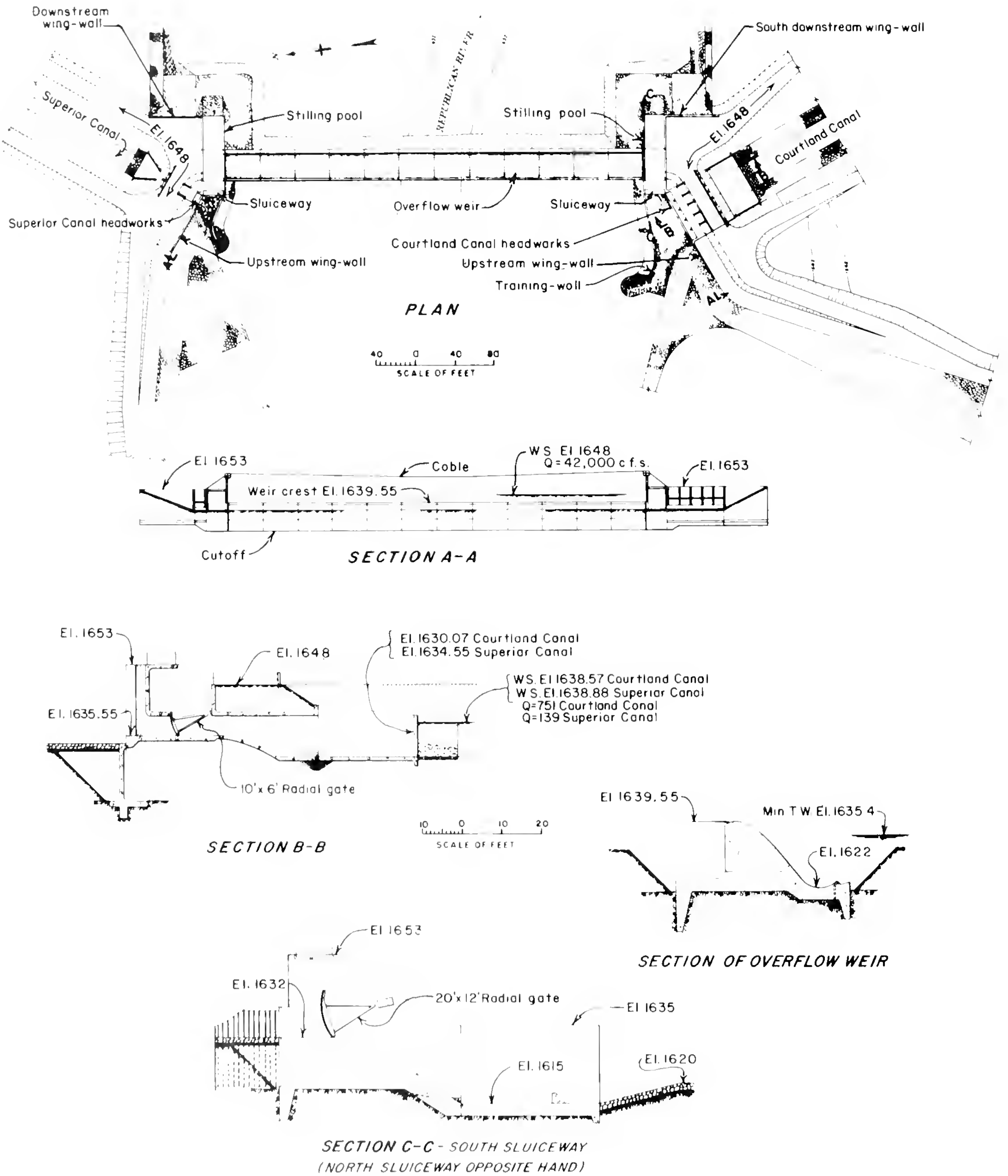
Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Naponee[1]	1	18	9	127
Franklin South Side	3	45	20	150
Courtland No. 1	4	63	44.5	475
Courtland No. 3A	4	15	28	100
Courtland No. 3B	3	9	26	60
Courtland No. 4	3	27	18.7	80

[1]Constructed in 1964 by the Bostwick Irrigation District, Nebr. (diesel).



PURPOSE	ELEVATIONS	STORAGE ACRE-FEET
Flood control	1582.6 to 1595.3	50,460
Conservation	1571.7 to 1582.6	24,930
Inactive	1562.1 to 1571.7	11,706
Dead	1525± to 1562.1	5,054
	Total Storage Capacity	92,150

Lovewell Dam, Plan and Sections

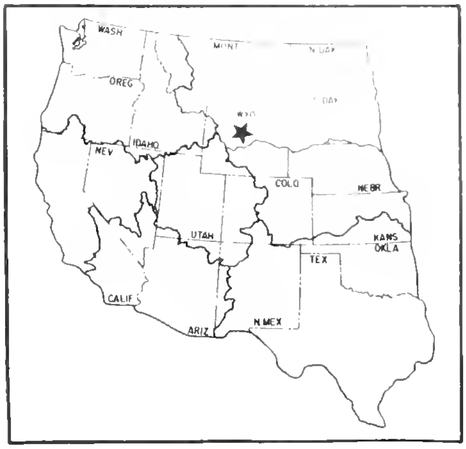


Superior-Courtland Diversion Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Boysen Unit

Wyoming: Fremont County

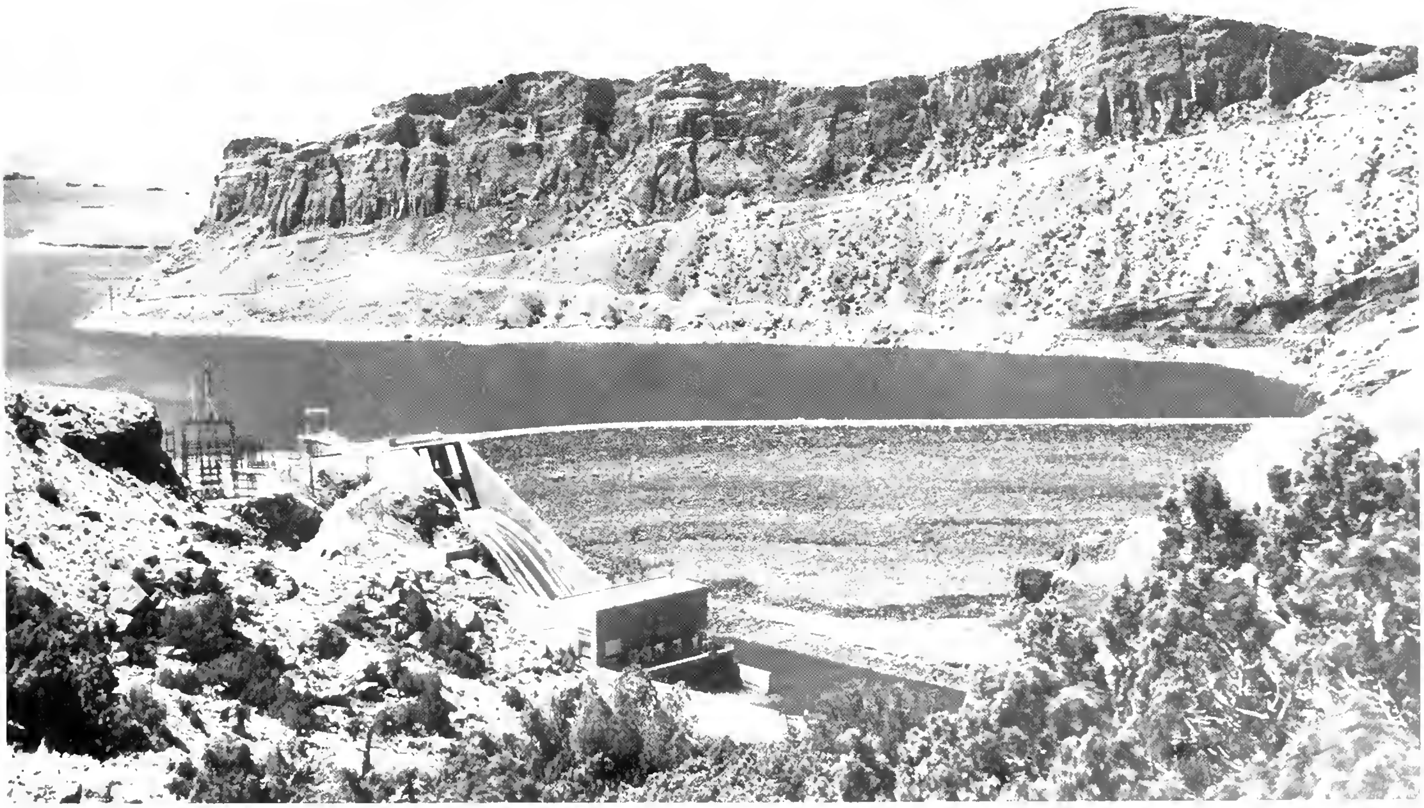
Upper Missouri Region
Water and Power Resources Service



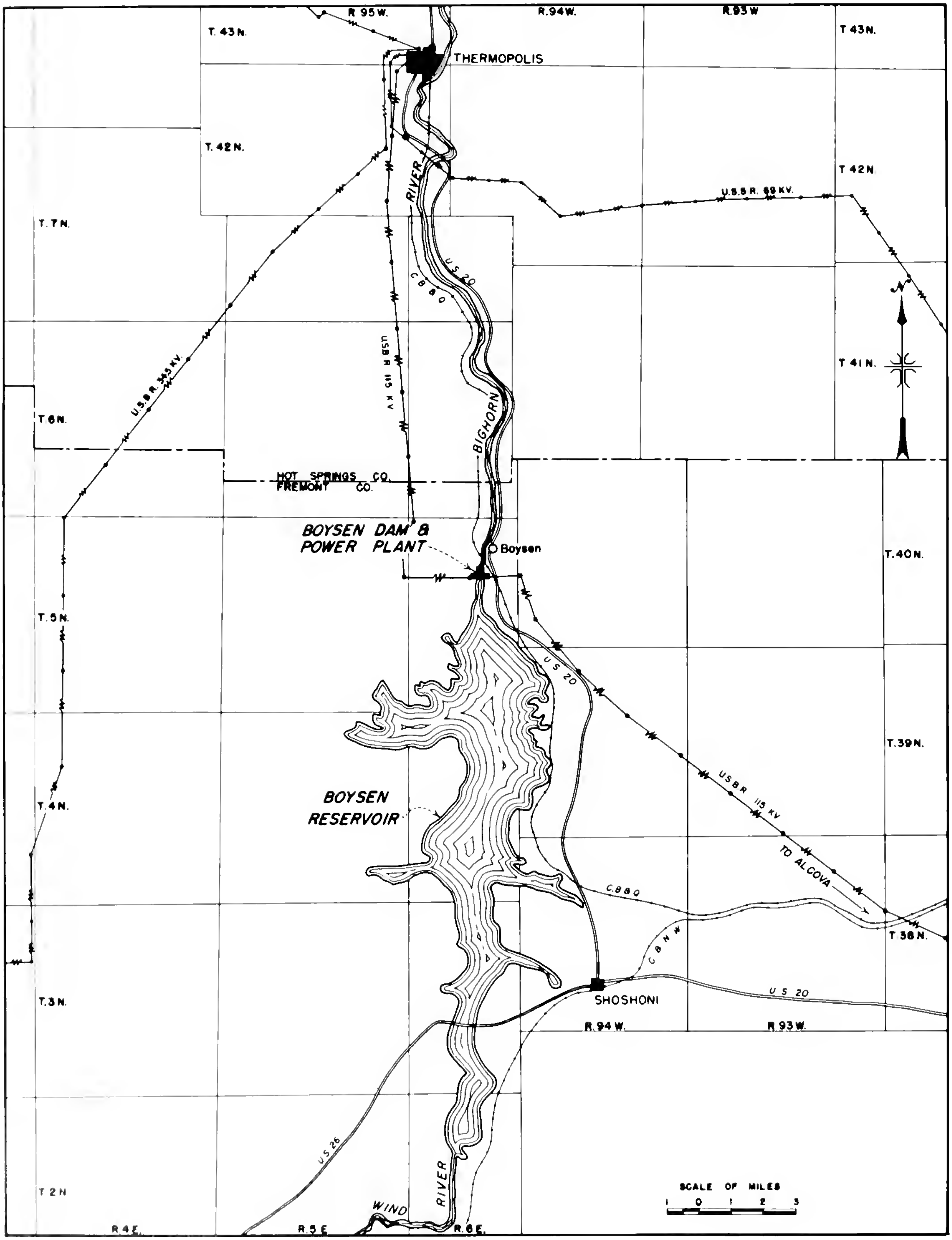
The Boysen Unit, on the Wind River about 20 miles south of Thermopolis, Wyo., consists of Boysen Dam, Reservoir, and Powerplant. Boysen Dam impounds the waters of Wind River, providing regulation of the streamflow for power generation, irrigation, flood control, sediment retention, fish propagation, and recreation development.

PLAN

Irrigation was not included as an integral part of the Boysen Unit. However, Boysen Reservoir is essential to irrigation in the Wind River Basin above the reservoir and the Bighorn Basin below the reservoir. Releases from Boysen Reservoir supply water for 7,441 acres on the Hanover-Bluff Unit, and 2,380 acres within the Lucerne area of the Owl Creek Unit. Another 41,000 acres of privately owned land below Boysen Dam are provided supplemental water by contract. Low-season streamflow, which formerly had to satisfy prior rights downstream of Boysen Reservoir, have been made available to upstream irrigation by exchange of an equal amount of stored water released from Boysen Reservoir. Storage contracts for irrigation of about 20,000 acres of land above Boysen are held by private irrigation entities.



Boysen Dam


R 95 W.
R.94W.
R.93W
T. 43 N.
T 43N.
THERMOPOLIS
T. 42 N.
T 42N
U.S.B.R. 69 KV.
T. 7 N.
RIVER
US 20
C B & Q
USB R 115 KV
U.S.B.R. 345 KV.
T 41 N.
BIGHORN
T. 6 N.
HOT SPRINGS CO.
FREMONT CO.
BOYSEN DAM &
POWER PLANT
Boysen
T.40 N.
T. 5 N.
US 20
T.39 N.
USBR 115 KV
TO ALCOVA
BOYSEN
RESERVOIR
T. 4 N.
C B & Q
C & N W
T 38 N.
T. 3 N.
SHOSHONI
US 20
R. 94 W.
R 93 W.
US 26
RIVER
WIND
T 2 N
SCALE OF MILES
1 0 1 2 3
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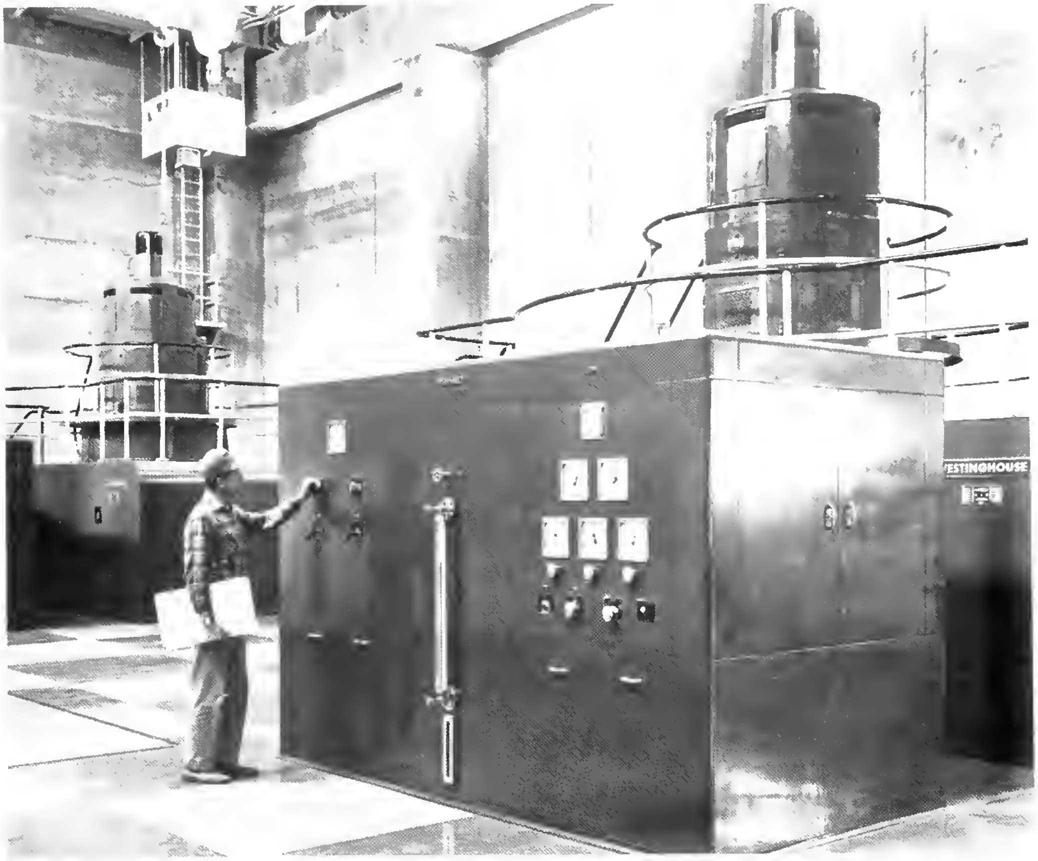
R. 5 E
R. 6 E.

Boysen Unit



Boysen Powerplant

Power generated at the 15,000-kilowatt Boysen Powerplant is fed into the Western Division, Pick-Sloan Missouri Basin Program transmission facilities for use within that division. In addition, floods are controlled, the river loses its siltload, municipal water supplies are augmented, fish and wildlife habitats are improved, and recreation possibilities are expanded.

Boysen Dam and Powerplant

Boysen Dam is a zoned earthfill structure having a structural height of 220 feet. An overflow, weir-type spillway controlled by radial gates is located on the right abutment and discharges immediately upstream and left of the powerplant.

Design discharge through the spillway is 25,000 cubic feet per second at elevation 4725.0. The Boysen Reservoir has a total controlled storage capacity of 802,000 acre-feet at water surface elevation 4725.0.

The outlet works is on the right abutment of the dam. Discharge is through a 66-inch-diameter steel pipe located above the power penstock and a 57-inch-diameter steel pipe joined to the 10-foot-diameter power penstock serving Unit 1 in the powerhouse.

The powerplant has an installed capacity of 15,000 kilowatts developed by two 7,500-kilowatt units operating under an average head of 99 feet. Each unit is served by a 10-foot-diameter steel penstock joined to a common 15-foot-diameter steel penstock immediately upstream from the powerplant. The 15-foot-diameter penstock leading from the intake structure to the units was located to utilize the bore of an existing railroad tunnel made available through relocation of the CB&Q Railroad.

Other features of the construction activity were the relocation of 13.5 miles of the railroad track, which required a tunnel 1.25 miles long, seven bridges, two sidings, and other construction features.

DEVELOPMENT

Early History

Settlement in the vicinity of the Boysen Unit began about 1850; the first known irrigation works were constructed in the 1860's along the Popo Agie River near Lander, Wyo. During the next 15 years, settlements became more extensive, and irrigation works were constructed by private organizations and individuals in the areas where diversions were available. Irrigation continued as a private endeavor until about 1920, when opportunities for low-cost diversions were practically exhausted.

In 1908, a concrete dam was constructed across the Wind River about 1.5 miles downstream from the present site of Boysen Dam, primarily for power purposes. A flood in 1923 raised the water surface in the reservoir and inundated several miles of railroad tracks. A portion of the dam was blasted away to reduce the reservoir area and forestall future flooding. Repairs to the dam were never undertaken, and generation of power ceased in the early 1930's. The dam was removed in 1948 to improve the tail-water conditions for the Boysen Powerplant.

Investigations

Investigations of the area were made by the Bureau of Reclamation in 1904 and again in 1916-17. In 1939, the Corps of Engineers made additional studies of the Bighorn River, recommending construction of a dam at the site of the old dam. In 1941, the Bureau of Reclamation resumed investigations and studies, and a report was published in 1942. The Boysen Unit was included in the Missouri River Basin program, as outlined in Senate Document 191. The report recommended construction of a dam about 1.5 miles upstream from the old site, where relocation costs would be more reasonable.

Authorization

Authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction began on Boysen Dam and Powerplant and relocation of the CB&Q Railroad on September 19, 1947, and was completed December 11, 1952.

Operating Agency

The unit is operated by the Bureau of Reclamation.

BENEFITS

Irrigation

The Boysen Unit provides irrigation water through storage for lands below and above the reservoir. No direct irrigation is made from the unit.

Hydroelectric Power

Hydroelectric power is tied into the transmission lines to Alcova, Thermopolis, and Pilot Butte-Thermopolis.

Flood Control

The reservoir has been effective in reducing damage to property. Total damages reduced by the reservoir since construction totaled about $18 million at the end of 1977.

Recreation

Boysen Reservoir quickly became popular for camping, fishing, boating, and sightseeing. The recreation area is being expanded. The narrow gorge in the Owl Creek range is an additional attraction. The unit had 297,100 visitor days in 1977.

PROJECT DATA

Power Generation

Fiscal year	Boysen Powerplant, kWh
1968	100,459,700
1969	97,582,200
1970	85,259,000
1971	96,259,000
1972	119,310,000
1973	112,457,000
1974	112,457,000
1975	93,427,000
1976	101,358,000
Transitional Quarter	20,800,000
1977	65,258,000

Facilities in Operation

Storage dams	1	
Powerplants	1	
Plant capacity	15,000	kW

Climatic Conditions

Annual precipitation	9.5	in
Temperature:		
Maximum	108	°F
Minimum	−37	°F
Mean	47	°F
Growing season	148	days

ENGINEERING DATA

Water Supply

WIND RIVER

Drainage area above Boysen Dam	7,700	mi²
Annual discharge below Boysen Dam		
Maximum (1965)	1,448,000	acre-ft
Minimum (1961)	444,100	acre-ft
Average (1952-1977)	1,036,600	acre-ft

Storage Facilities

BOYSEN DAM

Type: Zoned earthfill
Location: On Wind River about 20 mi upstream from Thermopolis, Wyo.
Construction period: 1947-52

Date of closure (first storage): October 1951		
Total capacity to El. 4732.2	952,400	acre-ft
Active capacity, El. 4685-4717	403,800	acre-ft
Surface area	22,166	acres
Dimensions:		
Structural height	220	ft
Hydraulic height	117	ft
Top width	30	ft
Maximum base width	919	ft
Crest length	1143	ft
Crest elevation	4758.0	ft
Volume	1,527,000	yd³

Spillway: Concrete-line chute in right abutment, controlled by two 30- by 25-ft radial gates.

Elevation top of gates	4725.0	ft
Crest elevation	4700.0	ft
Capacity at El. 4725	25,000	ft³/s

Outlet works: Concrete-lined tunnel through right abutment. River releases are through 66-in-diameter outlet pipe and 57-in-diameter power penstock bypass pipe, each controlled by one 48-in-diameter hollow-jet valve.

Capacity at El. 4725	1,300	ft³/s

Power releases are through a 15-ft-diameter steel penstock through the outlet tunnel to the powerplant.

Foundation: Folded and faulted shales and sandstones lying over pre-Cambrian diorites, with up to 70 ft of alluvium in the riverbed.

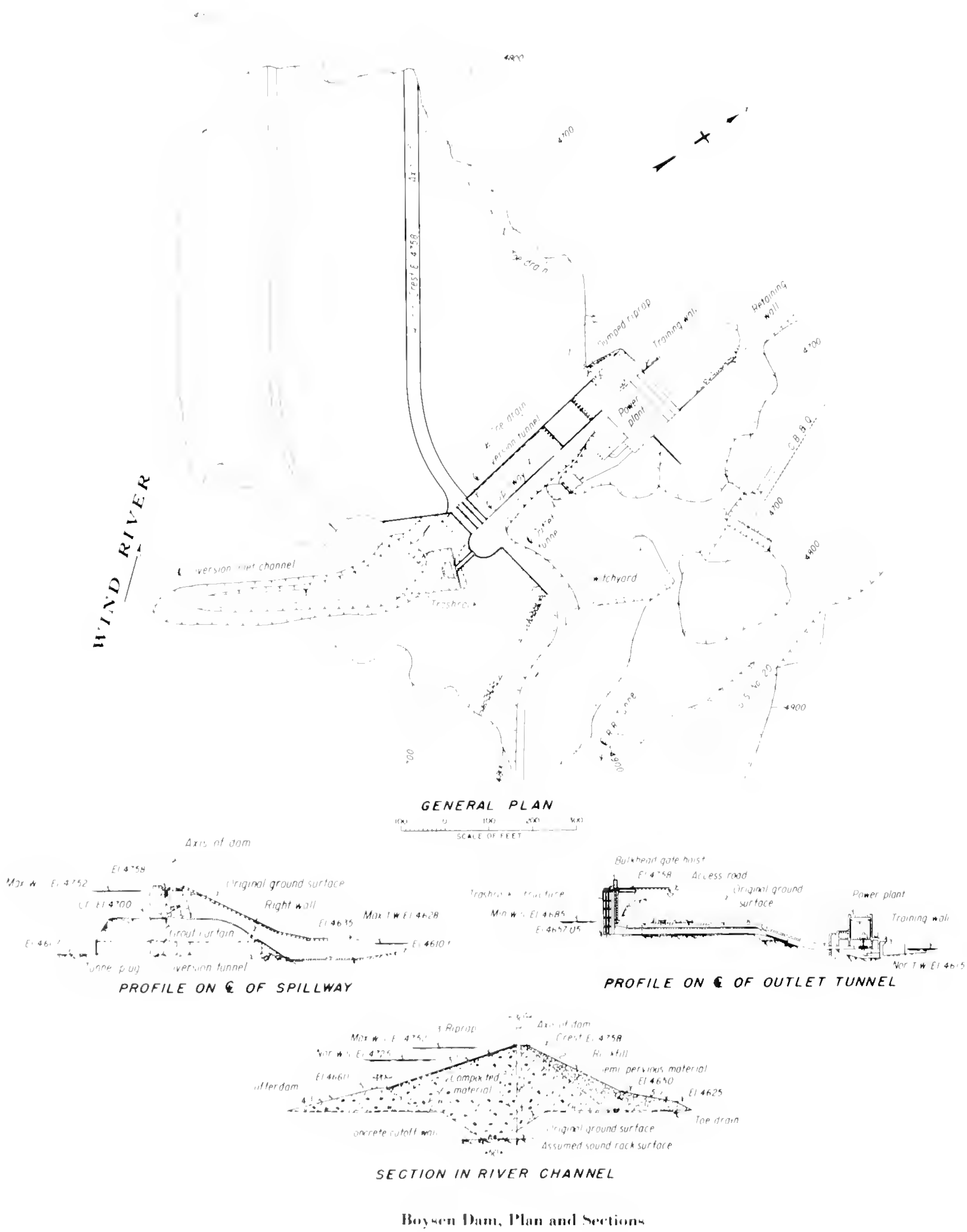
Special treatment: Concrete blanket grouting and grout curtain beneath cutoff trench.

Power Facilities

Boysen Powerplant

Location: Boysen Dam
Year of initial operation: 1952
Year last generator placed in operation: 1952

Nameplace capacity	15,000	kW
Number and capacity of generators (2)	7,500	kW
Maximum head	121	ft

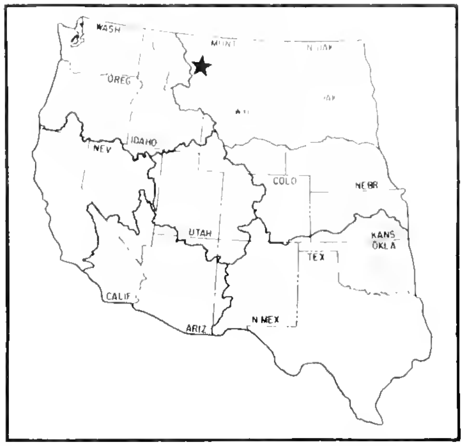


Boysen Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Canyon Ferry Unit

Montana: Broadwater and Lewis and Clark Counties

Upper Missouri Region
Water and Power Resources Service



The Canyon Ferry Unit is a multiple-purpose project which makes an important contribution to the power supply, flood control, and irrigation in the upper Missouri Basin. While not directly including irrigation, the unit is the key feature in the plan to irrigate 155,600 acres of new land and to furnish storage regulation for supplemental irrigation for 82,000 acres now inadequately irrigated in the upper Missouri area. Principal structures are the Canyon Ferry Dam and Powerplant, about 17 miles northeast of Helena, Mont.

PLAN

Located 50 miles downstream from where the Gallatin, Madison, and Jefferson Rivers join to form the Missouri River, Canyon Ferry Dam intercepts the runoff from about 15,860 square miles, and stores the unused floodwater and unappropriated water in a 2,051,000-acre-foot reservoir. The reservoir permits upstream irrigation development by reregulating residual flows of the river to maintain the capacities at the powerplants below the reservoir.

In addition to providing power for irrigation pumping, the Canyon Ferry Powerplant provides low-cost energy for use by farm, residential, and commercial consumers.

Canyon Ferry Dam

Canyon Ferry Dam and Powerplant are on the Missouri River about 1.5 miles downstream from the original Canyon Ferry Dam and the Montana Power Company's 6,700-kilowatt powerplant in the backwater of Hauser Lake. The dam is a concrete gravity structure approximately 1,000 feet in length along the crest with a structural height of 225 feet. It contains 414,400 cubic yards of concrete.

The spillway is an overflow section in the central portion of the dam, controlled by four radial gates. The spillway capacity is 150,000 cubic feet per second. The total capacity is 2,051,000 acre-feet at elevation 3800.0. Four river outlets are in the spillway section of the dam. The maximum discharge capacity of these outlets is 9,500 cubic feet per second. One 156-inch-diameter pumping intake pipe is embedded in the concrete of the dam near the left abutment for the Helena Valley Pumping Plant. Three 162-inch-diameter penstock pipes for the power generating units are embedded in the dam near the right abutment.

The powerplant is on the right downstream toe of the dam adjacent to the spillway apron. It is of reinforced concrete construction and houses three 16,667-kilowatt vertical-shaft generators driven by 23,500-horsepower turbines.

DEVELOPMENT

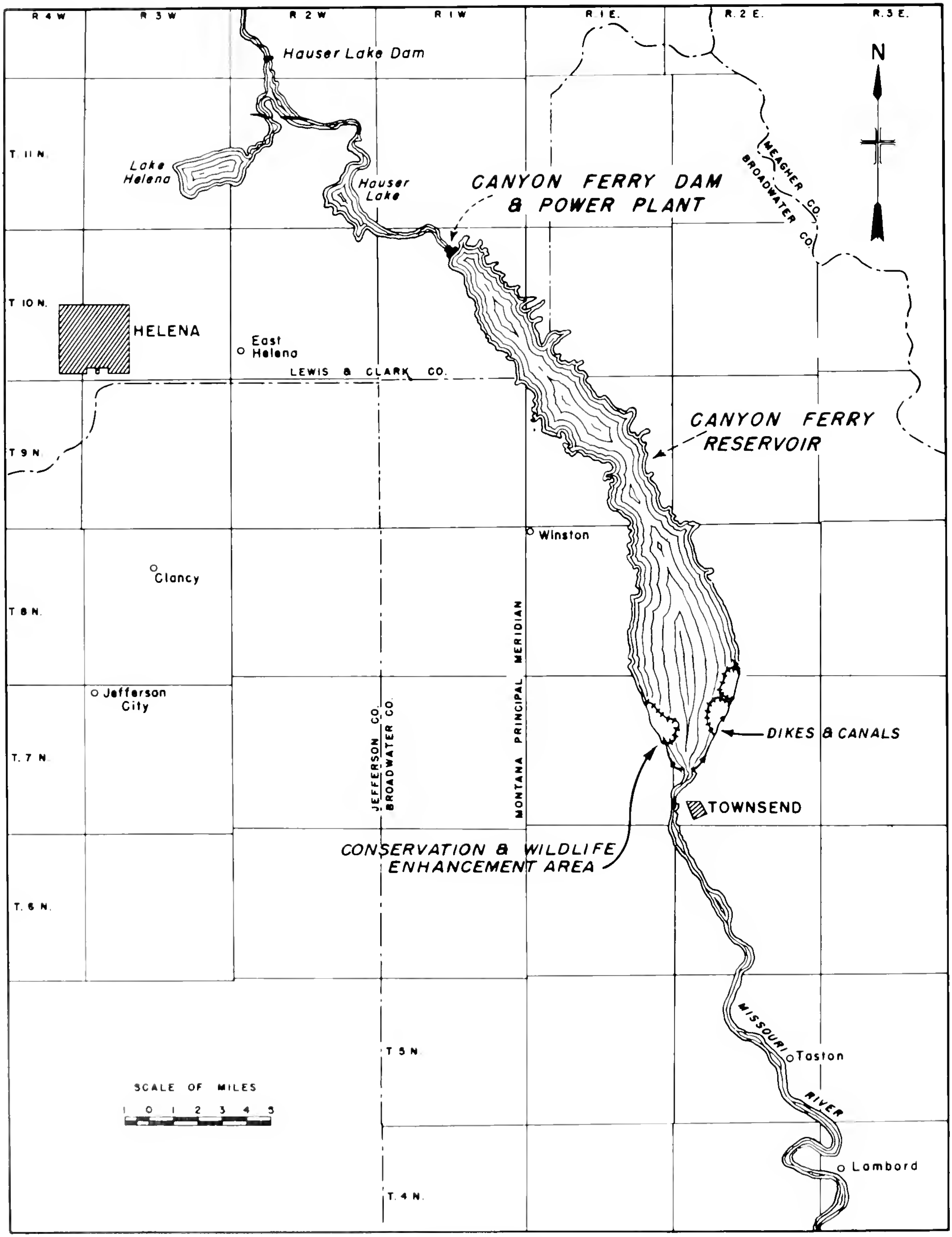
Early History

In 1846, the American Fur Trading Company established a post at Fort Benton which for many years was a major center of the area. The discovery of lode and placer gold at Bannock in 1862, and a year later at Virginia Gulch, brought an influx of prospectors and miners. Further discoveries of gold as well as rich deposits of silver and lead followed, and mining and smelting became an important industry.

Following the high silver production period, 1863-93, a different type of settler moved into the area and dryland farming and ranching operations began on an ever-increasing scale. Earliest agricultural enterprises were largely gardening and minor dairying around military forts and stage posts. Soon, however, cattle were driven into the area and stockmen began establishing headquarters along the stream valleys and in the foothills.

Investigations

The first extensive survey of irrigation possibilities, both upstream and downstream from Canyon Ferry, was conducted in 1941 under terms of a three-party agreement between the Montana Water Board, Montana Power Company, and the Bureau of Reclamation. The results of the survey established a pattern for development of the water resources of the Canyon Ferry Unit.



Canyon Ferry Unit

Authorization

The project was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of Canyon Ferry Dam began May 24, 1949, and was completed June 23, 1954. The first power unit began operating December 18, 1953, followed by the other two in March 1954.

Conservation and Wildlife Enhancement

Since initial filling of Canyon Ferry Lake in 1955, wind blown, fine-grained material from exposed flats at the upper end of the lake has been a major contributor to air pollution in the area near the lake. The flats were exposed when the lake was drawn down to provide storage space for excessive spring inflows or when water levels had been low because of low precipitation and runoff. The Montana Department of Health has reported the average deposition of material in the Townsend area to be 301 tons per square mile per month, which far exceeds the 15 to 20 tons considered as acceptable. These large amounts of blowing and deposited material caused a deterioration of the living environment for farmers and stockmen in the general area and especially for the town of Townsend. These conditions also have an adverse effect on forage crops and livestock.

In June 1968, the Governor of Montana suggested that the best long-range solution would be attained through a cooperative program between the Bureau of Reclamation and the Montana Fish and Game Department. A dike system at the upper end of the lake that would include waterfowl-development features had been planned by the Fish and Game Department, but was beyond the financial capabilities of that agency. Therefore, Federal assistance was requested. Construction began in 1972 and was essentially completed in 1978.

The waterfowl facilities provide habitat for nesting and breeding, supplemental resting and feeding sites for migratory birds, and public hunting and observation of waterfowl and upland game birds.

Operating Agency

Operations are by the Bureau of Reclamation. The unit was transferred to operation and maintenance January 1, 1955.

Canyon Ferry Dam

BENEFITS

Irrigation

Canyon Ferry Dam and Lake provide storage for irrigation development in the upper Missouri River Basin. The economic development of the areas benefited accrues to other units of the project.

Hydroelectric Power

Electric energy produced at the 50,000-kilowatt Canyon Ferry Powerplant is marketed by the Missouri River Basin Transmission Division.

Recreation

Located in a scenic mountainous region, Canyon Ferry Lake offers many recreation opportunities for Montana residents and vacationing tourists. The Park Division of the Montana State Highway Commission is providing a development program which includes areas for picnicking, camping, boating, fishing and swimming. The area had 395,900 visitor days in 1977.

PROJECT DATA

Facilities in Operation

Storage dams	1
Powerplants	1

Power Generation

Fiscal Year	Canyon Ferry Powerplant (kWh)
1968	436,953,000
1969	469,955,000
1970	460,255,000
1971	484,270,000
1972	486,556,000
1973	412,352,000
1974	436,048,000
1975	449,992,000
1976	508,139,000
T.Q.[1]	127,655,000
1977	359,417,000

[1]Transitional quarter.

ENGINEERING DATA

Water Supply

MISSOURI RIVER

Drainage area above Canyon Ferry Dam	15,860	mi²
Annual discharge near Toston, Mont.:		
Maximum (1976)	5,451,500	acre-ft
Minimum (1941)	2,119,400	acre-ft
Average	3,784,000	acre-ft

Storage Facilities

CANYON FERRY DAM

Type: Concrete gravity
Location: On the Missouri River 27 mi downstream from Townsend, Mont.
Construction period: 1949-54
Date of closure (first storage): December 1951
Reservoir, Canyon Ferry Lake:

Average annual inflow, 1926-77	3,587,000	acre-ft
Total capacity to El. 3800	2,051,000	acre-ft
Active capacity, El. 3728-3770	713,000	acre-ft
Surface area	35,200	acres

Dimensions:

Structural height	225	ft
Hydraulic height	172	ft
Top width	20	ft
Maximum base width	173	ft
Crest length	1,000	ft
Crest elevation	3808.5	ft
Volume	414,400	yd³

Spillway: Overflow section at center of dam, controlled by four 51- by 34.5-ft radial gates.

Elevation top of gates	3800.0	ft
Crest elevation	3766.0	ft
Capacity at El. 3800	150,000	ft³/s

Outlet works:
River outlets: Four 2-ft-diameter conduits through spillway section of dam, each controlled by a 77-in regulating gate.

Capacity at El. 3800	9,500	ft³/s

Power outlets: Three 13.5-ft-diameter penstocks through dam at right of spillway section.
Intake for pumping plant: One steel pipe, 13 ft inside diameter, left of spillway section.
Foundation: Massive, fine-grained, hard and dense hornfels (transformed Empire shale) fractured into an exceedingly complex and closely spaced system of joints, with several minor and one major fault zone and a major bedding plane slip.
Special treatment: Grout blanket over foundation area; grout curtain under dam.
Mass concrete: Aggregate from natural deposit about 1 mi above the dam, supplemented from commercial sources in the Helena Valley; Type II (low-alkali) cement used with about 23 percent pozzolan (fly ash); temperature control by circulating river water through embedded pipe system.

Volume	349,500	yd³
Maximum size aggregate	8	in
Average net water-cement ratio by weight:		
Interior	0.66	
Exterior	0.45	
Cement-pozzolan content	235	lb/yd³

Contraction joints: Transverse joints spaced at 45- to 60-ft intervals, pressure grouted after concrete cooled.

Power Facilities

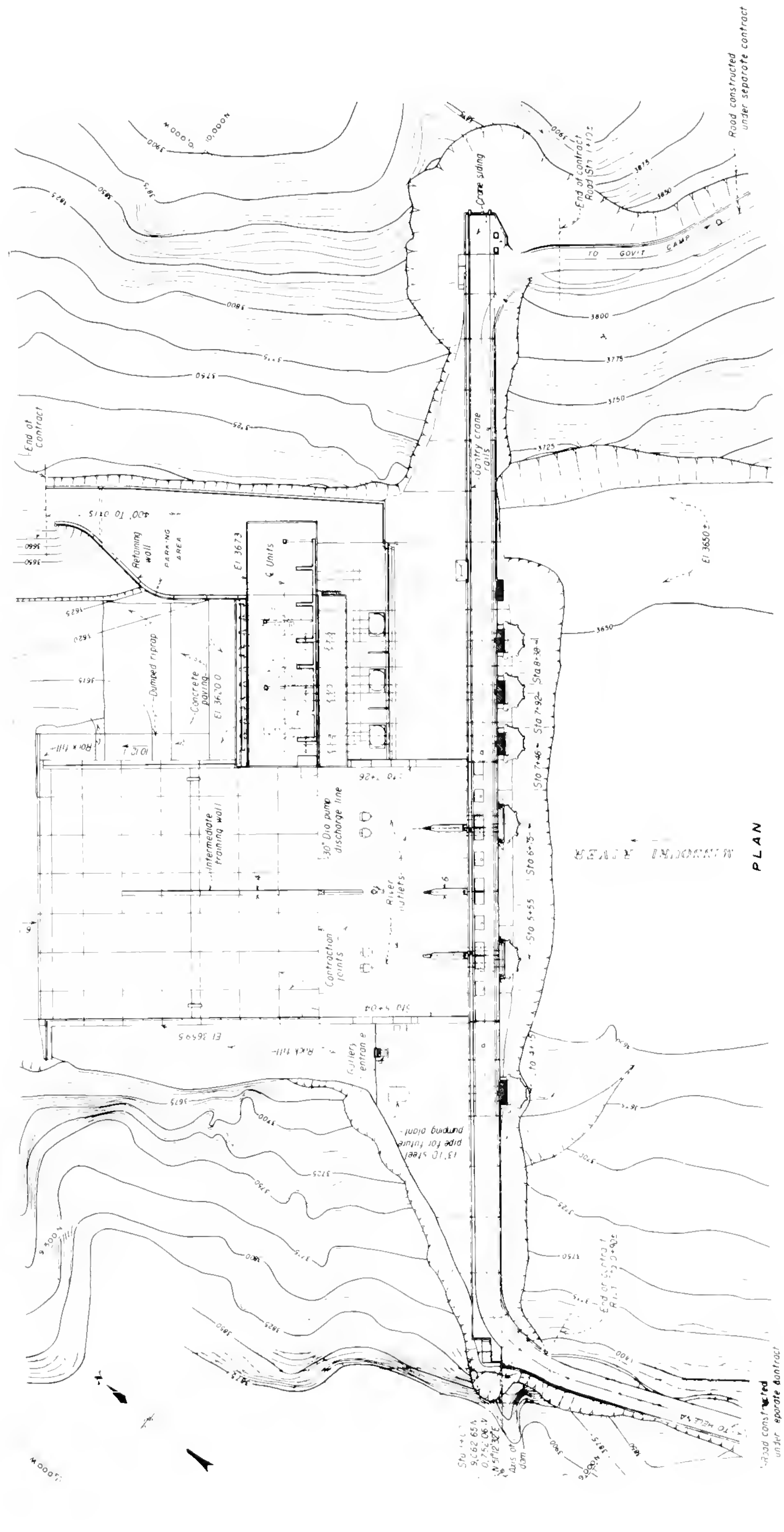
CANYON FERRY POWERPLANT

Location: Canyon Ferry Dam
Year of initial operation: 1953
Year last generator placed in operation: 1954

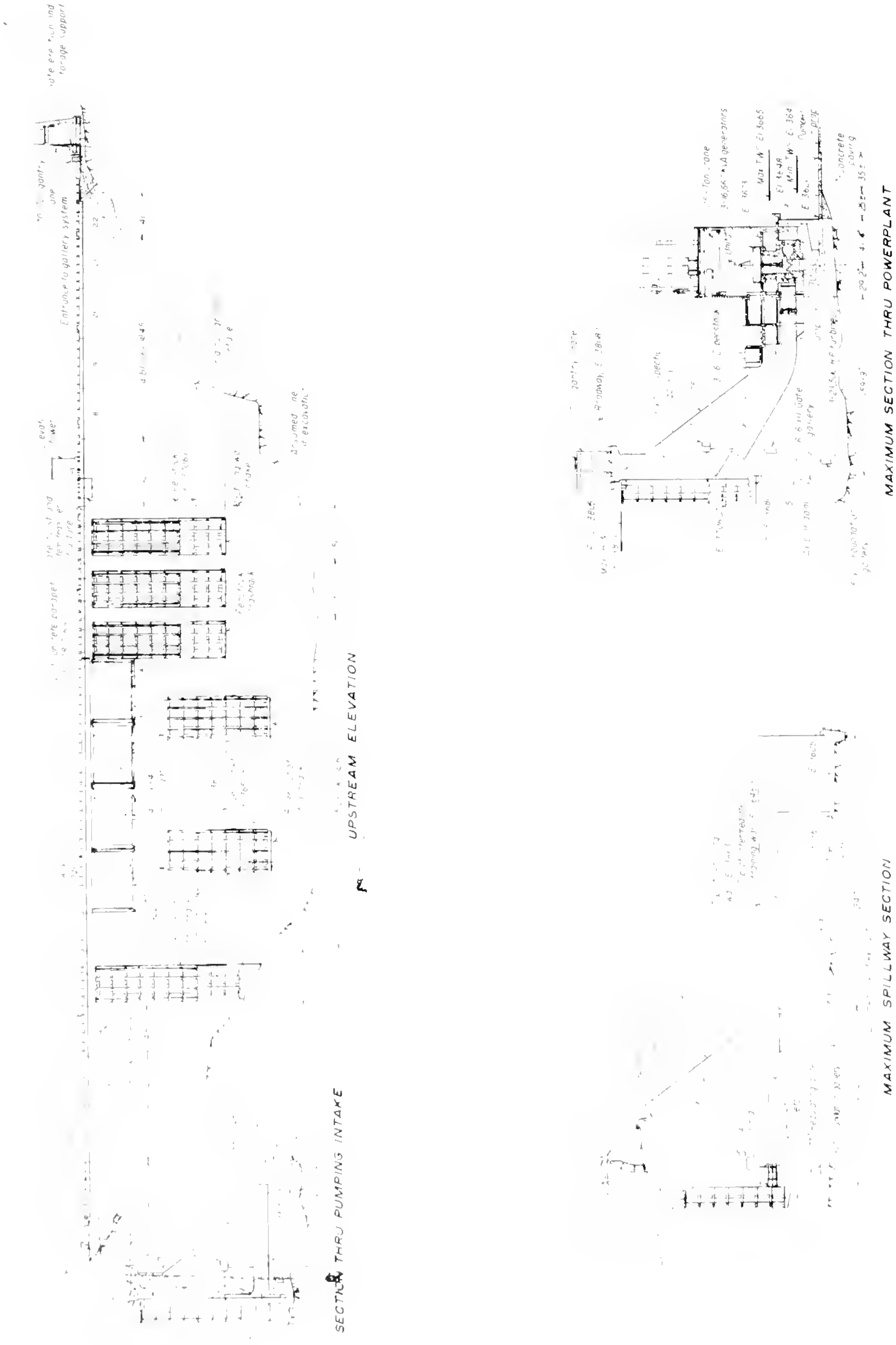
Nameplate capacity	50,000	kW
Number and capacity of generators (3)	16,667	kW
Maximum head	160	ft

SWITCHYARDS

Number in operation	1	
Total capacity of transformers	62,500	kVA



Canyon Ferry Dam, Plan

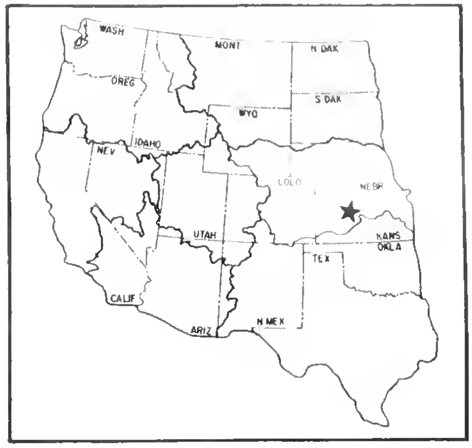


Canyon Ferry Dam. Sections

Pick-Sloan Missouri Basin Program
Cedar Bluff Unit, Smoky Hill Division

Kansas: Ellis and Trego Counties

Lower Missouri Region
Water and Power Resources Service



The Cedar Bluff Unit is on the north side of Smoky Hill River, 18 miles southwest of Ellis, Kans. It consists of an earthfill dam and reservoir, a water delivery system to serve the lands of Cedar Bluff Irrigation District No. 6, water service to the Cedar Bluff National Fish Hatchery, and municipal and industrial water service to Russell, Kans. The unit also protects the downstream valley from floods.

PLAN

The lands of the Cedar Bluff Irrigation District No. 6 served by the unit total 6,800 irrigable acres. The reservoir storage capacity and the Smoky Hill River flows provide up to 4,000 acre-feet of water annually for the Cedar Bluff National Fish Hatchery, and up to 2,000 acre-feet of water annually for the city of Russell.

Cedar Bluff Dam

Cedar Bluff Dam is a rolled earthfill structure with rock riprap on the upstream face. The dam rises 134 feet above streambed, has a crest length of 12,560 feet, and a volume of 8,490,000 cubic yards.

The uncontrolled concrete overflow spillway is located on the right abutment. An ungated orifice through the spillway crest operates when water rises into the flood control capacity. Eight gated sluiceways through the base of the spillway crest also can aid in rapid evacuation of the flood control reservoir capacity. Gated outlet works through the base of the dam release water into the canal for irrigation, to the fish hatchery, and into the river for the city of Russell and for other downstream requirements.

The total capacity of Cedar Bluff Reservoir is 376,950 acre-feet: 149,770 acre-feet for irrigation, the fish hatchery, and municipal use; 191,860 acre-feet for flood control; and the remaining 35,320 acre-feet for inactive and dead capacity.

Cedar Bluff Canal

The Cedar Bluff Canal originates at the reservoir outlet works and extends eastward on the north side of the river. The canal and its lateral system serve a total of 6,800 acres: 6,342 by gravity, and 458 by canal-side pumps. The canal is 18.1 miles long.

DEVELOPMENT

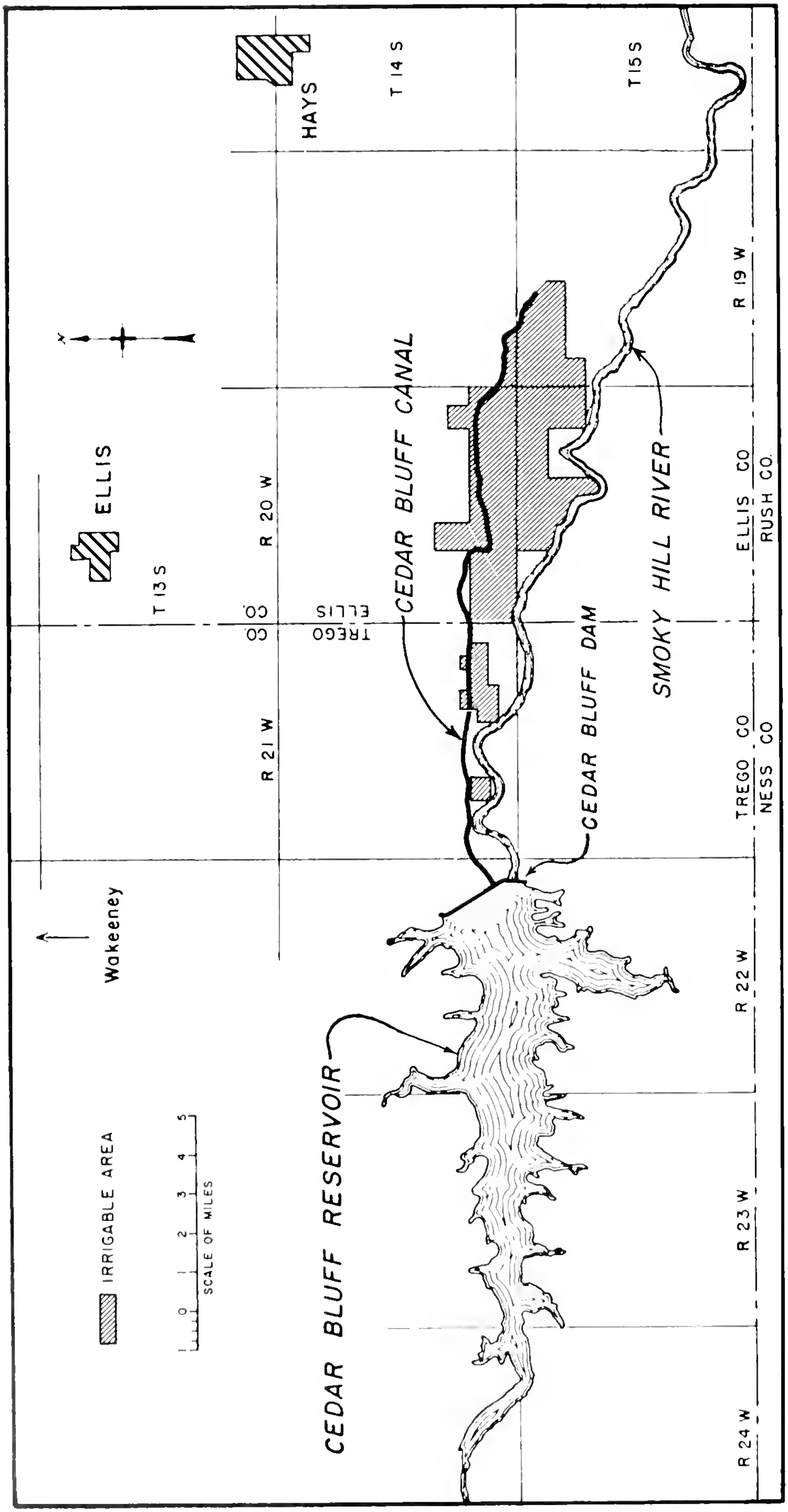
Taos Indians constructed a pueblo at the present site of the Scott County State Park, diverted the waters of a large spring, and dug irrigation ditches to serve their fields of maize. A settler, who homesteaded the land in the park, built his home near the pueblo ruins and reconstructed the Indians' irrigation system. However, until 1872 there were only 12 homesteaders in Ellis County, and most agricultural attempts were failures.

In 1875, large numbers of immigrant farmers established homes in the southern part of Ellis County; one of the colonies occupied part of the present project area. The agricultural production was limited to the raising of wheat, except for small vegetable gardens. Cattle grazing also was carried on to some extent. The predominant crop of the area is corn.

Investigations

The extreme drought in western Kansas during 1930-40 focused nationwide attention on Cedar Bluff and the surrounding areas. A popular demand developed for formal investigations to determine the practicability of projects for irrigation, flood control, and other possible water utilization. This area was otherwise entirely dependent upon dry farming, with wheat as the major crop. The towns of Hays, Russell, Victoria, and Gorham also were concerned over decreasing municipal well water supplies and became interested in a reservoir to supplement their existing sources.

The Bureau of Reclamation studied the problem in the local area while conducting investigations of the entire



Cedar Bluff Unit

Cedar Bluff Dam

Missouri River Basin. Surveys of the Smoky Hill River Basin and the Cedar Bluff Unit were started in October 1941, but discontinued during World War II; they were resumed in March 1946.

Authorization

The Cedar Bluff Unit was authorized by the Flood Control Act of December 22, 1944, Public Law 534, 78th Congress, 2d session (58 Stat. 887). This act approved and, in part, authorized the comprehensive Missouri River Basin development plans presented in Senate Document 191, as revised and coordinated with the Corps of Engineers plans by Senate Document 247. Both documents were of the 78th Congress, 2d session.

Construction

Construction of Cedar Bluff Dam was begun April 1, 1949, and the dam and reservoir were completed September 29, 1951. Construction of the water delivery system to serve lands in the Cedar Bluff Irrigation District No. 6 began in 1961, and water was available to the entire 6,200 acres of project lands originally included in the unit by July 1963. By amendment No. 1 to contract No. 14-06-700-2118, dated October 27, 1969, the irrigable acreage was increased to 6,800.

Operating Agencies

Cedar Bluff Dam and Reservoir are operated and maintained by the Bureau of Reclamation. Operation of the reservoir is coordinated with that of other dams and reservoirs in the Kansas River Basin. The Corps of Engineers furnishes data and information on operational procedures for regulation of water stored in the flood control capacity. Operation of the recreation areas is administered by the Kansas State Park and Resources Authority. Operation and maintenance of all irrigation facilities is by the Cedar Bluff Irrigation District No. 6. The Kansas Forestry, Fish and Game Commission administers the water surface and wildlife lands.

BENEFITS

Irrigation

Principal crops grown under irrigation are sorghums, corn, hay, and ensilage. The introduction of these and other crops permits diversification and the adoption of good soil and crop management practices. With a dependable food supply available, raising and fattening cattle and hogs are stable and profitable sources of income.

Municipal Water

Up to 2,000 acre-feet of water is available annually from the reservoir for use by the city of Russell. Releases are made directly to the Smoky Hill River for diversion by city-owned pumps and pipelines. In 1966, the State of Kansas approved a water right granting the city of Russell a storage limit in Cedar Bluff Reservoir of 2,700 acre-feet and maximum releases from storage of 2,000 acre-feet per year.

Flood Control

The flood of May 1938 had an estimated peak flow of 97,000 cubic feet per second at Cedar Bluff Dam. Bef construction of the dam and reservoir, this and numerous other floods caused severe damage to crops, livestock, and property in the valley. Cedar Bluff Dam and Reservoir now control the floodwaters and ordinarily maintains the outflow at or below the channel capacity.

Recreation and Fish and Wildlife

Excellent hunting, fishing, boating, water skiing, swimming, picnicking, and camping attract many visitors to the reservoir each year. Facilities include campgrounds, picnic areas, and boat-launching ramps. The Cedar Bluff Fish Hatchery, located immediately below the dam, ensures an adequate stocking program.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	6,800	acres
Number of irrigated farms	66	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	5,795	482,078
1969	6,235	587,504
1970	5,423	538,736
1971	5,897	610,884
1972	5,654	918,831
1973	6,144	1,318,497
1974	6,755	1,777,708
1975	6,755	1,515,177
1976	6,763	1,419,238
1977	6,747	894,405

Facilities in Operation

Storage dams	1	
Canals	18.1	mi
Laterals	25.1	mi
Drains	1.7	mi

Climatic Conditions

Annual precipitation	23.1	in
Temperature:		
Maximum	112	°F
Minimum	−23	°F
Mean	53	°F
Growing season	166	days
Elevation of irrigable area	2070.0	ft

Settlement:

Number of persons served with project water (1977):

Farm irrigation service	140
Municipal water releases to Russell, Kans.	6,307
Total	6,447

ENGINEERING DATA

Water Supply

SMOKY HILL RIVER

Drainage area above Cedar Bluff Dam	4,980	mi²
Annual discharge at Cedar Bluff Dam:		
Maximum (1951)	434,100	acre-ft
Minimum (1954)	11,400	acre-ft
Average	60,566	acre-ft
Average annual diversion	14,565	acre-ft

Storage Facilities

CEDAR BLUFF DAM

Type: Zoned earthfill
Location: On the Smoky Hill River, about 18 mi southwest of Ellis, Kans.
Construction period: 1949-51
Reservoir, Cedar Bluff:

Average annual inflow	60,566	acre-ft
Total capacity to El. 2166	376,950	acre-ft
Active capacity, El. 2107.8 to 2166	341,630	acre-ft
Surface area, top of conservation capacity	6,869	acres
Dimensions:		
Structural height	202	ft
Hydraulic height	102	ft
Top width	30	ft
Maximum base width	910	ft
Crest length	12,560	ft
Crest elevation	2198.0	ft
Total volume	8,490,000	yd³

Spillway: Uncontrolled concrete weir and concrete-lined channel at right abutment, with uncontrolled 14.5- by 10-ft orifice through crest at its center, and with eight sluiceways through base of crest, each controlled by one 5-ft-square slide gate.

Crest length	150.5	ft
Crest elevation:		
Weir	2166.0	ft
Orifice	2144.0	ft
Sluices	2134.8	ft
Capacity at El. 2192	91,000	ft³/s

Outlet works: Concrete conduit through base of dam at left abutment controlled by one 4- by 5-ft slide gate.

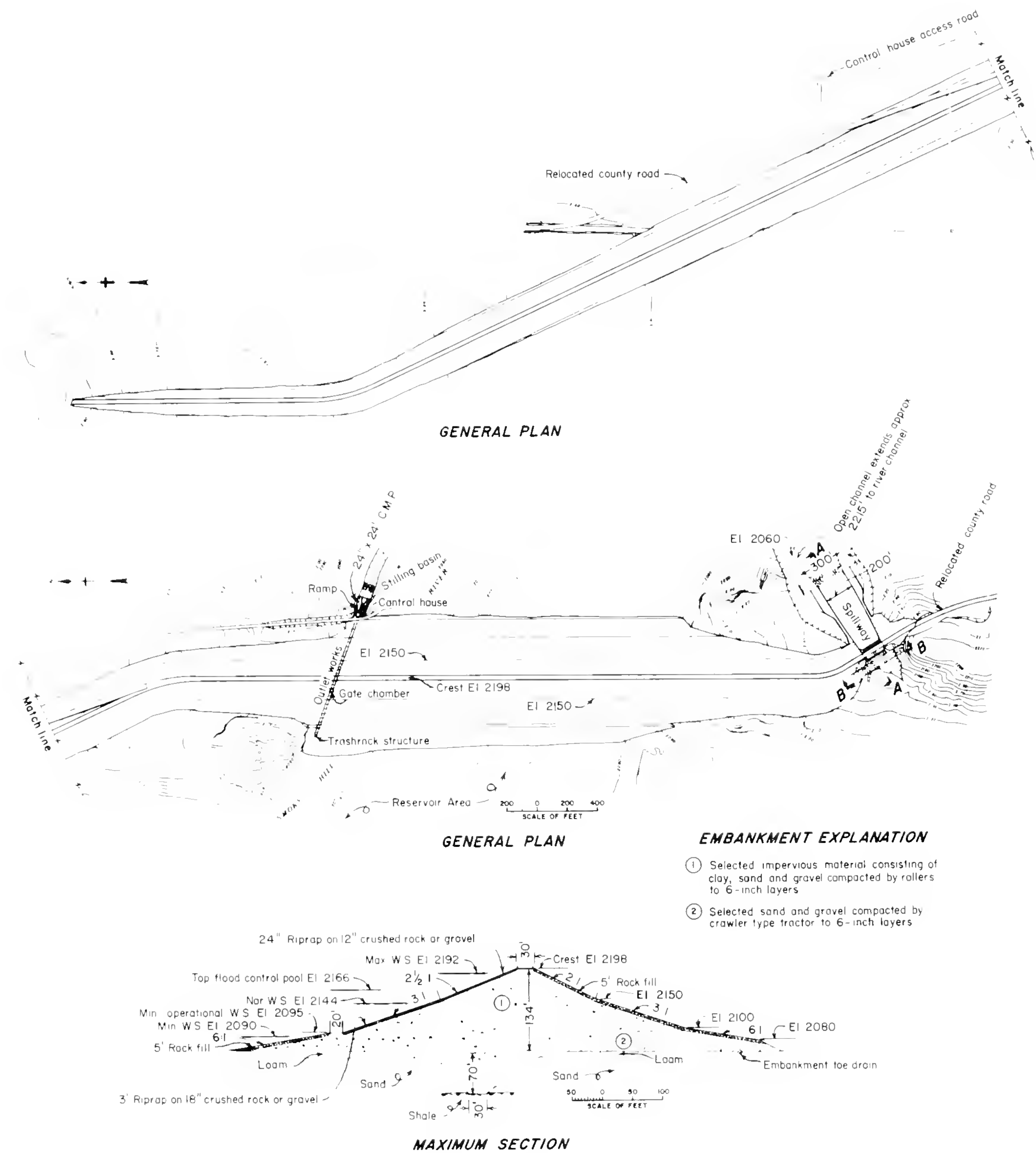
Capacity at El. 2144	800	ft³/s

Carriage Facilities

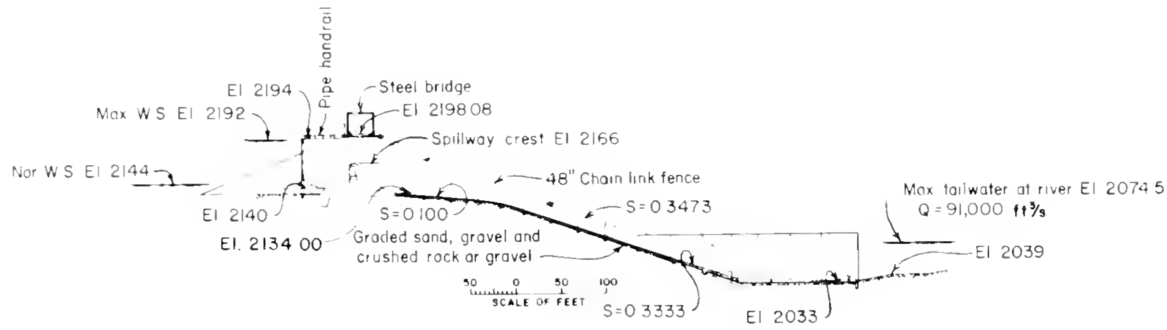
CEDAR BLUFF CANAL

Location: On the north side of the Smoky Hill River from Cedar Bluff Dam running in an easterly direction to near the town of Antonino, Kans.
Construction period: 1961-63

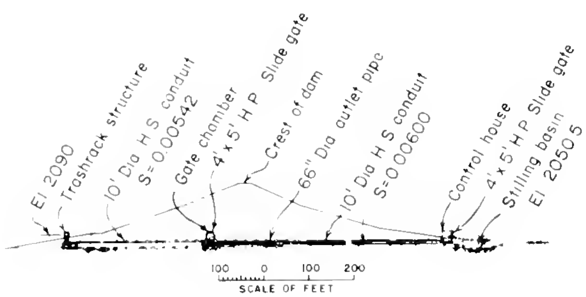
Length	18.1	mi
Diversion capacity	125	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	4.1	ft
Typical maximum section, earth lined:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	4.1	ft
Lining thickness	2	ft



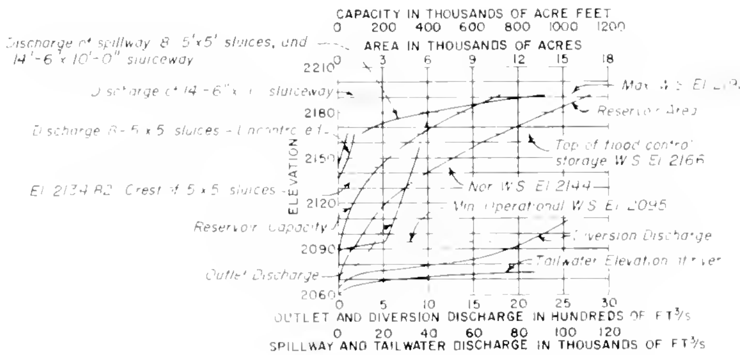
Cedar Bluff Dam, Plan and Section



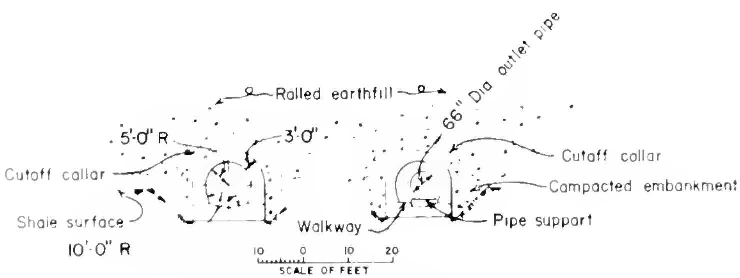
SECTION A-A



SECTION ALONG ℄ OF OUTLET WORKS

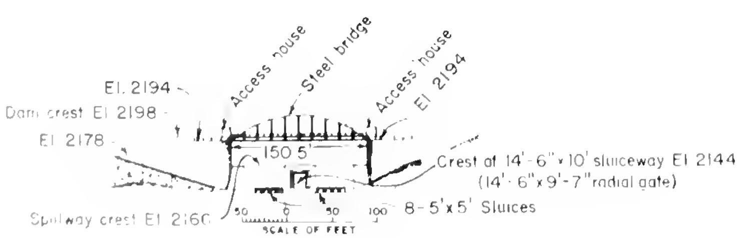


AREA-CAPACITY-DISCHARGE CURVES



UPSTREAM OUTLET CONDUIT

DOWNSTREAM OUTLET CONDUIT



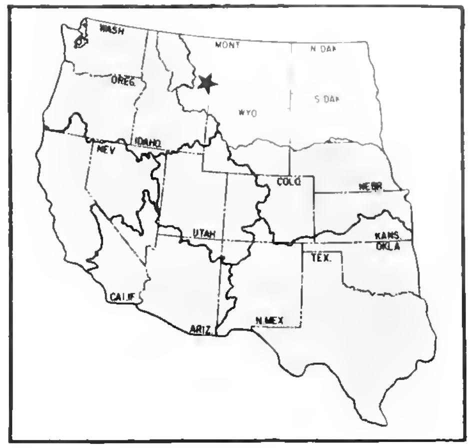
ELEVATION B-B

Cedar Bluff Dam, Sections

Pick-Sloan Missouri Basin Program
Crow Creek Pump Unit, Three Forks Division

Montana: Broadwater County

Upper Missouri Region
Water and Power Resources Service



The Crow Creek Pump Unit was developed at the request of the Commissioners of Broadwater County for facilities to irrigate an acreage of land equal to that inundated by Canyon Ferry Lake before the land in the reservoir area was taken out of production. This acreage is part of the 23,400 acres of new irrigable land in the Crow Creek Unit of the Three Forks Division and the Broadwater-Missouri Unit described in Senate Document 191. Features include Crow Creek Pumping Plant, the Toston Tunnel, Toston Canal, Lombard Canal, and the lateral and drainage systems.

PLAN

Water is pumped from the west bank of the Missouri River by the Crow Creek Pumping Plant and flows through the Toston Tunnel to the Toston Canal, thence to the Lombard Canal for distribution to project land.

The controlled water surface at the Broadwater-Missouri Diversion Dam approximately 1.5 miles below the pump site maintains a water depth at the pumping plant of more than 5 feet. The 5,018 acres of land in the Crow Creek Pump Unit that can be irrigated require an average annual diversion of 16,800 acre-feet at a maximum rate of 100 cubic feet per second.

Pumping Plant

The Crow Creek Pumping Plant is on the left bank of the Missouri River about 6 miles upstream from Toston, Mont. The plant contains three units. Each 33.3-cubic-foot-per-second pump is driven by a 900-horsepower synchronous motor operating against a total dynamic head of 180 feet.

Toston Tunnel and Canal

The 6.5-foot concrete-lined, horseshoe shaped Toston Tunnel has a design capacity of 100 cubic feet per second. It is 2,044 feet long, with 120 feet of 6.5-foot covered conduit inlet. The outlet transition is 15 feet long and connects with the 100-cubic-foot-per-second Toston Canal, which is 7.8 miles long.

Lombard Canal

The Lombard Canal diverts water from the Toston Canal about 1.5 miles from the tunnel to irrigate lands in the northern section of the unit. The Lombard Canal is 3 miles in length and has a capacity of 60 cubic feet per second.

Lateral and Drainage Systems

The lateral system has a total length of 10 miles with capacity to irrigate 4,510 acres. The drainage system is 4.7 miles in length.

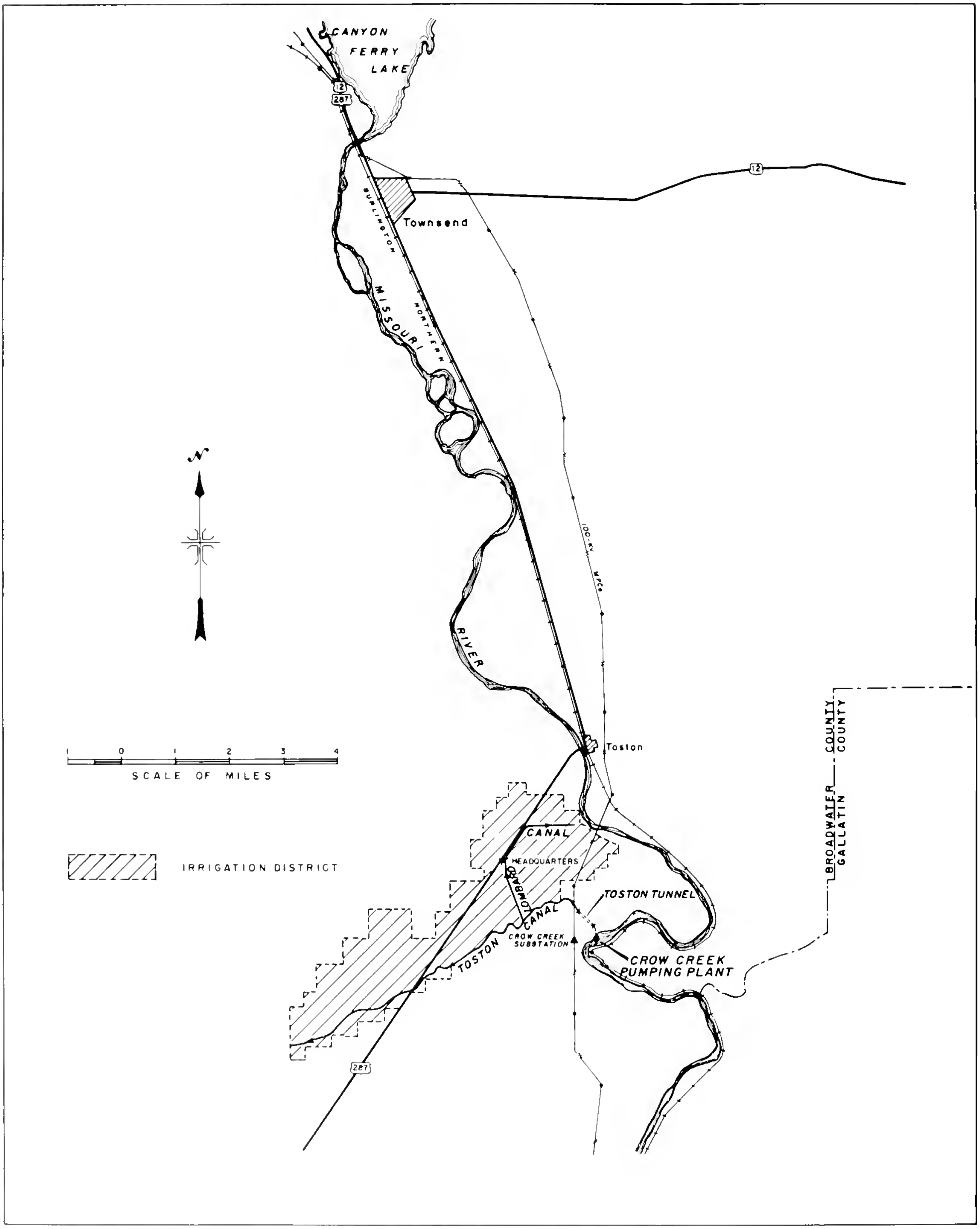
DEVELOPMENT

Early History

The first trading post in the vicinity was established at Three Forks in 1810, and the first settlement on Crow Creek was made in 1865. Following the discovery of gold at Radersburg, several large ranches were established along Crow Creek between 1865 and 1880. The area was homesteaded between 1912 and 1914 under the Homestead Act, which allowed 160 acres to each entry. Because of small units and drought conditions beginning in 1918 and continuing into the early 1920's, many of the settlers moved away and the lands were idle until 1944, when 100 acres were put into wheat production. By 1949, about one-fourth of the irrigable acreage was used for the production of wheat.

Investigations

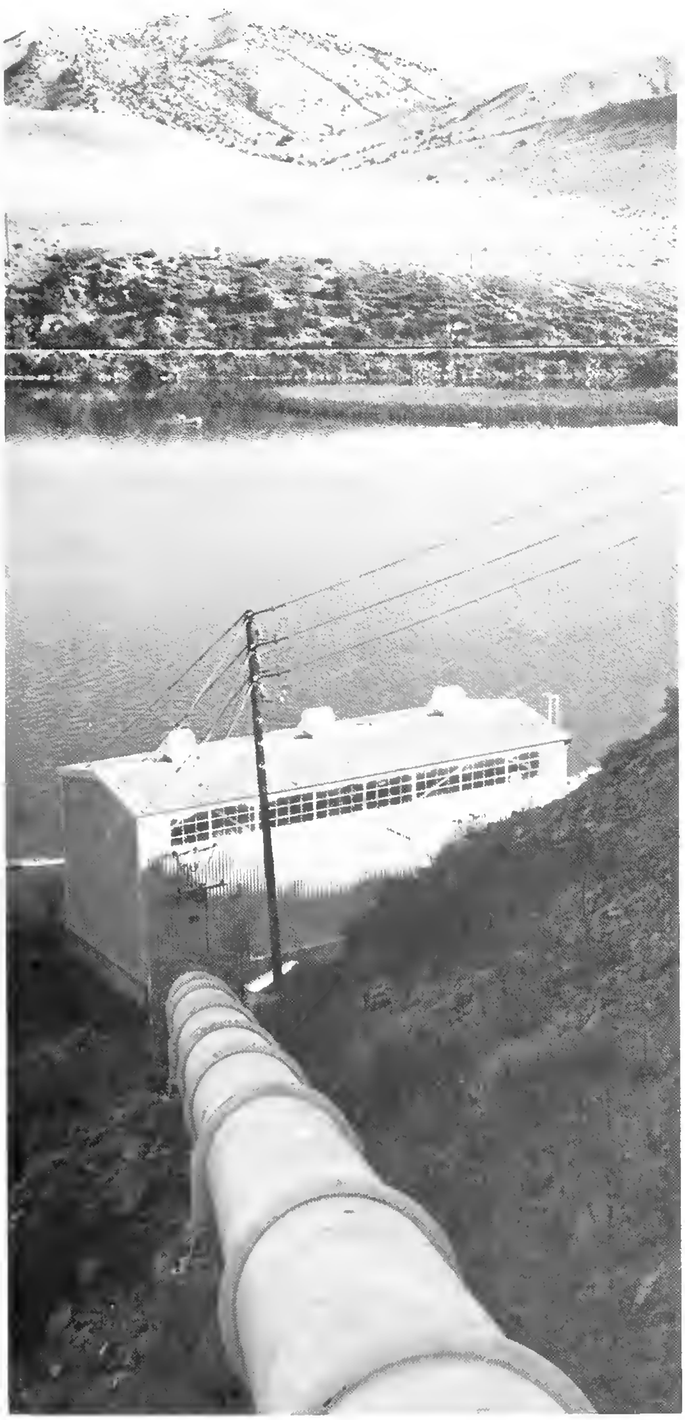
The Reclamation Service made the first investigation of the area, including the Crow Creek Pump Unit, in 1905 and 1906 for a Madison River project. The plan proposed construction of a reservoir on the Madison [illegible] and an expensive diversion canal along steep [illegible]



Crow Creek Pump Unit

quiring numerous tunnels, flumes, and deep cuts. In 1920, a private firm employed by the former Crow Creek Irrigation District made a second report. This plan envisioned the irrigation of 18,000 acres from a proposed Glendale Reservoir located on Crow Creek. It was later expanded to include a diversion canal from the Jefferson River with a total project area of 65,000 acres.

A reconnaissance made by the Bureau of Reclamation in 1942 on the Missouri River Basin from Three Forks to



Crow Creek Pumping Plant

Canyon Ferry estimated the total irrigable area at 32,800 acres within the Crow Creek Unit, including the 8,000 acres along the main canal in the Jefferson River Basin. The initial plan of irrigation by gravity diversion from the Jefferson River was revised and the irrigable area was reduced to 23,400 acres of new land and about 5,300 acres of supplemental land to be served by water diverted from the Madison River.

Authorization

This unit was authorized by the Flood Control Act of July 24, 1946, which extended the original Basin Act of 1944. Construction was initiated in connection with the Canyon Ferry Unit under a specific provision in fiscal year 1949 and in subsequent appropriation acts for the Department of the Interior.

Construction

Construction began in 1952 and was substantially completed in 1954.

Operating Agency

Operation and maintenance functions are performed by the Toston Irrigation District.

BENEFITS

Irrigation

Grain and livestock predominate in the area, but the establishment of irrigation produced an increase in the crops of sugar beets, potatoes, and hay.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	5,018	acres
Number of irrigated farms	32	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,644	502,098
1969	4,630	594,629
1970	4,603	597,711
1971	4,692	760,259
1972	4,712	1,255,896
1973	4,729	1,344,57[illegible]
1974	4,761	1,51[illegible]
1975	4,770	[illegible]
1976	4,841	[illegible]
1977	4,945	[illegible]

Facilities in Operation

Canals	11	mi
Laterals	10	mi
Pumping plants	1	
Drains	4.7	mi

Climatic Conditions

Annual precipitation	11.4	in
Temperature:		
Maximum	105	°F
Minimum	−39	°F
Mean	43	°F
Growing season	104-108	days
Elevation of irrigable area	3940-4120.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	40

ENGINEERING DATA

Water Supply

Missouri River

(See Canyon Ferry Unit for streamflow data.)

Average annual diversion	18,620	acre-ft

Carriage Facilities

Crow Creek Pumping Plant Discharge Line

Location: West from Crow Creek Pumping Plant on the Missouri River about 3 mi south of Toston, Mont.
Construction period: 1953-54
Description: Welded steel pipe

Length	950	ft
Diameter	52	in
Capacity	100	ft³/s

Toston Tunnel

Location: Northwest from end of Crow Creek Pumping Plant discharge line, about 3 mi south of Toston, Mont.
Construction period: 1952-53

Length	2,044	ft
Capacity	100	ft³/s
Cross section: Horseshoe		
Diameter	6.5	ft
Lining: Concrete		

Toston Canal

Location: Generally southwest from end of Toston Tunnel, about 3 mi south of Toston, Mont., to vicinity of Warm Springs Creek, about 8 mi southwest of Toston.
Construction period: 1953-54

Length	7.8	mi
Diversion capacity	100	ft³/s
Typical maximum section in earth:		
Bottom width	8	ft
Side slopes	1.5:1	
Water depth	3.4	ft

Lombard Canal

Location: From mile 2.2 on Toston Canal, about 3.5 mi south of Toston, Mont., generally north to a point about 2 mi southwest of Toston, then east to the Missouri River.
Construction period: 1953-54

Length	3	mi
Diversion capacity	60	ft³/s
Typical maximum section in earth:		
Bottom width	7	ft
Side slopes	1.5:1	
Water depth	2.78	ft

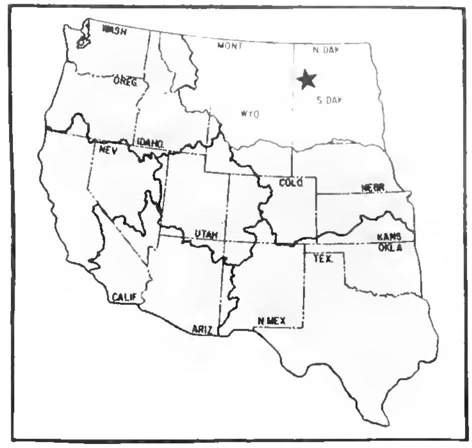
Crow Creek Pumping Plant

Number of units	3	
Total capacity	100	ft³/s
Total dynamic head	180	ft
Total horsepower	2,700	

Pick-Sloan Missouri Basin Program
Dickinson Unit

North Dakota: Stark County

Upper Missouri Region
Water and Power Resources Service



Dickinson Dam and Reservoir (Edward Arthur Patterson Lake) store water for irrigating valley lands downstream from the dam, and for a municipal water supply for the city of Dickinson, N. Dak. Some 400 acres of irrigable lands, in isolated tracts, are served by privately constructed pumping plants located along the Heart River near Dickinson. Flood control, fish and wildlife, and recreation benefits also are realized.

PLAN

The water supplied from Edward Arthur Patterson Lake is pumped by private operators; therefore, the Federal Government does not contemplate the construction or operation of irrigation distribution works.

Dickinson Dam

Dickinson Dam is a homogeneous earthfill structure across the Heart River, 1.5 miles west of Dickinson. It has a structural height of 62 feet and is 2,275 feet long across the crest. It contains 324,000 cubic yards of materials. A combined overflow spillway and outlet works is located near the right abutment of the dam. The capacity of the spillway is 33,200 cubic feet per second at water surface elevation 2428.9 and of the outlet works, 40 cubic feet per second at water surface elevation 2416.5.

DEVELOPMENT

Early History

Settlement of the area began after 1864. The early occupants were ranchers who settled along the streams and used the public domain for grazing large herds of livestock. With the building of the Northern Pacific Railway into the Heart River Basin in the 1880's, immigration became general and large ranches soon gave way to homesteads. Large numbers of settlers came during 1900-10, and engaged in the production of cash grain crops. Favorable prices and rainfall encouraged grain farming, and as a result extensive areas of rangeland were plowed up and the remaining range was grazed intensively. Although livestock production continued to be important, the increased demand for wheat during World War I brought on a tremendous expansion in wheat acreage. The drought years of the 1930's and prevailing low prices seriously disrupted the economy and led to emigration and abandonment of farms.

Investigations

The Reclamation Service first recognized the potentialities of the Heart River Basin by making a reconnaissance survey of the area in 1903-04. The comparatively high cost of developing the basin and lack of active support from the landowners led to the conclusion that further studies were not justified. The demand for irrigation and flood control increased and decreased with the climatic cycles.

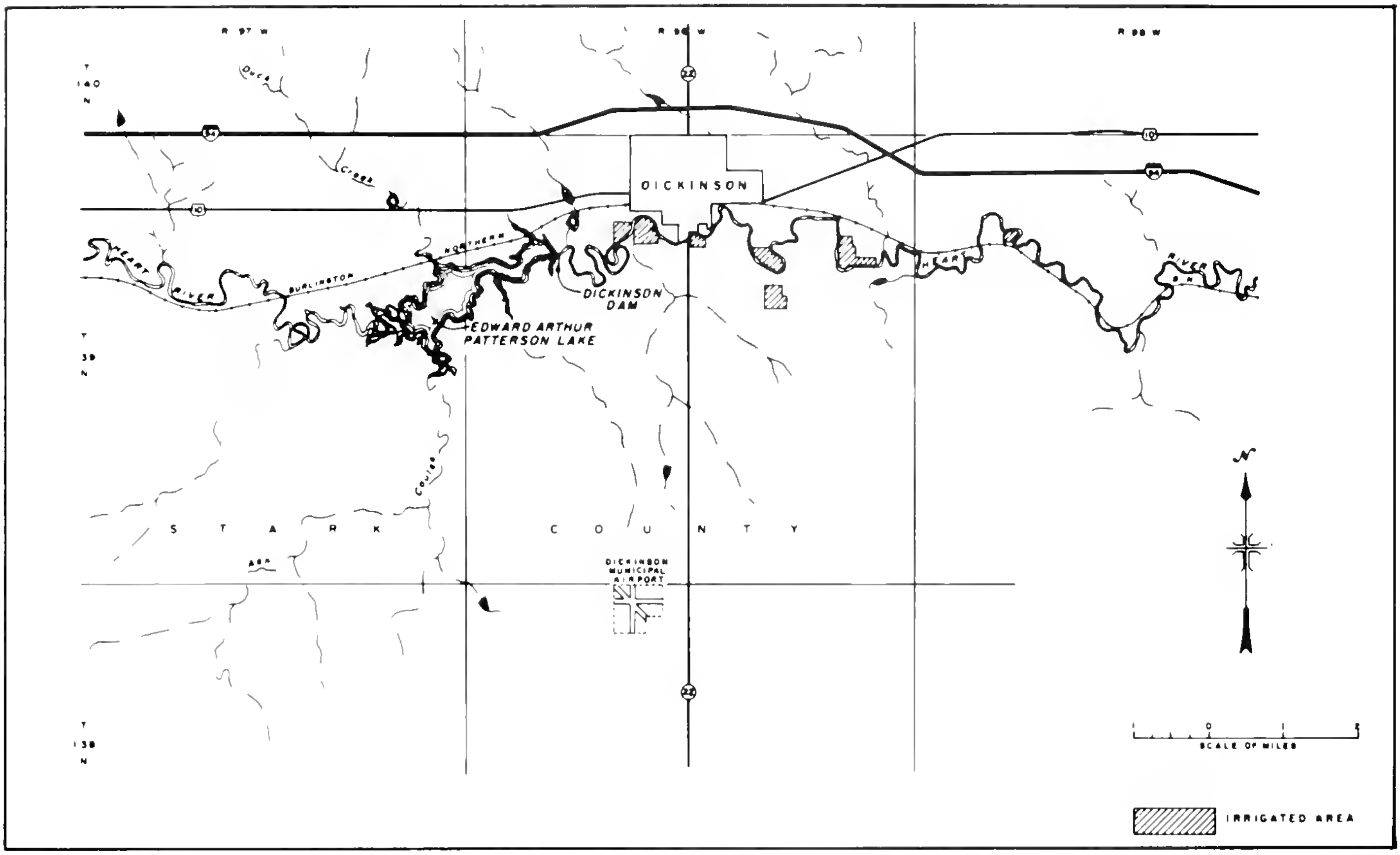
The Bureau of Reclamation began new investigations in 1926. The study showed that land could be irrigated and floods controlled, but no further work was recommended. The Corps of Engineers conducted surveys and issued reports in 1934 and 1937, and in 1942 the Bureau of Reclamation completed an investigation of the Heart River Basin and proposed the Heart Butte and Dickinson Units for development.

Authorization

The Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191, as revised and coordinated by Senate Document 247, 78th Congress, 2d session, authorized the unit.

Construction

Construction of Dickinson Dam began in March 1949 and was completed in March 1950. Initial water deliveries were made to the city of Dickinson in May 195[illegible].



Dickinson Unit

Dickinson Dam and Edward Arthur Patterson Lake

Operating Agency

Dickinson Dam and Edward Arthur Patterson Lake are operated by the Bureau of Reclamation.

BENEFITS

Irrigation

Storage of floodwater has transformed 400 acres of irrigable lands from uncertain dry-farming to production of alfalfa, oats, corn, barley, potatoes, and truck crops.

Municipal and Industrial Water

The storage of water has enabled the city of Dickinson to maintain a water supply for municipal and industrial use.

Recreation

Edward Arthur Patterson Lake is located in the prairie uplands where there are no natural lakes. Although small, it has provided new types of recreation for southwestern North Dakota and is highly popular for camping, picnicking, swimming, boating, and fishing. Designated areas are leased to a youth group and cabin owners. Dickinson City Park Board administers the reservoir area for recreational and agricultural uses. Public use of the unit amounted to 409,300 visitor days in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	400	acres
Number of irrigated farms	8	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	263	16,787
1969	310	15,770
1970	247	24,000
1971	215	21,200
1972	205	18,801
1973	199	30,830
1974	300	36,700
1975	300	34,200
1976	374	41,950
1977	135	22,056

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	16.3	in
Temperature:		
Maximum	108	°F
Minimum	−37	°F
Mean	42	°F
Growing season	121	days
Elevation of irrigable area	2410-2465.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	20
Municipal water service	15,000
Total	15,020

ENGINEERING DATA

Water Supply

HEART RIVER

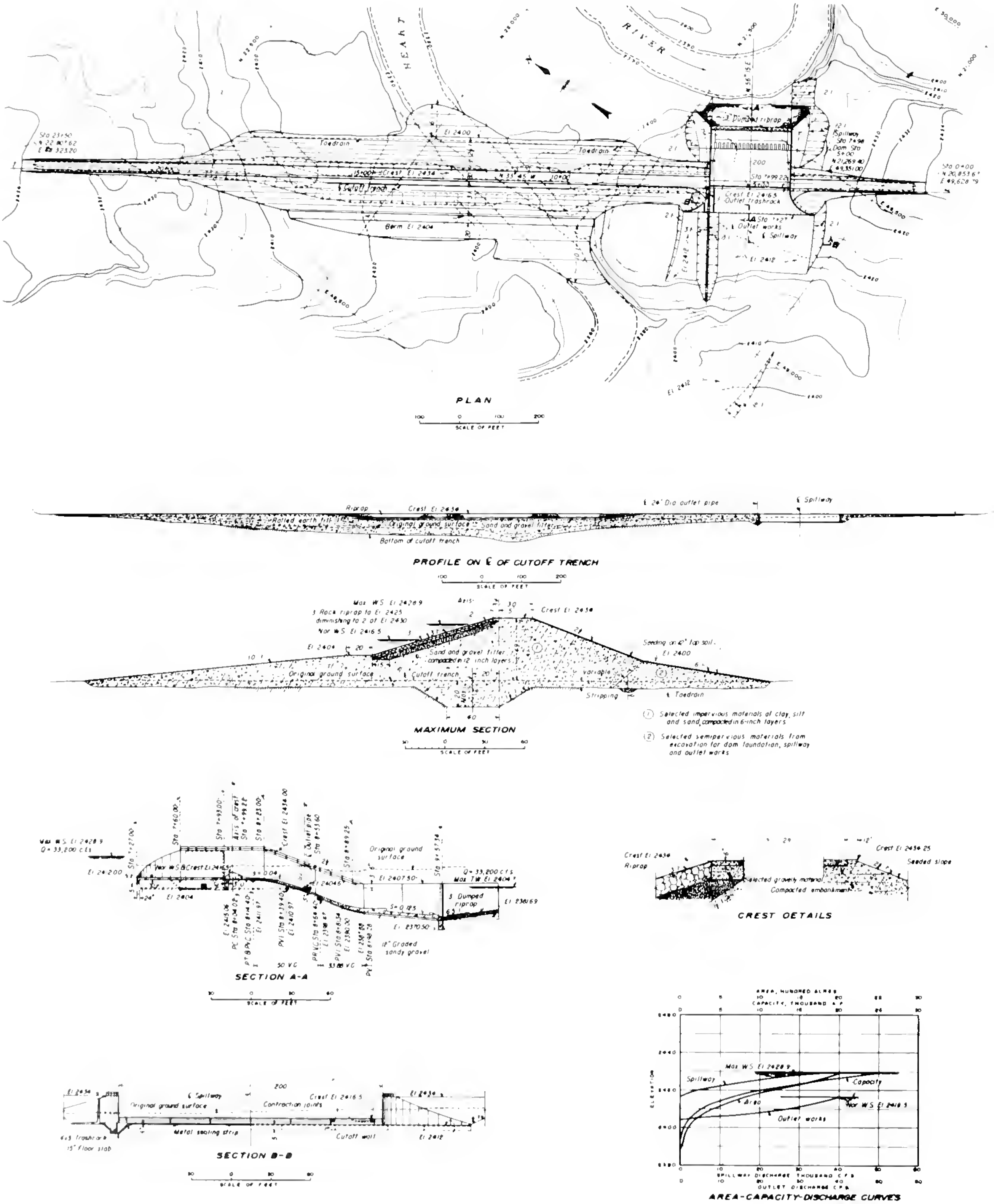
Drainage area above Dickinson Dam	405	mi²
Annual discharge below Dickinson Dam:		
Maximum (1972)	59,300	acre-ft
Minimum (1968)	100	acre-ft
Average	19,400	acre-ft

Storage Facilities

DICKINSON DAM

Type: Homogeneous earthfill
Location: On the Heart River 1.5 mi west of Dickinson, N. Dak.
Construction period: 1949-50
Date of closure (first storage): May 1950

Reservoir, Edward Arthur Patterson Lake:		
Total capacity to El. 2416.5	6,676	acre-ft
Active capacity, El. 2405-2416.5	5,441	acre-ft
Surface area	819	acres
Dimensions:		
Structural height	62	ft
Hydraulic height	49	ft
Top width	30	ft
Maximum base width	520	ft
Crest length	2,275	ft
Crest elevation	2434.0	ft
Volume	324,000	yd³
Spillway: Uncontrolled concrete crest and concrete-lined channel at right abutment.		
Crest length	200	ft
Crest elevation	2416.5	ft
Capacity at El. 2428.9	33,200	ft³/s
Outlet works: Intake in left wall of spillway and 24-in pipe in concrete box structure along left wall of spillway leading to city of Dickinson 30-in supply line. Controlled by one 2-ft-square slide gate.		
Capacity at El. 2416.5	40	ft³/s

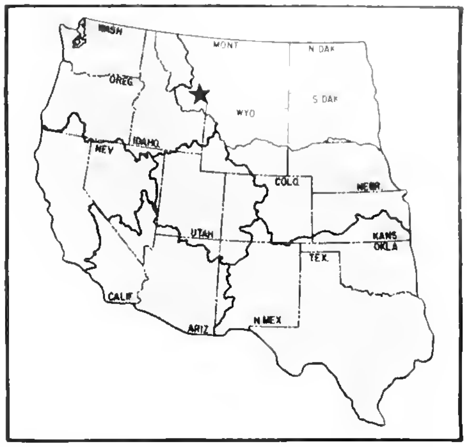


Dickinson Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
East Bench Unit

Montana: Beaverhead and Madison Counties

Upper Missouri Region
Water and Power Resources Service



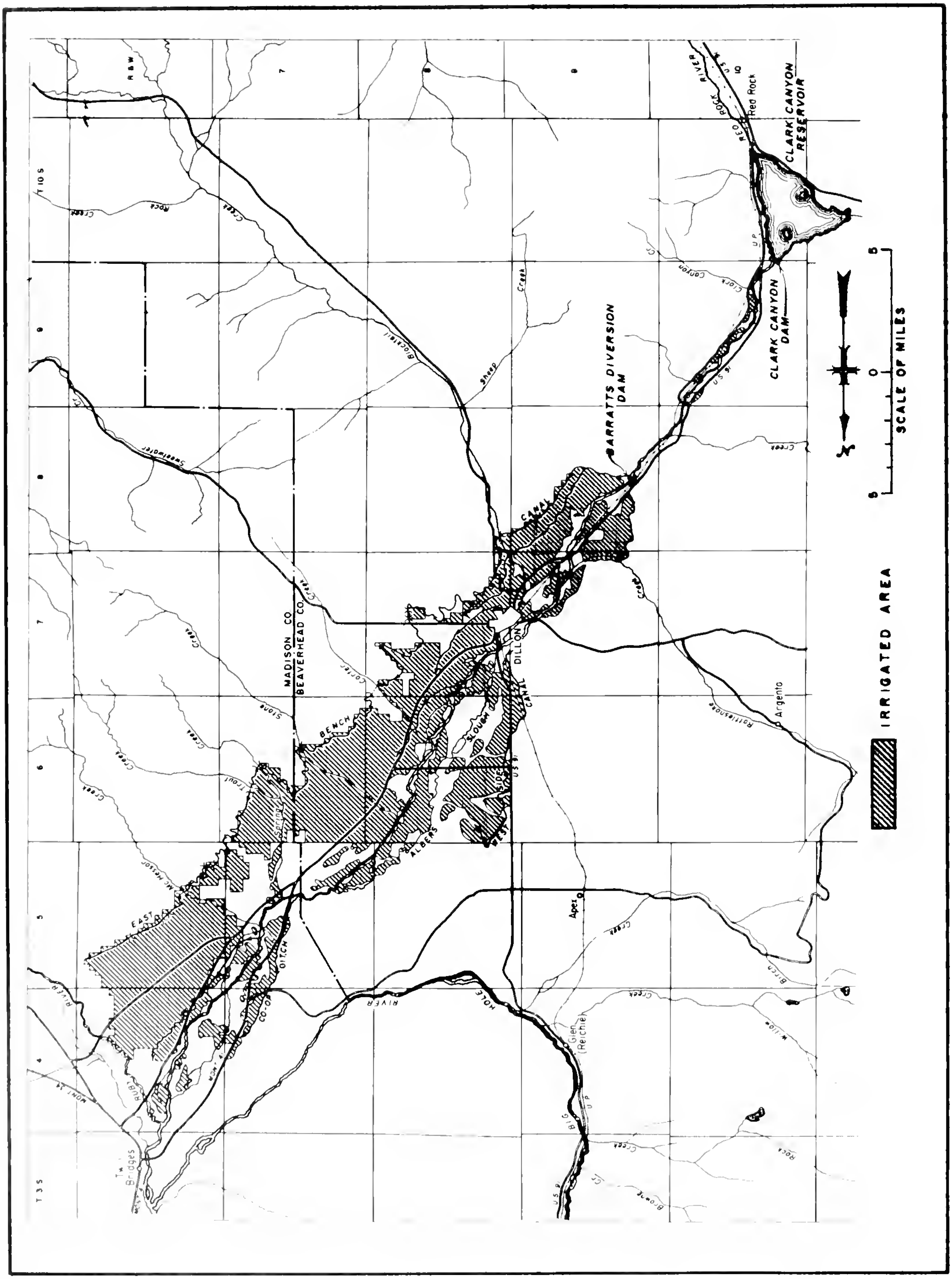
The East Bench Unit is in southwestern Montana, along the Beaverhead River. The unit provides full irrigation service to 21,800 acres and supplemental irrigation service to 28,000 acres. Principal features include Clark Canyon Dam and Reservoir, Barretts Diversion Dam, East Bench Canal, and a system of laterals and drains.

PLAN

Clark Canyon Dam has been constructed at the head of the Beaverhead River to impound surplus flows of Horse Prairie Creek and Red Rock River, which join to form the Beaverhead River. Water stored at Clark Canyon Reservoir will be released into the Beaverhead River for downstream irrigation.

Barretts Diversion Dam, 11 miles below Clark Canyon Dam, diverts water from Beaverhead River to the East Bench Canal and the Canyon Canal. About 17,200 acres of irrigable land on East Bench are served through a system of laterals, and the remaining acreage on the bench is served directly from the East Bench Canal. The Canyon Canal is a private facility which supplies a portion of the formerly irrigated valley land. Drains and wasteways have been built to intercept and convey excess water from the benchland to safe disposal points and eventually into the Beaverhead River.

Clark Canyon Dam



East Bench Unit

Clark Canyon Dam recreation area

Clark Canyon Dam and Reservoir

Clark Canyon Dam is constructed at the head of the Beaverhead River. The zoned earthfill dam has a structural height of 147.5 feet, a crest length of 2,950 feet, and a volume of 1,970,000 cubic yards of material. The spillway consists of an approach channel, concrete inlet channel, ungated concrete crest, concrete chute, concrete stilling basin, and an outlet channel. The outlet works consists of an approach channel; concrete intake structure; concrete conduit; a gate chamber with four 3- by 6.5-foot high-pressure gates, two of which serve for emergency ahead of the regulating gates; concrete access shaft and shaft house; and a concrete stilling basin. The outlet channel is shared by the outlet works and spillway.

Clark Canyon Reservoir has a total capacity of 257,152 acre-feet and an active capacity of 126,117 acre-feet. The reservoir surface area is 5,903 acres.

Barretts Diversion Dam

Barretts Diversion Dam is a concrete, gated structure with embankment wings on the Beaverhead River 8 miles southwest of Dillon, Mont. The spillway capacity is 2,500 cubic feet per second, controlled by one 24- by 10-foot radial gate. The sluiceway is controlled by one 8-by 10-foot radial gate. The headworks capacity of East Bench Canal is 440 cubic feet per second, controlled by two 10- by 8-foot radial gates. The Canyon Canal headworks capacity is 200 cubic feet per second, controlled by one 10- by 8-foot radial gate. One 24-inch-diameter slide gate and one 36- by 30-inch slide gate, in series, control the discharge of water into the existing Rebich Ditch, which has a capacity of 12 cubic feet per second. A fish excluder is upstream of the canal headworks.

East Bench Canal

East Bench Canal heads at Barretts Diversion Dam and runs in a northeasterly direction for 44.2 miles. Initial capacity of the canal is 440 cubic feet per second.

Lateral and Drainage System

The lateral system has a total length of 61.1 miles. The drainage system has a total length of 16.7 miles.

DEVELOPMENT

Early History

Cattle were first raised commercially in 1857 in the Beaverhead Valley, and agricultural settlement began as early as 1862. The local market for farm produce and cattle at that time was restricted to miners and Army personnel. The cattle industry became well established by 1879, the date of completion of the first railroad to the vicinity. Before the railroad was built, overland cattle drives were made to Salt Lake City and other points to the south. Severe drought caused a setback in the cattle industry in 1886.

Farming was taken up in earnest in the early 1900's. Settlement was encouraged, in part, as a result of vigorous campaigns by the railroads. The low rainfall and short growing season have tended to discourage farming operations, especially dry-farming. As a result, livestock ranching is the predominant activity.

Investigations

The first comprehensive inventory of the water resources relating to the unit was made by the War Department during 1928-33. In the fall of 1938, the Bureau of Reclamation began investigations that ultimately led to a reconnaissance report for the Missouri River and its tributaries. Field work was started in May 1940, and a draft of the report was completed in May 1943. The final report was published in Senate Document 191 (78th Congress, 2d session). The East Bench Unit was included in the plan for the Pick-Sloan Missouri Basin Program (formerly Missouri River Basin Project) presented in this report. Following authorization of the Pick-Sloan Missouri River Basin Program, detailed and semidetailed investigations were begun throughout the basin. Investigations for the East Bench Unit were conducted in 1956.

Authorization

The unit features were authorized by the Flood Control Acts of 1944 and 1946 (58 Stat. 887 and 60 Stat. 641).

Construction

The contract for the construction of Clark Canyon Dam was awarded in September 1961, and the structure was completed in 1964. Other project features were begun in 1961 and completed in 1963.

Barretts Diversion Dam

Operating Agency

Operation and maintenance functions are being performed by the East Bench Irrigation District.

BENEFITS

Irrigation

Unit irrigation benefits consist of increased production of goods and services and improvements in the general welfare. Direct irrigation benefits consist of the increase in net farm income resulting from the use of the unit's water.

Flood Control

Controlled flows of the Beaverhead River at its head result in extensive flood control benefits downstream.

Recreation

Recreation facilities are being provided by the Federal Government. The recreation use at the unit in 1977 amounted to 22,100 visitor days.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	21,800	acres
Supplemental irrigation service	28,000	acres
Total	49,800	acres
Number of irrigated farms	166	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	47,364	2,103,455
1969	47,896	2,767,873
1970	48,031	3,114,710
1971	48,102	3,451,800
1972	47,583	4,688,711
1973	45,944	6,650,578
1974	45,989	7,219,274
1975	47,398	7,382,081
1976	48,454	7,647,559
1977	48,417	7,382,951

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	44.2	mi
Laterals	61.1	mi
Drains	16.7	mi

Climatic Conditions

Annual precipitation	11.5	in
Temperature:		
Maximum	100	°F
Minimum	−40	°F
Average	43	°F
Growing season	95	days
Elevation of irrigable area	4700-5450.0	ft

Settlement

Number of persons served (1977)	694

ENGINEERING DATA

Water Supply

BEAVERHEAD RIVER

Drainage area at Barretts	2,737	mi^2
Annual discharge near Dillon, Mont.:		
Maximum (1976)	444,500	acre-ft
Minimum (1967)	125,000	acre-ft
Average	280,200	acre-ft

Storage Facilities

CLARK CANYON DAM

Type: Zoned earthfill
Location: On the Beaverhead River about 20 mi southwest of Dillon, Mont.
Construction period: 1961-64
Date of closure (first storage): Aug. 28, 1964

Reservoir, Clark Canyon:		
Total capacity to El. 5560.4	257,152	acre-ft
Active capacity, El. 5470.6-5535.7	126,117	acre-ft
Surface area	5,903	acres
Dimensions:		
Structural height	147.5	ft
Hydraulic height	113.9	ft
Top width	36	ft
Maximum base width	800	ft
Crest length	2,950	ft
Crest elevation	5578.0	ft
Total volume	1,970,000	yd^3

Spillway: Uncontrolled concrete crest and concrete-lined chute at left abutment.		
Crest length	67	ft
Crest elevation	5560.4	ft
Capacity at El. 5571.9	9,520	ft^3/s
Outlet works: Concrete-lined conduit (9-ft circular) through left abutment, controlled by two emergency and two regulating 3- by 6.5-ft high-pressure gates.		
Capacity at El. 5547	2,325	ft^3/s

Diversion Facilities

BARRETTS DIVERSION DAM

Type: Concrete gate structure with embankment wings
Location: On Beaverhead River about 11 mi downstream from Clark Canyon Dam.
Year completed: 1963

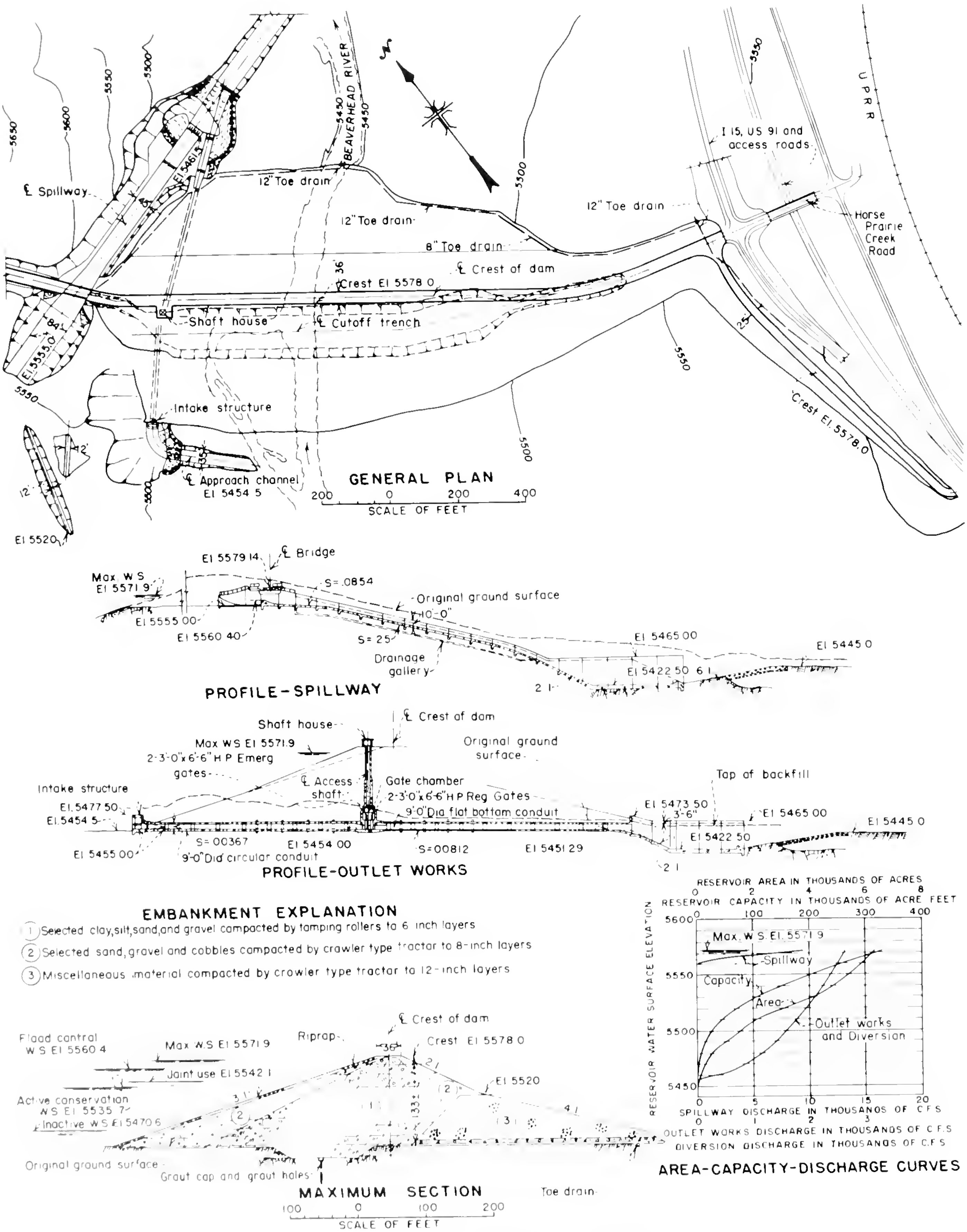
Dimensions:		
Hydraulic height	10	ft
Crest length	1,720	ft
Elevation of controlled water surface	5255.0	ft
Volume (concrete)	1,390	yd^3
Spillway: One 24- by 10-ft radial gate.		
Capacity	2,500	ft^3/s
East Bench Canal headworks: Two 10- by 8-ft radial gates.		
Capacity	440	ft^3/s
Canyon Canal headworks: One 10- by 8-ft radial gate.		
Capacity	200	ft^3/s
Rebich Ditch headworks: One 24-in-diameter slide gate and one 36- by 30-in slide gate in series.		
Capacity	12	ft^3/s

Carriage Facilities

EAST BENCH CANAL

Location: From Barretts Diversion Dam, 44.2 mi in a northeasterly direction.
Construction period: 1961-64

Length	44.2	mi
Initial capacity	440	ft^3/s
Typical maximum section:		
Bottom width	22	ft
Side slopes	2:1	
Water depth	6.57	ft

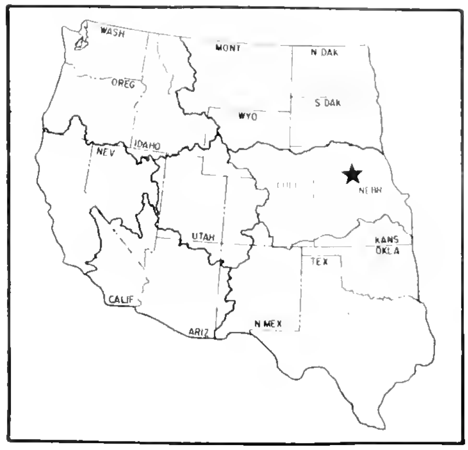


Clark Canyon Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Farwell Unit, Middle Loup Division

Nebraska: Custer, Valley, Sherman, and Howard Counties

Lower Missouri Region
Water and Power Resources Service



The Farwell Unit lies between the North and Middle Loup Rivers in central Nebraska. The unit furnishes a full supply of water to 52,530 acres of irrigable land. Flood control, recreation, and fish and wildlife benefits also are provided. Principal features are Sherman Dam and Reservoir, Arcadia Diversion Dam, Sherman Feeder Canal, the Farwell Canals, a system of laterals, and 1 large and 37 small pumping plants.

PLAN

Water from the Middle Loup River is diverted at the Arcadia Diversion Dam and conveyed by the Sherman Feeder Canal for storage in the Sherman Reservoir on Oak Creek. The Farwell Main, Central, and South Canals convey water from Sherman Dam to the irrigable area.

Arcadia Diversion Works and Feeder Canal

Arcadia Diversion Dam is on the Middle Loup River about 8.5 miles upstream from Arcadia, Nebr. The 7,960-foot-long dam has a height of 8 feet above streambed and a diversion capacity of 850 cubic feet per second. The dam consists of a concrete gate structure (twelve 30 -by 10-foot radial gates), embankment wings, sluiceway, and diversion headworks. The sluiceway is controlled by one 14- by 10-foot radial gate, and the headworks by two 20- by 7-foot radial gates.

Sherman Feeder Canal begins at Arcadia Diversion Dam and runs in a southeasterly direction 19.1 miles to Sherman Reservoir. A 2,200-foot-long settling basin is located 0.6 mile below the Arcadia Diversion Dam on the Sherman Feeder Canal. A circular concrete-lined tunnel 2,053 feet in length and 11.5 feet in diameter conveys the water through the Middle Loup-Oak Creek Divide area.

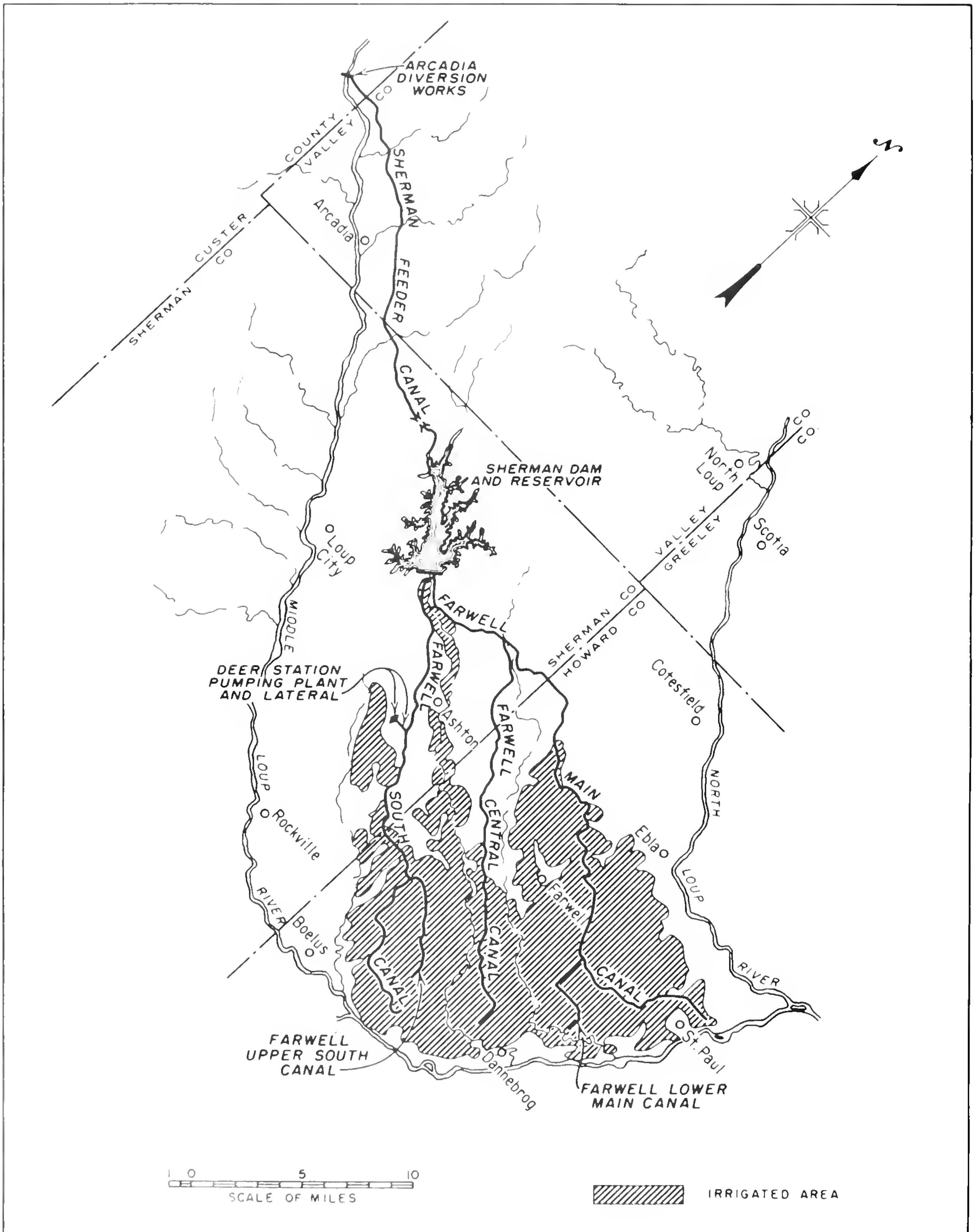
Sherman Dam and Reservoir

Sherman Dam lies across Oak Creek, about 5 miles northeast of Loup City. The dam is a homogeneous earthfill structure with a structural height of 134 feet, a crest length of 4,450 feet, and a total volume of 1,892,000 cubic yards.

The spillway is a morning-glory type, with an uncontrolled

Arcadia Diversion Dam

Sherman Dam and Reservoir



Farwell Unit

inlet. A concrete conduit and stilling basin near the left abutment of the dam has a discharge capacity of 1,095 cubic feet per second into Oak Creek.

The irrigation outlet works is also in the left abutment. A pressure conduit, gate chamber, and horseshoe-shaped conduit containing an outlet pipe are connected to two high-pressure regulating gates in the gate structure for release to a stilling basin, which in turn supplies water to the Farwell Main Canal. Capacity of the outlet is 960 cubic feet per second.

Sherman Reservoir has a total capacity of 69,076 acre-feet, an active capacity of 58,580 acre-feet, and a surface area of 2,868 acres.

Canals

The Farwell Main Canal begins at the outlet works downstream from Sherman Dam and has an initial capacity of 960 cubic feet per second. Farwell Main Canal conveys water to the irrigable lands and supplies water to the Farwell South and Farwell Central Canals. Two additional smaller canals branch from these three principal canals. The unit has a total of 114.8 miles of canals with capacities ranging from 960 to 80 cubic feet per second. Approximately 268 miles of laterals provide gravity flow distribution of irrigation water.

Pumping Plants

Thirty-eight pumping plants lift water for subsequent gravity flow to district lands. Deer Station Pumping Plant, the largest, consists of four motor-driven units with a total capacity of 27 cubic feet per second. It lifts water against a dynamic head of 106 feet to a lateral. The other pumping units are designed as lifts of from 6.7 to 53.7 feet. Each unit serves more than one water user. Two additional pumping units have been installed by the irrigation district to help meet peak supply requirements by pumping and by reclaiming project water flowing in Turkey Creek.

DEVELOPMENT

Early History

In 1854, through treaties with the Indian tribes, land along the Missouri River was ceded to the United States, opening the way for the establishment of the Territory of Nebraska and for its admission to the Union as a State in 1867. By 1870, settlement had extended throughout most of the Platte River Valley and was reaching the Loup Valleys to the north. Howard County, which includes most of the Farwell Unit lands, was organized by act of the State legislature in 1871. Since the time of the arrival of the early settlers in the Farwell area, irrigation development has been recognized as a necessity.

Investigations

Although not broad enough to include the Farwell Unit lands, various investigations have been made since 1894 by organizations seeking irrigation development along the Middle Loup River. No attempts were made to use the waters of the river to irrigate the uplands where most of the irrigable lands are situated. The Bureau of Reclamation completed a comprehensive investigation of the unit in September 1955, which led to its authorization for construction.

Authorization

The Missouri River Basin Project was authorized by the Flood Control Act of December 22, 1944 (58 Stat. 887), as amended and supplemented. The unit was reauthorized by Public Law 952 (84th Cong.) on August 3, 1956.

Construction

Construction of Sherman Dam began in August 1959, and was completed in January 1962. Construction of the Arcadia Diversion Works and Sherman Feeder Canal began in August 1960, and was completed in November 1962. Work on the distribution system started in June 1961 and was completed in August 1966.

BENEFITS

Irrigation

Lands in the unit are highly productive and the growing season ample. Principal crops irrigated are alfalfa, small grains, sugar beets, and corn to provide feed for a thriving livestock-feeding economy—beef cattle, hogs, and poultry.

Delivery of silt-free irrigation water on a contract basis to the lower system of the Middle Loup Public Power and Irrigation District alleviates diversion and sediment problems.

Flood Control

Between the Arcadia diversion site and Loup City, there are about 8,300 acres of crop and pasture lands, many miles of roads, several miles of railroad tracks, and a portion of the town of Arcadia which are subject to damage from floodflows of the Middle Loup River. The Arcadia Diversion Dam provides protection to this area.

Between Sherman Dam and the mouth of Oak Creek, approximately 6,350 acres of lands are subject to flood damage, including the towns of Ashton and Dannebrog. Sherman Dam and Reservoir greatly reduce the flood hazard for this area.

Recreation and Fish and Wildlife

Sherman Reservoir provides excellent opportunities for outdoor recreation and fish and wildlife activities. Favorite attractions are fishing, boating, water skiing, and picnicking. High temperatures that prevail during the summer, together with the cleanliness of the fresh water in the reservoir, make the lake an attractive spot for recreation. Many varieties of game fish make this a fisherman's paradise in central Nebraska. Around the lakeshore are locations suitable for picnicking, overnight camping, and cabin areas.

Arcadia Diversion Dam also provides opportunities for outdoor recreation, particularly fishing and picnicking.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	50,051	acres
Number of irrigated farms	318	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value,[1] dollars
1968	32,336	3,369,391
1969	34,726	5,050,870
1970	36,970	4,945,321
1971	37,435	4,732,300
1972	35,373	5,536,321
1973	38,785	8,642,706
1974	40,481	12,783,331
1975	43,702	10,488,828
1976	45,365	10,345,560
1977	48,446	8,924,534

[1]Includes additional revenue

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	114.8	mi
Laterals	268.2	mi
Tunnels	1	
Pumping plants	38	

Climatic Conditions

Annual precipitation	23.49	in
Temperature:		
Maximum	111	°F
Minimum	−33	°F
Mean	50	°F
Growing season	154	days
Elevation of irrigable area	1780-2210.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	960

ENGINEERING DATA

Water Supply

MIDDLE LOUP RIVER

Drainage area at Arcadia Diversion Dam	4,654	mi²
Annual discharge:		
Maximum (1962)	697,900	acre-ft
Minimum (1975)	378,700	acre-ft
Average	491,700	acre-ft

Storage Facilities

SHERMAN DAM

Location: Across Oak Creek, about 5 mi northeast of Loup City, Nebr.
Construction period: 1959-62
Reservoir, Sherman:

Total capacity to El. 2162	69,076	acre-ft
Active capacity	58,580	acre-ft
Surface area	2,868	acres
Dimensions:		
Structural height	134	ft
Top width	30	ft
Maximum base width	610	ft
Crest length	4,450	ft
Crest elevation	2178.0	ft
Total volume	1,892,000	yd³
Spillway: Morning-glory type, uncontrolled inlet near left abutment.		
Crest elevation	2162.0	ft
Capacity	1,095	ft³/s
Outlet works: Concrete-lined tunnel near left abutment, controlled by two 6- by 7.5-ft high-pressure gates.		
Capacity	960	ft³/s

Diversion Facilities

ARCADIA DIVERSION DAM

Type: Concrete gate structure, embankment wings
Location: On the Middle Loup River, about 8.5 mi upstream from Arcadia, Nebr.
Construction period: 1960-62
Dimensions:

Height above streambed	8	ft
Crest length	7,960	ft
Crest elevation	2201.0	ft
Volume	14,000	yd³
River regulating structure: Twelve 30- by 10-ft radial gates.		
Capacity	20,000	ft³/s
Headworks: Two 20- by 7-ft radial gates.		
Capacity	850	ft³/s

Carriage Facilities

SHERMAN FEEDER CANAL

Location: From Arcadia Diversion Dam to Sherman Dam.
Construction period: 1960-62

Length	19.1	mi
Diversion capacity	850	ft³/s
Typical maximum section:		
Bottom width	28	ft
Side slopes	2:1	
Water depth	8.5	ft

SHERMAN FEEDER TUNNEL

Location: Near the terminus of the Sherman Feeder Canal.
Construction period: 1960-62
Length .... 2,053 ft
Capacity .... 850 ft³/s
Cross section: Circular
Diameter .... 11.6 ft
Lining: Concrete .... 10.5 in

FARWELL MAIN AND LOWER MAIN CANAL

Location: From Sherman Dam in a southeasterly direction to the vicinity of St. Paul, Nebr.
Construction period: 1961-63
Length .... 37.5 mi
Initial capacity .... 960 ft³/s
Typical maximum section:
Bottom width .... 32 ft
Side slopes 2:1
Water depth .... 9 ft

FARWELL CENTRAL CANAL

Location: From Farwell Main Canal southeasterly to the vicinity of Dannebrog, Nebr.
Construction period: 1961-64
Length .... 18.5 mi
Initial capacity .... 170 ft³/s
Typical maximum section:
Bottom width .... 14 ft
Side slopes 2:1
Water depth .... 4.1 ft

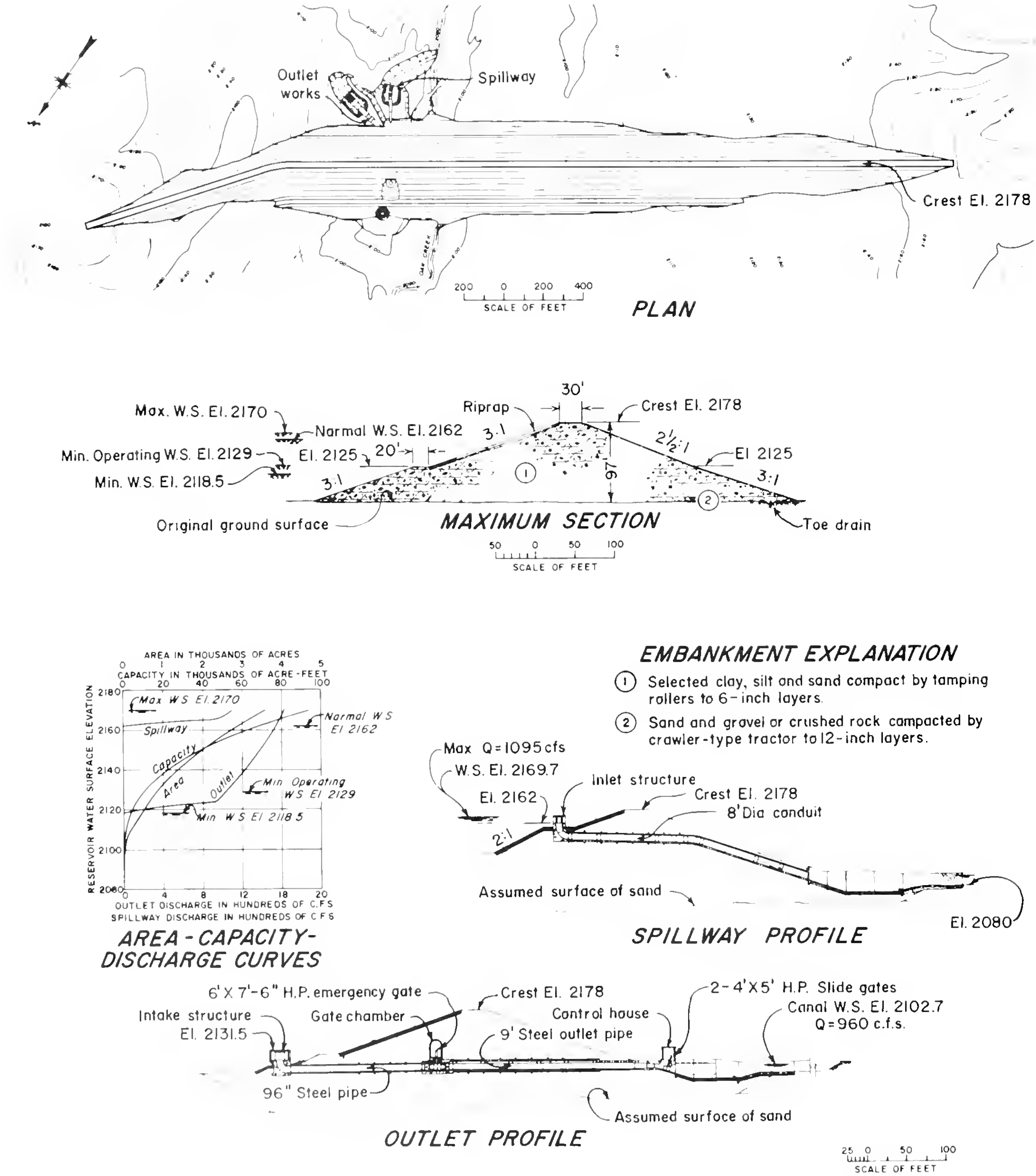
FARWELL SOUTH AND UPPER SOUTH CANAL

Location: From Farwell Main Canal southeasterly to the vicinity of Boelus, Nebr.
Construction period: 1963-65
Length .... 39.7 mi
Initial capacity .... 340 ft³/s
Typical maximum section:
Bottom width .... 20 ft
Side slopes 2:1
Water depth .... 5.9 ft

PUMPING PLANT[2]

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Deer Station	4	27	106	450

[2]Does not include 37 small pumping plants.

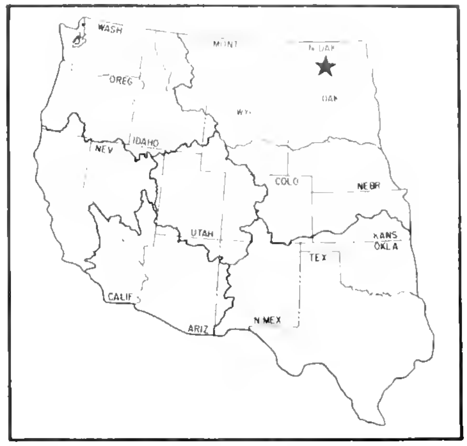


Sherman Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Fort Clark Unit

North Dakota: Mercer and Oliver Counties

Upper Missouri Region
Water and Power Resources Service

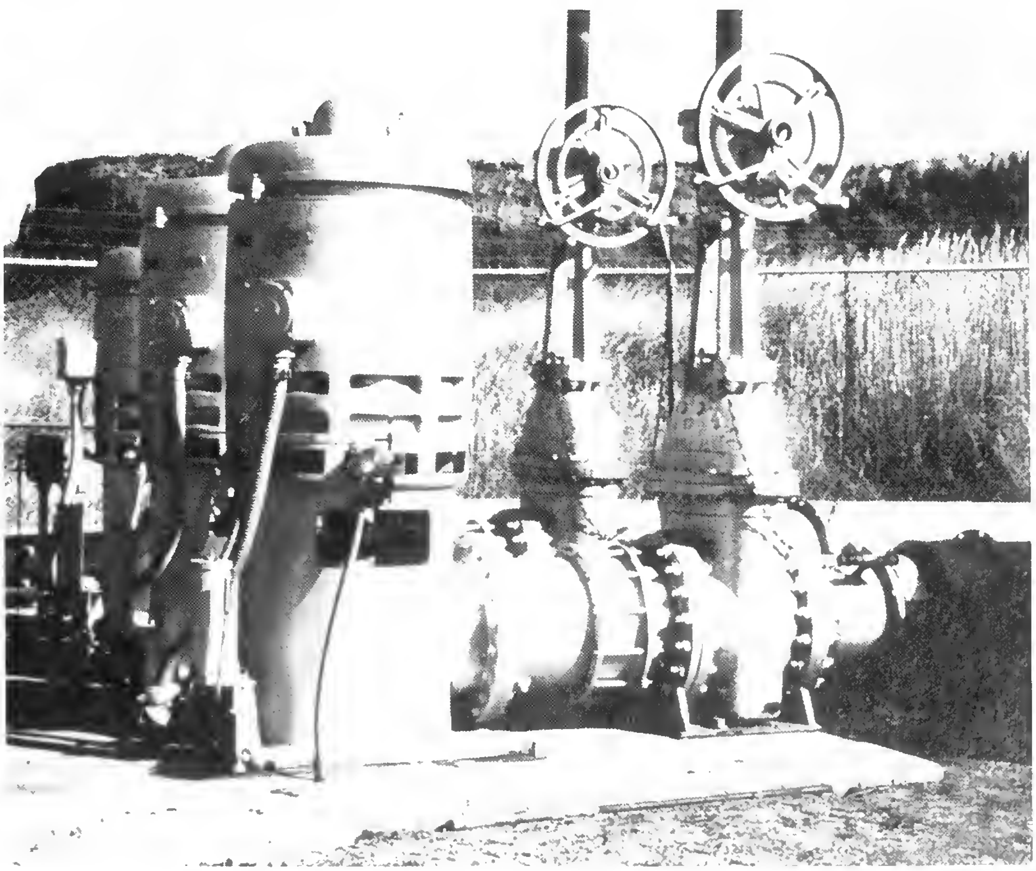


The Fort Clark Unit extends along the west bank of the Missouri River for about 6 miles from Fort Clark, N. Dak., to within 2.5 miles of Stanton, N. Dak. The unit is designed to irrigate 1,929 acres of bench and bottomland bordering the Missouri River. The irrigable land of the unit is served through a system of four pumping plants, two canals, and a lateral system.

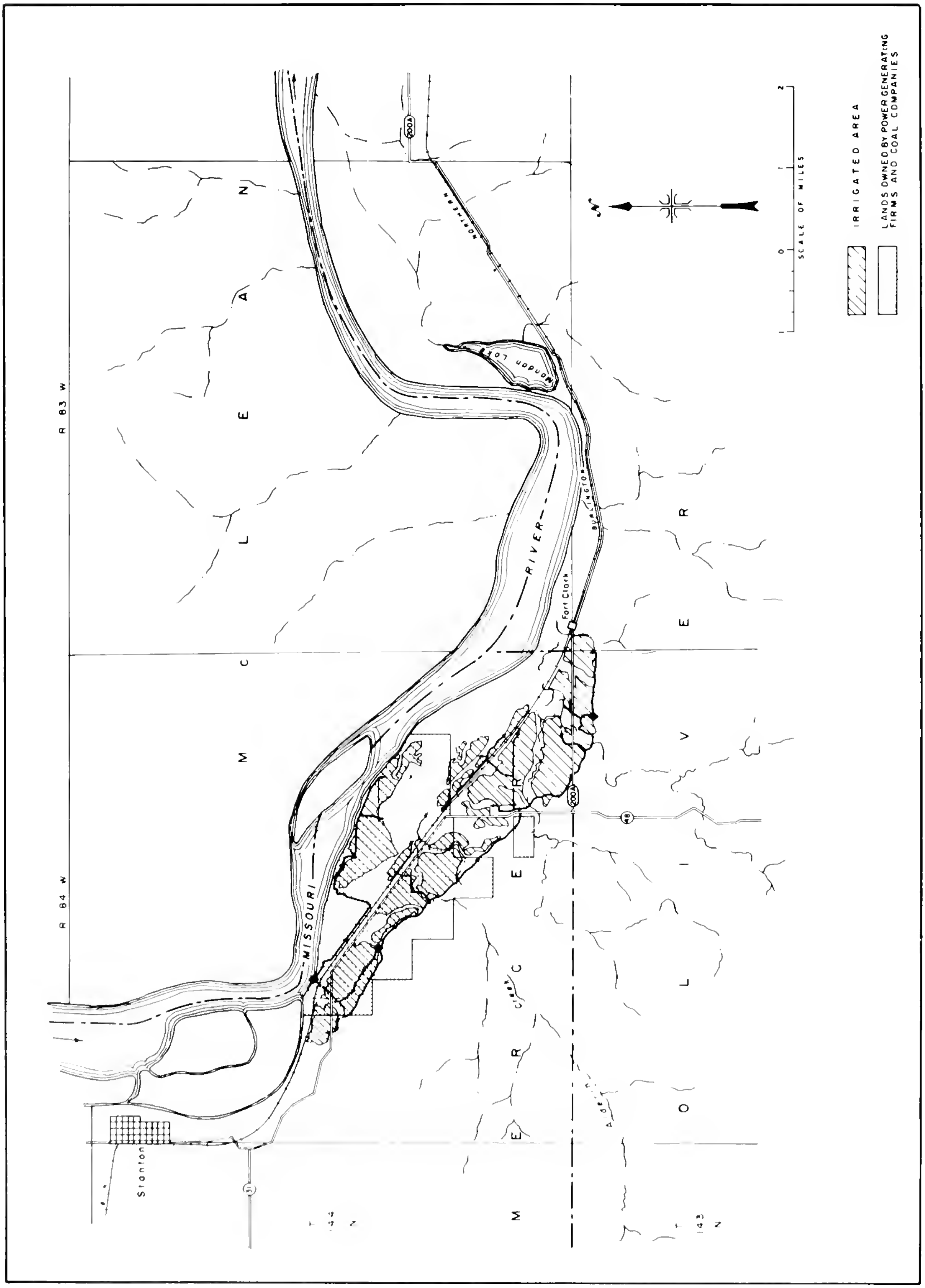
PLAN

The Fort Clark main pumping plant is located along the steep bank of the Missouri River, near the upstream reach of the unit area, about 3 miles southeast of Stanton. This 30-cubic-foot-per-second plant pumps water to Canal B, which serves most of the land in the unit. A 7-cubic-foot-per-second pumping plant about 1 mile downstream from the main pumping plant supplies water to Canal A, to serve the lower benchlands in the unit. It is located in the pumphouse for a power generation plant and pumps water for irrigation that has been used as cooling water in the powerplant.

The two relift plants, Nos. 1 and 2, are similar in arrangement and include motor-driven pumps of 5 and 4 cubic feet per second capacity, respectively. Plant No. 1 is located near the heading of Canal B, and serves 159



Fort Clark Pumping Plant



Fort Clark Unit

acres of land above the canal. Plant No. 2 is located near the downstream reach of Canal B and provides water to 162 acres which cannot be served by the gravity section of Canal B.

DEVELOPMENT

Early History

Settlement of the Fort Clark Unit area began with the establishment of a fur trading post in 1820. In 1831, a fort was constructed at the post by the Federal Government as one of its strategic locations along the Missouri River. Pioneers followed the fur traders and hunters, and became the first permanent settlers in the area. In 1882, land was homesteaded near Fort Clark, opening a new period of rapid agricultural development. During the drought years, there was some emigration from the area, which resulted in an increase in the size of farm operations.

Investigations

Surveys of the Fort Clark Unit began with public land surveys made by the Surveyor General in 1880-81. During 1889-91, the area was mapped as part of the Missouri River Commission's survey of the Missouri River from Fort Benton, Mont., to Sioux City, Iowa. That work was done under the direction of the Corps of Engineers. In the summer of 1939, the area was mapped in greater detail by the Bureau of Reclamation as part of the Missouri River investigations in North Dakota. Those investigations were the direct result of an act passed by the 75th Congress, 3d session, authorizing the Department of the Interior to distribute electric energy generated at Fort Peck Dam in Montana. Irrigation developments were entirely lacking in the Fort Clark area. However, some attempts were made to irrigate adjacent vicinities, with poor success because of the lack of proper irrigation techniques and inadequate power for pumping. These circumstances prompted the early development of the Fort Clark Unit.

Authorization

The Fort Clark Unit was authorized by the Flood Control Acts of December 22, 1944, and July 24, 1946.

Construction

Construction of the irrigation facilities began April 25, 1953, and was completed August 1, 1953.

Operating Agency

Operation and maintenance of the Fort Clark Unit is performed by the Fort Clark Irrigation District.

BENEFITS

Irrigation

Wheat growing is largely confined to dry land. From the irrigated sections, hay, grain, and corn silage are made available for livestock feeding in the vicinity. Potatoes and grains are cash crops.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	1,929	acres
Number of irrigated farms	25	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,244	49,337
1969	1,244	73,216
1970	1,166	68,269
1971	1,121	65,551
1972	1,087	95,231
1973	1,024	142,881
1974	1,130	165,720
1975	1,142	147,005
1976	910	105,080
1977	734	89,599

Facilities in Operation

Canals	7	mi
Laterals	6	mi
Pumping plants	4	
Drains	6	mi

Climatic Conditions

Annual precipitation	15.4	in
Temperature:		
Maximum	116	°F
Minimum	−49	°F
Mean	40	°F
Growing season	130	days
Elevation of irrigable area	1670-1770.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	42

ENGINEERING DATA

Water Supply

MISSOURI RIVER

Drainage area above Garrison Dam	181,400	mi²
Annual discharge at Garrison Dam:		
Maximum (1975)	23,892,000	acre-ft
Minimum (1977)	15,161,500	acre-ft
Average	19,365,200	acre-ft
Annual diversion (1977)	1,000	acre-ft

Carriage Facilities

CANAL A:

Location: East along the Missouri River from Basin Electric Power Cooperative pump-house.
Construction period: 1952-53

Length	1.6 mi
Initial capacity	7 ft³/s
Typical maximum section in earth:	
Bottom width	3 ft
Side slopes	1.5:1
Water depth	1.6 ft

CANAL B:

Location: Generally southeast from Fort Clark Pumping Plant on the Missouri River.
Construction period: 1952-53

Length	6.4 mi
Initial capacity	30 ft³/s
Typical maximum section in earth:	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2.5 ft

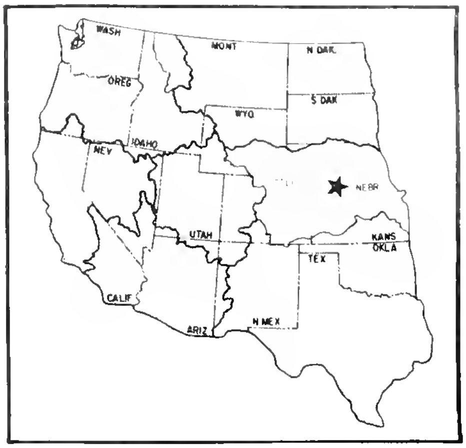
PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Fort Clark Main	2	30	95	400
Relift No. 1	1	5	31	25
Relift No. 2	1	4	17	10
Fort Clark Canal A	1	7	50	50

Pick-Sloan Missouri Basin Program
Frenchman-Cambridge Division

Nebraska: Chase, Hayes, Hitchcock, Frontier, Red Willow, Furnas, and Harlan Counties

Lower Missouri Region
Water and Power Resources Service



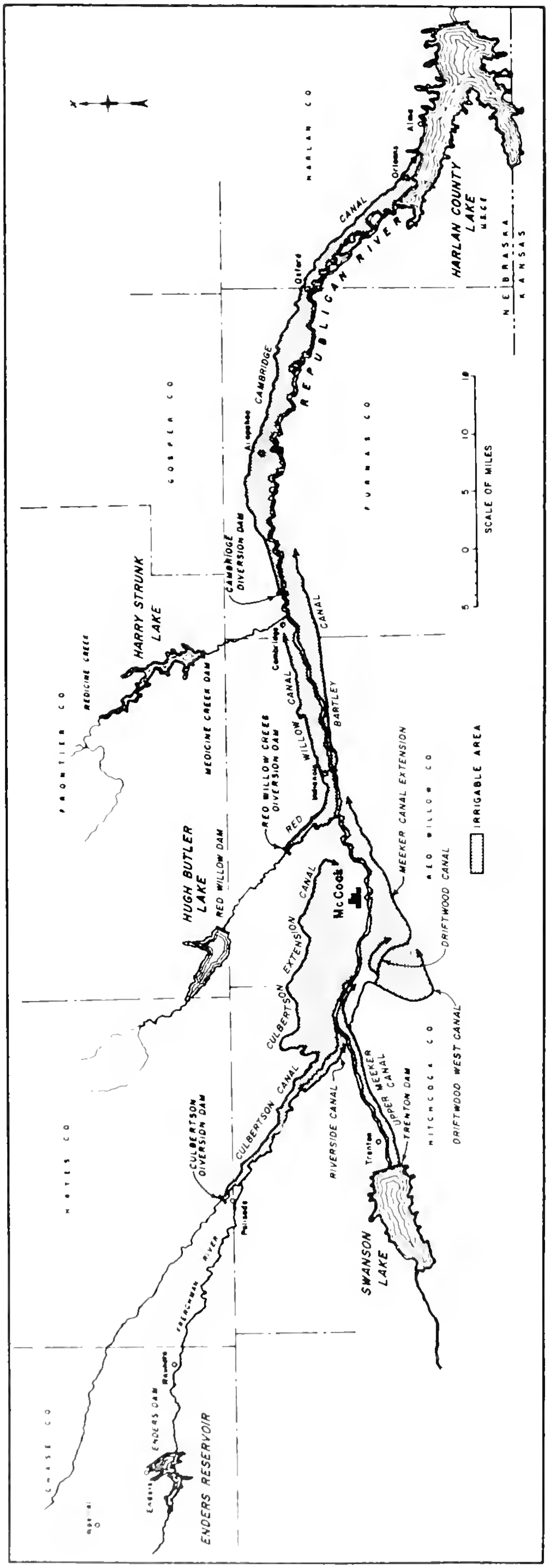
PLAN

The Frenchman-Cambridge Division, in southwestern Nebraska, extends from Palisade southeastward along Frenchman River and from Trenton eastward along the Republican River to Orleans and Alma. Storage facilities for the division consist of the Enders Reservoir and Swanson, Hugh Butler, and Harry Strunk Lakes. The four dams, reservoirs, and irrigation systems provide storage to irrigate 66,090 acres of project lands, flood control, fish and wildlife conservation, and recreation along the Republican River and its three tributaries, the Frenchman River, and Red Willow and Medicine Creeks.

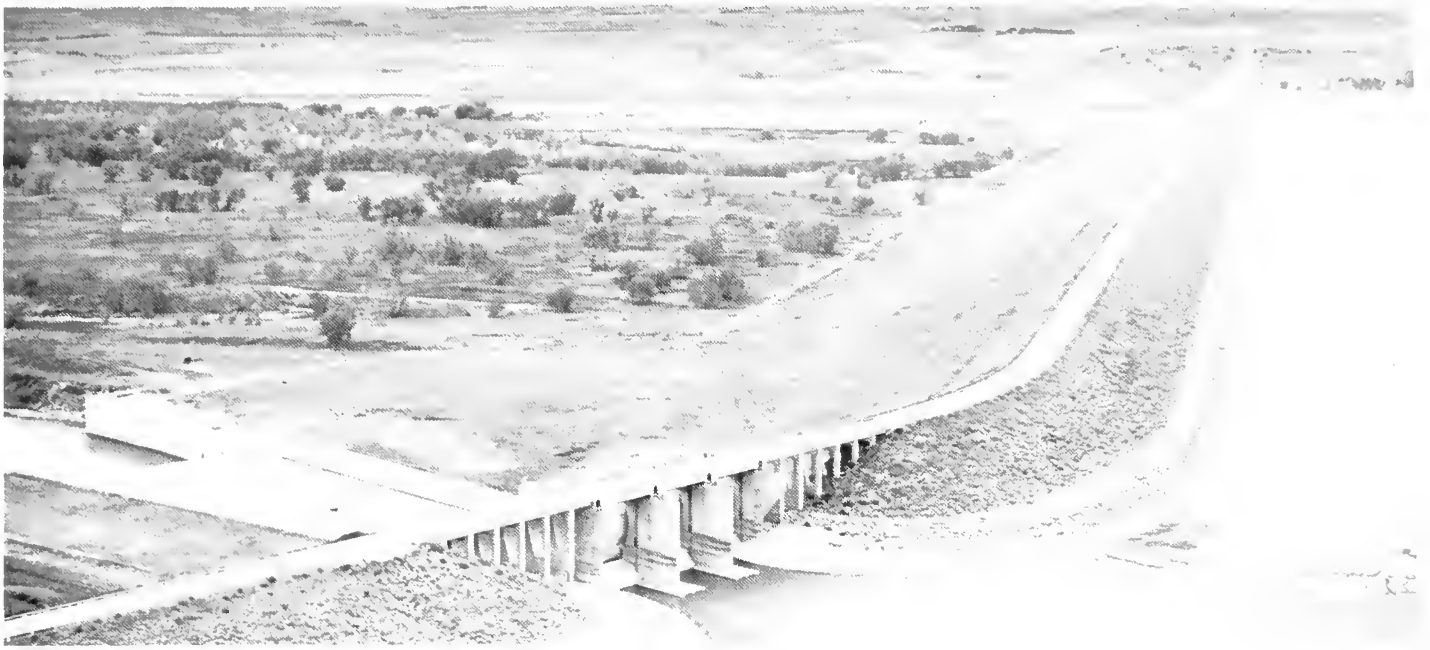
Facilities of the division store and deliver a full water supply to 56,490 acres of irrigable land and a supplemental supply to 9,600 acres along the Republican River and its tributaries.

Irrigation releases are made from all reservoirs to the streams for diversion into downstream canal systems. In addition, irrigation releases are made from Swanson Lake directly into the Meeker-Driftwood Canal system. Enders Dam and Reservoir, Trenton Dam and Swanson Lake,

Enders Dam



Frenchman-Cambridge Division



Trenton Dam

Red Willow Dam and Hugh Butler Lake, and Medicine Creek Dam and Harry Strunk Lake are located on the Frenchman River, Republican River, Red Willow Creek, and Medicine Creek, respectively.

The Culbertson Diversion Dam and the Culbertson Canal and laterals in the Frenchman Valley Irrigation District were privately built about 1890. Project construction in the 1950's included rehabilitation of the diversion dam and enlargement and rehabilitation of the canal to add a supplemental water supply for the 9,600 acres in the district and carry water to the Culbertson Extension Canal that serves 11,490 acres in the Hitchcock and Red Willow Irrigation District.

The 45,000 acres in the Frenchman-Cambridge Irrigation District are served by the Meeker-Driftwood, Red Willow, Bartley, and Cambridge Canal systems. The Meeker-Driftwood canal system begins at Trenton Dam and includes the Upper Meeker, Upper Meeker Sub, Driftwood, Driftwood West, Driftwood Sub, and Meeker Extension Canals. Red Willow, Bartley, and Cambridge Diversion Dams divert water from Red Willow Creek and the Republican River to the Red Willow, Bartley, and Cambridge Canals.

The total length of the canals in the division is 205.3 miles. In addition, 181.4 miles of laterals distribute irrigation water to the farms, and there are approximately 34 miles of subsurface drains.

Enders Dam

Enders Dam, an earthfill structure 1.5 miles south of Enders, Nebr., has a structural height of 134 feet, and a concrete spillway located in the right abutment with six 50- by 30-foot radial gates. There is a 10-foot-wide uncontrolled overflow section through the center of the spillway. An earthfill dike 26 feet high begins about 4,000 feet north of the left abutment of the dam. The outlet works through the dam is controlled by two 60-inch hollow-jet valves.

Culbertson Diversion Dam and Canal System

The Culbertson Diversion Dam is a concrete structure containing two 14- by 9.5-foot radial-type spillway gates and a 30-inch-diameter bypass conduit. The canal headworks is a concrete structure containing two 10- by 6-foot radial gates and a spillway stilling basin. The diversion capacity required is 400 cubic feet per second at water surface elevation 2740.2. The spillway gates are designed for a capacity of 1,250 cubic feet per second, at water surface elevation 2741.0 and tailwater at elevation 2737.0. The remainder of the flood will flow over the wasteway and low-lying flood plain to the south of the main channel and will re-enter the main channel downstream from the diversion dam. The 30-inch bypass conduit is required to meet downstream water needs and to assist in sluicing deposited material through the dam. The canal is 27.3 miles long.

Trenton Dam

Trenton Dam, on the Republican River near Trenton, Nebr., is an earthfill structure with a structural height of 144 feet. The spillway is at the left abutment. Two gated sluiceways permit river releases. A concrete conduit through the base of the dam near the right abutment provides for releases through a stilling basin to the Upper Meeker Canal to serve lands of the Meeker-Driftwood Unit. These lands are located along the south side of the Republican River from the dam to a point about 8 miles east of McCook. Regulation of releases through the conduit is by a 4-foot-square high-pressure gate at the control house adjacent to the stilling basin. The reservoir behind the dam is called Swanson Lake.

Meeker Canal System

The Upper Meeker Canal begins at Trenton Dam and extends 15.2 miles along the south side of the Republican River to a point just south of Culbertson, to serve canals of the Meeker-Driftwood Unit. The canal has a capacity of 284 cubic feet per second. The 6.3-mile-long Upper Meeker Subcanal has a capacity of 30 cubic feet per second and supplies the existing Meeker Canal.

The Driftwood Canal begins at the end of the Upper Meeker Canal and extends south, southeasterly, and northeast on the south side of the Republican River Valley to within 8 miles east of McCook. It has a capacity of 225 cubic feet per second and is 13.7 miles long.

The remaining canals of this system, Driftwood West, Driftwood Sub, and Meeker Extension, have a total length of about 27 miles, have capacities ranging from 30 to 90 cubic feet per second, and serve lands farther east in the Meeker-Driftwood Unit south of McCook. The Meeker-Driftwood Canal system serves 16,476 irrigable acres.

Red Willow Dam

Red Willow Dam, located on Red Willow Creek about 10 miles northwest of McCook, is an earthfill embankment with a structural height of 126 feet that forms a reservoir of 86,630 acre-feet. An ungated concrete spillway is located in the right abutment. An outlet works through the base of the dam provides for river and irrigation releases for downstream diversions. The reservoir behind this dam is Hugh Butler Lake.

Red Willow Creek Diversion Dam and Canal System

Red Willow Creek Diversion Dam, located on Red Willow Creek about 6 miles northwest of Indianola, is a concrete baffled apron weir with earth embankments at both ends. The dam diverts water into the Red Willow Canal to serve lands of the Red Willow Unit lying north of the Republican River. The canal is 24.1 miles long, has a capacity of 90 cubic feet per second, and serves 4,932 acres of irrigable land.

Bartley Diversion Dam and Canal System

The Bartley Diversion Dam is located on the Republican River about 2 miles southeast of Indianola, Nebr. The dam is a concrete weir with embankment wings and has a total length of 3,100 feet. The Bartley Canal originates at the dam and supplies water to the portion of the Red Willow Unit south of the river. The canal is 19.4 miles long and serves 6,539 acres.

Medicine Creek Dam

Medicine Creek Dam is on Medicine Creek 2 miles west and 7 miles north of Cambridge, Nebr. This earthfill embankment dam has a structural height of 165 feet, and an uncontrolled concrete spillway in the left abutment. The outlet works through the dam consists of a concrete conduit and 44-inch-diameter steel pipe controlled by a high-pressure gate. Harry Strunk Lake is formed by the dam.

Cambridge Diversion Dam and Canal System

Cambridge Diversion Dam is located on the Republican River about 2 miles east of Cambridge. It is a concrete and earthfill dam having a total length of 900 feet. The Cambridge Canal begins at the dam and extends along the Republican River 49.2 miles to the Harlan County Reservoir to serve 17,053 acres of the Cambridge Unit.

DEVELOPMENT

The Frenchman-Cambridge area was inhabited in the 15th century by a tribe of Indians who subsisted on corn and fish, according to anthropologists who found the remains of a large Indian village in the Medicine Creek Valley. It is believed that they were driven from their homes by floods and droughts which destroyed their means of subsistence.

A similar fate threatened the settlers during the latter part of the 19th century when they attempted farming in southwestern Nebraska. Many of the pioneers, after having been flooded or burned out, became discouraged and abandoned their farms. Those who remained visualized the possibility of developing irrigation along the Republican and Frenchman Rivers. Irrigation systems now in use near Culbertson and McCook are successful survivors of the early attempts to irrigate the land.

Medicine Creek Dam

Investigations

A combination of extreme drought, low prices for farm products, and a disastrous flood in 1935 forced farm and business leaders of the area to seek aid in planning and establishing a sound agricultural economy. Intensive investigations initiated in 1939 and continued during the succeeding years provided the foundation for a plan for controlling floods and storing water for irrigation. This plan, which was included in the overall development of the Missouri River Basin, was published as Senate Document 191. The initial investigations made by the Bureau of Reclamation were completed and reported upon in March 1940. On April 8, 1946, the Frenchman-Cambridge Irrigation District was formed, and on November 1, 1946, the first contract for the construction of Enders Dam was awarded.

The definite plan report of February 1951 for the division was approved by the Commissioner of Reclamation on September 13, 1951. A feasibility report on Red Willow Dam and Reservoir, dated October 1957, transferred jurisdiction over the facility from the Corps of Engineers to the Bureau of Reclamation (Public Law 85-783).

Authorization

The basic plan for the division was authorized by the Flood Control Act of December 22, 1944. The initial stage of development, as recommended in Senate Document 191, received authorization at the same time.

Construction

Construction of the division was started on March 1, 1947. Cambridge and Medicine Creek Dams were completed in 1949; Enders Dam, 1951; Trenton Dam, 1953; Bartley Diversion Dam, 1954; Culbertson Diversion Dam, 1959; and Red Willow Dam, 1962. Cambridge Canal and Bartley Canal were completed in 1954; Driftwood Canal, 1959; Red Willow Canal, 1964; Culbertson Canal enlargement, 1961; and the Culbertson Extension Canal, 1961.

Operating Agencies

Enders Dam and Reservoir, Trenton Dam and Swanson Lake, Red Willow Dam and Hugh Butler Lake, and Medicine Creek Dam and Harry Strunk Lake are operated and maintained by the Bureau of Reclamation. When water surfaces rise above the top of the conservation capacities, the dams and reservoirs are operated under instructions provided by the Corps of Engineers.

The Frenchman-Cambridge Irrigation District operates and maintains Bartley Diversion Dam, its canal and laterals; Cambridge Diversion Dam, its canal and laterals; Meeker-Driftwood distribution system; and Red Willow Creek Diversion Dam, its canal and laterals.

The Frenchman Valley Irrigation District operates and maintains the Culbertson Diversion Dam and the Culbertson Canal. The seepage losses on the Culbertson Canal are shared with the H&RW Irrigation District.

The H&RW Irrigation District operates and maintains the Culbertson Extension Canal.

Government lands surrounding the reservoirs of the division and water surfaces used for recreation and wildlife are managed by the Nebraska Game and Parks Commission.

BENEFITS

Irrigation

Agriculture is the basic industry in the Frenchman-Cambridge Division area. Irrigation has provided a more desirable balance between crop and livestock production. Crop yields have greatly improved since construction of the division's irrigation facilities; principal crops include corn, wheat, alfalfa hay, and sorghums.

Flood Control

The 1935 flood on the Republican River took 110 lives; the 1947 flood on Medicine Creek claimed 13. In 1957, a major flood caused $16 million in property damage and loss. Today, floodwaters are stored in the reservoirs of the division or released at rates which minimize downstream damage.

Recreation and Fish and Wildlife

The reservoirs of the division provide many thousands of persons from Nebraska and surrounding States with the water-oriented sports of boating, skiing, swimming, fishing, camping, and waterfowl hunting. Anglers enjoy excellent fishing for bass, catfish, crappie, pike, drum, walleye, and other common warm-water species. Numerous tracts at each reservoir and impoundment provide food and cover for pheasant, quail, small fur-bearing animals, and mule and white-tail deer.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	56,490	acres
Supplemental irrigation service	9,600	acres
Total	66,090	acres
Number of irrigated farms:		
Frenchman-Cambridge Irrigation District	385	
Frenchman Valley Irrigation District	70	
H&RW Irrigation District	70	
Total	525	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
Frenchman-Cambridge Irrigation District		
1968	37,695	4,390,942
1969	36,940	5,054,595
1970	37,099	5,236,162
1971	40,785	5,779,256
1972	40,051	7,375,789
1973	41,418	11,778,196
1974	43,851	17,012,026
1975	43,859	12,712,180
1976	43,862	10,248,791
1977	43,960	10,904,526
Frenchman Valley Irrigation District		
1968	8,978	850,753
1969	8,845	935,658
1970	6,500	967,592
1971	7,563	1,032,056
1972	6,888	1,390,791
1973	8,350	2,166,107
1974	8,861	3,048,051
1975	9,060	2,414,596
1976	9,022	1,688,078
1977	9,044	2,087,557
H&RW Irrigation District		
1968	11,085	1,447,409
1969	10,945	1,419,273
1970	10,752	1,268,771
1971	10,622	1,342,578
1972	9,312	1,736,889
1973	10,663	2,882,763
1974	11,444	4,034,081
1975	11,124	2,723,421
1976	11,364	2,675,380
1977	11,407	2,706,356

Facilities in Operation

Storage dams	4	
Diversion dams	4	
Canals	205.3	mi
Laterals	181.4	mi

Climatic Conditions

Annual precipitation	20	in
Temperature:		
Maximum	110	°F
Minimum	−22	°F
Mean	52	°F
Growing season	161	days
Elevation of irrigable area	2000-2740.0	ft

Settlement

Number of persons served with project water (1977): farm irrigation service:	
Frenchman-Cambridge Irrigation District	635
Frenchman Valley Irrigation District	150
H&RW Irrigation District	173

ENGINEERING DATA

Water Supply

FRENCHMAN RIVER

Drainage area at Enders Dam (total)	950	mi²
Direct contributing area	790	mi²
Annual discharge at Enders Dam:		
Maximum (1951)	75,500	acre-ft
Minimum (1976)	32,400	acre-ft
Average	58,604	acre-ft

REPUBLICAN RIVER

Drainage area at Trenton Dam (total)	8,620	mi²
Direct contributing area	3,940	mi²
Annual discharge at Trenton Dam:		
Maximum (1935)	544,900	acre-ft
Minimum (1954)	47,400	acre-ft
Average	123,646	acre-ft

MEDICINE CREEK

Drainage area at Medicine Creek Dam (total)	880	mi²
Direct contributing area	640	mi²
Annual discharge at Medicine Creek Dam:		
Maximum (1947)	106,700	acre-ft
Minimum (1974)	36,800	acre-ft
Average	56,329	acre-ft

RED WILLOW CREEK

Drainage area at Red Willow Dam (total)	730	mi²
Direct contributing area	310	mi²
Annual discharge at Red Willow Dam:		
Maximum (1951)	34,600	acre-ft
Minimum (1939)	12,900	acre-ft
Average	21,652	acre-ft

Storage Facilities

ENDERS DAM AND DIKE

Type: Homogeneous earthfill. (A dike, 6,420 ft long and 26 ft high, begins about 4,000 ft north of the left abutment of the dam).
Location: On the Frenchman River 1.5 mi from Enders, Nebr.
Construction period: 1947-51
Date of closure (first storage): October 23, 1950
Reservoir, Enders:

Average depleted annual inflow	58,604	acre-ft
Total capacity to El. 3127	74,520	acre-ft
Active capacity, El. 3080-3127	64,552	acre-ft
Surface area at El. 3127	2,405	acres
Dimensions:		
Structural height	134	ft
Hydraulic height	93	ft
Top width	30	ft
Maximum base width	670	ft
Crest length	2,603	ft
Crest elevation	3137.5	ft
Volume	1,950,000	yd³

Spillway: Concrete-lined open channel at right abutment of dam, controlled by six 50- by 30-ft radial gates. There is a 10-ft-wide uncontrolled overflow section in the center with the sill at El. 3112.3. (Bottom of flood control capacity)

Elevation top of gates	3127.0	ft
Controlled crest elevation	3097.0	ft
Capacity at El. 3129	200,000	ft³/s

Outlet works: Concrete conduit through right abutment controlled by two 60-in hollow-jet valves at the ends of 84-in steel pipes.

Capacity at El. 3129	1,431	ft³/s

Foundation: Ogallala formation.

TRENTON DAM

Type: Zoned earthfill
Location: On the Republican River 2.5 mi west of Trenton, Nebr.
Construction period: 1949-53
Date of closure (first storage): May 4, 1953
Reservoir, Swanson Lake:

Average depleted annual inflow	123,646	acre-ft
Total capacity to El. 2773	253,950	acre-ft
Active capacity, El. 2710-2773	238,440	acre-ft
Surface area at El. 2773	7,980	acres
Dimensions:		
Structural height	144	ft
Hydraulic height	80	ft
Top width	30	ft
Maximum base width	800	ft
Crest length	8,600	ft
Crest elevation	2793.0	ft
Volume	8,130,000	yd³

Spillway: Concrete-lined open channel at left abutment, controlled by three 42- by 30-ft radial gates.

Elevation top of gates	2773.0	ft
Crest elevation	2743.0	ft
Capacity at El. 2785	133,000	ft³/s

Two sluiceway openings through spillway crest, controlled by two 6- by 7.5-ft slide gates, provide for river releases.

Capacity at El. 2773 (river outlets)	4,300	ft³/s

Outlet works: Concrete conduit through base of dam near right abutment, controlled by one 4-ft-square, high-pressure slide gate, provides for releases to stilling basin that supplies Upper Meeker Canal.

Capacity at El. 2785 (canal outlet)	756	ft³/s

Foundation: Sedimentary deposits consisting of Pierre shale overlain with Ogallala sands and sediments, which are in turn overlain by loess deposits. The ancient riverbed has cut into the shale to a depth of about 65 feet at the dam site and has filled with an alluvial deposit of sand and fine gravel.

MEDICINE CREEK DAM

Type: Zoned earthfill
Location: On Medicine Creek about 2 mi west and 7 mi north of Cambridge, Nebr.
Construction period: 1948-49
Date of closure (first storage): August 8, 1949
Reservoir, Harry Strunk Lake:

Average depleted annual inflow	56,329	acre-ft
Total capacity to El. 2386.2	89,313	acre-ft
Active capacity, El. 2335-2386.2	79,765	acre-ft
Surface area at El. 2386.2	3,460	acres
Dimensions:		
Structural height	165	ft
Hydraulic height	86	ft
Top width	30	ft
Maximum base width	840	ft
Crest length	5,665	ft
Crest elevation	2415.0	ft
Volume	2,730,000	yd³

Spillway: Uncontrolled concrete crest and concrete-lined channel at left abutment. A 13-ft-wide notch opening in the center is 20.1 ft lower than the crest on each side.

Crest length	213	ft

Crest elevation:		
Center notch	2366.1	ft
Other weirs	2386.2	ft
Capacity at El. 2408.9	97,800	ft³/s
Outlet works: Concrete conduit through base of dam controlled by one 3.25-ft-square slide gate.		
Capacity at El. 2347.3	300	ft³/s

RED WILLOW DAM

Type: Zoned earthfill		
Location: On Red Willow Creek about 10 mi northwest of McCook, Nebr.		
Construction period: 1960-62		
Date of closure (first storage): September 5, 1961		
Reservoir, Hugh Butler Lake:		
Average depleted annual inflow	21,652	acre-ft
Total capacity to El. 2604.9	86,630	acre-ft
Active capacity, El. 2558-2604.9	76,180	acre-ft
Surface area at El. 2581.8	1,629	acres
Dimensions:		
Structural height	126	ft
Hydraulic height	123	ft
Top width	30	ft
Maximum base width	785	ft
Crest length	3,159	ft
Crest elevation	2634.0	ft
Volume	2,969,000	yd³
Spillway: Ungated morning-glory		
Crest diameter, inside	31.5	ft
Crest elevation	2604.9	ft
Capacity	4,910	ft³/s
Outlet works:		
Capacity at El. 2604.9 (top of flood-control capacity)	1,200	ft³/s

Diversion Facilities

CULBERTSON DIVERSION DAM

Type: Concrete gated with bypass conduit		
Location: On Frenchman River near Palisade, Nebr.		
Year completed: 1959		
Dimensions:		
Structural height	17	ft
Hydraulic height	7	ft
Weir crest length	30	ft
Dikes:		
Crest elevation	2744.0	ft
Length	150	ft
Spillway: Concrete gated		
Capacity	1,250	ft³/s
Headworks:		
Diversion capacity, Culbertson Canal	400	ft³/s

RED WILLOW CREEK DIVERSION DAM

Type: Concrete weir, embankment wings		
Location: On Red Willow Creek northwest of Indianola, Nebr.		
Year completed: 1963		
Dimensions:		
Structural height	44	ft
Hydraulic height	11	ft
Weir crest length	105	ft
Weir crest elevation	2447.2	ft
Dikes:		
Crest elevation	2459.3	ft
Length	1,095	ft
Volume	35,000	yd³
Spillway: Concrete gravity		
Capacity	8,800	ft³/s
Sluiceway: Concrete, one 6- by 18-ft radial gate.		
Headworks: Concrete, two 5-ft-square slide gates.		
Diversion capacity, Red Willow Canal	90	ft³/s

BARTLEY DIVERSION DAM

Type: Concrete weir, embankment wings		
Location: On the Republican River about 2 mi southeast of Indianola, Nebr.		
Year completed: 1954		
Dimensions:		
Structural height	27	ft
Hydraulic height	3	ft
Weir crest elevation	2353.25	ft
Weir crest length	700	ft
Dikes:		
Crest elevation	2365.0	ft
Length	3,100	ft
Volume	60,000	yd³
Spillway: Concrete gravity		
Capacity	87,500	ft³/s
Sluiceway: Concrete, two 10- by 16-ft radial gates.		
Headworks: Concrete, two 10- by 3-ft top seal radial gates.		
Diversion capacity, Bartley Canal	130	ft³/s

CAMBRIDGE DIVERSION DAM

Type: Concrete weir, embankment wings		
Location: On the Republican River about 2 mi east of Cambridge, Nebr.		
Year completed: 1949		
Dimensions:		
Structural height	33	ft
Hydraulic height	2	ft
Weir crest length	350	ft
Weir crest elevation	2236.0	ft
Dikes:		
Crest elevation	2250.0	ft
Length	1,020	ft
Volume	18,500	yd³
Spillway: Concrete gravity		
Capacity	90,000	ft³/s
Sluiceway: Concrete, two 10- by 14-ft radial gates.		
Headworks: Concrete, four 10- by 14-ft hand-operated radial gates.		
Diversion capacity, Cambridge Canal	325	ft³/s

Carriage Facilities

CULBERTSON CANAL AND EXTENSIONS[1]

Location: From Culbertson Diversion Dam near Palisade, Nebr., generally southeast to a point 4 mi east of McCook, Nebr., to serve the Frenchman Unit.		
Construction period: 1959-61		
Length	48.6	mi
Diversion capacity	400	ft³/s
Typical maximum section in earth, or earth lined:		
Bottom width	20	ft
Side slopes	2:1	
Water depth	6.2	ft
Lining thickness	2	ft

[1]Original: 21.3 miles long. Extension: 27.3 miles long.

Upper Meeker Canal, Subcanal, and Meeker Extension Canal

Location: From Trenton Dam generally east along the Republican River to just southwest of Indianola, Nebr., to serve the Meeker-Driftwood Unit.
Construction period: 1956-59

Length:	
Upper Meeker Canal and Subcanal	21.5 mi
Meeker Extension Canal	10.6 mi
Diversion capacity:	
Upper Meeker Canal and Subcanal	284 ft³/s
Meeker Extension Canal	90 ft³/s
Typical maximum section, in earth or earth lined (Upper Meeker Canal and Subcanal):	
Bottom width	16 ft
Side slopes	1.5:1
Water depth	5 ft
Lining thickness	2 ft
Typical maximum section, concrete lined (Upper Meeker Canal and Subcanal):	
Bottom width	9 ft
Side slopes	1.5:1
Water depth	4.76 ft
Lining thickness	4 in
Typical maximum section in earth (Meeker Extension Canal):	
Bottom width	10 ft
Side slopes	1.5:1
Water depth	3.2 ft

Driftwood Canal and Extensions

Location: From end of Upper Meeker Canal generally southeast on the south side of the Republican River to about 8 mi southwest of McCook, Nebr.
Construction period: 1957-59

Length[2]	13.7 mi
Diversion capacity	225 ft³/s
Typical maximum section, in earth or earth lined:	
Bottom width	16 ft
Side slopes	2:1
Water depth	4.6 ft
Lining thickness	2 ft

[2]Length of extension: 17.2 miles, 30- to 60-ft³/s capacity.

Red Willow Canal

Location: From Red Willow Creek Diversion Dam southeasterly along the north side of the Republican River.
Construction period: 1961-64

Length	24.1 mi
Diversion capacity	90 ft³/s
Typical maximum section, in earth or earth lined:	
Bottom width	10 ft
Side slopes	1.5:1
Water depth	3.8 ft
Lining thickness	1.5 ft

Bartley Canal

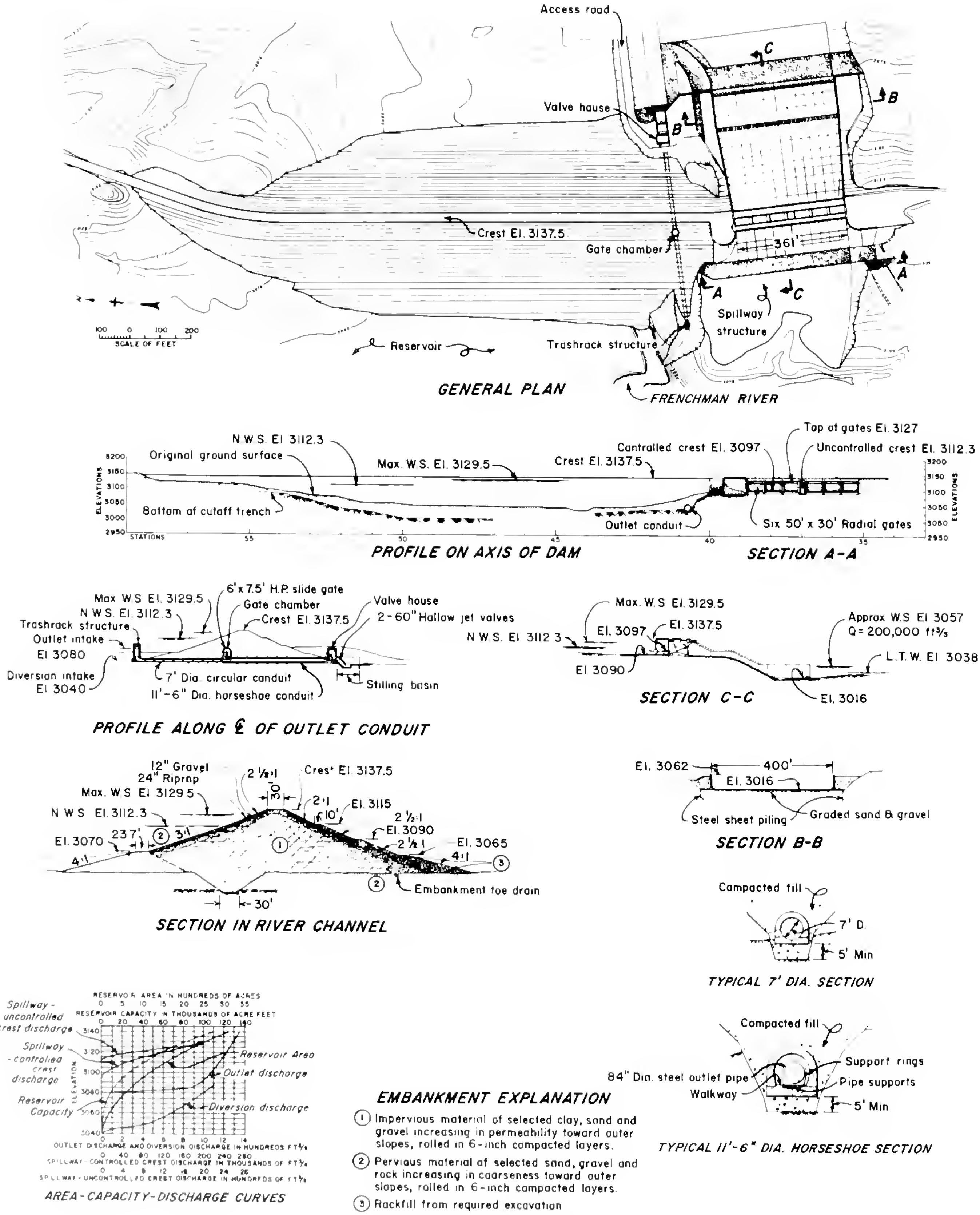
Location: From Bartley Diversion Dam on the Republican River near Indianola, Nebr., generally east along the south side of the river past Cambridge, Nebr., for irrigation of part of the Red Willow Unit.
Construction period: 1953-54

Length	19.4 mi
Diversion capacity	130 ft³/s
Typical maximum section in earth:	
Bottom width	8 ft
Side slopes	3:1
Water depth	3.8 ft
Typical maximum section, earth lined:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	3.8 ft
Lining thickness	2 ft

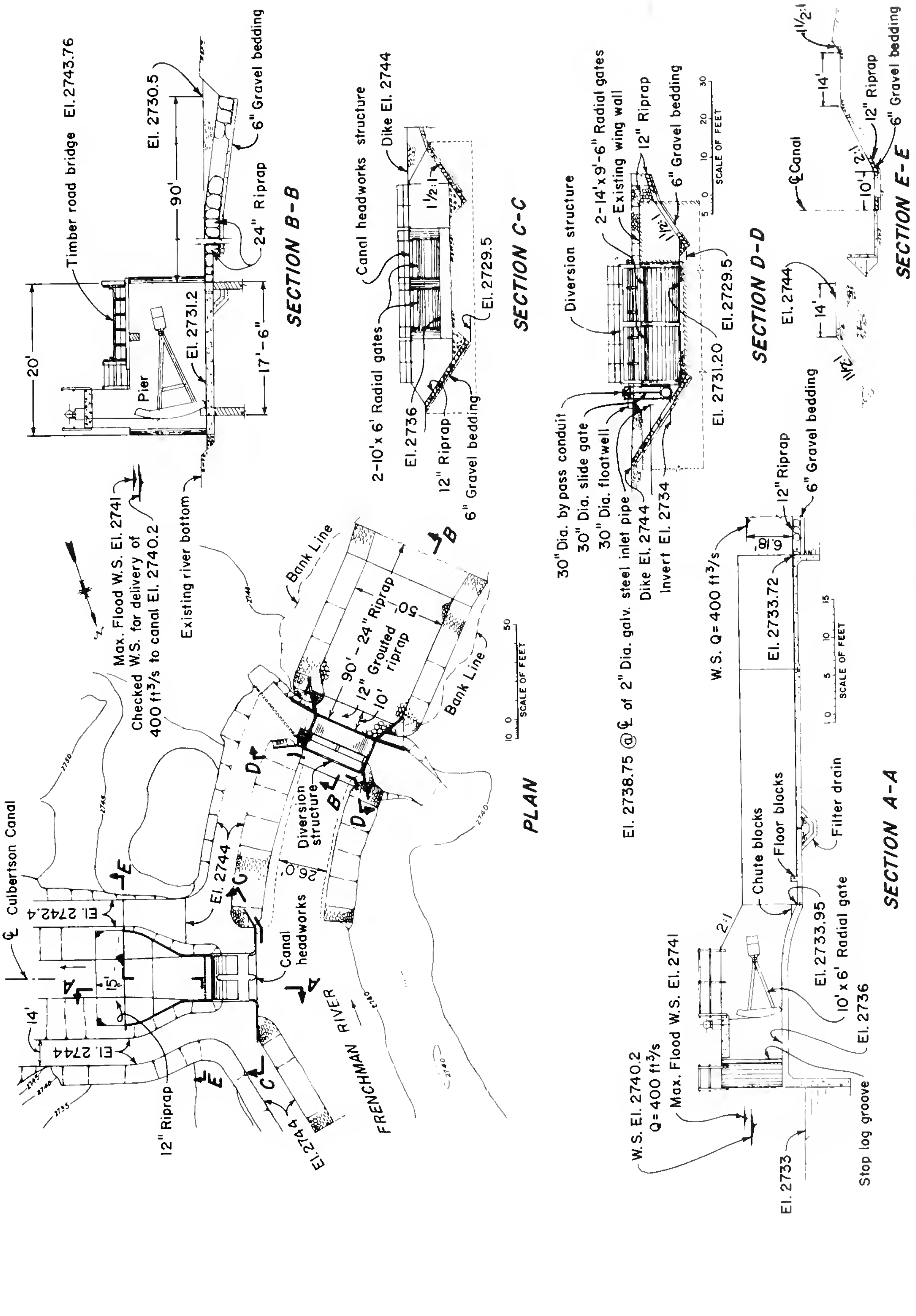
Cambridge Canal

Location: From Cambridge Diversion Dam near Cambridge, Nebr., generally east along the north side of the Republican River to Harlan County Reservoir.
Construction period: 1948-54

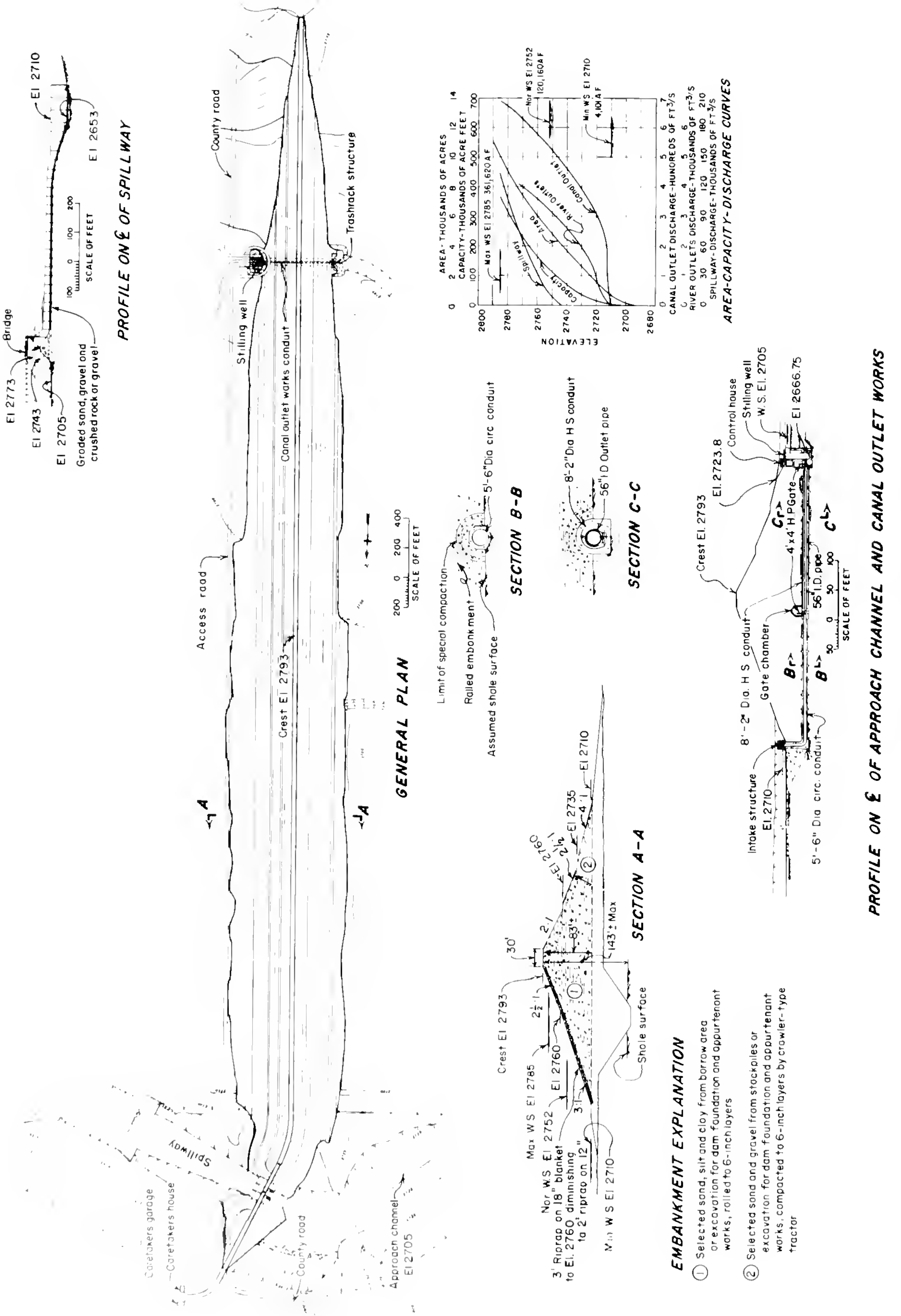
Length	49.2 mi
Diversion capacity	325 ft³/s
Typical maximum section in earth:	
Bottom width	16 ft
Side slopes	1.5:1
Water depth	5.2 ft
Typical maximum section, earth lined:	
Bottom width	11.5 ft
Side slopes	1.5:1
Water depth	5.4 ft
Lining thickness	2 ft



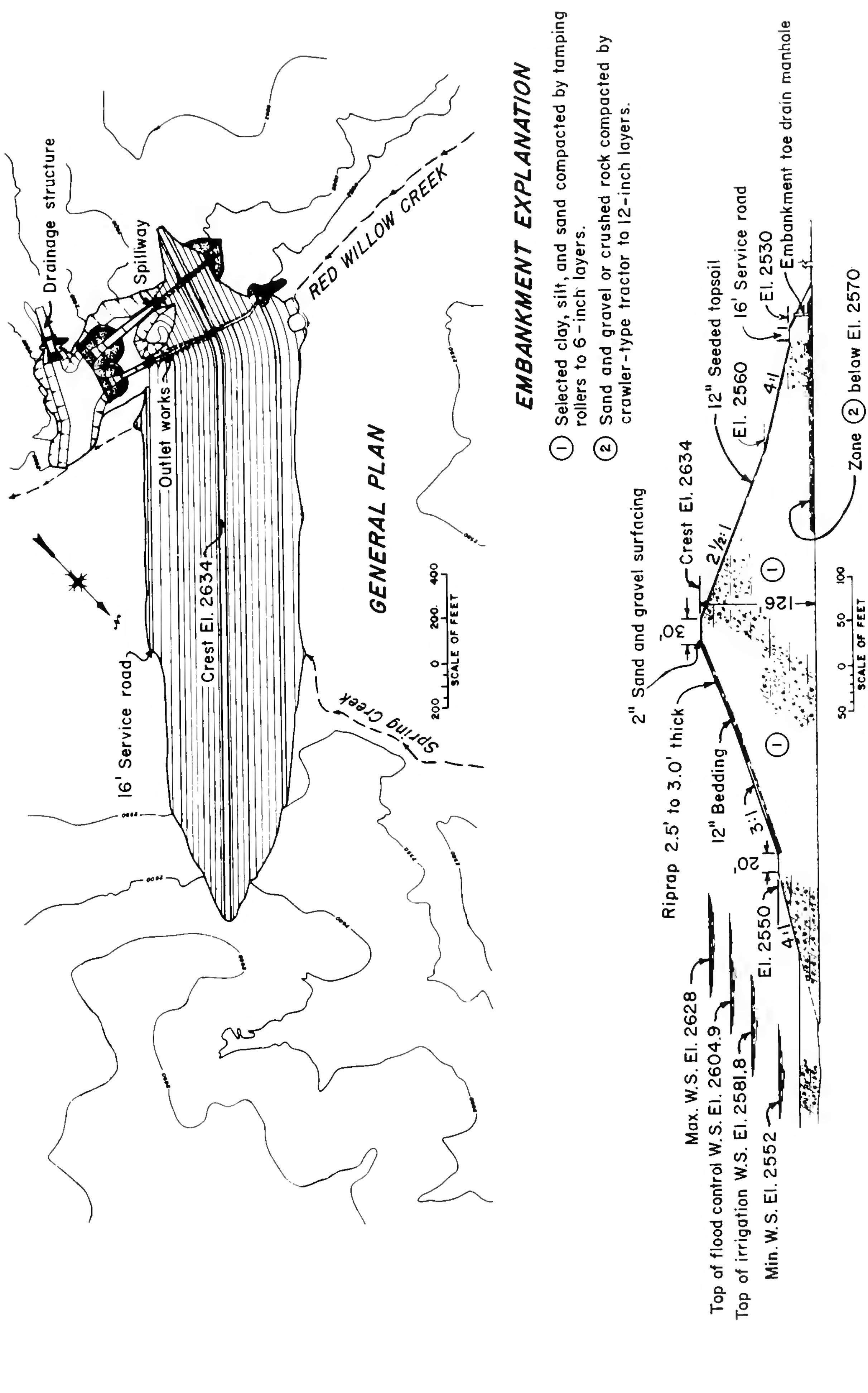
Enders Dam, Plan and Sections



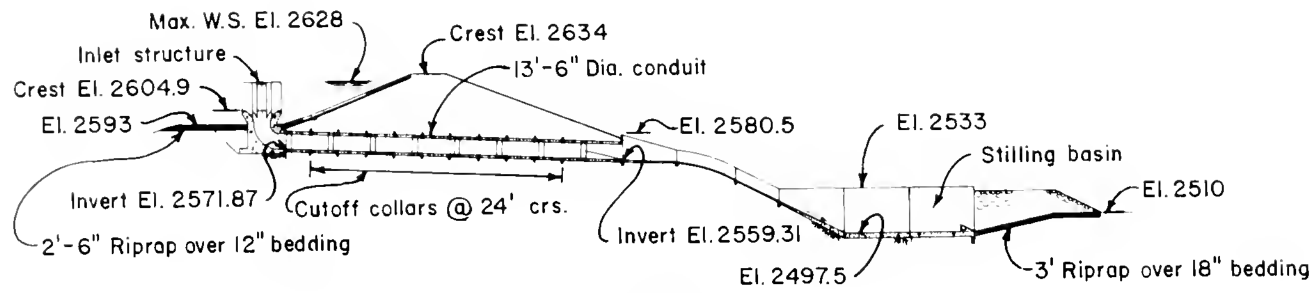
Culbertson Diversion Dam, Plan and Sections



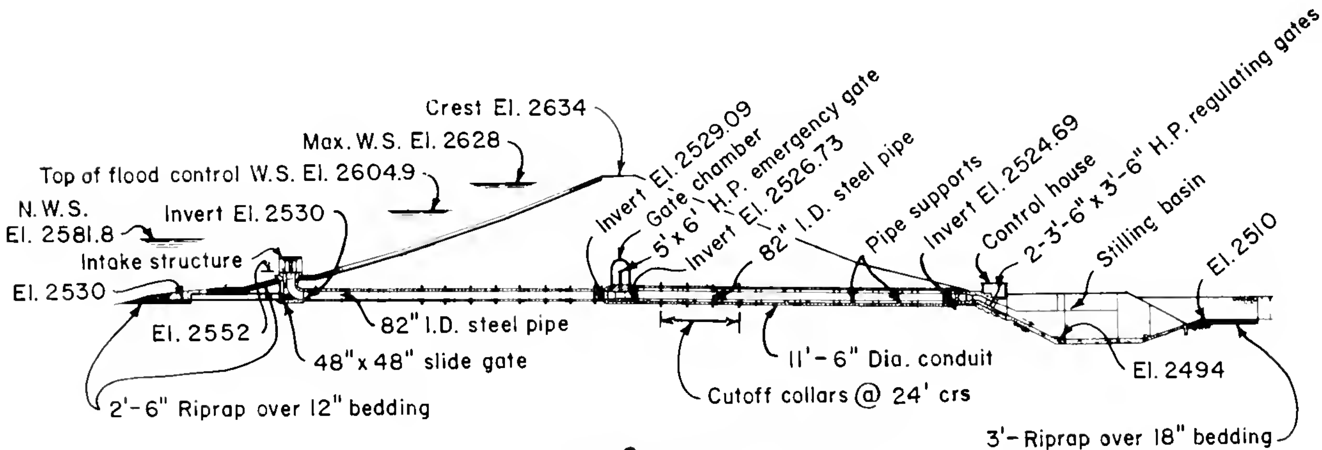
Trenton Dam, Plan and Sections



Red Willow Dam, Plan and Section



PROFILE ON ℄ SPILLWAY



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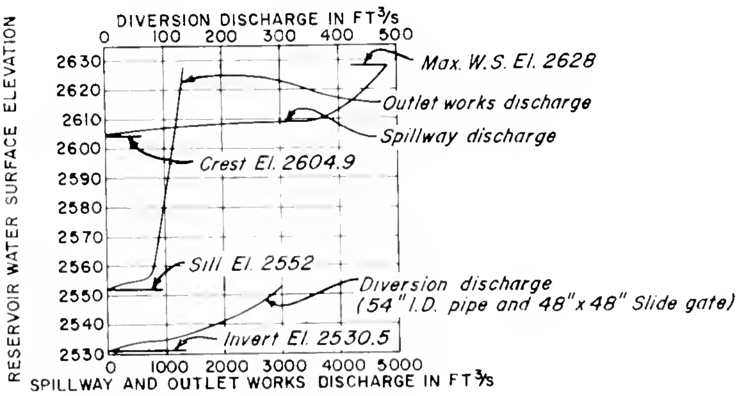
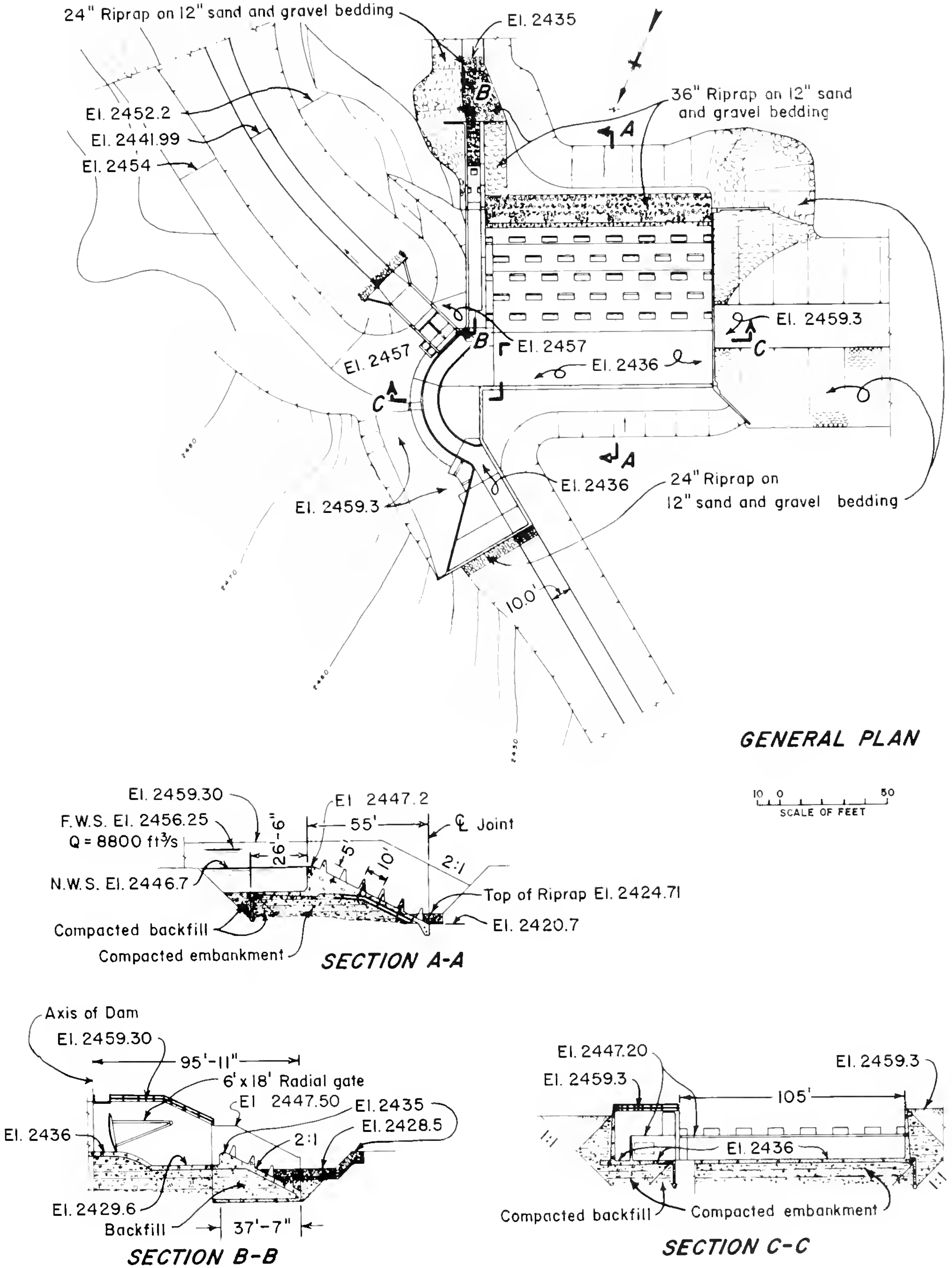
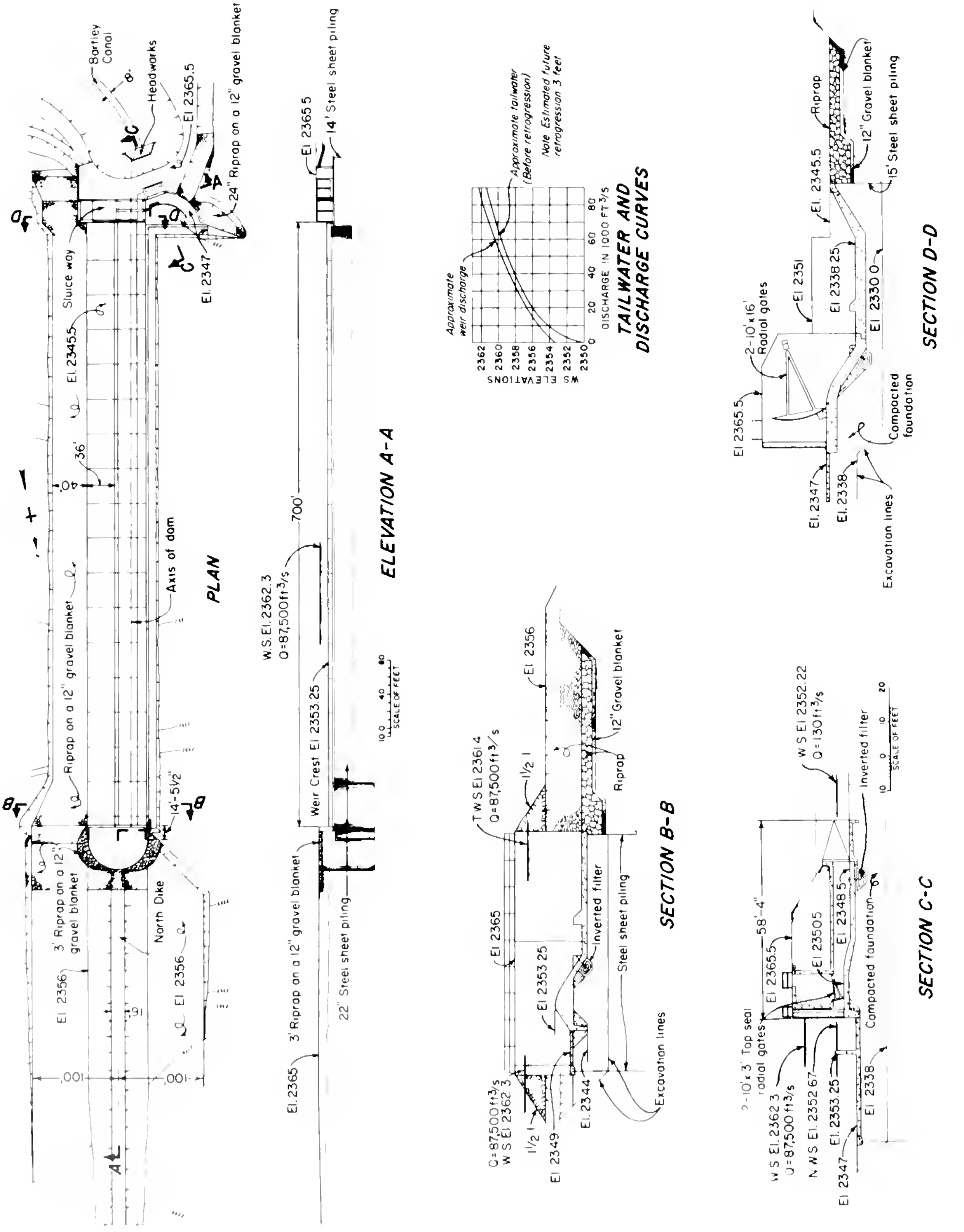


DISCHARGE CURVES

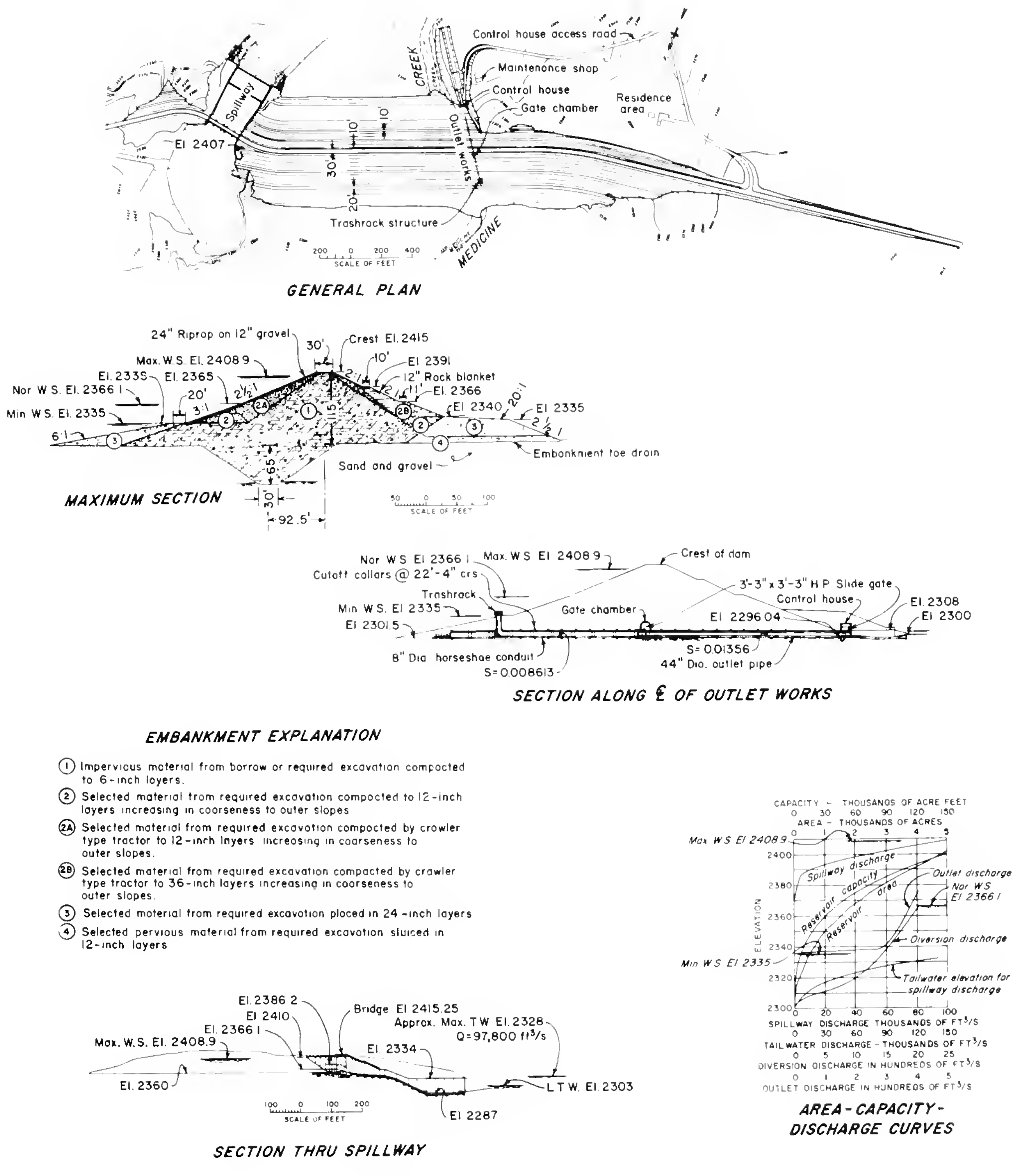
Red Willow Dam, Profiles



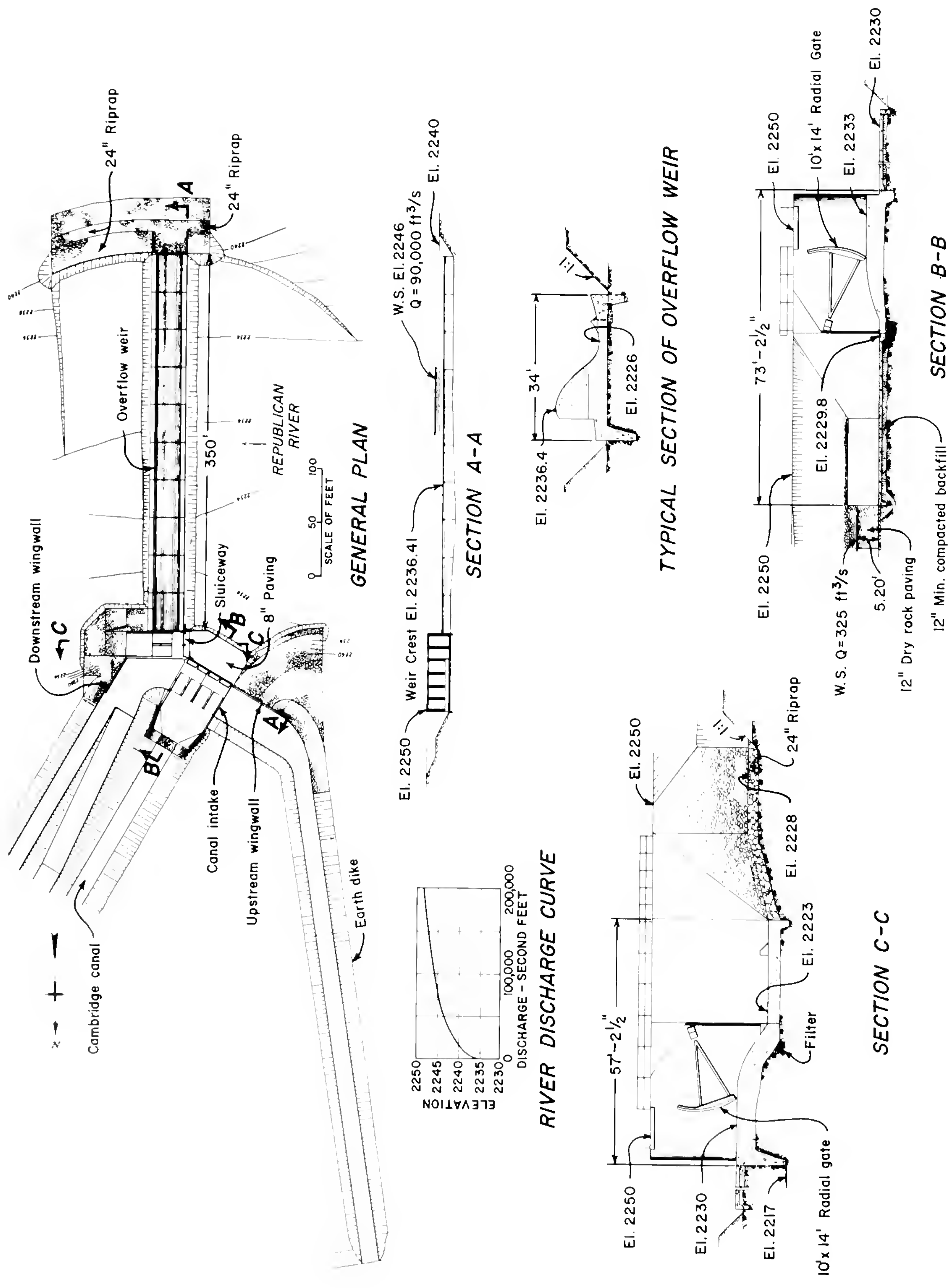
Red Willow Creek Diversion Dam, Plan and Sections



Bartley Diversion Dam, Plan and Sections



Medicine Creek Dam, Plan and Sections

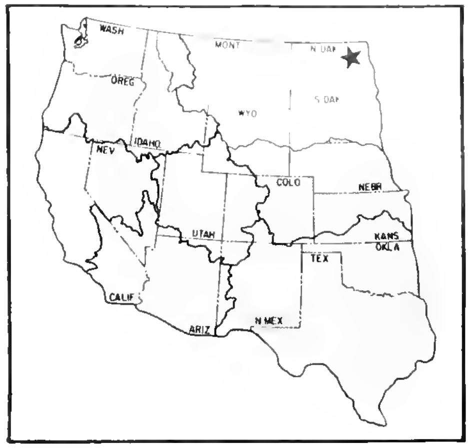


Cambridge Diversion Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Garrison Diversion Unit
(Initial Stage)

North Dakota and South Dakota

Upper Missouri Region
Water and Power Resources Service



The Garrison Diversion Unit would divert water from Lake Sakakawea, formed by Garrison Dam on the Missouri River. The water would be used for irrigation of about one million acres in east-central North Dakota, municipal and industrial use in several towns and cities, fish and wildlife, and recreation in Devils Lake and other impoundments. Flood control and pollution abatement are other purposes. Initial stage construction was authorized in August 1965 (79 Stat. 433) to irrigate about 250,000 acres. Principal supply works include the 2,050-cubic-foot-per-second capacity Snake Creek Pumping Plant, Audubon Lake, the 1,950-cubic-foot-per-second McClusky Canal, and the Lonetree Reservoir at the headwaters of the Sheyenne River. Power for pumping will be supplied from Pick-Sloan Missouri Basin Program facilities.

The plan includes Jamestown Reservoir, already constructed under separate authorization on the James River. Other facilities complete or substantially complete are the Snake Creek Pumping Plant, McClusky Canal, and Wintering Dam. Required to complete the unit are Lonetree Dam and Dikes and other carriage, storage, distribution, and drainage facilities. Several alternatives are under consideration for the Garrison Diversion Unit.

PLAN

Water from Lake Sakakawea will be pumped by the Snake Creek Pumping Plant into Audubon Lake, then released into the McClusky Canal. Under the authorized plan, the canal conveys the water 74 miles across the drainage divide to the Lonetree Reservoir, providing water enroute to irrigate an area of 6,515 acres near Lincoln Valley in Sheridan County about 20 miles southwest of Harvey, N. Dak. Lonetree Reservoir, which will regulate the diverted water, will have a total storage capacity of 535,000 acre-feet and a maximum water surface area of 20,300 acres.

Distribution Facilities

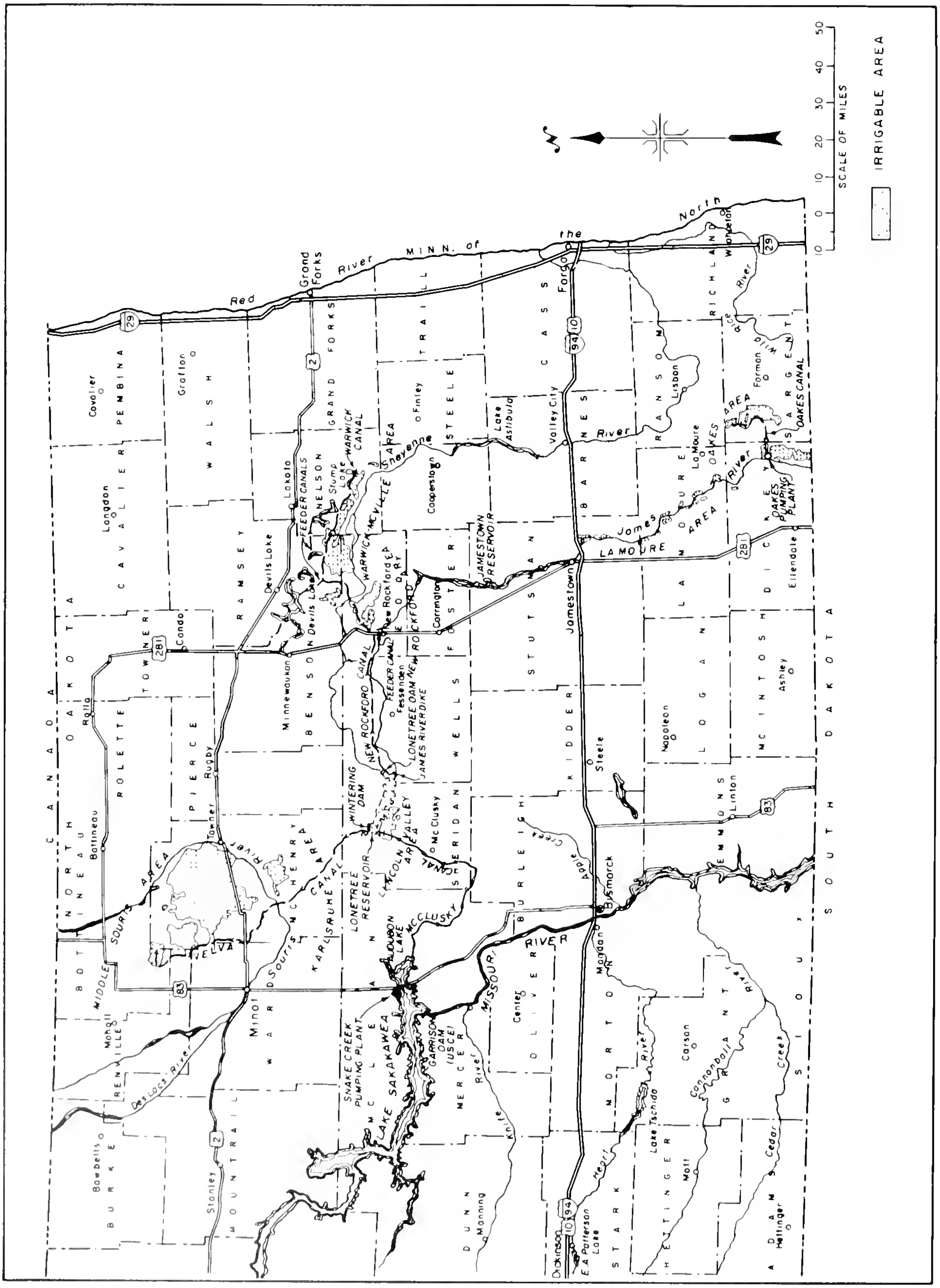
Velva Canal would extend in a northwesterly direction from Lonetree Reservoir to deliver water to 116,000 irrigable acres in the Souris Section, the city of Minot, N. Dak., and several smaller communities. It would have an initial capacity of 2,000 cubic feet per second, and be about 84 miles long. Several feeder laterals would be required to distribute water supplies.

New Rockford Canal would originate at Lonetree Dam with an initial capacity of 1,600 cubic feet per second. It would follow uplands between the Sheyenne and James Rivers to serve 20,935 acres in New Rockford, 47,220 acres in Warwick-McVille, 13,350 acres in LaMoure, and 45,980 acres in Oakes areas. Water would be supplied through a feeder canal to the James River near New Rockford, N. Dak., for use in LaMoure and Oakes in southeastern North Dakota. New Rockford Canal would be 56 miles long and would terminate on the west side of the Sheyenne River, approximately 15 miles northeast of New Rockford.

Warwick Canal would begin at the end of New Rockford Canal and immediately cross under the Sheyenne River to deliver water to the Warwick-McVille area and Devils Lake. It would have a capacity of 770 cubic feet per second and be 9 miles long, ending at the Devils Lake Feeder Canal. Three feeder laterals would distribute water to the irrigable lands.

Devils Lake Feeder Canal would carry up to 400 cubic feet per second a distance of 13 miles to Devils Lake. The water quality of Devils Lake and companion lakes would be improved and stabilized by the diversions from Lake Sakakawea. Stump Lake Feeder Canal would convey water from Devils Lake farther eastward to Stump Lake. This canal would be 10 miles long and have a capacity of 310 cubic feet per second.

The James River channel between New Rockford and LaMoure, N. Dak., would be modified to permit passage of releases from James River Feeder Canal and Jamestown Dam for irrigation of 59,300 acres in the LaMoure



Garrison Diversion Unit

Snake Creek Pumping Plant

and Oakes sections. The modified channel would have a capacity of 450 cubic feet per second at normal flows.

Oakes Canal and Taayer Reservoir would be supplied by the Oakes Pumping Plant and deliver water from James River near Oakes to the 45,980-acre Oakes area. Capacity of the canal would be 320 cubic feet per second and the length would be about 11 miles. Taayer Reservoir, an offstream impoundment 10 miles east of the pumping plant, would be used to meet peak demands. The reservoir would be filled from Oakes Canal during low irrigation demand periods and a pumping plant would deliver water from the reservoir to the canal during high demand periods. The reservoir would have a total storage capacity of 28,500 acre-feet and a maximum water surface area of 1,440 acres.

Laterals under 50 cubic feet per second would be buried pipelines pressurized by pumping plants located adjacent to a canal or open feeder lateral. A drainage system consisting of open collector drains and buried pipe drains would be installed to control ground water. The project system would include 210 miles of open laterals, 480 miles of buried distribution pipelines, 300 miles of open drains, 1,730 miles of buried pipe drains and 70 pumping plants.

DEVELOPMENT

Early History

Lewis and Clark made the first systematic exploration of the Missouri River Valley in 1804-06. In 1836, the steamboat "Yellowstone" sailed to the mouth of the Yellowstone River and opened an era of flourishing river navigation that ended soon after the Northern Pacific Railroad reached Bismarck, N. Dak., in 1873.

In 1862, the Homestead Act started a wave of settlement that ended with the area near its peak population in the 1910-20 decade. The 160- and 320-acre farm patterns of the homestead and tree-claim farms were uneconomically small for this semiarid to dry climate. Sporadic years of adversity, followed by the disastrous drought in the 1930's, started a migration from the land. This brought on a trend to larger farms which continued after 1939 because of full mechanization of grain farming.

Investigations

In 1890, the Geological Survey surveyed the divide that separates the Missouri River from the Souris and James Rivers in search of a practical route for diverting Missouri River water to the James and Souris basins.

Snake Creek Pumping Plant

In the early 1920's, diversion of Missouri River water into central and eastern North Dakota again was brought to the public's attention by two plans. One proposed a diversion dam in eastern Montana to supply a canal leading into North Dakota, the other proposed a tunnel across the narrow divide from the Missouri River near Garrison, N. Dak., to the Souris River.

Since 1922, the State Engineer has worked on plans to divert flows of the Missouri River and has enlisted the aid of Federal agencies in developing a plan. By 1933, a long diversion canal, a river-level tunnel, a high dam near the present site of Garrison Dam, and a lignite-powered pumping plant had been studied.

The Corps of Engineers, in 1935, announced in House Document 238, 73d Congress (308 report) that Garrison damsite "offers exceptional advantage in the matter of storage and also in the matter of controlled navigation releases." However, foundation conditions were determined unsatisfactory for a high dam and the site was abandoned in favor of Fort Peck Dam on the Missouri River.

Completion of Fort Peck Dam in 1939, during the seemingly hopeless distress of the drought decade of the 1930's, and the virtual disappearance of Devils Lake led to a renewed insistence that the Missouri River be put to work on the blowing prairies of the new Northern Dust Bowl. Investigations were begun by the Bureau of Reclamation in search of a feasible plan for irrigation from the Missouri River below the 19-million-acre-foot Fort Peck Reservoir. Reclamation's Investigation Report No. 66 was first presented publicly in Minot, N. Dak., in 1942. It proposed to divert from the Missouri River at a low diversion dam below Fort Peck Dam in Montana to a long canal and reservoir system extending into North Dakota. The proposal was named the Missouri-Souris Project and would irrigate 1,275,000 acres and provide a water supply for cities and towns in a wide area and replenish Devils Lake and numerous streams.

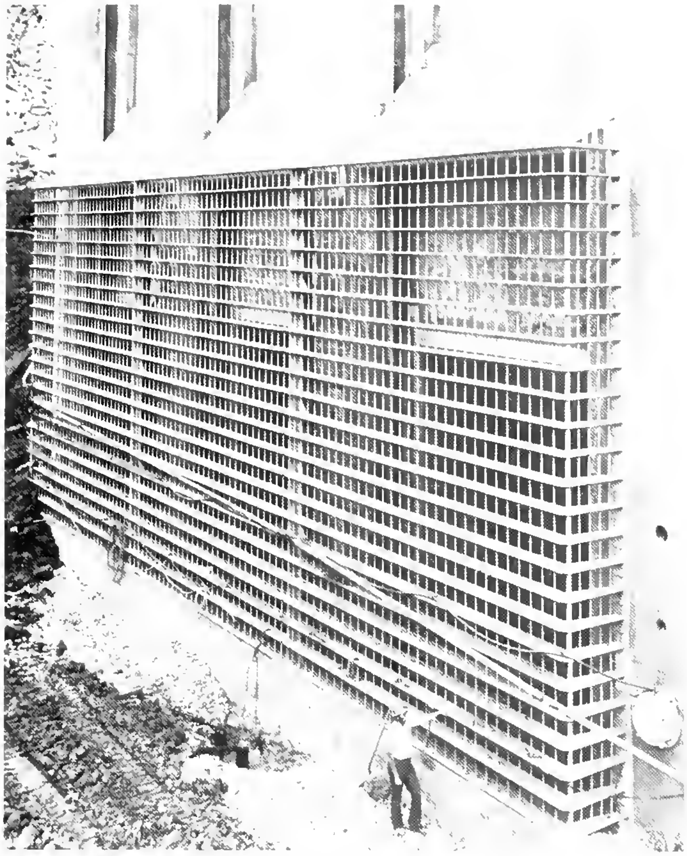
Disastrous floods along the Missouri River in 1942 and 1943 focused national attention on this drought-ridden, flood-devastated river basin and spurred comprehensive planning by both the Bureau of Reclamation and Corps of Engineers. Separate generalized plans, containing flood control, irrigation, hydropower, navigation, and incidental uses, were prepared by each agency and reported during the 78th Congress, by the Bureau of Reclamation in Senate Document 191 (Sloan Plan), and by the Corps of Engineers in House Document 475 (Pick Plan). The plans were revised and coordinated in the Missouri River Basin Project (Pick-Sloan Plan) and approved by the Congress in the Flood Control Act of 1944.

Garrison Dam was completed in 1956. Further project planning for the Garrison Diversion Unit (formerly Missouri-Souris Project) after 1944 resulted in substantial modification in the plan. This affected the location of some of the irrigable land, and took advantage of Lake Sakakawea as a point of diversion to the North and South Dakota portions.

Authorization

Garrison Diversion Unit is a modification of the Missouri-Souris development of the Missouri River Basin Project, now known as the Pick-Sloan Missouri Basin Program, authorized by the Flood Control Act of 1944, approved December 22, 1944, 78th Congress (58 Stat. 887).

The initial stage of the Garrison Diversion Unit (250,000 acres) was authorized by act of Congress on August 5, 1965 (79 Stat. 433).



Metal trash rack at the inlet of Snake Creek Pumping Plant

Construction

Construction work began on Snake Creek Pumping Plant on September 2, 1968, and was completed on December 3, 1975. Construction on the 74-mile McClusky Canal began in July 1970 and was nearing completion in 1977.

BENEFITS

Irrigation

Principal crops now grown on project lands include wheat, oats, barley, flax, corn, tame hay, and pasture. Irrigation will permit new crops such as alfalfa and potatoes and will increase the yields per acre for the grain crops.

Municipal and Industrial Water

Original plans were to deliver about 40,000 acre-feet of municipal and industrial water annually to project supply facilities, with the users providing winter storage and conveyance facilities to the point of use.

Thirty-two communities, which include the 15 identified in the initial stage, and one rural water district have expressed a need and interest in receiving Garrison Diversion Unit water: 28 in North Dakota; 3 in South Dakota; and 1 in Minnesota. In the event all 32 communities could feasibly obtain project water, about 70,000 acre-feet of water delivery eventually would be required. Garrison Diversion Unit system capacities also will be sufficient to provide an additional 30,000 acre-feet.

Preliminary cost comparisons show that it may be more economical for some of these towns to obtain future water supplies from facilities of the Garrison Diversion Unit than to utilize local sources, which supply mainly ground water.

Recreation and Fish and Wildlife

The plan of development for the unit will provide increased recreation opportunities in an area which now does not offer a wide range of outdoor activity.

The authorized plan provides for nine recreation developments at six locations within the project: Lake Brekken-Holmes, Lonetree Reservoir, Devils Lake, Stump Lake, Taayer Reservoir, and Jamestown Reservoir. The National Park Service has prepared plans in various degrees of detail for developing recreation sites in these areas. The Bureau of Reclamation is involved in updating these plans and developing future detailed plans. Two recreation sites have been developed at Jamestown Reservoir. Some lands for recreation development have been acquired by the Bureau of Reclamation at Lake Brekken-Holmes and at Lonetree Reservoir. The Garrison Diversion Conservancy District has acquired some lands at Devils Lake, Stump Lake, and Lake Brekken-Holmes for future development.

Two sites at Devils Lake, Ziebach Pass and Highway No. 2, have been partially developed by the conservancy district and the Tri-County Park Board, and through the

McClusky Canal

Youth Conservation Corps program. Some work has been done to establish trees and grass on lands acquired for recreation development at Lake Brekken-Holmes and at Lonetree Reservoir. Public use of features and facilities of the unit amounted to 418,400 visitor days in 1977. Devils and Stump Lakes provided 398,700 visitor days, and McClusky Canal provided 19,700.

A fish and wildlife plan totaling 146,530 acres would be designed to mitigate habitat losses due primarily to drainage of existing wetlands in the project areas. Primary emphasis of this plan would be to restore complexes of drained wetlands to original condition and develop surrounding grasslands for cover. These areas would be dispersed over lands in the 25-county conservancy district.

PROJECT DATA

Facilities in Operation

Storage dams	1	
Canals	73.6	mi
Pumping plants	1	

ENGINEERING DATA

Storage Facilities

WINTERING DAM

Type: Zoned earthfill
Location: 12.5 mi southwest of Anamoose, N. Dak.
Construction period: 1975-76
Reservoir, Lonetree:
No water will be stored until Lonetree Dam, James River Dike, and eight smaller dikes, which form the reservoir, are constructed.

Structural height	40	ft
Hydraulic height	34	ft
Top width	30	ft
Maximum base width	230	ft
Crest length	5,180	ft
Crest elevation	1651.0	ft
Volume	746,000	yd^3

Cutoff trench:
Slurry and sheet piling through the Wintering River outwash channel of silt, sand, and gravel deposits to the clay (glacial till) contact.
Spillway: None
Outlet works: None

Carriage Facilities

MCCLUSKY CANAL (ALL REACHES)

Location: From Audubon Lake southeast and then north to Lonetree Reservoir.
Construction period: 1970-78

Length	73.6	mi
Capacity	1,950	ft^3/s
Excavation required	55,000,000	yd^3
Maximum cut	115	ft
Average depth of cut	40	ft
Slope	0.00003	
Typical maximum section in earth:		
Bottom width	25	ft
Side slopes	2:1	
Water depth	17.3	ft
Water surface width	94	ft
Right-of-way requirements	360-2,250	ft

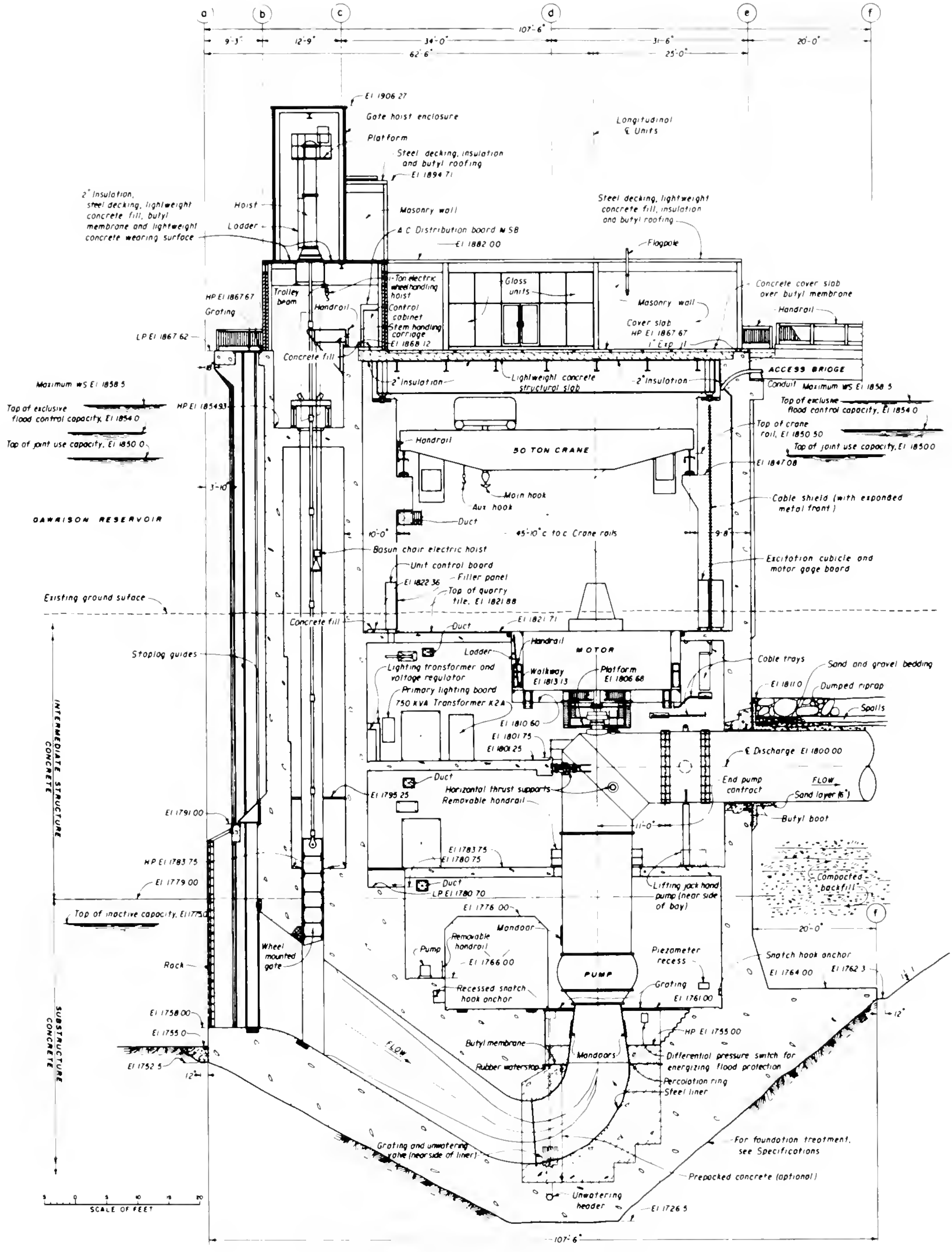
Crossings: About 21 bridges and one tunnel

SNAKE CREEK PUMPING PLANT

Location: 5.5 mi northwest of Coleharbor, N. Dak.
Construction period: 1968-75
Type of structure: Reinforced concrete
Size of structure: 87 by 130 by 180 ft high
Operating range — Lake Sakakawea
Elevation 1776-1850.

Number and size of pumps (3)	685	ft^3/s
Number and size of motors (3)	8,000	hp
Plant capacity	2,050	ft^3/s
Discharge tubes: 11-ft-diameter, 450-ft-long		
Concrete	10,500	yd^3

First tested: October 1975



TRANSVERSE SECTION THRU ℄ UNIT S2

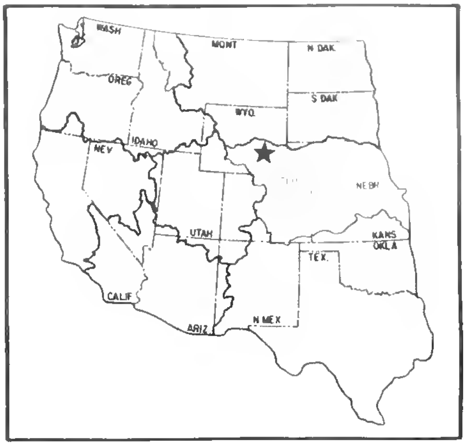
Snake Creek Pumping Plant, Section

Wintering Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Glendo Unit, Oregon Trail Division

Wyoming: Natrona, Converse, and Platte Counties

Lower Missouri Region
Water and Power Resources Service



The Glendo Unit is a multiple-purpose natural resource development. It consists of Glendo Dam, Reservoir, and Powerplant; Fremont Canyon Powerplant; and Gray Reef Dam and its reregulating reservoir. The unit features are located on the North Platte River in eastern and central Wyoming and are adjacent to, and work in conjunction with, other units of the Pick-Sloan Missouri Basin Program and the Kendrick and North Platte Projects.

The unit furnishes a maximum of 40,000 acre-feet of water annually from Glendo Reservoir for irrigation in Wyoming and Nebraska, and electrical power is supplied to Wyoming, Colorado, and Nebraska by Glendo and Fremont Canyon Powerplants, which have installed capacities of 24,000 and 48,000 kilowatts, respectively.

The Glendo Unit is operated in conformity with the North Platte River Decree of 1945. It provides irrigation, power generation, flood control, fish and wildlife enhancement, recreation, sediment retention, pollution abatement, and improvement of the quality of municipal and industrial water supply in the North Platte River Valley between Gray Reef Dam and Glendo Reservoir.

PLAN

The irrigation water from Glendo Reservoir is delivered to water users in the North Platte River Valley at and below Whalen Diversion Dam, a feature of the North Platte Project. These water users have early natural flow water rights but no storage rights and, therefore, need the dependable storage provided by Glendo Reservoir.

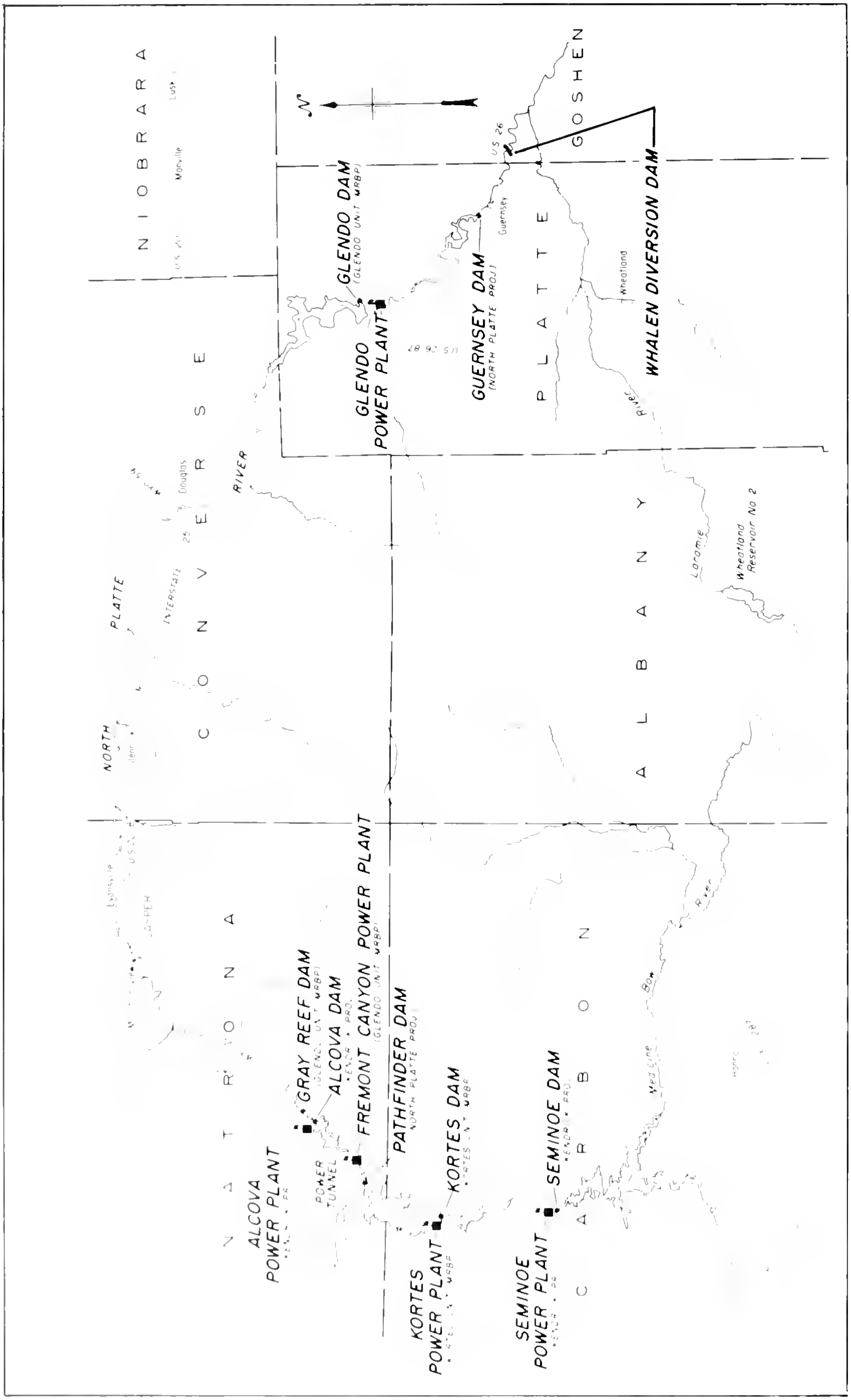
An amendment to the North Platte River Decree was approved in 1953 by the States of Colorado, Wyoming, and Nebraska, and by the U.S. Supreme Court. It provides for retaining the existing regimen of the natural flow of the North Platte River below Pathfinder Dam, except that not more than 40,000 acre-feet of water plus space obtained by evaporation losses may be stored in Glendo Reservoir for irrigation during any water year, and the amount held in storage at any time for irrigation may not exceed 100,000 acre-feet. The amended decree permits the release from storage of 15,000 acre-feet of water annually to Wyoming and 25,000 acre-feet annually to Nebraska for irrigation.

Within the limits of the amended decree, storage facilities of the North Platte River system provide considerable flexibility. Maximum capacity for regulation and storage is afforded through exchange of water between Glendo Reservoir and upstream reservoirs. Exchange water stored in Glendo is released by the close of the irrigation season. The proprietary and contractual interests in storage water are identifiable at all times regardless of location of the water in the system. Floodwater stored in Glendo Reservoir is released under regulations prescribed by the Secretary of the Army under authority of the Flood Control Act of 1944.

Glendo Dam, Reservoir, and Powerplant

Glendo Dam is a zoned earthfill structure on the North Platte River about 4.5 miles southeast of Glendo. The embankment has a structural height of 190 feet and a length of 2,096 feet along the crest. About 2,440 feet of

Glendo Dam


NIOBRARA
CONVERSE
NATRONA
GOSHEN
PLATTE
ALBANY
CARBON
GLENDO DAM
(GLENDO UNIT MRBP)
GLENDO POWER PLANT
GUERNSEY DAM
(NORTH PLATTE PROJ.)
WHALEN DIVERSION DAM
GRAY REEF DAM
ALCOVA DAM
FREMONT CANYON POWER PLANT
(GLENDO UNIT MRBP)
PATHFINDER DAM
(NORTH PLATTE PROJ.)
KORTES DAM
SEMINOE DAM
ALCOVA POWER PLANT
KORTES POWER PLANT
SEMINOE POWER PLANT
POWER TUNNEL
NORTH PLATTE RIVER
Laramie River
Medicine Bow River
Wheatland Reservoir No 2
Douglas
Guernsey
Wheatland
Manville
US 26
INTERSTATE 25

Glendo Unit

dikes are required across a low area on the south side of the reservoir 1.5 miles west of the dam. The dam forms a reservoir 14 miles in length, having a total capacity of 789,402 acre-feet at water surface elevation 4653, the top of the flood control capacity. Space is provided in the reservoir for storing 115,000 acre-feet of sediment, an estimated 100-year accumulation. There are 454,337 acre-feet allotted for irrigation and power and 271,917 acre-feet for flood control. In addition, a surcharge capacity of 329,251 acre-feet is available. These capacities differ slightly from the original storage allocations because of sediment accumulation.

An uncontrolled concrete spillway 45 feet wide is located about 450 feet north of the right abutment of the dam. The Glendo Powerplant is joined to the Glendo Reservoir by a diversion tunnel 21 feet in diameter and 2,100 feet long. The plant contains two units having a maximum rated head of 130 feet. Each unit has an installed capacity of 12,000 kilowatts.

Fremont Canyon Powerplant

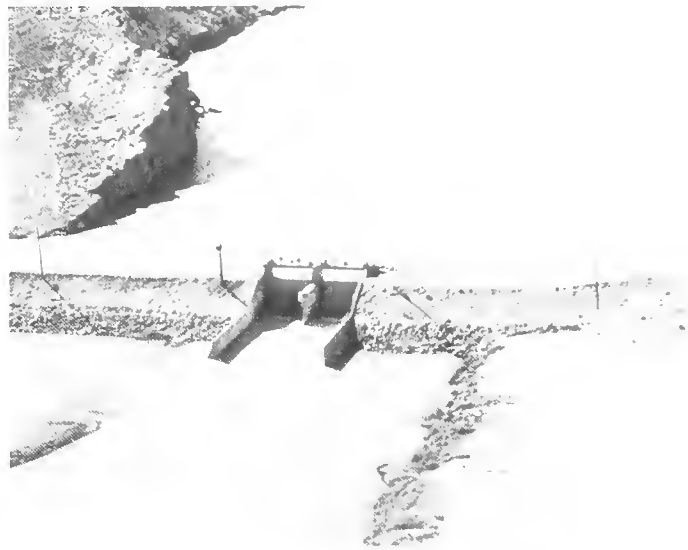
The Fremont Canyon Powerplant, on the left bank of the North Platte River at the head of Alcova Reservoir, consists of two 24,000-kilowatt generators, driven by two 33,500-horsepower Francis-type hydraulic turbines. The turbines operate at a maximum head of 350 feet and an effective head of 300 feet. The powerplant generates power during releases of stored floodwater, irrigation water, and water to satisfy prior water rights from Pathfinder Reservoir of the North Platte Project. Water for power generation is conveyed to the powerplant by a 3-mile-long 18-foot-diameter, concrete-lined pressure tunnel. The tunnel branches to two 10.75-foot-diameter penstocks upstream of the powerplant. This conduit is controlled by a 14- by 18-foot fixed-wheel gate located 243 feet downstream from the inlet. Access to the powerplant is provided by a 1,692-foot-long unlined tunnel 16.5 feet high and containing a 16-foot-wide roadway.

Gray Reef Dam and Reservoir

Gray Reef Dam is on the North Platte River about 27 miles southwest of Casper, and 2 miles downstream from Alcova Dam. The earthfill structure has a structural height of 36 feet, a crest length of 650 feet, and contains a volume of 40,000 cubic yards of material.

The spillway consists of a concrete chute near the center of the dam controlled by two 35- by 20-foot radial gates. Capacity of the spillway is 20,000 cubic feet per second. There are no outlet works in the dam.

The reservoir has a total capacity of 1,800 acre-feet, with a surface area of 182 acres. Gray Reef Reservoir is operated to reregulate widely fluctuating water releases from the Alcova Powerplant of the Kendrick Project.



Gray Reef Dam

DEVELOPMENT

Early History

From the beginning of the early settlement, livestock ranching has been the principal economic activity in the area. The North Platte River Valley served as a passage for early explorers and later as a route for settlers from the eastern States through the higher plains to the Rocky Mountains and the western States. Sites of stations which served the Pony Express, the Overland Stage, and the first transcontinental telegraph are still to be found.

The first irrigation systems in the valley were built shortly after 1880 without large storage reservoirs. The North Platte Project, authorized by the Congress in 1903, was completed in 1927. Pathfinder Dam and Reservoir were built during 1905-09. The Guernsey Dam and Reservoir were completed in 1927. The Kendrick Project was first investigated in 1904, and construction started in 1936. Seminoe and Alcova Dams were completed in 1939.

Investigations

Preliminary investigations for the Kortes Unit started in 1933 and for the Glendo Unit in 1944. Both were included in Senate Document 191 as a part of the Missouri River Basin Project and were authorized for construction under the Flood Control Act of 1944.

The original authorization provided for a storage capacity of approximately 150,000 acre-feet in the Glendo Reservoir for additional sediment storage and replacement of capacity lost to sediment in Guernsey Reservoir; reregulation of return flows from upstream irrigation; and flood control and the development of power. Subsequent investigations disclosed the necessity for increasing the capacity of Glendo Reservoir to provide for adequate

Fremont Canyon Powerplant

control in the highly developed reach of the North Platte River Valley in Wyoming and Nebraska below the Glendo Reservoir site and the reregulation of upstream power releases so river water could be utilized more effectively for hydroelectric power production. As a result of these investigations, the total storage capacity was increased to 798,000 acre-feet, exclusive of a flood surcharge capacity of an additional 330,000 acre-feet.

Authorization

The Glendo Unit was authorized for construction under the Flood Control Act of December 22, 1944, Public Law 534, which approved the general plan set forth in Senate Documents 191 and 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session. The project was reauthorized by Public Law 503, 83d Congress, on July 16, 1954.

Construction of Gray Reef Dam and Reservoir was authorized separately by Public Law 85-695 (72 Stat. 687), approved August 20, 1958.

Construction

Construction began December 1954 on the Glendo Dam, Reservoir, and Powerplant and was completed in 1958. Construction of the Fremont Canyon Powerplant and power conduit was begun in 1956 and completed in 1961. Construction of Gray Reef Dam and Reservoir was started in 1959 and completed in 1961.

Operating Agency

The Bureau of Reclamation operates and maintains all of the unit's works.

BENEFITS

Irrigation

Water is released from Glendo Reservoir to supplement the irrigation water supplies of contracting users in Wyoming and Nebraska. The water users need dependable storage in addition to their natural flow water rights. This makes possible the improvement of crop production and an increased crop yield. Principal crops are sugar beets, beans, potatoes, alfalfa, corn, and small grains.

Flood Control

Glendo Reservoir controls floods that menaced the local area and the valley downstream prior to the unit's construction.

Hydroelectric Power

Addition of Glendo Unit power generation facilities increases available power in the North Platte River Basin by about 500 million kilowatt-hours annually. This increase comes principally from the Glendo and Fremont Canyon Powerplants; however, some of the gain is due to the conversion of the Alcova Powerplant from seasonal to year-round operation made possible by the regulation afforded by Glendo Reservoir.

Recreation and Fish and Wildlife

The unit provides opportunities for recreation, fishing, and hunting. Camping, picnicking, boating, and water sports are available at Glendo Reservoir and some facilities are available at Gray Reef Reservoir. Glendo Reservoir is stocked with fish by the Wyoming Game and Fish Commission and, to a lesser extent, fishing is afforded at Gray Reef Reservoir. Hunting for waterfowl is available at both reservoirs.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	44,625	acres
Number of irrigated farms	264	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value[1], dollars
1968	27,599	3,306,062
1969	26,781	3,447,572
1970	27,223	3,777,974
1971	27,026	3,971,762
1972	27,041	5,123,204
1973	26,739	6,725,317
1974	26,991	10,747,508
1975	27,286	9,961,622
1976	35,835	9,134,767
1977	35,667	8,903,015

[1]Includes additional revenue.

Facilities in Operation

Storage dams	1
Reregulation dams	1
Powerplants	2

Climatic Conditions

Annual precipitation	13.5	in
Temperature:		
Maximum	108	°F
Minimum	−35	°F
Mean	48	°F
Growing season	147	days
Elevation of irrigable area	4000.0	ft

Settlement

Number of persons served with project water (1977):	
Supplemental irrigation service	930

ENGINEERING DATA

Water Supply

NORTH PLATTE RIVER

Drainage area above Glendo Dam	15,500	mi²
Annual runoff at Glendo Dam:		
Maximum (1973)	2,493,000	acre-ft
Minimum (1934)	470,000	acre-ft
Average	1,275,000	acre-ft

Storage Facilities

GLENDO DAM AND DIKES

Type: Zoned earthfill (three closely spaced dikes totaling 2,440 ft in length are located about 1.5 mi west of the dam)
Location: On the North Platte River about 4.5 miles southeast of Glendo, Wyo.
Construction period: 1955-58
Reservoir, Glendo:

Average annual inflow	1,093,000	acre-ft
Total capacity to El. 4653	789,402	acre-ft
Active capacity[2], El. 4570-4653	726,254	acre-ft
Surface area	17,975	acres
Dimensions:		
Structural height	190	ft
Hydraulic height	145	ft
Top width	35	ft
Maximum base width	1,066	ft
Crest length	2,096	ft
Crest elevation	4675.0	ft
Total volume	2,676,000	yd³

Spillway: Uncontrolled concrete crest and concrete-lined chute at right abutment.

Crest length	45	ft
Crest elevation	4653.0	ft
Capacity at El. 4669	10,335	ft³/s

Outlet works: Intake structure on south side of reservoir about 0.5 mi upstream from dam, controlled by one 16.5- by 21-ft fixed-wheel gate, a 21-ft-diameter concrete-lined tunnel through neck of land formed by loop in the river below the dam, terminating near powerplant, about 0.75 mi south of dam.
River outlets: Three branches from outlet conduit, each controlled by one 7.25- by 7.75-ft slide gate.

Capacity at El. 4669[2]	13,000	ft³/s

Power outlets: Two penstock branches from outlet conduit.

GRAY REEF DAM

Type: Earthfill (reregulation)
Location: On North Platte River, about 27 mi southwest of Casper and about 2 mi downstream from Alcova Dam.
Construction period: 1959-61
Reservoir, Gray Reef:

Total capacity to El. 5332	1,800	acre-ft
Active capacity	1,750	acre-ft
Surface area	182	acres
Dimensions:		
Structural height	36	ft
Top width	20	ft
Maximum base width	160	ft
Crest length	650	ft
Crest elevation	5338.0	ft
Total volume	40,000	yd³

Spillway: Concrete chute near center of the dam, controlled by two 35- by 20-ft radial gates.

Capacity	20,000	ft³/s

Outlet works: None

[2]With power outlets closed.

Power Facilities

GLENDO POWERPLANT

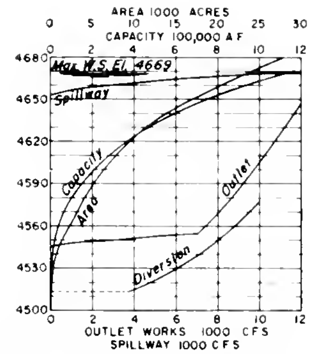
Location: On right bank of North Platte River, about 4,000 ft south of Glendo Dam.
Year of initial operation: 1958

Nameplate capacity	24,000	kW
Number and capacity of generators (2)	12,000	kW
Maximum head	130	ft

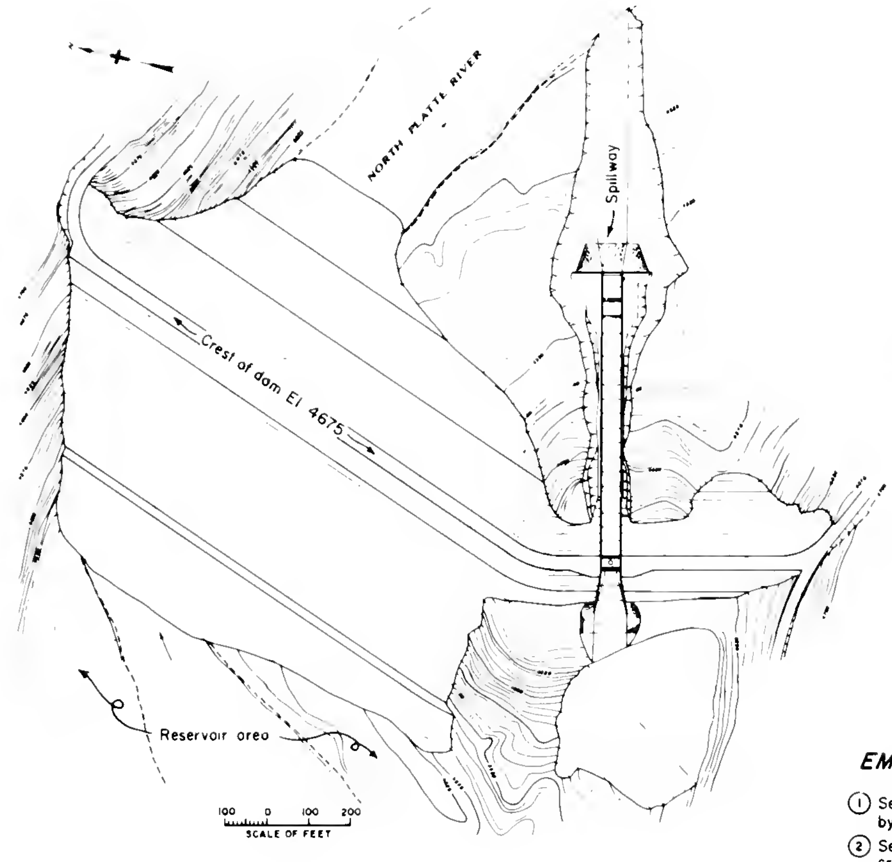
FREMONT CANYON POWERPLANT

Location: On the left bank of North Platte River.
Year of initial operation: 1960

Nameplate capacity	48,000	kW
Number and capacity of generators (2)	24,000	kW
Maximum head	350	ft



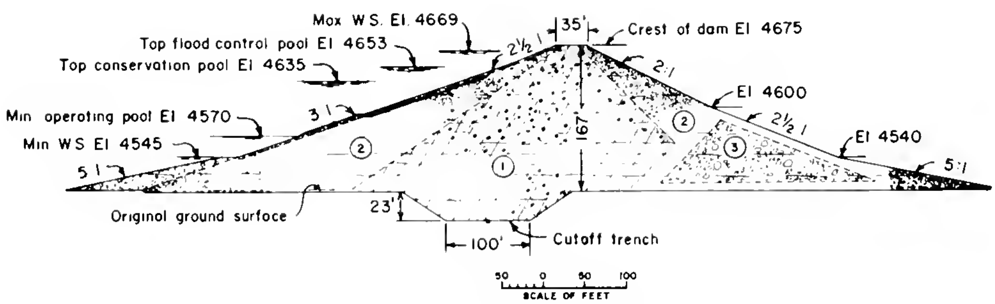
AREA - CAPACITY - DISCHARGE CURVES



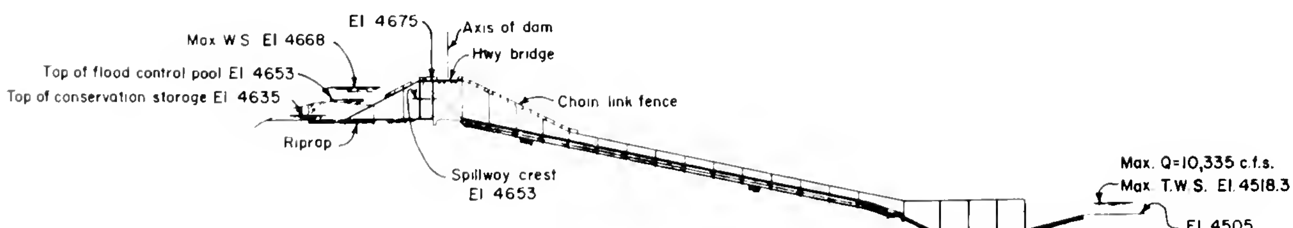
PLAN

EMBANKMENT EXPLANATION

1. Selected clay, silt, sand and gravel compacted by tamping rollers to 6-inch layers
2. Selected sand, gravel and cobbles compacted by crawler-type tractors to 12-inch layers
3. Selected miscellaneous material compacted by tamping rollers to 12-inch layers

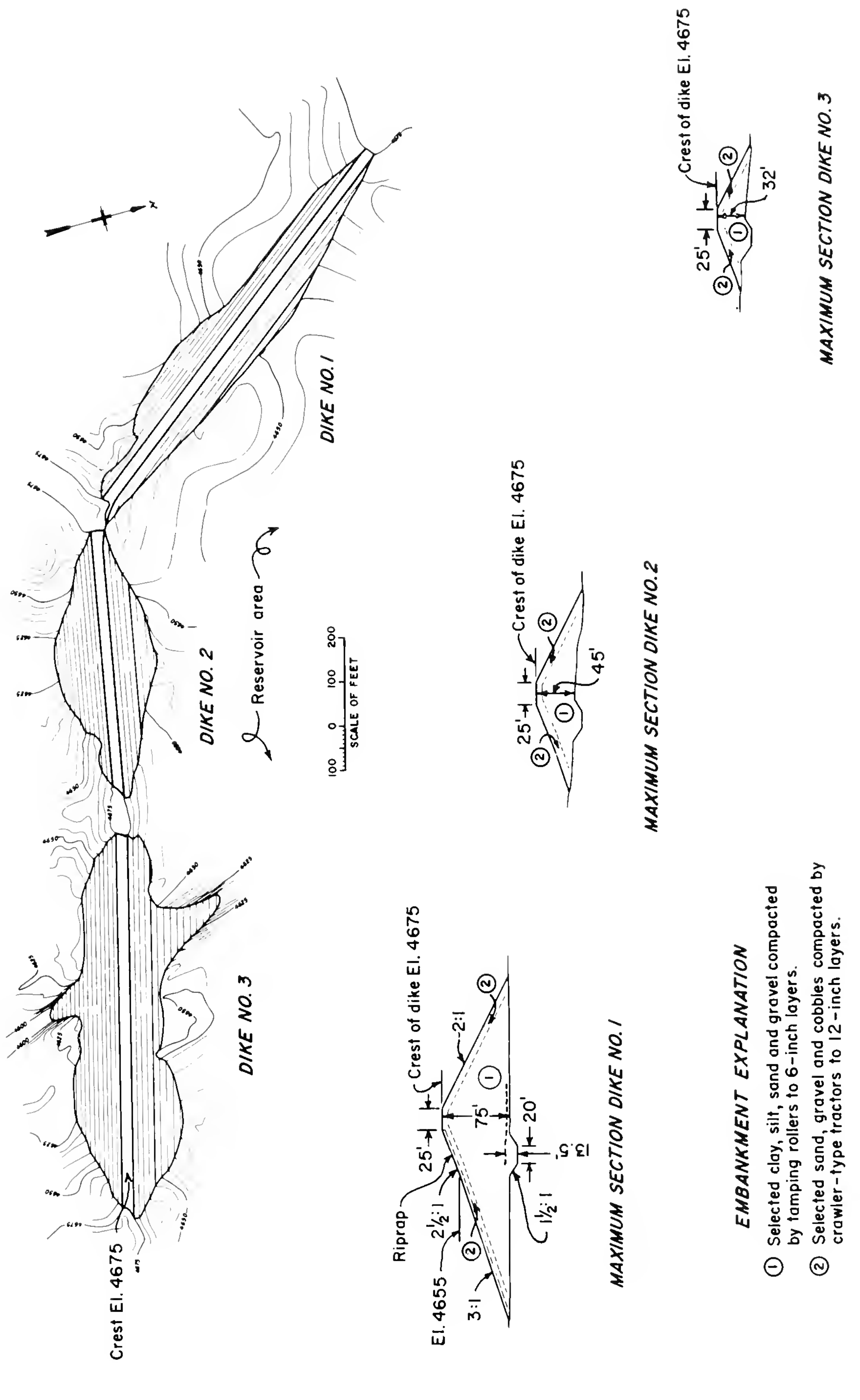


MAXIMUM SECTION

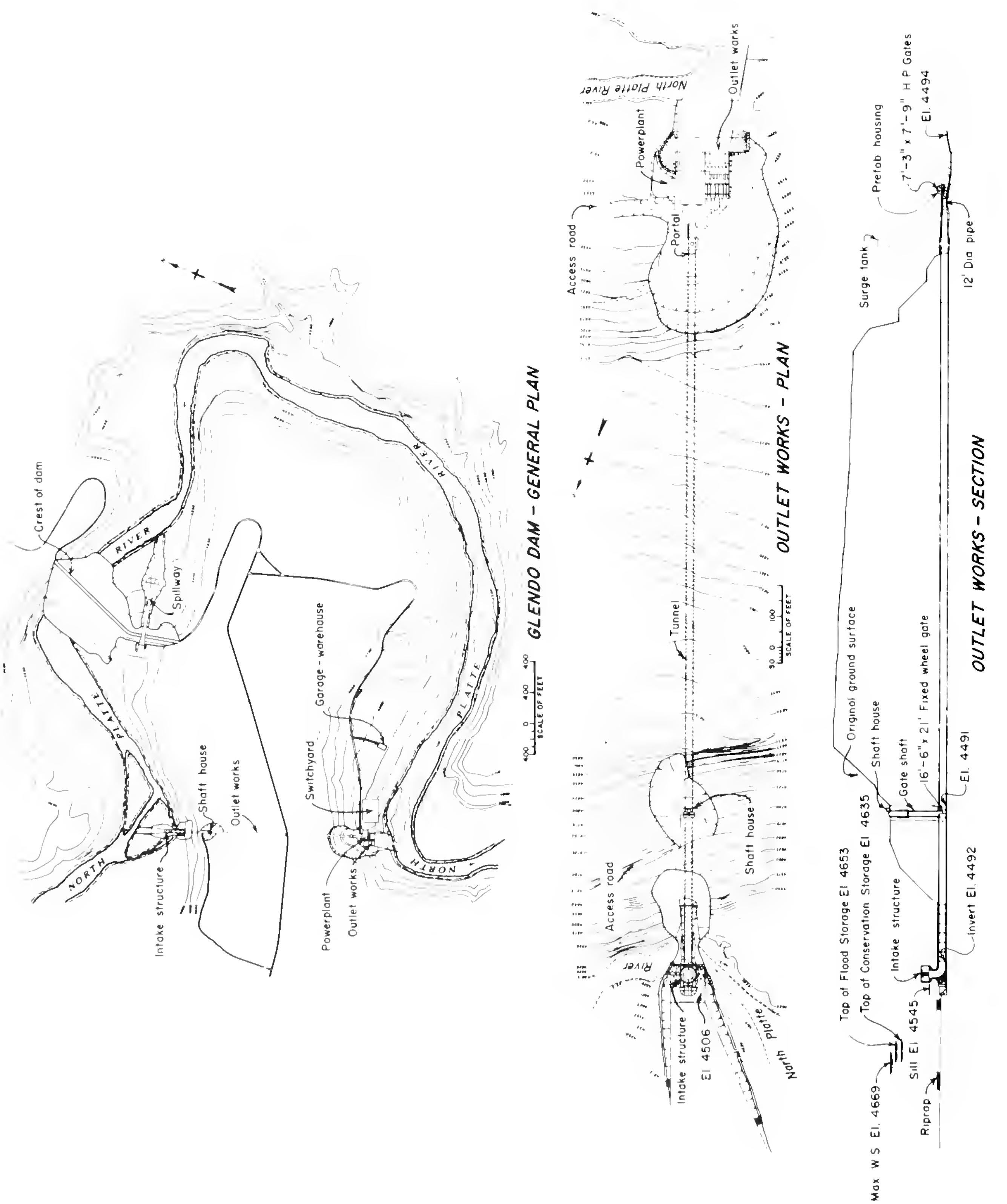


SECTION THROUGH SPILLWAY

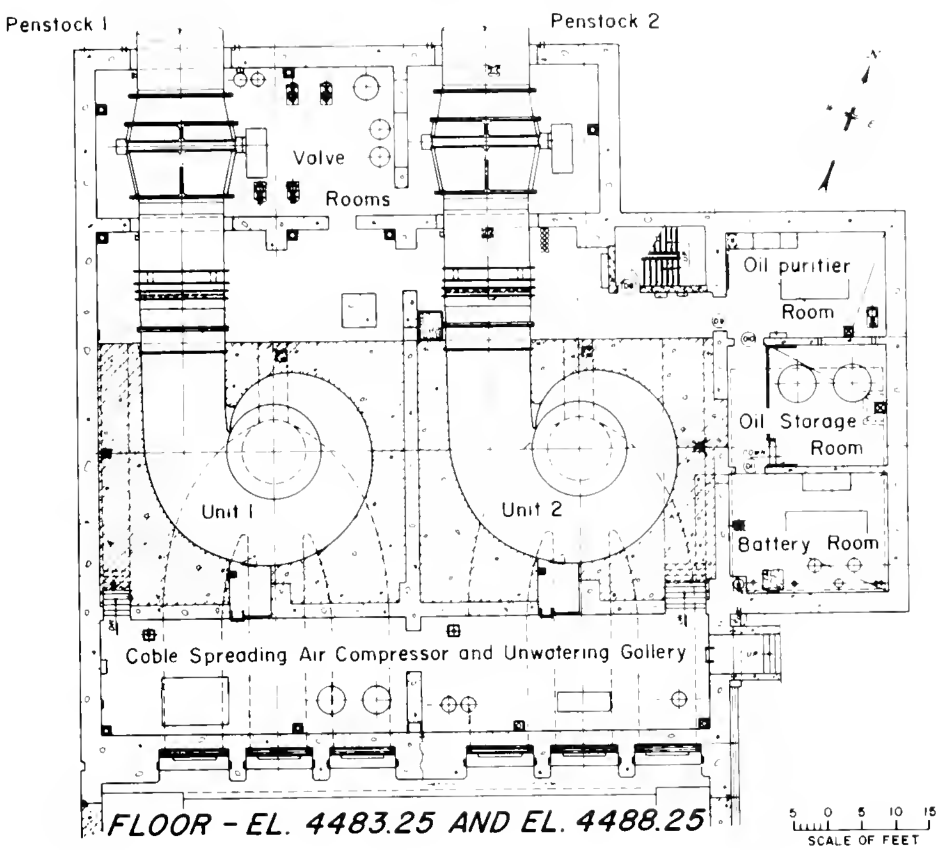
Glendo Dam, Plan and Sections

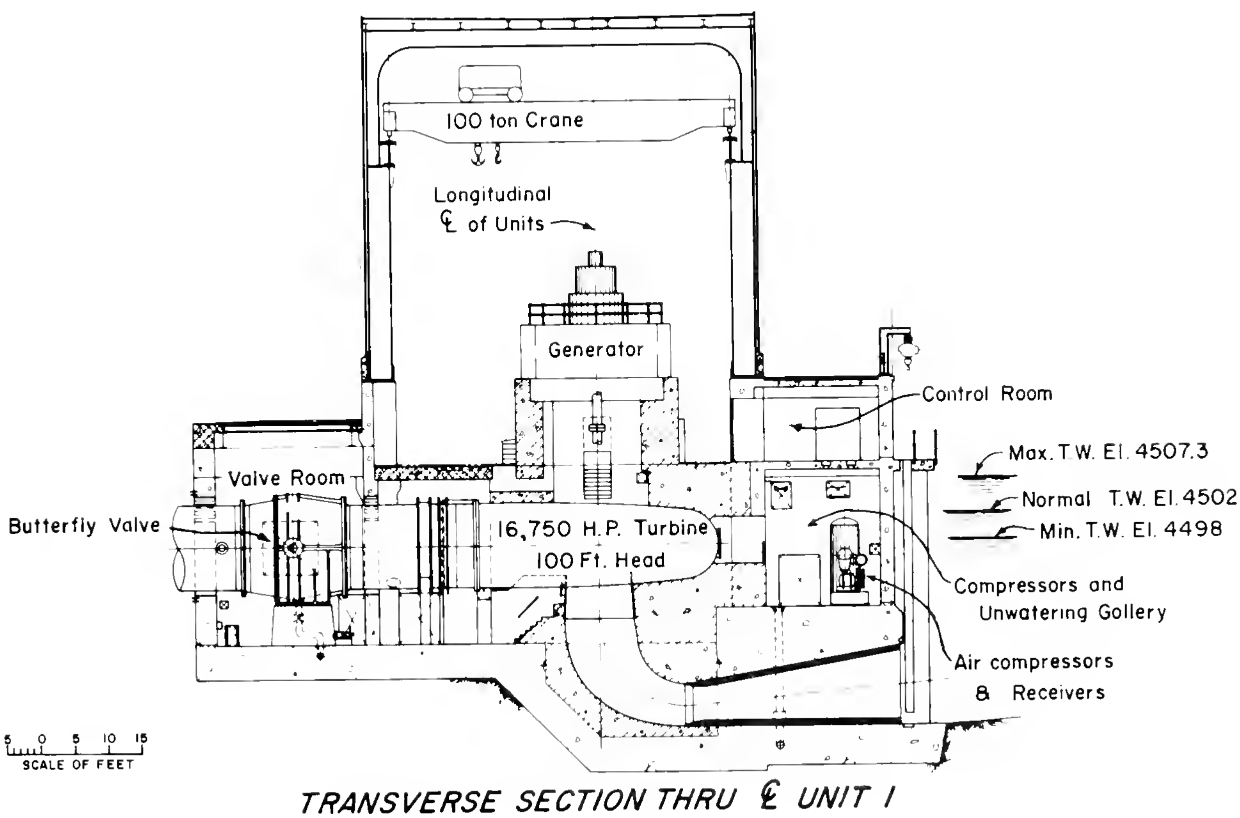


Glendo Dikes, Plan and Section

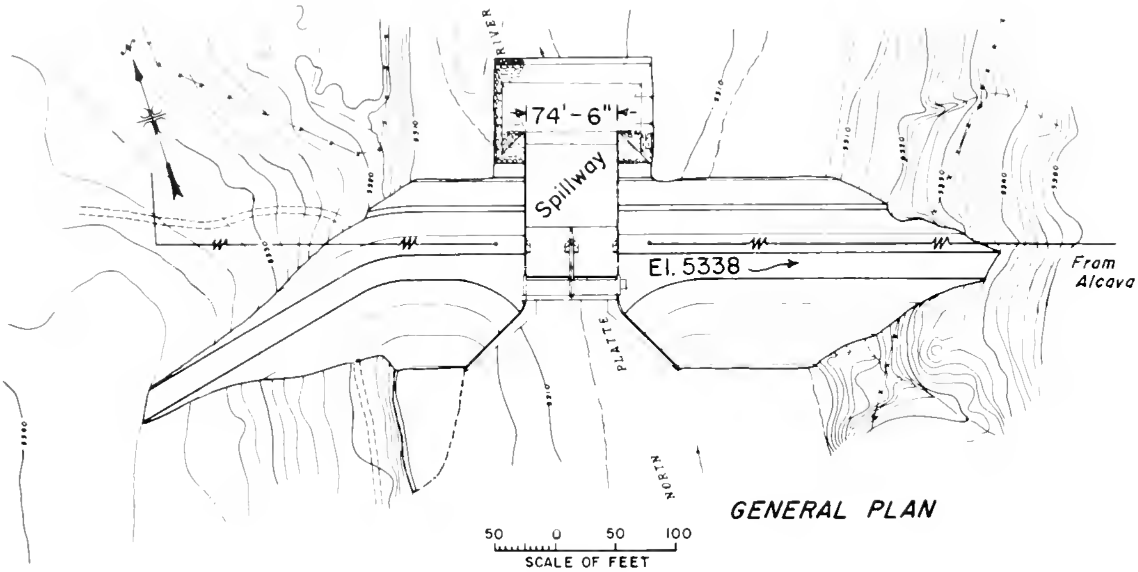


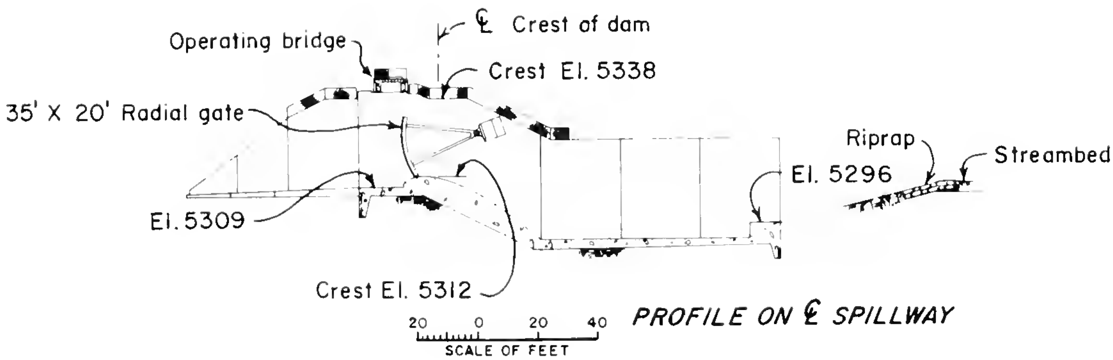
Glendo Dam, Outlet Works





Glendo Powerplant



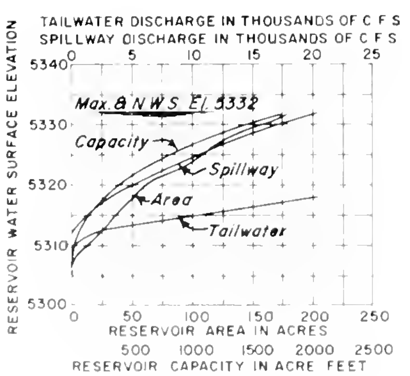


EMBANKMENT EXPLANATION

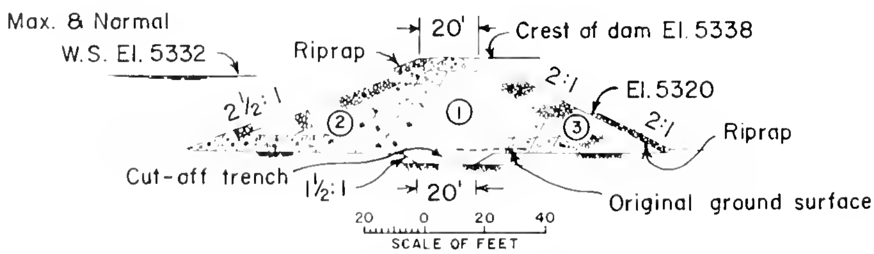
① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6"-inch layers.

② Selected sand, gravel, and cobbles dumped in 3-foot layers.

③ Rock fill dumped in 3-foot layers.

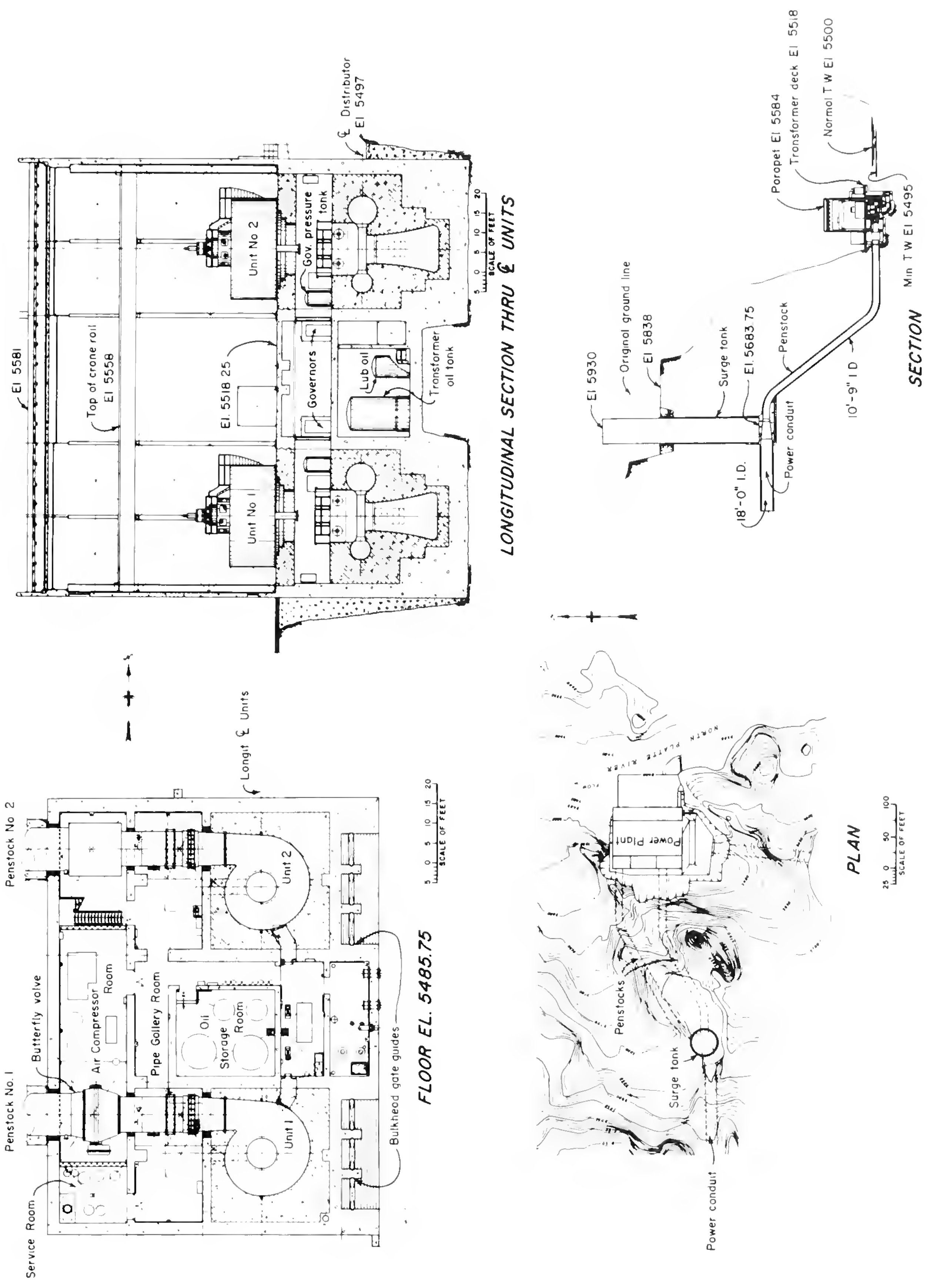


AREA-CAPACITY-DISCHARGE CURVES

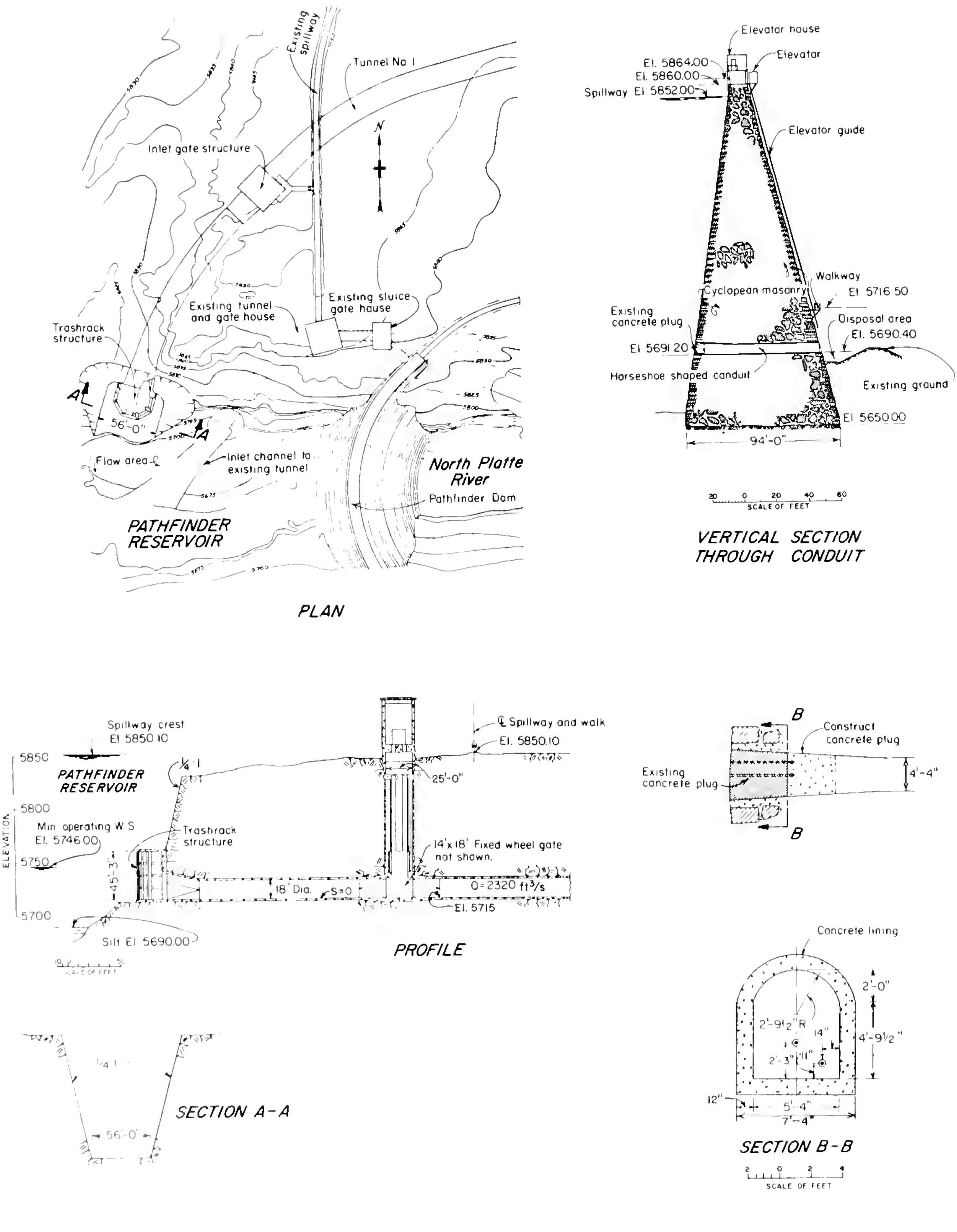


MAXIMUM SECTION

Gray Reef Dam, Plan and Sections



Fremont Canyon Powerplant, Plan and Sections

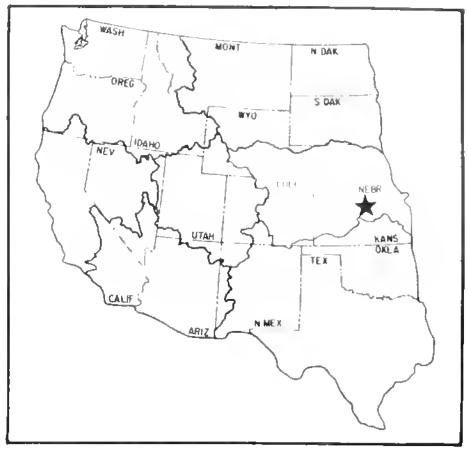


Fremont Canyon Power Conduit Inlet

Pick-Sloan Missouri Basin Program
Glen Elder Unit, Solomon Division

Kansas: Mitchell, Osborne, Cloud, and Ottawa Counties

Lower Missouri Region
Water and Power Resources Service



Glen Elder Unit, Solomon Division, was part of the comprehensive development plan for the Missouri River Basin presented in Senate Document 191, 78th Congress, 2d Session, April 1944. It was specified as one of six units in the Smoky Hill River Basin required to meet flood control and irrigation needs of the basin.

Glen Elder Unit is located in the Solomon River Valley in Osborne, Mitchell, Cloud, and Ottawa Counties in north-central Kansas. The unit consists of Glen Elder Dam and its reservoir, Waconda Lake, and protective dikes and appurtenant structures. The dam is a multipurpose structure on the river approximately 6.5 miles below the confluence of the north and south forks of the Solomon River in Mitchell County immediately above the town of Glen Elder. Waconda Lake parallels U.S. Highway No. 24 and the Missouri Pacific Railroad from Glen Elder to Downs, Kans.

PLAN

Glen Elder Dam is one of the key flood control features in the Kansas River Basin. It provides a high degree of flood protection to the lower Solomon River Valley, and when operated in conjunction with other basin reservoirs contributes effectively to the control of flooding on the lower Smoky Hill and Kansas Rivers. It provides municipal and industrial water for Beloit, Kans., on the Solomon River about 12 miles downstream, and three rural water districts, together with recreation, fish and wildlife conservation, and water quality benefits. After satisfying these purposes, sufficient yield is available from the reservoir to irrigate approximately 30,000 acres of potential project lands located immediately downstream of the structure, should that project function be authorized.

Glen Elder Dam and Waconda Lake

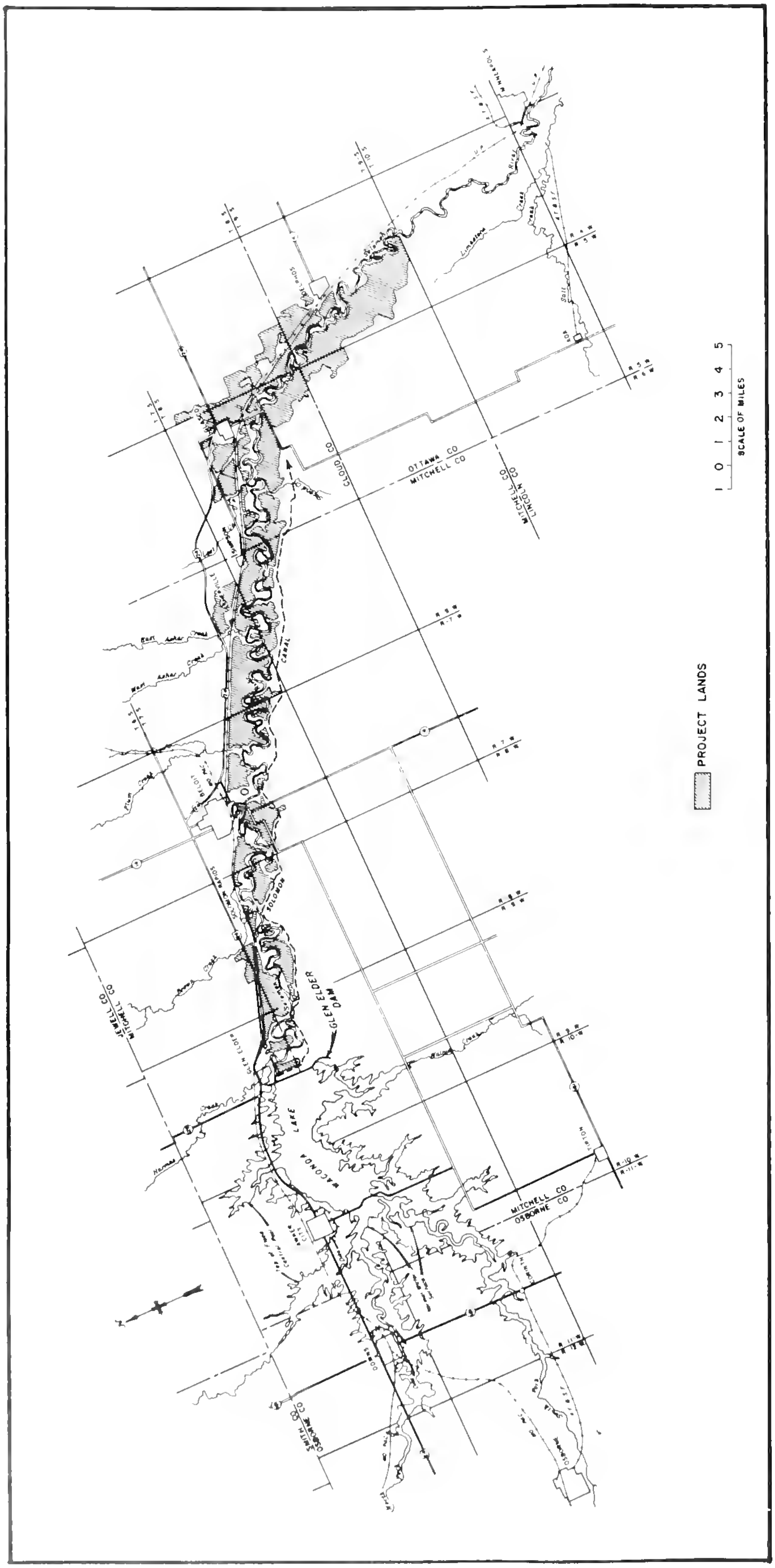
Glen Elder Dam is an earthfill structure 15,275 feet long with a crest width of 30 feet, a maximum base width of 1,008 feet, and a maximum enbankment height of 115 feet above the streambed. The structure's maximum height above the foundation is 142 feet. The dam contains approximately 10,026,000 cubic yards of embankment materials. A rim dike, 1,825 feet long, was constructed across a low saddle immediately north of the left abutment to complete the dam's crest.

Waconda Lake has a total storage capacity of 963,775 acre-feet allocated as follows: 1,236 acre-feet for dead storage at elevation 1407.8; 35,435 acre-feet for inactive storage at elevation 1428.0; 204,789 acre-feet of conservation capacity at elevation 1455.6; and 722,315 acre-feet for flood control at elevation 1488.3.

At the top of conservation capacity, elevation 1455.6, Waconda Lake has a surface area of 12,602 acres with 100 miles of shoreline. At the top of the flood capacity, elevation 1488.3, it has a surface area of 33,682 acres. The surcharge elevation is 1492.9 feet and at this level the total reservoir capacity is 1,128,741 acre-feet of water.

The surcharge of 173,000 acre-feet in combination with a spillway capacity of 263,000 cubic feet per second gives protection against the inflow design flood, having a peak of 437,000 cubic feet per second and a 3-day volume of 900,000 acre-feet.

The spillway structure, which is located in the right abutment, is controlled by twelve 50- by 21.76-foot radial gates. Both a county highway bridge and a separate operating bridge span the 644-foot-wide spillway structure. The spillway channel opens into the Solomon River approximately 1 mile northeast of the spillway structure. A separate river outlet works structure is located in the left abutment adjacent to the original river channel. It consists of a trashrack-protected intake structure, a steel-lined 12.5-foot-diameter inlet conduit, a gate chamber and access shaft with a 9- by 12-foot emergency gate, a 12.25-foot pipe inside a concrete horseshoe conduit, a conduit access house, a steel bifurcation pipe section encased in concrete, two 6.5- by 8-foot high-pressure control gates, a control house, and a stilling basin. A



Glen Elder Unit

Glen Elder Dam

12.25-foot-diameter steel pipe stub was provided immediately ahead of the bifurcation section for a future irrigation diversion outlet works.

Appurtenant works include protective dikes at Cawker City and Downs to keep reservoir waters from flooding low-lying areas, coupled with diversion drains above the towns to prevent local storm water from flooding behind the dikes. Both dikes have sump storage areas and pump equipped outlet works to discharge excess storm water into the reservoir. Other facilities include recreation and fish and wildlife developments.

DEVELOPMENT

Early History

Settlers first began to arrive in this vicinity in the late 1850's; however, the heaviest influx, which coincided with reports of excellent area crops and the building of access railroads, occurred in the late 1870's. The population of the area reached a peak in 1890 but has declined since the 1920's. The principal exception to this trend is Beloit, which has experienced a consistent population growth.

Since its earliest settlement, the Solomon River Valley has experienced many damaging floods, indicating the critical need for flood control measures. As a result of a disastrous flood in 1951, plans were formulated for construction of sufficient flood control structures to solve this problem. Kirwin and Webster Reservoirs were constructed first as part of a multireservoir flood-control plan, with their capacities designed for future incorporation of Waconda Lake storage. Construction of Glen Elder Dam and Waconda Lake was completed in January 1969.

The city of Beloit had formerly obtained its municipal water supply from the surface flows of the Solomon River. These proved to be inadequate, and, at times, restrictions on use were imposed. The city therefore requested that a municipal water supply be included as a project purpose of the Glen Elder Unit, which has resulted in the unit providing water to that city as well as to three rural water districts.

Investigations

Field investigations prior to construction of the Glen Elder Dam and Waconda Lake were originally conducted in 1940 as a part of a reconnaissance of the Solomon River Basin. The investigations were performed at several sites by the Bureau of Reclamation and the Corps of Engineers. After a devastating flood in July 1951 on the Kansas River, to which the Solomon River was a large contributor, it was determined that the potential reservoir should have a capacity of about 900,000 acre-feet. This conclusion, the review of data obtained during foundation and materials exploration programs, and considerations of the influence of the potential dam and reservoir on local communities and land areas were major factors in the final site selection.

A definite plan report was published in June 1961, in which flood control was described as a major project purpose. Irrigation was excluded from the report. However, Public Law 88-442 required that if an irrigation system were to be incorporated into the plan it must be reauthorized, and studies for this purpose were initiated in fiscal year 1968. The preparation of a feasibility report began but was suspended in fiscal year 1972 in anticipation of the need to complete the study under new criteria promulgated by the Water Resources Council. Studies under these new procedures have not been authorized to date.

Glen Elder Irrigation District No. 8 was approved by the Chief Engineer, Division of Water Resources, Kansas State Board of Agriculture, on November 16, 1976. The first board of directors was elected in February 1977. As a result of significant changes in the available water supply for the Kirwin and Webster Units, the Bureau of Reclamation initiated a water management study of the Solomon River in October 1976 to examine the factors affecting surface water supplies of the basin and help verify the potential water supply available for the irrigation phase of the Glen Elder Unit.

Authorization

The overall development plan, as revised and coordinated with the Corps of Engineers plan by Senate Document 247, was approved by the Flood Control Act of 1944 (Public Law 534, 78th Congress, 2d session). The Glen Elder Unit was authorized for construction by the Flood Control Act of 1946 (Public Law 526, 79th Congress, 2d session).

Construction

Purchases of rights-of-way commenced in June 1963. Work on the dam and reservoir and appurtenant structures began in November 1964, and was completed in January 1969.

Operating Agency

The Bureau of Reclamation operates and maintains the unit.

BENEFITS

Glen Elder Dam and Waconda Lake provide flood protection to the lower Solomon River Valley and to the lower Smoky Hill and Kansas Rivers when operated in conjunction with other basin reservoirs. The unit provides a dependable water supply to Beloit, as well as to three rural water districts. Lands around the reservoir are being used for fish and wildlife enhancement and recreation purposes, and minimum downstream flows are maintained to provide good water quality. There is enough storage in the reservoir to irrigate a project of approximately 30,000 acres after satisfying the requirements for the present project purposes.

PROJECT DATA

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	25.48	in
Temperature:		
Maximum	113	°F
Minimum	−27	°F
Mean	54	°F

Settlement

Number of persons served with project water (1977):	
Municipal water service	7,037

ENGINEERING DATA

Water Supply

SOLOMON RIVER

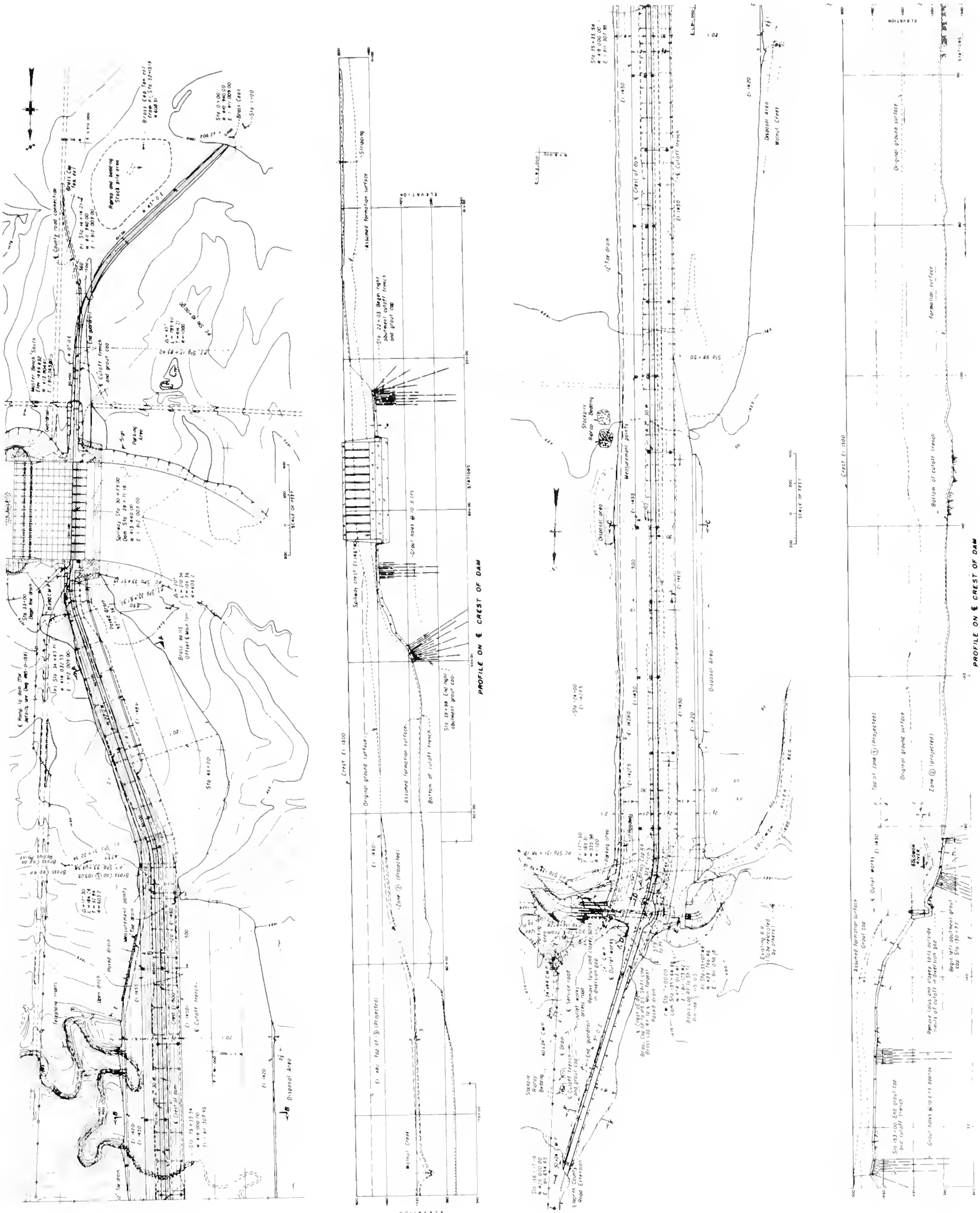
Drainage area	4,945	mi²
Annual discharge at Glen Elder Dam:		
Maximum (1973)	255,920	acre-ft
Minimum (1971)	11,024	acre-ft
Average	92,612	acre-ft
Annual average municipal and industrial water supply	445	acre-ft

Storage Facility

GLEN ELDER DAM

Type: Zoned earthfill
Location: On Solomon River directly upstream from Glen Elder, Kans.
Construction period: 1963-69
Date of closure (first storage): October 17, 1967

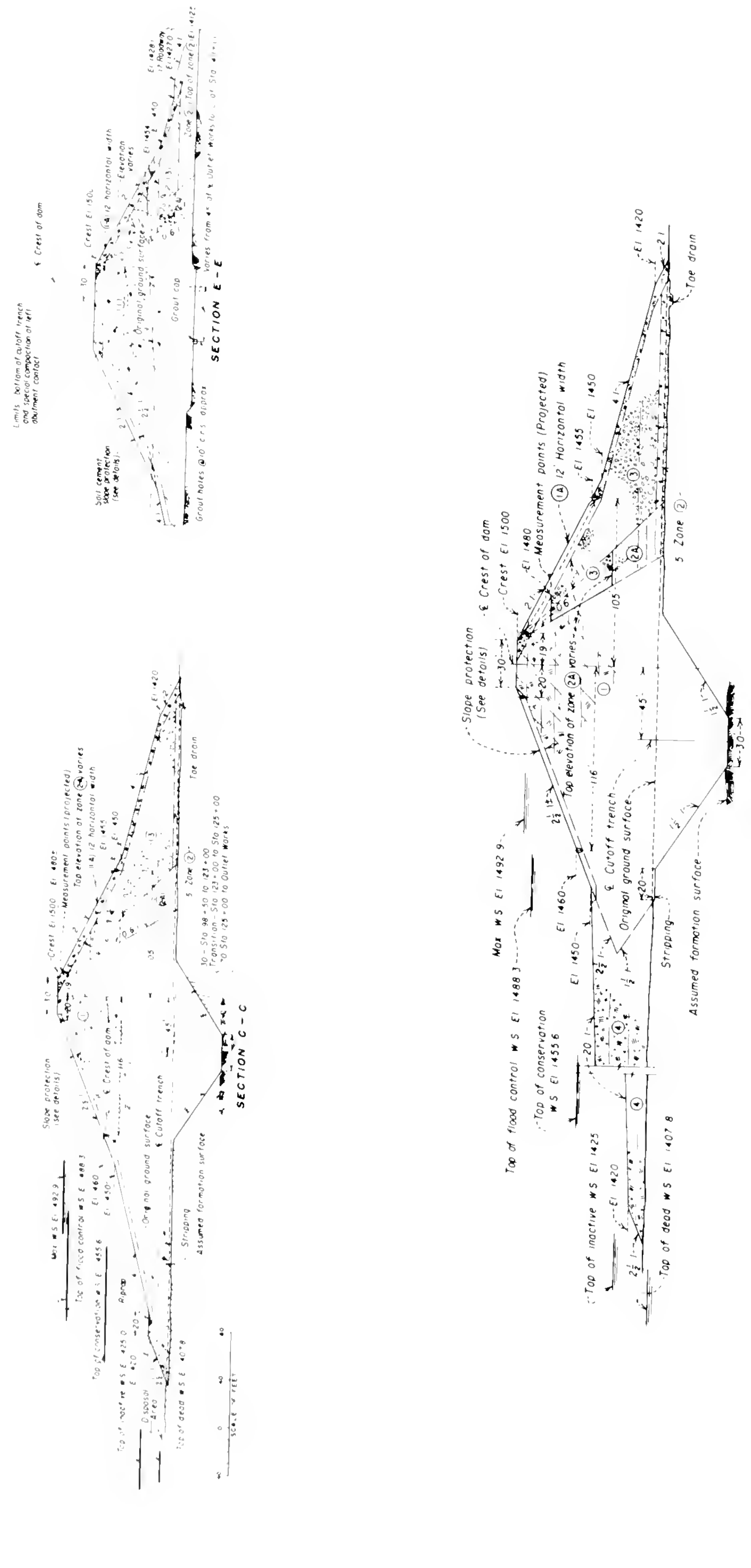
Reservoir, Waconda Lake:		
Average annual inflow	150,297	acre-ft
Total capacity to El. 1488.3	963,775	acre-ft
Active capacity, El. 1455.6	204,789	acre-ft
Surface area	12,602	acres
Dimensions:		
Structural height	142	ft
Hydraulic height	108	ft
Top width	30	ft
Maximum base width	1,008	ft
Crest length	15,275	ft
Crest elevation	1500.0	ft
Total volume	10,026,000	yd²
Spillway: Concrete-lined open channel in right abutment, controlled by twelve 50- by 21.76-ft radial gates		
Crest length	644	ft
Crest elevation	1467.4	ft
Capacity at El. 1492.9	263,000	ft³/s
Outlet works: A trashrack-protected intake structure consisting of a steel-lined 12.5-ft-diameter inlet conduit, a gate chamber and access shaft with a 9- by 12-ft emergency gate, a 12.25-ft pipe inside a concrete horseshoe conduit, a conduit access house, a steel bifurcation pipe section encased in concrete, two 6.5- by 8-ft high-pressure control gates, a control house, and a stilling basin. A 12.25-ft steel pipe stub is provided immediately ahead of the bifurcation section for a future irrigation diversion outlet works.		
Capacity at El. 1455.6	4,000	ft³/s



SOUTH SECTION

NORTH SECTION

Glen Elder Dam, Plan and Profile

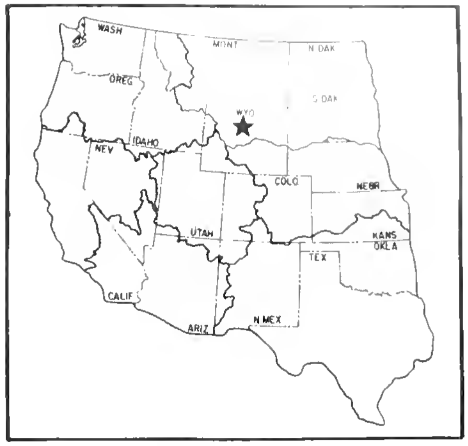


Glen Elder Dam, Sections

Pick-Sloan Missouri Basin Program
Hanover-Bluff Unit

Wyoming: Big Horn and Washakie Counties

Upper Missouri Region
Water and Power Resources Service



The Hanover-Bluff Unit is in north-central Wyoming near Worland. By enlarging and rehabilitating existing facilities used by the Hanover and Bluff Irrigation Districts, and constructing new canals, pumping plants, and laterals, 7,441 acres can be irrigated.

PLAN

The Hanover-Bluff Unit comprises two areas served from a common diversion on the Bighorn River: The Highland-Hanover area with 6,105 acres of irrigable land; and the Upper Bluff area with 1,336 acres of irrigable land. A diversion dam across the Bighorn River diverts water to the Upper Hanover Canal, which supplies lands in the Hanover Irrigation District. This canal extends downstream on the west side of the river for 3 miles, then crosses the river in a flume to supply all Hanover land. The first 13 miles of this canal have been enlarged and are used also to supply the land in the Highland-Hanover area.

Irrigation of land in the Highland-Hanover area is accomplished by use of five pumping plants, three of which pump directly from the Upper Hanover Canal. About 15 miles of pump canals and 12 miles of laterals serve the land.

Bluff Canal, originally constructed to supply the Bluff Irrigation District from a lower diversion on the Bighorn River, continues to be used to supply that land, as well as the Upper Bluff area. Bluff Canal was extended 1 mile to join the Upper Hanover Canal at a point 3 miles below the Hanover Diversion Dam. Initial capacity of the Bluff Canal is 92 cubic feet per second, and total length of the part of the canal used to supply Upper Bluff land is 9.1 miles.

Irrigation in the Upper Bluff area is accomplished by three pumping plants and about 8 miles of lateral systems.

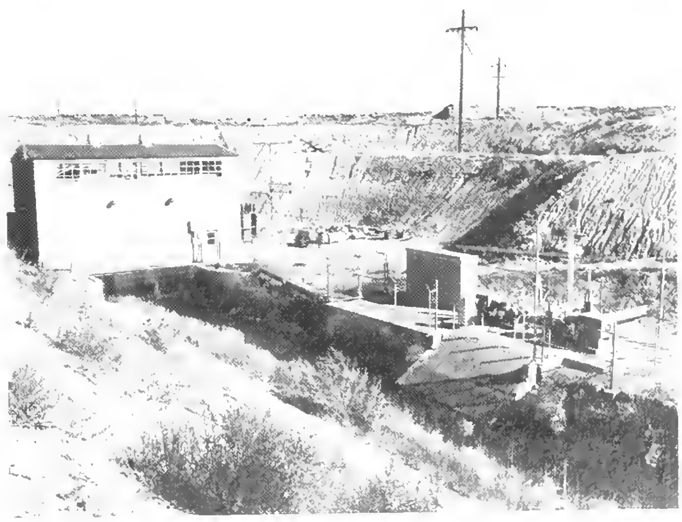
DEVELOPMENT

Early History

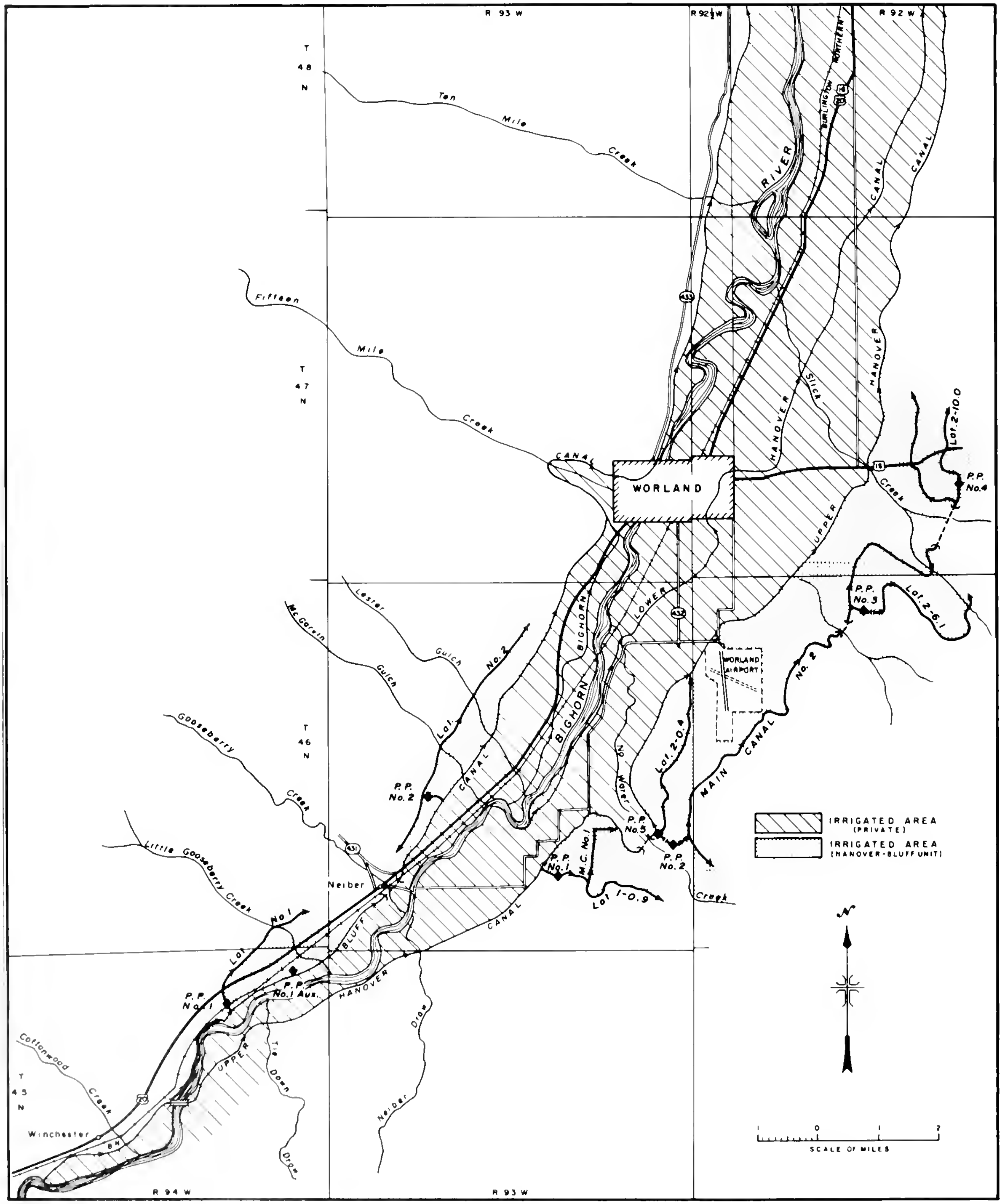
Settlement of the Bighorn River Basin and the Worland area began soon after 1879 when stockmen drove the first large herds of cattle into the area. One of the early ranches in the basin was established in 1884 on a tributary of Nowood Creek in Washakie County. The first settlement near the project was made in 1900 on No Water Creek. Early irrigation development was confined largely to small scattered tracts of land used in connection with ranching operations.

Extension of the railroad to Worland in 1906 hastened agricultural development. Since 1900, the acreage of irrigated land has increased from less than 1,000 to more than 40,000 acres.

After 1906, the population of Worland and Washakie County increased rapidly with the development of irrigation and communication and service facilities. During the



Hanover Pumping Plants Nos. 2 and 5



Hanover-Bluff Unit

past few years, the accelerated production of petroleum and natural gas has contributed considerably to the population growth of Worland.

Investigations

The Bureau of Reclamation made a reconnaissance investigation of potential irrigation development in the Bighorn Basin in 1941. Results of this investigation are included in a report dated June 1942. Detailed surveys and investigations of the area were begun in 1949-50, when the unit was divided into the Hanover Unit and the Bluff Unit. The investigations included detailed topographic mapping, land classification surveys, foundation explorations of canal and pump sites, land development studies, economic and repayment investigations, and preparation of cost estimates. The proposals were incorporated in the overall plan for development of the resources of the Missouri River Basin as presented in Senate Document 191. A supplemental appropriation bill that included funds for starting construction was signed by the President on August 26, 1954, and work was immediately resumed on preparation of design data. Hanover and Bluff Units were combined into one unit under this supplemental appropriation bill.

Authorization

The units were authorized as the Big Horn Pumping Units by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

The original Bluff Canal was constructed in 1904 to serve 2,800 acres of land. Large-scale irrigation on the west side of the Bighorn River began with completion of the Bighorn Canal in 1907 for irrigation of 25,000 acres between Gooseberry Creek and the Greybull River. The Lower Hanover Canal was constructed on the east side of the river in 1906 and the Upper Hanover Canal was constructed in 1910.

The first contract for construction of six pumping plants was awarded in April 1955, followed by contracts for construction of new canals and rehabilitation of other facilities. Construction of the six pumping plants was completed in 1956 and of the canals in 1957. Hanover No. 5 pumping plant and Bluff No. 1 auxiliary pumping plant were added in 1958.

Rehabilitation and Betterment

In 1975, the Highland-Hanover Irrigation District secured an emergency loan from the Federal Government to cover their portion of the cost of replacing the Hanover Diversion Dam and No Water Creek Siphon.

The original timber-crib and rockfill diversion dam on the Bighorn River was replaced with a concrete weir diversion dam. The dam has a crest length of 250 feet and a structural height of 8.25 feet. The outlet works to the Hanover Canal also was replaced. The Upper Hanover Canal has an initial diversion capacity of 487 cubic feet per second and is controlled by two 6-foot-high by 14-foot-wide steel vertical roller gates. A third gate of equal size is located on the left abutment of the diversion dam and serves as a sluiceway.

The original steel pipe siphon structure, located across No Water Creek on the Upper Hanover Canal, was replaced with a 120-inch inside diameter reinforced concrete pipe siphon with a total length of 2,264 feet. The concrete pipe siphon has a capacity of 500 cubic feet per second and is directly upstream of Highland-Hanover Irrigation District Pumping Plants No. 2 and No. 5.

Operating Agencies

Following the completion of construction and rehabilitation, the entire unit was turned over to the Highland-Hanover Irrigation District and Upper Bluff Irrigation District for operation and maintenance.

BENEFITS

Irrigation

The principal crops grown in the Hanover-Bluff Unit include small grains, alfalfa and other hay crops, silage, and sugar beets.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	7,441	acres
Number of farms	36	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,142	1,040,884
1969	7,257	1,216,591
1970	7,354	1,334,705
1971	7,354	1,436,066
1972	7,301	1,542,239
1973	7,354	2,021,646
1974	7,354	3,459,180
1975	7,354	3,511,724
1976	7,354	2,420,618
1977	7,322	1,884,597

Facilities in Operation

Canals	15	mi
Laterals	19	mi
Pumping plants	8	
Drains	2	mi

Climatic Conditions

Annual precipitation	8	in
Temperature:		
Maximum	106	°F
Minimum	−40	°F
Mean	44	°F
Growing season	144	days
Elevation of irrigable area	4200.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	156

ENGINEERING DATA

Water Supply

Bighorn River

(See Boysen Unit for streamflow data.)

Average annual diversion[1]	34,030	acre-ft

[1]Estimated with full development.

Diversion Facilities

Hanover Diversion Dam

Type: Original timber-crib rockfill structure constructed in 1910. Replaced with concrete weir diversion dam in 1975.
Location: On the Bighorn River approximately 17 mi south of Worland, Wyo.
Year completed: 1975
Dimensions:

Structural height	8.25	ft
Hydraulic height	8.25	ft
Crest length	250	ft
Crest elevation	4190.75	ft

Spillway: Overflow crest
Headworks:
Upper Hanover Canal: Concrete canal section controlled by two 6- by 14-ft vertical roller metal gates.

Diversion capacity	187	ft³/s

Sluiceway: 6- by 14-ft vertical roller metal gate on left abutment of diversion dam.

Carriage Facilities

Upper Hanover Canal (rehabilitated reach)

Location: From a diversion dam on the Bighorn River near Winchester, Wyo., generally northeast.
Construction period: Privately constructed in 1910. Thirteen miles enlarged by Reclamation in 1956.

Length	15	mi
Diversion capacity	187	ft³/s
Typical maximum section in earth:		
Bottom width	20	ft
Side slopes	1.5:1	
Water depth	7	ft
Typical maximum section, asphalt membrane lined:		
Bottom width	14	ft
Side slopes	2:1	
Water depth	5.9	ft

Bluff Canal (rehabilitated reach)

Location: From Upper Hanover Canal 2 mi northeast of Winchester, Wyo., generally northeast along west side of the Bighorn River.
Construction period: Privately constructed in 1904. Enlarged and extended by Reclamation in 1957.

Length	9.1	mi
Diversion capacity	92	ft³/s
Typical maximum section in earth:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	3.2	ft

Main Canal No. 1

Location: Generally east from Upper Hanover Canal about 7 mi south of Worland, Wyo.
Construction period: 1956-57

Length	1.8	mi
Diversion capacity	15	ft³/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.5	ft

Main Canal No. 2

Location: Generally northeast from Upper Hanover Canal about 6 mi south of Worland, Wyo.
Construction period: 1956-57

Length	13.1	mi
Diversion capacity	97	ft³/s
Typical maximum section in earth:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	3.4	ft

No Water Creek Siphon

Location: Upper Hanover Creek across No Water Creek approximately 4 mi south of Worland, Wyo.
Construction period: Original steel pipe siphon constructed in 1910. Replaced with reinforced concrete pipe siphon in 1976.
Type: Reinforced concrete pipe, reinforced concrete inlet and outlet structures
Dimensions:

Length	2,264	ft
Inside diameter	10	ft

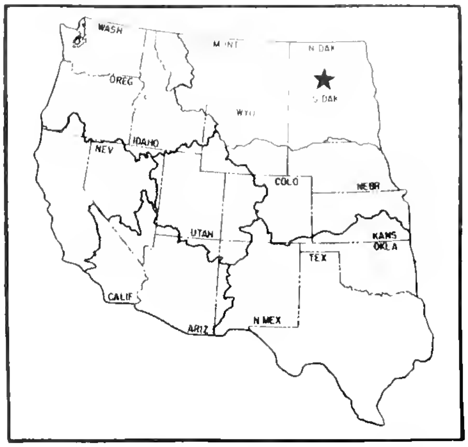
Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Hanover No. 1	2	20	88	300
Hanover No. 2	1	100	43-109	1,300
Hanover No. 3	2	17	73	200
Hanover No. 4	2	17	65	200
Hanover No. 5	2	25	114	450
Bluff No. 1	2	17	104	300
Bluff No. 1, Auxiliary	1	3	26	20
Bluff No. 2	2	20	45	120

Pick-Sloan Missouri Basin Program
Heart Butte Unit

North Dakota: Grant and Morton Counties

Upper Missouri Region
Water and Power Resources Service



The Heart Butte Unit lies in scattered tracts along the Heart River from Heart Butte Dam to the Missouri River. There are approximately 10,000 acres of irrigable land which range in size from 35 to 1,000 acres.

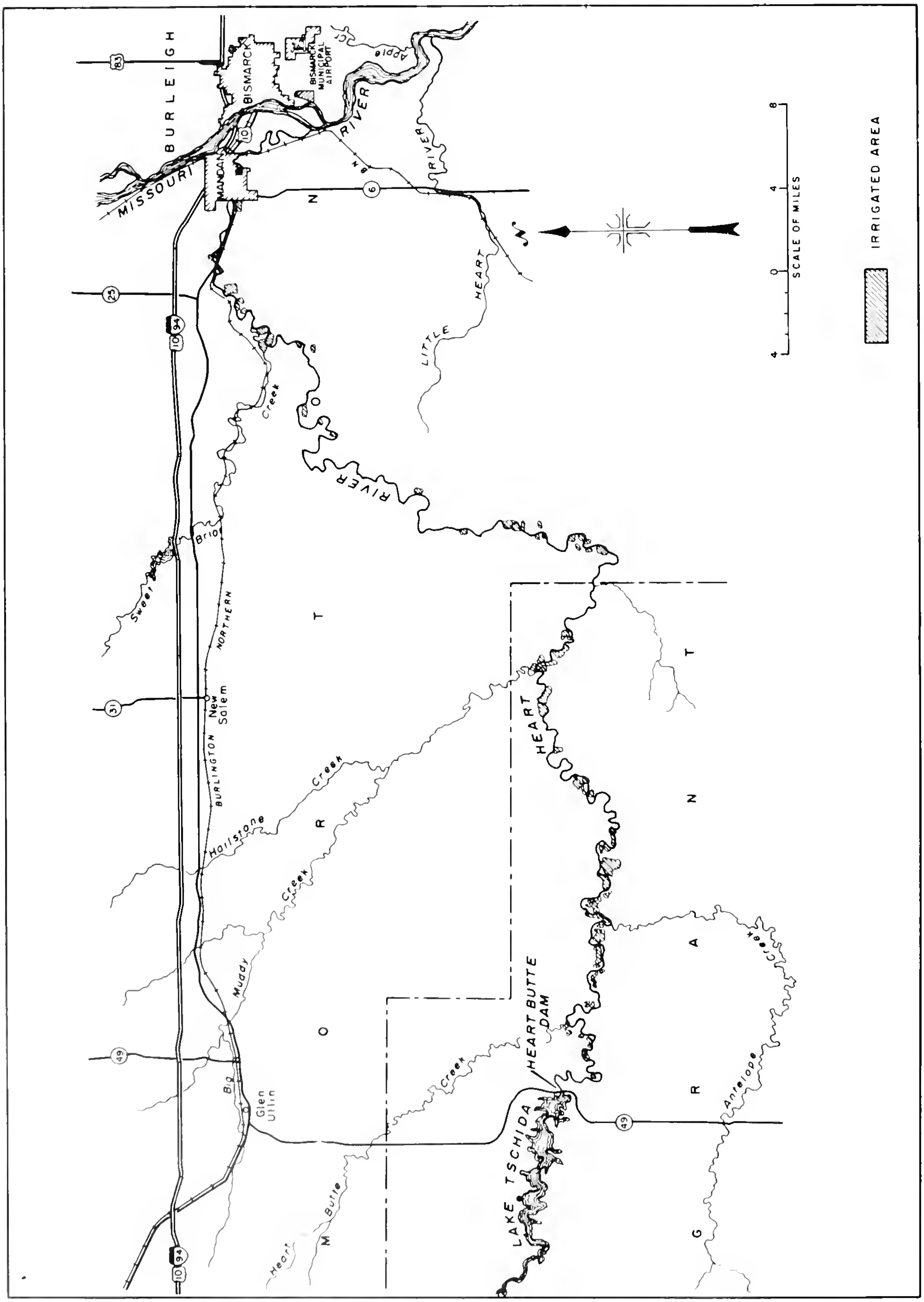
The Western Heart River Irrigation District contains 2,508 acres of irrigable land. This land is served by project pumping plants in the western section of the unit. Other private irrigators downstream from Heart Butte Dam have formed the Lower Heart Irrigation Company and have contracted with the Bureau of Reclamation for a water supply to irrigate up to 4,224 acres. The remaining irrigable land probably will be developed by the landowners contracting with the Federal Government for a water supply.

Features constructed include Heart Butte Dam and 29 river pumping plants, 1 relift plant, and 17 miles of laterals. The ultimate development, including project and private development, will include about 70 river pumping plants.

PLAN

Water released from Lake Tschida to the Western Heart River Irrigation District is pumped to the lateral system by motor-driven pumps which vary in size from 3 to 6 cubic feet per second. The lift from the river averages 25 feet. One relift plant is required to discharge the water to

Heart Butte Dam



Heart Butte Unit

higher lands. Power for the pumping plants is supplied from the Missouri River Basin Project. All laterals and drains have earth sections.

Heart Butte Dam and Lake Tschida

The dam is a homogeneous earthfill type, with a structural height of 142 feet and a crest length of 1,850 feet. It contains 1,140,000 cubic yards of earth materials. The dam is on the Heart River in Grant County approximately 18 miles south of Glen Ullin, N. Dak. The spillway is a morning-glory type, leading to a 14-foot tube with a capacity of 5,700 cubic feet per second. The outlet works consists of a gated tube with a capacity of 700 cubic feet per second.

The reservoir has a total capacity of 223,646 acre-feet, of which 147,861 acre-feet are for flood control storage, and 206,365 acre-feet are for surcharge. The lake covers an area of 6,576 acres at top of flood control.

DEVELOPMENT

Early History

The region was first occupied by ranchers, who settled along the streams and used the public domain for grazing livestock. Large numbers of settlers came during 1900-10, and emphasis was placed upon the production of cash grain crops. High prices and favorable rainfall encouraged grain farming, which resulted in plowing up of extensive areas of rangeland and overgrazing of the remaining range. Although livestock continued to be important, the demand for wheat during 1914-20 brought about tremendous expansion in wheat acreage. The drought years of the 1930's and prevailing low prices seriously disrupted the economy and led to emigration and abandonment of farms.

Investigations

By 1942, the demands on agricultural production in the United States had exceeded the ability of farms to produce, and farmers in the subhumid area were developing an interest in irrigation. Damaging floods were recurring in the Heart River Valley and along the Missouri and Mississippi Rivers. The President's Great Plains Drought Area Committee had prepared a report in 1936 stressing the need for conservation of great plains resources, and the conditions in the Heart River Valley prompted a new detailed survey in 1942 by the Bureau of Reclamation.

A detailed land classification survey of the lands below Heart Butte Dam was made by Reclamation in 1945. A development report covering the Heart Butte Unit was completed February 10, 1947. Because of greater requirement for flood control storage, the design of Heart Butte Dam was revised to provide a total storage capacity of 225,500 acre-feet.

The spillway design flood, when routed through the reservoir, resulted in an additional 200,500 acre-feet of surcharge and the powerplant was eliminated.

Authorization

Authorized as a part of the Heart River Unit by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of the initial phase of the unit began in April 1948 and was essentially completed by December 1949.

Operating Agency

Heart Butte Dam and Reservoir are operated by the Bureau of Reclamation. The Western Heart River Irrigation Project is operated and maintained by the Western Heart River Irrigation District. Private irrigators in the Lower Heart Irrigation Company operate and maintain individual pumps.

BENEFITS

Irrigation

The availability of water, when needed for irrigation, and pumping facilities enables the transformation of suitable dry land to irrigated production and contributes to restoring the economic stability of the area.

Flood Control

The control of the riverflows by Heart Butte Reservoir, coupled with the levees at Mandan, N. Dak., prevented a record flow of the Heart River from flooding Mandan in the spring of 1950. Without the dam, the flow at Mandan would have reached about 40,000 cubic feet per second.

Recreation and Fish and Wildlife

Lake Tschida is the only sizable body of water in the area and it has become a popular recreation center. Picnicking, swimming, boating, camping, water skiing, and fishing are popular summer activities. Fall and winter activities include hunting, ice fishing, snowmobiling, and ice skating. Designated areas along the shoreline of the reservoir have been leased to the Boy Scouts and other youth groups, and 238 sites for summer homes and trailers have been leased. The more remote areas are leased for agricultural uses. Public use of the unit amounted to 235,000 visitor days in 1977.

Administration of recreation areas and facilities will be transferred from the North Dakota Game and Fish Department to the Bureau of Reclamation on January 1, 1979. The North Dakota Game and Fish Department will retain administration of the agricultural leases and the fish and wildlife activities.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Available for full service	6,620	acres
Ultimate full service	10,000	acres
Number of irrigated farms	58	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	2,424	142,252
1969	2,429	150,851
1970	2,421	157,331
1971	2,395	185,483
1972	2,430	204,619
1973	2,451	256,380
1974	3,590	484,810
1975	3,469	461,002
1976	3,302	560,763
1977	3,900	611,007

Facilities in Operation

Storage dams	1	
Laterals	17	mi
Pumping plants	30	
Drains	1	mi

Climatic Conditions

Annual precipitation	16.2	in
Temperature:		
Maximum	107	°F
Minimum	−37	°F
Mean	43	°F
Growing season	131	days
Elevation of irrigable area	1630-1990.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	198

ENGINEERING DATA

Water Supply

HEART RIVER

Drainage area at Heart Butte Dam	1,810	mi²
Annual discharge at Heart Butte Dam:		
Maximum (1972)	242,900	acre-ft
Minimum (1962)	9,000	acre-ft
Average	99,200	acre-ft

Storage Facilities

HEART BUTTE DAM AND DIKE

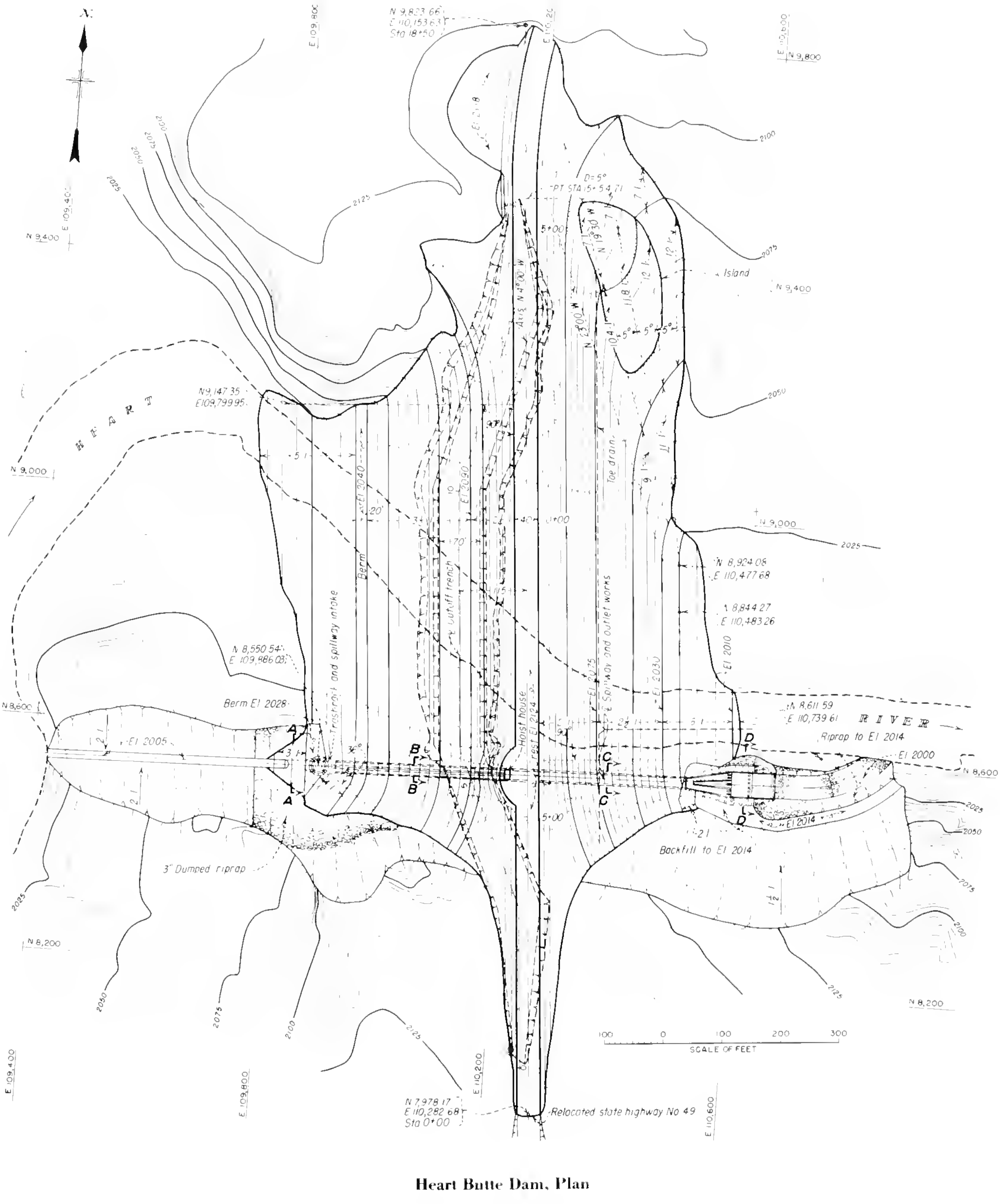
Type: Homogeneous earthfill. (Dike, 2,884 ft long and 11.5 ft high, closes low area about 1.5 mi southwest of dam).		
Location: On the Heart River 18 mi south of Glen Ullin, N. Dak.		
Construction period: 1948-49		
Date of closure (first storage): October 4, 1949		
Reservoir, Lake Tschida:		
Total capacity to El. 2094.5	223,646	acre-ft
Active capacity El. 2030-2064.5	69,030	acre-ft
Surface area	6,576	acres
Dimensions:		
Structural height	142	ft
Hydraulic height	118	ft
Top width	40	ft
Maximum base width	835	ft
Crest length	1,850	ft
Crest elevation	2124.0	ft
Volume	1,140,000	yd³
Spillway: Uncontrolled concrete morning-glory crest and conduit through right abutment.		
Crest diameter	27	ft
Crest elevation	2064.5	ft
Capacity at El. 2118.2	5,700	ft³/s
Outlet works: Intake structure around base of spillway crest leading to concrete conduit on top of spillway conduit to control structure at center of dam, where outlet discharge joins spillway discharge in outlet conduit.		
Capacity at El. 2064.5	700	ft³/s

Carriage Facilities

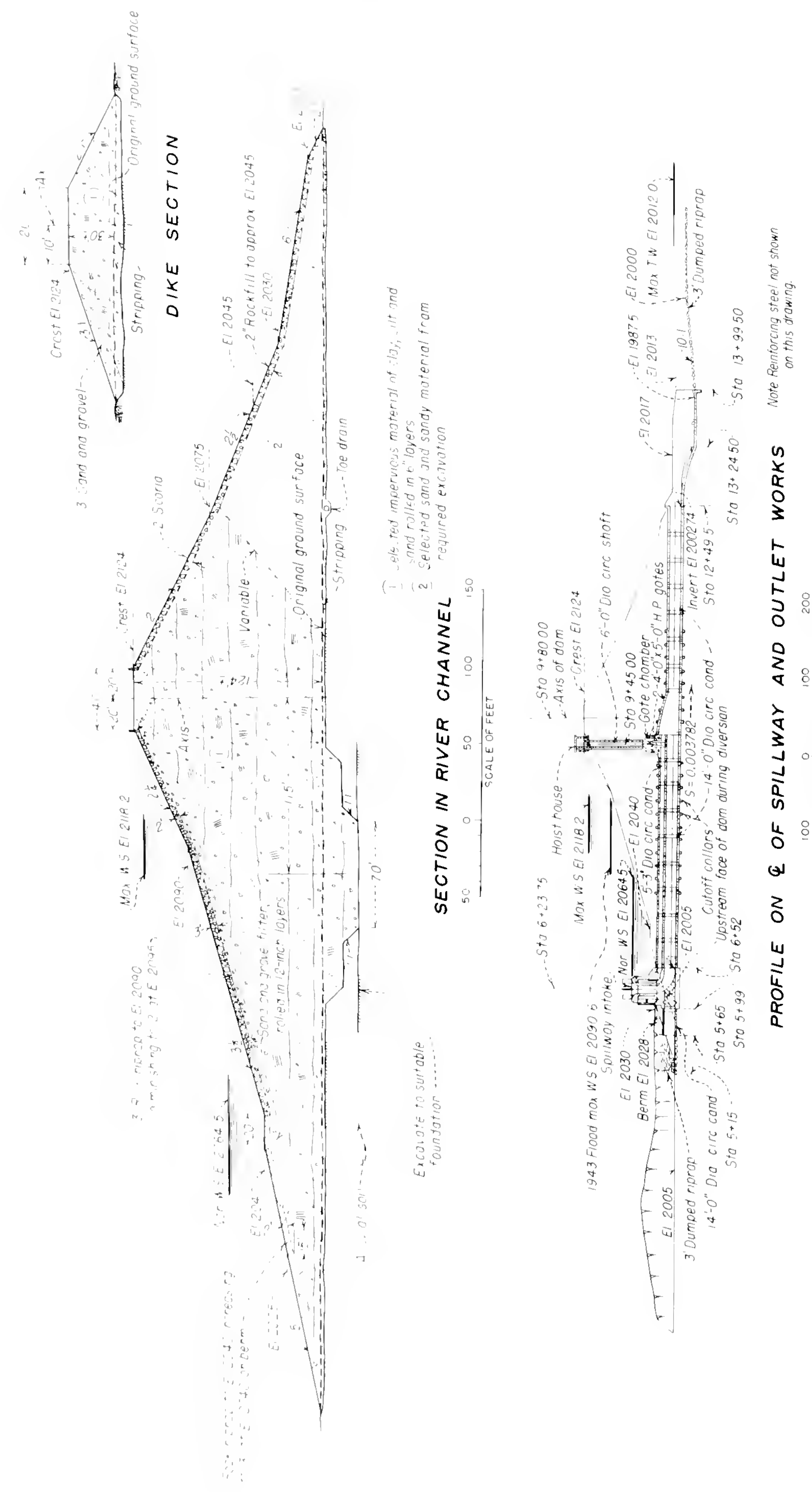
(Western Heart River Irrigation District only)

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
18B, 18C, 18F, 18G, 18H, 20, 21, 22, 25, 26, 27A, 27-0.2, 28, 30A, 30-5, 30-6, 31, 32, 33, 34, 35, 36, 37, 18J, 27B, 31A, 34A, 35A.	1 for each plant.	108	21-52	705
27 (27-3, 27-6)	2	9	30	45
29 (29-3, 29-6)	2	9	34	60



Heart Butte Dam, Plan

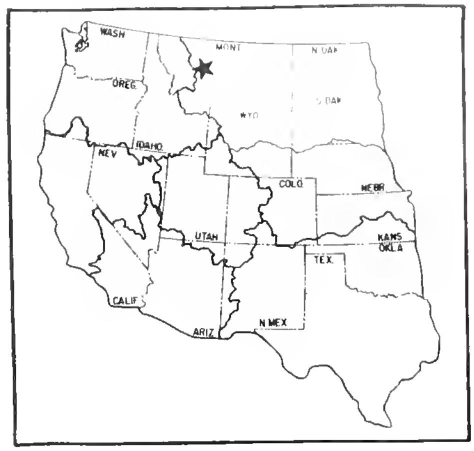


Heart Butte Dam, Sections

Pick-Sloan Missouri Basin Program
Helena Valley Unit

Montana: Lewis and Clark County

Upper Missouri Region
Water and Power Resources Service

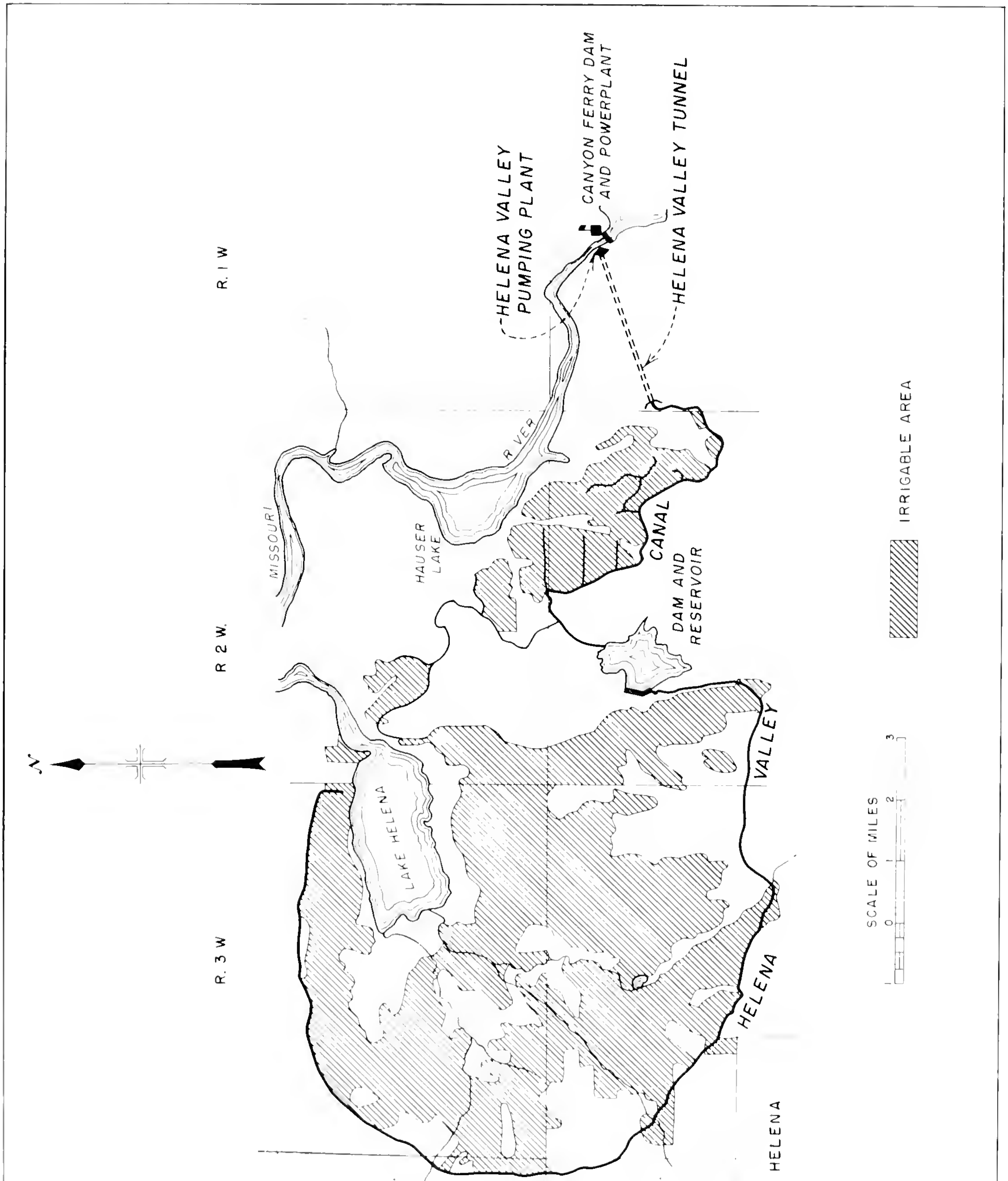


Helena Valley Unit is in central Montana, adjoining the city of Helena, and 3.5 miles west of Canyon Ferry Dam on the Missouri River. The principal purposes of the unit are irrigation and municipal water for the city of Helena. Features of the development are a tunnel, dam and regulating reservoir, canal, pumping plant, and other facilities to furnish water to 16,440 acres of land and for municipal use.

PLAN

The Helena Valley Unit water supply is discharged from Canyon Ferry Reservoir, 17 miles east of Helena on the Missouri River. Helena Valley Pumping Plant, below Canyon Ferry Dam, lifts water by turbine-driven pumps to Helena Valley Tunnel. This water flows by gravity through the 2.7-mile tunnel under the Spokane Hills into Helena Valley. Helena Valley Canal conveys the water around the south, west, and north sides of the valley, terminating in a wasteway into Lake Helena. Helena Valley Reservoir, with an active capacity of 5,900 acre-feet, is located at mile 11 of the Helena Valley Canal. This reservoir regulates pumped water and supplies water through a two-level outlet works to the municipal works constructed by the city of Helena.

Helena Valley Dam and Reservoir



Helena Valley Unit

Helena Valley Pumping Plant

Helena Valley Pumping Plant

Helena Valley Pumping Plant, 500 feet downstream from Canyon Ferry Dam, houses two 5,000-horsepower Francis-type hydraulic turbines; each turbine is connected directly to a 150-cubic-foot-per-second centrifugal pump; the two pumps lift a total of 300 cubic feet per second of water to the inlet end of the Helena Valley Tunnel. Water is supplied to the pumping plant by a 10-foot-diameter welded steel penstock pipe from Canyon Ferry Dam. A portion of the water from the reservoir is pumped up to the tunnel through a 75-inch-diameter discharge line; the remainder is discharged into the Missouri River. A 10-foot-long reducer section at the upstream end connects the penstock pipe to the 13-foot-diameter conduit liner pipe in Canyon Ferry Dam. A 60-ton fixed-wheel gate in the upstream face of Canyon Ferry Dam regulates the flow of water into the penstock. An exposed manifold provides for future installation of a small powerplant. A 92-inch butterfly valve is located in each of the two branches for the turbines.

Helena Valley Tunnel

The Helena Valley Tunnel passes through a high range of hills on the left bank of the Missouri River, 14 miles east of Helena, Mont. The gravity flow tunnel conveys water in a westerly direction through the Spokane Hills which separate Helena Valley and the Missouri River. The water is pumped into the tunnel from Canyon Ferry Reservoir by two hydraulic turbine-driven pumps. The tunnel is concrete lined, horseshoe shaped, 7 feet in diameter, and 2.7 miles long. The tunnel capacity is 300 cubic feet per second with water depth at 5.5 feet. The invert at the tunnel inlet end is 73.41 feet above Canyon Ferry Reservoir maximum water surface elevation and 211.16 feet above the horizontal centerline of the pumps.

Helena Valley Dam, Reservoir, and Canal

Water flowing from Helena Valley Tunnel at mile 2.8 discharges into the 300-cubic-foot-per-second Helena Valley Canal. The canal is 31.7 miles long, with 10.2 miles unlined and 21.5 miles lined. At mile 11, the canal discharges into a 10,500-acre-foot-capacity regulating reservoir. Helena Valley Dam, which forms the reservoir, is an earthfill structure 91 feet high, with a crest length of 2,650 feet. A 600-foot-long dike extends from the left abutment of the dam.

The reservoir has 5,900 acre-feet of conservation storage for irrigation and municipal water. An outlet built into the dam supplies municipal water to the city of Helena. The 350-cubic-foot-per-second outlet to the Helena Valley Canal is located in the dike. Between the reservoir and mile 17, the canal provides facilities for future supplemental service to 10 irrigation ditches which have been diverting water from Prickly Pear Creek; between miles 17 and 22, facilities are provided for supplemental service to existing ditches diverting water from Prickly Pear and Tenmile Creeks. The canal terminates at Lake Helena, which occupies the lower part of the valley.

The reservoir area upstream from the dam has been earth blanketed to reduce seepage from the reservoir, and pressure relief wells have been installed near the downstream toe of the dam. These measures have not been totally effective and other measures are being considered to relieve the uplift pressures on the downstream toe of the dam.

Lateral and Drainage System

The lateral system is 64.8 miles long, which includes 51.9 miles unlined, 12.7 miles lined, and 0.2 mile of pipe. The drainage system is 56.5 miles long, including 26.6 miles of open drains and 29.9 miles of pipe drains.

DEVELOPMENT

Early History

Helena was established in 1864, following the discovery of gold in Last Chance Gulch, and was a thriving gold camp by 1865. Many of the miners, disappointed in their quest for gold, took up homesteads in the valley.

The water from Prickly Pear, Tenmile, Silver, and McClellan Creeks was appropriated for irrigation purposes concurrently with the land claims, and shortages of water were noted as early as 1866. In 1883, the Water Corporation of Prickly Pear Valley was formed by people claiming water rights out of Prickly Pear Creek.

From 1910 to 1920, Lewis and Clark County was rather heavily settled. As agriculture yields and prices dropped rapidly after 1919, farm bankruptcies, foreclosures, and attractive industrial opportunities in other sections of the country induced people to leave the area.

Investigations

In 1905-06, a preliminary investigation by the Reclamation Service proposed diversion of Madison River waters to supply irrigable land in the Helena Valley by a canal. In 1912, The Montana Reservoir and Irrigation Co., now a subsidiary of the Montana Power Company, developed an irrigation system to serve an area similar to that planned by Reclamation and erected pumping plants on the north and south shores of Lake Helena. The Montana Reservoir and Irrigation Co. contract expired in 1942, but the company operated the pumps and served the land on the same basis beyond that time. Reconnaissance investigations of the Helena Valley Basin by the Bureau of Reclamation were reported in 1940 and 1943. Various reservoir sites and other alternatives were investigated. The recommended plan involved pumping irrigation water from Canyon Ferry Reservoir. This plan was outlined in Senate Document 191, 78th Congress, 2d session.

Authorization

The unit was authorized by the Flood Control Acts of December 22, 1944, and July 24, 1946.

Construction

Construction of facilities was begun in 1957 and completed in 1958.

Operating Agency

Operation and maintenance functions are performed by the Helena Valley Irrigation District.

BENEFITS

Irrigation

Full irrigation development provides for a more intensive land use and greater diversification through the production of potatoes, alfalfa, grain, and irrigated pasture. Livestock production has been supplemented by fattening cattle, sheep, and hogs, and increased production of dairy and poultry products.

Municipal Water

Facilities incorporated into the unit provide for a supplemental water supply for the city of Helena.

Recreation

The unit provided 4,700 visitor-days in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	15,608	acres
Supplemental irrigation service	832	acres
Total	16,440	acres
Number of farms	207	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	12,922	879,750
1969	12,784	1,182,624
1970	13,114	733,631
1971	13,200	1,153,155
1972	12,612	1,218,126
1973	12,366	2,302,688
1974	12,351	1,375,345
1975	11,653	1,344,250
1976	14,391	1,632,154
1977	13,660	2,376,327

Facilities in Operation

Storage dams (regulation)	1	
Canals	31.7	mi
Laterals	64.8	mi
Pumping plants	1	
Tunnels	2.6	mi
Drains	56.5	mi

Climatic Conditions

Annual precipitation	11.38	in
Temperature:		
Maximum	105	°F
Minimum	−42	°F
Mean	43	°F
Growing season	146	days
Elevation of irrigable area	3750.0	ft

Settlement

Number of persons served (1977):	
On farms	540
City of Helena	26,000

ENGINEERING DATA

Water Supply

Missouri River

Drainage area above Canyon Ferry Dam	15,860	mi²
Annual discharge near Toston, Mont.:		
Maximum (1976)	5,451,500	acre-ft
Minimum (1961)	2,119,400	acre-ft
Average	3,784,000	acre-ft
Annual diversion, Helena Valley Pumping Plant	74,300	acre-ft

Storage Facilities

Helena Valley Dam

Type: Zoned earthfill
Location: Offstream, about 8 mi northeast of Helena, Mont.
Construction period: 1957-58
Date of closure (first storage): March 1959
Reservoir, Helena Valley:
Inflow from Missouri River below Canyon Ferry Dam through Helena Valley Pumping Plant, Tunnel, and Canal.

Total capacity to El. 3820	10,500	acre-ft
Active capacity, El. 3805-3820	5,900	acre-ft
Surface area	531	acres
Dimensions:		
Structural height	91	ft
Hydraulic height	65.1	ft
Top width	20	ft
Maximum base width	445	ft
Crest length	2,650	ft
Crest elevation (at maximum section)	3828.0	ft
Volume	304,000	yd³

Spillway: None
Outlet works:
Municipal outlet: Approach channel, two intake structures, a 30-in-diameter steel pipe encased in concrete from each intake structure to the gate chamber, concrete gate chamber with two 24-in gate valves, a concrete 6-ft-diameter access shaft, and a 30-in-diameter steel pipe encased in concrete from the gate chamber to the downstream end of the outlet works.
Capacity at El. 3805 .... 50 ft³/s
Canal outlet: An unwatering channel, a section of canal, a concrete headworks structure with two 72- by 78-in cast-iron slide gates for controlling flow through two 8.5- by 6.67-ft concrete conduits, and an outlet transition to the Helena Valley Canal.
Capacity at El. 3807 .... 350 ft³/s

Carriage Facilities

Helena Valley Canal

Location: From Helena Valley Tunnel to Helena Valley Reservoir, terminating in Lake Helena.
Construction period: 1957-58

Length	31.7	mi
Capacity (maximum)	350	ft³/s
Typical maximum section in earth:		
Bottom width	16	ft
Side slopes	2:1	
Water depth	5.6	ft

Helena Valley Tunnel

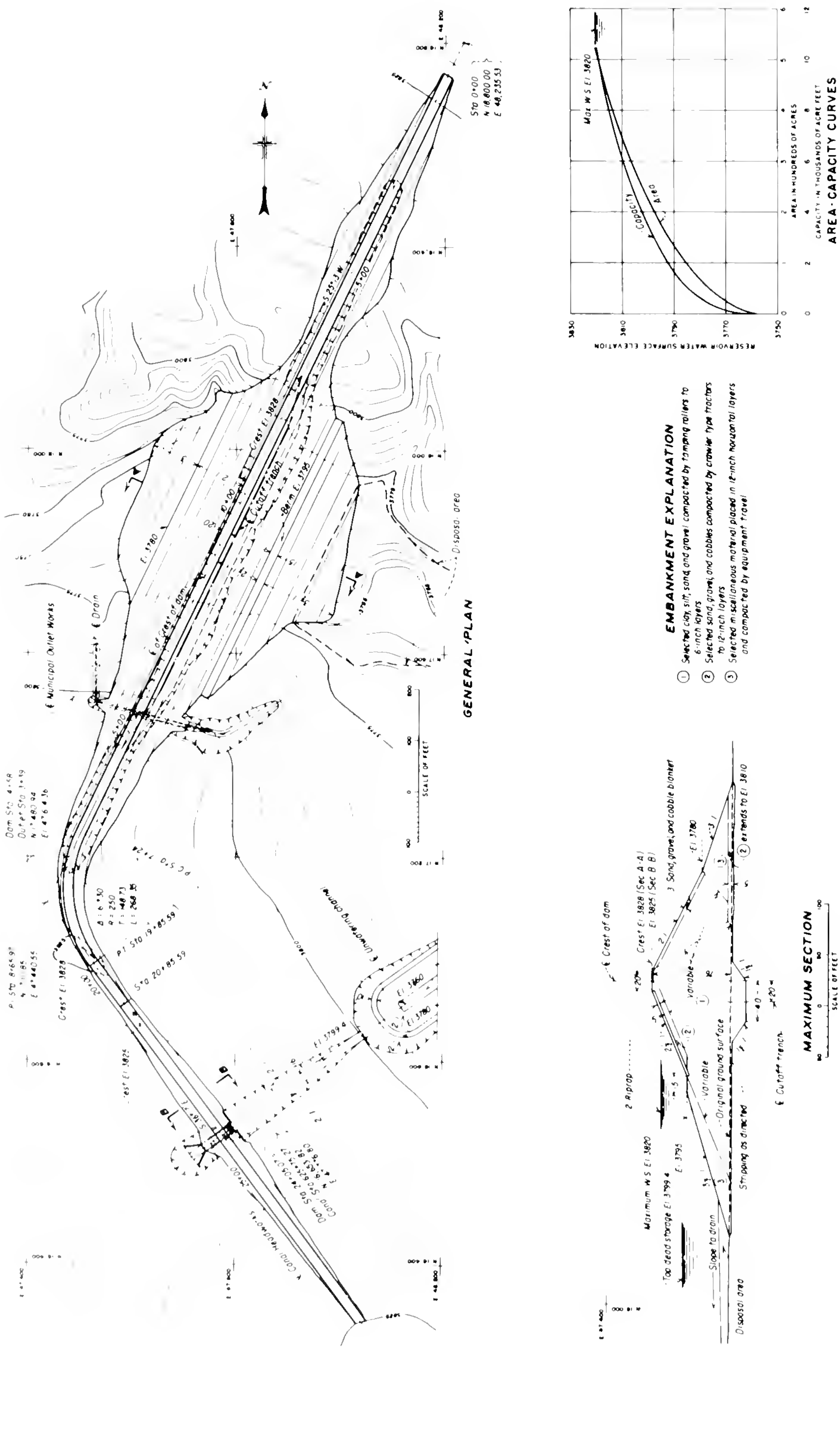
Location: From a point 500 ft downstream from Canyon Ferry Dam westerly through the Spokane Hills to the Helena Valley Canal.
Construction period: 1957-58

Length	13,985	ft
Capacity	300	ft³/s
Cross section: Horseshoe		
Diameter	7	ft
Lining: Concrete		

Pumping Plant

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Helena Valley	2	300	145	[1]10,000

[1]Direct-connected hydraulic turbine.

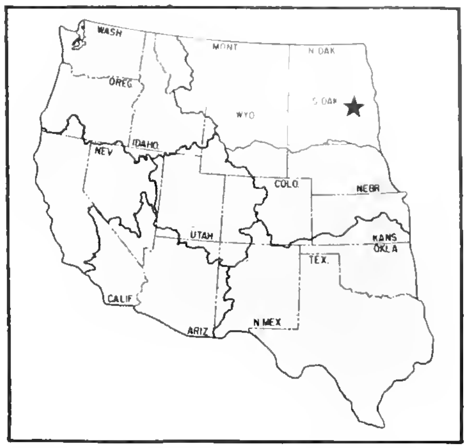


Helena Valley Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
James Diversion Dam, Oahe Unit

South Dakota: Brown and Spink Counties

Upper Missouri Region
Water and Power Resources Service



The James Diversion Dam and Reservoir are located on the James River in east-central South Dakota, approximately 17 miles north of Huron. The dam presently provides a supplemental water supply for the city of Huron, S. Dak. In the Oahe Unit plan, the primary purpose of the James Diversion Dam is to provide a pool for pumping natural and return flows to Byron Reservoir, through the proposed James Pumping Plant and the James Canal, for use on the East Lake Plain Area.

PLAN

The plan of development provided for the early construction of the James Diversion Dam to furnish the city of Huron with an additional 1,900-acre-foot water supply annually for municipal and industrial purposes. The water is conveyed to the city via the James River. The dam provides sufficient supplemental water to meet the future needs of the city, assuming normal growth rates and assuming that the runoff of the James River will be comparable to that received during prior dry periods. It is possible that return flows to the James River resulting from irrigation development of the Oahe Unit, or the Garrison Diversion Unit in North Dakota, will provide additional water for the city. The James Diversion Dam will become an integral part of the Oahe Unit when the unit is developed. The present plan does not include any irrigation prior to development of the Oahe Unit.

The plan provides for fish and wildlife enhancement and recreation development.

James Diversion Dam

The James Diversion Dam is a 50-foot concrete gravity ogee weir with flanking earth dikes. The dam has a 6-foot-square cast iron slide gate and a manual lift installed in a sluiceway at elevation 1225.0. An earth channel auxiliary spillway 150 feet wide and 1,900 feet long is excavated across the flood plain to the right of the dam. The channel inlet invert is constructed of rock riprap at elevation 1242.0. The capacity of the reservoir is 4,875 acre-feet at spillway crest elevation 1240.5.

DEVELOPMENT

Early History

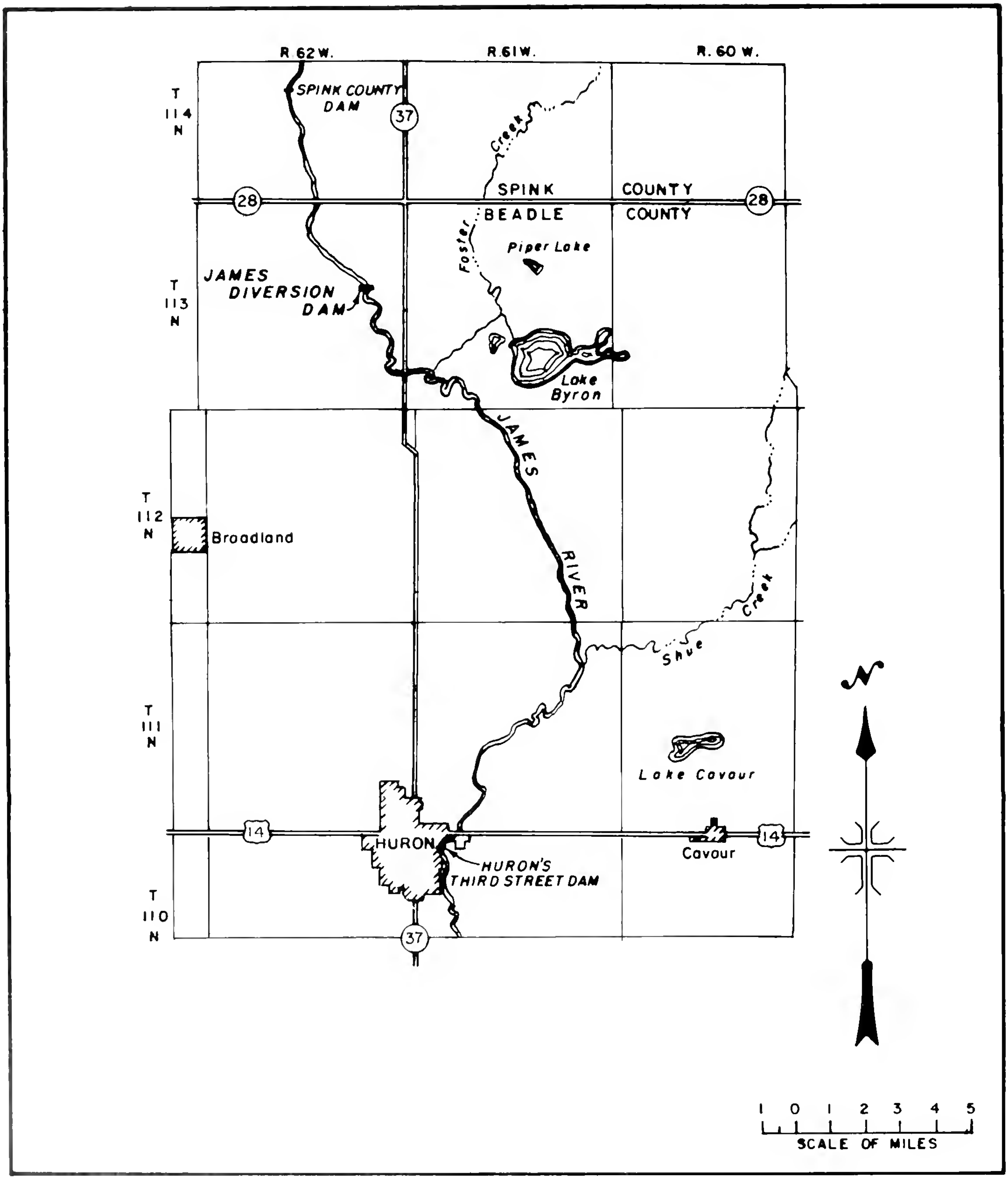
The general area that encompasses the Oahe Unit was open for homestead entry by 1873. There was a great influx of settlers from about 1876 to 1883, along with extensive railroad development. The area has highly variable annual precipitation patterns and periodic insect infestations that have affected grain and forage production, and stability of the predominantly agricultural economy.

The search for a water supply to irrigate lands in the James River Basin had already begun when South Dakota became a State in 1889. Early efforts to use the artesian water underlying the portions of the James River Valley for irrigation were frustrating because of the limited supply of water and its poor quality.

During the 1920's and 1930's there was considerable interest in the construction of dams on the Missouri River for navigation, flood control, hydroelectric power, and irrigation along the James River since its erratic flows could not provide a reliable and sustained water supply.

Investigations

The severe and extended drought period of the 1930's and extensive flooding along the Missouri River and some of its tributaries during the early 1940's prompted the Congress to direct the Bureau of Reclamation and the Corps of Engineers to undertake studies for the development of the resources of the Missouri River Basin. The Bureau of Reclamation directed its attention to evaluating the resources for irrigation and related land



James Diversion Dam, Oahe Unit

James Diversion Dam

resource developments and municipal and industrial water; the Corps of Engineers conducted its studies on flood control and navigation. Both agencies considered the possibilities of hydroelectric power generation. After review by the Congress, the two general plans for development were combined, modified, and authorized by the Flood Control Act of 1944.

The Oahe Unit, a plan predominantly for irrigation development, was a part of the overall plan for development of the resources of the Missouri River Basin.

The Bureau of Reclamation conducted further engineering, land resources, and economic studies in the 1940's and 1950's throughout the Missouri River Basin area, including a feasibility study of the Oahe Unit as a part of the Missouri River Basin Project. These studies identified the Oahe Unit irrigable lands within Sully, Brown, Spink, Marshall, and Day Counties in east-central South Dakota with an ultimate irrigation development potential of 495,000 acres. The initial stage development is comprised of 190,000 acres in Brown and Spink Counties.

The city of Huron requested the Bureau of Reclamation to construct the James Diversion Dam before the construction of the Oahe Unit, to provide additional municipal water.

The report on the James Diversion Dam of the Oahe Unit was completed in March 1962.

Authorization

The James Diversion Dam, Oahe Unit, is part of the Pick-Sloan Missouri Basin Program which was authorized by the Flood Control Act of 1944 (59 Stat. 887) as supplemented and extended by the Flood Control Act of 1946 (60 Stat. 641). Funds for the diversion dam investigations were specifically identified in Public Works Appropriation Act of 1961 (74 Stat. 743); construction funds were authorized in the Appropriation Act of 1963, (P.L. 87-800, 78 Stat. 1220) and continued in the Appropriation Act of 1964.

Construction

The contract for construction of the James Diversion Dam was awarded on July 18, 1963. All contract work was completed by November 4, 1964.

Operating Agency

James Diversion Dam and Reservoir are operated and maintained by the city of Huron specifically for municipal water storage purposes.

BENEFITS

Municipal Water

The city of Huron is assured an adequate supplemental municipal water supply to meet its foreseeable future needs.

Recreation and Fish and Wildlife

Recreation and fish and wildlife developments associated with the reservoir and associated lands are managed by the South Dakota Department of Game, Fish, and Parks under contract with the Bureau of Reclamation.

Various facilities associated with outdoor recreation are provided at the five developed recreation areas around the reservoir. Facilities include campgrounds, picnic areas, sanitary facilities, and boat ramp developments, in addition to a scenic overlook. There were 4,500 visitor days at James Diversion Reservoir in 1977.

PROJECT DATA

Facilities in Operation

Diversion dams	1	

Climatic Conditions

Annual precipitation	19.4	in
Temperature:		
Maximum	112	°F
Minimum	−39	°F
Mean	45	°F

Settlement

Number of persons served with project water (1977):	
Supplemental municipal water service	14,300

ENGINEERING DATA

Water Supply

JAMES RIVER

Drainage area above James River at Huron	1,600	mi²
Annual discharge at Huron:		
Maximum (1969)	731,000	acre-ft
Minimum (1959)	400	acre-ft
Average	170,800	acre-ft

Storage Facilities

JAMES DIVERSION DAM

Type: Concrete gravity ogee weir with flanking earth dikes
Location: On James River, 17 mi upstream from Huron, S. Dak.
Construction period: 1963-64
Date of closure: (first storage) December 7, 1964

Reservoir, James Diversion:

Total capacity to El. 1240.5	4,875	acre-ft
Active capacity, El. 1227-1240.5	4,875	acre-ft
Surface area	960	acres

Diversion capacity: (Functioning as storage dam only at present time.)

Dimensions:

Structural height	47	ft
Hydraulic height	20	ft
Weir crest length	50	ft
Total length	280	ft
Weir crest elevation	1240.5	ft
Crest elevation	1247.0	ft
Weir capacity at El. 1242	300	ft³/s
Volume of concrete	1,450	yd³

Sluice gate: One 6-ft-square cast iron slide gate with a manually operated lift.

Discharge capacity at water surface El. 1240.5	500	ft³/s

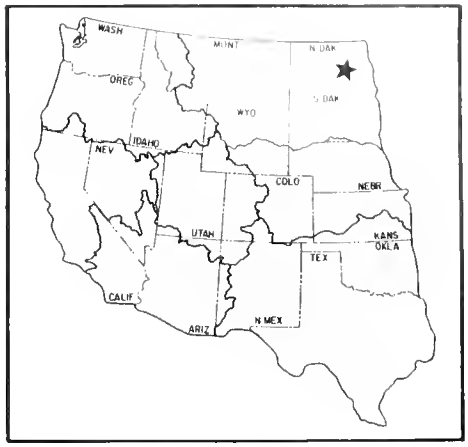
Auxiliary spillway: Earth channel, with uncontrolled overflow riprap crest, located across flood plain to right of dam and discharging into James River below dam.

Crest length	150	ft
Crest elevation	1242.0	ft
Capacity at El. 1247	2,400	ft³/s

Pick-Sloan Missouri Basin Program
Jamestown Dam and Reservoir

North Dakota: Foster, Stutsman, LaMoure, and Dickey Counties

Upper Missouri Region
Water and Power Resources Service



Jamestown Dam and Reservoir in central North Dakota provide flood protection and have a potential municipal water supply for the city of Jamestown, N. Dak. When the Garrison Diversion Unit is constructed, Jamestown Reservoir will control and reregulate water required for irrigation of lands downstream along the James River to near the South Dakota border. The reservoir also provides recreation opportunities and fish and wildlife conservation.

PLAN

The flood control feature of Jamestown Dam is effective in reducing flood dangers in Jamestown, N. Dak., and areas downstream along the James River. There is no power installation at the dam. However, provision has been made in the outlet works for future installation of power penstocks should the need arise. Pipes and valves have been installed in the gate chamber from which a pipe can be extended 6,100 feet to the existing municipal water treatment plant in Jamestown. Jamestown is thus assured an adequate surface water supply.

Jamestown Dam and Reservoir

Jamestown Dam

The dam is a zoned, rolled earthfill structure with a structural height of 110 feet. The spillway is a morning-glory inlet leading to a concrete conduit through the right abutment of the dam. The outlet works consists of a high-pressure gate-controlled conduit through the left abutment of the dam. The reservoir has a total storage capacity of 220,978 acre-feet from streambed to elevation 1454, the spillway crest, of which 185,435 acre-feet are for flood control.

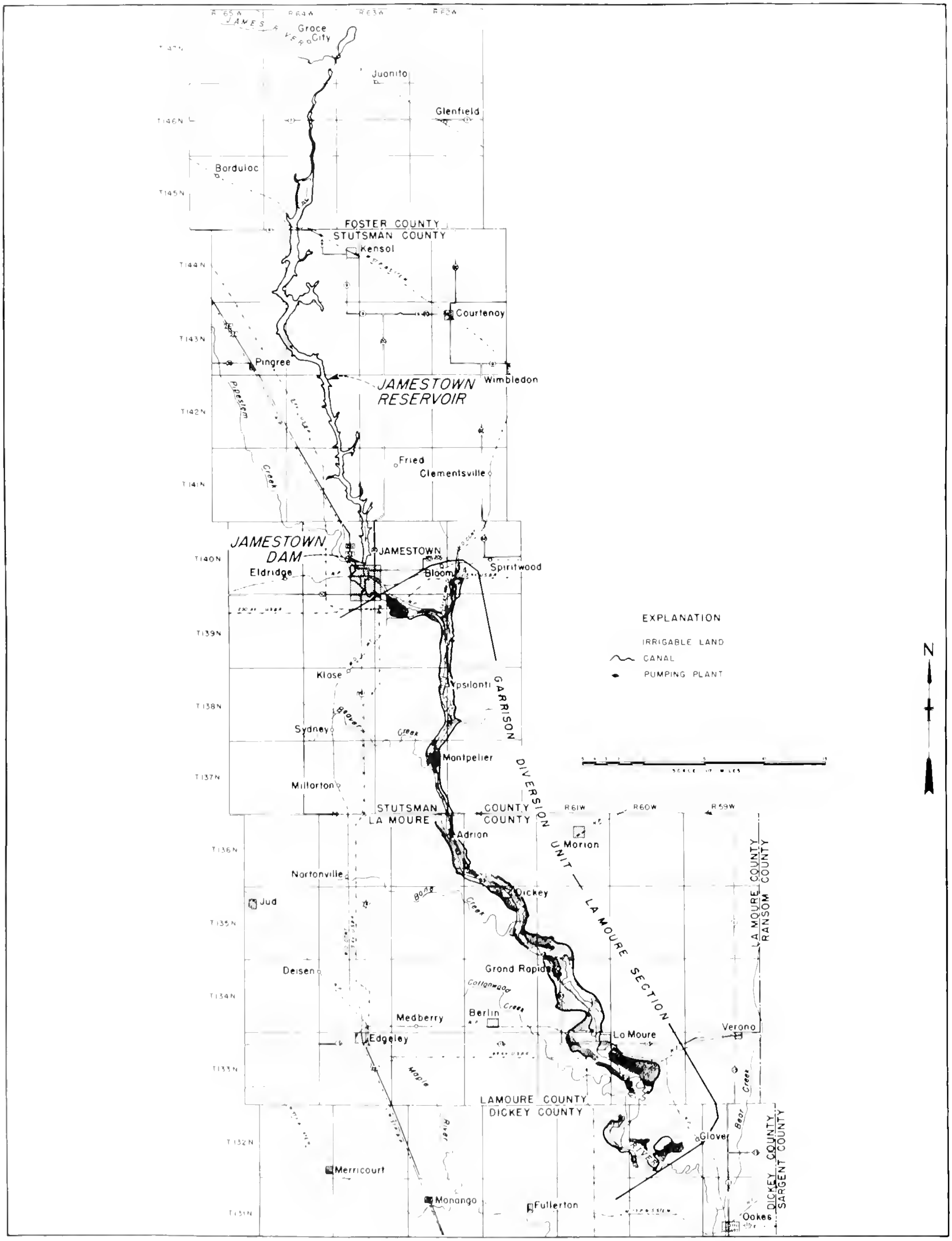
DEVELOPMENT

Early History

Settlement in the James River Valley near Jamestown began with construction of the Northern Pacific Railway in 1871 when railroad workers and their military guards established a camp on the bank of the river. This camp later became Jamestown. The most rapid settlement of the valley was from 1890 to 1910. During the war years, 1914-20, a strong demand for wheat was a factor in making it the most important cash crop. During the drought period in the 1930's, with almost complete crop failure for several years, many farmers were forced to abandon their holdings and leave the area, and livestock numbers were drastically reduced because of feed shortages.

Investigations

Early preliminary reports for the development of the James River Basin in North Dakota were made in 1926. The Corps of Engineers reported on the project in 1933, and the Bureau of Reclamation made its first studies of the Jamestown Unit in 1940. In 1947, the Corps of Engineers completed an additional study on flood control



PSMBP, Jamestown Dam

for the James River and its tributaries. The Bureau of Reclamation continued its investigations on Jamestown Dam and Reservoir as a multipurpose structure in the authorized plan for the development of the Missouri River Basin and prepared a definite plan report on Jamestown Dam and Reservoir, dated December 1951.

Authorization

Authorized as a part of the Missouri-Souris development by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction work on Jamestown Dam began April 18, 1952, and was completed in February 1954.

Operating Agency

Operation and maintenance are the responsibility of the Bureau of Reclamation.

BENEFITS

Irrigation and Municipal Water

When the Garrison Diversion Unit is completed, the Jamestown Reservoir will provide control and reregulation of water required for irrigation of lands downstream along the James River to near the South Dakota border. Jamestown is assured an adequate municipal water supply.

Flood Control

Construction of Jamestown Dam and Reservoir was an advance facility of the Garrison Diversion Unit under a special appropriation made by Congress to provide urgently needed flood protection to the city of Jamestown.

Recreation

Recreational use and agricultural leasing at Jamestown Reservoir are administered by the Stutsman County Board of Park Commissioners under an agreement with the Bureau of Reclamation dated August 6, 1954. Initial development of a recreation park, including access roads, water wells, trees, a swimming beach, and picnicking facilities was accomplished using Federal money specifically appropriated for the purpose. Campgrounds and trailer facilities have been constructed by cooperative efforts. Total number of visitor days in 1977 was estimated at 705,600. The reservoir is stocked with fish by the North Dakota Game and Fish Dept., and is on one of the greatest migratory waterfowl flyways in North Dakota.

PROJECT DATA

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	17.4	in
Temperature:		
Maximum	108	°F
Minimum	−36	°F
Mean	40	°F
Growing season	140	days
Elevation of irrigable area	2400.0	ft

ENGINEERING DATA

Water Supply

JAMES RIVER

Drainage area above Jamestown Dam	1,291	mi²
Annual discharge at Jamestown Dam:		
Maximum (1966)	155,500	acre-ft
Minimum (1977)	2,900	acre-ft
Average	38,000	acre-ft

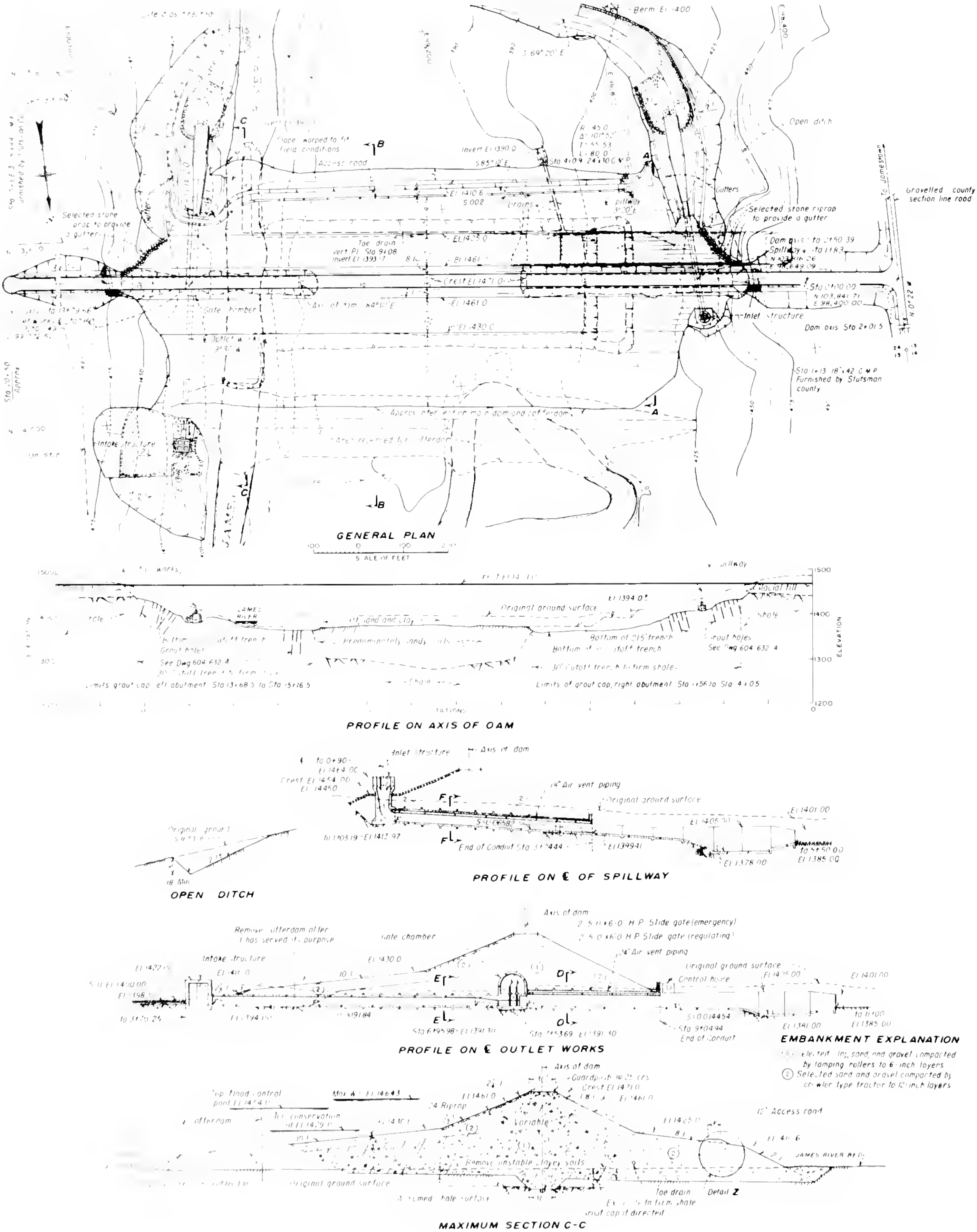
Storage Facilities

JAMESTOWN DAM

Type: Zoned earthfill
Location: On James River at Jamestown, N. Dak.
Construction period: 1952-54
Date of closure (first storage): February 1954

Reservoir, Jamestown:		
Total capacity to El. 1454	220,978	acre-ft
Active capacity, El. 1400-1429.8	28,088	acre-ft
Surface area	13,200	acres
Dimensions:		
Structural height	110	ft
Hydraulic height	69	ft
Top width	30	ft
Maximum base width	730	ft
Crest length	1,418	ft
Crest elevation	1471.0	ft
Volume	963,000	yd³
Spillway: Uncontrolled concrete morning-glory crest and conduit at right abutment.		
Crest diameter	24.3	ft
Crest elevation	1454.0	ft
Capacity at El. 1464	2,930	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by two 5- by 6-ft slide gates.		
Capacity at El. 1464.4	2,990	ft³/s

Foundation: Pierre shale deeply eroded by glacial streams and refilled with up to 120 ft of glacial sands and gravels and alluvial silt, clay, and sand.

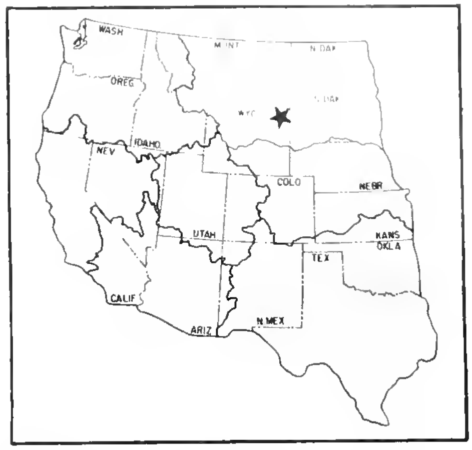


Jamestown Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Keyhole Unit

Wyoming: Crook County

Upper Missouri Region
Water and Power Resources Service



Keyhole Unit, consisting of Keyhole Dam and Reservoir, is on the Belle Fourche River about 17 miles northeast of Moorcroft, Wyo. Keyhole Reservoir is a multipurpose facility that provides storage for irrigation, flood control, fish and wildlife conservation, recreation, sediment control, and municipal and industrial water supply.

PLAN

Keyhole Reservoir provides a supplemental water supply to the 57,068-acre Belle Fourche Project located about 146 miles downstream in western South Dakota. Water for the project is released into the Belle Fourche River and then diverted for project purposes. Water also is furnished to the Belle Fourche-Wyoming Water Association for approximately 1,300 acres of privately developed land and associated facilities around the reservoir and downstream from the dam for a distance of about 25 miles. Contractual arrangements for furnishing water to a housing development near the reservoir are pending.

The apportionment of inflows to Keyhole Reservoir is set forth in the provisions of the Belle Fourche River Compact negotiated by the States of Wyoming and South Dakota and confirmed by the Congress in 1944 (58 Stat. 94).

The compact provides that the unappropriated flow of the Belle Fourche River, as of the date of the compact, shall be allocated 10 percent to Wyoming and 90 percent to South Dakota, provided that Wyoming shall have unrestricted use for domestic and stock water purposes. Wyoming can purchase 10 percent of the storage capacity of Keyhole Reservoir to regulate its portion of the unappropriated water.

Keyhole Dam

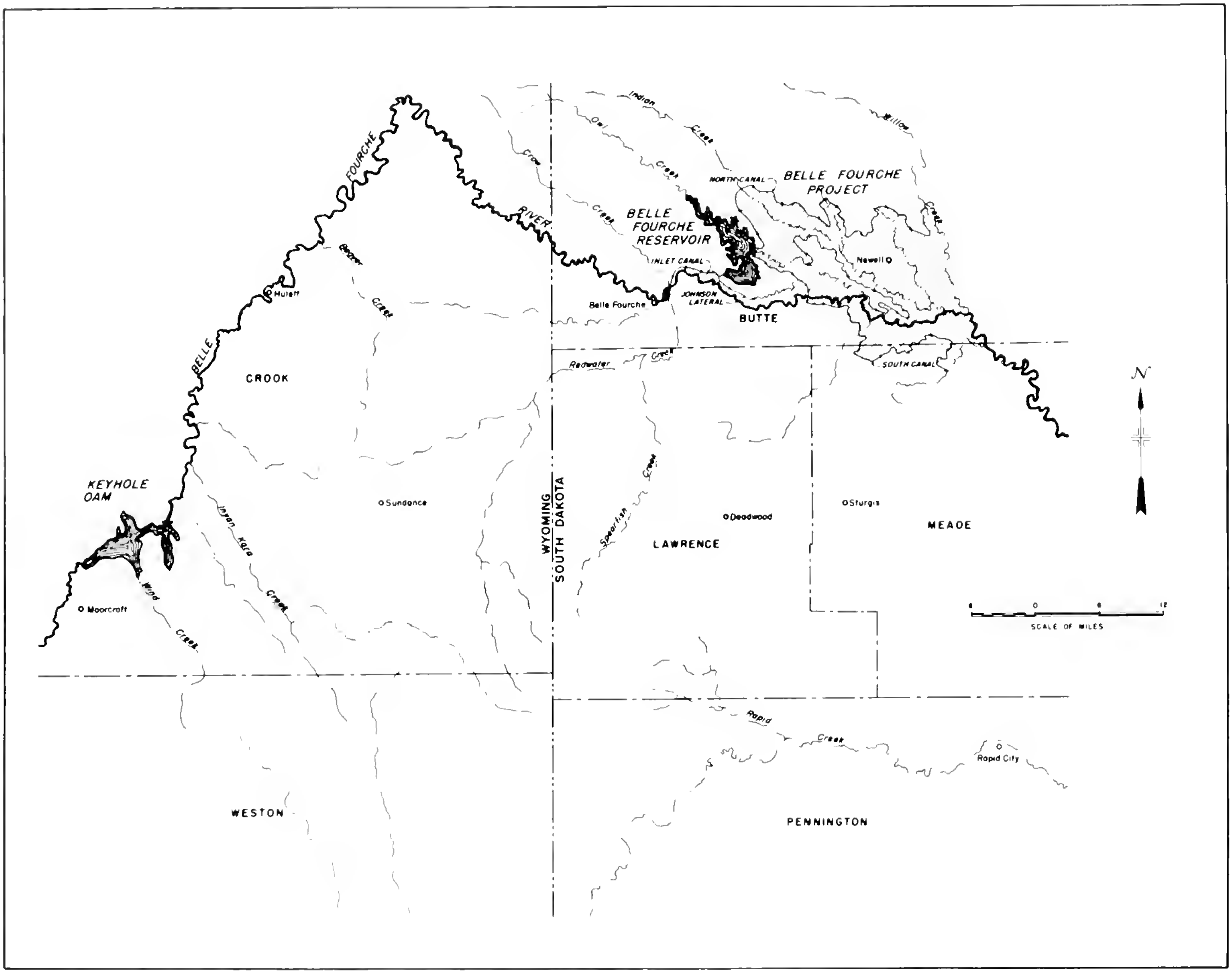
Keyhole Dam

The primary feature of the unit is Keyhole Dam across the Belle Fourche River, which forms a reservoir with a total capacity of 340,100 acre-feet and water surface of 13,686 acres.

Keyhole Dam is a zoned earthfill structure with a maximum structural height of 168 feet, and a crest length of 3,420 feet, including the 2,120-foot dike extension of the right bank.

The spillway is a vertical slot-type uncontrolled concrete-crested structure with a concrete-lined open channel located in the dike near the right abutment of the dam. The spillway has a crest length of 19.25 feet topped by a concrete bridgedeck on the crest of the dam. Spillway discharge capacity is 11,000 cubic feet per second.

The outlet works consists of a concrete-lined horseshoe-shaped tunnel 9.5 feet wide by 8.25 feet high through the left abutment. Release capacities of about 1,480 cubic feet per second are controlled by two vertical lift, high-pressure hydraulic slide gates.



Keyhole Unit

DEVELOPMENT

Early History

French trappers settled in the vicinity of Belle Fourche and, reportedly, engaged in fur trading with the Indians as early as 1854. Settlement in the area began with the gold rush to the Black Hills in 1876. Livestock became the principal industry in the general area. The Chicago and Northwestern Railroad reached the city of Belle Fourche in 1891 and, for the remainder of the 19th century, the city was considered the largest original shipping point for livestock in the United States.

Investigations

Belle Fourche Project lands which are provided water service directly from the Belle Fourche River and then to the Inlet Canal without advantage of regulatory storage had been plagued with repeated and prolonged water shortages since the project was first irrigated in 1908. The intense and extended drought of the 1930's further emphasized the inadequate water storage and supply facilities.

Several investigations of storage possibilities on the main stem of the Belle Fourche River and its tributaries were made during 1917 through 1941 by the Bureau of Reclamation and the Corps of Engineers. These studies showed that the Keyhole site was the most favorable for construction of a dam to provide improved water supplies to the project. Subsequently, it was included in the Missouri River Basin Project plan.

Authorization

Keyhole Unit was authorized by the Flood Control Act of 1944 (Public Law 534, 78th Congress) which approved the general comprehensive plans set forth in Senate Document 191 and House Document 475 as revised and coordinated by Senate Document 247, 78th Congress. Initial funds for construction were provided by the Second Supplemental Appropriation Act, 1948 (Public Law 299, 80th Congress).

Construction

Construction of Keyhole Dam began on June 29, 1950, and was completed on October 25, 1952. Impoundment of water began in March 1952.

Operating Agency

Keyhole Dam and Reservoir are operated and maintained by the Bureau of Reclamation.

BENEFITS

Irrigation

Supplemental supply of stored water is provided to the Belle Fourche Project and the Belle Fourche-Wyoming Water Association which have 57,068 acres and 1,300 acres of irrigated land, respectively. Under present conditions, the integrated irrigation-dryland farms produce alfalfa, corn, small grains, pasture, and livestock. The principal products are used to provide a stable feed supply for stock-cow herds and sheep and fattening of cattle and lambs.

Flood Control

Flood control benefits are provided by use of the available conservation capacity and the exclusive flood control and surcharge capacities above the crest of the spillway.

Recreation

Numerous facilities associated with outdoor recreation provided at Keyhole Reservoir include picnic grounds, campgrounds, boat ramp developments, swimming beach, and scenic overlooks. The recreation areas are administered by the Wyoming Recreation Commission. The warm-water fishery at the reservoir is maintained by the Wyoming Game and Fish Department. There were 339,500 recreation visitor days to the Keyhole Reservoir area in 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:
Reported under Belle Fourche Project.

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	17.4	in
Temperature:		
Maximum	102	°F
Minimum	−36	°F
Mean	44	°F

ENGINEERING DATA

Water Supply

BELLE FOURCHE RIVER

Drainage area at Keyhole Dam	1,950	mi²
Annual discharge at Keyhole Dam:		
Maximum (1955)	38,100	acre-ft
Minimum (1965)	1,300	acre-ft
Average	13,700	acre-ft

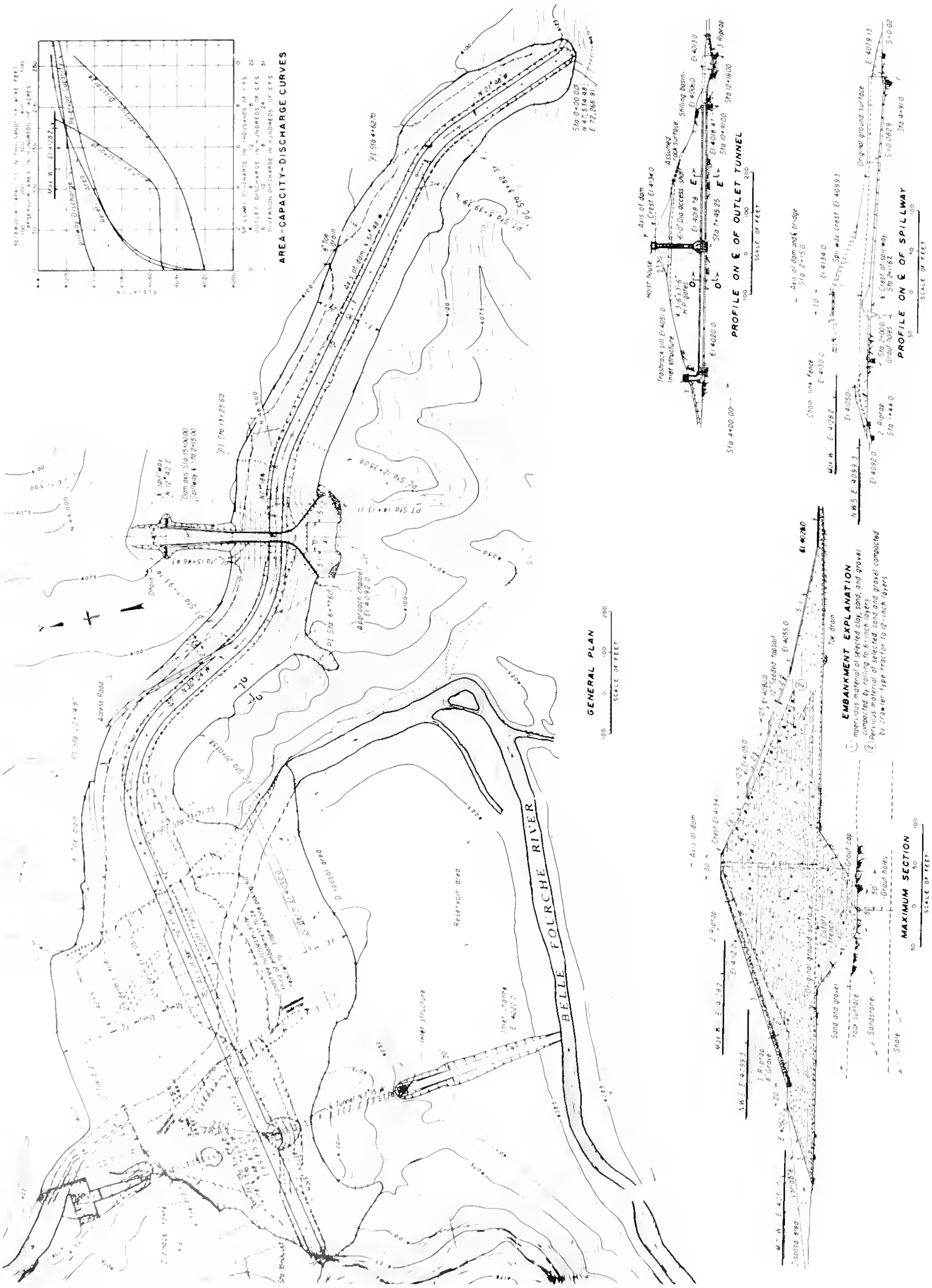
Storage Facilities

KEYHOLE DAM

Type: Zoned earthfill
Location: On the Belle Fourche River about 17 mi northeast of Moorcroft, Wyo.
Construction period: 1950-52
Date of closure (first storage): February 12, 1952

Reservoir, Keyhole:		
Total capacity to El. 4111.5	340,100	acre-ft
Active capacity, El. 4051-4099.3	190,400	acre-ft
Surface area at El. 4099.3	13,686	acres
Dimensions:		
Structural height	168	ft
Hydraulic height	83	ft
Top width	30	ft
Maximum base width	825	ft
Crest length	3,420	ft
Crest elevation	4134.0	ft
Total volume	1,335,000	yd³
Spillway: Uncontrolled concrete crest and concrete-lined open channel at the right abutment.		
Crest length	19.25	ft
Crest elevation	4099.3	ft
Capacity at El. 4128.2	11,000	ft³/s
Outlet works: Concrete lined tunnel through left abutment, controlled by two 3.5-ft-square slide gates.		
Capacity at El. 4128.2	1,480	ft³/s

Foundation: Somewhat pervious, soft to medium hard Dakota sandstone overlain by up to 50 ft of sand and gravel in the riverbed, and dark gray shale in the abutments.
Special treatment: Grout curtain under cutoff trench.

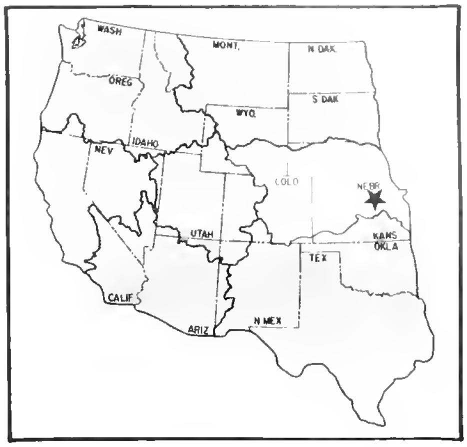


Keyhole Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Kirwin Unit, Solomon Division

Kansas: Phillips, Smith, and Osborne Counties

Lower Missouri Region
Water and Power Resources Service



The Kirwin Unit is located along the North Fork of the Solomon River in the State of Kansas. The unit features include a multiple-purpose dam and reservoir and a canal, lateral, and drainage system used to serve 11,435 irrigable acres. In addition to the irrigation benefits provided by the unit, it protects the downstream area from floods, conserves and enhances fish and wildlife, and provides recreation opportunities.

PLAN

The principal features of the unit consist of Kirwin Dam and Reservoir; Kirwin Main, North, and South Canals; and a lateral system to distribute the water to the unit lands.

Kirwin Dam

Kirwin Dam, on the North Fork of the Solomon River near Kirwin, Kans., was completed in August 1955. The dam is a rolled earthfill structure, with a structural height of 169 feet and a crest length of 12,646 feet. About 9,537,000 cubic yards of earth and rock and 44,000 cubic yards of concrete were used in constructing the dam, spillway, and outlet works. The initial capacity of the reservoir was 314,550 acre-feet; 89,650 for irrigation, 215,115 for flood control, and the remainder for dead storage. A concrete spillway on the right abutment of the dam can discharge 96,000 cubic feet per second of water at the maximum water surface elevation 1773. Fifteen gated sluiceways, discharging through the bottom of the overflow section into the spillway chute, are used primarily to make controlled releases of floodwaters.

The outlet works through the dam acts as a canal and river outlet. Both releases are made from a stilling well located near the downstream side of the dam. The capacity of the canal outlet is 175 cubic feet per second, and the capacity of the river outlet is 100 cubic feet per second.

Canal and Drainage Systems

Kirwin Main Canal begins at the stilling well at the downstream face of the dam and extends 13.4 miles on the north side of the river, where it branches into the Kirwin North and Kirwin South Canals. The initial capacity of the main canal is 175 cubic feet per second. The Kirwin North Canal continues on the north side of the river 14.3 miles and has an initial capacity of 70 cubic feet per second. The Kirwin South Canal crosses the river in a siphon, extends along the south side of the river for 16.3 miles, and has an initial capacity of 60 cubic feet per second.

Laterals extend from all three canals to serve the project lands. These laterals consist of the Kirwin Main, Kirwin North, and Kirwin South, and total approximately 38 miles in length. In addition, there are about 2.5 miles of drains.

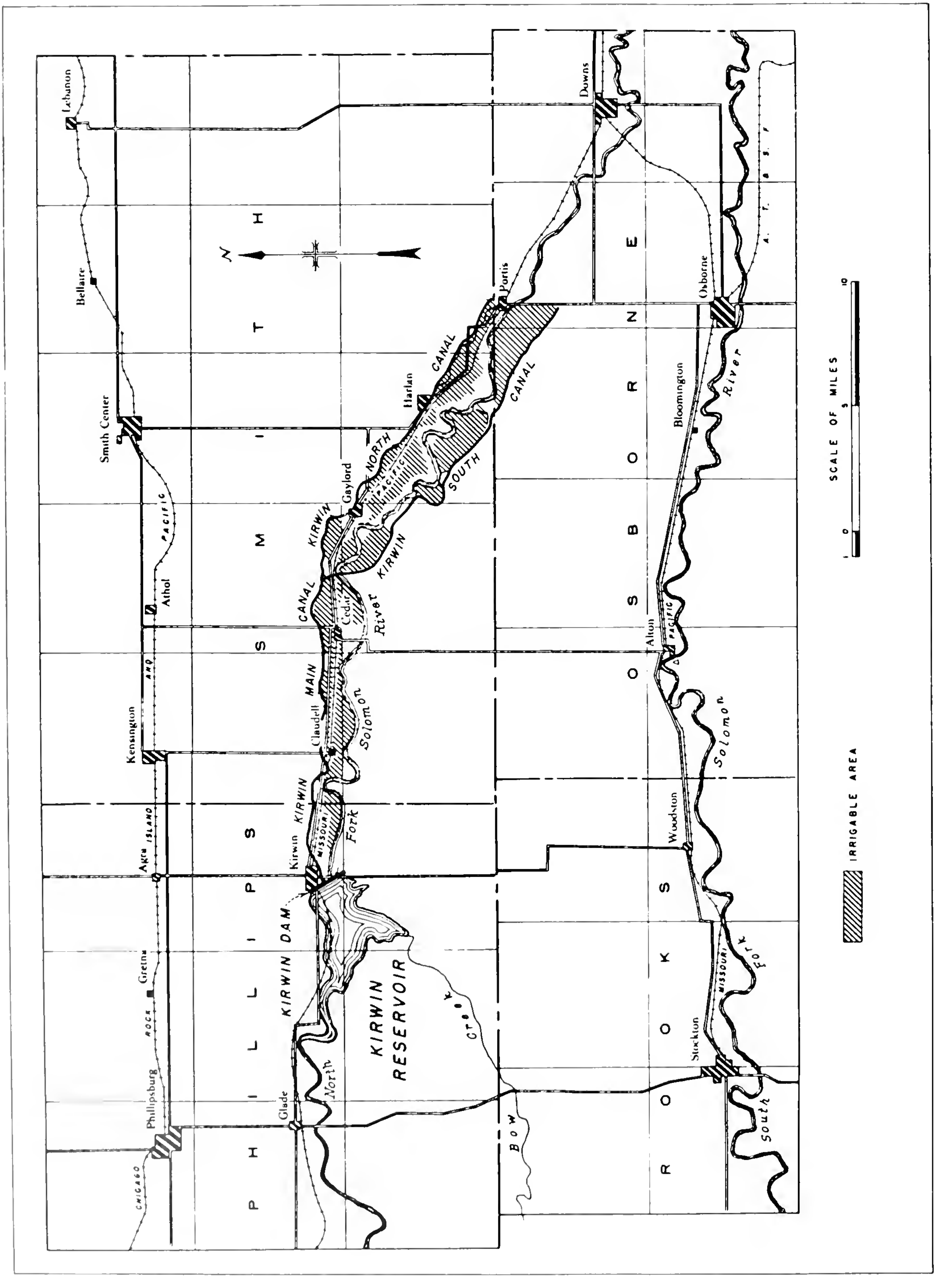
DEVELOPMENT

Early History

In 1879, the central branch of the Union Pacific Railroad was constructed through the valley of the North Fork of the Solomon River to Kirwin and the town became the center of activity during the early days of settlement. The settlers had aspirations for a prosperous and well-developed area. However, because of the frequent droughts that occurred over the years, these hopes were not realized and many of the early homesteads were abandoned. Prolonged droughts of the 1930's and damaging floods focused attention on flood control needs and water conservation. As a result of the investigations by the Bureau of Reclamation and the need for irrigation in the area, Kirwin Irrigation District No. 1 was organized officially in August 1950.

Investigations

Detailed plans for developing the water resources of the unit were initiated soon after construction was authorized by the Flood Control Act of December 1944.


Lebanon
Bellaire
Smith Center
Athol
Kensington
Agra
Gretna
Phillipsburg
Glade
Kirwin
Claudell
Cedar
Gaylord
Harlan
Portis
Downs
Osborne
Bloomington
Alton
Woodston
Stockton
S M I T H
P H I L L I P S
O S B O R N E
R O O K S
KIRWIN DAM
KIRWIN RESERVOIR
KIRWIN MAIN CANAL
NORTH KIRWIN CANAL
SOUTH KIRWIN CANAL
Solomon River
North Fork
MISSOURI
PACIFIC
CHICAGO ROCK ISLAND AND PACIFIC
A. T. & S. F.
Bow Creek
South Fork
N
SCALE OF MILES
0
5
10
IRRIGABLE AREA

Kirwin Unit

Kirwin Dam

After the disastrous Kansas River flood of July 1951, public demand for adequate flood control resulted in appropriations authorized by the Congress for that purpose in the Supplemental Appropriation Act of November 1951. The act directed the immediate construction of Kirwin Dam and Reservoir for flood control, but permitted further study before the irrigation aspects of the unit were begun.

The magnitude of the unprecedented flood of July 1951 demonstrated fully the necessity for further regulation and control of the water resources in the Kansas River Basin and required modification of previous plans for the dam, the most important change being that the capacity of the reservoir for flood control was more than doubled.

Authorization

The unit was authorized by the Flood Control Act of December 22, 1944, Public Law 534.

Construction

Construction of Kirwin Dam started in March 1952 and was completed in August 1955. The Kirwin Main, North, and South Canals were completed in January 1958.

Operating Agency

Kirwin Dam and Reservoir are operated and maintained by the Bureau of Reclamation. Operation of the reservoir is coordinated with that of other reservoirs in the Kansas River Basin. Water in the flood control capacity is regulated in accordance with instructions furnished by the Corps of Engineers.

Operation and maintenance of the canals, laterals, and drains are the responsibility of the irrigation district.

The Bureau of Sport Fisheries and Wildlife administers the water surface and the larger portion of the Kirwin Reservoir lands as the Kirwin National Wildlife Refuge.

BENEFITS

Irrigation

Lands of the unit are highly productive and the growing season is ample for field crops. A wide variety of crops can be grown in this area, but the principal crops are corn, grain sorghum, and alfalfa hay.

Flood Control

Before construction of Kirwin Dam and Reservoir, numerous floods damaged or destroyed valley crops, livestock, and property and contributed to losses far downstream along the mainstem rivers. The flood control capacity provided in Kirwin Reservoir is large enough to completely control the largest flood of record and maintain the outflow at a safe channel capacity. As a result, most of the floodwaters can now be harnessed for beneficial use.

Recreation and Fish and Wildlife

Kirwin Reservoir provides unequaled opportunities for waterfowl management in a semiarid region. The reservoir lies within the Central Flyway and provides a resting and feeding area during spring and fall migrations and winter months. Tens of thousands of migrating [illegible] visit the area each year and include such rare [illegible] the whooping crane, white-fronted goose, and white pelican. Rolling prairie lands and croplands surrounding the reservoir provide excellent habitat for prairie chicken, pheasant, and bobwhite quail.

Many people visit the area each year to watch the migrating birds. Recreational activities such as fishing, boating, swimming, camping, and water skiing are popular. The Kirwin National Wildlife Refuge area includes the reservoir water surface and about 10,700 acres of adjacent publicly owned land.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	11,435	acres
Number of irrigated farms	91	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	9,667	1,197,673
1969	9,554	1,296,575
1970	9,500	1,403,457
1971	9,852	1,441,894
1972	9,165	1,347,608
1973	9,088	2,248,579
1974	9,597	2,582,132
1975	9,410	2,365,720
1976	9,266	2,179,551
1977	9,464	1,772,582

Facilities in Operation

Storage dams	1	
Canals	46.1	mi
Laterals	37.7	mi
Drains	2.4	mi

Climatic Conditions

Annual precipitation	24.2	in
Temperature:		
Maximum	112	°F
Minimum	−22	°F
Mean	54	°F
Growing season	166	days
Elevation of irrigable area	1620.0	ft

Settlement

Number of persons served with project water (1977):		
Farm irrigation service	350	

ENGINEERING DATA

Water Supply

North Fork, Solomon River

Drainage area above Kirwin Dam	1,373	mi^2
Annual discharge at Kirwin Dam:		
Maximum (1951)	288,200	acre-ft
Minimum (1956)	7,600	acre-ft
Average	49,900	acre-ft
Average annual diversion	19,172	acre-ft

Storage Facilities

Kirwin Dam

Type: Zoned earthfill
Location: On the North Fork, Solomon River, near Kirwin, Kans.
Construction period: 1952-55
Date of closure (first storage): March 7, 1955

Reservoir, Kirwin:		
Average annual inflow, 1920-76	49,900	acre-ft
Total capacity to El. 1757.3	314,550	acre-ft
Active capacity, El. 1693.0-1757.3	304,765	acre-ft
Surface area	10,640	acres
Dimensions:		
Structural height	169	ft
Hydraulic height	97.3	ft
Top width	30	ft
Maximum base width	960	ft
Crest length	12,646	ft
Crest elevation	1779.0	ft

Spillway: Uncontrolled concrete crest and concrete-lined chute at right abutment. Fifteen sluiceways, each controlled by one 5-ft-square slide gate, pass through base of spillway crest.

Crest length	400	ft
Crest elevation	1757.3	ft
Capacity at El. 1773	96,000	ft^3/s

Outlet works: Concrete conduit through base of dam near river channel controlled by one 4- by 5-ft slide gate for canal releases. River outlet in 42-in conduit off stilling well controlled by one 36-in sluice gate.

Capacity at El. 1701:		
River outlets	100	ft^3/s
Canal outlets	175	ft^3/s

Foundation: Fractured Niobrara chalk in abutments, Carlisle shale in river channel, overlain up to 100 ft deep with alluvial sand, silt, and clay layers.

Carriage Facilities

Kirwin Main Canal

Location: From Kirwin Dam outlet near Kirwin, Kans., eastward along north side of the Solomon River to vicinity of Cedar, Kans.
Construction period: 1956-57

Length	13.4	mi
Diversion capacity	175	ft^3/s

Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth[4]	4.8	ft
Typical maximum section, compacted earth lining:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth	4.2	ft
Lining thickness:		
On bottom	2	ft
On sides (horizontal)	6	ft

KIRWIN NORTH CANAL

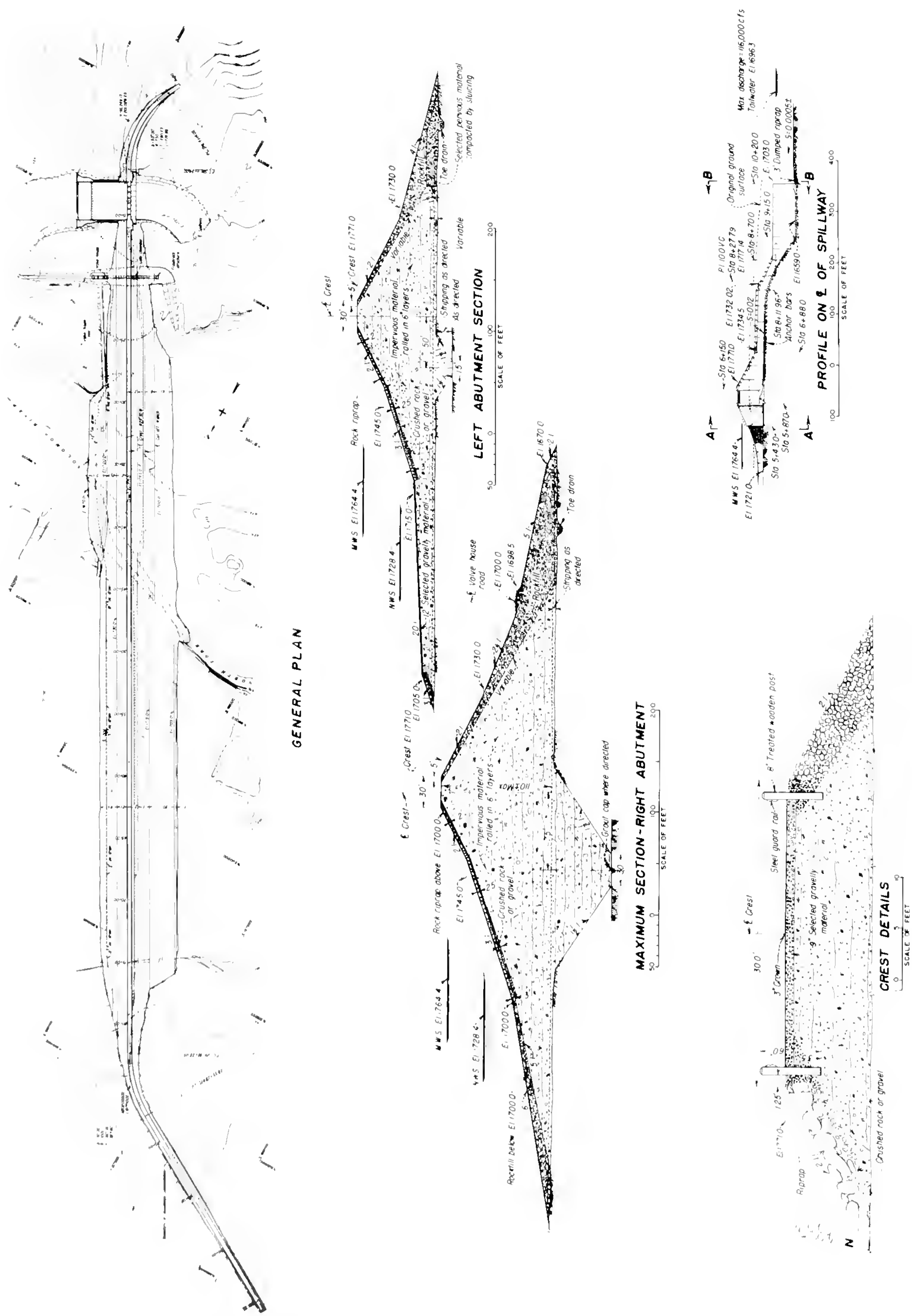
Location: From end of Kirwin Main Canal near Cedar, Kans., generally southeast along north side of the Solomon River to vicinity of Portis, Kans.

Construction period: 1956-57		
Length	14.3	mi
Diversion capacity	70	ft^3/s
Typical maximum section in earth:		
Bottom width	9	ft
Side slopes	1.5:1	
Water depth	4	ft
Typical maximum section, compacted earth lining:		
Bottom width	9	ft
Side slopes	1.5:1	
Water depth	2.9	ft
Lining thickness:		
On bottom	1.5	ft
On sides (horizontal)	4	ft

KIRWIN SOUTH CANAL

Location: From Kirwin Main Canal near Cedar, Kans., across the Solomon River and southeast along the south side of the river to vicinity of Portis, Kans.

Construction period: 1957-58		
Length	16.3	mi
Diversion capacity	60	ft^3/s
Typical maximum section in earth:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	2.7	ft
Typical maximum section, compacted earth lining:		
Bottom width	6	ft
Side slopes	2:1	
Water depth	2.55	ft
Lining thickness:		
On bottom	1.5	ft
On sides (horizontal)	4	ft

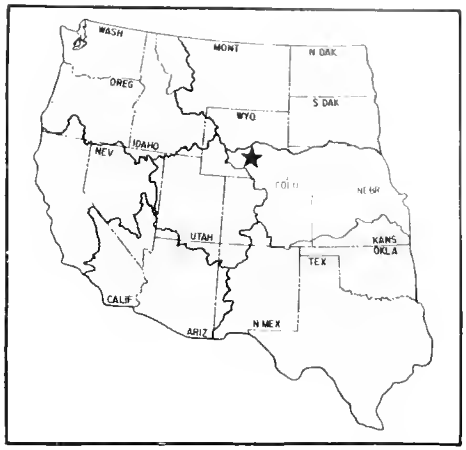


Kirwin Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Kortes Unit, Oregon Trail Division

Wyoming: Carbon County

Lower Missouri Region
Water and Power Resources Service



The Kortes Unit, consisting of Kortes Dam, Reservoir, and Powerplant, is in central Wyoming in a narrow gorge of the North Platte River 2 miles below Seminoe Dam in the Kendrick Project, and about 60 miles southwest of Casper, Wyo. It was the first unit initiated by the Bureau of Reclamation under the Missouri River Basin Project. The 36,000-kilowatt powerplant generates more than 140 million kilowatt-hours annually.

Kortes Dam and Powerplant

PLAN

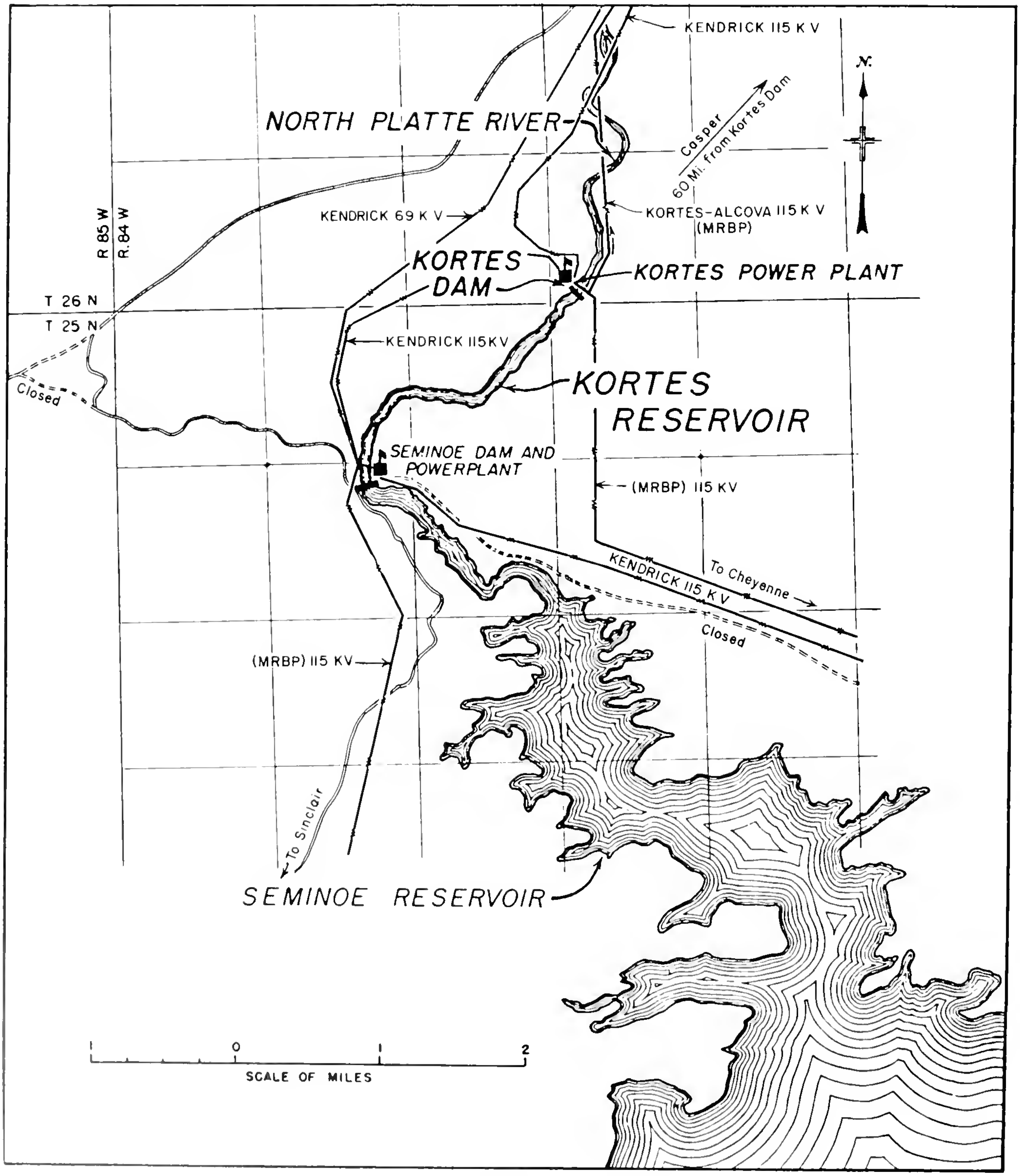
Water released from Seminoe Dam to Pathfinder Reservoir passes through the Kortes turbines to generate power, which is distributed by the Government-owned interconnected transmission system to localities in the intermountain and Great Plains areas.

The small reservoir storage at Kortes influenced plans for plant operation. Maximum benefits are obtained when the Kortes Reservoir remains full and the power releases are coordinated with those from the Seminoe plant to maintain a full reservoir. The Seminoe facilities operate both plants with remote-control apparatus.

Kortes Dam

Kortes Dam is constructed in the 1,000-foot gorge of the Black Canyon on the North Platte River. The level of water in Kortes Reservoir controls the tailwater elevation of Seminoe Powerplant. The dam is constructed at the optimum location to develop the most head between Seminoe tailwater and Pathfinder high water surface elevation. About 200 of the 300 feet available are used. The concrete gravity structure has a maximum height above foundation rock of 244 feet and contains 147,000 cubic yards of concrete.

The 83-acre Kortes Reservoir is confined to the narrow canyon and provides storage for only 4,700 acre-feet of water. Other principal features include a 50,000-cubic-foot-per-second uncontrolled spillway through the right abutment, a switchyard on the top of the dam, and transmission taplines to the canyon rim.



KENDRICK 115 K V
N.
NORTH PLATTE RIVER
Casper
60 Mi. from Kortes Dam
KENDRICK 69 K V
KORTES-ALCOVA 115 K V
(MRBP)
R 85 W
R. 84 W
KORTES
DAM
KORTES POWER PLANT
T 26 N
T 25 N
KENDRICK 115KV
KORTES
RESERVOIR
Closed
SEMINOE DAM AND
POWERPLANT
(MRBP) 115 KV
KENDRICK 115 K V
To Cheyenne
Closed
(MRBP) 115 KV
To Sinclair
SEMINOE RESERVOIR
1 0 1 2
SCALE OF MILES

Kortes Unit

The reinforced-concrete powerhouse occupies the entire width of the canyon at the toe of the dam. The plant has three 18,500-horsepower Francis-type turbines and three 12,000-kilowatt generators.

DEVELOPMENT

Early History

The North Platte River valley served as a route to the unsettled West for explorers and traders and for emigrants in search of home sites. The Oregon, California, Mormon, Pony Express, and Overland Trails followed the North Platte and Sweetwater Rivers and crossed the Continental Divide at South Pass.

There were numerous trading posts, army forts, and stage stations located along these trails. Fort Laramie, Fort Steele, and Fort Caspar have been restored for their historic value. Settlement in the valley began in the early 1880's. The first irrigation systems were constructed without large storage reservoirs. Kortes Dam is named after the Kortes Ranch, 2 miles downstream from the present dam location.

Investigations

Investigations for development of a dam and reservoir at the Kortes site were conducted intermittently after 1933. Based on information obtained during these investigations, the Kortes Unit was included in Senate Document 191.

Authorization

Kortes power development was found feasible by the Secretary of the Interior as a supplement to the Kendrick Project on November 26, 1941, but it was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Documents 191 and 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of Kortes Dam was started in 1946 and completed in 1951. Because of the enormous increase in power demands in the area and power sales commitments, an accelerated power program was developed which consisted of erecting generating equipment and machinery concurrently with the dam and powerhouse construction, placing the generators into service before the powerhouse was completed, construction of temporary transmission facilities, and providing temporary protection for the operating equipment during the construction period.

As a result of this program, two units were placed into service 6 months before the completion of the powerhouse and the dam and 6 months earlier than they would have been without this accelerated program.

Operating Agency

The Bureau of Reclamation operates and maintains the dam and powerplant.

BENEFITS

Hydroelectric Power

Hydroelectric power from the Kortes Unit is distributed over high-voltage lines for distribution by municipalities, Rural Electric Associations, and private utilities to the consumers.

Recreation

The Kortes Reservoir receives limited recreational use since Kortes Dam and the steep shoreline restrict access in general to the North Platte River immediately below Seminoe Dam. Trout fishing is the main recreational activity at the reservoir. Senate Bill 2553 was passed in the 90th Congress authorizing the modification of the operation of Kortes Reservoir to provide a minimum streamflow of 500 cubic feet per second in the North Platte River between Kortes Reservoir and the normal headwaters of Pathfinder Reservoir. The minimum flow permits maintenance of a fishery in a stretch of the North Platte River, commonly referred to as the "Miracle Mile."

PROJECT DATA

Facilities in Operation

Storage dam	1
Powerplant	1
Transmission lines [1]	
Substation	1

[1] Transmission system partly Kendrick Project and partly Pick-Sloan Missouri Basin Program Transmission Division, which were transferred to the Western Area Power Administration, Department of Energy.

Power Generation

Fiscal Year	Kortes Powerplant (kWh)
1968	119,370,000
1969	148,555,000
1970	175,113,000
1971	240,395,000
1972	157,858,000
1973	171,125,000
1974	224,121,000
1975	174,329,000
1976	159,042,000
1977	111,240,000

ENGINEERING DATA

Water Supply

NORTH PLATTE RIVER

(See Kendrick Project for streamflow data.)

Storage Facilities

KORTES DAM

Type: Concrete gravity
Location: On the North Platte River 60 mi southwest of Casper, Wyo.
Construction period: 1946-51
Date of closure (first storage): February 6, 1950
Reservoir, Kortes:
Average annual inflow: Releases from Seminoe Reservoir.

Total capacity to El. 6142	4,760	acre-ft
Active capacity	4,600	acre-ft
Surface area	83	acres
Dimensions:		
Structural height	244	ft
Hydraulic height	200	ft
Crest width	24	ft
Maximum base width	193	ft
Crest length	440	ft
Crest elevation	6169.0	ft
Total volume	147,000	yd^3

Spillway: Uncontrolled concrete crest and concrete-lined tunnel in right abutment.

Crest length	118	ft
Crest elevation	6142.0	ft
Capacity at El. 6165.7	50,000	ft^3/s

Outlet works: Three 108-in-diameter steel penstocks sloping through dam to powerhouse, each controlled by one 96-in ring-follower gate.
Foundation: Relatively fresh, unweathered, high-quality granite, complexly fractured, with prominent sheeted and jointed zones, in many of which the granite has altered to clay.
Special treatment: Cement grout blanket and curtain under upstream toe of dam.
Mass concrete: Natural aggregate from deposit 4 mi downstream; oversize crushed. Type II (low alkali) cement; temperature control by circulating river water through embedded pipe system below El. 6065.

Volume	147,000	yd^3
Maximum size aggregate	6.5	in
Average net water-cement ratio (by weight):		
Exterior concrete	0.52	
Interior concrete	0.60	
Cement content:		
Exterior concrete	0.91	bbl/yd^3
Interior concrete	0.81	bbl/yd^3

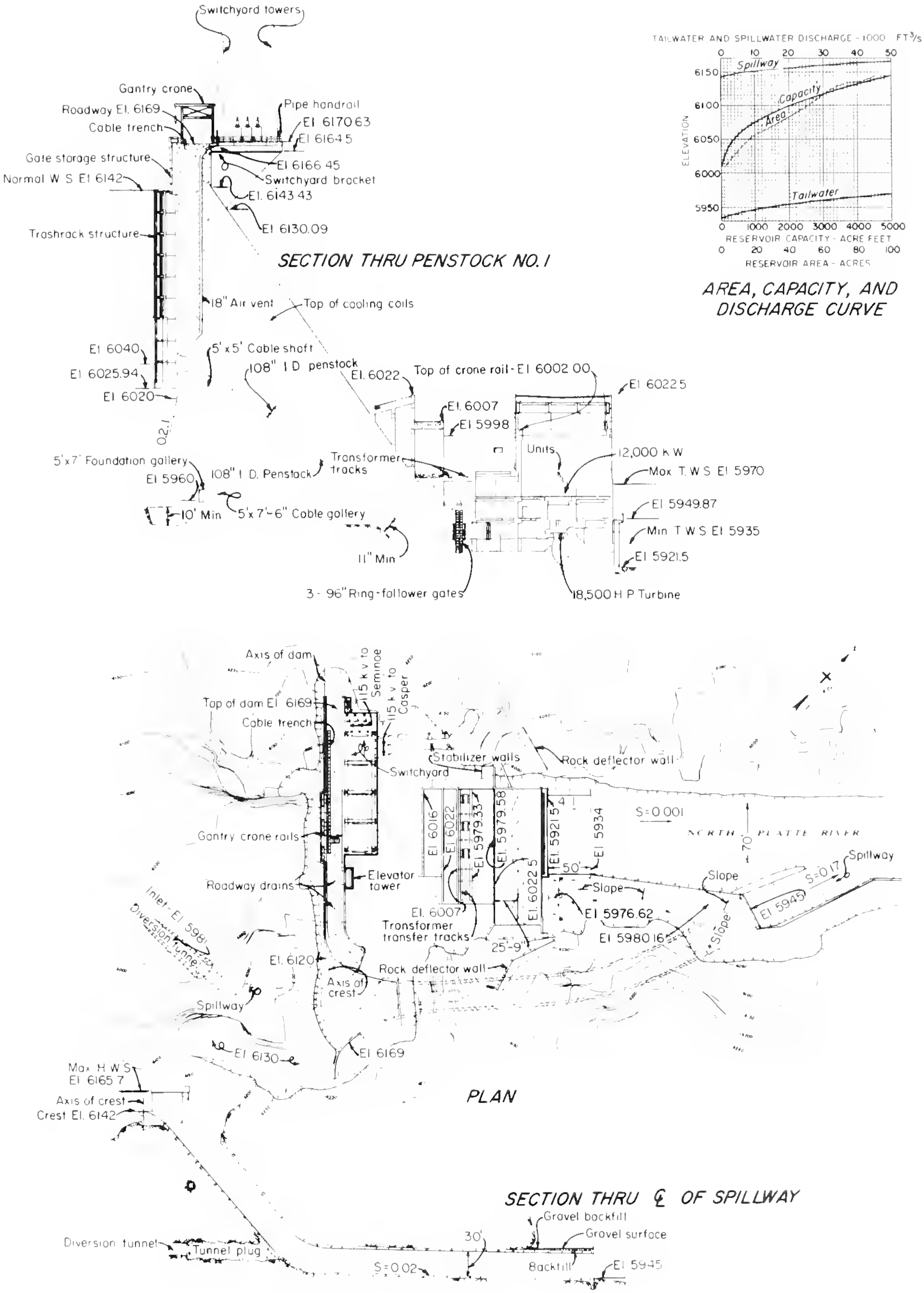
Contraction joints: Transverse joints 64 ft apart, grouted after cooling.

Power Facilities

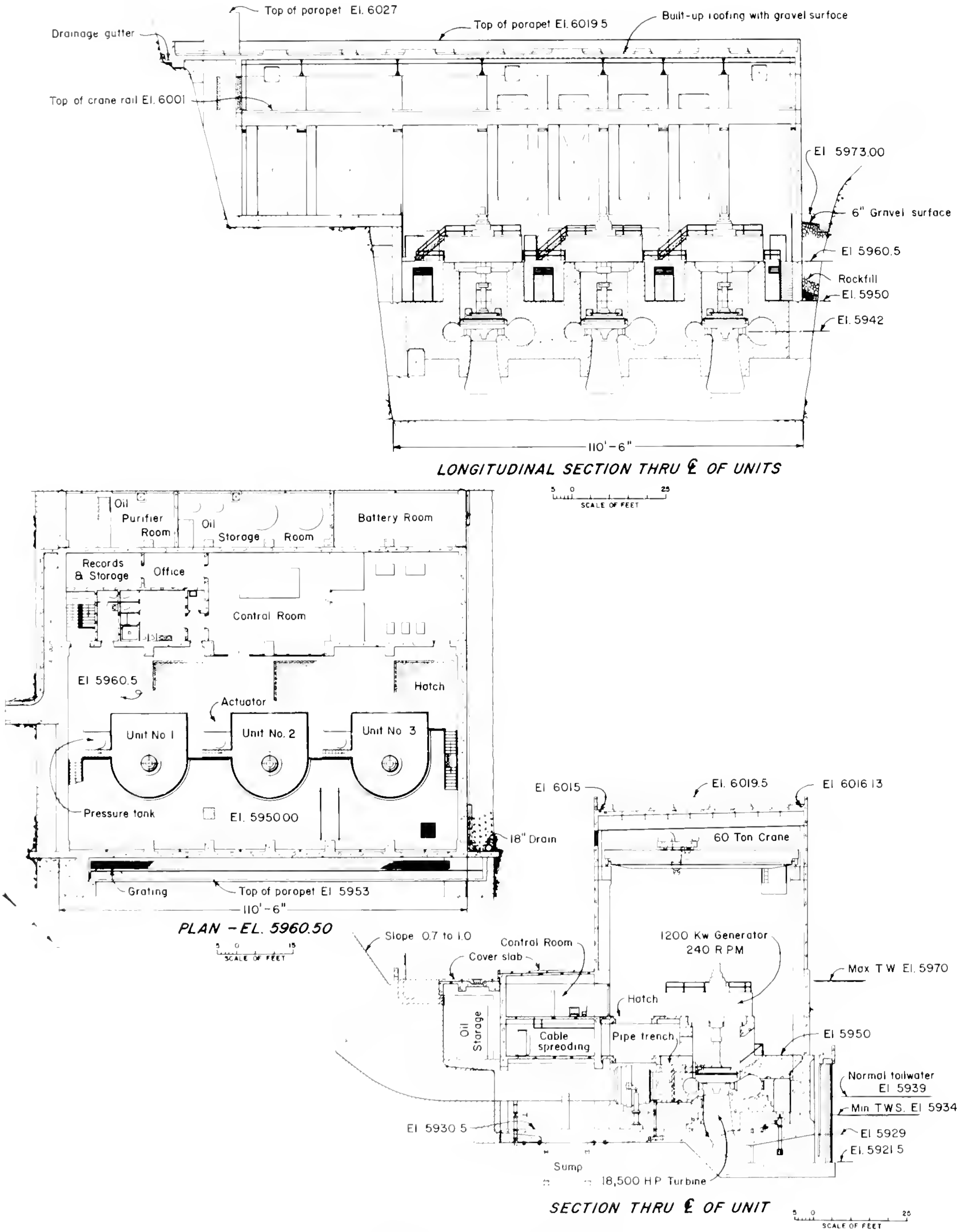
KORTES POWERPLANT

Location: Kortes Dam
Year of initial operation: 1950
Year last generator placed in operation: 1951

Nameplate capacity	36,000	kW
Number and capacity of generators (3)	12,000	kW
Maximum head	207	ft



Kortes Dam and Powerplant, Plan and Sections

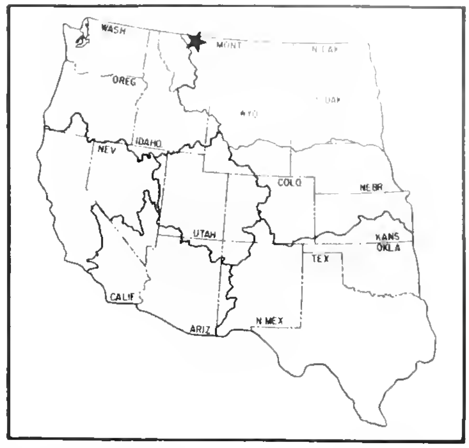


Kortes Powerplant, Plan and Sections

Pick-Sloan Missouri Basin Program
Lower Marias Unit

Montana: Liberty and Toole Counties

Upper Missouri Region
Water and Power Resources Service



The Lower Marias Unit is in north-central Montana along the Marias River. The unit has an adequate supply of irrigation water to irrigate 127,000 acres of land and also will control floods to make possible the multiple-purpose use of Fort Peck Reservoir.

Tiber Dam and Dike and Lake Elwell have been constructed. The irrigation features were not included because the irrigation district did not negotiate a repayment contract with the United States and those features are no longer part of the Lower Marias Unit.

PLAN

Since completion in 1956, Tiber Dam and Lake Elwell have served important functions in flood control, recreation, fish and wildlife, and municipal and industrial water supplies.

A minimum flow will be maintained in the river below Lake Elwell to meet downstream demands, such as stock water and support of fish and wildlife, and other downstream water rights.

The 400,838-acre-foot capacity to be allocated exclusively to flood control in Lake Elwell will regulate the Marias River and assist in flood control of the Missouri River. Sufficient dead storage will be available in Lake Elwell to impound the entire siltload of the river for several hundred years.

Municipal and domestic water from Lake Elwell is being contracted for by the city of Chester, the Tiber County Water District, and Devon Water Inc.

Tiber Dam

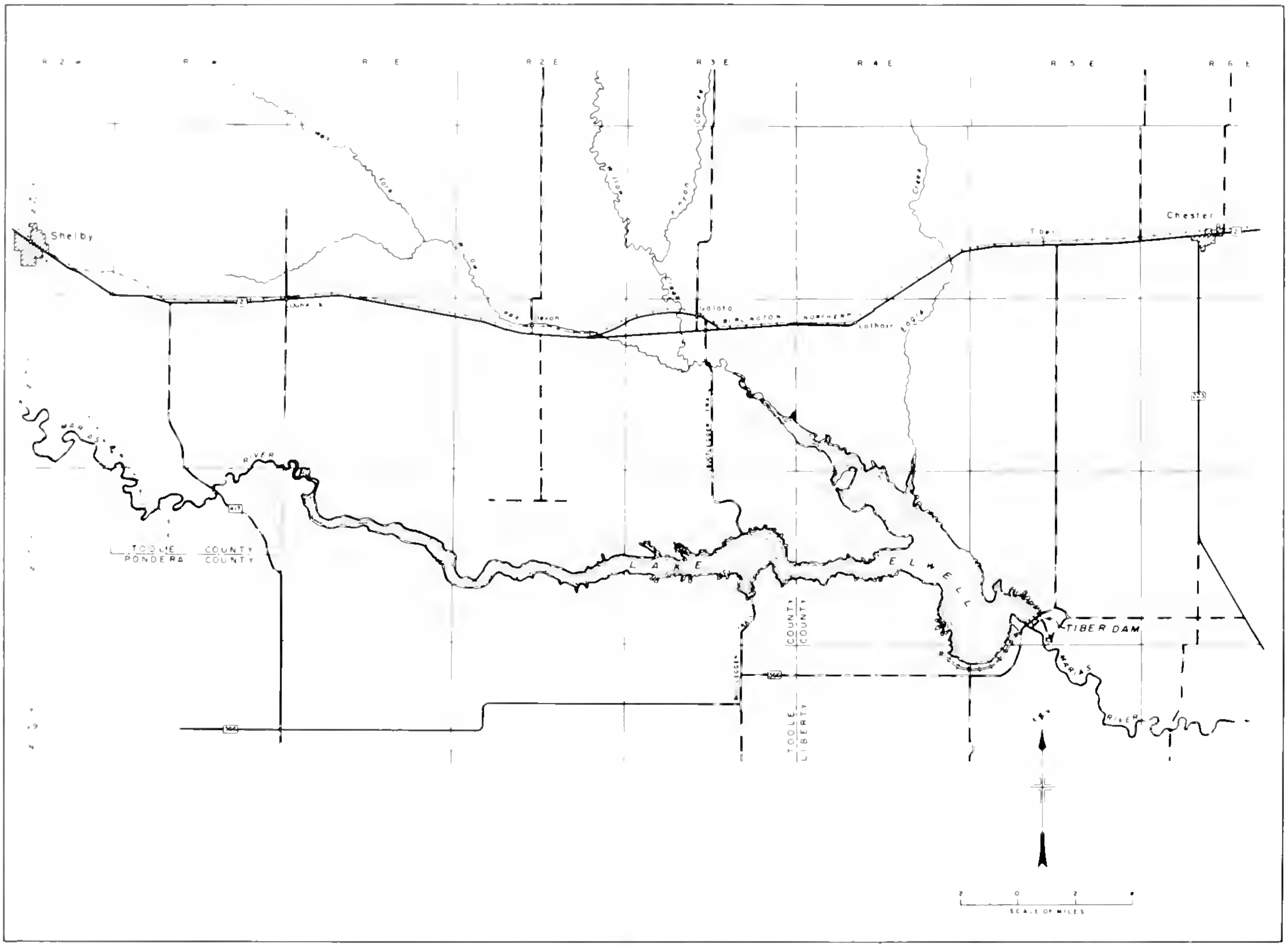
Tiber Dam is a zoned earthfill structure containing 11,485,000 cubic yards of embankment materials. The dam has a crest length of 4,526 feet and a structural height of 206 feet. A 14-foot-diameter concrete-lined tunnel which was used for river diversion during construction serves as a river outlet. An earthfill dike closes a saddle on the south rim of the reservoir near the dam. It contains 2,340,000 cubic yards of embankment. This dike is 16,650 feet in length and has a maximum height of 56.3 feet. Following dam modification, the dam and dike will be 5 feet higher. The auxiliary outlet works, at the left abutment of the dam, is controlled by a 7.25- by 9.25-foot outlet gate with a capacity of 4,240 cubic feet per second and discharges into a 10.75-foot-diameter concrete-lined tunnel. Lake Elwell has a storage capacity of 1,368,158 acre-feet; 389,695 acre-feet of this storage will be allocated to active conservation, and 400,838 acre-feet to exclusive flood control.

Settlement of the crest section of Tiber Dam spillway began following initial filling of the reservoir in 1956. The rate of settlement was alarming following the flood of 1964 and the heavy runoff of 1965. This settlement was attributed to a weakness of the underlying shale formation in which small lenses of gypsum were slowly being dissolved as water passed through the shale. Measures to protect the structure were approved by the Congress and construction initiated in 1967. This work, completed in 1970, consisted of modifying the canal outlet works for use as an auxiliary outlet works and closing the entrance channel of the spillway by a temporary earthfill cofferdam. To accommodate these changed conditions, revised operating criteria were established for the reservoir and active capacity was eliminated. Work on modification of the spillway to restore the active conservation capacity was begun in 1976.

DEVELOPMENT

Early History

In 1846, the American Fur Company established headquarters on the site which is now Fort Benton, about 35 miles southeast of Tiber Dam. It served as a terminus of river traffic from St. Louis, Mo., during the 1860's and 1870's. Stockraising began in the 1880's and large cattle companies predominated until the drought of 1903. Public lands suitable for agriculture were homesteaded



Lower Marias Unit

tracts of 160 to 320 acres between 1908 and 1914. From 1917 to 1920, drought prevailed and many farms were abandoned. This gradually resulted in increased size of farm operations until the average dryland farm unit of today consists of more than 1,600 acres.

Investigations

The first investigation of the area which is now within the Lower Marias Unit was started in 1903 by the Reclamation Service. The surveys disclosed that a potential irrigation project could use the Marias River water for irrigation of lands lying between that river and Big Sandy Creek. The plan centered on a damsite near the Liberty-Hill County line.

Investigations and studies of the irrigation potential were numerous, but no action was taken on these early proposals until in 1930 when local interest reached a new high because of the drought. The Montana State Water Conservation Board reviewed the previous studies and issued a report in 1935. In 1937, a committee was formed to promote development of Marias water resources. As a result of the committee's action, an exhaustive survey of the project possibilities was made by the Bureau of Reclamation and a report was released in 1939.

In the further investigations which covered the entire river system, all possible damsites were compared and pumping projects were considered. The Lower Marias Unit with Tiber Dam and Lake Elwell was selected as the most desirable plan of development because of the relative need of the local area and its important relationship to the overall Missouri River Basin Program (now Pick-Sloan Missouri Basin Program). During 1940-41, the recorded flow of the Marias River reached an alltime low, limiting to 110,000 acres the land that could be irrigated by initial storage of the Marias River runoff. The studies were completed in 1941 and the plan selected for the Lower Marias Unit was presented in an unpublished report dated April 1944.

Authorization

The unit was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the

Tiber Dam and Lake Elwell

general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session. Additional appropriations were approved August 10, 1972, by Public Law 92-371, 86 Stat. 525.

Construction

Construction of Tiber Dam began September 15, 1952, and was completed March 6, 1956. The final river closure was made on October 27, 1954. Construction of the auxiliary outlet works and spillway cofferdam was begun in December 1967 and completed in June 1969. Construction on the spillway modification was begun in December 1976.

Operating Agency

The Bureau of Reclamation is the operating agency.

BENEFITS

Irrigation

Three private irrigators are pumping water from Lake Elwell through temporary facilities under 1-year contracts. The total acreage irrigated in 1977 was about 400 acres.

Flood Control

Lake Elwell, in addition to contributing to the abatement of floods on the Marias River, makes possible greater utilization of Fort Peck Reservoir on the Missouri River and provides regulation of the Marias River to meet downstream demands for fish and wildlife, irrigation, and silt control.

Municipal and Domestic Water

The city of Chester has a contract for withdrawal of up to 500 acre-feet of water annually. The Tiber County Water District has a 40-year contract for use of up to 1,540 acre-feet annually. Devon Water Inc. also has a 40-year contract for use of up to 70 acre-feet annually.

Recreation

Lake Elwell has been planted with rainbow trout. Picnicking, swimming, boating, fishing, and hunting are popular sports. Public-use areas with minimum facilities are available; sites also are available for vacation homes and for group camps. The recreational use at the unit in 1977 amounted to 23,400 visitor days.

PROJECT DATA

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	12.8	in
Temperature:		
Maximum	111	°F
Minimum	−51	°F
Mean	44	°F
Growing season	130	days
Elevation of irrigable area	2800-2935.0	ft

ENGINEERING DATA

Water Supply

MARIAS RIVER

Drainage area above Tiber Dam	4,375	mi²
Annual discharge at Tiber Dam:		
Maximum (1959)	1,076,800	acre-ft
Minimum (1956)	138,000	acre-ft
Average	661,400	acre-ft

Storage Facilities

TIBER DAM AND DIKE

Type: Zoned earthfill. (Dike closes low saddle beginning about 1 mi southwest of the right abutment of the dam.)
Location: On the Marias River about 13 mi south of Tiber, Mont.
Construction period: 1952-56
Date of closure (first storage): October 27, 1954

Reservoir, Lake Elwell:

Total capacity to El. 3012.5[1]	1,368,158	acre-ft
Inactive and dead storage, streambed to El. 2966.4[1]	577,625	acre-ft
Active conservation, El. 2966.4 to 2993[1]	389,695	acre-ft
Exclusive flood control, El. 2993 to 3012.5[1]	400,838	acre-ft
Surface area, El. 3005.5	21,300	acres

Dimensions:	*Dam*	*Dike*
Structural height	206 ft	56.3 ft
Hydraulic height	189 ft	Offstream
Top width	30 ft	25 ft
Maximum base width	1,300 ft	310 ft
Crest length	4,526 ft	16,650 ft
Crest elevation	3026.0 ft	3026.0 ft
Total volume	11,485,000 yd³	2,340,000 yd³

Spillway: Concrete crest and concrete-lined open channel at right abutment of dam controlled by three 22- by 38-ft radial gates.[1]

Elevation top of gates	3012.5	ft
Crest elevation	2975.0	ft
Capacity at El. 3020.2	68,470	ft³/s

Outlet works:
River: Concrete-lined tunnel through right abutment containing two discharge pipes, 72- and 22-in diameter, controlled by one 5-ft-square high-pressure gate and one 24-in gate valve in the gate chamber, respectively. Flow is regulated by one 18-in butterfly valve and one 5-ft-square high-pressure gate downstream from the gate chamber.

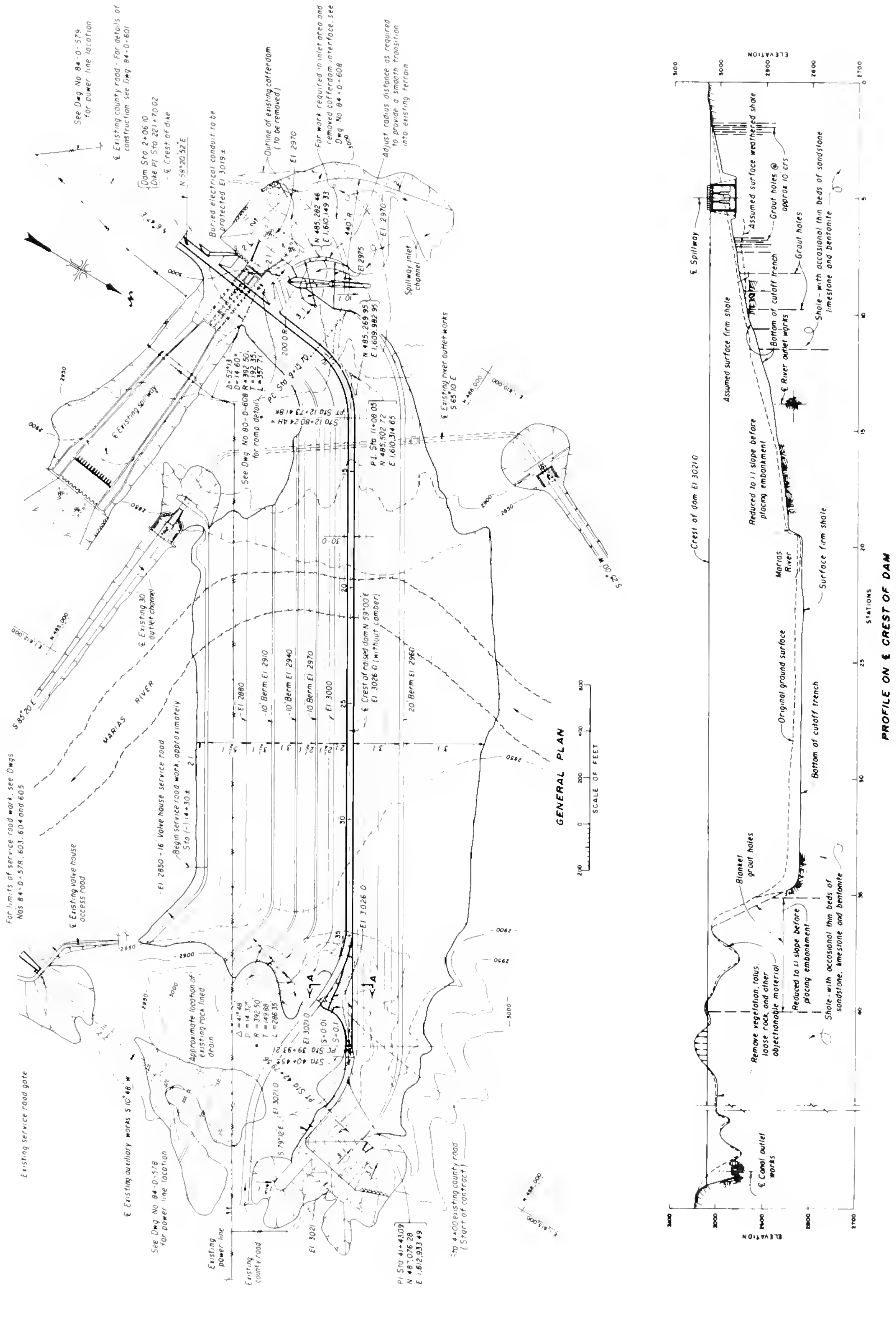
Capacity of 72-in pipe at El. 3020.2	1,540	ft³/s
Capacity of 22-in pipe at El. 3020.2	65	ft³/s

Auxiliary outlet works: Concrete-lined tunnel through left abutment controlled by a 7.25-by 9.25-ft outlet gate.

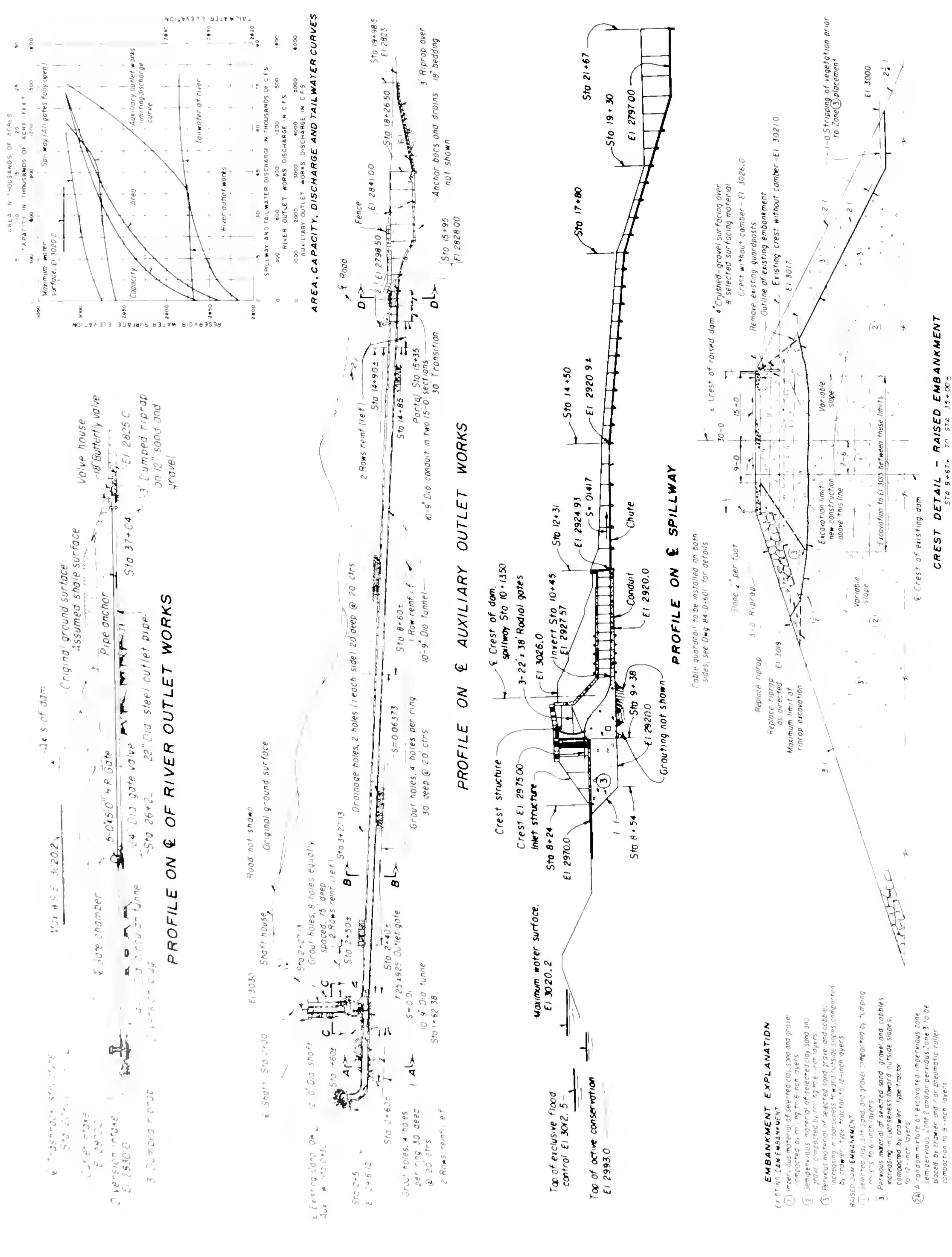
Capacity at El. 3020.2	4,240	ft³/s

[1]A cofferdam protects the spillway while it is undergoing rehabilitation. Storage allocation shown will be effective after completion of dam and spillway.

Tiber Dam spillway rehabilitation



Tiber Dam, Plan

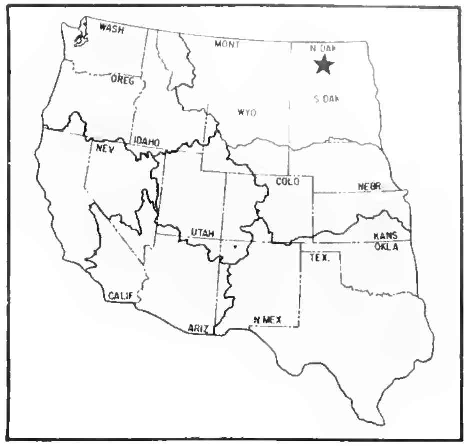


Tiber Dam, Sections

Pick-Sloan Missouri Basin Program
Minot Extension, Garrison Diversion Unit

North Dakota: Ward County

Upper Missouri Region
Water and Power Resources Service



The Minot Extension of the Garrison Diversion Unit is located east of the Souris River in Ward County of north-central North Dakota.

The original plan, as presented in the feasibility report of July 1969, proposed that initial water for Minot, N. Dak., be obtained by construction of storage and conveyance facilities from the Velva Canal of the Garrison Diversion Unit. This plan was modified by the supplemental report of March 1970 to construct ground-water conveyance facilities utilizing the Sundre Aquifer near the city until water is available from the Garrison Diversion Unit.

PLAN

The extension will provide 25,890 acre-feet of municipal and industrial water annually to the city in a two-phase development. The completed first phase uses the Sundre Aquifer near Minot, and supplies 4,150 acre-feet of water. The city developed the Sundre Aquifer by constructing wells, installing well pumps, constructing a collection system, and making arrangements for transmitting electric power to the well pumps and the Sundre Pumping Plant. Water is delivered from the wells to a buried concrete forebay regulating tank with a capacity of 3,210 cubic feet at the Sundre Pumping Plant. This forebay regulating tank is the beginning of the Federal project. Federal features include the 3.9-mile Sundre Pipeline and the 3.6-mile Minot Pipeline. The pipelines convey water from the forebay regulating tank to the city's water treatment plant. A maximum of 802,000 cubic feet per day can be delivered.

The second phase will divert 21,470 acre-feet of Missouri River water through the Garrison Diversion Unit facilities by year 2020 to meet long-term municipal and industrial water needs and for fish and wildlife enhancement and recreation purposes. Principal supply works would include two pumping plants lifting water from Velva Canal through a pipeline to a regulating reservoir on Livingston Creek. From the reservoir, water would be conveyed by the Minot Pipeline to the city's water treatment plant.

Sundre Pipeline

The Sundre Pipeline consists of 635 feet of 24-inch, 19,795 feet of 27-inch, and 75 feet of 30-inch pipe. The pipeline lies between the forebay located southeast of the city and the line's junction with the Minot Pipeline east of the city.

Minot Pipeline

The Minot Pipeline has 18,970 feet of 48-inch pipeline. It transports water from its junction with the Sundre Pipeline to the city's water treatment plant located southwest of the city of Minot.

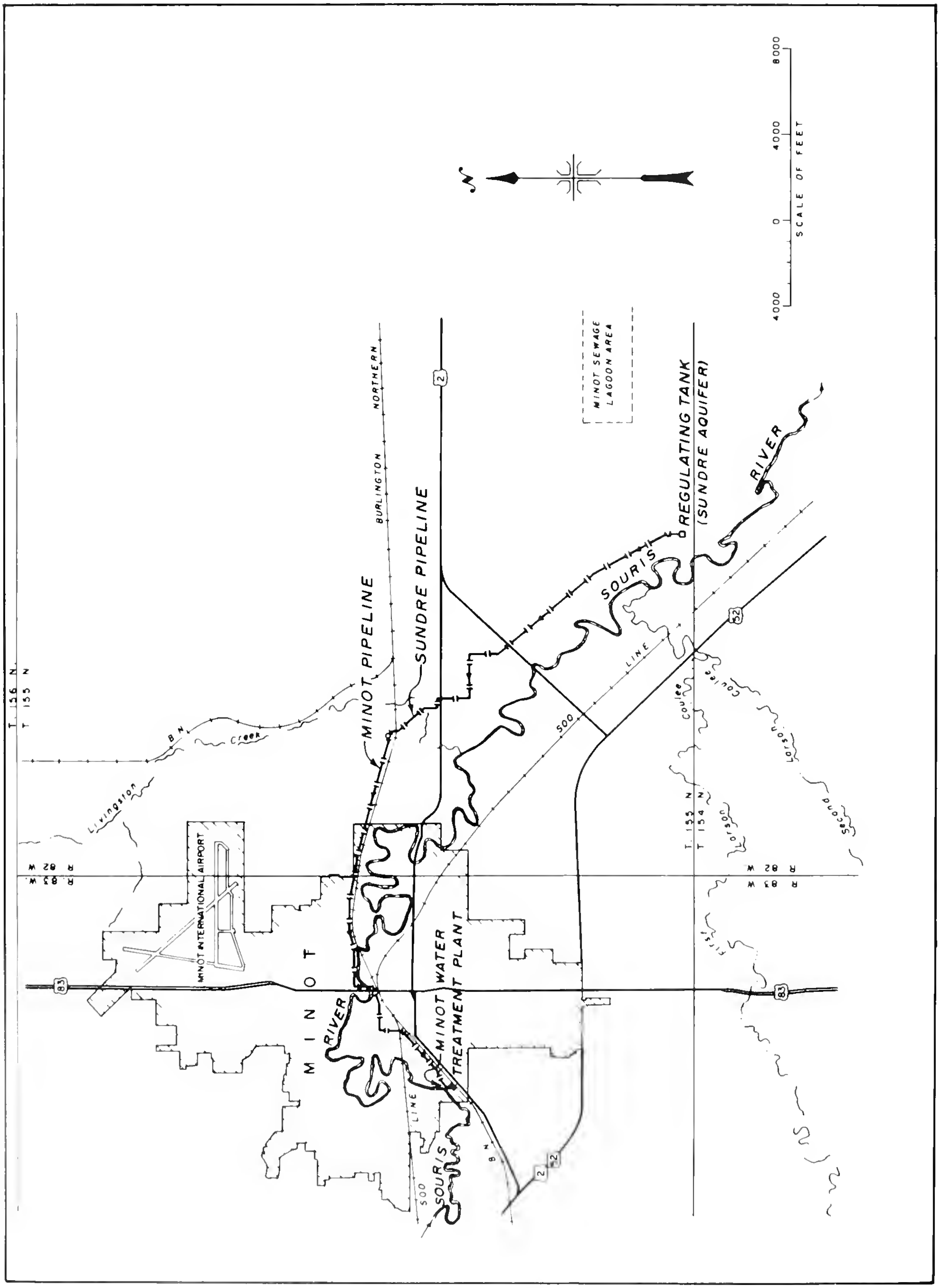
DEVELOPMENT

Early History

Minot's origin and early growth can be attributed mainly to the extension of the Great Northern Railroad through the area. The townsite was selected by railroad officials when the tracks reached the Souris River in 1886. The city was incorporated in 1887 and when Ward County was established in 1888, Minot became the county seat.

Minot was a division point for the Great Northern Railroad and, when the Surrey cutoff from Fargo to Minot was completed in 1912, it became the main Great Northern station in North Dakota. The Soo Line Railroad was constructed into Minot in 1893.

Minot was called the "Magic City" because of its phenomenal growth to a population of 5,000 during its first year of incorporation. Completion of major railroad construction in the area along with a severe drought and locust invasion resulted in a population decrease to 1,277 in 1900, but the city began growing rapidly again after the turn of the century. The population in 1977 was about 34,000, making it the fourth largest city in North Dakota.



Minot Extension, Garrison Diversion Unit

Minot Pipeline

Investigations

In the late 1940's, when the Bureau of Reclamation was considering diversion of water from the Missouri River for irrigation in the Souris and adjacent river basins, the city began focusing attention on obtaining water from the potential project. Meanwhile, studies continued on locating ground-water aquifers, methods of recharging a developed aquifer, and possibilities of obtaining more water from the Souris River.

A consulting firm was hired in 1959 by the city to study potential sources of water. The firm studied pumping from the Missouri River (Lake Sakakawea) and the development of ground water from known aquifers within a radius of 8 miles from the city. Of these two plans, the plan for pumping from the Missouri River was determined by the consultant to be the better source to meet long-term requirements. However, the city did not construct the proposed plan.

In 1965, the Corps of Engineers conducted a review survey of the Souris River and its flood control aspects. Conclusions were that potential reservoir sites on Souris River and its tributaries would adequately serve a flood control function but that the city's requirements for municipal and industrial water could best be met by importing water from the Missouri River.

In 1966, the city of Minot proposed that facilities necessary to supply its water requirements be constructed as a part of the Garrison Diversion Unit. With support of the Garrison Diversion Conservancy District, the North Dakota State Water Commission, and the North Dakota congressional delegation, the city was instrumental in obtaining a write-in of funds in the Public Works Appropriation Act, 1967, for a reconnaissance study of the proposal. The study was completed in June 1967.

This led to the feasibility investigation which was begun in February 1968. Funding was obtained by a write-in requested by the North Dakota congressional delegation. Field surveys were completed in the fall of 1968 and the study was completed in May 1969.

Authorization

The Minot Extension was authorized by Public Law 91-415 dated September 25, 1970.

Construction

Sundre Pipeline was begun April 1973 and completed in September 1974. Minot Pipeline was begun in May 1973 and completed in October 1975.

Operating Agency

Operation and maintenance are performed by the city of Minot.

BENEFITS

Municipal and Industrial Water

Municipal and industrial water is supplied to the city of Minot.

PROJECT DATA

Facilities in Operation

Pipelines	7	mi

Climatic Conditions

Annual precipitation	17.4	in
Temperature:		
Maximum	104	°F
Minimum	−34	°F
Mean	40	°F

Settlement

Number of persons served with project water (1977):

Supplemental municipal water service	32,790

ENGINEERING DATA

Carriage Facilities

Sundre Pipeline

Location: From buried forebay tank north of the Sundre Aquifer northwest to tie with Minot pipeline.
Construction period: 1973-74

Length	3.9	mi
Diameter	24, 27, and 30	in
Capacity	9.3	ft^3/s

Description: Reinforced plastic mortar pressure pipe

Minot Pipeline

Location: From the tie with Sundre pipeline west to the treatment plant.
Construction period: 1973-75

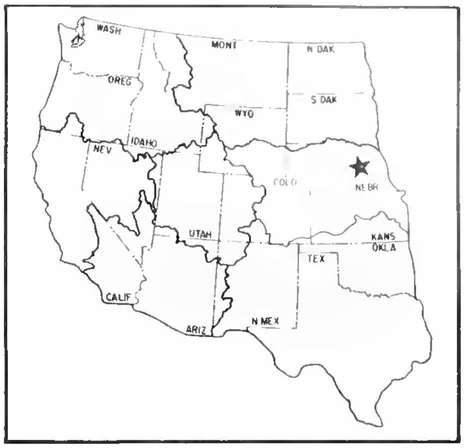
Length	3.6	mi
Diameter	48	in
Capacity	75	ft^3/s

Description: Reinforced plastic mortar pressure pipe. The river crossing section is 48-in-diameter prestressed concrete cylinder pipe.

Pick-Sloan Missouri Basin Program
North Loup Division (Authorized)

Nebraska: Loup, Garfield, Valley, Greeley, Howard, Merrick, and Nance Counties

Lower Missouri Region
Water and Power Resources Service



The authorized North Loup Division will be located within the Loup River drainage basin in central Nebraska. Diversion facilities will be on the Calamus and North Loup Rivers. The plan provides for direct surface water service to 53,000 acres of land. Operation of the division will provide a sustained ground-water supply for the development of an additional 17,000 acres by private investment. Of the 70,000 acres benefiting from project development, 43,500 are considered to be nonirrigated and 26,500 are considered to be irrigated. The Twin Loups Reclamation District and the Twin Loups Irrigation District will benefit from and pay for the irrigation facilities. In addition to irrigation, the division will include recreation and fish and wildlife benefits.

PLAN

Principal features of the division will include Calamus Dam and Reservoir, Kent Diversion Dam, Davis Creek Dam and Reservoir, five principal canals, one major and several small pumping plants, and laterals. Provisions for necessary surface and subsurface drainage systems also are included in the plan. Recreation enhancement facilities are included; however, no features for fish and wildlife enhancement are incorporated in the present plan.

The lengths and capacities of the canals and laterals, and the number of units, capacities, heads, and horsepower requirements for the pumping plants are as authorized and based on feasibility designs contained in House Document No. 491, the February 1971 reevaluation statement, and the April 1978 special report. As preconstruction planning studies and detailed design data collection progresses, changes are expected in canal and lateral lengths and capacities, and in pumping plant requirements for the various features.

Calamus Dam

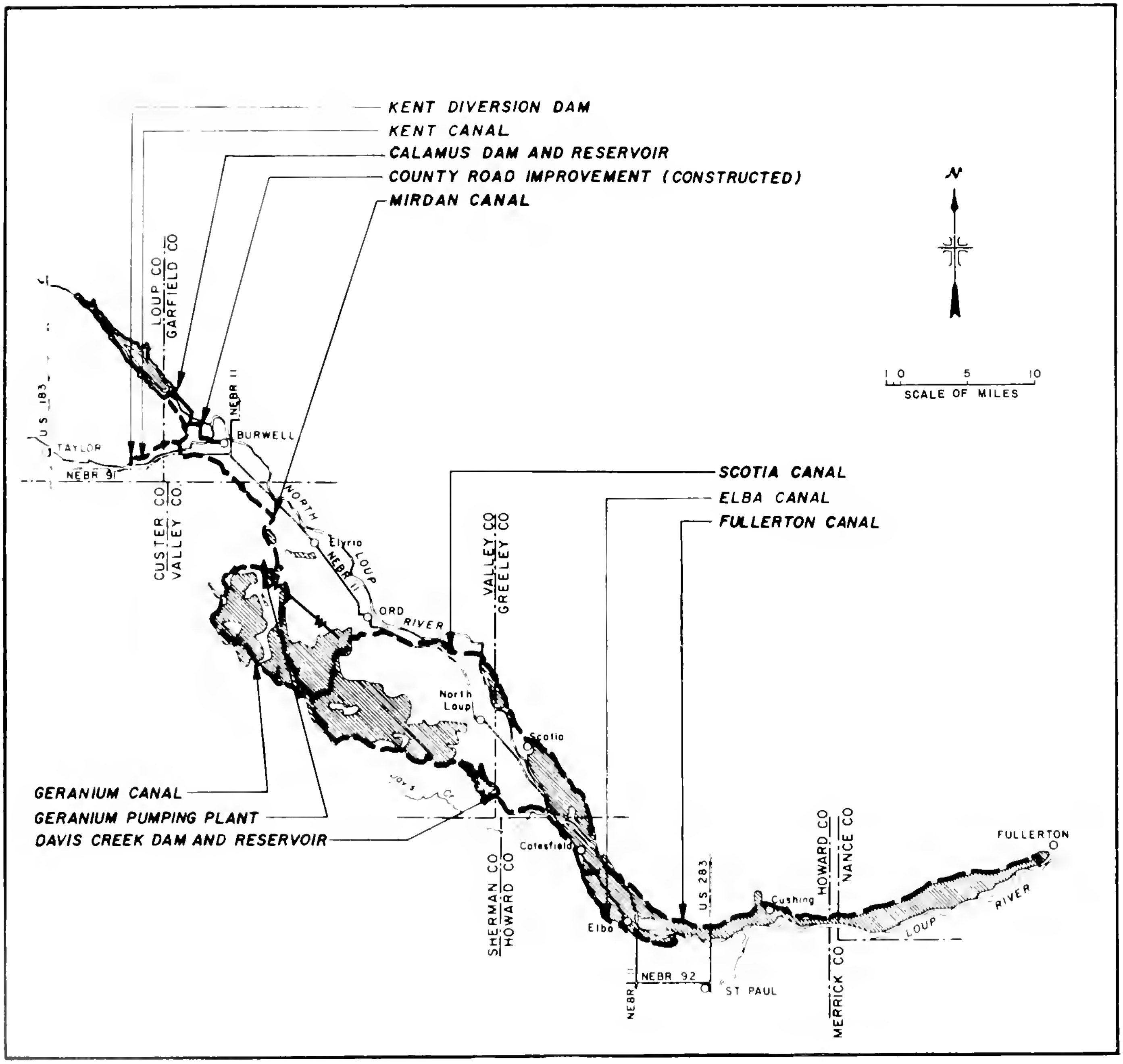
Calamus Dam will be located across the Calamus River approximately 5.5 miles northwest of Burwell, Nebr. The dam will be constructed of rolled earthfill with a maximum height above streambed of 85 feet and a crest length of 6,400 feet. The elevation of the crest will be 2255.0 feet. The embankment volume will be 4,320,000 cubic yards.

The upstream slope of the dam will be protected by either a 3-foot layer of rock riprap laid over an 18-inch gravel bedding or a 2.5-foot layer of soil cement. An impervious blanket 10 feet thick will extend upstream 500 feet from the upstream toe. This, together with an earthfill cutoff trench to a depth of 30 feet below the ground surface, will reduce percolation under the dam. Water percolating to the downstream toe of the dam will be intercepted and drained by inspection and drainage wells and a 5-foot-thick sand and gravel drain will be located under the downstream toe. The crest of the dam will be 30 feet wide.

The river outlet works will have a capacity to discharge 2,340 cubic feet per second. It will consist of a trashrack, inlet transition, and a 9.5-foot-diameter steel-lined conduit to a 6.5- by 10-foot outlet gate installed in a gate chamber 30 feet upstream from the dam axis. Downstream of the gate chamber will be a 9-foot-diameter steel pipe encased in concrete terminating in a wye branch, with each branch containing two 5.5-foot high-pressure gates in control houses.

One branch of the wye will carry water to the canal outlet works. This branch can discharge 720 cubic feet per second into the Mirdan Canal when the reservoir water surface is at the bottom of the conservation capacity, elevation 2213.3. After passing through high-pressure gates, the water will go through a wave suppressor and then a 20-foot-wide Parshall flume. Beyond the flume, the water will enter the canal at water surface elevation 2206.5. The need for a fish screen in the canal is being studied.

The other branch of the wye will control the water required for returns to the Calamus River. The branch to the river also will be used to discharge part of the inflow design flood. All natural flows of the Calamus River



North Loup Division

during July and August, and those of September when storage water is available to meet division needs, will be returned to the river. Beyond the high-pressure gates will be a stilling basin. The releases will be measured at a gaging station located about 2 miles downstream from the damsite.

The spillway will be a morning-glory type with a crest 30 feet in diameter located in the upstream slope of the dam at elevation 2244.0. Spilled water will drop 44 feet into a 10-foot-diameter conduit extending through the dam. At the outlet end of the conduit, a stilling basin will dissipate the energy of the water before it enters the Calamus River channel below the dam. With the use of 27,400 acre-feet of surcharge, the maximum discharge through the spillway will be 2,760 cubic feet per second under conditions of the inflow design flood. In addition, the river outlet will be used to pass part of the inflow design flood.

Kent Diversion Dam

Kent Diversion Dam will be located in Loup County on the North Loup River about 8 miles upstream from its confluence with the Calamus River. It will be a concrete ogee structure with a height above streambed of 9 feet. Its length will be 1,000 feet and the canal headworks capacity will be 500 cubic feet per second. The structure will be used to desilt and divert water from the North Loup River into the Kent Canal.

Davis Creek Dam

Davis Creek Dam will be located on a tributary to Davis Creek about 5.5 miles south of North Loup. The dam and blankets near each end will be of rolled earth with a maximum height of the embankment above streambed of 103 feet and a length of 2,900 at crest elevation 2089.

The upstream slope of the dam will be protected by either a 3-foot layer of rock riprap on an 18-inch gravel bedding, or a 2.5-foot layer of soil cement. The downstream slope will be covered with 12 inches of topsoil and seeded to grass. Drainage will be accommodated by a sand and gravel blanket with a tile toe drain, located in the downstream toe of the dam. The embankment will have a volume of 2,800,000 cubic yards.

A single canal outlet will have the capacity to discharge 440 cubic feet per second with water in the reservoir at the bottom of the conservation capacity, elevation 2003.0. It will consist of a trashrack, inlet transition, and a 6-foot-diameter conduit to a 5-foot-square high-pressure control gate installed in a gate chamber 50 feet upstream from the crest of the dam. Below the control gate there will be a 72-inch-diameter steel pipe in a 10-foot 4-inch concrete conduit. The steel pipe will terminate in a wye with each branch containing a 3.5-foot-square high-pressure regulating gate. Water from the outlet will pass into a stilling basin to dissipate energy before entering the Fullerton Canal at water surface elevation 1980.0.

The spillway will be a rectangular drop inlet covered by a trashrack with a crest elevation of 2076 ft. A concrete conduit 4.5 feet in diameter will extend from the bottom of the drop inlet to a stilling basin beyond the downstream toe of the dam. This basin will dissipate the energy in the water before it discharges into an excavated channel that will join the Fullerton Canal.

Pumping Plants

One large and nine small pumping plants will be constructed in the division.

Geranium Pumping Plant will be located less than a mile west of the Mirdan Canal, southwest of Elyria, Nebr. It will permit irrigation of 8,700 acres situated too high for gravity service. The plant will consist of four units, two with 350-horsepower motors and two with 1,000-horsepower motors, capable of lifting a total of 160 cubic feet per second of water at a dynamic head of 115 feet. The average annual power requirement for this plant is estimated at 2,907,600 kilowatt-hours, with a peak demand of 2,015 kilowatts. Pick-Sloan Missouri Basin Program power will serve the plant.

The nine small pumping plants will be located along canals and laterals and will range in capacity from 1 to 11.3 cubic feet per second with lifts of 4 to 58 feet. Electric motors will range from 1 to 120 horsepower. Local utilities will provide electric power for these plants.

Canals and Laterals

Six canals will serve the lands of the division. They are the Mirdan, Kent, Geranium, Scotia, Fullerton, and Elba Canals, and range in capacity from 80 to 720 cubic feet per second and in length from 4 to 49 miles. Concrete lining or compacted earth lining will be required for some reaches of the canals. The lateral system consists of 212 miles of laterals with capacities ranging from 4 to 80 cubic feet per second.

DEVELOPMENT

Early History

The first settlers started arriving in the Platte River Valley by way of the Oregon Trail in 1832. However, the Loup River area remained unsettled until the late 1860's. From the beginning, the farmers were plagued with invasions of grasshoppers and other pests, but the greatest deterrents to stability in the agricultural economy were insufficient rainfall and recurring droughts. There were attempts to irrigate, with individuals devising and operating simple methods to bring water to the land.

Several cooperative and district-type irrigation plans were conceived, and a few irrigation systems were built.

Some irrigation districts were eventually organized; the largest was the North Loup River Public Power and Irrigation District. Other irrigation development is generally limited to water being pumped from the river to irrigate adjacent lands. The Twin Loups Reclamation District, organized in 1954, and the Twin Loups Irrigation District, organized in 1958, were formed as legal entities of the State of Nebraska to operate the North Loup Division.

Investigations

Investigations in the area were conducted by private engineering firms beginning in 1933. The Bureau of Reclamation made its first study in 1943 and the resulting recommendations for irrigation development in the Loup Valley were included in Senate Document 191. This plan received basic congressional approval and authorization by the Flood Control Acts of 1944 and 1946.

A more intensive investigation was undertaken late in 1944 and a preliminary report was completed for the Lower Platte River Basin in 1951. Plans for a North Loup Division, similar to those in Senate Document 191, were included in this broad basin plan.

Detailed studies in 1954 resulted in publication of a feasibility report that was included in House Document No. 491, 87th Congress, 2d session, dated 1962.

Authorization

The division was authorized by the Reclamation Project Authorization Act of 1972, Public Law 92-514, on October 20, 1972. The Public Works for Water and Power Development and Energy Research Appropriation Act of 1976 authorized and provided funds for a construction start.

Construction

Construction began on June 4, 1976, with execution of the first contract in connection with improvement of the county road for access to Calamus Dam site. This road improvement was completed June 16, 1977.

Operating Agencies

It is planned that the irrigation district will, by contract, vest all operation, maintenance, and replacement responsibility in the reclamation district. Fish and wildlife facilities and lands will be administered by the State of Nebraska.

BENEFITS

Irrigation

The North Loup Division will provide a water supply to the area that can be served economically by gravity and private farm pumps.

Recreation and Fish and Wildlife

The division will provide increased recreation opportunities, particularly those associated with water sports. Fish and wildlife resources will be benefited by the water development project. Principal benefits will be to fishing and hunting.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	53,000	acres
Potential by private investment	17,000	acres

Facilities to be Constructed

Storage dams	2	
Diversion dams	1	
Pumping plants[1]	1	
Canals	162	mi
Laterals	212	mi

[1]Plus nine small plants

Climatic Conditions

Average annual precipitation	24	in
Temperature:		
Maximum	114	°F
Minimum	−39	°F
Mean	50	°F
Growing season	150	days

ENGINEERING DATA

Water Supply

CALAMUS AND NORTH LOUP RIVERS

Drainage areas above damsites:		
Calamus Dam	110	mi²
Davis Creek Dam	6.5	mi²
Kent Diversion Dam	240	mi²
Average annual inflow to Calamus Reservoir	216,600	acre-ft

Storage Facilities

CALAMUS DAM

Type: Rolled earthfill
Location: On the Calamus River about 5.5 mi northwest of Burwell, Nebr.

Reservoir, Calamus:		
Total capacity to El. 2244	127,300	acre-ft
Surface area	5,127	acres
Dimensions:		
Structural height	115	ft
Crest length	6,400	ft
Crest elevation	2255.0	ft
Volume	4,320,000	yd³
Spillway: Morning-glory type near center of dam.		
Crest diameter	30	ft
Crest elevation	2244.0	ft
Capacity at El. 2249	2,760	ft³/s
Outlet works: Trashrack, inlet transition, conduit, gate structures, and control house regulating releases to river return and Mirdan Canal.		
Canal outlet capacity at water surface El. 2213.3	720	ft³/s
River return outlet capacity	2,340	ft³/s

DAVIS CREEK DAM

Type: Rolled earthfill
Location: On a tributary to Davis Creek about 5.5 mi south of North Loup, Nebr.

Reservoir, Davis Creek:		
Total capacity to El. 2076	32,500	acre-ft
Surface area	1,145	acres
Dimensions:		
Structural height	153	ft
Crest length	2,900	ft
Crest elevation	2089.0	ft
Volume	2,800,000	yd³
Spillway: Rectangular drop inlet covered with a trashrack.		
Crest elevation	2076.0	ft
Capacity	430	ft³/s
Outlet works: Trashrack, inlet transition, and a conduit controlled by high-pressure gates installed in a gate chamber.		
Capacity at water surface El. 2003	440	ft³/s

Diversion Facilities

KENT DIVERSION DAM

Type: Concrete ogee structure
Location: About 8 mi upstream from confluence of North Loup and Calamus Rivers, and on the North Loup River.

Dimensions:		
Height above streambed	9	ft
Crest length	1,000	ft
Canal headworks capacity	500	ft³/s

Carriage Facilities

MIRDAN CANAL

Location: Extends from Calamus Dam south of North Loup River to Davis Creek Reservoir.

Length	47	mi
Diversion capacity	720	ft³/s

KENT CANAL

Location: From Kent Diversion Dam to Mirdan Canal.

Length	4	mi
Diversion capacity	500	ft³/s

GERANIUM CANAL

Location: From Geranium Pumping Plant to serve lands south of the plant.

Length	18	mi
Diversion capacity	160	ft³/s

Scotia Canal

Location: From Mirdan Canal along south and then north of North Loup River to serve lands in the area of Scotia, Nebr.
Length .... 34 mi
Diversion capacity .... 240 ft^3/s

Fullerton Canal

Location: From Davis Creek Dam along south and north of the North Loup and Loup Rivers to serve lands as far as Fullerton, Nebr.
Length .... 49 mi
Diversion capacity .... 440 ft^3/s

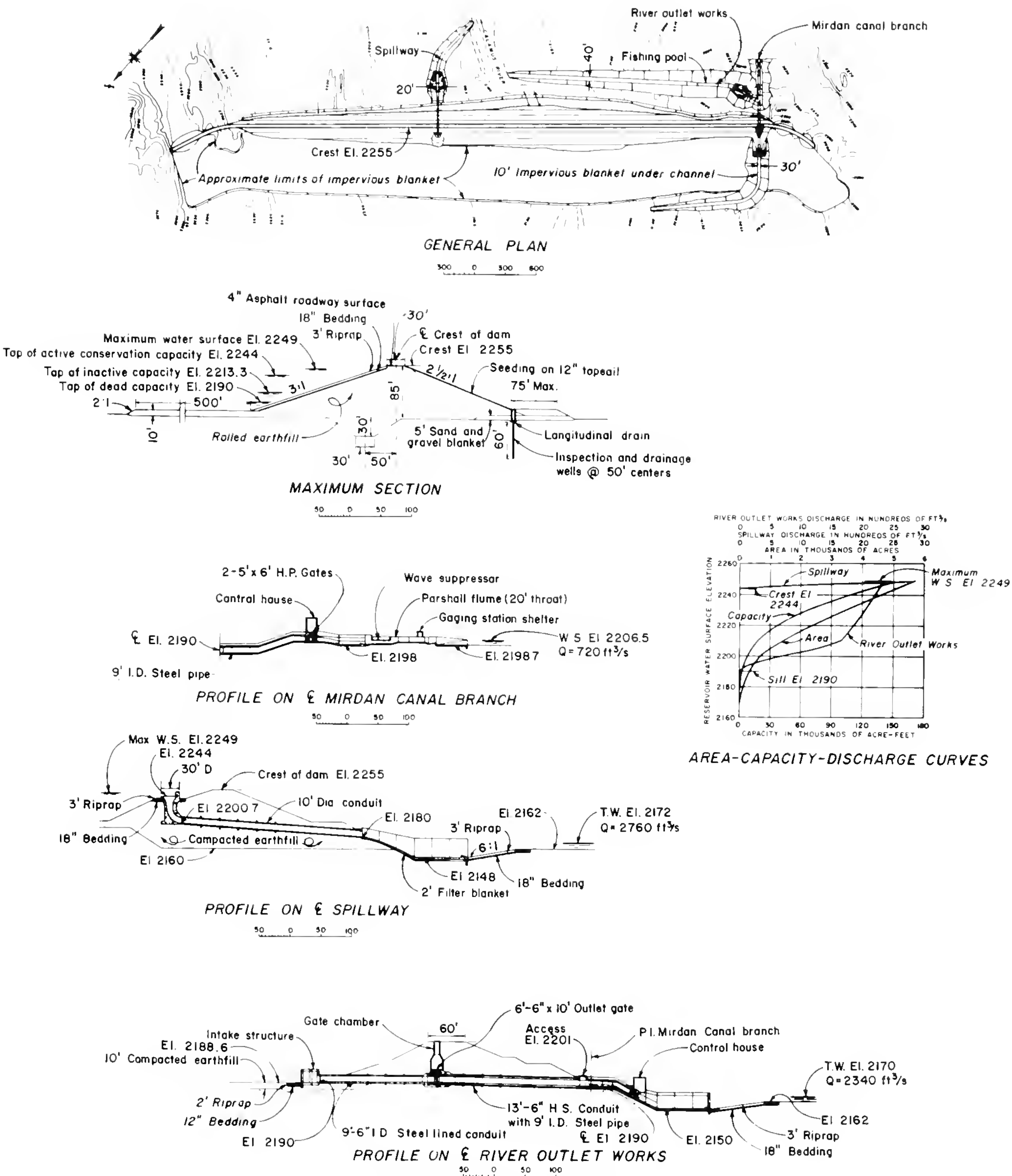
Elba Canal

Location: Branches off from Fullerton Canal to serve lands south of North Loup River near Elba, Nebr.
Length .... 10 mi
Diversion capacity .... 80 ft^3/s

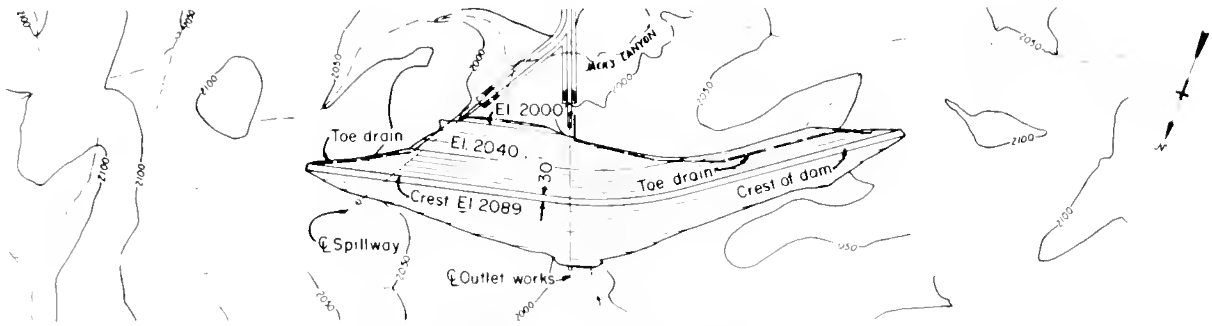
Pumping Plants

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horsepower
Geranium	4	160	115	2,700

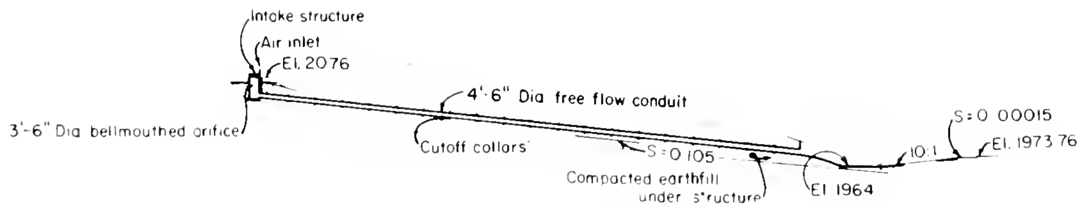
Note: In addition, there are nine small pumping plants ranging in capacity from 1 to 11.3 ft^3/s, lifts from 4 to 58 ft, and motors ranging from 1 to 120 horsepower.



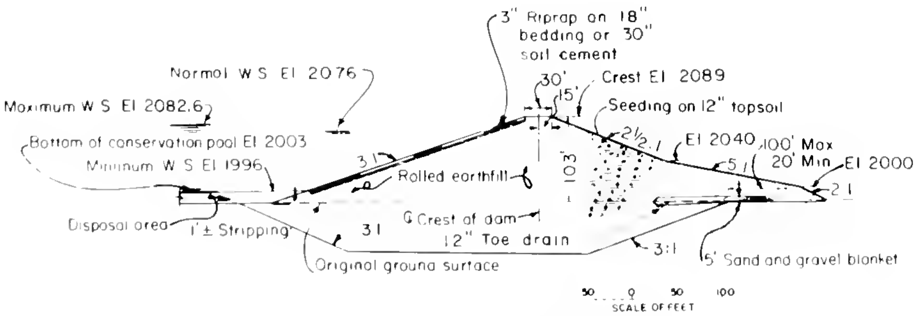
Calamus Dam, Plan and Sections



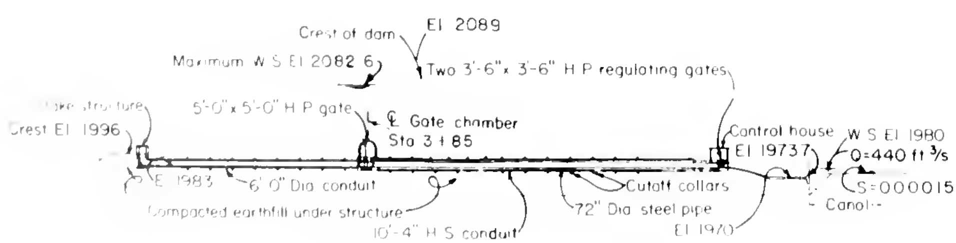
GENERAL PLAN



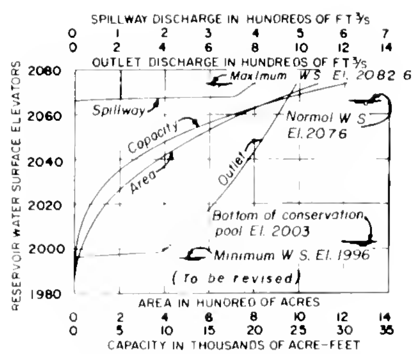
PROFILE ON ℄ SPILLWAY



MAXIMUM SECTION



PROFILE ON ℄ OUTLET WORKS



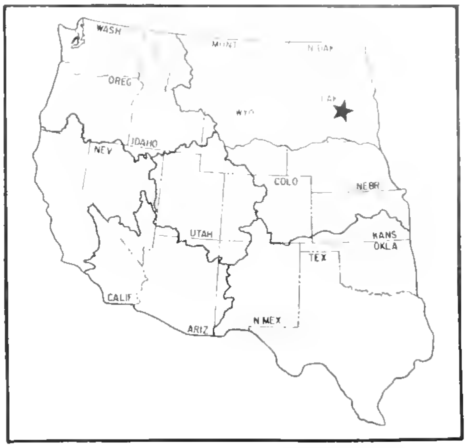
AREA - CAPACITY - DISCHARGE CURVES

Davis Creek Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Oahe Unit
(Initial Stage)

South Dakota: Brown and Spink Counties

Upper Missouri Region
Water and Power Resources Service



The initial stage of Oahe Unit is a multipurpose project authorized for the irrigation of 190,000 acres in the north-central part of the eastern half of South Dakota. The unit also will include municipal and industrial water supplies, fish and wildlife conservation and development, water-based recreation, and flood control.

Facilities partially completed are the Oahe Pumping Plant structure and sections of the Pierre Canal. Also completed earlier under separate authorization is the James Diversion Dam on the James River.

Facilities required to complete the unit include the pumping plant, Pierre Canal, and other carriage, storage, distribution, and drainage facilities.

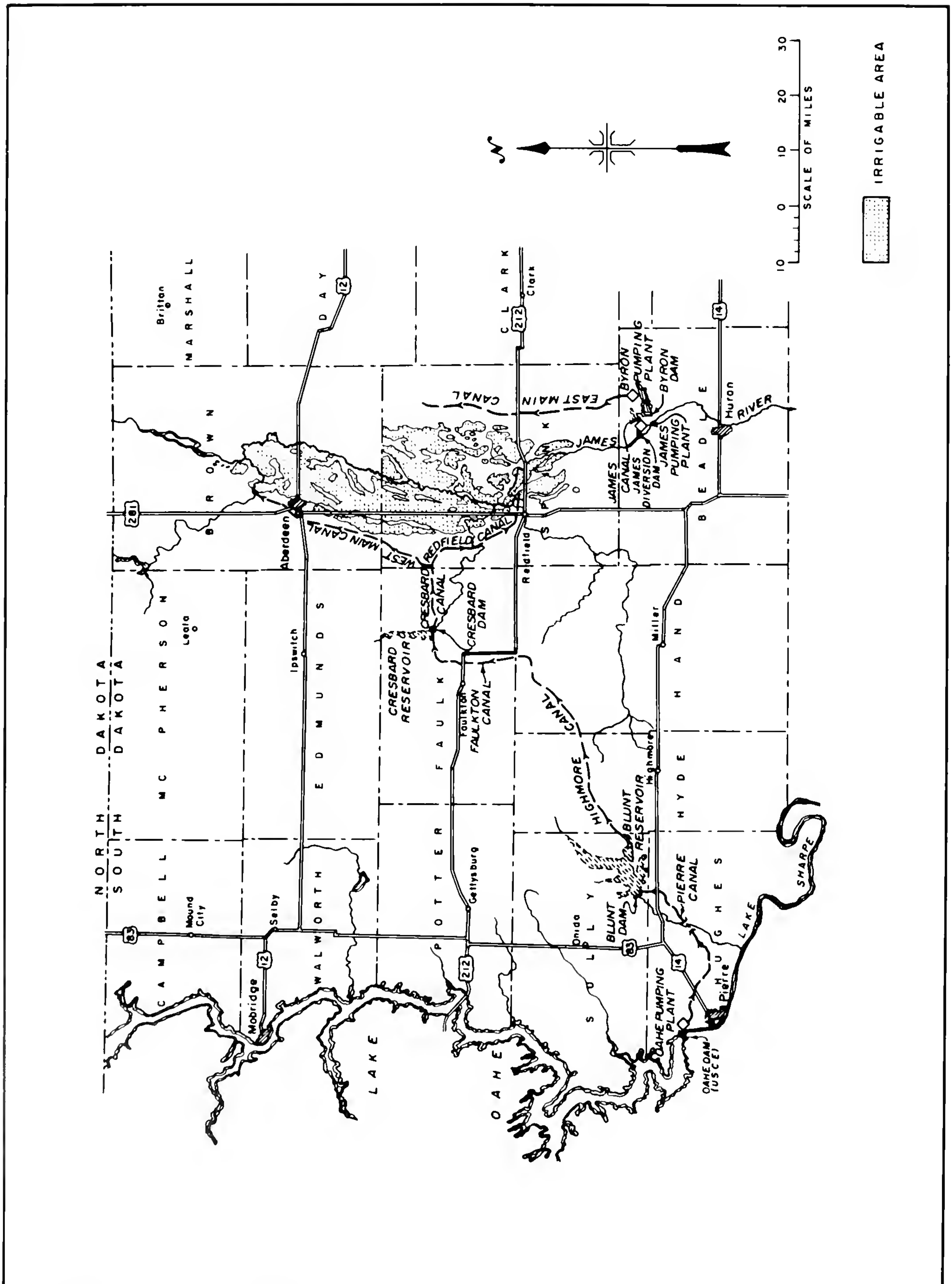
PLAN

Oahe Unit lands are situated in the area known geologically as "Lake Dakota Plain" (commonly known as the Lake Plain) of the James River Valley in Brown and Spink Counties of South Dakota. The James River traverses the Lake Plain area in a southerly direction, dividing the West Lake Plain from the East Lake Plain.

The principal supply works for the Oahe Unit under the authorized plan included the Oahe Pumping Plant, 214 miles of main canals, three regulating reservoirs, James Diversion Dam and Reservoir (existing), James Pumping Plant on the James River, and Byron Pumping Plant at Byron Reservoir. Other irrigation works included 955 miles of distribution laterals, 935 miles of open drains, and 2,970 miles of closed (pipe) drains, relift pumping plants, and electrical distribution facilities for providing energy to operate the major pumping plants.

The water supply for the unit is principally Lake Oahe, an impoundment on the Missouri River formed by Oahe Dam near Pierre, S. Dak. The dam was constructed by the Corps of Engineers for several purposes including flood control, hydroelectric power generation, navigation, and irrigation. A small portion of the water supply for Oahe Unit would be floodflows of the James River and irrigation return flows accruing to the James River.

Oahe Pumping Plant


NORTH DAKOTA
SOUTH DAKOTA
CAMPBELL
MC PHERSON
BROWN
MARSHALL
DAY
CLARK
WALWORTH
EDMUNDS
POTTER
FAULK
SPINK
BEADLE
HAND
HYDE
SULLY
HUGHES
Britton
Leola
Aberdeen
Ipswitch
Mound City
Selby
Mobridge
Gettysburg
Faulkton
Redfield
Clark
Miller
Highmore
Huron
Onida
Pierre
LAKE OAHE
LAKE SHARPE
JAMES RIVER
WEST MAIN CANAL
EAST MAIN CANAL
REDFIELD CANAL
CRESBARD CANAL
CRESBARD RESERVOIR
CRESBARD DAM
FAULKTON CANAL
HIGHMORE CANAL
BLUNT RESERVOIR
BLUNT DAM
PIERRE CANAL
OAHE PUMPING PLANT
OAHE DAM (USCE)
JAMES CANAL
JAMES DIVERSION DAM
JAMES PUMPING PLANT
BYRON PUMPING PLANT
BYRON DAM
SCALE OF MILES
10 0 10 20 30
IRRIGABLE AREA

Oahe Unit

Pierre Canal

Under the authorized plan, water would be pumped from Lake Oahe by the Oahe Pumping Plant located at Oahe Dam into the 36-mile-long Pierre Canal for conveyance to Blunt Reservoir. Pumping lift would average 122 feet. From Blunt Reservoir, the water would flow by gravity through the Highmore and Faulkton Canals, a distance of 62 miles, to Cresbard Reservoir. From Cresbard Reservoir, the water would be conveyed a distance of 12 miles via Cresbard Canal to the West Main and Redfield Canals to supply water to West Lake Plain irrigable lands on the west side of the James River and to the James River. Water supplied to the James River would be pumped by the James Pumping Plant into Byron Reservoir. Some relift pumping of water would be required in the lateral distribution system.

Lake Oahe water, irrigation return flows, and James River floodflows would be pumped from the James River for irrigation of the East Lake Plain lands on the east side of the James River. The James Pumping Plant, to be located at the existing James Diversion Dam, would lift water from the James River into the 3-mile-long James Canal which terminates at Byron Reservoir. The pump lift would average 28.5 feet.

The James Diversion Dam was constructed in 1964 as an advance facility of the Oahe Unit to provide municipal water for the city of Huron, S. Dak. It also provides recreation and fishing.

Deliveries to East Lake Plain land would be made from Byron Reservoir by the Byron Pumping Plant and a canal and lateral system with some relift pumping.

There would be an extensive closed (pipe) and open drainage system for all of the irrigable area.

An additional 305,000 acres in the Missouri Slope area of central South Dakota and within the Lake Plain area are suitable for irrigation and have potential for future development. This acreage could be provided irrigation water from the planned facilities for the initial stage development of 190,000 acres; however, modification or enlargement of most of the facilities would be required.

DEVELOPMENT

Early History

The general area that encompasses the Oahe Unit was open for homestead entry by 1873. There was a great influx of homesteaders from about 1876 to 1883, along with extensive railroad development.

Variable annual precipitation patterns have affected grain and forage production and stability of the economy that is predominantly agriculture-oriented. The search for a water supply to irrigate lands in the James River Basin already had begun when South Dakota became a State in 1889. Early efforts to use the artesian water underlying portions of the James River Valley were frustrating because of the limited water supply and its poor quality for irrigation.

During the 1920's and 1930's, there was considerable interest in the construction of dams on the Missouri River for navigation, flood control, hydroelectric power generation, and irrigation along the James River in the James River Valley. It was known that the erratic flows of the James River could not provide a reliable, sustained water supply for irrigation development.

Investigations

The severe and extended drought period of the 1930's and extensive flooding on the Missouri River and some of its tributaries during the early 1940's prompted the Congress to direct the Bureau of Reclamation and the Corps of Engineers to study the possible development of the resources of the Missouri River Basin. The Bureau of Reclamation directed its attention to evaluating the resources for irrigation and related land resources development and municipal and industrial water. The Corps of Engineers conducted its studies on flood control and navigation. Both agencies considered the possibilities of hydroelectric power generation. After review by the Congress, the two general plans for development were combined and authorized by the Flood Control Act of 1944 as the Missouri River Basin Project.

The Oahe Unit, was a part of the overall plan for development of the resources of the Missouri River Basin. Oahe Dam, studied by the Corps of Engineers was also part of the overall plan; construction of that dam was completed in 1962.

The Bureau of Reclamation conducted further engineering, land resources, and economic studies in the 1940's and 1950's throughout the Missouri River Basin area, including a feasibility study of the Oahe Unit as a part of the Missouri River Basin Project. These studies identified the Oahe Unit irrigable lands within Sully, Brown, Spink, Marshall, and Day Counties in east-central South Dakota with an ultimate irrigation development potential of 495,000 acres. The initial stage development is comprised of 190,000 acres of irrigable land in Brown and Spink Counties.

Authorization

Oahe Unit is part of the Pick-Sloan Missouri Basin Program which was authorized by the Flood Control Act of 1944 (58 Stat. 887) as supplemented and extended by the Flood Control Act of 1946 (60 Stat. 641). The provisions of Public Law 88-442 (78 Stat. 446), however, require new authorization by the Congress of any units of the Pick-Sloan Missouri Basin Program on which construction was not underway before August 14, 1964. The initial stage of the Oahe Unit was specifically authorized by the act of August 3, 1968 (82 Stat. 624).

The authorization provided for irrigation of an initial stage development of 190,000 acres. Fish and wildlife conservation and enhancement, recreation, municipal water supplies, flood control, and other project purposes also would be served. The general plans are set out in the Secretary of the Interior's report of June 1965 and contained in House Document 163, which was modified by House Report No. 1612 dated July 2, 1968, and Senate Report No. 699 dated October 31, 1967.

Construction

Construction funds for the Oahe Unit were first made available in 1971; however, the funds were placed in reserve and then released in 1972 for initiating acquisition of lands and rights. Actual construction activities began on May 16, 1974, and continued through 1977.

Funding for continuing construction of facilities for the Oahe Unit was discontinued at the end of fiscal year 1977.

Construction work is not complete on any single facility of the Oahe Unit, except the James Diversion Dam.

Operating Agencies

Contractual arrangements with the Oahe Conservancy Sub-District for operation and maintenance of the Oahe Unit facilities were executed on January 8, 1969. Participating and security contracts with the West Brown and the Spink County Irrigation Districts were signed on December 23, 1969.

The James Diversion Dam is the only completed and operational facility for the Oahe Unit and is currently operated and maintained by the city of Huron specifically for municipal water storage. The recreation and fish and wildlife developments associated with James Diversion Dam and Reservoir are administered by the South Dakota Department of Game, Fish, and Parks.

BENEFITS

Irrigation

Principal crops expected to be grown under irrigation development with a stable water supply would include crops now grown under dryland conditions in the area, such as corn, alfalfa, small grains, and sunflowers, in addition to new crops such as sugar beets and potatoes.

Municipal and Industrial Water

Seventeen towns and cities have been identified for municipal and industrial water supplies from the Oahe Unit facilities. Rural and community water systems also could benefit.

Recreation and Fish and Wildlife

Five areas associated with the reservoirs and existing lakes were planned for extensive water-oriented recreation developments. At the existing James Diversion Dam, there were 4,500 visitor days in 1977. Fish and wildlife habitat developments are also part of the authorized plan.

Flood Control

Flood control benefits would be inherent in the overall operation of the Oahe Unit facilities for serving the East Lake Plain whenever there would be diversion of floodflows from the James River to Byron Reservoir.

PROJECT DATA

Land Area (Authorized)

Irrigable area:	
Full irrigation service	190,000 acres

Facilities in Operation

None, except James Diversion Dam and Reservoir, which are currently operated for municipal water storage for Huron, S. Dak.

Climatic Conditions

Annual precipitation	19	in
Temperature:		
Maximum	115	°F
Minimum	−40	°F
Mean	45	°F
Growing season	135	days
Elevation of irrigable area	1295-1310.0	ft

ENGINEERING DATA

Water Supply

LAKE OAHE

Drainage area at Oahe Dam	243,500	mi²
Annual discharge near Pierre, S. Dak:		
Maximum (1976)	26,235,000	acre-ft
Minimum (1963)	13,328,900	acre-ft
Average	18,698,500	acre-ft

Storage Facilities

OAHE DAM AND LAKE OAHE (EXISTING, CONSTRUCTED AND OPERATED BY CORPS OF ENGINEERS)

Type: Rolled earthfill
Location: On Missouri River about 6 mi north of Pierre, S. Dak.
Construction period: 1948-62

Active capacity	16,962,000	acre-ft

Diversion Facilities

PIERRE CANAL

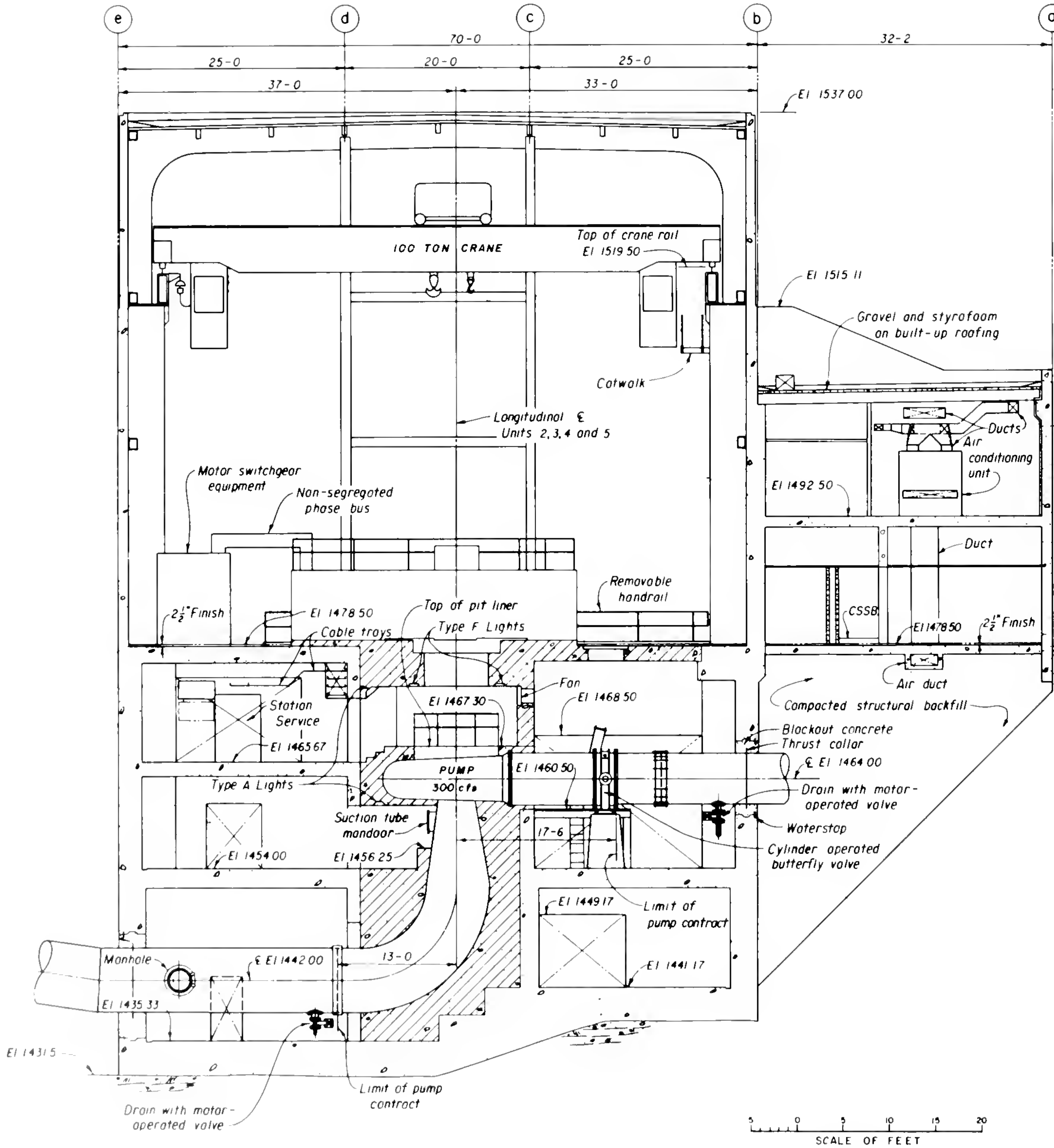
Location: From Oahe Pumping Plant, easterly to Blunt Reservoir.

Length	36	mi
Capacity	1,440	ft³/s
Typical maximum section in earth:		
Bottom width	44	ft
Side slopes	2:1	
Water depth	11	ft

OAHE PUMPING PLANT

Location: 6 mi north of Pierre, S. Dak.
Construction period: 1974-77 (not complete)
Type of structure: Reinforced concrete
Size of structure: Pumping plant, 219 by 70 by 100 ft high.
Valve structure 121 by 39 ft

Operating range-Lake Oahe elevations	1540.0-1617.0	ft
Initial plant capacity	1,200	ft³/s
Ultimate	3,200	ft³/s
Concrete	18,300	yd³



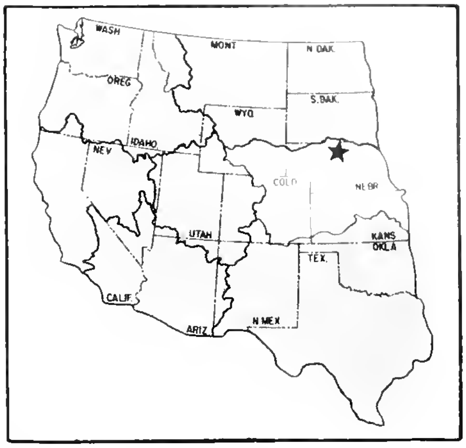
TRANSVERSE SECTION THRU UNIT 3
(UNITS 2, 4, AND 5 SIMILAR)

Oahe Pumping Plant, Transverse Section

Pick-Sloan Missouri Basin Program
O'Neill Unit (Authorized)

Nebraska: Brown, Rock, Cherry, Keya Paha, and Holt Counties

Lower Missouri Region
Water and Power Resources Service



The authorized O'Neill Unit will be located in north-central Nebraska within the Niobrara River Basin. Diversion and storage facilities will be located in Brown, Cherry, and Keya Paha Counties. The irrigable lands are in Holt and Keya Paha Counties. The unit will supply water to 77,000 acres of irrigable land, enhance the recreation and fish and wildlife opportunities of the area, and provide flood control benefits.

PLAN

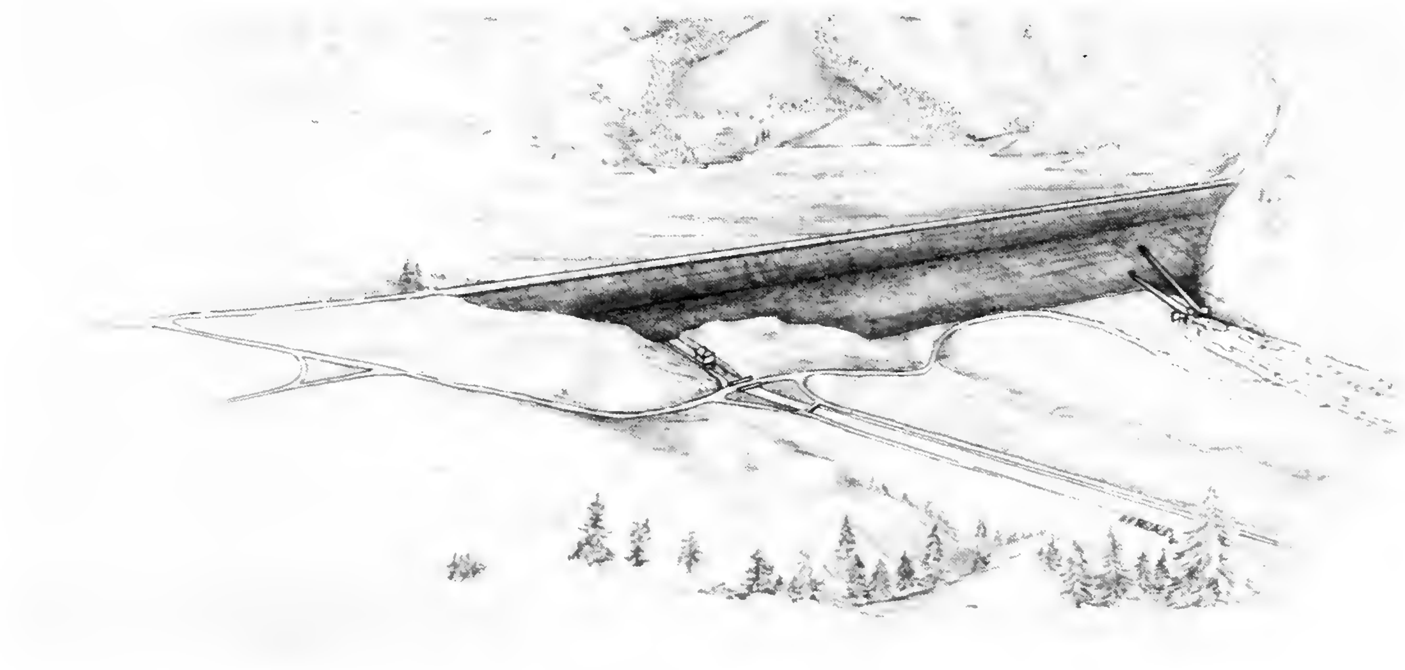
The O'Neill Unit will be a multipurpose project to serve the lands of the North Central Nebraska Reclamation District and the Niobrara Basin Irrigation District. These lands consist of 8,000 irrigable acres in the Springview service area and 69,000 irrigable acres in the O'Neill service area. Principal project features will include Norden Dam and Reservoir, Springview Pumping Plant, and the O'Neill, Springview, Atkinson, Eagle, and Blackbird canal and lateral systems.

The statistics presented here were developed from the feasibility studies and may be subject to reanalysis during the final design.

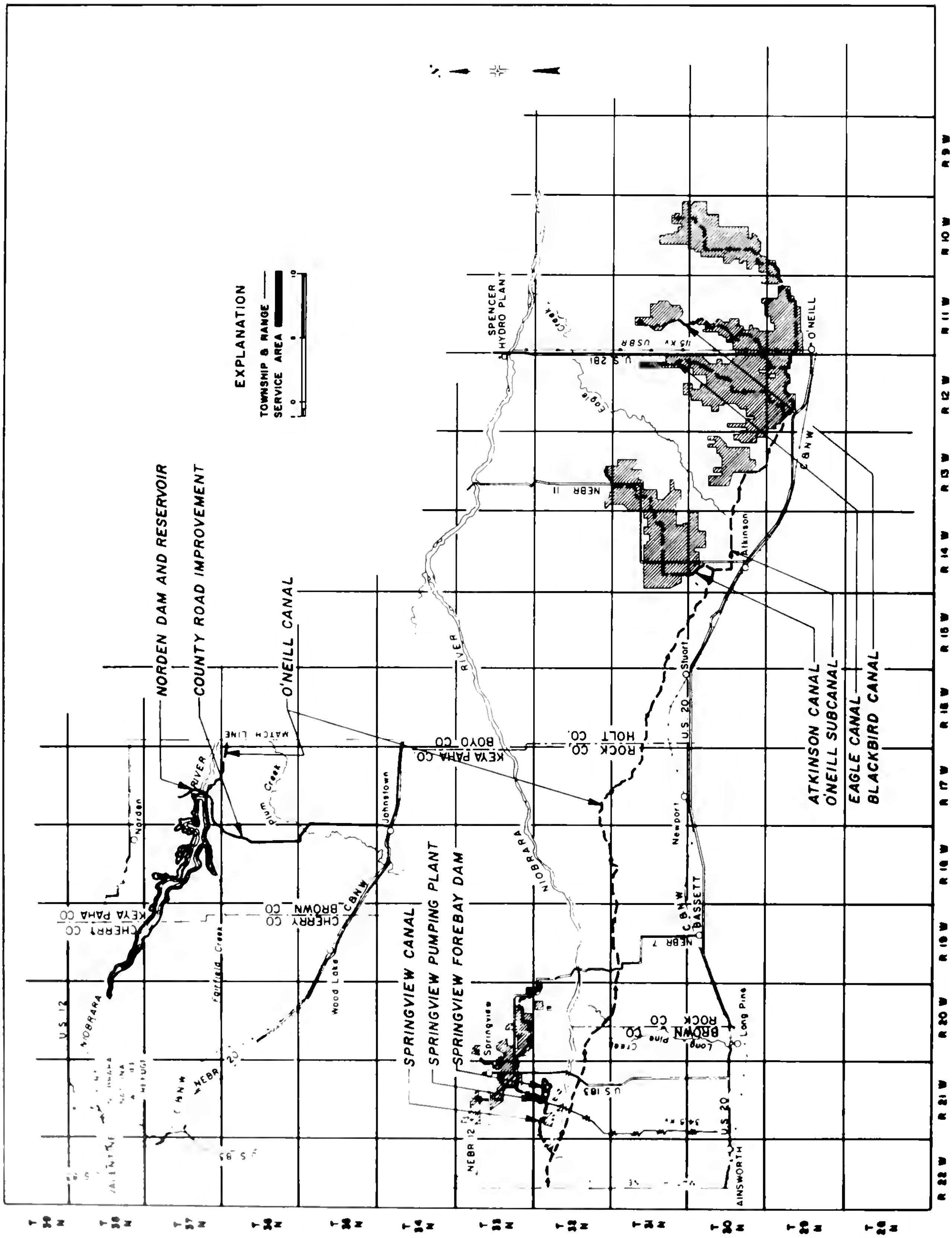
Norden Dam

Norden Dam will be a rolled earthfill structure rising 182 feet above the streambed. It will have a crest length of 3,700 feet and a crest elevation of 2281.0 feet. The dam will contain about 8,800,000 cubic yards of material. The upstream face of the dam will be protected by riprap over a sand and gravel blanket or by a layer of soil cement, and the downstream face will be covered with topsoil seeded to grass. The reservoir will have a total capacity of 414,500 acre-feet.

The spillway will be a morning-glory type ungated intake structure with a capacity of 16,600 cubic feet per second at the maximum water surface elevation of 2275.4 feet. The river outlet works will have a capacity of 4,190 cubic



Artist's concept of Norden Dam



EXPLANATION
TOWNSHIP & RANGE
SERVICE AREA
NORDEN DAM AND RESERVOIR
COUNTY ROAD IMPROVEMENT
O'NEILL CANAL
SPRINGVIEW CANAL
SPRINGVIEW PUMPING PLANT
SPRINGVIEW FOREBAY DAM
ATKINSON CANAL
O'NEILL SUBCANAL
EAGLE CANAL
BLACKBIRD CANAL
SPENCER HYDRO PLANT
MATCH LINE
KEYA PAHA CO
BOYD CO
ROCK CO
HOLT CO
CHERRY CO
BROWN CO
NIOBRARA
RIVER
Plum Creek
Eagle
Long Pine Creek
Fairfield Creek
O'NEILL
Atkinson
Stuart
Newport
BASSETT
Long Pine
AINSWORTH
Springview
Johnstown
Wood Lake
Norden
U.S. 281
U.S. 20
U.S. 183
U.S. 12
NEBR 11
NEBR 7
NEBR 12
NEBR 20
C&NW
R 22 W
R 21 W
R 20 W
R 19 W
R 18 W
R 17 W
R 16 W
R 15 W
R 14 W
R 13 W
R 12 W
R 11 W
R 10 W
R 9 W

O'Neill Unit

feet per second. Both structures will be located in the north abutment of the dam. With a surcharge capacity of 149,600 acre-feet, these structures will provide protection against an inflow-design flood of 87,000 cubic feet per second with an 8.5-day volume of 272,300 acre-feet.

The canal outlet works in the south abutment of the dam will deliver irrigation water to the O'Neill Canal at a maximum rate of 1,270 cubic feet per second. A flow measuring structure will be installed in the canal about 400 feet downstream from the stilling basin of the outlet works.

Springview Pumping Plant

This pumping plant will be located in Keya Paha County and will serve about 7,300 acres of irrigable land. Approximately 700 acres will be irrigated from the section of Springview Canal between the Niobrara River Siphon and the pumping plant. The plant will contain six units operating under a static head of 300 feet and a dynamic head of 325 feet. The plant has been designed for a capacity of 132 cubic feet per second using motors totaling 6,050-horsepower. The pumps range in capacity from 7.5 to 30 cubic feet per second. The plant will be semiautomatic in operation, with industrial-type motor-control equipment. The 10,200-foot discharge line from the pump manifold will be 54-inch steel pipe.

Pick-Sloan Missouri Basin Program power for pumping will be wheeled to an existing substation south of Ainsworth, served by the Nebraska Public Power System. A 17.5-mile, 34.5-kilovolt transmission line will be constructed to the pumping plant. The plant will have a peak demand of about 4,515 kilowatts and will require an average of 7,328,750 kilowatt-hours of energy annually.

O'Neill Canal

The O'Neill Canal will be about 100 miles long and have an initial capacity of 1,400 cubic feet per second. The canal will be concrete lined for the first 28 miles and earth lined for the remainder of its length. It will parallel the Niobrara River for about 16 miles before entering the adjacent sandhills area for 12 miles. The remainder of the canal's reach is located in tablelands where the topography is predominantly flat.

Canal and Lateral Systems

Four other canals will deliver water to laterals or serve the irrigable lands of the unit directly. The canals are Springview (18 miles), Atkinson (17 miles), Eagle (16 miles), and Blackbird (16 miles), and have initial capacities of 130, 350, 220, and 170 cubic feet per second, respectively. The laterals will have capacities ranging from 4 to 80 cubic feet per second. These canals and lateral systems will be lined with compacted earth for most of their length. The laterals will total about 195 miles in length.

DEVELOPMENT

Early History

Pioneers first visited the Niobrara River Valley in 1789. Generally, however, explorers who passed through the Nebraska territory followed the Republican, Platte, and Missouri River Valleys on their westward journey, bypassing the Niobrara River Valley.

Settlement of Holt and Keya Paha Counties began in 1873 and 1878. The majority of the new settlers were farmers who established homesteads on the tillable lands north of the sandhills. By 1890, nearly all of the arable land of the O'Neill Unit area had been homesteaded. Droughts in the 1890's and 1930's caused many farmers to move out of the area, and population losses have continued.

Investigations

Although the need for irrigation in the O'Neill area has been recognized for many years and an irrigation plan was developed in the 1890's, positive action was not taken until 1946 when, as a result of efforts by local interests, the Bureau of Reclamation began a reconnaissance study of the Niobrara River Basin. Recommendations for irrigation development of the basin were included in Public Law 612, 83d Congress, 2d session, August 21, 1954. The O'Neill Unit was one of four to receive conditional authorization as a part of the Missouri River Basin Project. The Springview area, although possessing a favorable benefit-cost ratio, was not included because of high pumping costs. Further investigations of the unit were initiated for the O'Neill area in 1955 and for the Springview area in 1959. The findings were summarized in a feasibility report which was published in House Document No. 378, 90th Congress. In April 1971, a statement was published which updated costs and benefits, and reevaluated the economic justification and financial feasibility of the O'Neill Unit. A definite plan report was issued in February 1977 updating the costs and benefits of the unit and reflecting certain minor modifications in the design.

Authorization

The unit was authorized by the Reclamation Project Authorization Act of 1972, Public Law 92-514, on October 20, 1972. The Public Works for Water and Power Development and Energy Research Appropriation Act, 1976, authorized and provided funds to begin construction.

Operating Agencies

It is planned that the Niobrara Basin Irrigation District will, by contract, vest all operation, maintenance, and replacement responsibility in the North Central Nebraska Reclamation District. Recreation and fish and wildlife facilities will be managed by the State of Nebraska.

BENEFITS

Irrigation

With irrigation development, an impetus will be provided to stabilize the general economy and to reverse the downward trend of the economic forces. Although farm size and rural population may continue to follow present trends, the O'Neill Unit will have a tendency to slow the rapid increase in farm sizes within the project boundaries and to decrease the population loss.

Flood Control

Flood damages on the lower Niobrara River have never been significant because serious floods infrequently develop in this hydrologically unique basin. However, by virtue of its operation for other purposes and through the use of the unregulated surcharge capacity, Norden Dam and Reservoir will provide minor flood control benefits.

Recreation and Fish and Wildlife

Recreation opportunities will be provided at Norden Reservoir through a program of land acquisition accompanied by the development of recreation facilities. Fish and wildlife interests will be served through the creation of Norden Reservoir, maintenance of minimum flows below the dam, and enhancement of fish and wildlife resources.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	77,000	acres

Facilities to be Constructed

Storage dam	1	
Pumping plant	1	
Canals	167	mi
Laterals	195	mi

Climatic Conditions

Average annual precipitation	21	in
Temperature:		
Maximum	112	°F
Minimum	−35	°F
Mean	48	°F
Growing season	148	days

ENGINEERING DATA

Water Supply

NIOBRARA RIVER

Drainage area above damsite	6,610	mi^2
Contributing drainage area above damsite	2,400	mi^2
Annual discharge at Norden Dam site (historical and estimated):		
Maximum	777,100	acre-ft
Minimum	494,000	acre-ft
Average	643,400	acre-ft

Storage Facilities

NORDEN DAM

Type: Rolled earthfill		
Location: On the Niobrara River about 14 mi north of Johnstown, Nebr.		
Reservoir, Norden:		
Total capacity to El. 2254	414,500	acre-ft
Active capacity, El. 2232-2254	125,000	acre-ft
Surface area top of active conservation capacity	6,248	acres
Dimensions:		
Height above streambed	182	ft
Crest length	3,700	ft
Top width	30	ft
Crest elevation	2281.0	ft
Volume	8,800,000	yd^3
Spillway: Morning-glory type ungated intake structure at left abutment.		
Crest elevation	2254.0	ft
Capacity at water surface El. 2275.4	16,600	ft^3/s
River outlet works: The river outlet works will consist of an intake structure connected to a circular conduit through the left abutment of the dam. An access shaft and gate chamber will be located at a point of transition from the circular conduit to a flat-bottomed conduit and high-pressure gates will be installed at this transition at the bottom of the gate chamber. An outlet will be constructed at the downstream end of the flat-bottomed conduit.		
Capacity at water surface El. 2275.4	4,190	ft^3/s

Canal outlet works: The canal outlet works will consist of an intake with trashracks connected to a twin-barrel conduit through the right abutment of the dam. Slide gates and controls will be located about midpoint along the conduit and a wave suppressor will be incorporated in the design of the outlet.	
Capacity at water surface El. 2232	1,270 ft³/s
Foundation: The dam will be situated predominantly in the Brule formation, which consists of moderately soft to cemented silts with very small amounts of clay, very fine sand, and volcanic ash.	

Carriage Facilities

O'Neill Canal

Location: Will parallel the Niobrara River for about 16 mi before entering sandhills.	
Initial capacity	1,400 ft³/s
Length	100 mi
Lining: Concrete and earth lined	

Springview Canal

Location: North of Niobrara River in vicinity of Springview.	
Initial capacity	130 ft³/s
Length	18 mi
Lining: Compacted earth	

Atkinson Canal

Location: North of Atkinson and south of Niobrara River.	
Initial capacity	350 ft³/s
Length	17 mi
Lining: Compacted earth	

Eagle Canal

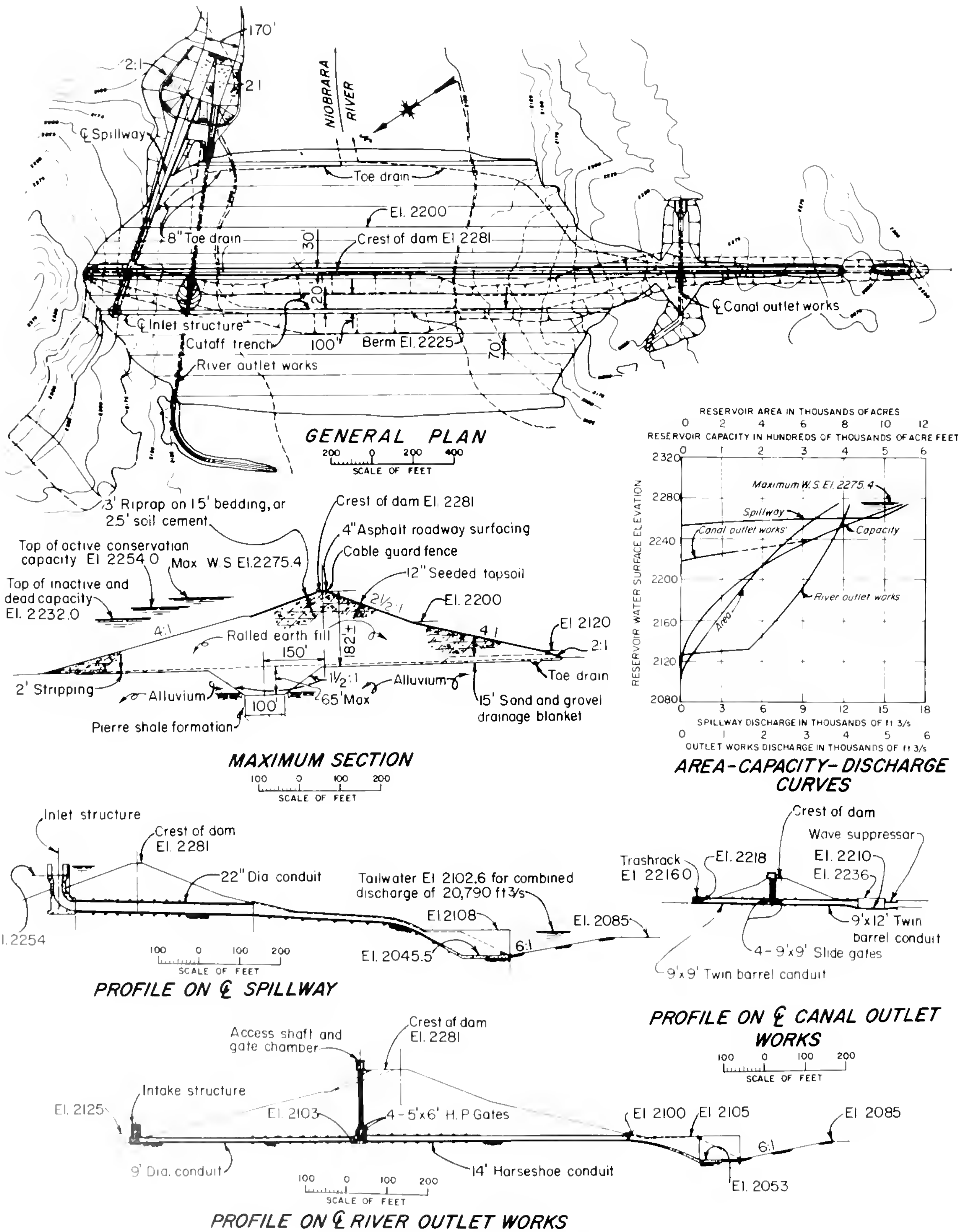
Location: Northwest of O'Neill and south of Niobrara River.	
Initial capacity	220 ft³/s
Length	16 mi
Lining: Compacted earth	

Blackbird Canal

Location: North of O'Neill and south of Niobrara River.	
Initial capacity	170 ft³/s
Length	16 mi
Lining: Compacted earth	

Springview Pumping Plant

Location: Keya Paha County	
Number of units	6
Total capacity	132 ft³/s
Total dynamic head	325 ft
Total horsepower	6,050

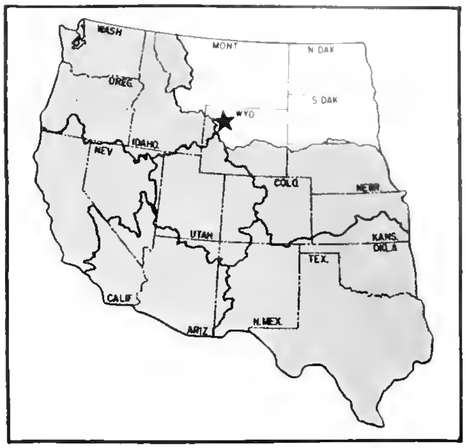


Norden Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Owl Creek Unit

Wyoming: Hot Springs County

Upper Missouri Region
Water and Power Resources Service

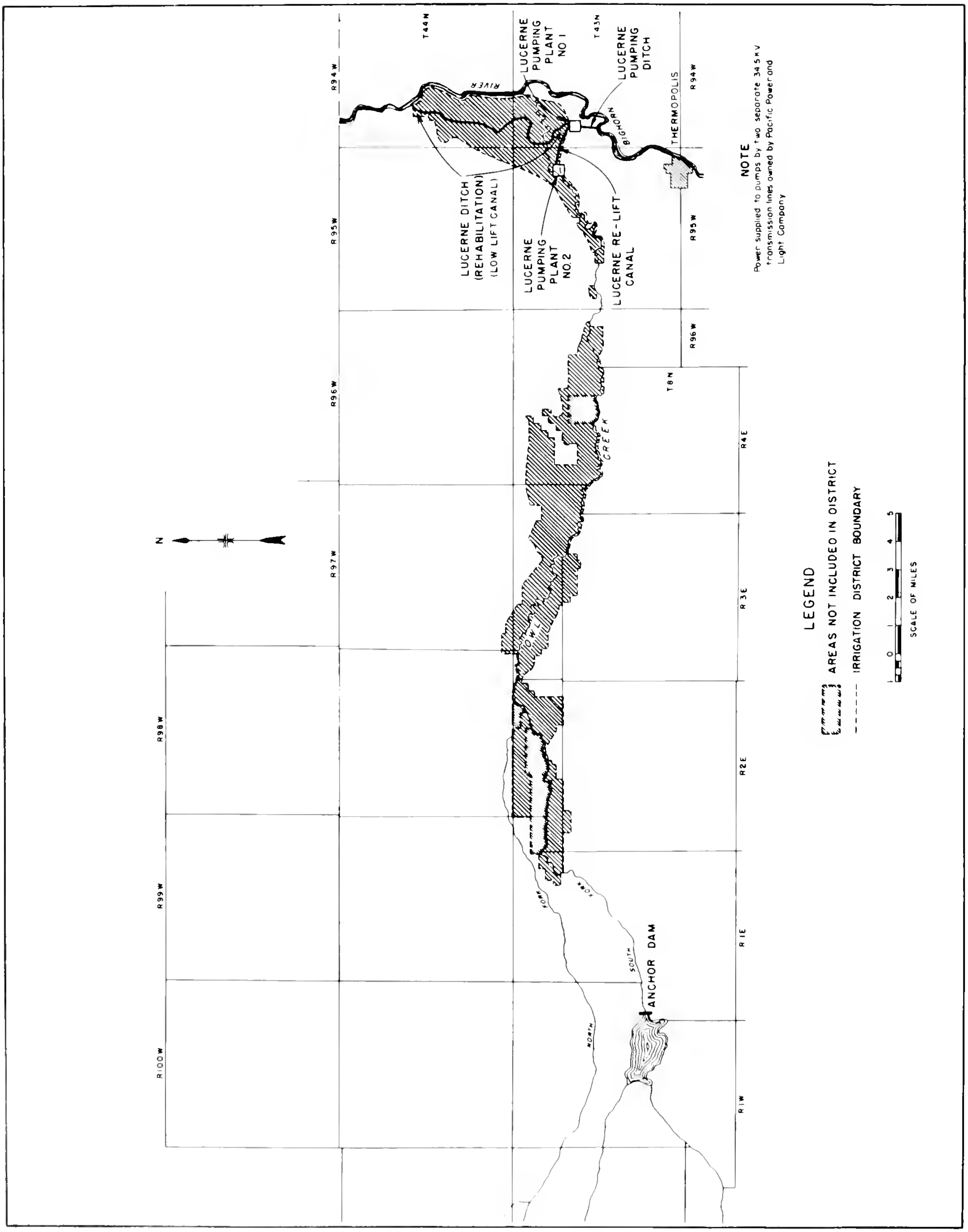


PLAN

Owl Creek Unit is in Hot Springs County in north-central Wyoming, west and north of the city of Thermopolis. Owl Creek heads in the Absaroka Mountains and flows eastward, north of the Owl Creek Mountains, joining the Bighorn River 6 miles north of Thermopolis. The unit comprises a narrow valley extending about 30 miles westerly from the mouth of Owl Creek. The development provides supplemental water to 11,251 acres of irrigated land to stabilize the agricultural economy of the area. Principal features of the development include Anchor Dam and Reservoir and pumping facilities to deliver water to the three distinct areas of the unit.

The Owl Creek Unit features Anchor Dam and Reservoir on the South Fork of Owl Creek, about 35 miles west from Thermopolis, Wyo. The water supplied from Anchor Reservoir is augmented during periods of short supply by pumping from the Bighorn River. The pumping plants required construction and rehabilitation of pump canal facilities. Distribution facilities are privately owned.

Anchor Dam



Owl Creek Unit

Lucerne Pumping Plant No. 1

Anchor Dam and Reservoir

Anchor Dam is a concrete thin-arch dam in a narrow gorge on the South Fork of Owl Creek. The structure is 208 feet high with a crest length of 660 feet. The spillway is an uncontrolled overflow type notched into the central part of the dam, with a maximum discharge capacity of 13,500 cubic feet per second. Reservoir discharge is provided by two 30-inch-diameter conduits through the dam at the left end of the spillway, controlled by 30-inch hollow-jet valves located in a valve house on the downstream face of the dam. One 3.25-foot-square slide gate is provided at the upstream face of the dam for each outlet for emergency closure and servicing. A 42-inch-diameter conduit through the dam is provided for evacuation of the reservoir, controlled by a 3.25-foot-square slide gate at the upstream face. Anchor Reservoir has an active capacity of 17,160 acre-feet with a surface of 437 acres. During the initial filling of the reservoir, a series of sinkholes and leaks developed. To correct these conditions, sinkholes have been filled and leaks blanketed with earth. Progress has been made in improving the effectiveness of the reservoir and some benefits are realized for irrigation and flood control. Usually enough water can be stored during runoff to extend the irrigation deliveries into late July or early August.

Lucerne Pumping Plants

Lucerne Pumping Plant No. 1 is about 3.5 miles north of Thermopolis. It consists of two pumps operating under a 67-foot head, which deliver 40 cubic feet per second to the Lucerne Ditch, and two pumps operating under a 136-foot head delivering 44 cubic feet per second into the Lucerne Relift Canal to supply Plant No. 2. Plant No. 2 has two pumps operating under a 24.5-foot head to relift 33 cubic feet per second from the Lucerne Relift Canal to the Dempsey Ditch. This plant, of open-type construction, is at the end of the Lucerne Relift Canal. The ditches and other irrigation facilities are provided by and maintained by the irrigation district.

DEVELOPMENT

Early History

After early settlement of Owl Creek Valley in 1871, the development of irrigated agriculture followed rapidly. The first water rights were recorded in 1880. By 1905, the inhabitants of the area realized that the irrigated acreage had surpassed the available water supply from the creek. However, individual landowners were permitted to continue making application for water rights, and rights for approximately 28,800 acres are now recognized on the stream, although the average cropped acreage is about 17,000.

Investigations

For more than 50 years attempts have been made by local farmers and ranchers to sponsor a project for augmenting the supply of irrigation water in Owl Creek. As early as 1909, a small group of landowners employed an engineer to determine whether additional water could be brought into the Owl Creek drainage area from Wind River. Beginning about 1934, various organizations were formed to develop specific storage or pumping facilities. After experiencing extreme shortages of irrigation water during 1930-40, the assistance of the Bureau of Reclamation was requested in developing a program to relieve excessive fluctuations in the water supply.

Reclamation conducted a series of investigations beginning in 1941 and discussed a storage development with local water users in 1946. These discussions culminated in 1947 in the formation of the Owl Creek Irrigation District, which included 13,324 acres of irrigated land. This district serves as the contracting entity for the supplemental supply to be furnished from Anchor Reservoir and for the development under the Lucerne pumping system.

Authorization

The project was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of Anchor Dam began in 1957 and was completed in 1960. Lucerne Pumping Plants No. 1 and 2 and the Lucerne Relift Canal were completed in 1956.

Operating Agency

Operation and maintenance are performed by the Owl Creek Irrigation District.

BENEFITS

Irrigation

Livestock production is the major enterprise in the unit. Grains and hay for livestock are the principal crops. Beets, dry beans, and corn also are grown in the lower area. Stabilization of the water supply makes possible the extension of these row crops into the middle area.

Recreation and Fish and Wildlife

Benefits for fish and wildlife and recreation opportunities are provided. In 1977, there were 300 visitor days.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation	11,251	acres
Number of irrigated farms	60	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	10,891	610,574
1969	10,921	618,100
1970	10,645	548,742
1971	10,921	677,691
1972	10,921	691,244
1973	10,921	1,155,750
1974	10,921	1,374,661
1975	10,921	1,160,127
1976	10,921	1,967,015
1977	10,921	1,557,945

Facilities in Operation

Storage dams	1	
Pumping plants	2	
Canals	4.8	mi

Climatic Conditions

Annual precipitation	13	in
Temperature:		
Maximum	109	°F
Minimum	−37	°F
Mean	44	°F
Growing season	109-126	days
Elevation of irrigable area	4350-6300.0	ft

Settlement

Number of persons served with project water (1977)	
Farm irrigation service	250

ENGINEERING DATA

Water Supply

WIND RIVER

Drainage area above Boysen Dam	7,700	mi²
Annual discharge below Boysen Dam:		
Maximum (1965)	1,448,000	acre-ft
Minimum (1961)	444,100	acre-ft
Average	1,036,600	acre-ft

SOUTH FORK, OWL CREEK

Drainage area above Anchor Dam	125	mi²
Annual discharge near Anchor Dam:		
Maximum (1974)	22,000	acre-ft
Minimum (1977)	8,600	acre-ft
Average	15,400	acre-ft

Storage Facilities

ANCHOR DAM

Type: Concrete thin arch
Location: South Fork, Owl Creek, about 35 mi west of Thermopolis, Wyo.
Construction period: 1957-60
Date of closure (first storage): November 1960
Reservoir, Anchor:

Total capacity to El. 6441	17,228	acre-ft
Active capacity, El. 6345-6441	17,160	acre-ft
Surface area	437	acres
Dimensions:		
Structural height	208	ft
Hydraulic height	146	ft
Top width	13.7	ft
Maximum base width	54.2	ft
Crest length	660	ft
Crest elevation	6452.5	ft
Total volume	69,000	yd³

Spillway: Uncontrolled overflow weir set in a notch in the crest of the dam, discharging from a ski-jump-type bucket.

Crest length	100	ft
Crest elevation	6441.0	ft
Capacity at El. 6451.5	13,500	ft³/s

Outlet works: Two 30-in conduits through the dam, controlled by 30-in hollow-jet valves.

Capacity at El. 6381	300	ft³/s

Carriage Facilities

Lucerne Pumping Ditch

Location: From existing heading on the Bighorn River about 4 mi north of Thermopolis, generally north to Lucerne Pumping Plant No. 1.
Construction period: 1956
Dimensions:

Length	0.7 mi
Diversion capacity	94 ft³/s
Typical maximum section in earth:	
Bottom width	8 ft
Side slopes	1.5:1
Water depth	3 ft

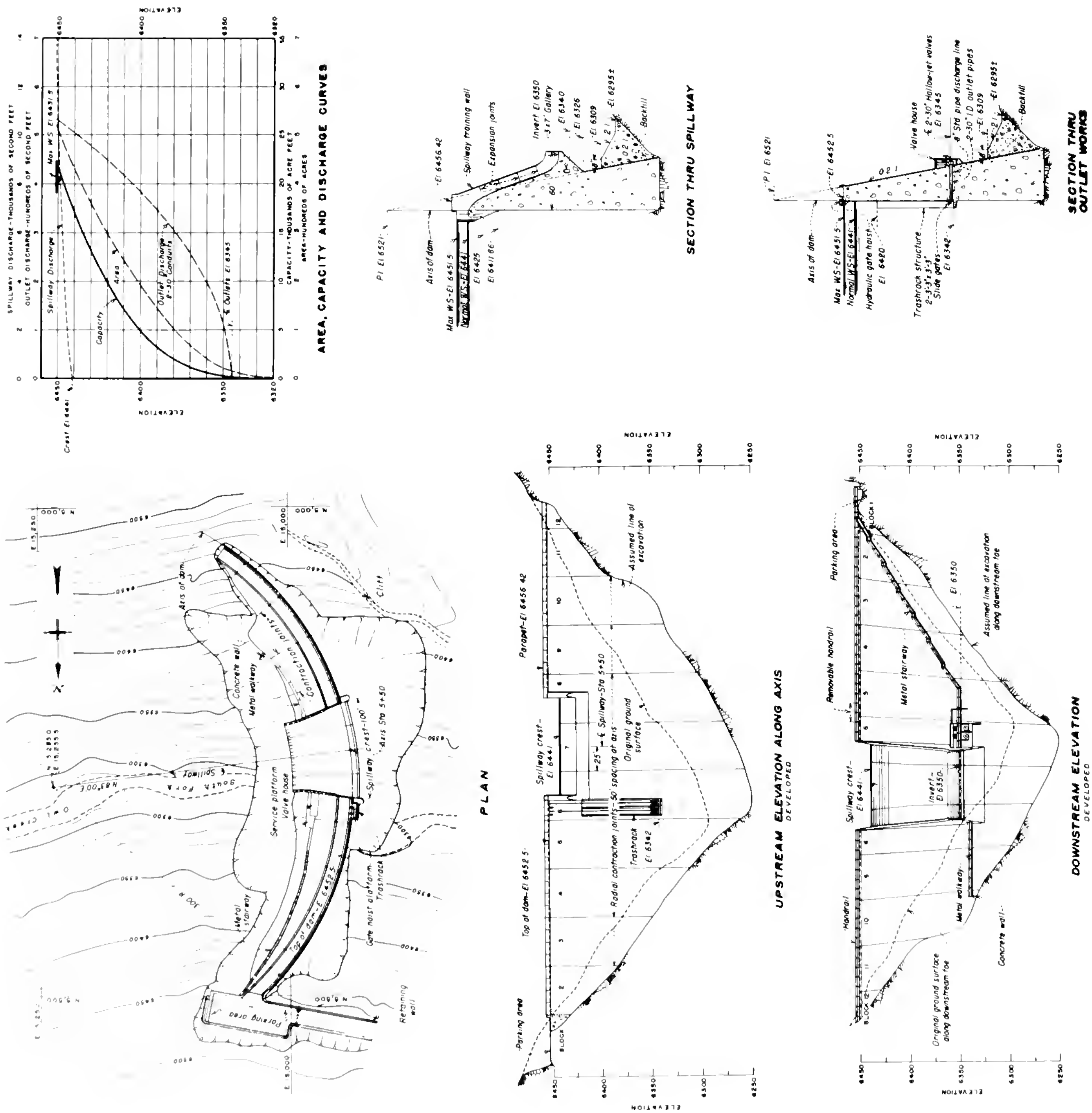
Lucerne Relift Canal

Location: From Lucerne Pumping Plant No. 1, about 5 mi north of Thermopolis, generally west to Lucerne Pumping Plant No. 2.
Construction period: 1956
Dimensions:

Length	3 mi
Diversion capacity	44 ft³/s
Typical maximum section in earth:	
Bottom width	7 ft
Side slopes	1.5:1
Water depth	2.1 ft
Typical maximum section, concrete lined:	
Bottom width	4 ft
Side slopes	1.25:1
Water depth	1.92 ft
Lining thickness	3 in

Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Lucerne No. 1	4	84	67-136	1,300
Lucerne No. 2	2	33	24.5	120



Anchor Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Polecat Bench Area, Shoshone Extensions Unit
(Advance Planning)

Wyoming: Park County

Upper Missouri Region
Water and Power Resources Service

The Polecat Bench Area is in northwestern Wyoming, immediately south of the Montana State line and north of the existing Shoshone Project. The project will irrigate 19,260 acres, 17,600 acres on Polecat Bench and 1,660 acres on Frannie Loop. The proposed development will include a fish and wildlife plan and a recreation site.

PLAN

The Polecat Bench Area is a physical extension of the Shoshone Project. Water for the project will be stored in the existing Buffalo Bill Reservoir, west of Cody, Wyo. Delivery will be made through the existing Shoshone Canyon Conduit and Heart Mountain Canal that now serve the Heart Mountain Division of the Shoshone Project. Polecat Canal will begin at the terminus of the Heart Mountain Canal and extend to Holden Reservoir on the bench. Holden Canal will begin at Holden Reservoir and with its lateral system will complete the irrigation deliveries on the bench. The water will then enter a pipe system that will use the vertical drop off the bench to generate sufficient pressure for irrigation of the Frannie Loop area with sideroll sprinklers. Other facilities include a pumping plant on the southwest end of the bench, laterals, and drains.

Holden Dam and Reservoir

Holden Dam will be an earthfill structure with a maximum height of 65 feet above natural ground, a crest length of approximately 6,070 feet, and a graveled road across the crest. Three small dikes will be required to contain the reservoir at maximum capacity.

The 4-foot-wide spillway will provide for a maximum emergency discharge of 98 cubic feet per second over a fixed crest. The spillway will be incorporated in a concrete structure that also will contain the outlet control works.

Holden Reservoir will be an offstream storage feature on Polecat Bench. The total capacity at elevation 5001.5 will be 9,900 acre-feet.

Canals and Laterals

The water distribution system for the Polecat Bench Area will consist of approximately 76 miles of open canals, tunnels, and siphons, and 3.9 miles of pressure pipe in the Frannie Loop distribution system.

The main canals are Polecat and Holden Canals. Polecat Canal, with a constant capacity of 212 cubic feet per second, will begin at the terminus of Heart Mountain Canal, extend northeastward about 18 miles, and end with a chute into the proposed Holden Reservoir. Holden Canal will originate at the outlet works of Holden Reservoir with an initial capacity of 164 cubic feet per second. It will have a total length of 8.4 miles to the point on the edge of the bench where it enters the pressure pipe system that will serve the lands on Frannie Loop.

Pumping Plant

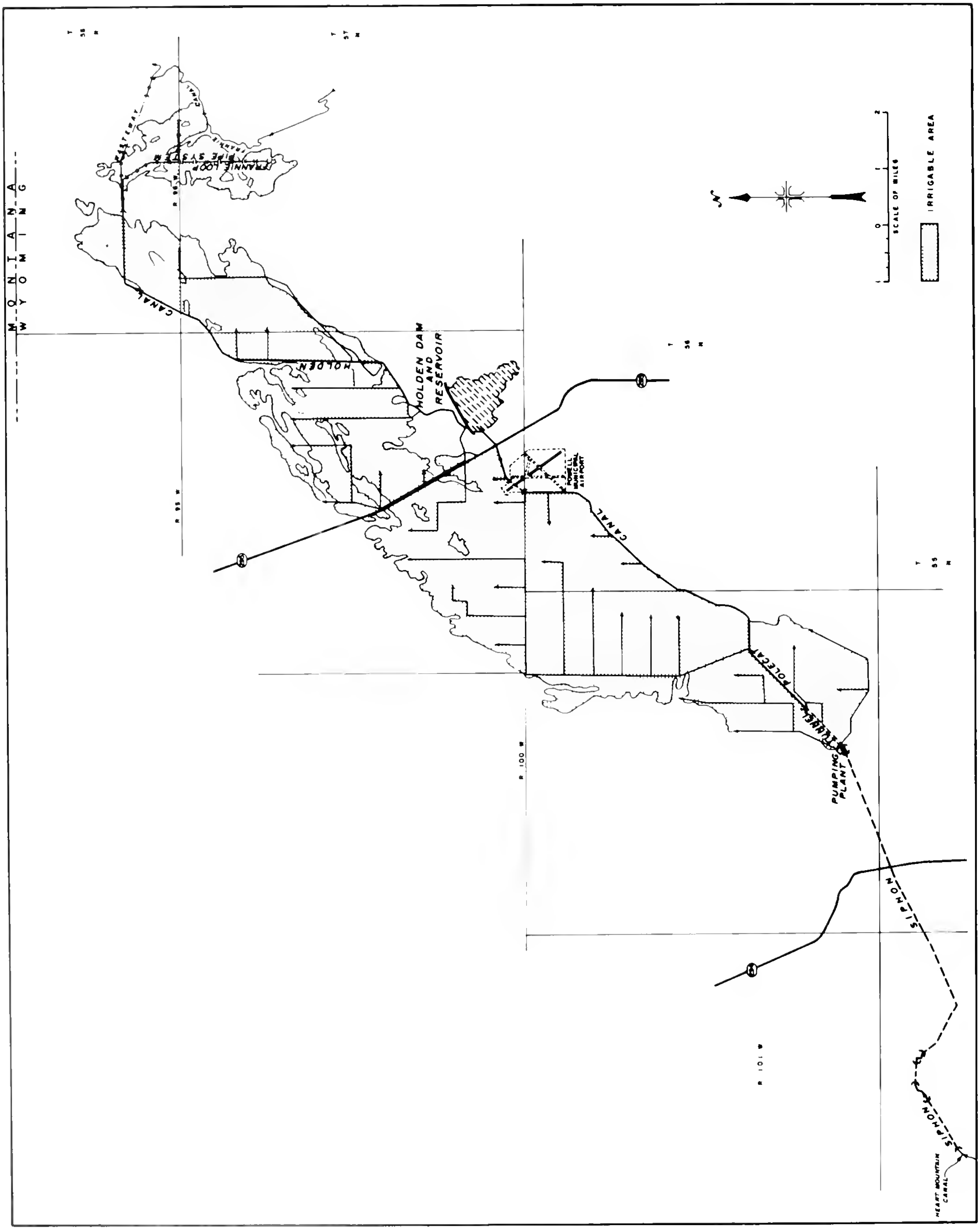
The Polecat Bench Pumping Plant will pump water from Polecat Canal to 2,760 irrigable acres on the southwest end of the bench that cannot be supplied by gravity. The design capacity of this pumping plant will be 78.9 cubic feet per second (rated capacity of 68.6 cubic feet per second) pumping against a total head of 67 feet.

DEVELOPMENT

Early History

The first homestead claim was filed on Polecat Bench in 1909. Irrigation facilities were not available and dryland farming was so difficult that the last homesteader on the bench moved to Powell in 1929.

Many of the early homesteading cabins were moved from Polecat Bench with horsedrawn block and tackle. As a result, few remains of the early homesteading era can be seen on the bench. Lumber was always in short supply and those buildings not moved were readily dismantled and the wood used elsewhere.



Polecat Bench Area

Polecat Bench Area

Investigations

Shoshone Project was originally planned for irrigation of a much larger area than has been developed. During early planning of the Heart Mountain Division in 1919, preliminary surveys were made on Polecat Bench and Chapman Bench. Also, under consideration were plans to include areas to the south of the Shoshone Project.

During surveys and studies leading to formulation of the plan presented in Senate Document No. 191, 78th Congress, it was concluded that excess Shoshone River water might be used on the lands to the south. However, later investigations disclosed that only very small portions of the land to the south would meet revised land classification standards. Therefore, the overall plan was revised to include the Polecat Bench and Frannie Loop areas, to be known as the Shoshone Extensions Unit (North) and the areas to the south of Dry Creek, to be known as Shoshone Extensions Unit (South).

A detailed land classification was completed in the Polecat Bench and Frannie Loop areas in 1953. Because of the principal landowner's opposition to development, as expressed in December 1954, a report was not completed.

A new interest developed when the largest landholding was sold in the spring of 1963 to owners who were actively in favor of irrigation development on Polecat Bench. As a further indication of local support, a number of owners of small farms within the Shoshone Project expressed the desire to be given preference when irrigable lands in the Polecat Bench Area now in public domain are opened to settlement. This support led the Congress to appropriate funds through the Public Works Appropriation Act of fiscal year 1964 for detailed investigations.

A feasibility report was published in December 1966 (revised July 1967). In March 1970 a reevaluation statement was prepared which updated the economic and financial analyses. These two reports were published as House Document No. 92-340, 92nd Congress, 2nd session.

Congressional hearings on Polecat Bench were held in 1972 in Powell, Wyo., and in Washington, D.C.

Authorization

Polecat Bench Area, Shoshone Extensions Unit, is part of the Pick-Sloan Missouri Basin Program. It was authorized for construction by the act of March 11, 1976 (90 Stat. 205), Public Law 94-228, 94th Congress.

Construction

Completion of a definite plan report is scheduled for fiscal year 1979. Estimated construction time for most of the project works and facilities is about 4.5 years, beginning in fiscal year 1981.

BENEFITS

Irrigation

With irrigation development, the area will develop irrigated land use similar to the type prevalent on the Shoshone Project. This would be cash crop farming (primarily sugar beets, barley, and dry edible beans) in conjunction with a livestock feeding enterprise.

Recreation and Fish and Wildlife

Only minimum basic facilities will be supplied for the fish and game and recreation functions since no non-Federal entity is willing to cost-share the facilities. It is estimated that the proposed Holden Reservoir will have 10,000 visitor-days annually, and the area will attract hunting estimated at 475 big game hunter-days and 305 small game hunter-days.

PROJECT DATA

Climatic Conditions

Annual precipitation	8	in
Temperature:		
Maximum	103	°F
Minimum	−36	°F
Mean	44	°F
Growing season	136	days
Elevation of irrigable area	5000.0	ft

ENGINEERING DATA

Water Supply

SHOSHONE RIVER

Drainage area above Buffalo Bill Dam	1,520	mi²
Annual discharge below Buffalo Bill Dam:		
Maximum (1928)	1,359,400	acre-ft
Minimum (1961)	445,600	acre-ft
Average	861,700	acre-ft

Storage Facilities[1]

HOLDEN DAM

Type: Earthfill		
Location: Offstream - Shoshone River.		
Reservoir, Holden:		
Total capacity to El. 5001.5	9,900	acre-ft
Active capacity	8,500	acre-ft
Surface area	600	acres
Dimensions:		
Structural height	65	ft
Hydraulic height	55	ft
Crest width	30	ft
Maximum base width	380	ft
Crest length	6,070	ft
Crest elevation	5011.0	ft
Spillway: Fixed-crest		
Crest length	4	ft
Crest elevation	5001.5	ft
Capacity at El. 4984	98	ft³/s
Outlet works: Capacity at El. 4948	164	ft³/s

Carriage Facilities[1]

POLECAT CANAL

Location: From the 27-mile mark of Heart Mountain Canal northeasterly to Holden Reservoir.		
Length	18	mi
Capacity	212	ft³/s
Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	2:1	
Water depth	4.6	ft

HOLDEN CANAL

Location: From outlet works of Holden Reservoir to beginning of Frannie Loop pressure pipe system.		
Length	8.4	mi
Capacity	164	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	2:1	
Water depth	2.9	ft

POLECAT BENCH PUMPING PLANT

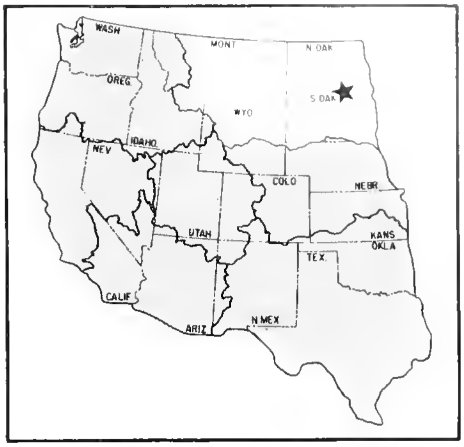
Location: About 9 mi southwest of Holden Dam.		
Number of units	5	
Total capacity	68.6	ft³/s
Total dynamic head	67	ft
Total horsepower	700	

[1]These features are authorized but not constructed.

Pick-Sloan Missouri Basin Program
Pollock-Herreid Unit
(Advance Planning)

South Dakota: Campbell County

Upper Missouri Region
Water and Power Resources Service



The Pollock-Herreid Unit is a multipurpose development plan for diversion of water by pumping from Lake Oahe to irrigate 15,000 acres of land. The unit is situated in the extreme north-central part of South Dakota, immediately south of the North Dakota-South Dakota boundary. Benefits also would accrue for fish and wildlife conservation and resources, and municipal and industrial water needs.

PLAN

Water for the Pollock-Herreid Unit would be pumped from Lake Oahe and conveyed through the 7-mile Pollock Canal to existing Lake Pocasse, a subimpoundment of Lake Oahe, which will serve as the regulatory reservoir. Lake Oahe is an impoundment on the Missouri River, formed by Oahe Dam. The dam was constructed by the Corps of Engineers for multipurposes, including flood control, hydroelectric power generation, navigation, and irrigation. Water would be diverted from Lake Pocasse for irrigation by pumping into the 18-mile Herreid Canal, and then conveyed to the irrigable lands through a series of laterals totaling about 56 miles in length. A drainage system totaling 50 miles of open drains and 115 miles of closed drains (pipe) also would be provided.

DEVELOPMENT

Early History

The general north-central area of South Dakota, which includes the Pollock-Herreid Unit, was open for homestead entry by 1873. There was a great influx of settlers from about 1876 to 1883, along with extensive railroad development. The area experiences highly variable annual precipitation patterns, which affect crop production and the stability of the agricultural economy of the area.

The Flood Control Act of 1944 and the completion of the Oahe Dam have contributed to the continuing interest in irrigation development for the area.

Investigations

The Bureau of Reclamation made the initial investigation for possible irrigation of the Pollock-Herreid Unit. The 1959 report on the study showed that the unit was not feasible for gravity irrigation development. Subsequently, local irrigation interests urged a feasibility study for sprinkler irrigation development that would use Lake Pocasse as a regulatory impoundment. This study was initiated in 1964, and in 1968 a report identified the unit as feasible and economically justified for sprinkler irrigation. Supplemental economic evaluations were made in 1971 and 1975 to reflect continuing changes in interest rates, costs, and benefits.

Authorization

The Pollock-Herreid Unit is a part of the Pick-Sloan Missouri Basin Program which was authorized by the Flood Control Act of 1944 (58 Stat. 887) as supplemented and extended by the Flood Control Act of 1946 (60 Stat. 641). The provisions of Public Law 88-442 (78 Stat. 446) required authorization by the Congress of any units of the program on which construction was not underway before August 14, 1964. The Pollock-Herreid Unit was specifically authorized by the Omnibus Bill under Public Law 94-228 on March 11, 1976. An advance planning study for the unit was initiated in 1977.

Operating Agency

The Pollock-Herreid Irrigation District, which encompasses the Pollock-Herreid Unit, was formed on February 8, 1963. The district will serve as the contracting entity for operation and maintenance.

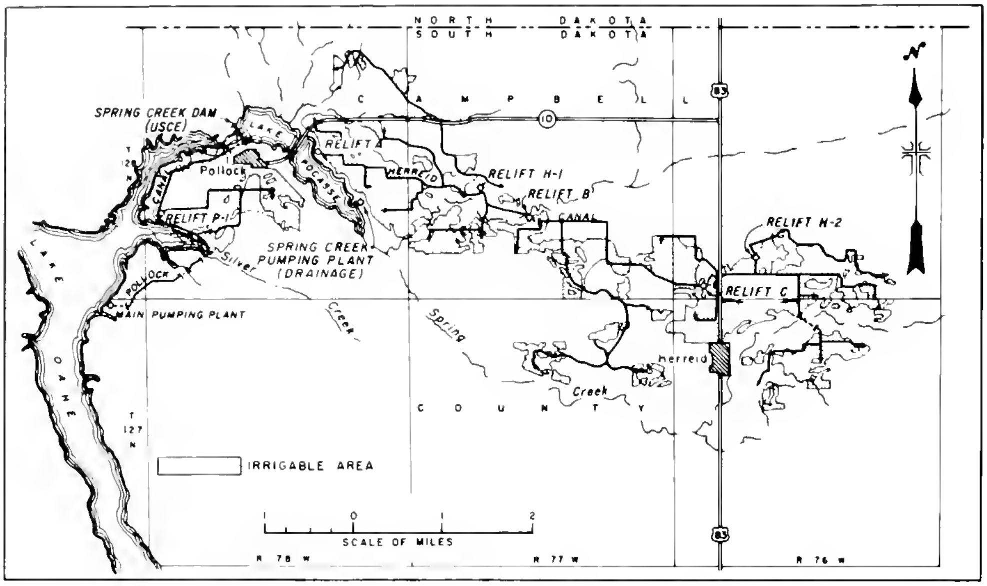
BENEFITS

Irrigation

Principal crops expected to be grown under irrigation development include crops now raised under dryland conditions in the area, such as alfalfa, small grain, and corn.

Municipal and Industrial Water

Pollock and Herreid, S. Dak., would receive municipal and industrial water supplies from the Pollock-Herreid Unit facilities.



Pollock-Herreid Unit

Fish and Wildlife

Lake Pocasse would function as the regulatory storage for the Pollock-Herreid Unit; however, it would continue to be managed by the Fish and Wildlife Service as part of the Pocasse National Wildlife Refuge. About 1,050 acres of marsh land and upland would be developed and managed for enhancing wildlife habitat.

PROJECT DATA

Land Areas (Authorized)

Irrigable area:

Full irrigation service	15,000	acres

Climatic Conditions

Annual precipitation	15	in
Temperature:		
Maximum	118	°F
Minimum	−51	°F
Mean	43	°F
Growing season	124	days
Elevation of irrigable area	1625-1800.0	ft

ENGINEERING DATA

Water Supply

LAKE OAHE

Drainage area at Oahe Dam	243,500	mi²
Annual discharge near Pierre, S. Dak.:		
Maximum (1976)	26,235,000	acre-ft
Minimum (1963)	13,328,900	acre-ft
Average	18,698,500	acre-ft

Storage Facilities:

OAHE DAM AND LAKE OAHE (existing, constructed and operated by Corps of Engineers)

Type: Rolled earth
Location: On Missouri River about 6 mi north of Pierre, S. Dak.
Construction period: 1948-62

Active (multiuse) storage capacity	16,962,000	acre-ft

LAKE POCASSE (existing, constructed by Corps of Engineers and operated by Fish and Wildlife Service)

Type: Zoned earthfill
Location: Subimpoundment of Lake Oahe on Spring Creek near Pollock, S. Dak.
Construction period: 1961

Total capacity	11,000	acre-ft
Surface area	1,560	acres

Carriage Facilities (Authorized)

POLLOCK CANAL

Location: Lake Oahe to Lake Pocasse.

Length	7	mi
Capacity	170	ft³/s
Typical maximum section in earth:		
Bottom width	16	ft
Side slopes	2:1	
Water depth	4.4	ft

HERREID CANAL

Location: Lake Pocasse easterly to lower end of unit.

Length	18	mi
Initial capacity	240	ft³/s
Typical maximum section in earth:		
Bottom width	16	ft
Side slopes	2:1	
Water depth	5.1	ft

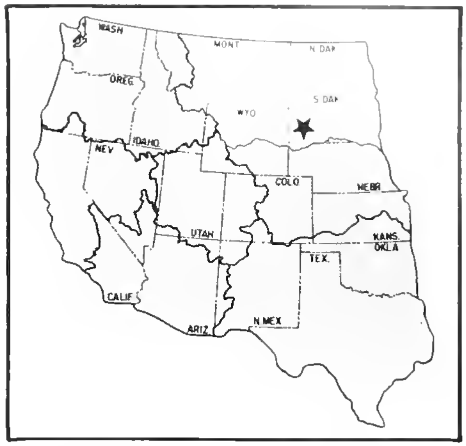
PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Main	4	170	110	3,200
Relift A	6	240	56	2,100
Relift B	4	160	44	1,100
Relift C	4	100	72	1,100
Relift P-1	3	40	32	240
Relift P-2	3	14	56	140
Relift H-1	3	31	33	175
Relift H-2	3	18	41	135
Spring Creek	2	20	24	80

Pick-Sloan Missouri Basin Program
Rapid Valley Unit

South Dakota: Pennington County

Upper Missouri Region
Water and Power Resources Service



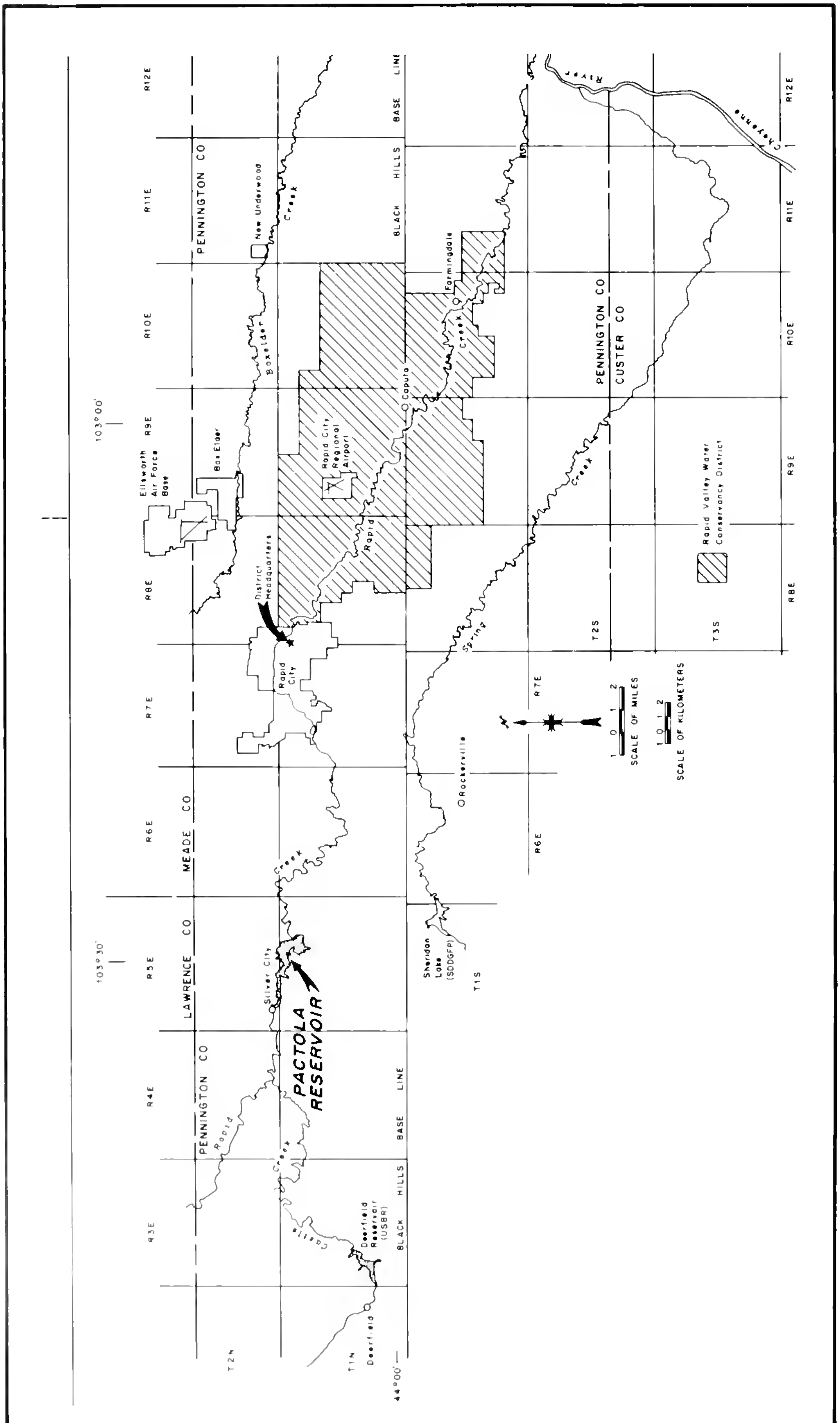
Rapid Valley Unit consists of Pactola Dam and Reservoir located on Rapid Creek about 15 miles west of Rapid City, S. Dak. There are 8,900 acres of privately developed land and associated irrigation diversion and supply works in the Rapid Valley Water Conservancy District. The land is situated along Rapid Creek immediately downstream from Rapid City for a distance of about 20 miles and is provided a supplemental irrigation water supply from Pactola Reservoir. The reservoir provides the major supply of water for Rapid City, including Ellsworth Air Force Base, and flood protection along Rapid Creek. Fish and wildlife benefits also are provided, along with water-based recreation opportunities.

Pactola Reservoir supplements the supply of stored water available from Deerfield Reservoir (Rapid Valley Project). Thus a full water supply is provided for irrigation and municipal purposes.

Pactola Dam

Pactola Dam is a zoned earthfill structure, 230 feet high, 40 feet wide at the crest, and 1,255 feet long. It has an open-cut channel spillway in the left abutment with a 240-foot uncontrolled concrete crest and a design capacity of 38,400 cubic feet per second. The outlet works consist of a concrete horseshoe-shaped tunnel through the left

Pactola Dam



Rapid Valley Unit

abutment with two high-pressure slide gates. There are two dikes to the left of the spillway having a total crest length of 2,100 feet. Pactola Reservoir has a total storage capacity of 99,000 acre-feet, of which 43,000 acre-feet is exclusive flood control storage, regulated by the Corps of Engineers. Conservation storage amounts to 55,000 acre-feet; dead and inactive storages total 1,000 acre-feet. Water surface area at spillway crest level is 1,232 acres.

DEVELOPMENT

Early History

Prior to the gold rush of 1876, Indians hunted in the Black Hills, adjoining foothills, and surrounding prairie lands. The gold rush brought a great influx of people to the area, and subsequent clashes between the Indians and the newcomers resulted in deeding the Black Hills area to the Federal Government. Rapid City was founded in 1876. The first railroad reached Rapid City in 1886, and extensive development soon followed.

Investigations

Interest in developing the water resources of Rapid Creek was accentuated by realization that additional sources of water were necessary to meet the irrigation and municipal water needs of the general area. In 1948, landowners in the Rapid Valley Water Conservancy District and adjoining areas petitioned the Bureau of Reclamation to construct Pactola Dam and Reservoir for storage of irrigation water. In 1949, the city commissioners of Rapid City submitted a resolution to Reclamation requesting storage in a proposed Pactola Reservoir for municipal uses, including water for Ellsworth Air Force Base. Reclamation undertook a thorough investigation of potential dam and reservoir sites and irrigation and municipal water needs.

Authorization

The Rapid Valley Unit was included in the plan for development of the Missouri River Basin as outlined in Senate Document 191, 78th Congress, and authorized by the Flood Control Act of 1944 (Public Law 534). This approved the general comprehensive plan set forth in Senate Document 191 and House Document 475 as revised and coordinated by Senate Document 247, 78th Congress, 2nd session.

Construction

Construction of Pactola Dam began November 25, 1952, and was completed on August 15, 1956.

Operating Agency

Pactola Dam and Reservoir are operated and maintained by the Bureau of Reclamation on a pooled storage basis with Deerfield Reservoir (Rapid Valley Project). Water became available from Pactola Reservoir on May 1, 1958.

BENEFITS

Irrigation

Supplemental stored water is available to the 8,900 acres of irrigated land within the Rapid Valley Water Conservancy District. Under present conditions, the integrated irrigation-dryland farms produce corn, alfalfa, small grains, and pasture. The principal products contribute to a stable feed supply for stockcow herds and fattening of cattle.

Municipal Water

The major portion of the municipal water needs for Rapid City, including the Ellsworth Air Force Base, is provided from storage in Pactola Reservoir.

Flood Control

Pactola Reservoir provides flood protection benefits to Rapid City and to agricultural lands and rural and suburban developments along Rapid Creek.

Recreation and Fish and Wildlife

Numerous facilities associated with outdoor recreation are provided at Pactola Reservoir, including picnic grounds, campgrounds, and boat ramp developments, in addition to a visitor center and scenic overlooks. The recreation areas are administered by the Forest Service. Visitor days for 1977 totaled 638,900. The combined cold and warm water fishery at the reservoir is maintained by the South Dakota Department of Game, Fish, and Parks.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	8,900	acres
Number of irrigated farms	56	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,000	297,040
1969	7,100	373,955
1970	7,400	496,230
1971	7,500	378,250
1972	7,200	311,265
1973	7,448	529,165
1974	7,265	930,600
1975	7,160	659,878
1976	7,324	880,851
1977	7,203	871,906

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	17.4	in
Temperature:		
Maximum	107	°F
Minimum	−34	°F
Mean	47	°F
Growing season	150	days
Elevation of irrigable area	3000.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	299
Municipal water service	43,800
Total	44,099

ENGINEERING DATA

Water Supply

Rapid Creek drainage area above Pactola Dam	319	mi²
Annual discharge at Pactola Dam:		
Maximum (1965)	72,200	acre-ft
Minimum (1962)	9,400	acre-ft
Average	29,500	acre-ft

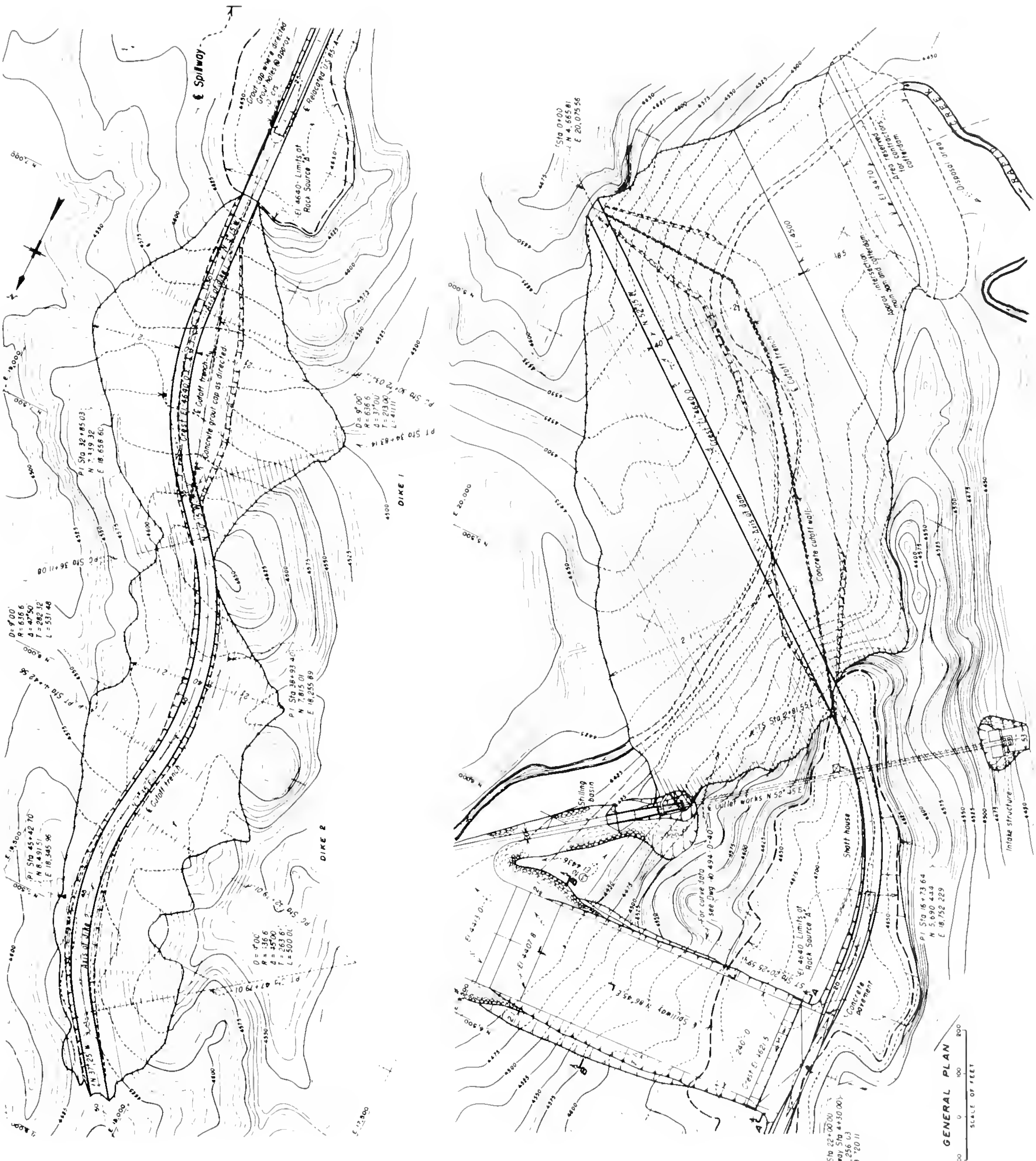
Storage Facilities

PACTOLA DAM

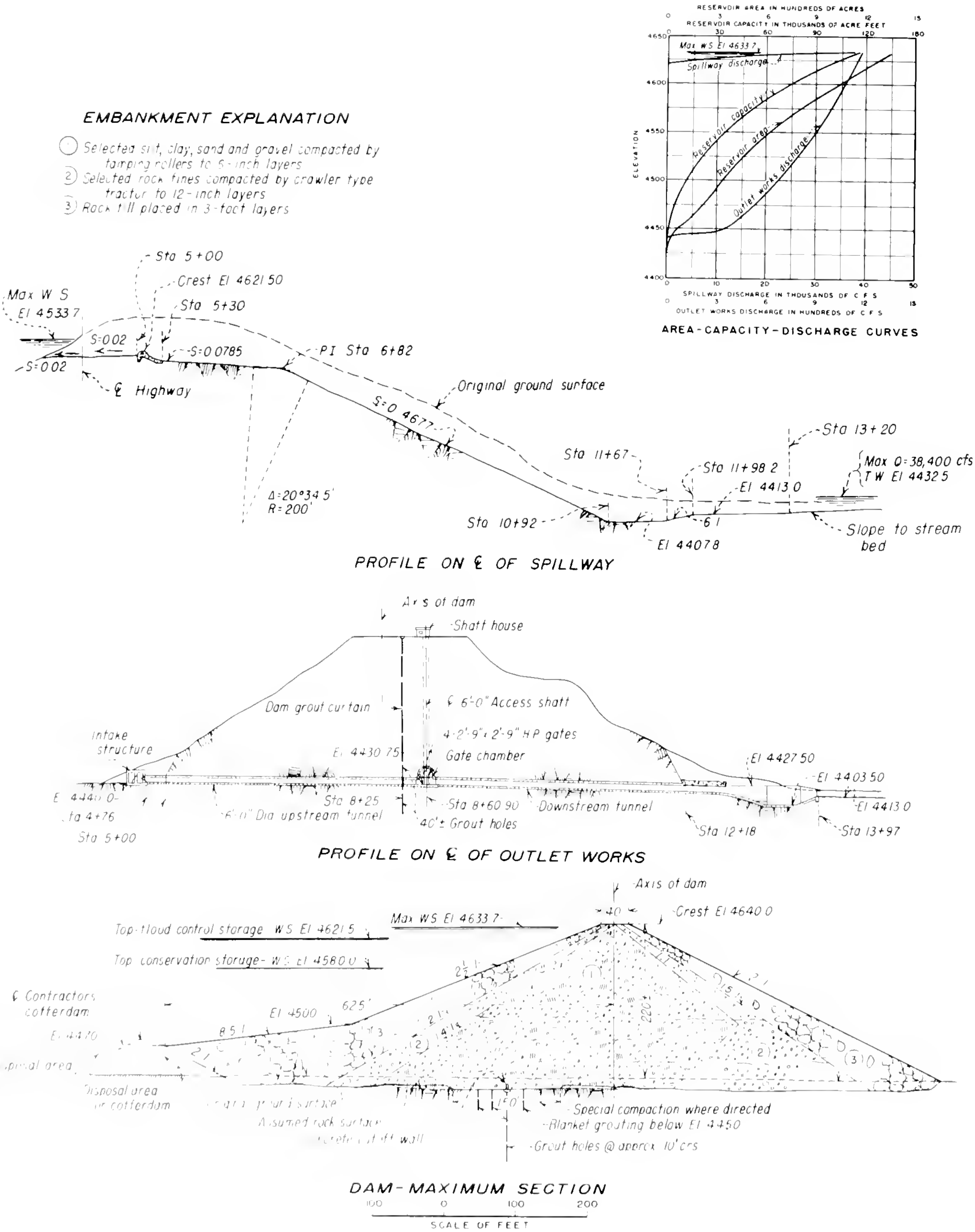
Type: Zoned earthfill. Two dikes to the left of the spillway total 2,100 ft in length.
Location: On Rapid Creek 15 mi west of Rapid City, S. Dak.
Construction period: 1952-56
Date of closure (first storage): August 1956

Reservoir, Pactola:		
Total capacity to El. 4621.5	99,000	acre-ft
Active capacity, El. 4456.1-4580.2	55,000	acre-ft
Surface area	1,232	acres
Dimensions:		
Structural height	230	ft
Hydraulic height	220	ft
Top width	40	ft
Maximum base width	1,100	ft
Crest length	1,255	ft
Crest elevation	4640.1	ft
Total volume	4,225,000	yd³
Spillway: Uncontrolled concrete crest and open cut channel in left abutment.		
Crest length	240.5	ft
Crest elevation	4621.5	ft
Capacity at El. 4633.7	38,400	ft³/s
Outlet works: Concrete-lined tunnel through left abutment, controlled by two 2.75-ft-square high-pressure slide gates.		
Capacity at El. 4633.7	1,150	ft³/s

Foundation—Special treatment: Grout blanket and grout curtain under cutoff wall; abutments grouted.



Pactola Dam, Plan

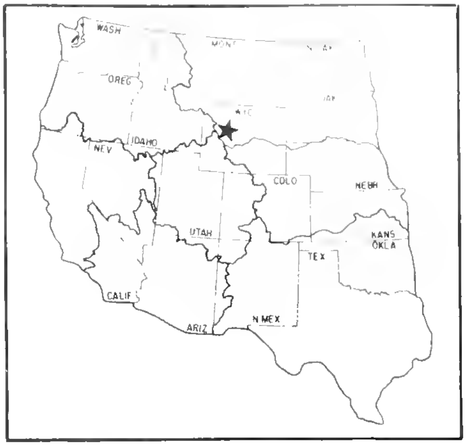


Pactola Dam, Sections

Pick-Sloan Missouri Basin Program
Riverton Unit

Wyoming: Fremont County

Upper Missouri Region
Water and Power Resources Service



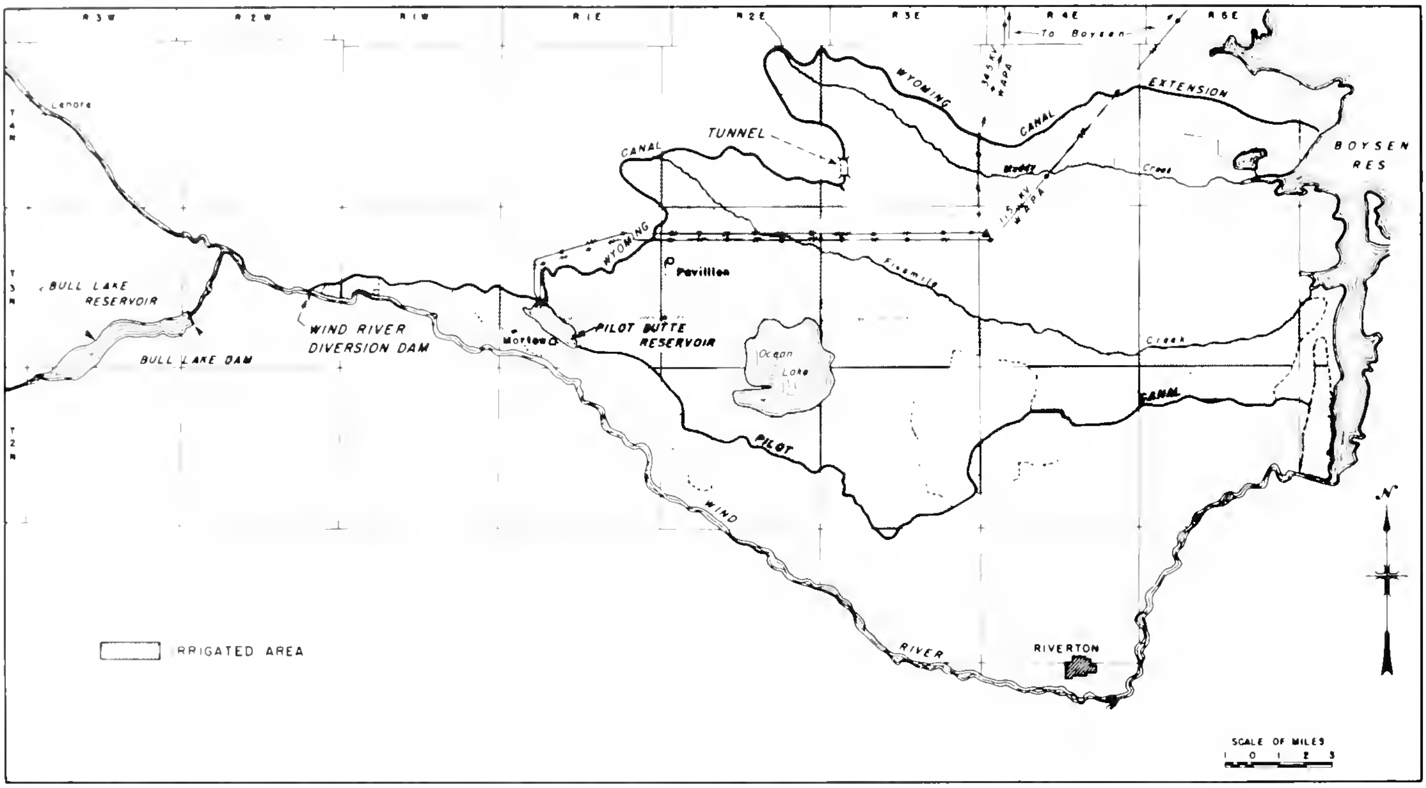
PLAN

The Riverton Unit is located in central Wyoming in Fremont County on the ceded portion of the Wind River Indian Reservation. The unit lands lie in the Wind River Basin and to the north of the river. Direct flow water from Wind River and stored water from Bull Lake Creek are used to provide irrigation service to 59,713 acres.

Unit features are Bull Lake Dam, Pilot Butte Dam, Wind River Diversion Dam, and Pilot Butte Powerplant, together with approximately 100 miles of main canals, 300 miles of laterals, and 335 miles of drains.

The unit receives its water supply from the Wind River and its tributaries. The principal storage is provided by Bull Lake Reservoir on Bull Lake Creek. Supplemental storage is provided by Pilot Butte Reservoir, an off-stream reservoir supplied with water diverted from the Wind River by the Wind River Diversion Dam. Water released from Bull Lake Reservoir flows through Bull Lake Creek to the Wind River where it augments the natural flow of that stream. Water for the unit lands is

Bull Lake Dam



Riverton Unit

delivered through the Wyoming Canal, which leads from the Wind River Diversion Dam to the Pilot Butte Reservoir and beyond to the distribution system. Pilot Canal flows in a generally easterly direction from Pilot Butte Reservoir, servicing lands lying south of those supplied by the Wyoming Canal.

Bull Lake Dam and Reservoir

Bull Lake Dam is a modified homogeneous earthfill dam 81 feet high and containing 820,000 cubic yards of material. The spillway is a concrete chute 100 feet wide, controlled by three automatic radial gates. The capacity of the spillway is 11,000 cubic feet per second. The capacity of the outlet works is 4,000 cubic feet per second. Bull Lake Dam creates a reservoir of 152,000 acre-feet.

Pilot Butte Dam and Reservoir

Pilot Butte Reservoir is located 10 miles below the Wind River Diversion Dam. It is formed by three earthfill embankments that constitute Pilot Butte Dam. The main embankment is 51 feet high and has a volume of 135,000 cubic yards. To complete the reservoir, two other embankments were required, one 25 feet high containing 51,000 cubic yards of material, and the other 12 feet high containing 19,000 cubic yards of material. The reservoir has an active capacity of 31,600 acre-feet.

Wind River Diversion Dam

Located 34 miles northwest of Riverton, Wyo., the Wind River Diversion Dam is a concrete weir with earth dikes, and has a hydraulic height of 19 feet and a volume of 124,000 cubic yards. The spillway is a concrete ogee weir with a capacity of 40,000 cubic feet per second. The outlet works to Wyoming Canal has a capacity of 2,200 cubic feet per second.

Powerplant and Transmission Lines

The Pilot Butte Powerplant, located at the drop from the Wyoming Canal to Pilot Butte Reservoir, has been shut down since June 15, 1973, because of high operation and maintenance costs and penstock problems. The plant had two generating units which operated under a maximum head of 105 feet with a total capacity of 1,600 kilowatts. Power was distributed over 76 miles of transmission lines.

Canal Distribution and Drainage Systems

There are two main canals in the unit. The Wyoming Canal is 62.4 miles long and has a capacity of 2,200 cubic feet per second; the Pilot Canal is 38.2 miles long with a capacity of 1,000 cubic feet per second. About 66 percent of the total length of these two canals is lined.

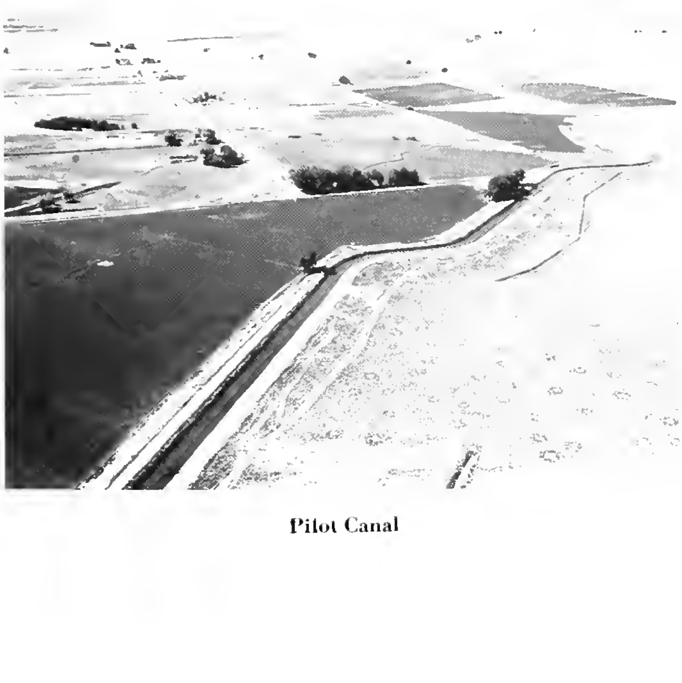
Pilot Butte Dam

A total of 300 miles, 104 miles lined and 6 miles of pipeline, make up the system of laterals. The drainage system extends 335 miles, of which 141 miles are closed pipelines.

DEVELOPMENT

Early History

Since the unit lands were largely included in the Wind River Indian Reservation during the earliest days of western development, settlement came comparatively late. On March 3, 1905, the Congress passed an act ratifying an agreement with the Indians of the Wind River Reservation, ceding lands north of Wind River to the United States. Provisions were made for the disposal of these lands under the homestead, townsite, coal, and mineral land laws.



Pilot Canal

Investigations

The first reference to the area as a possible irrigation project is found in the third annual report of the Reclamation Service. The reconnaissance was presumably made in July 1904. On February 20, 1906, the State of Wyoming was granted a permit to make a survey for the development of irrigable land. Following the survey by the State, a private company began construction of an irrigation project in the fall of 1906. Wyoming Canal No. 2 was placed in operation in 1908, and in 1915 the irrigation works for the Riverton Valley had been completed. In 1916-17, the Bureau of Reclamation conducted investigations of the higher lands of the project involving a greater cost per acre for the Office of Indian Affairs. All the vacant land within the project was withdrawn from entry and construction was begun on the project as an Indian irrigation project.

Authorization

The project was authorized for construction by the Secretary of the Interior on June 19, 1918, under the terms of the Indian Appropriation Act for fiscal year 1919, approved by the Congress on May 25, 1918. By the act of June 5, 1920, the project was placed under the jurisdiction of the Bureau of Reclamation. On September 25, 1970, Public Law 91-409 reauthorized the project as the Riverton Unit of the Pick-Sloan Missouri Basin Program.

Construction

Actual construction began on the main canal in January 1920. Construction of the Wind River Diversion Dam was started in July 1921 and completed in 1923.

In 1925, water was delivered to the project lands. Further construction was carried out in the 1930's and following the end of World War II. The construction period for Bull Lake Dam was 1936-38. Coincidental with the construction of canals and laterals to serve new lands in recent years, major work in draining land already irrigated has been carried out.

Rehabilitation and Betterment

The unit is being modified to include relief to water users, construction, betterment of works, land rehabilitation, water conservation, fish and wildlife conservation and development, flood control, and silt control on the entire unit. Unit modifications consist mainly of addition of sediment excluders at the Wyoming Canal headworks, repair of Wind River Diversion Dam, lining for main canals, lining and pipe for laterals, drains, and fish and wildlife facilities.

Operating Agency

The unit is operated and maintained by the Midvale Irrigation District.

BENEFITS

Irrigation

Principal crops are alfalfa, beans, alfalfa seed, sugar beets, barley, oats, wheat, sunflower seeds, and potatoes.

Recreation and Fish and Wildlife

Bull Lake Reservoir offers boating and good trout fishing. Ocean Lake, an offstream reservoir located in the center of the irrigated lands about 15 miles northwest of Riverton, is not a storage reservoir, but was created as a result of operation of the unit. With a surface area of 6,100 acres, this lake is famous for its crappie and ling fishing. Winter fishing is popular. A day-use camp has been provided by the Wyoming State Game and Fish Commission and several privately operated fishing camps rent cabins and boats to sportsmen. In 1977, the unit had 18,200 visitor days.

Flood Control

Bull Lake has greatly reduced flooding on Bull Lake Creek and contributes to the abatement of floods on the Wind River.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	59,713	acres
Number of irrigated farms	300	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	51,350	3,197,303
1969	52,187	4,026,213
1970	52,354	3,761,553
1971	53,030	4,161,568
1972	54,281	5,080,135
1973	54,679	7,830,103
1974	58,614	9,295,755
1975	58,218	10,182,038
1976	57,741	10,648,674
1977	53,949	7,625,215

Facilities in Operation

Storage dams	2	
Diversion dams	1	
Canals	100	mi
Laterals	300	mi
Drains	335	mi
Transmission lines	75.8	mi
Substations	3	

Climatic Conditions

Annual precipitation	9	in
Temperature:		
Maximum	101	°F
Minimum	−42	°F
Mean	44	°F
Growing season	142	days
Elevation of irrigable area	4700-5500.0	ft

Settlement

Number of persons served with project water (1977)	1,013	

ENGINEERING DATA

Water Supply

WIND RIVER

Drainage area above Crowheart, Wyo.	1,891	mi²
Annual discharge near Crowheart:		
Maximum (1951)	1,195,600	acre-ft
Minimum (1977)	484,800	acre-ft
Average	897,900	acre-ft

Storage Facilities

BULL LAKE DAM

Type: Modified homogeneous earthfill
Location: On Bull Lake Creek, 31 mi northwest of Lander, Wyo.
Construction period: 1936-38
Date of closure (first storage): April 1938

Reservoir, Bull Lake:		
Total capacity at El. 5805	152,500	acre-ft
Active capacity, El. 5739-5805	151,700	acre-ft
Surface area	3,157	acres
Dimensions:		
Structural height	81	ft
Hydraulic height	68	ft
Top width	30	ft
Maximum base width	544	ft
Crest length	3,456	ft
Crest elevation	5813.0	ft
Total volume	820,000	yd³
Spillway: Concrete-lined open channel near center of dam, controlled by three 29- by 11-ft radial gates.		
Elevation top of gates	5805.0	ft
Crest elevation	5794.0	ft
Capacity at El. 5805	11,000	ft³/s
Outlet works: Twin-section concrete conduit through base of dam, controlled by four 5-ft-square slide gates.		
Capacity at El. 5805	4,000	ft³/s

PILOT BUTTE DAM

Type: Zoned earthfill. Embankment Nos. 2 and 3 close low areas north of Embankment No. 1.
Location: Offstream, 22 mi northwest of Riverton, Wyo.
Construction period: 1922-26
Date of closure (first storage): December 1926

Reservoir, Pilot Butte:
Water supply is from Wind River through Wyoming Canal, heading at Wind River Diversion Dam.

Total capacity to El. 5460	36,900	acre-ft
Active capacity, El. 5410-5460	31,600	acre-ft
Surface area	900	acres

Dimensions:	*Embankment* No. 1	No. 2	No. 3
Hydraulic height	Offstream	Offstream	Offstream
Structural height	51 ft	25 ft	12 ft
Top width	19.4 ft	26 ft	12 ft
Maximum base width	220 ft	200 ft	60 ft
Crest length	1,300 ft	1,200 ft	3,400 ft
Crest elevation	5469.5 ft	5469.5 ft	5467.0 ft
Volume	135,000 yd³	51,000 yd³	19,000 yd³

Spillway: Uncontrolled concrete-lined open channel in right abutment of main embankment.

Crest length	100	ft
Crest elevation	5460.0	ft
Capacity at El. 5461.3	500	ft³/s

Outlet works: Concrete conduit through foundation near center of main embankment, controlled by three 4.8- by 6-ft slide gates.

Capacity at El. 5460	1,000	ft³/s

Diversion Facilities

WIND RIVER DIVERSION DAM

Type: Concrete ogee weir, embankment wing
Location: On Wind River; 32 mi northwest of Riverton, Wyo.
Year completed: 1923
Dimensions:

Structural height	37	ft
Hydraulic height	19	ft
Weir crest length	651	ft
Total crest length	2,464	ft
Weir crest elevation	5570.25	ft
Volume	124,000	yd³

Spillway: Concrete gravity, ogee

Capacity	40,000	ft³/s

Headworks: Concrete, six 10-ft-square radial gates.

Diversion capacity	2,200	ft³/s

Carriage Facilities

WYOMING CANAL

Location: From Wind River Diversion Dam on Wind River, about 32 mi northwest of Riverton, Wyo., generally northeast along northern edge of irrigated area.
Construction period: 1920-51

Length	62.4	mi
Diversion capacity	2,200	ft³/s
Typical maximum section in earth:		
Bottom width	65	ft
Side slopes	1.5:1	
Water depth	10	ft
Typical maximum section, concrete lined:		
Bottom width	12.5	ft
Side slopes	1.5:1	
Water depth	10	ft
Lining thickness	6	in

PILOT CANAL

Location: From Pilot Butte Reservoir generally southeast along southern edge of irrigated area.
Construction period: 1926-47

Length	38.2	mi
Diversion capacity	1,000	ft³/s
Typical maximum section in earth:		
Bottom width	30	ft
Side slopes	2:1	
Water depth	10	ft
Typical maximum section, lined with buried asphalt membrane:		
Bottom width	30	ft
Side slopes	2:1	
Water depth	10	ft

Power Facilities

PILOT BUTTE POWERPLANT

Location: At drop from Wyoming Canal to Pilot Butte Reservoir.
Year of initial operation: 1925
Year last generator placed in operation: 1929
Date of last operation: June 15, 1973

Nameplate capacity	1,600	kW
Number and capacity of generators ...... (2)	800	kW
Maximum head	105	ft

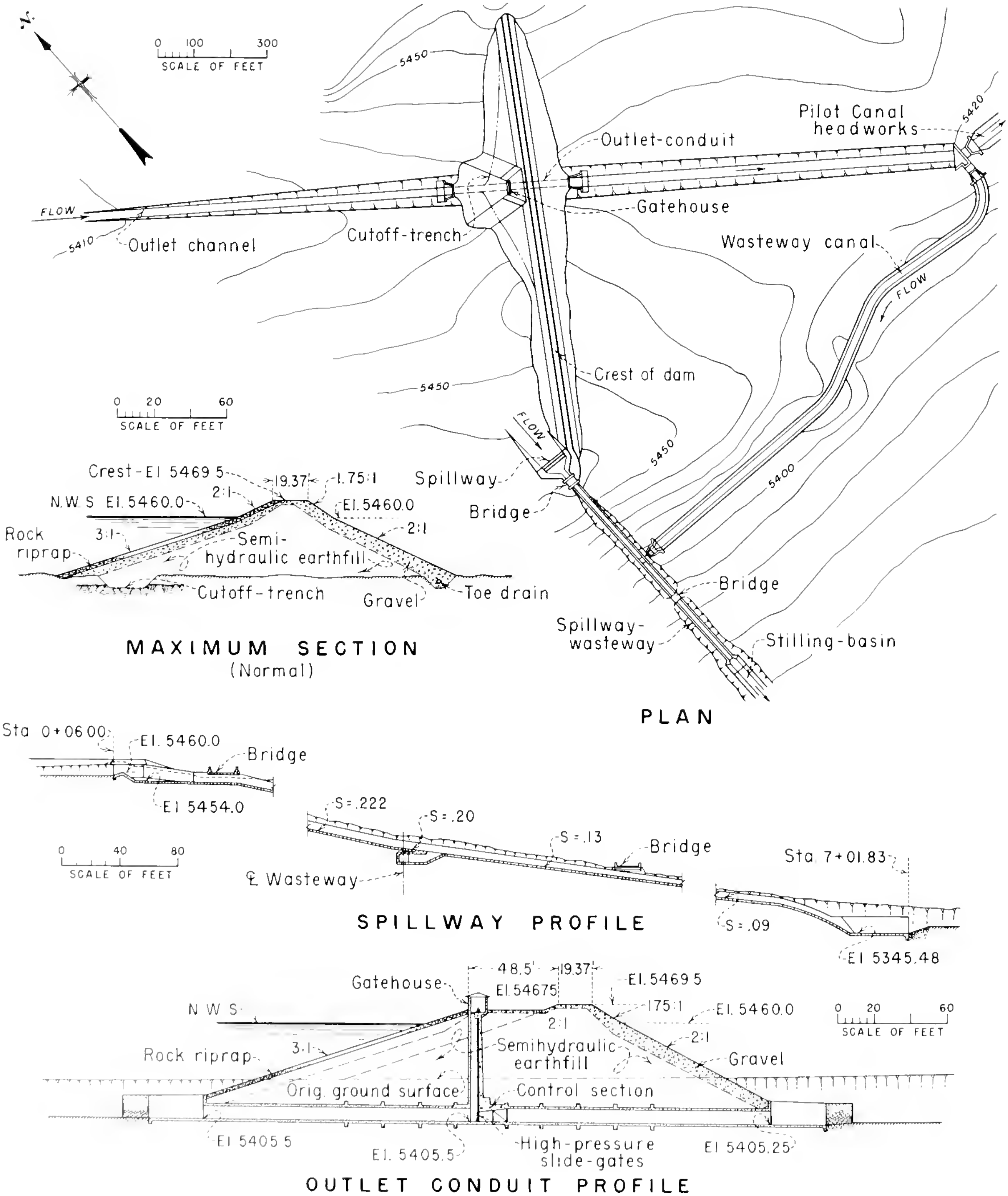
SUBSTATIONS

Number in operation	3	
Capacity of transformers	4,970	kVA

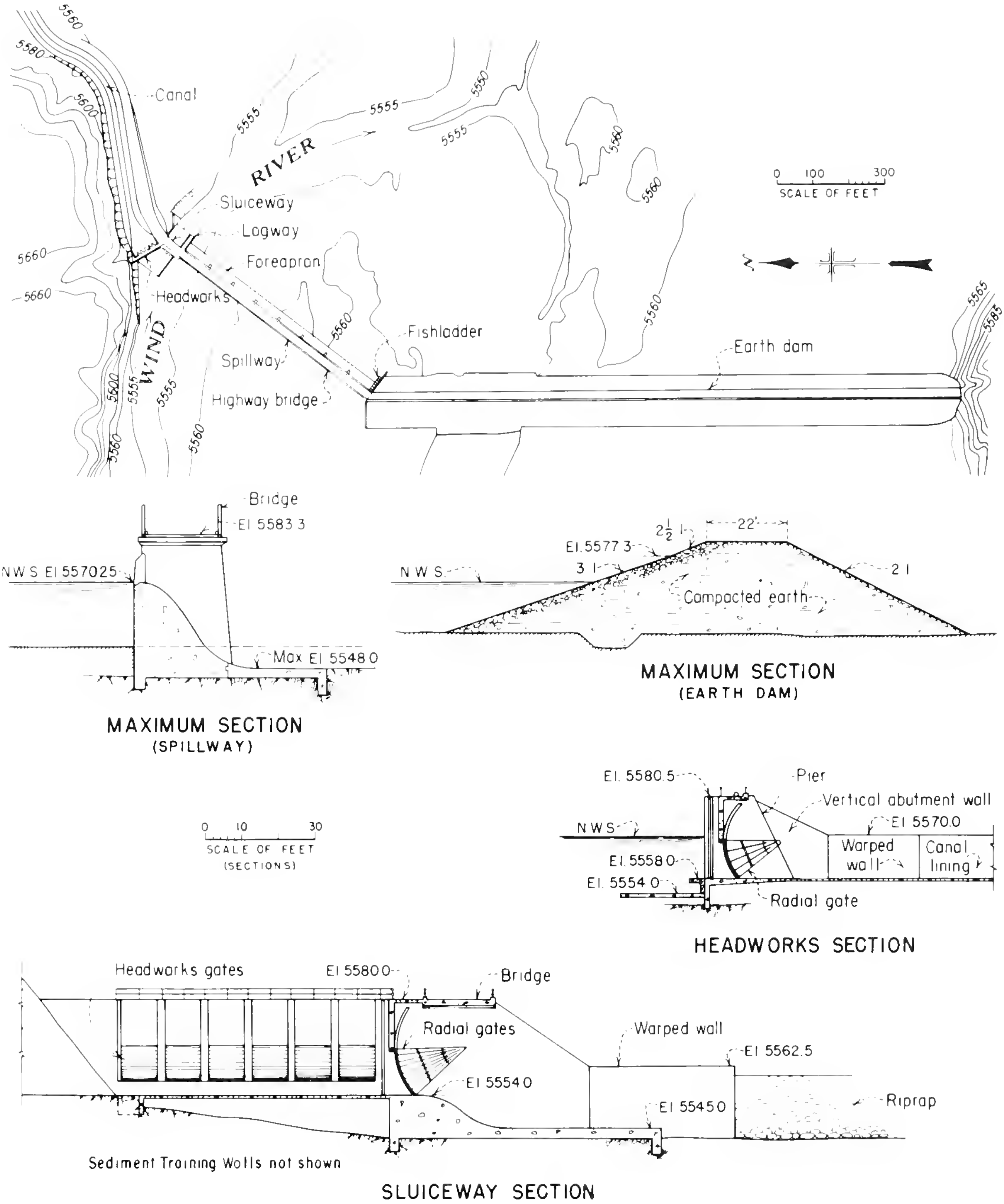
TRANSMISSION LINES

Total number of lines	7
Total circuit miles	75.8

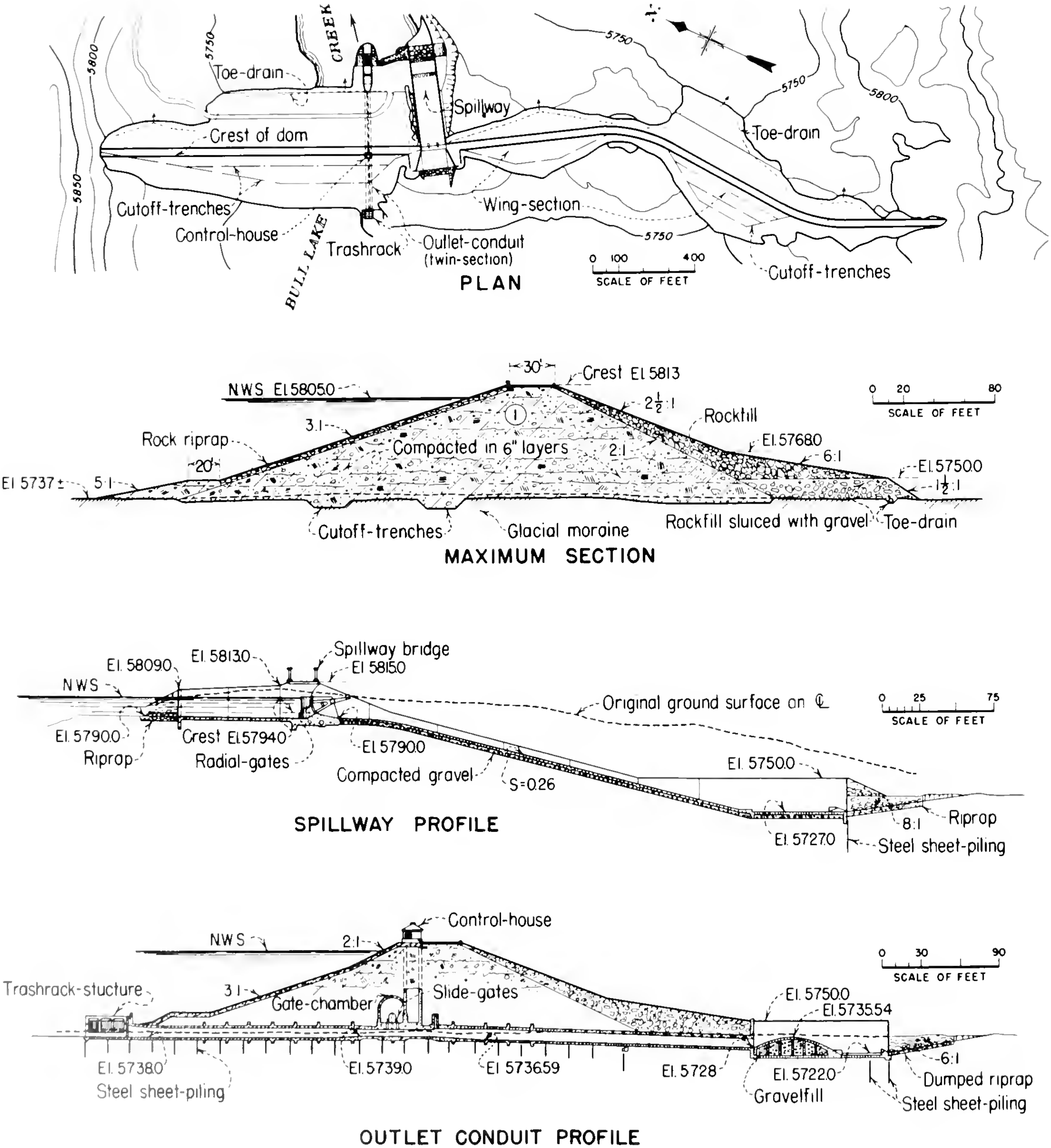
Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
Pilot Butte Powerplant Thermopolis Substation — Line No. 1	34.5	2,000	48.7	1939
Line No. 1 — Pavillion Substation—Line No. 2	34.5	1,000	3.2	1923
Line No. 1—Muddy Junction Line No. 2—Five Mile Junction	34.5	1,000	3.2	1939
Pilot Butte Powerplant—Deshaw Substation	34.5	5,000	4.2	1947
Pilot Butte Powerplant—RVEA Substation	34.5	1,000	5.0	1923
Five Mile Junction PP&L (Riverton)	34.5	1,000	8.5	1923
Pilot Butte Powerplant—Morton Substation	2.3	1,600	3.0	----



Bull Lake Dam, Plan and Sections



Pilot Butte Dam, Plan and Sections

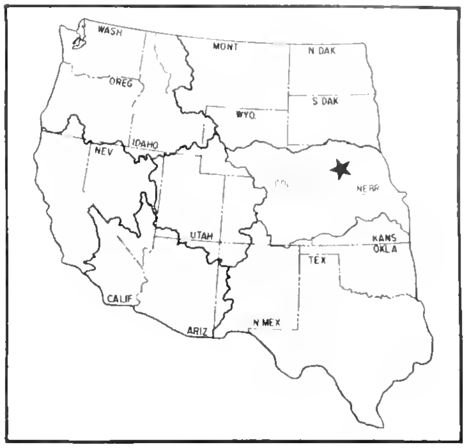


Wind River Diversion Dam

Pick-Sloan Missouri Basin Program
Sargent Unit, Middle Loup Division

Nebraska: Blaine, Custer, and Valley Counties

Lower Missouri Region
Water and Power Resources Service



The Sargent Unit extends along the Middle Loup River Valley between the towns of Milburn and Comstock, Nebr. Generally, the lands are within the Loess Hills region.

Irrigation facilities consist of the Milburn Diversion Dam on the Middle Loup River, the 39.6-mile-long Sargent Canal, 44.2 miles of laterals, 19.4 miles of drains, and a small pump lifting installation. Benefits include flood control, recreation, and fish and wildlife conservation and enhancement.

Originally, another canal was to have been included in the unit plan; however, this phase of the development has been dropped from the plan indefinitely.

PLAN

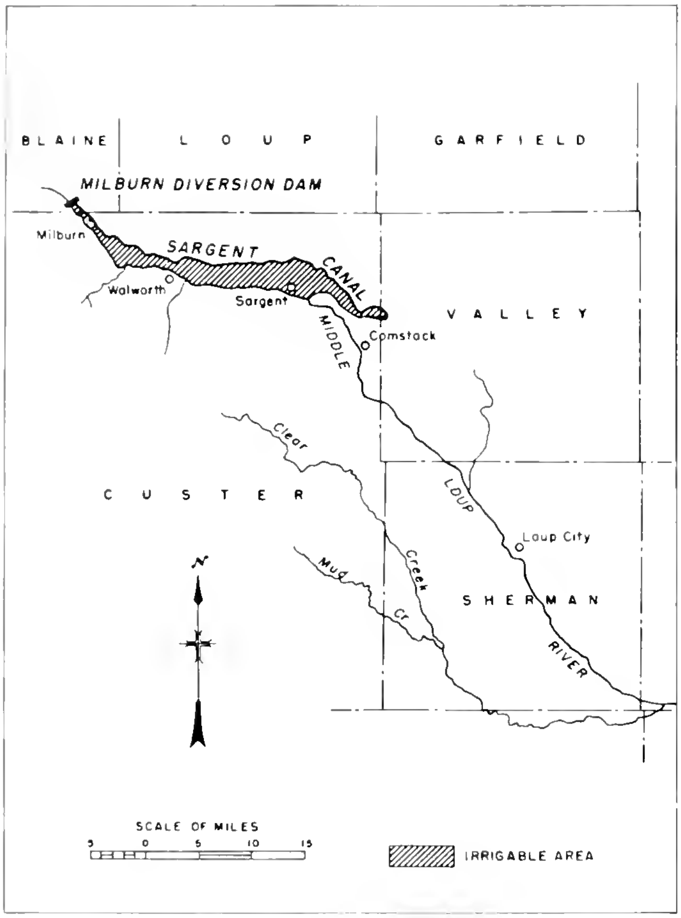
The Milburn Diversion Dam diverts water from the Middle Loup River and delivers it through the Sargent Canal to 13,363 irrigable acres of the unit located north of the river.

The diversion dam is near Milburn, 27 miles upstream from Sargent. In addition to diverting water for irrigation, the structure is used to control sediment. Much of the sediment moves along the bottom of the diversion dam pool to the sluiceway. The sluiceway skims surface water to the Sargent Canal headworks and releases sediment-laden bottom flows to the river. The diverted water enters a settling basin which traps most of the sediment not caught in the sluicing operation. Trapped sediment is removed from the basin by a hydraulic dredge.

Milburn Diversion Dam and Canal System

The Milburn Diversion Dam is a concrete weir structure with a hydraulic height of 13 feet. With wing dikes, it is 3,880 feet in length. The dam diverts water into the Sargent Canal at 260 cubic feet per second. The canal is

Milburn Diversion Dam



Sargent Unit

39.6 miles long, and the laterals are 44.2 miles long. The Woods Park Pumping Plant, near the end of the canal, serves about 180 acres. It has a capacity of 6 cubic feet per second and a lift of 19.5 feet.

DEVELOPMENT

Early History

Selection of Council Bluffs by President Lincoln as the starting point of the railroad to serve the West was conducive to the settlement of this territory. Cattlemen were first to settle in the Middle Loup River Valley. Rapid economic expansion occurred between 1870 and 1890, when principal railroads were constructed across the State.

Immigrants formed the backbone of the Sargent area's population. They constructed several irrigation projects along the Middle Loup River during the drought period of the middle 1890's. Interest in the early project dwindled when rainfall was received in the following few years. As a result, most of the irrigation systems fell into disuse, and eventually all of them were abandoned. There was little subsequent development during the first 25 years of the 20th century.

Investigations

In 1939, the Sargent Public Irrigation District was organized to irrigate approximately 25,000 acres of valley land along the north side of the Middle Loup River. Repeated and unsuccessful attempts were made to obtain development funds from the Public Works Administration.

In 1946, local leaders again undertook an aggressive campaign for development. In January 1950, the Loup Basin Reclamation District was organized and the Bureau of Reclamation was requested to make a detailed investigation. The Sargent Unit definite plan report for the initial development was approved May 20, 1953.

Authorization

The Sargent Unit was authorized by the Flood Control Acts of December 22, 1944, and July 24, 1946.

Construction

Construction of the Milburn Diversion Dam began in March 1955 and was completed in May 1956. The Sargent Canal and laterals were started in January 1955 and finished in December 1957.

Operating Agencies

The Loup Basin Reclamation District operates and maintains the diversion dam works, laterals, drains, and other irrigation works of the Sargent Unit. The Loup Basin Reclamation District acts as the contracting agency for the Sargent Irrigation District and the Farwell Irrigation District (Farwell Unit) in matters concerning the diversion and canal works. The Sargent Irrigation District and Farwell Irrigation District are the contracting agencies for the lateral and drainage works of their respective units within the Middle Loup Division.

BENEFITS

Irrigation

Principal irrigated crops in the unit include alfalfa, corn, and silage. Beef cattle serve as an important source of farm income. Under irrigation, average crop yields have increased considerably, with a resultant increase in farm income.

Flood Control

On numerous occasions, seasonal and flash floods have menaced the city of Sargent and the bottom lands of the Middle Loup River, causing damage to crops and transportation and communication facilities. The construction of the Sargent Canal along the north edge of the valley controls the upland runoff and provides flood protection to Sargent.

Recreation and Fish and Wildlife

Fishing and picnicking below Milburn Diversion Dam are the principal recreational activities in the area. Picnic tables, fire grates, and other facilities have been installed through the cooperative efforts of the Loup Basin Reclamation District, Sargent Lions Club, Sargent Chamber of Commerce, Loup Valley Wildlife Association, Mid-Nebraska Wildlife Club, Nebraska Game and Parks Commission, and the Bureau of Reclamation. Recreation facilities are administered by the Nebraska Game and Parks Commission.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	13,363	acres
Number of irrigated farms	165	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	9,953	993,555
1969	13,144	1,260,833
1970	10,535	1,504,118
1971	11,402	1,387,694
1972	11,249	1,423,993
1973	12,763	2,542,816
1974	12,564	3,842,728
1975	13,042	3,227,369
1976	12,668	2,525,191
1977	12,555	2,270,621

Facilities in Operation

Diversion dams	1	
Canals	39.6	mi
Laterals	44.2	mi
Drains	19.4	mi

Climatic Conditions

Annual precipitation	22	in
Temperature:		
Maximum	116	°F
Minimum	−36	°F
Mean	49	°F
Growing season	128	days
Elevation of irrigable area	2248-2510.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	258

ENGINEERING DATA

Water Supply

MIDDLE LOUP RIVER

Drainage area at Milburn Diversion Dam	4,009	mi^2
Direct contributing area	162	mi^2
Estimated annual discharge at Dunning, Nebr.:		
(1952) - Dismal River	721,100	acre-ft
Maximum (1971) - Middle Loup River	738,500	acre-ft
(1950) - Dismal River	72,400	acre-ft
Minimum (1950) - Middle Loup River	72,400	acre-ft
Average	520,200	acre-ft
Average annual diversion at Milburn Diversion Dam (1957-1976)	21,857	acre-ft

Diversion Facilities

MILBURN DIVERSION DAM

Type: Concrete ogee-gated weir, embankment wings, stilling basin
Location: On the Middle Loup River, about 23 mi northwest of Sargent, Nebr.
Year constructed: 1955-1956
Dimensions:

Structural height	24.5	ft
Hydraulic height	13	ft
Weir crest length	76	ft
Total length	3,880	ft
Weir crest elevation	2481.0	ft
Volume	70,000	yd^3

Sluiceway: Concrete gated structure, two 11- by 13-ft radial gates.
Gate structure: Concrete, two 22- by 7-ft radial gates.
Headworks:
Sargent Canal: Concrete, one 10- by 8.5-ft radial gate.

Diversion capacity	260	ft^3/s

Carriage Facilities

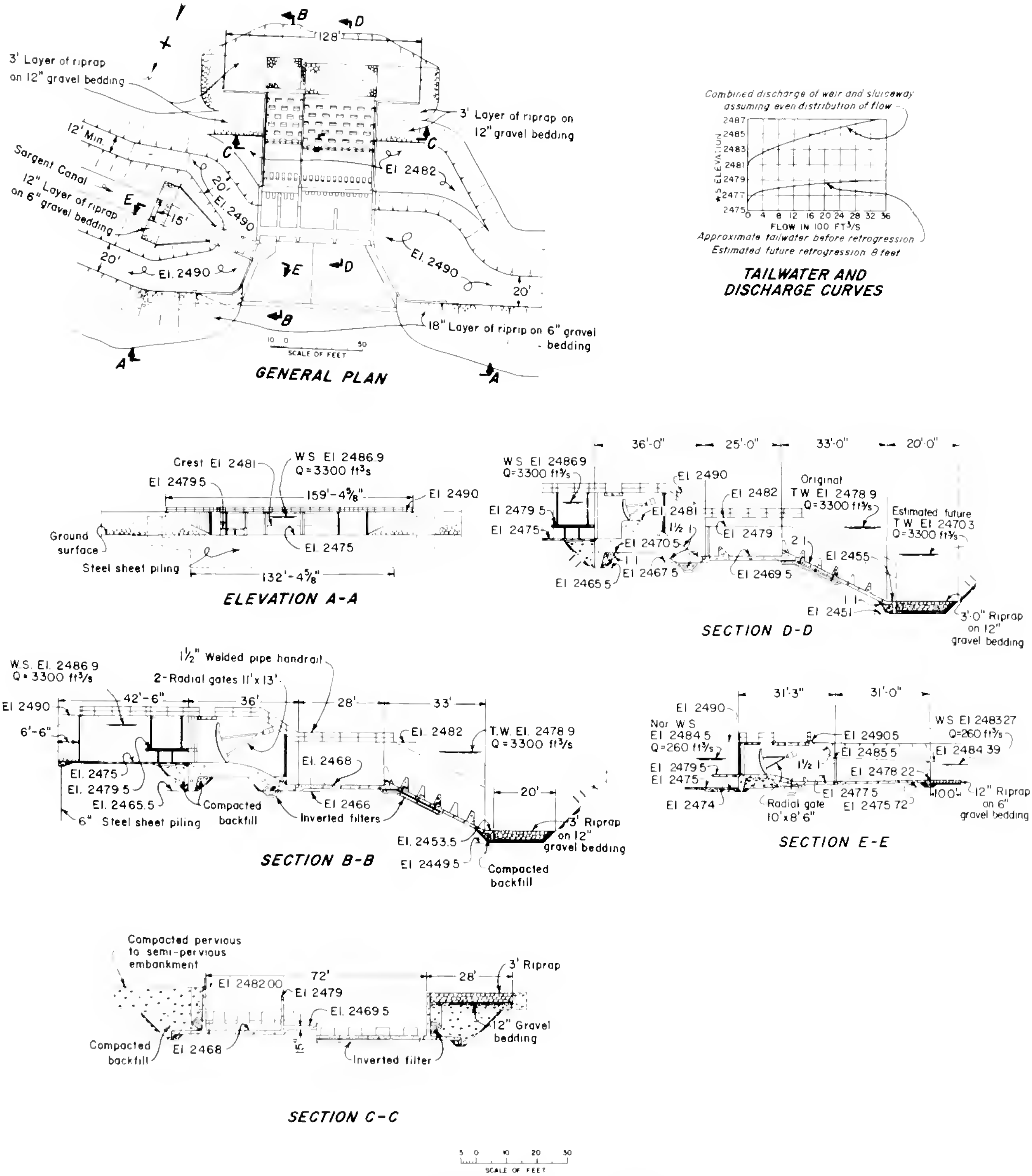
SARGENT CANAL

Location: From Milburn Diversion Dam on the Middle Loup River about 3 mi northwest of Milburn, Nebr., generally east along the north side of the Middle Loup River to about 10 mi southeast of Sargent, Nebr.
Construction period: 1955-1957

Length	39.6	mi
Diversion capacity	260	ft^3/s
Typical maximum section in earth:		
Bottom width	15	ft
Side slopes	2:1	
Water depth	5	ft

PUMPING PLANT

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horse-power
Woods Park	1	6	19.5	[illegible]

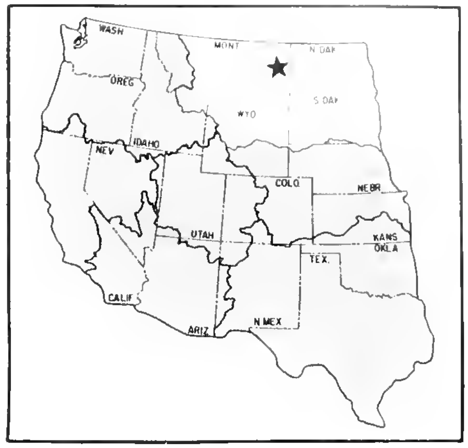


Milburn Diversion Dam, Plan and Sections

Pick-Sloan Missouri Basin Program
Savage Unit

Montana: Richland County

Upper Missouri Region
Water and Power Resources Service



There are 2,200 acres of irrigable land in the Savage Unit. The town of Savage is about 1 mile east of the center of the unit. Principal features include a feeder canal, pumping plant, and main canal.

PLAN

Water is delivered to the pumping plant by means of a feeder canal about 100 feet long extending from the Lower Yellowstone Project Main Canal. The present capacity of the canal is sufficient, without enlargement, to supply the Savage Unit.

The pumping plant is located about 3.5 miles south of the town of Savage. It contains two motor-driven 250-horsepower pumps, each discharging 21 cubic feet per second with an 84-foot head. Power to operate the pumps is delivered over lines of the Montana-Dakota Utilities Co. to a Reclamation-constructed substation at Savage, 4 miles northeast of the pumping plant; then from the substation to the pumping plant by a 12.4-kilovolt transmission line built by the Lower Yellowstone Rural Electrification Administration under a joint-use agreement with the Bureau of Reclamation.

The 7.8-mile-long canal has a capacity of 44 cubic feet per second. The laterals, constructed to serve 2,200 acres, total 6.2 miles in length.

DEVELOPMENT

Early History

Landowners of the Savage Unit have been interested in irrigation for many years. Agitation for development arose as early as 1920 and, as the Lower Yellowstone Project prospered and became fully developed, interest in getting water to the adjacent higher land increased. Private capital was not available, however, to finance the cost of construction. With pumping necessary, lack of power presented a problem to either private or Federal development until power from Fort Peck Dam became available. Proposing to use this source of power, the farmers and community leaders requested the assistance of the Bureau of Reclamation in the irrigation development of the unit.

Investigations

The area now comprising the Savage Unit was surveyed during the investigations and construction of the Lower Yellowstone Project in 1903-09. Additional investigations were made in 1941. The detailed investigations leading to construction of the unit were undertaken during 1945-46.

Authorization

Savage Unit was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.

Construction

Construction of the irrigation facilities began April 18, 1949, and was completed December 6, 1949. The first water was made available for irrigation on May 27, 1950.

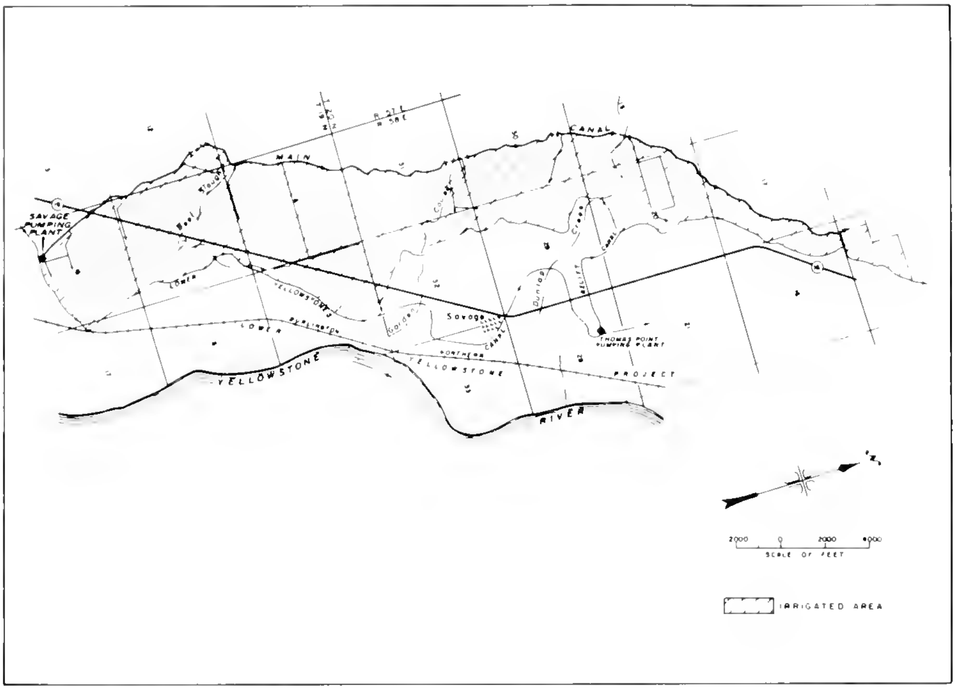
Operating Agency

On August 8, 1950, the Board of Control of the Lower Yellowstone Project became the operating agency and assumed the operation and maintenance responsibilities.

BENEFITS

Irrigation

The principal crops include small grains, alfalfa and other hay crops, pasture, silage, beans, and sugar



Savage Unit

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	2,200	acres
Number of farms	22	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,963	196,287
1969	2,026	240,577
1970	1,787	209,742
1971	1,881	233,295
1972	1,938	298,933
1973	2,009	456,281
1974	2,020	763,719
1975	2,058	677,278
1976	2,054	442,608
1977	1,982	443,384

Facilities in Operation

Canals	7.8	mi
Laterals	6.2	mi
Pumping plants	1	

Climatic Conditions

Annual precipitation	14	in
Temperature:		
Maximum	111	°F
Minimum	−53	°F
Mean	45	°F
Growing season	129	days
Elevation of irrigable area	1900.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	40

ENGINEERING DATA

Water Supply

YELLOWSTONE RIVER

(See Lower Yellowstone Project for streamflow data.[1])

Average annual diversion, (1966-77)	6,000	acre-ft

[1]Savage Unit receives its water supply by pumping from Lower Yellowstone Project Main Canal.

Carriage Facilities

MAIN CANAL

Location: Generally north from Savage Unit Pumping Plant on the Lower Yellowstone Project Main Canal about 4 mi south of Savage, Mont.

Construction period: 1949

Length	7.8	mi
Diversion capacity	44	ft³/s
Typical maximum section in earth:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	2.8	ft

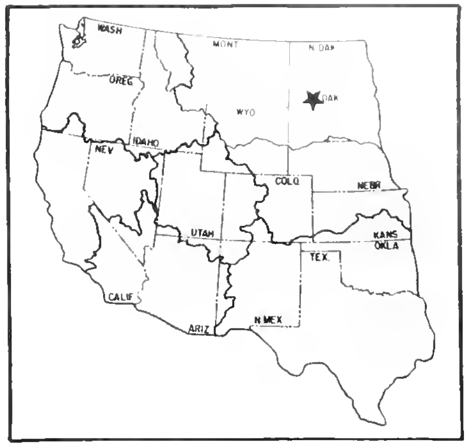
SAVAGE PUMPING PLANT

Number of units	2	
Total capacity	42	ft³/s
Total dynamic head	84	ft
Total horsepower	500	

Pick-Sloan Missouri Basin Program
Shadehill Unit

South Dakota: Perkins County

Upper Missouri Region
Water and Poweer Resources Service



Shadehill Unit consists of Shadehill Dam and Reservoir on the Grand River in the northwestern part of South Dakota, located approximately 12 miles south of Lemmon, S. Dak., and immediately downstream from the confluence of the North Fork and the South Fork of the Grand River. The reservoir stores irrigation water for 3,000 acres of privately developed lands. Associated diversion facilities divert directly from the reservoir or from the Grand River downstream from the dam. In addition, the reservoir provides benefits for flood control, fish and wildlife conservation, recreation, and silt detention.

Shadehill Dam

The Shadehill Dam and associated dikes are rolled-fill earth structures. The dam has a crest length of 12,843 feet and a maximum structural height of 145 feet. The two dikes have a total length of 1,360 feet with maximum structural heights of 83 and 18 feet. Shadehill Reservoir has an active capacity of 81,400 acre-feet.

The uncontrolled service spillway is a reinforced concrete conduit, 13.5 feet in diameter, with a morning-glory inlet, and was designed to accommodate a maximum flow of 5,700 cubic feet per second.

The controlled outlet works is a horseshoe-shaped concrete conduit with a capacity of 600 cubic feet per second. The original outlet works was modified in 1960 to provide a 600-cubic-foot-per-second-capacity outlet extension to the Grand River. This modification provides additional flood control capacity and permits flood control releases to the Grand River when the reservoir water level is below the crest of the spillway.

An open-cut unlined emergency spillway with a bottom width of 1,500 feet and capacity of 127,000 cubic feet per second is located immediately upstream from the left abutment. The spillway discharges into Flat Creek, a tributary of the Grand River downstream from Shadehill Dam. The drainage basin area above Shadehill Dam is about 3,120 square miles.

DEVELOPMENT

Early History

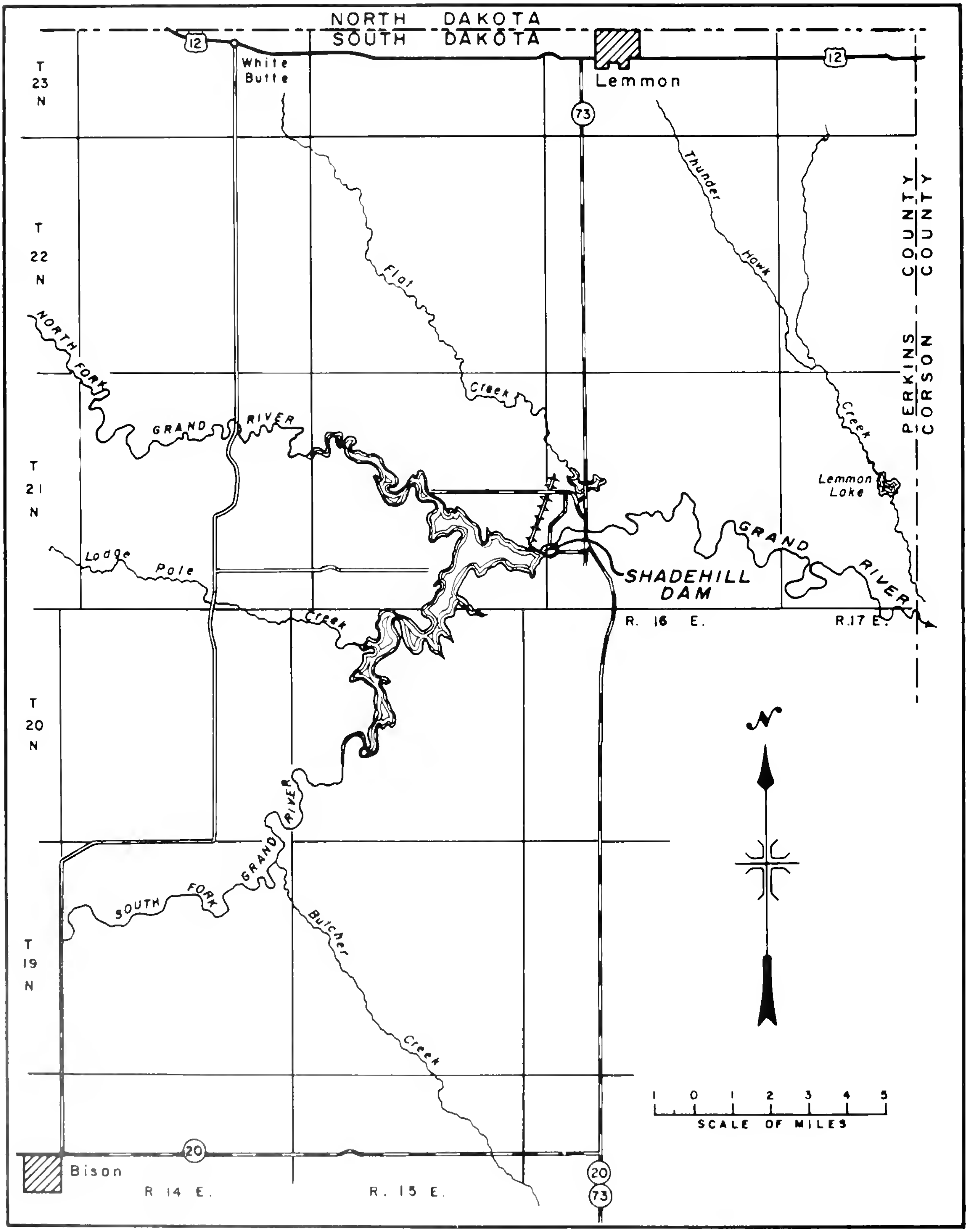
The early settlers in this area were cattlemen who established widely separated ranches on the open range. The major settlement took place from 1900 to 1910, after the railroad was extended into the region. Favorable crop yields and prices stimulated farming operations, and most of the lands which appeared suitable for tillage were brought under cultivation. Recurring years of deficient precipitation, combined with submarginal quality of much of the cultivated land, contributed toward the abandonment of much of the cropland for tillage.

In 1938, following urgent requests by local residents as a result of several extreme drought years, the Bureau of Reclamation made an inspection of the Shadehill Unit area which led to the initiation of further investigations.

Investigations

Investigations leading to the development of the Shadehill Unit began in 1931. In the course of studies made by the Corps of Engineers, a topographic survey was made of the reservoir site on the Grand River immediately downstream from the confluence of the North and South Forks. This was followed by a reconnaissance survey by the Bureau of Reclamation in 1938-39 to determine the quality of available water and conduct limited field investigations. In 1941, while the Indian Service was preparing plans for the construction of Blue Horse Dam, approximately 30 miles downstream from Shadehill Dam, the Bureau of Reclamation was making further studies for a reservoir at the Shadehill site. It was jointly agreed that the Shadehill Unit would be the preferable initial development as it offered a greater probability for rapid conversion to irrigation. The Indian Service would participate in the cost and receive part of the stored water for use on reservation lands.

A water supply and quality study of the Grand River and detailed engineering field surveys of the dam and reser-



Shadehill Unit

voir site were carried out from 1945 to 1948. Land classification surveys of potentially irrigable lands that could receive irrigation water service from Shadehill Reservoir were also undertaken during this period.

Authorization

The unit was authorized by the Flood Control Act of December 22, 1944, Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2nd session.

Construction

Construction of Shadehill Dam began April 19, 1949, and was completed August 15, 1951. The first impoundment of water was made on July 1, 1950.

Operating Agency

Shadehill Dam and Reservoir are operated and maintained by the Bureau of Reclamation.

BENEFITS

Irrigation

A full supply of irrigation water is available from Shadehill Reservoir to 3,000 acres of land under the administration of the West River Conservancy Sub-District. The integrated irrigated-dryland farms produce alfalfa, corn, and livestock.

Flood Control

Flood control benefits are provided by the use of conservation storage, as available, and the exclusive flood control space and surcharge space above the crest of the spillway.

Recreation and Fish and Wildlife

Facilities provided for outdoor recreation at Shadehill Reservoir include picnic grounds, campgrounds, boat ramp developments, swimming beaches, and areas for lease of seasonal cabins. All recreation areas and facilities, including fishery, are administered by the South Dakota Department of Game, Fish, and Parks. There were 79,100 visitor days at Shadehill Reservoir in 1977.

Shadehill Dam

UNIT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	3,000	acres
Number of irrigated farms	19	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1976	1,908	354,946
1977	2,420	286,240

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	15.7	in
Temperature:		
Maximum	115	°F
Minimum	−45	°F
Mean	43	°F
Growing season	126	days
Elevation of irrigable area	2190.0	ft

Settlement

Number of persons served with project water:

Farm irrigation service	106

ENGINEERING DATA

Water Supply

Grand River drainage area above Shadehill Dam	3,120	mi²
Annual discharge at Shadehill Dam:		
Maximum (1950)	388,200	acre-ft
Minimum (1951)	400	acre-ft
Average	84,000	acre-ft

Storage Facilities

SHADEHILL DAM AND DIKES

Type: Modified homogeneous earthfill. Two dikes, totaling 1,360 ft in length and a maximum of 83 ft high, close 2 saddles south of the right abutment of the dam.
Location: On the Grand River about 12 mi south of Lemmon, S. Dak.
Construction period: 1949-51
Date of closure (first storage): July 1, 1950
Reservoir, Shadehill:

Total capacity to El. 2302	357,382	acre-ft
Active capacity, El. 2250.8-2272	81,400	acre-ft
Surface area	9,900	acres

Dimensions:

Structural height	145	ft
Hydraulic height	102	ft
Top width	30	ft
Maximum base width	938	ft
Crest length	12,843	ft
Crest elevation	2318.0	ft
Total volume	3,500,000	yd³

Spillways:
Service spillway: Uncontrolled concrete morning-glory inlet and concrete conduit through dam at left side of the original river channel.

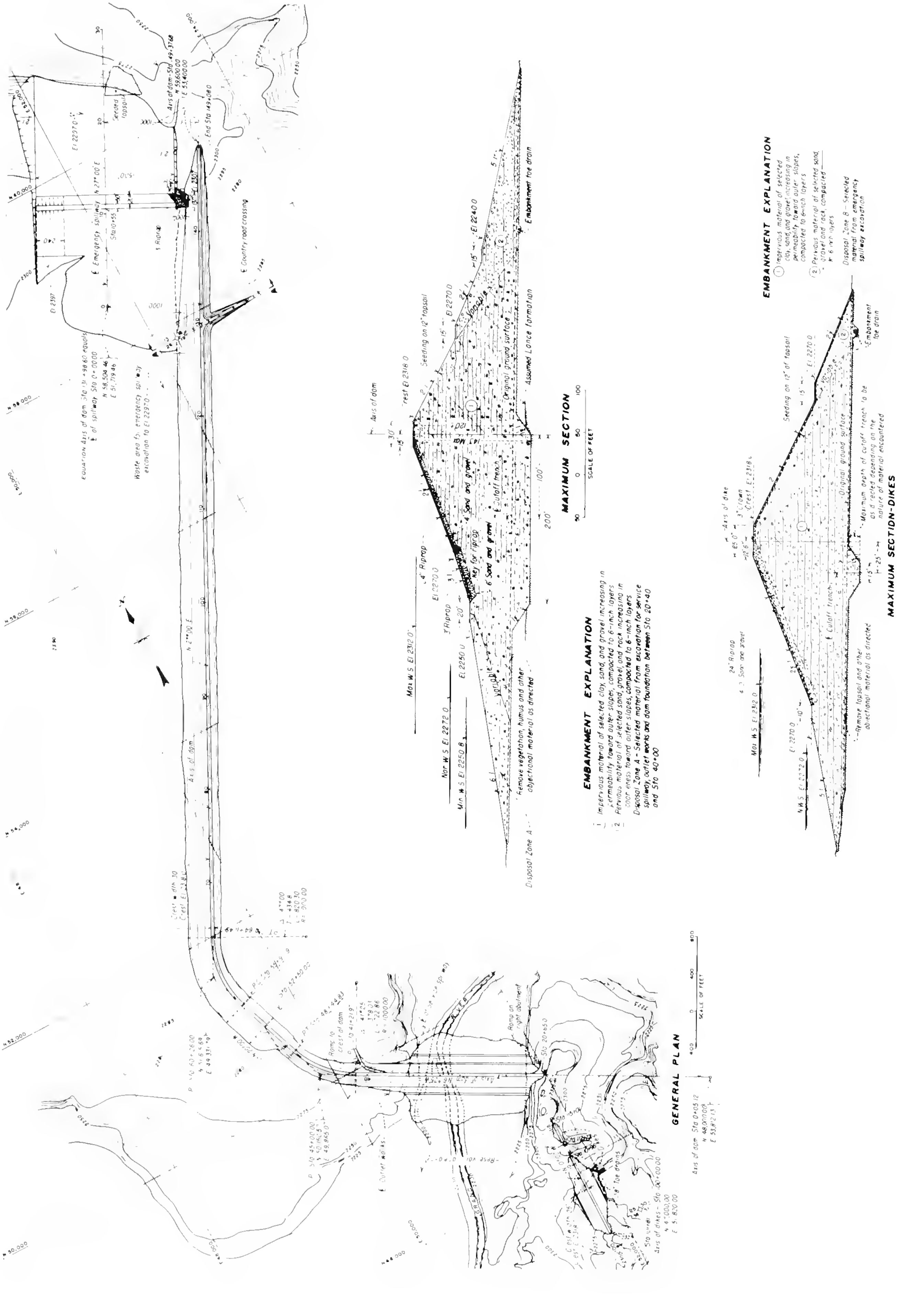
Crest elevation	2272.0	ft
Capacity at El. 2312	5,700	ft³/s

Emergency spillway: Unlined open cut 1,500 ft wide at north end of the dam.

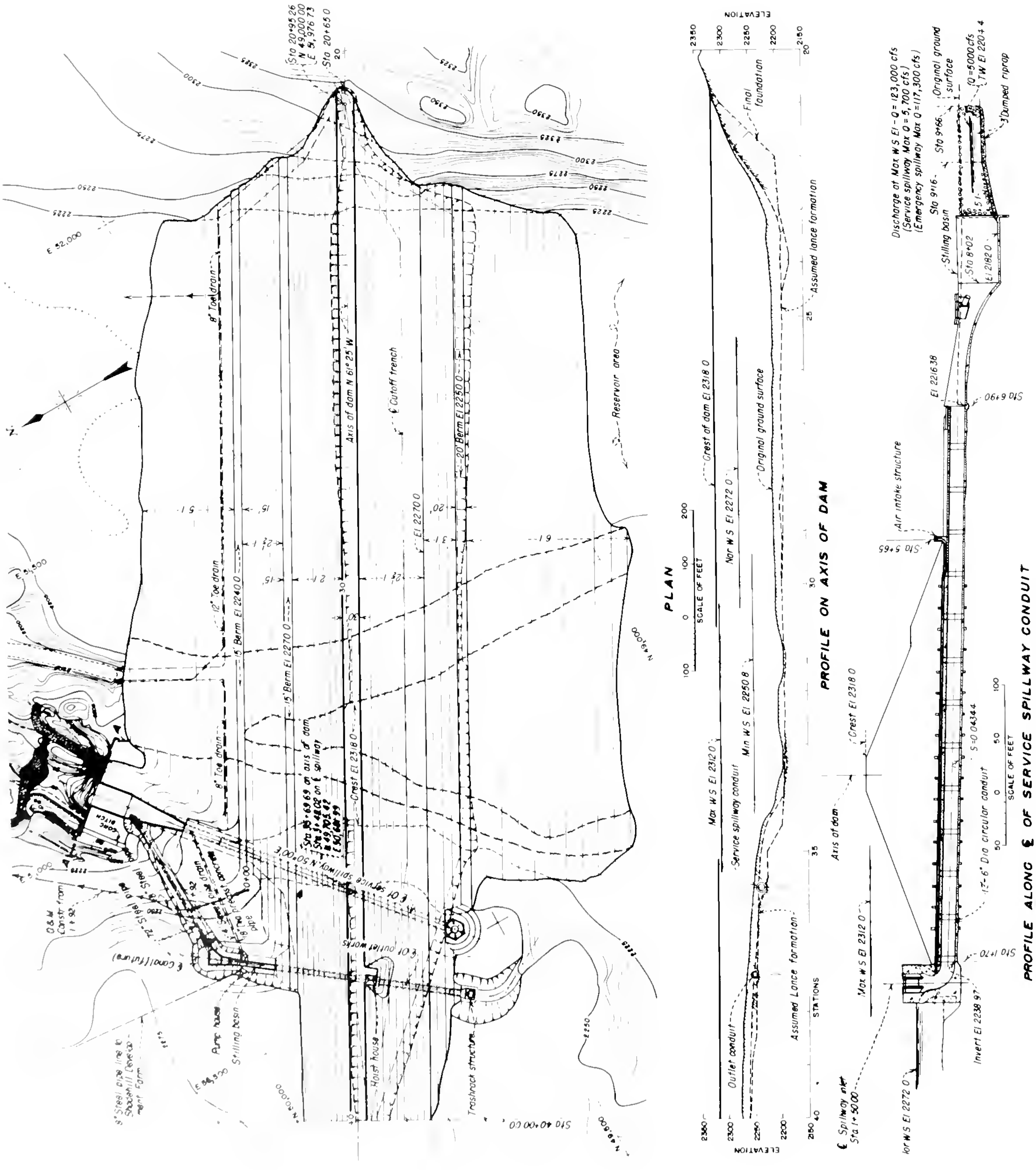
Crest elevation	2302.0	ft
Capacity at El. 2312	127,000	ft³/s

Outlet works: Steel-lined concrete conduit through dam at left side of the original river channel, controlled by one 6-ft-square radial gate.

Capacity at El. 2260	360	ft³/s



Shadehill Dam, Plan and Sections

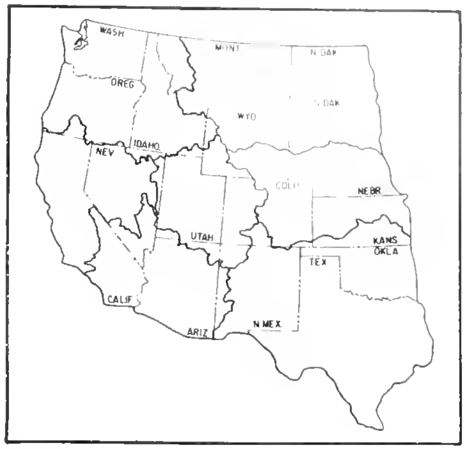


Shadehill Dam, Plan and Profiles

Pick-Sloan Missouri Basin Program
Transmission Division

Colorado, Iowa, Minnesota, Montana, Nebraska, North Dakota, South Dakota, and Wyoming

Upper Missouri and Lower Missouri Regions
Water and Power Resources Service



The Transmission Division consists of a network of transmission lines and substations necessary to deliver electric power generated by Bureau of Reclamation hydroplants within the Missouri River Basin and Corps of Engineers' hydroplants constructed on the main stem of the Missouri River. Power is sold to municipalities, rural electric cooperatives, Federal authorities, and public bodies within the basin. The Transmission Division is among the power marketing functions transferred to the Department of Energy by the Department of Energy Organization Act approved August 4, 1977. However, repayment responsibility for those facilities originally authorized and constructed as parts of Reclamation projects remains with the Bureau of Reclamation.

The Transmission Division is administratively subdivided into the Eastern and Western Divisions. The Eastern Division (headquarters at the Billings Area Office, Western Area Power Administration) consists of over 7,000 miles of high-voltage transmission lines reaching from Great Falls, Mont., on the west, to Granite Falls, Minn., and Maysville, Mo., on the east, and to Grand Island, Nebr., on the south. The Western Division (headquarters at Denver Area Office, Western Area Power Administration) consists of nearly 3,500 miles of transmission lines extending from Yellowtail Powerplant in southern Montana, to Chadron and Ogallala, Nebr., on the east, and to Lamar and Wray, Colo., on the south.

Power transmission facilities authorized and constructed as part of the Colorado-Big Thompson, Kendrick, North Platte, and Shoshone Projects have been administratively integrated into the Western Division for operational purposes, and are included in the tabulations below.

ENGINEERING DATA

Power Facilities

GARRISON POWERPLANT

Location: At Garrison Dam on the Missouri River in North Dakota.

Year of initial operation: 1956		
Year last generator placed in operation: 1960		
Nameplate capacity		400,000 kW
Number and nameplate capacity of generators	(5)	80,000 kW

OAHE POWERPLANT

Location: At Oahe Dam on the Missouri River in South Dakota.

Year of initial operation: 1962		
Year last generator placed in operation: 1963		
Nameplate capacity		595,000 kW
Number and nameplate capacity of generators	(7)	85,000 kW

BIG BEND POWERPLANT

Location: At Big Bend Dam on the Missouri River in South Dakota.

Year of initial operation: 1964		
Year last generator placed in operation: 1966		
Nameplate capacity		468,000 kW
Number and nameplate capacity of generators	(8)	58,500 kW

FORT RANDALL POWERPLANT

Location: At Fort Randall Dam on the Missouri River in South Dakota.

Year of initial operation: 1954		
Year last generator placed in operation: 1956		
Nameplate capacity		320,000 kW
Number and nameplate capacity of generators	(8)	40,000 kW

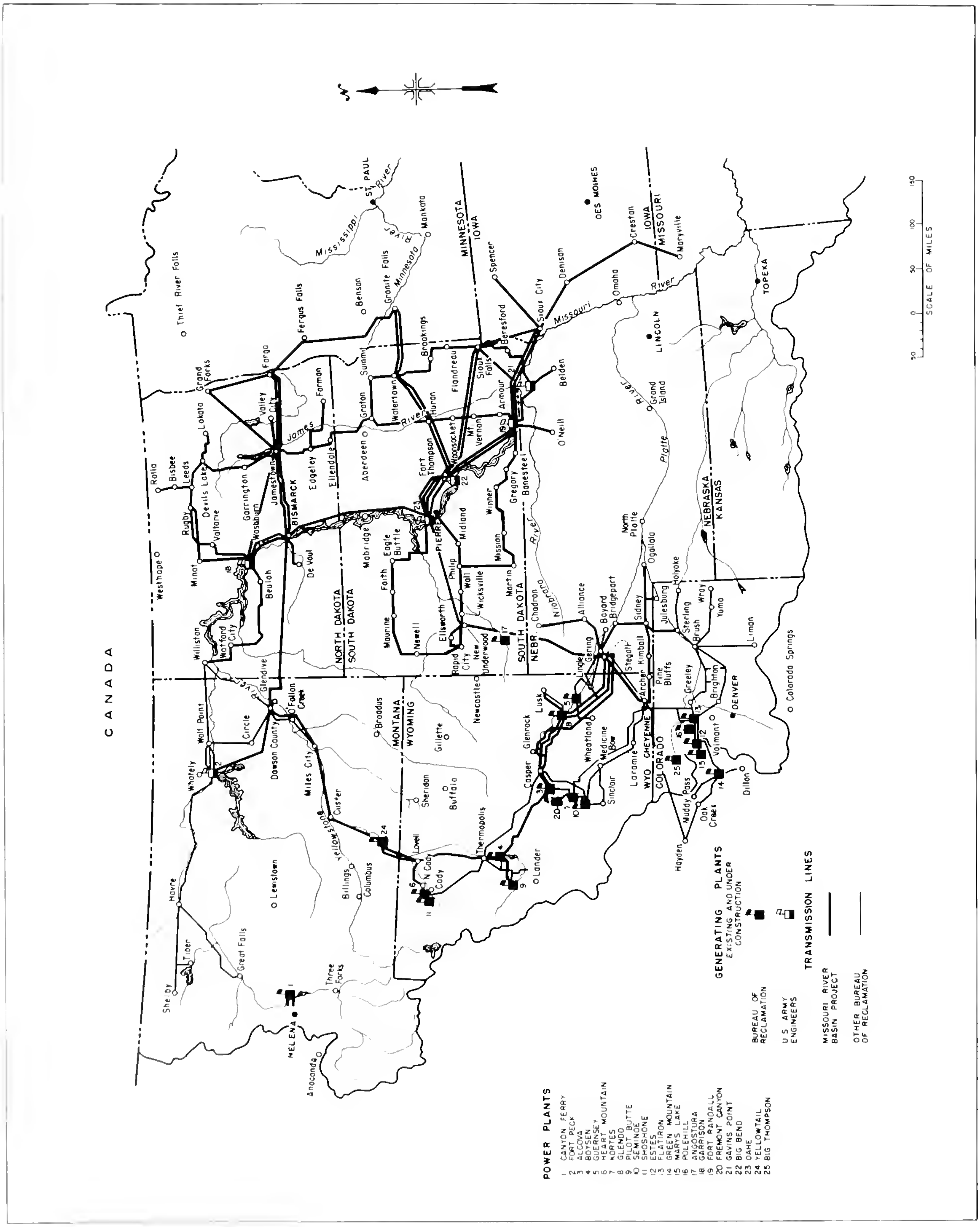
GAVINS POINT POWERPLANT

Location: At Gavins Point Dam on the Missouri River in South Dakota.

Year of initial operation: 1956		
Year last generator placed in operation: 1957		
Nameplate capacity		100,000 kW
Number and nameplate capacity of generators	(3)	33,333 kW

TRANSMISSION FACILITIES

Substations (excluding leased facilities):	
Number in operation	150
Capacity of transformers	6,656,979 kVA
Transmission lines (excluding leased facilities):	
Total number of lines	192
Total circuit miles	9,640



Transmission Division

TRANSMISSION LINES

Designation	Capacity, kV	Circuit miles	Year placed in service
Montana			
Yellowtail Powerplant — Custer Substation	230.0	61.20	1966
Yellowtail Switchyard — Yellowtail Substation (Pacific Power & Light)	230.0	0.92	1970
Canyon Ferry Powerplant — East Helena ("A")	115.0	7.46	1953
Canyon Ferry Powerplant — East Helena ("B")	115.0	7.46	1954
Crow Creek — Crow Creek Pumping Plant	4.2	0.40	1954
Eastern Division (northern area)			
Dawson County Substation — Bismarck Substation	230.0	208.95	1960
Fargo Substation — Morris Substation	230.0	104.70	1960
Jamestown Substation — Fargo Substation (No. 1)	230.0	83.03	1957
Jamestown Substation — Fargo Substation (No. 2)	230.0	84.30	1962
Garrison — Bismarck	230.0	62.71	1952
Garrison — Leland-Olds-Bismarck	230.0	86.69	1953
Bismarck Substation — Jamestown Substation (No. 1)	230.0	98.32	1953
Bismarck Substation — Jamestown Substation (No. 2)	230.0	99.33	1961
Bismarck Substation — Glenham Tap	230.0	94.97	1956
Garrison Powerplant — Jamestown Substation	230.0	137.63	1962
Dawson County Substation — Custer Substation	230.0	160.21	1964
Garrison Powerplant — Wm. J. Neal Powerplant	115.0	57.17	1952
Garrison Powerplant — Mallard Substation	115.0	57.02	1961
Mallard Substation — Rugby Substation	115.0	58.43	1961
Wm. J. Neal Powerplant — Towner Substation — Rugby Substation	115.0	55.95	1952
Rugby Substation — Devils Lake Substation	115.0	58.85	1952
Devils Lake Substation — Lakota Substation	115.0	26.22	1953
Devils Lake Substation — Jamestown Substation	115.0	102.87	1952
Fargo Substation — Grand Forks Substation	115.0	82.79	1957
Jamestown Substation — Valley City Substation	115.0	35.31	1952
Jamestown Substation — Groton Substation	115.0	117.85	1956
Jamestown Substation — Grand Forks Substation	115.0	110.36	1962
Williston Substation — Garrison Powerplant	115.0	170.28	1951
Forman Substation — Summit Substation	115.0	45.21	1970
Garrison Powerplant — Snake Creek Pumping Plant	115.0	14.60	1975
Valley City Substation — Forman Substation	115.0	62.21	1970
Leeds Substation — Rolla Substation	69.0	42.55	1952
Bismarck Substation — DeVaul Substation	69.0	40.64	1953
Edgeley Substation — Forman Substation	69.0	66.40	1953
Eastern Division (southern area)			
Fort Thompson Substation — Grand Island Substation	345.0	241.70	1970
Fort Randall Powerplant — Fort Thompson Substation (No. 1)	230.0	87.20	1954
Fort Randall Powerplant — Fort Thompson Substation (No. 2)	230.0	87.20	1962
Fort Randall Powerplant — Sioux City Substation (No. 1)	230.0	121.93	1955
Fort Randall Powerplant — Sioux City Substation (No. 2)	230.0	121.93	1962
Fort Thompson Substation — Big Bend Powerplant (No. 1)	230.0	7.13	1964
Fort Thompson Substation — Huron Substation (No. 1)	230.0	59.28	1956
Fort Thompson Substation — Huron Substation (No. 2)	230.0	59.28	1963
Fort Thompson Substation — Sioux Falls Substation	230.0	146.14	1965
Fort Thompson Substation — V. T. Hanlon Substation — Sioux Falls Substation	230.0	146.39	1965
Granite Falls Substation — Minnesota Valley	230.0	2.60	1958
Granite Falls Substation — Morris Substation	230.0	60.28	1960
Huron Substation — Watertown Substation (No. 1)	230.0	71.12	1956
Fort Thompson Substation — Big Bend Powerplant (No. 2)	230.0	7.26	1965
Huron Substation — Watertown Substation (No. 2)	230.0	71.12	1963
New Underwood Substation — Stegall Substation	230.0	80.28	1966
New Underwood Substation — Oahe Powerplant	230.0	127.75	1976
Oahe Powerplant — Fort Thompson Substation (No. 1)	230.0	57.42	1962
Oahe Powerplant — Fort Thompson Substation (No. 2)	230.0	57.42	1962
Oahe Powerplant — Fort Thompson Substation (No. 3)	230.0	55.31	1954
Oahe Powerplant — Fort Thompson Substation (No. 4)	230.0	55.31	1954
Oahe Powerplant — Glenham Tap	230.0	76.72	1956
Sioux City Substation — Denison Substation	230.0	64.00	1970
Sioux Falls Substation — Sioux City Substation	230.0	75.90	1965
Utica Junction — Sioux Falls Substation	230.0	66.84	1959
Watertown Substation — Granite Falls Substation	230.0	74.56	1957
Watertown Substation — F. L. Blair Substation — Granite Falls Substation	230.0	74.71	1963
Denison Substation — Creston Substation	161.0	81.34	1963
Sioux City Substation — Spencer Substation	161.0	66.50	1963
Fort Randall Powerplant — Mt. Vernon Substation	115.0	53.27	1954
Creston Substation — Maryville Substation (NWEPC)	161.0	62.34	1965
Mt. Vernon Substation — Huron Substation	115.0	54.73	1952
Huron Substation — Groton Substation	115.0	73.33	1953
Groton Substation — Summit Substation — Watertown Substation	115.0	82.86	1953
Watertown Substation — Brookings Substation	115.0	50.17	1954
Brookings Substation — Sioux Falls Substation	115.0	59.68	1953

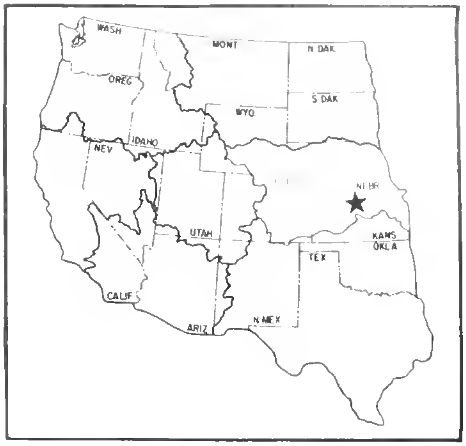
TRANSMISSION LINES—Continued

Designation	Capacity, kV	Circuit miles	Year placed in service
Eastern Division (southern area)—Continued			
Fort Randall Powerplant — Gavins Point Powerplant	115.0	72.65	1954
Gavins Point Powerplant — Manning Substation — Sioux Falls Substation	115.0	93.90	1953
Gregory Substation — Mission Substation	115.0	67.35	1952
Forman Substation — Summit Substation	115.0	23.73	1970
Fort Randall Powerplant — Gregory Substation	115.0	49.56	1952
Fort Randall Powerplant — O'Neill Substation	115.0	44.06	1952
Gavins Point Powerplant — Belden Substation	115.0	32.33	1955
Oahe Powerplant — Maurine — Rapid City Substation	115.0	228.07	1962
Pierre Substation — Philip Substation	115.0	71.15	1954
Fort Thompson Substation — Big Bend Powerplant	13.8	7.06	1964
Mission Substation — Philip Substation	115.0	115.40	1963
New Underwood Substation — Philip Substation	115.0	57.66	1953
New Underwood Substation — Rapid City Substation No. 1	115.0	29.74	1953
New Underwood Substation — Rapid City Substation No. 2	115.0	18.87	1966
Oahe Powerplant — Pierre Substation	115.0	5.85	1954
Western Division			
BIG HORN AREA			
Boysen—Alcova			
Boysen—Raderville	115.0	54.40	1952
Raderville—Alcova	115.0	45.16	1952
Boysen—Pilot Butte	115.0	37.30	1952
Boysen—Thermopolis	115.0	19.00	1952
Lovell—Yellowtail No. 1	115.0	46.85	1956
Lovell—Yellowtail No. 2	115.0	46.80	1966
Thermopolis—Lovell			
Thermopolis—PP&L Worland Tap	115.0	30.80	1953
PP&L Worland Tap — Basin	115.0	14.90	1953
Basin—Greybull Tap	115.0	12.05	1953
Greybull Tap — Lovell	115.0	26.55	1953
Heart Mountain—Lovell			
Garland Tap—Lovell	69.0	18.50	1953
Boysen—PP&L Fremont Junction	34.5	0.60	1952
Pilot Butte—Boysen			
Boysen Tap—Boysen	34.5	13.17	1947
NORTH PLATTE AREA			
Archer—Stegall	230.0	61.24	1966
Glenrock—Stegall	230.0	126.35	1967
New Underwood—Stegall			
S. Dak. State Line (Str. 80/2)—Wayside	230.0	0.24	1966
Wayside Tap—Stegall	230.0	93.06	1966
Alcova—Casper (North Line)	115.0	28.60	1957
Alcova—Fremont Canyon	115.0	8.10	1960
Archer—Sidney			
Archer—Pine Bluffs	115.0	29.08	1949
Pine Bluffs—Bushnell Tap	115.0	16.56	1961
Bushnell Tap—Kimball	115.0	7.90	1961
Kimball—Sidney	115.0	33.55	1961
Casper—Glendo (North)			
Casper—Glenrock Tap (North)	115.0	36.10	1957
Glenrock Tap—Glendo (North)	115.0	49.10	1957
Western Division—Continued			
Casper—Glendo (South)			
Casper—Glenrock Tap (South)	115.0	34.10	1950
Glenrock Tap—Glendo (South)	115.0	46.03	1950
Cheyenne—Archer (South)	115.0	2.66	1974
	115.0	6.62	1966
Gering—Chadron			
Gering—Morrill County Tap	115.0	23.70	1950
Morrill County Tap—Alliance	115.0	23.75	1950
Alliance—PEMA Box Butte Tap	115.0	13.72	1951
PEMA Box Butte Tap—Dunlap	115.0	15.43	1951
Dunlap—Chadron	115.0	24.91	1951
Gering—Sidney			
Gering—McGrew Tap (TS6T)	115.0	14.95	1949
McGrew Tap—Bridgeport	115.0	17.39	1949
Bridgeport—Wheatbelt PPD Dalton Tap	115.0	20.56	1949
Wheatbelt PPD Dalton Tap—Sidney	115.0	16.59	1949
Sidney—Podolak	115.0	33.33	1965
Glendo—Stegall (North)			
Glendo—Lingle Tap	115.0	41.31	1957
Lingle Tap—Lyman Tap	115.0	14.93	1957
Lyman Tap—Stegall	115.0	18.90	1957
Lingle Tap—Lingle	115.0	5.70	1957
Lyman Tap—Lyman	115.0	0.21	1966
Glendo—Stegall (South)			
Glendo—Guernsey Rural	115.0	18.70	1950
Guernsey Rural—Stegall	115.0	59.22	1950
Guernsey Rural—Guernsey	115.0	4.22	1952
Kortes—Alcova (East)	115.0	28.73	1971
Kortes—Alcova (West)	115.0	28.60	1949
Kortes—Cheyenne			
Kortes—PP&L Gem City Tap	115.0	97.13	1960
PP&L Gem City Tap—Cheyenne	115.0	44.44	1960
Lyman—Torrington	115.0	13.41	1974
Ogallala (Tri-State)—Ogallala	115.0	0.18	1951
Seminoe—Sinclair			
Seminoe—PP&L Bairoil Tap	115.0	3.20	1952
PP&L Bairoil Tap—Sinclair	115.0	24.96	1952
Sidney—Beaver Creek			
Sidney—Peetz Tap (PS Co.)	115.0	16.54	1950
Peetz Tap (PS Co.)—Sterling	115.0	22.70	1950
Sidney—Ogallala (Tri-State)			
Sidney—Colton Tap (Wheatbelt PPD)	115.0	6.91	1951
Colton Tap (Wheatbelt PPD) —Chappell	115.0	21.37	1951
Chappell—Julesburg Tap	115.0	10.49	1951
Julesburg Tap—Big Springs Tap	115.0	7.10	1951
Big Springs Tap—Ogallala (Tri-State)	115.0	22.98	1951
Julesburg Tap—Julesburg	115.0	7.05	1953
Stegall—Gering (North)	115.0	15.95	1956
Stegall—Gering (South)	115.0	15.92	1950
Glendo—Lusk Rural Tap	69.0	34.61	1950
Podolak—Lusk	69.0	2.50	1950
Podolak—Lusk Rural	69.0	0.04	1954
Heart Mountain—Thermopolis			
So. Cody Tap Line (Glendale Tap—Glendale)	69.0	1.97	1970
Lyman—Lyman Nebraska Tap	34.5	4.30	1966
Lyman—Lyman Jct.			
Cheyenne—Warren A.F. Base Boundary No. 1	13.8	2.18	1941
Cheyenne—Warren A.F. Base Boundary No. 2	13.8	2.18	1941
Pine Bluffs Sub-Pine Bluffs	12.5	2.68	1950
	12.5	0.68	1976
RIVERTON AREA			
Pilot Butte—Boysen			
Pilot Butte—Pavillion Tap	34.5	6.20	1939
Pavillion Tap—Muddy Ridge Tap	34.5	11.89	1939
Muddy Ridge Tap—Boysen Tap	34.5	14.40	1939
Pavillion Tap—Pavillion	34.5	1.00	1923
Pavillion—RVEA Sub.	34.5	2.20	1923

Pick-Sloan Missouri Basin Program
Webster Unit, Solomon Division

Kansas: Rooks and Osborne Counties

Lower Missouri Region
Water and Power Resources Service



The Webster Unit is located between Woodston and Osborne, Kans., on the north side of the South Fork of the Solomon River. Webster Dam, 8 miles west of the city of Stockton, is the principal feature of the unit. The unit provides flood control for areas downstream of the dam, irrigation water to 8,500 irrigable acres of the Webster Irrigation District No. 4, fish and wildlife conservation and enhancement, and recreation opportunities. The Woodston Diversion Dam, four pumping plants, Osborne Canal, laterals, and drains complete the facilities which make up the unit.

PLAN

The unit lands are served by the Osborne Canal which originates at the Woodston Diversion Dam about 16 miles downstream from Webster Dam. Pumping plants lift water from the canal to small tracts that would not otherwise be accessible for water from the unit. The water is conveyed to these lands by laterals and to other unit areas by gravity-fed laterals.

Webster Dam

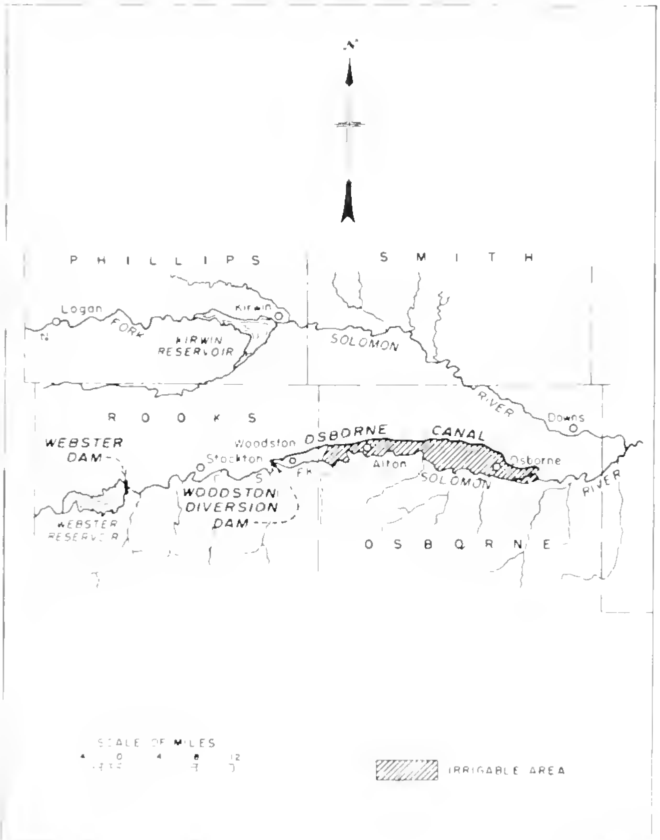
Webster Dam is on the South Fork of the Solomon River adjacent to the original townsite of Webster in Rooks County, Kansas. It is a modified homogeneous earthfill embankment 10,720 feet long with a structural height of 154 feet. An earthfill dike fills a low saddle to the northwest of the left end of the dam.

The spillway is located on the left abutment of the dam. It is a concrete structure with an overflow section controlled by three large radial gates. The spillway has a maximum capacity of 138,000 cubic feet per second.

The outlet works through the dam is located on the north bank of the river immediately south of the spillway. The outlet works is used to release water to the stream for downstream requirements and for diversion into the Osborne Canal at Woodston Diversion Dam.

The Webster Reservoir has a total capacity of 260,740 acre-feet, of which 72,070 acre-feet are for irrigation and 183,370 acre-feet are for flood control.

Webster Dam



Webster Unit

Woodston Diversion Dam and Canal System

The Woodston Diversion Dam is located on the South Fork of the Solomon River about 1.5 miles west of Woodston. It is a concrete ogee-type spillway 151 feet long with earthfill dikes 2,150 feet long. The dam has a hydraulic height of 14 feet. The concrete spillway section has a maximum capacity of 14,000 cubic feet per second. The dam diverts water into the Osborne Canal, which is 32.6 miles in length and has an initial capacity of 160 cubic feet per second. The canal, a lateral system totaling 29.9 miles in length, and four pumping plants serve the 8,500 acres of unit lands.[1] The four pumping plants are used for land which cannot be fed by gravity. There are approximately 2 miles of drains which serve the unit.

DEVELOPMENT

Early History

Settlement in Osborne County started in 1869 and Rooks County was settled 2 years later.

In 1874, destruction of crops by grasshoppers caused a temporary setback in Osborne County, but in 1880 the population of the two counties had increased to 20,630. The hope of a prosperous era, encouraged by good crop yields obtained during the 1880's, turned to disappointment during the following years when it became apparent that periods of favorable precipitation were to be interrupted frequently by droughts. Recurrent cycles of wet and dry years resulted in a corresponding fluctuation from farm settlement to abandonment of the farms.

The present Webster Unit has been dry-farmed since the initial settlement, except for a few farms on the South Fork of the Solomon River and its tributaries where small pumping plants were installed to irrigate the fields. These pumps and the irrigation systems were experimental and, for the most part, did not result in permanent installations. Interest in irrigated agriculture lagged because when the river water was most needed, the river generally was low and the water was of poor quality.

Investigations

The need for a multiple-purpose project became apparent as the area became settled and the floods and droughts continued. At the requests of local authorities, the Bureau of Reclamation initiated investigations in the vicinity of the present unit in 1939. The Corps of Engineers, in cooperation with these investigations, indicated that there would be substantial benefits from flood control, together with those available from irrigation and other uses.

The magnitude of the unprecedented flood of July 1951 demonstrated the necessity for regulation and control of the water resources of the basin and sparked public demand for adequate flood control. Investigations were accelerated, and modifications of the initial plan of development resulted in more than doubling the flood-control capacity of the reservoir.

The plan for irrigation was presented in a definite plan report, which was approved in February 1957, after authorization of the flood-control plan.

Authorization

The unit was authorized by the Flood Control Acts of December 22, 1944, and July 24, 1946.

Construction

Construction of Webster Dam was commenced in January 1953 and was completed in June 1956. Construction of Woodston Diversion Dam was started in June 1957 and completed in February 1959. Osborne Canal was started in March 1958 and completed in April 1961.

[1]Canal turnouts and laterals serve 7,307 acres; pumps serve 1,193 acres.

Operating Agencies

Webster Dam and Reservoir are operated and maintained by the Bureau of Reclamation. Operation of the reservoir is coordinated with others in the Kansas River Basin. The Corps of Engineers furnishes data and operational procedures for regulation of water in the flood control capacity.

Webster Irrigation District No. 4 operates and maintains the irrigation facilities. Both the Kansas Forestry, Fish and Game Commission and the Kansas State Park and Resources Authority are involved in the management of recreation and fish and wildlife interests at the reservoir and diversion dam, surface waters, and adjacent lands set aside for those purposes.

BENEFITS

Irrigation

The irrigable lands in the unit are fertile and highly productive. Before irrigation, wheat was the main source of cash farm income. Under irrigation, principal crops are corn, grain sorghum, and silage. With a dependable feed supply available, raising and fattening cattle and hogs have become important industries.

Flood Control

Webster Dam and Reservoir provide a high degree of flood protection for the South Fork of the Solomon River, materially assist in the reduction of flood damages in the lower Solomon River Valley, and contribute to flood protection of the valleys of the Kansas and Missouri Rivers.

Recreation and Fish and Wildlife

Recreation opportunities at Webster Dam and Reservoir, Woodston Diversion Dam, and surrounding areas set aside for that purpose consist of picnicking, camping, swimming, boating, fishing, and other related activities. Normal operation of the Webster Reservoir provides a stable or slightly rising water level which is ideal for spawning fish.

PROJECT DATA

Land Areas (1977)

Irrigable area:	
Full irrigation service	8,500 acres
Number of irrigated farms	81

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	6,995	791,570
1969	6,951	937,253
1970	7,132	1,016,474
1971	6,603	884,013
1972	[2]	184,162
1973	5,136	1,172,955
1974	6,776	2,023,607
1975	6,362	1,690,797
1976	7,099	1,635,036
1977	6,486	1,195,188

[2]Data not available.

Facilities in Operation

Storage dams	1
Diversion dams	1
Canals	32.6 mi
Laterals	29.9 mi
Drains	2.2 mi
Pumping plants	4

Climatic Conditions

Annual precipitation	25.4 in
Temperature:	
Maximum	112 °F
Minimum	−22 °F
Mean	54 °F
Growing season	163 days
Elevation of irrigable area	1500-1700.0 ft

Settlement:

Number of persons served with project water (1977):	
Farm irrigation service	290

ENGINEERING DATA

Water Supply

SOUTH FORK, SOLOMON RIVER

Drainage area at Webster Dam	1,125 mi²
Annual discharge at Webster, Kans.:	
Maximum (1951)	360,400 acre-ft
Minimum (1972)	700 acre-ft
Average	48,200 acre-ft
Average annual diversion, 1960-76	13,032 acre-ft

Storage Facilities

WEBSTER DAM AND DIKE

Type: Zoned earthfill. Dike, about 2,640 ft long and 12 ft high, closes low area near north end of dam.
Location: On the South Fork, Solomon River, about 8 mi west of Stockton, Kans.
Construction period: 1953-56
Date of closure (first storage): May 3, 1956
Reservoir, Webster:

Average annual inflow, 1920-76	48,200 acre-ft
Total capacity to El. 1923.7	260,740 acre-ft
Active capacity, El. 1855.5-1923.7	255,440 acre-ft
Surface area	8,480 acres

Dimensions:

Structural height	154	ft
Hydraulic height	86.7	ft
Top width	30	ft
Maximum base width	940	ft
Crest length	10,720	ft
Crest elevation	1944.0	ft
Volume	8,145,000	yd^3

Spillway: Concrete-lined chute at left abutment controlled by three 33.3- by 39.5-ft radial gates.

Elevation top of gates	1923.7	ft
Crest elevation	1884.6	ft
Capacity at El. 1938	138,000	ft^3/s

Outlet works: Concrete conduit through base of dam near right abutment, controlled by one 3.5-ft-square high-pressure slide gate.

Capacity at El. 1889.6	380	ft^3/s

Foundation: Up to 60 ft of alluvial refill overlying Carlisle shale in the riverbed, chalky limestone in the abutments.

Diversion Facilities

Woodston Diversion Dam

Type: Concrete overflow, embankment wing
Location: 1.5 mi west of Woodston, Kans.
Construction period: 1957-59
Dimensions:

Structural height	30	ft
Hydraulic height	14	ft
Length of weir	151	ft
Crest elevation of weir	1687.0	ft
Length of embankment	2,150	ft
Volume	80,000	yd^3

Headworks:
Type: Gated sluiceway and gated canal, left abutment.

Capacity	160	ft^3/s
Spillway: Capacity at El. 1692	14,000	ft^3/s

Carriage Facilities

Osborne Canal

Location: East of Woodston Diversion Dam, parallel and north of South Fork, Solomon River.
Construction period: 1958-61

Length	32.6	mi
Diversion capacity	161	ft^3/s

Typical maximum section in earth:

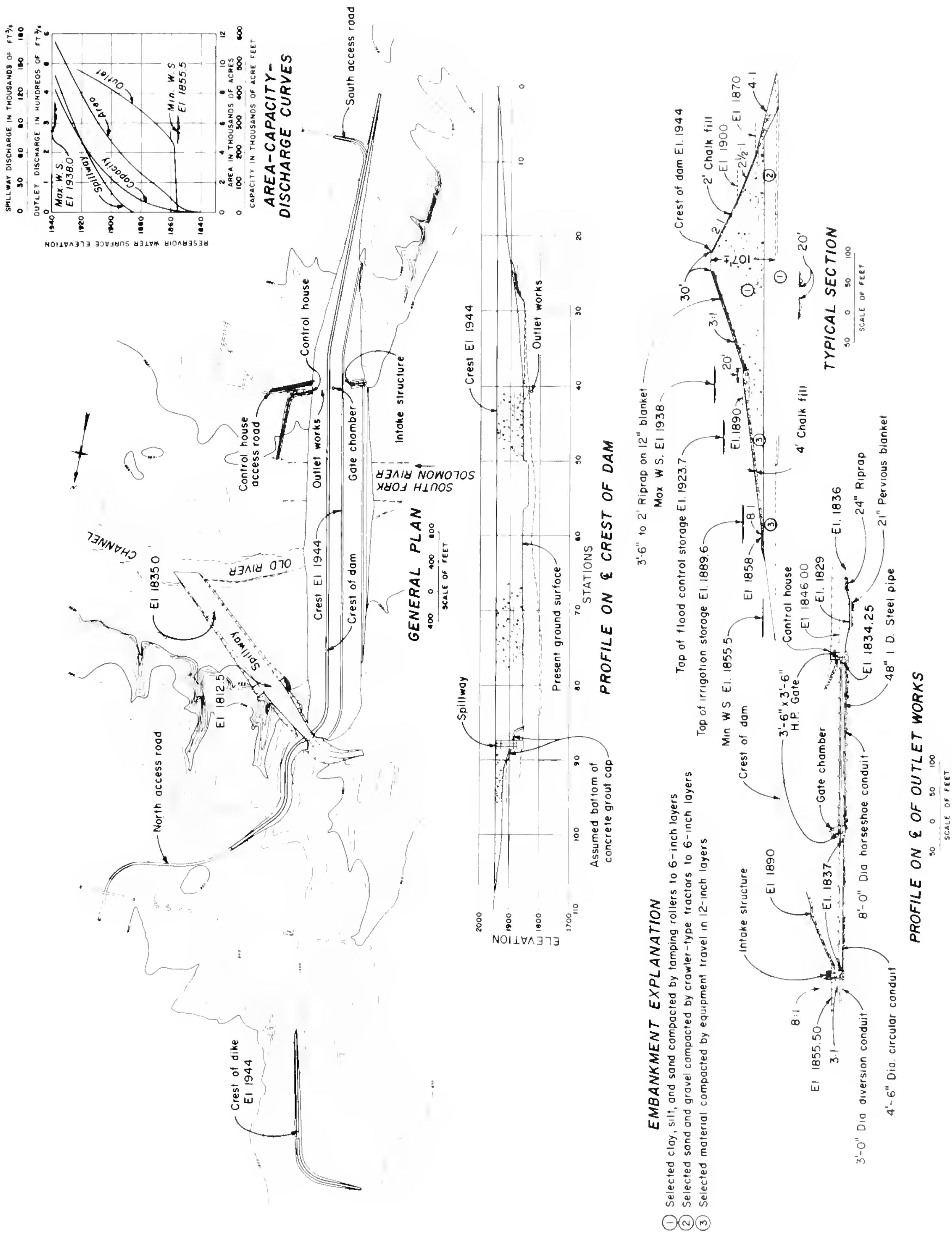
Bottom width	12	ft
Side slopes	2:1	
Water depth	4.2	ft

Typical maximum section, earth lined:

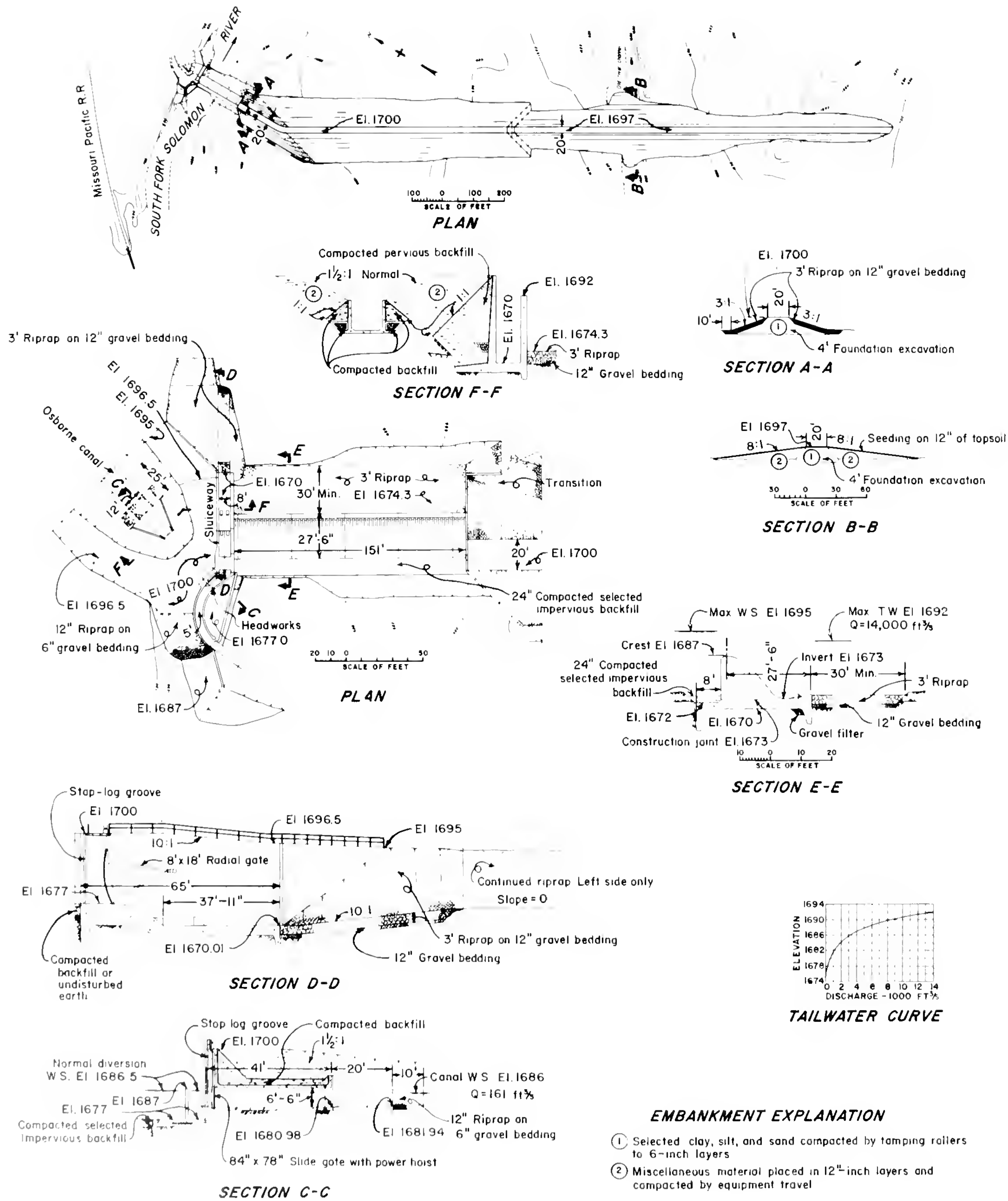
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	2.6	ft
Lining thickness	1.5	ft

Pumping Plants

Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horsepower
3.5 Right	2	6	9	12.5
3.5 Left	2	12	30	60
6.4 Right	2	9	8	15
7.5 Left	2	9	40	60



Webster Dam and Dike, Plan and Sections

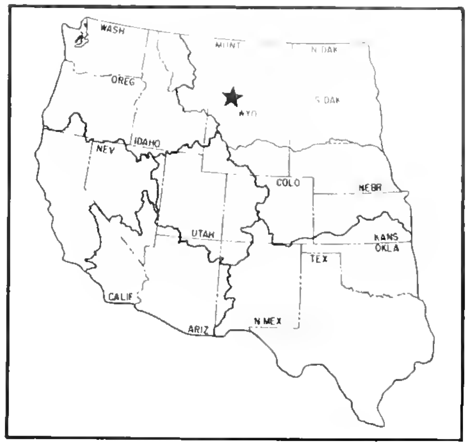


Woodston Diversion Dam, Plans and Sections

Pick-Sloan Missouri Basin Program
Yellowtail Unit

Montana: Big Horn and Carbon Counties
Wyoming: Big Horn County

Upper Missouri Region
Water and Power Resources Service



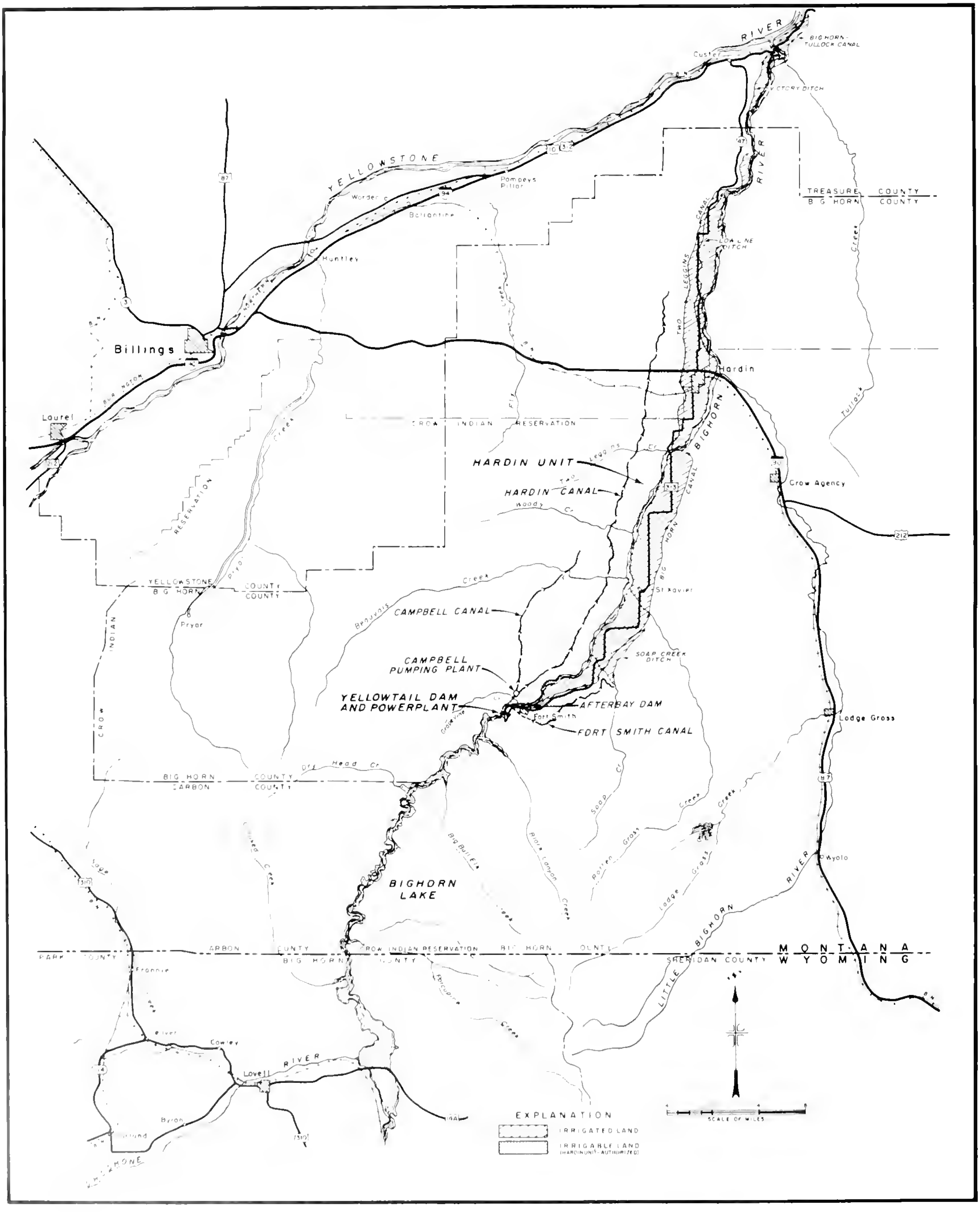
PLAN

The Yellowtail Unit in south-central Montana is a multipurpose development providing irrigation water, flood control, and power generation. Facilities consist of Yellowtail Dam and Bighorn Lake on the Bighorn River, Yellowtail Powerplant at the toe of the dam, Yellowtail Afterbay Dam a short distance downstream, and related structures.

The Crow Indian Reservation, spreading over about 3,500 square miles, encompasses the damsite, a portion of the reservoir area, and about two-thirds of the area of the potential Hardin Unit. The Hardin Unit is proposed to use Yellowtail storage for irrigation.

Yellowtail Dam, at the mouth of Bighorn Canyon, impounds flows of the Bighorn River for multipurpose use. Bighorn Lake is about 72 miles long at maximum water surface elevation, 66 miles long at the top of joint-use storage, and extends into the Bighorn Basin of Wyoming. The reservoir is confined in the canyon for most of its length. The widely varying releases from the powerplant will be regulated by the Yellowtail Afterbay Dam, constructed 2.2 miles downstream from Yellowtail Dam. The afterbay minimizes downstream fluctuations in Bighorn River.

Yellowtail Dam and Afterbay Dam



Yellowtail Unit

Yellowtail Dam spillway release

Yellowtail Dam and Reservoir

Hardin Unit (Potential)

Irrigation storage in Bighorn Lake would be used principally by the potential Hardin Unit, which would provide for irrigation of 42,600 acres of land that require full irrigation service and 950 acres that require a supplemental water supply.

The 862 cubic feet per second of water needed for the Hardin Unit would be diverted through the left abutment of Yellowtail Dam into the Grapevine Tunnel, which would carry the water 0.9 mile to the Grapevine Penstock. The penstock would deliver 70 cubic feet per second to the Fort Smith Canal and 792 cubic feet per second to the Campbell Pumping Plant.

The tunnel and penstock would be designed to operate under pressure to take advantage of reservoir head on hydraulic turbines that would be used for the pumps. The pumping plant, planned to be of the outdoor type, would contain two units capable of lifting 239 cubic feet per second of water at maximum head to the Campbell Canal. Turbine discharges from the pumping plant would go directly into the Hardin Canal, and all of the 553 cubic feet per second discharged would be needed to irrigate land on Hardin Bench.

The irrigation system would involve 76 miles of canals and 100 miles of laterals, ranging in capacity from 553 to 70 cubic feet per second.

Yellowtail Dam and Bighorn Lake

Yellowtail Dam is a concrete thin-arch structure with a structural height of 525 feet, a crest length of 1,480 feet, and a volume of 1,545,664 cubic yards of concrete.

The spillway, in the left abutment of the dam, consists of an unlined inlet channel, an intake structure controlled by two 25- by 64.4-foot radial gates, a concrete-lined tunnel transition, a concrete-lined tunnel which ranges in diameter from 40.5 to 32 feet, and a stilling basin. Discharge capacity for the spillway is 92,000 cubic feet per second at maximum water surface elevation 3660.0. The outlet works consists of an irrigation outlet and an evacuation outlet, each with 84-inch-diameter outlet pipes and controlled by 84-inch ring-follower gates. Both outlets discharge into a stilling basin at the right of the powerplant at the toe of the dam.

A 9.5-foot-diameter tunnel intake is included in the left abutment of the dam for the Grapevine Tunnel, controlled by a 7.86- by 15.03-foot fixed-wheel gate. The complete Grapevine Tunnel is to be constructed as a feature of the Hardin Unit.

Bighorn Lake has a total capacity of 1,375,000 acre-feet and an active capacity of 363,700 acre-feet. At elevation 3657.0, the reservoir has a surface area of 17,300 acres.

Yellowtail Powerplant

Four 12-foot-diameter penstocks through the dam supply water to four 87,500 horsepower, Francis-type hydraulic turbines, each driving a 62,500-kilowatt generator. The powerplant structure is at the toe of Yellowtail Dam.

Yellowtail Afterbay Dam

The afterbay pool is formed by Yellowtail Afterbay Dam, constructed on the Bighorn River 2.2 miles downstream from Yellowtail Dam. The dam is a 72-foot-high concrete gravity structure with embankment wings. The afterbay dam has a crest length of 1,360 feet and consists of 21,600 cubic yards of concrete and 162,000 cubic yards of earth material and riprap.

Yellowtail Afterbay Reservoir has a capacity of 3,140 acre-feet. Discharges are used to provide a uniform daily flow into Bighorn River, leveling the peaking power discharges from Yellowtail Powerplant.

The spillway consists of an ogee crest controlled by five 30- by 13.5-foot radial gates. The sluiceway is controlled by three 120- by 96-inch cast-iron slide gates with automatic controls.

Headworks for the existing Bighorn Canal, adjacent to the sluiceway, are controlled by two 120- by 96-inch cast-iron slide gates with automatic controls. Diversion capacity for the canal headworks is 750 cubic feet per second.

Construction of the afterbay dam required removal of the existing headworks and the Bighorn Indian Diversion Dam midway between Yellowtail Dam and Yellowtail Afterbay Dam.

Yellowtail Afterbay Dam

DEVELOPMENT

Early History

The early history of the area is closely identified with that of the Crow Indian Reservation, which, as established under the ratified treaty of 1868, had an area of about 38 million acres. By an act of Congress, the reservation was defined as a triangular area lying between the 107th meridian, the Yellowstone River, and the southern boundary of Montana.

The Indians were primarily interested in hunting, trapping, and fishing. Encouraged by overzealous fur buyers, the game resources were rapidly diminished by hunters, and the Indians gradually retreated toward the mountains, leaving large areas of both grazing and arable land available for occupation and use. Because of the retreat, the size of the reservation was successively reduced in 1880, 1890, and 1904.

During 1900-10, many farmers came into the area under the Homestead Act of 1862, which encouraged the establishment of 160-acre farms.

About 1900, the Indian Service, foreseeing that fish and wildlife resources would become inadequate for the needs of the Crow Indian Reservation, began the establishment of farmland allotments among the Indians and instituted a program designed to encourage their interest in agriculture. Pending such use, much agricultural land was leased to settlers, and by 1910 practically all desirable lands were included in operating farms or ranches. Many Indian allotments were sold as they became patented. This practice was greatly accelerated after passage of the Crow Act in 1920, which provided for allotment of all reservation lands except mountainous areas and certain specified withholdings. The reservation now includes about 2,055,600 acres of the Indian land and 179,200 acres of land owned by others.

Investigations

First investigations by the Reclamation Service were made during 1903-05 to study feasibility of making a gravity diversion near the Yellowtail damsite to a canal system along the west side of the river. Investigations started in 1913, and a detailed report dated October 24, 1917, recommended construction of a gravity arch dam of rubble concrete about 480 feet high, a powerplant with 500 miles of transmission lines, and 62 miles of highline canals to irrigate 60,000 acres of benchland. Bureau of Reclamation investigations of the Yellowtail Dam and Bighorn Lake sites in 1939-42 were later summarized and published in Senate Document 191, 78th Congress, 2d session, in which a low dam at the Yellowtail site and one at the Kane site were proposed to be operated in conjunction with a total installed capacity of 105,000 kilowatts.

The definite plan report, dated January 1950, was approved by the Commissioner of Reclamation on November 10, 1950. The report substantiated conclusions that a single high dam at the Yellowtail site would be more economical than the two smaller dams.

Authorization

Construction of Yellowtail Dam was authorized by the Flood Control Act of December 22, 1944, (Public Law 534, which approved the general comprehensive plan set forth in Senate Document 191 and House Document 475, as revised and coordinated by Senate Document 247, 78th Congress, 2d session.)

Construction

Construction began on Yellowtail Dam and Powerplant in May 1961 and was completed in December 1967; construction of Yellowtail Afterbay Dam was started in April 1964 and completed in November 1966. Power units 3 and 4 began operation in August 1966, followed by unit 2 in October 1966 and unit 1 in November 1966.

Operating Agency

Operations are the responsibility of the Bureau of Reclamation; the unit was transferred to operation and maintenance on August 1, 1967.

BENEFITS

Irrigation

Bighorn Lake is the key feature of the entire irrigation development in the Lower Bighorn Basin, but the Hardin Unit will distribute water to basin lands. The area known locally as the Hardin Bench lies 100 feet or more above the Bighorn River and will be served by gravity. Twelve thousand seven hundred acres located on higher benches will be served by a pumping plant about 1 mile below Yellowtail Dam. The principal crop is anticipated to be sugarbeets. Hay, small grains, and corn will probably be grown in appropriate quantities to supply feed for livestock and to provide a suitable rotation for soil management.

Hydroelectric Power

Electric energy produced at the 250,000-kilowatt Yellowtail Powerplant is marketed through the transmission facilities of the Pick-Sloan Missouri Basin Program.

Recreation

Bighorn Lake, because of its outstanding scenic character and excellent fishing, offers many recreation opportunities for southern Montana and northern Wyoming residents, and for vacationing tourists. In 1977, visitor days totaled 375,700.

PROJECT DATA

Facilities in Operation

Storage dams	1
Reregulating dams	1
Powerplants	1

Climatic Conditions

Annual precipitation	20.5 in
Temperature:	
Maximum	106 °F
Minimum	−27 °F
Mean	50 °F
Growing season	148 days

Power Generation

Fiscal year	Yellowtail Powerplant (kWh)	Fiscal year	Yellowtail Powerplant (kWh)
1967	1,499,754,000	1973	1,071,348,000
1968	1,251,549,000	1974	1,130,374,000
1969	822,371,000	1975	1,140,909,000
1970	887,395,000	1976	1,327,871,000
1971	1,135,405,000	T.Q.	197,782,000
1972	1,296,355,000	1977	698,091,000

ENGINEERING DATA

Water Supply

BIGHORN RIVER

Drainage area above Yellowtail Dam	19,650 mi²
Annual discharge near St. Xavier:	
Maximum (1947)	3,662,600 acre-ft
Minimum (1966)	1,132,700 acre-ft
Average	2,604,000 acre-ft

Storage Facilities

YELLOWTAIL DAM

Type: Concrete thin arch
Location: On the Bighorn River about 45 mi southwest of Hardin, Mont.
Construction period: 1961-66
Date of closure (first storage): November 1965
Reservoir, Bighorn Lake:

Average annual inflow, 1935-78	2,626,000 acre-ft
Total capacity to El. 3657	1,375,000 acre-ft
Active capacity, El. 3547-3614	363,700 acre-ft
Surface area	17,300 acres
Dimensions:	
Structural height	525 ft
Hydraulic height	495 ft
Top width	22 ft
Maximum base width	147 ft
Crest length	1,480 ft
Crest elevation	3660.0 ft
Total volume	1,545,664 yd³

Spillway: Concrete tunnel through the left abutment, controlled by two 25- by 64.1-ft radial gates.

Elevation top of gates	3657.0 ft
Crest elevation	3593.0 ft
Capacity at El. 3660	92,000 ft³/s

Outlet works: Irrigation and evacuation outlets, each consisting of 84-in diameter pipes and controlled by 84-in ring-follower gates, discharging into stilling basin at right of powerplant.

Capacity irrigation outlet	2,500 ft³/s
Capacity evacuation outlet	2,500 ft³/s

Power outlet: Four 12-ft-diameter penstocks through the dam.

Reregulating and Diversion Facilities

YELLOWTAIL AFTERBAY DAM

Type: Concrete gravity with embankment wings
Location: On the Bighorn River, 2.2 mi downstream from Yellowtail Dam.
Construction period: 1964-65
Reservoir, Yellowtail Afterbay:

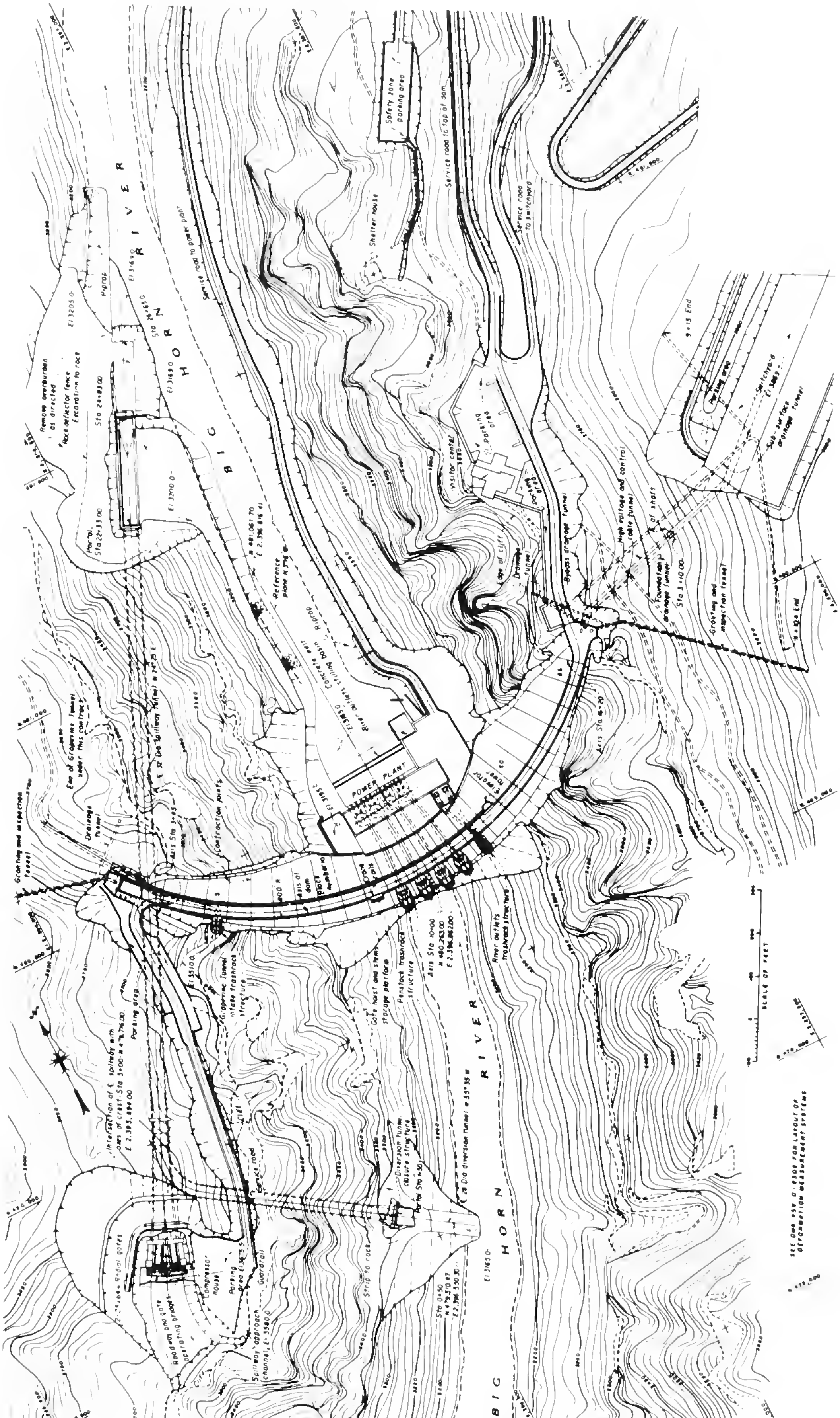
Total capacity to El. 3192	3,140	acre-ft
Active capacity, El. 3157-3192	3,140	acre-ft
Surface area	180	acres
Dimensions:		
Structural height	72	ft
Hydraulic height	36	ft
Top width, overflow weir	64	ft
Top width, embankment wings	28	ft
Base width	140	ft
Crest length	1,360	ft
Volume, concrete	21,600	yd³
Volume, earth materials and riprap	162,000	yd³
Volume, total	183,600	yd³
Spillway: Concrete ogee crest, controlled by five 30- by 13.5-ft radial gates.		
Capacity at El. 3192	3,100	ft³/s
Sluiceway: Three 120- by 96-in cast-iron slide gates.		
Headworks: Two 120- by 96-in cast-iron slide gates.		
Diversion capacity	750	ft³/s

Power Facilities

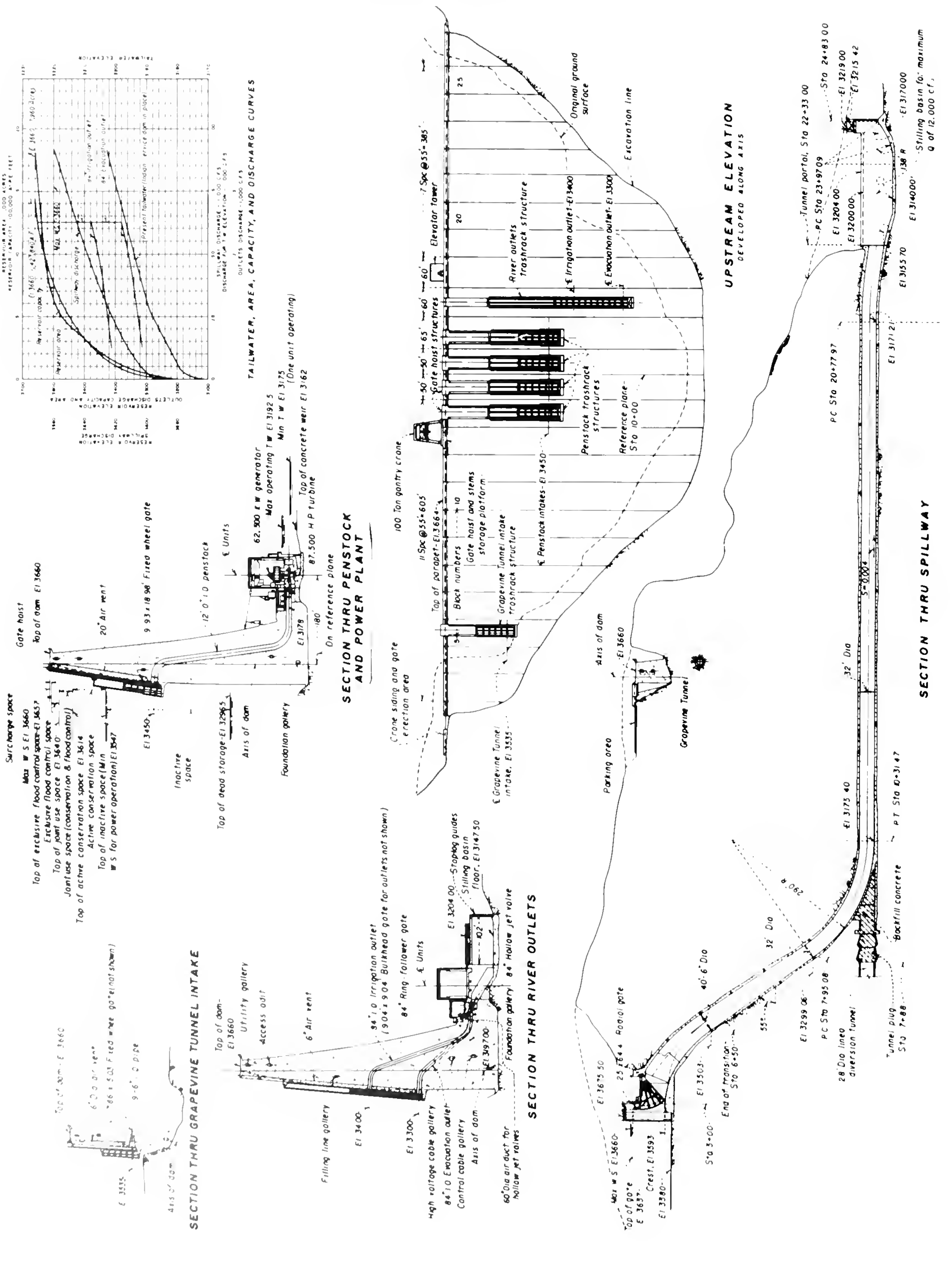
YELLOWTAIL POWERPLANT

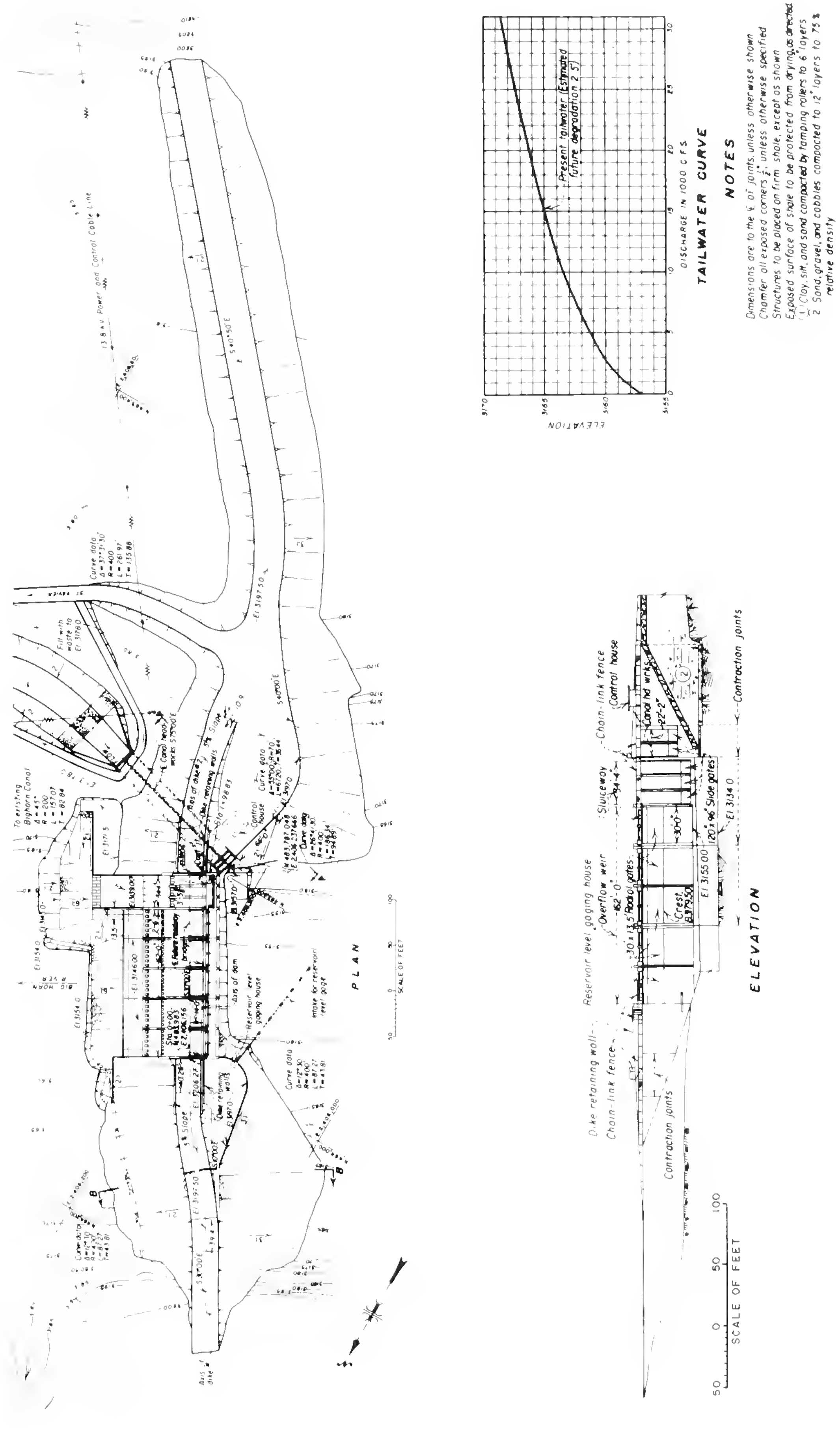
Location: At the toe of Yellowtail Dam.
Year of initial operation: 1966
Year last generator placed in operation: 1966

Nameplate capacity	250,000	kW
Number and capacity of generators (4)	62,500	kW
Switchyards:		
Number in operation	1	
Total kilovolt-ampere capacity of transformers	436,000	

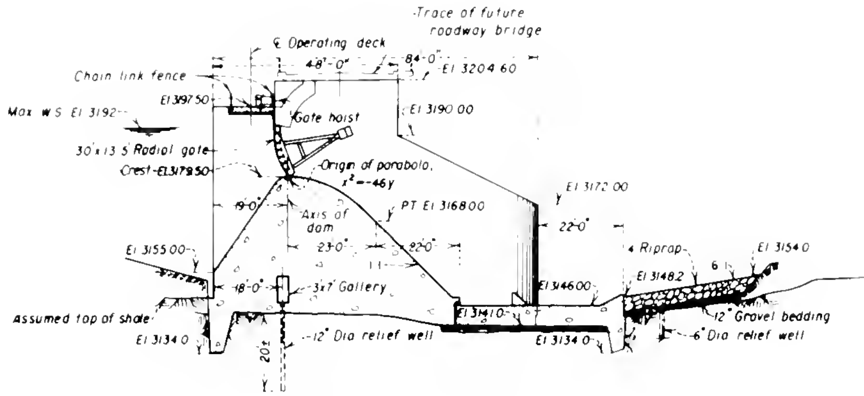


Yellowtail Dam, Plan

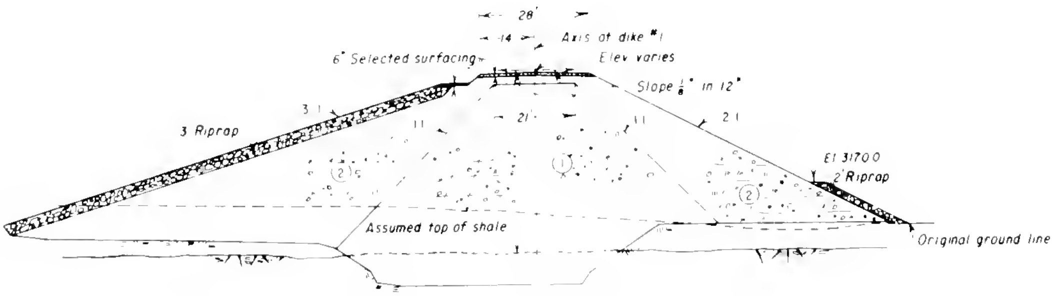

TAILWATER, AREA, CAPACITY, AND DISCHARGE CURVES
(One unit operating)
SECTION THRU PENSTOCK AND POWER PLANT
UPSTREAM ELEVATION
DEVELOPED ALONG AXIS
SECTION THRU SPILLWAY
SECTION THRU GRAPEVINE TUNNEL INTAKE
SECTION THRU RIVER OUTLETS
100 Ton gantry crane
Elevator tower
River outlets trashrack structure
Penstock trashrack structures
Grapevine Tunnel intake trashrack structure
Original ground surface
Excavation line
Parking area
Grapevine Tunnel
Backfill concrete
Stilling basin for maximum Q of 12,000 c.f.s.



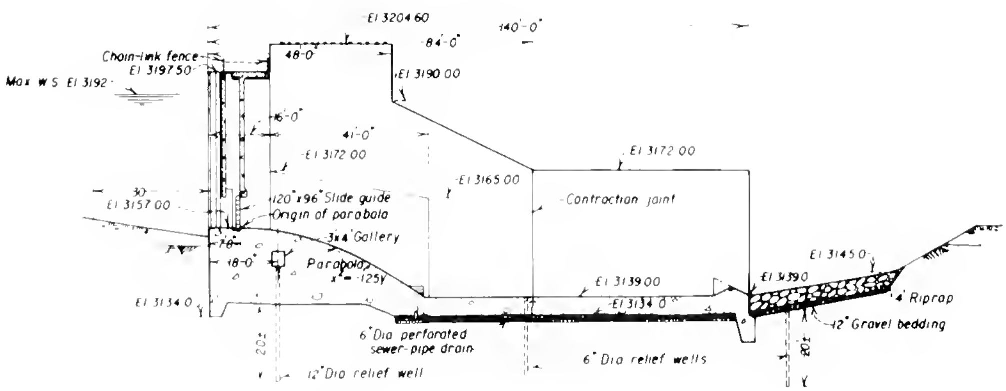
Yellowtail Afterbay Dam, Plan



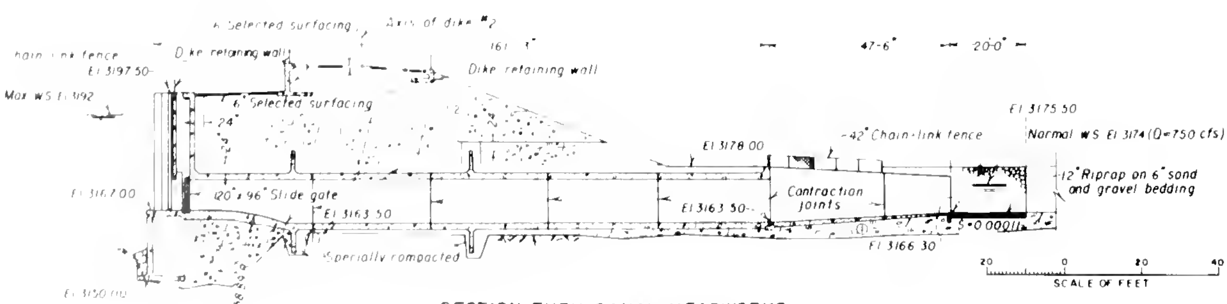
SECTION THRU OVERFLOW WEIR Sta 1 + 31



SECTION B - B Sta 1+25



SECTION THRU SLUICEWAY Sta 1 + 80



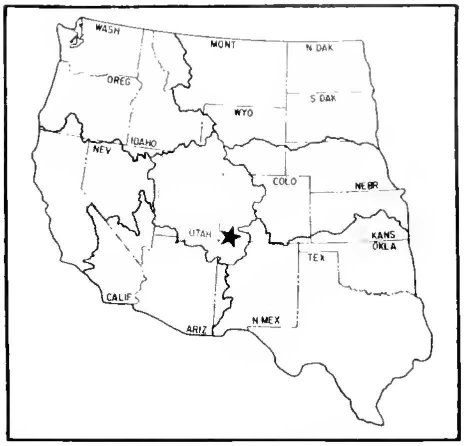
SECTION THRU CANAL HEADWORKS

Yellowtail Afterbay Dam, Sections

Pine River Project

Colorado: La Plata and Archuleta Counties

Upper Colorado Region
Water and Power Resources Service



The Pine River Project consists of Vallecito Dam and Reservoir, constructed to furnish supplemental water to about 55,000 acres of project and Indian lands.

PLAN

The project stores spring floodwaters to provide a supplemental water supply to 13,000 acres of Indian lands and to 42,000 acres of land outside the Indian reservation. Water is furnished to more than 50,000 of the 55,000 acres of project lands. Irrigation water is distributed through privately owned systems or through systems under jurisdiction of the Bureau of Indian Affairs.

Vallecito Dam

Storage for the project is impounded by this 162-foot-high earthfill structure, which contains 3,738,000 cubic yards of material. Vallecito Dam is on the Pine River, 18 miles northeast of Durango. The reservoir has a total capacity of 129,700 acre-feet. The spillway is a gate-controlled, concrete-lined open channel, 2,300 feet long at the right abutment. The outlet works is a twin section concrete conduit through the right abutment of the dam.

Vallecito Reservoir

DEVELOPMENT

Early History

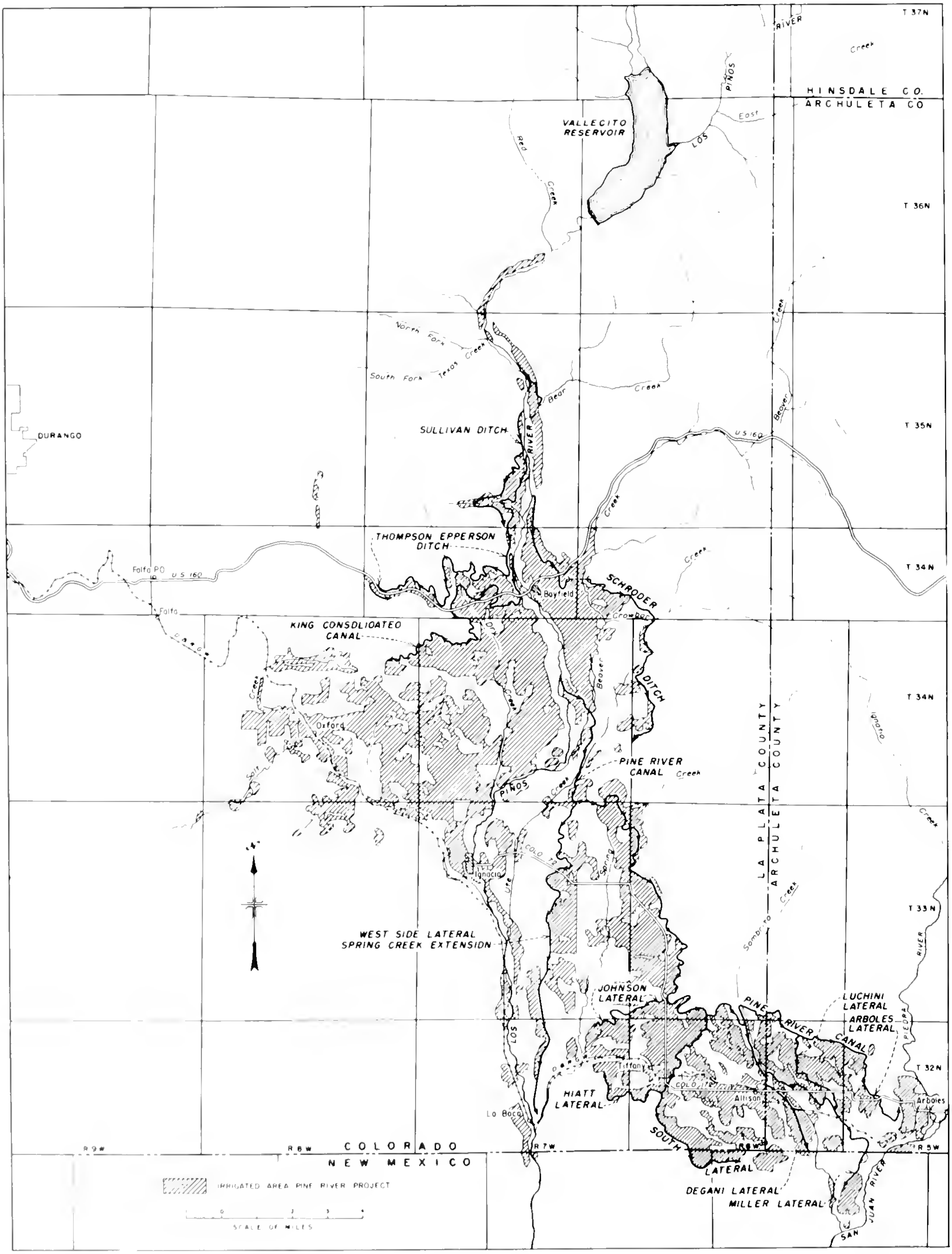
Settlement of the San Juan Basin was incidental to the discovery of gold and the rapid expansion of mining in the San Juan Mountains. This territory was located on the Ute Reservation. Persistent invasions by the miners led to so much friction that open warfare existed throughout the region except for the area around Parrott City where a private treaty was negotiated in 1873. Temporary peace was established in 1874 when the United States bought 3 million acres from the Indians. The territory purchased included the main body of the mountains and all of the prospective mineral land. The south boundary of this tract, called the Ute Ceded Lands, runs across the project just below Bayfield.

Farming was practiced on a small scale along the Mancos, La Plata, and Animas Rivers before the ceded lands were purchased from the Indians. After the purchase and the cessation of open warfare, these developments soon grew to their present size. Settlement along the Pine and Florida Rivers was not as rapid, because there was little desirable land outside the reservation. It was not until the reservation was opened for homesteading on May 4, 1899, that settlement really began. At this opening, the Ute Indians accepted 375 allotments of land, with a total area of 60,000 acres. Most of the remaining 636,000 acres were soon settled by farmers.

In 1938, there remained some 200,000 acres of this public domain (mostly grazing land) not taken up by settlers. By congressional action, this land was returned to Southern Ute Indian tribal ownership.

Investigations

The beginning of irrigation from Pine River dates back to about 1877, when small irrigation ditches were first



Pine River Project

Vallecito Dam and Reservoir

constructed along the Pine River for the Indian agencies and for a few small farm tracts. Water filings covering estimated water requirements for approximately 18,000 acres belonging to the Indians were made with the State Engineer in 1895. These claims were contested by the farmers, many of whom had made earlier filings, and an adjudication suit was filed in 1901. On October 25, 1930, the Federal court granted a priority to the Indians, as of July 25, 1868, of 212 cubic feet per second of water from the Pine River and 1 cubic foot per second from Dry Creek for irrigating 16,966 acres. This primary right of the Indians to the waters of the Pine River (Los Pinos) caused an acute shortage of water for other lands in the region since, in many years, the natural flow of the river during irrigation seasons was insufficient to meet the irrigation requirements of the Indians.

The possibility of storing flood and snowmelt waters for irrigation led to the Pine River investigation, which was included among a number of studies conducted by the Bureau of Reclamation during 1924 and 1925. As a result of a report on these surveys, the Secretary of the Interior appointed a committee to conduct irrigation investigations. The committee report was submitted to the Secretary in June 1928. Because of the importance of Southern Ute Indian lands in irrigation investigations, the Office of Indian Affairs handled investigations until 1934, when the Pine River Project was turned over to the Bureau of Reclamation for planning and construction. Funds were made available for starting construction of the project in the Interior Department appropriation act of 1937. Distribution facilities were not included as a part of the original project.

Authorization

The Pine River Project was approved for construction by the President on June 17, 1937, under the provisions of section 4 of the act of June 25, 1910 (36 Stat. 835), subsection B, section 4 of the act of December 5, 1924 (43 Stat. 701).

An extension of the Pine River Project was authorized by Public Law 485, 84th Congress, April 11, 1956, as a participating project of the Colorado River Storage Project. The extension was later found to be infeasible and was deleted from the plan (Colorado River Basin Act, September 30, 1968, Public Law 90-537).

Construction

Construction of Vallecito Dam commenced May 14, 1938, and was completed in early 1941.

Operating Agency

Features constructed by the Bureau of Reclamation are being operated by the Pine River Irrigation District.

BENEFITS

Irrigation

From the beginning of irrigation along the Pine River in 1877, there had been a shortage of water until the Vallecito Dam was completed in 1941. This storage facility has made possible an increase in potential irrigation from less than 17,000 to 55,000 acres, with the added assurance of attaining crop maturity. Improved pasture, alfalfa, wheat, oats, and barley are the principal crops grown on project lands.

Flood Control

Vallecito Dam prevents the flooding of crops, farmland, and structures along the river during spring runoff by storing the floodwater for controlled releases to benefit irrigation.

Recreation

In a beautiful setting in the San Juan National Forest, the Vallecito Reservoir area has facilities for camping, swimming, picnicking, boating, and good fishing for brown, rainbow, and brook trout. Recreation facilities are administered by the Forest Service and the Pine River Irrigation District. Visitor days during 1977 totaled approximately 349,200.

PROJECT DATA

Land Areas (1977)

Irrigable area available for supplemental irrigation service:		
Pine River	42,000	acres
Pine River Indian Irrigation service	13,000	acres
Total	55,000	acres
Number of irrigated farms	476	
Number of irrigated Indian farms	81	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
	Pine River	
1968	39,605	1,706,711
1969	36,038	1,904,765
1970	36,161	1,689,236
1971	38,682	2,310,332
1972	36,360	2,410,789
1973	37,553	2,587,064
1974	38,091	2,428,753
1975	37,345	2,758,646
1976	34,822	2,729,591
1977	37,680	3,258,768
	Pine River Indian Irrigation	
1968	11,390	440,449
1969	12,023	509,524
1970	12,462	485,191
1971	12,383	606,094
1972	12,690	620,611
1973	12,691	610,879
1974	12,722	563,024
1975	12,819	650,585
1976	12,909	611,375
1977	12,909	832,991

Facilities in Operation

Storage dams	1	
Diversion dams	5	
Canals	196	mi
Laterals	148	mi
Drains	19	mi

Climatic Conditions

Annual precipitation	16	in
Temperature:		
Maximum	101	°F
Minimum	−38	°F
Mean	46	°F
Growing season	110	days
Elevation of irrigable area	6500.0	ft

ENGINEERING DATA

Water Supply

PINE (LOS PINOS) RIVER

Drainage area at Vallecito Dam	270	mi^2
Annual discharge at Vallecito Dam:		
Maximum (1941)	506,200	acre-ft
Minimum (1977)	97,058	acre-ft
Average	253,500	acre-ft
Average annual diversion	166,200	acre-ft

Storage Facilities

VALLECITO DAM

Type: Zoned earthfill
Location: On the Pine (Los Pinos) River, 18 mi northeast of Durango, Colo.
Construction period: 1938-41
Date of closure (first storage): 1941
Reservoir, Vallecito:

Total capacity to El. 7665	129,700	acre-ft
Active capacity, El. 7580-7665	125,400	acre-ft
Surface area	2,720	acres
Dimensions:		
Structural height	162	ft
Hydraulic height	126	ft
Top width	35	ft
Maximum base width	900	ft
Crest length	4,010	ft
Crest elevation	7673.0	ft
Total volume	3,738,000	yd^3

Spillway: Concrete-lined open channel in right abutment, controlled by three 37- by 19-ft radial gates.

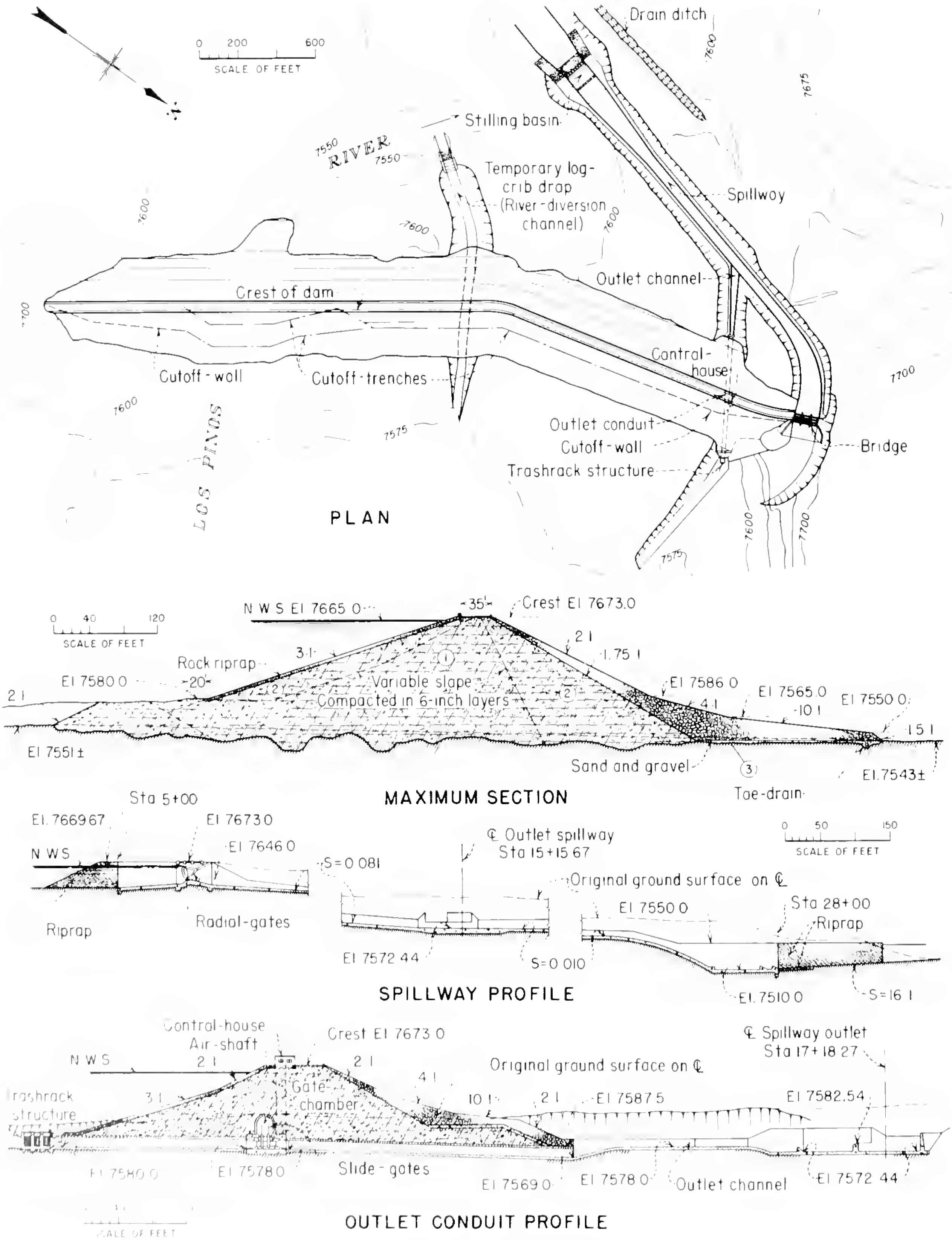
Elevation top of gates	7665.0	ft
Crest elevation	7646.0	ft
Capacity at El. 7665	30,000	ft^3/s

Outlet works: Twin-section concrete conduit through right abutment, controlled by two 5-ft-square slide gates.

Capacity at El. 7665	3,100	ft^3/s

Foundation: Recessional moraine covered with slope wash and alluvium up to 200 ft over strongly bedded horizontal formations of sandstone, shale, and mudstone.

Special treatment: Grout curtains beneath cutoff walls, supplemental grouting of abutments.

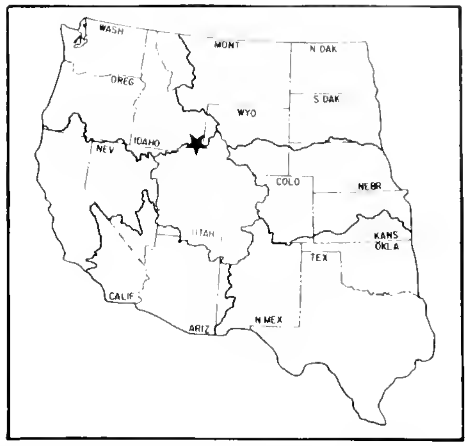


Vallecito Dam, Plan and Sections

Preston Bench Project

Idaho: Franklin County

Upper Colorado Region
Water and Power Resources Service



The Preston Bench Project, located in southeastern Idaho near the town of Preston, includes the Mink Creek Canal which supplies irrigation water for over 5,000 acres of highly developed land in the vicinity of Preston.

PLAN

The Mink Creek Canal replaced a privately constructed canal that was seriously threatened by landslides, was costly to maintain, and posed a constant financial threat to the water users. The canal water also provides additional water to project users.

Water is carried from Mink Creek through the project facilities to Worm Creek, from which it is diverted into privately built laterals and conveyed to project lands. Some of the project lands receive a partial supply through another canal system.

Mink Creek Canal

The Mink Creek Canal is 15 miles long and extends from a point on Mink Creek, 9 miles above its confluence with the Bear River, southward to Worm Creek northeast of Preston. The canal has a diversion capacity of 36 cubic feet per second. Major structure on the canal is Station Creek Tunnel, which pierces a prominent divide between Station Creek and Worm Creek. It is a concrete-lined, 6.5-foot horseshoe tunnel.

DEVELOPMENT

Early History

The first settlement of Preston Bench was established in 1866 near the present site of Preston, Idaho, which was founded in 1877. Wherever settlement occurred in the area, irrigation was practiced to some degree. Early development of irrigation measures on Preston Bench was started with the construction of a canal from Mink Creek in 1889. The canal was completed in 1899. During the winter of 1919-20, a landslide on the Bear River Bluff demolished 850 feet of the canal. A new section was constructed around the slide area and lined with concrete in the spring of 1920. During the following winter, the new concrete canal section was demolished by another slide. Other catastrophes caused by the unstable terrain in the Bear River Bluff area occurred in 1921, 1922, 1926, 1935 (when a tunnel caved in), 1936, 1937, 1941, and 1943, with evidence of other slides appearing during 1946 and 1947.

Investigations

Because potential slides threatened loss of the water supply, the Bureau of Reclamation undertook an investigation and issued a report recommending construction of an entirely new canal and tunnel in different terrain. The Congress authorized the project and appropriated money for construction during the fiscal year beginning July 1, 1948.

Authorization

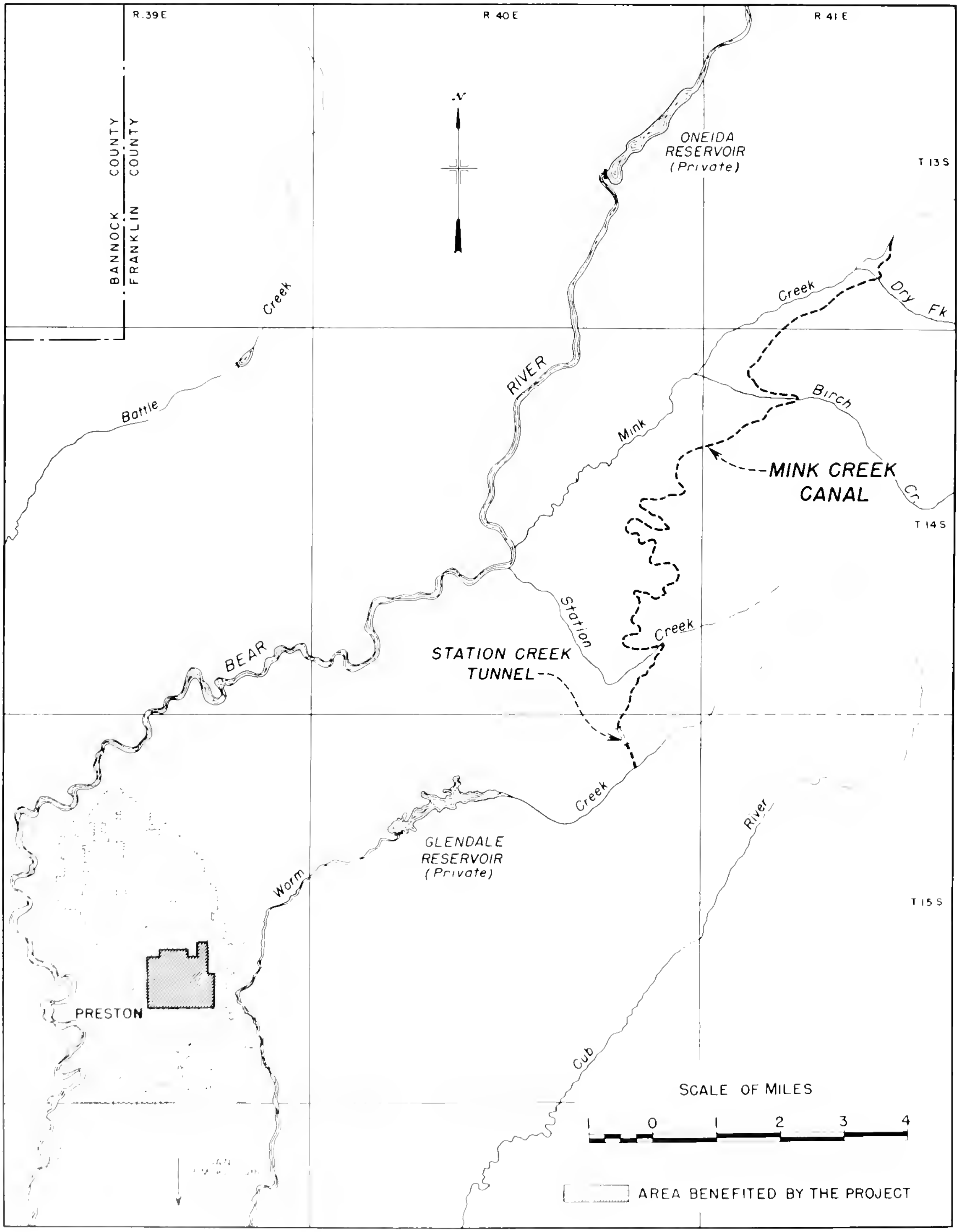
The project was authorized by the 80th Congress, act of June 15, 1948 (62 Stat. 442).

Construction

Construction began in October 1948 and was completed on November 23, 1949, when water first flowed through the entire length of Mink Creek Canal and through the Station Creek Tunnel. The project was placed in regular service in May 1950.

Operating Agency

The project is operated and maintained by the Preston, Riverdale, and Mink Creek Canal Company.



Preston Bench Project

BENEFITS

Irrigation

Principal crops produced are alfalfa, wheat, barley, oats, sugar beets, peas, and potatoes. Preston is the town which benefits most from the project farms.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	5,571	acres
Number of irrigated farms	118	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,500	443,501
1969	4,500	475,999
1970	4,500	502,164
1971	4,500	505,289
1972	4,500	505,686
1973	4,551	896,273
1974	4,566	789,503
1975	4,566	882,895
1976	4,792	861,618
1977	4,804	869,307

Facilities in Operation

Canals	16	mi
Laterals	20	mi
Drains	2	mi

Climatic Conditions

Annual precipitation	16	in
Temperature:		
Maximum	105	°F
Minimum	−32	°F
Mean	46	°F
Growing season	157	days
Elevation of irrigable area	4700.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	684
Urban, suburban, and industrial lands	402
Total	1,086

ENGINEERING DATA

Water Supply

MINK CREEK

Drainage area at head of Mink Creek Canal	12.9	mi^2
Annual discharge below mouth of Dry Fork:		
Maximum (1950)	80,600	acre-ft
Minimum (1949)	54,200	acre-ft
Average	65,200	acre-ft

Carriage Facilities

MINK CREEK CANAL

Location: From Mink Creek at a point about 9 mi above its confluence with Bear River and about 16 miles northeast of Preston, Idaho, generally southwest to Worm Creek, about 8 mi northeast of Preston.

Construction period: 1948-49

Length	15	mi
Diversion capacity	36	ft^3/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.35	ft

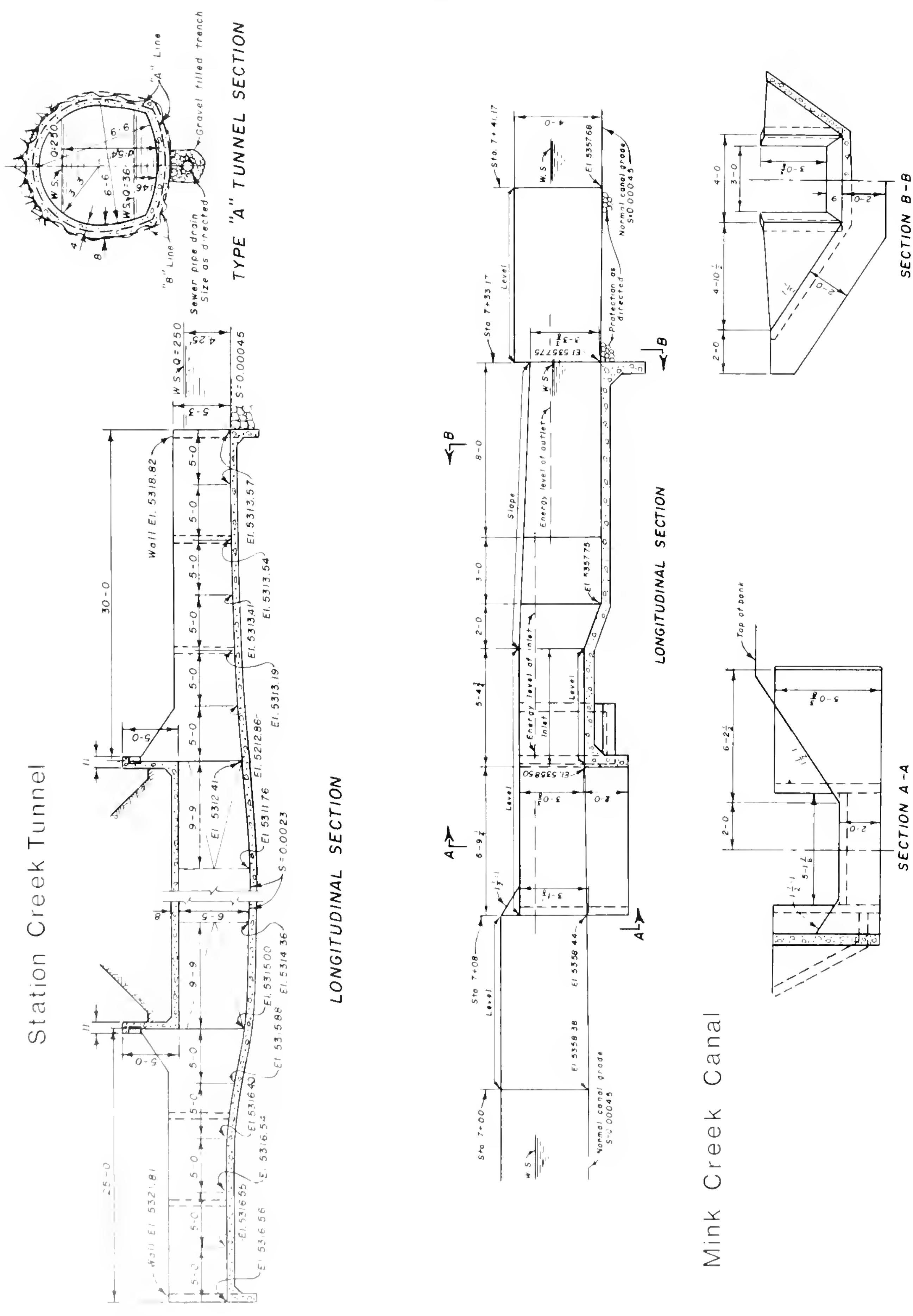
STATION CREEK TUNNEL (MINK CREEK CANAL)

Location: Through divide between Mink and Worm Creeks, about 8 mi northeast of Preston, Idaho.

Construction period: 1948-49

Length	1,126	ft
Capacity	250	ft^3/s
Cross section: Horseshoe		
Diameter	6.5	ft

Lining: Concrete

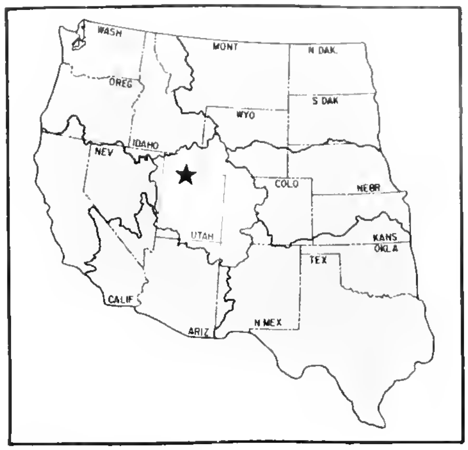


Preston Bench, Sections

Provo River Project

Utah: Salt Lake, Summit, Utah, and Wasatch Counties

Upper Colorado Region
Water and Power Resources Service



The Provo River Project provides a supplemental water supply for irrigation of 48,156 acres of highly developed farmlands in Utah, Salt Lake, and Wasatch Counties, as well as an assured domestic water supply for Salt Lake City, Provo, Orem, Pleasant Grove, Lindon, American Fork, and Lehi, Utah. The key structure of the project, Deer Creek Dam, is located on the Provo River east of the project lands. Other major structures are the powerplant at the dam, the 42-mile Salt Lake Aqueduct and Terminal Reservoir, Weber-Provo Diversion Canal, Duchesne Tunnel, Murdock Diversion Dam, Provo Reservoir Canal Enlargement, Jordan Narrows Siphon and Pumping Plant, and the South Lateral. The Salt Lake Aqueduct and Terminal Reservoir make up the Aqueduct Division; all other features are included in the Deer Creek Division.

PLAN

The Deer Creek Reservoir stores Provo River floodwater, surplus water of the Weber River diverted by the enlarged Weber-Provo Diversion Canal, and surplus water from the headwaters of the Duchesne River diverted by the 6-mile Duchesne Tunnel.

Releases from the reservoir for the Aqueduct Division are diverted at the dam into the Salt Lake Aqueduct, which carries water to a point near Salt Lake City to supplement the city's supply.

The Provo Reservoir Canal takes water from the Provo River at the Murdock Diversion Dam, about 7 miles downstream of the storage dam. This 23-mile-long canal serves the 46,609 acres in the Deer Creek Division. The Jordan Narrows Siphon and Pumping Plant furnishes water from the Provo Reservoir Canal and Jordan River to lands on the west side of Utah Lake and the Jordan River. The South Lateral delivers water supplies from the Jordan Narrows pump to the area south of the pump and west of the Jordan River. Deer Creek Powerplant generates 4,950 kilowatts of power.

Deer Creek Dam and Reservoir

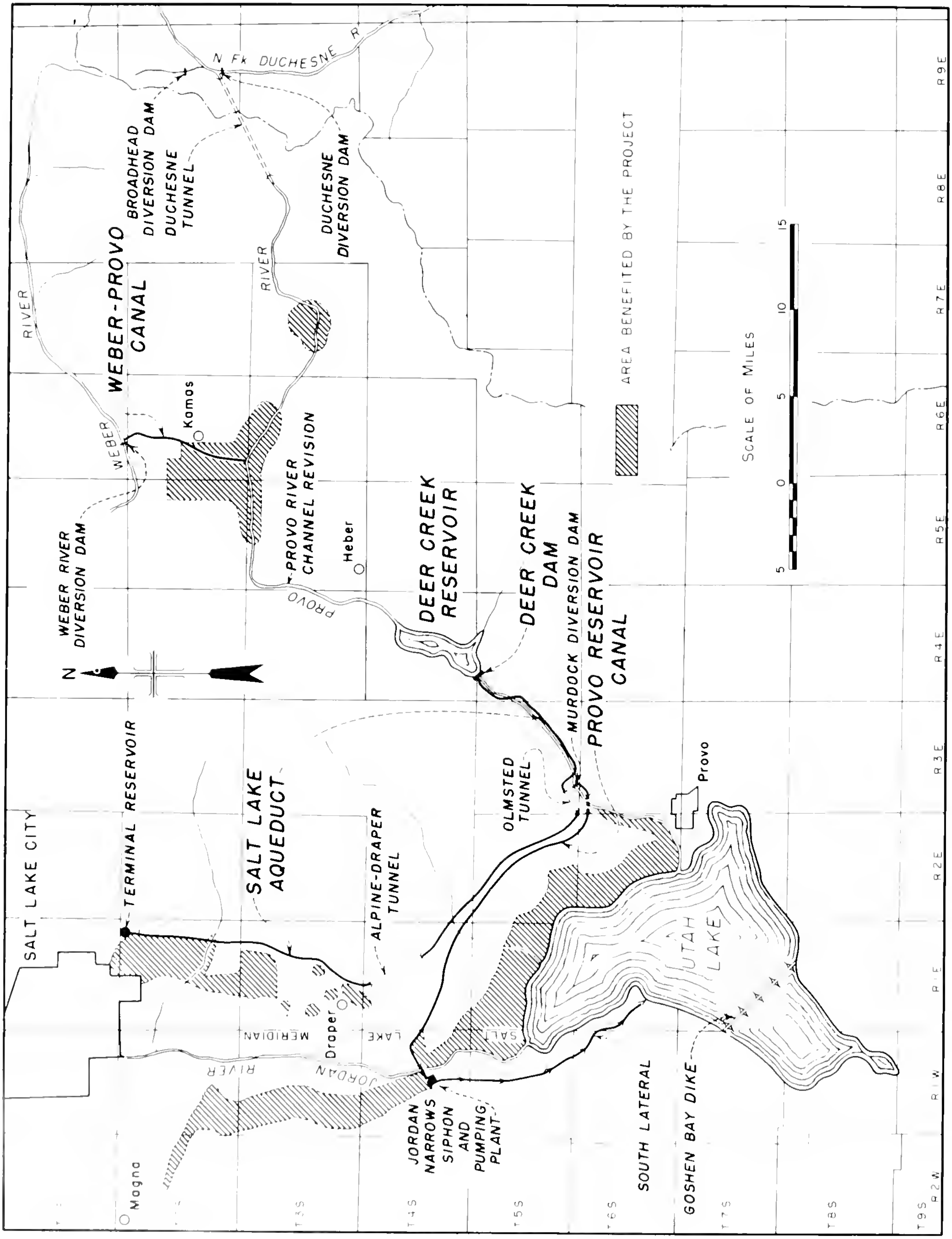
Deer Creek Dam is located on the Provo River about 16 miles northeast of Provo, Utah. It is a zoned earthfill structure 235 feet high with a crest length of 1,304 feet. The dam contains 2,810,000 cubic yards of material and forms a reservoir of 152,700 acre-foot capacity. The spillway is a concrete chute at the right abutment controlled by two radial gates. The capacity of the spillway is 12,000 cubic feet per second. The outlet works through the left abutment is a concrete-lined tunnel from the trashrack to the gate chamber, where two steel pipes lead to the powerplant. Releases are controlled by two tube valves. The outlet works has a capacity of 1,500 cubic feet per second.

Collection System

The principal features of the collection system are the Duchesne Diversion Dam, Duchesne Tunnel, Weber-Provo Diversion Dam, and Weber-Provo Diversion Canal.

The Duchesne Diversion Dam is on the North Fork of the Duchesne River, about 30 miles east of Heber City, Utah. The dam is a rockfill weir, concrete-core wall structure, 23 feet high, with a weir crest length of 270 feet. The 600-cubic-foot-per-second Duchesne Tunnel, which carries water from the diversion dam to the Provo River drainage basin, is horseshoe-shaped, concrete-lined, 9.25 feet in diameter, and 6 miles long.

The Weber-Provo Diversion Dam and Canal, originally a part of the Weber River Project, have been enlarged to supply water from the Weber River to the Deer Creek Reservoir on the Provo River. The dam, located 1 mile east of Oakley, Utah, is a concrete ogee overflow weir with embankment wings, and has a hydraulic height of 19 feet. The canal has a capacity of 1,000 cubic feet per second and a length of 9 miles, consisting of unlined, earth-lined, and concrete-lined sections.



Provo River Project

Deer Creek Dam and Reservoir

Aqueduct Division

The principal feature of the Aqueduct Division is the Salt Lake Aqueduct, a 69-inch-diameter concrete pipeline 41.7 miles long, with a capacity of 150 cubic feet per second. Through this pipeline flows the domestic water supply for Salt Lake City. Two tunnels are a part of the aqueduct: The concrete-lined, 78-inch-diameter, horseshoe-shaped Alpine-Draper Tunnel which is 15,037 feet long; and the Olmstead Tunnel, identical in cross section with the Alpine-Draper Tunnel, but 3,614 feet long. The concrete terminal reservoir, with a capacity of 122.8 acre-feet, completes the system.

Deer Creek Division

Deer Creek Division structures include Murdock Diversion Dam, a concrete ogee weir structure, 22 feet high; Provo Reservoir Canal, with a diversion capacity of 550 cubic feet per second and a total length of 23 miles, consisting of unlined and concrete-lined sections; the 65-cubic-foot-per-second capacity Jordan Narrows Pumping Plant; and the South Lateral, with a capacity of 40 cubic feet per second and a length of about 4 miles.

Deer Creek Powerplant

The powerplant was constructed on the substructure provided during the construction of Deer Creek Dam, has two 2,475-kilowatt generators, and was placed in operation in 1958.

DEVELOPMENT

Early History

The first written report concerning this territory was made by John C. Fremont in the account of his expedition of 1843. General William H. Ashley led a party of fur traders into the West from St. Louis in the spring of 1822, and in 1825 established a trading post at Utah Lake known as Fort Ashley. The Provo River and the city of Provo are said to have been named after a trapper named Provost who was in the vicinity of Utah Lake as early as 1820. In March 1849, a group went southward from Salt Lake with the intention of establishing a colony on the Provo River. The settlement, started at a place called Old Fort Field, is now within the city limits of Provo. A fort was built and crops planted; over 200 acres were plowed the first year for wheat, rye, and corn. In August 1850, settlements were made at American Fork, Lehi, and Pleasant Grove.

Investigations

Utah Lake supplied irrigation water for some areas in the Salt Lake Valley; however, during the drought years 1931-35, storage in Utah Lake fell from 850,000 to 20,000 acre-feet. It became apparent that construction of the Provo River Project was essential to provide an adequate water supply. The project plan resulted from extensive investigations conducted at various times after 1922 by the Bureau of Reclamation in cooperation with the Water Storage Commission of Utah. The desperate water shortage experienced by Salt Lake City in the 1930's and the consequent request to the Government for assistance in obtaining a dependable water supply for Salt Lake Valley gave rise to a concerted effort to obtain approval of the Provo River Project. The city of Provo and five other communities in Utah County, as well as Salt Lake City, all needing additional domestic water supplies, joined with the irrigation interests to sponsor the project.

Authorization

Construction of the project was initiated under the provisions of the National Industrial Recovery Act of June 16, 1933, and approved by the President on November 16, 1935, under the terms of subsection B of section 4 of the act of December 5, 1924 (43 Stat. 701). The Salt Lake Aqueduct was approved by the President on October 24, 1938. Deer Creek Powerplant was found feasible and authorized by the Secretary of the Interior on August 20, 1951, under the Reclamation Project Act of 1939.

Construction

Construction of the project began in May 1938, the first water becoming available in 1941 upon the completion of Deer Creek Dam.

Construction of some features of the project was severely hampered by wartime scarcities of manpower, materials, and funds. Work on the Duchesne Tunnel had to be stopped in 1942, although construction continued on a small scale on the canal system and Salt Lake Aqueduct.

Deer Creek Dam Outlet Works

In 1947, full-scale construction was resumed. Construction of features of the Aqueduct Division was started in 1939 and completed in 1951.

The Deer Creek Powerplant was completed in 1958.

Operating Agencies

All features of the Deer Creek Division are operated and maintained by the Provo River Water Users Association. The Metropolitan Water District of Salt Lake City operates and maintains the aqueduct system.

BENEFITS

Irrigation

A supplemental water supply has been provided for 48,156 acres of highly developed farmlands, thus assuring maturity of valuable crops. Principal crops are alfalfa, grain, peaches, apples, pears, sugar beets, and canning crops, such as sweet corn, peas, and tomatoes.

Municipal and Industrial Water

Municipal and industrial water service is provided for the metropolitan water districts of Salt Lake City, Provo, Orem, Pleasant Grove, Lewiston, American Fork, and Lehi. An average annual amount of 73,454 acre-feet is delivered to 343,345 people.

Recreation

Deer Creek Reservoir is on the Provo River about 16 miles northeast of Provo, Utah. Because a main highway crosses the dam, many visitors see the dam and reservoir during the year. The reservoir provides boating and excellent fishing in season, primarily for perch and native, rainbow, and brown trout. Two boat concessions, each with boats to rent to the public, are located on the shore of the reservoir. Camping, swimming, boating, water skiing, and other forms of recreational use have increased dramatically. The Utah State Division of Parks and Recreation has administering responsibility. A new boat launching ramp, camp, and picnic facilities have been provided. Total visitation to the reservoir during 1977 was 426,290 recreation days.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	48,156	acres
Number of irrigated farms	1,767	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	40,475	5,338,702
1969	40,288	4,417,168
1970	40,185	5,197,416
1971	40,000	5,136,865
1972	39,600	4,512,696
1973	39,475	8,764,320
1974	39,130	9,982,364
1975	39,032	8,852,339
1976	38,542	9,184,606
1977	37,425	9,493,586

Facilities in Operation

Storage dams	1	
Diversion dams	4	
Canals	32	mi
Aqueducts	41.7	mi
Laterals	3.8	mi
Pumping plants	1	
Powerplants	1	
Transmission lines	0.4	mi
Substations	1	

Climatic Conditions

Annual precipitation	15.8	in
Temperature:		
Maximum	110	°F
Minimum	−35	°F
Mean	49	°F
Growing season	124	days
Elevation of irrigable area	4650.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	7,345
Urban, suburban, and industrial service	336,000
Total	343,345

ENGINEERING DATA

Water Supply

PROVO RIVER[1]

Drainage area at Vivian Park	560	mi²
Annual discharge at Vivian Park:		
Maximum (1952)	427,639	acre-ft
Minimum (1942)	230,000	acre-ft
Average	265,900	acre-ft

DUCHESNE RIVER

Drainage area at Duchesne Tunnel	39	mi²
Annual discharge at Duchesne Tunnel:		
Maximum (1950)	52,950	acre-ft
Minimum (1931)	23,600	acre-ft
Average	39,910	acre-ft

WEBER RIVER

Drainage area 2.6 mi upstream from Weber-Provo Diversion Canal heading	163	mi²
Annual discharge at 2.6 mi upstream from Weber-Provo Diversion Canal beading:		
Maximum (1909)	294,000	acre-ft
Minimum (1934)	56,050	acre-ft
Average	159,400	acre-ft
Average annual diversion (all sources)	210,750	acre-ft

[1]Natural flow including transmountain diversions and Salt Lake Aqueduct diversions.

Storage Facilities

DEER CREEK DAM

Type: Zoned earthfill		
Location: On the Provo River 16 mi northeast of Provo, Utah.		
Construction period: 1938-41		
Date of closure (first storage): 1941		
Reservoir, Deer Creek:		
Average annual inflow, 1942-53	260,400	acre-ft
Total capacity to El. 5,417	152,700	acre-ft
Active capacity, El. 5303-5417	149,700	acre-ft
Surface area	2,683	acres
Dimensions:		
Structural height	235	ft
Hydraulic height	155	ft
Top width	35	ft
Maximum base width	1,000	ft
Crest length	1,304	ft
Crest elevation	5425.0	ft
Total volume	2,810,000	yd³
Spillway: Concrete crest and concrete-lined chute in right abutment, controlled by two 21- by 20-ft radial gates.		
Elevation top of gates	5417.0	ft
Crest elevation	5397.0	ft
Capacity at El. 5417	12,000	ft³/s
Outlet works: Concrete-lined tunnel through left abutment controlled by two 52-in tube valves in powerplant substructure at outlet end.		
Capacity at El. 5417	1,500	ft³/s
Foundation: Interbedded clay, sand, and gravel overlying alternating strata of slightly broken but firm sandstone and limestone.		
Special treatment: Cement grout curtain beneath cutoff walls; supplemental grouting of abutments.		

Diversion Facilities

Duchesne Diversion Dam

Type: Rockfill weir, concrete-core wall
Location: On the North Fork, Duchesne River, about 30 mi east of Heber, Utah.
Year completed: 1952
Dimensions:

Structural height	23	ft
Hydraulic height	17	ft
Weir crest length	270	ft
Total crest length	480	ft
Weir crest elevation	8169.75	ft
Volume	10,000	yd³

Sluiceway: Concrete gated structure, one 10- by 13-ft radial gate, at right abutment of dam.
Headworks: Diverts directly into Duchesne Tunnel through tunnel intake at right abutment of dam.

Diversion capacity	600	ft³/s

Murdock Diversion Dam

Type: Concrete ogee weir, embankment wing
Location: On the Provo River, about 6 mi north of Provo, Utah.
Year completed: 1950
Dimensions:

Structural height	22	ft
Hydraulic height	19	ft
Weir crest length	100	ft
Total crest length	370	ft
Weir crest elevation	4885.5	ft
Volume	9,000	yd³

Sluiceway: Concrete gate structure, one 16- by 14-ft radial gate at left side of dam.
Headworks: Concrete, one 16- by 13-ft radial gate. Revolving fish screen 40 ft upstream from gate.

Diversion capacity	550	ft³/s

Weber-Provo Diversion Dam

Type: Concrete ogee weir, embankment wings
Location: On the Weber River about 1 mi east of Oakley, Utah.
Year completed: 1930
Dimensions:

Structural height	25	ft
Hydraulic height	19	ft
Weir crest length	150	ft
Total crest length	1,795	ft
Weir crest elevation	6188.55	ft
Volume	15,000	yd³

Sluiceway: Adjacent to left end of overflow section, controlled by two 5- by 6-ft slide gates.
Headworks: Concrete, six 5- by 6-ft slide gates, at right angles to dam and adjacent to sluiceway.

Diversion capacity	1,000	ft³/s

Broadhead Diversion Dam

Type: Concrete ogee weir, embankment wings
Location: On Broadhead Creek, about 25 mi east of Kamas, Utah.
Year completed: 1953, replaced 1961.[2]
Dimensions:

Structural height	8	ft
Hydraulic height	5	ft
Weir crest length	15	ft
Total crest length	28	ft
Weir crest elevation	8198.0	ft
Volume	700	yd³

Sluiceway: At left side of dam, controlled by 3- by 4-ft slide gate.
Headworks: 30-in-diameter precast concrete pipe, controlled by 30-in-diameter slide gate.

Diversion capacity	22	ft³/s

[2]Replaces previous Reclamation-constructed dam of the same name.

Carriage Facilities

Duchesne Tunnel

Location: From point of diversion on the Duchesne River generally west 6 mi to a point about 14 mi east of Kamas, Utah.
Construction period: 1940-42
Concrete lined in 1949-52

Length	6	mi
Capacity	600	ft³/s

Cross section: Horseshoe

Diameter	9.25	ft

Lining: Concrete

Provo Reservoir Canal

Location: From Murdock Diversion Dam on the Provo River about 6 mi north of Provo, Utah, generally northwest 23 mi to a point about 6 mi south of Draper, Utah.
Construction period: Non-Reclamation construction. Enlarged by Reclamation in 1940-50.

Length	23	mi
Diversion capacity	550	ft³/s
Typical maximum section in earth:		
Bottom width	18	ft
Side slopes	1.25:1	
Water depth	5.68	ft
Typical maximum section, concrete lined:		
Bottom width	14	ft
Side slopes	1.25:1	
Water depth	4.34	ft
Lining thickness	4	in

Salt Lake Aqueduct

Location: From Deer Creek Dam generally southwest along the Provo River to a point 7 mi north of Provo, Utah, then generally north to Salt Lake City.
Construction period: 1939-51
Description: Concrete pipeline

Length	41.7	mi
Diameter	69	in
Capacity	150	ft³/s

Alpine-Draper Tunnel

Location: 20 mi northwest of Provo, Utah.
Construction period: 1938-41

Length	15,037	ft
Capacity	150	ft³/s

Cross section: Horseshoe

Diameter	6.5	ft

Lining: Concrete

OLMSTED TUNNEL

Location: 7 mi north of Provo, Utah.
Construction period: 1938-41

Length	3,614	ft
Capacity	150	ft³/s
Cross section: Horseshoe		
Diameter	6.5	ft
Lining: Concrete		
Thickness	3-7	in

TERMINAL RESERVOIR (SALT LAKE AQUEDUCT)

Location: In the southeast portion of metropolitan Salt Lake City.
Description: The principal features of the Terminal Reservoir are the automatic wasteway, the Venturi meter structure and the chlorination and control house, the Sam Park Reservoir inlet control structure,[3] the two 61.4-acre-ft storage units, and the influent and effluent piping system.
Dimensions (each storage unit):

Structural height	30.5	ft
Top width	271.8	ft
Top length	418.8	ft
Side slopes	1.5:1	
Total concrete in storage units and appurtenant structures	16,215	yd³

WEBER-PROVO DIVERSION CANAL

Location: From the Weber River at a point about 1 mi east of Oakley, Utah, generally south 9 mi to the Provo River.
Construction period: Originally constructed in 1929-30 as a part of the Weber River Project. Enlarged in 1941-47 under the Provo River Project.

Length	9	mi
Capacity	1,000	ft³/s
Typical maximum section in earth:		
Bottom width	24	ft
Side slopes	2:1	
Water depth	7.3	ft
Typical maximum section, concrete lined:		
Bottom width	12	ft
Side slopes	1.75:1	
Water depth	6.37	ft
Lining thickness	4	in
Typical maximum section, compacted earth lining:		
Bottom width	24	ft
Side slopes	1.75:1	
Water depth	7.3	ft
Lining thickness on bottom	2	ft
Measured horizontally, on sides	8	ft

SOUTH LATERAL

Location: From outlet Jordan Narrows Pumping Plant, generally south 3.8 mi.
Construction period: 1949-50

Length	3.8	mi
Capacity	40	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.2	ft
Typical maximum section, concrete lined:		
Bottom width	3	ft
Side slopes	1.5:1	
Water depth	2.2	ft
Lining thickness	4	in

JORDAN NARROWS PUMPING PLANT

Number of units	1	
Total capacity	65	ft³/s
Total dynamic head	103	ft
Total horsepower	1,050	

Power Facilities

DEER CREEK POWERPLANT

Location: At Deer Creek Dam.
Year of initial operation: 1958

Nameplate capacity	4,950	kW
Number and capacity of generators ...... (2)	2,475	kW
Maximum head	140	ft
Gross generation (1977)	24,580,000	kWh

SUBSTATIONS

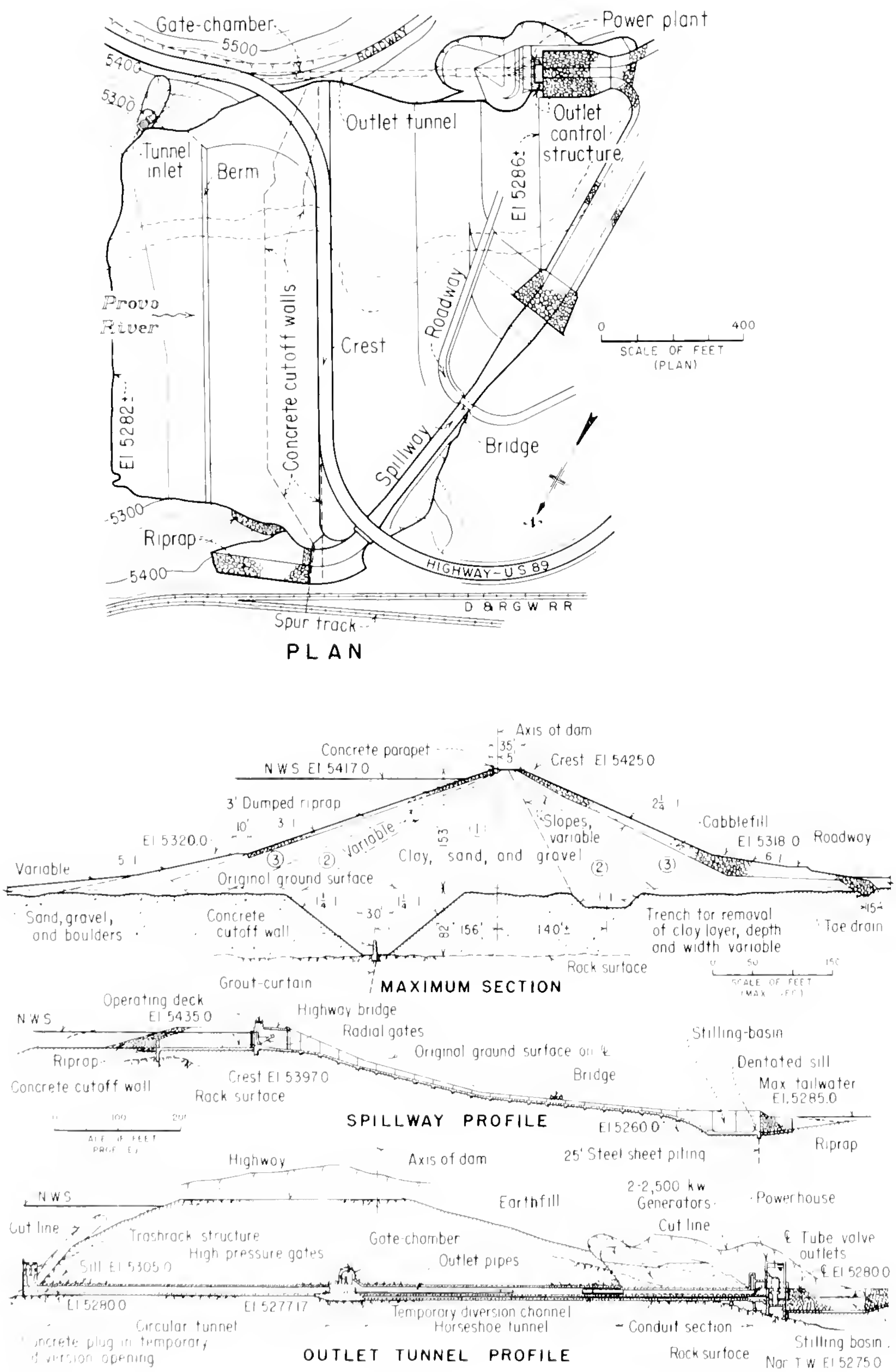
Number in operation	1	
Total capacity of transformers	6,250	kVA

TRANSMISSION LINES

Designation: Deer Creek Powerplant—Utah Power & Light Co. Tie Line.

Capacity	44	kV
Power capacity	5,000	kW
Circuit miles	0.4	
Year placed in service	1958	

[3]Sam Park Reservoir built by private interests.

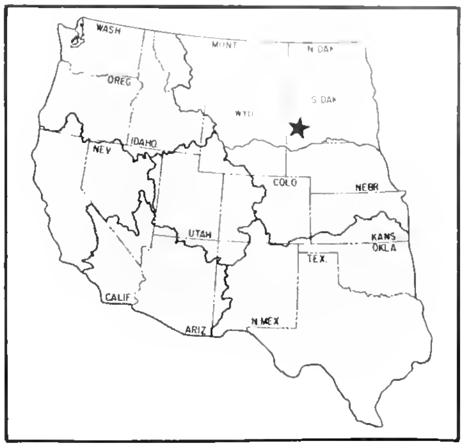


Deer Creek Dam, Plan and Sections

Rapid Valley Project

South Dakota: Pennington County

Upper Missouri Region
Water and Power Resources Service



Rapid Valley Project consists of Deerfield Dam and Reservoir, located on Castle Creek, a tributary of Rapid Creek, about 25 miles west of Rapid City, S. Dak. There are various irrigation diversion and supply works in the Rapid Valley Water Conservancy District, and 8,900 acres of privately developed land that are provided supplemental irrigation water from Deerfield Reservoir. The reservoir also provides a supplemental supply of water for Rapid City, including Ellsworth Air Force Base. Fish and wildlife benefits are provided, along with water-based recreation opportunities. Pactola Reservoir (Rapid Valley Unit) supplements the supply of stored water available from Deerfield Reservoir. Thus, a full water supply for irrigation and municipal purposes is provided.

Deerfield Dam

Deerfield Dam, a zoned earthfill structure, has a structural height of 133 feet, a crest length of 825 feet, and a crest width of 35 feet. The side-channel spillway located in the right abutment is concrete lined, with an uncontrolled crest 190 feet long and a capacity of 16,700 cubic feet per second. The outlet works consists of a 5-foot-diameter concrete conduit through the dam base, extending to a 39-inch-diameter steel pipe contained within a 6.5-foot horseshoe-shaped concrete conduit. The steel pipe has a discharge capacity of 275 cubic feet per second. Small releases for fish and wildlife needs can be made through a 6-inch-diameter pipe which parallels the 39-inch-diameter pipe. The reservoir has a capacity of 15,700 acre-feet and a 414-acre water surface area. Conservation storage is 15,200 acre-feet and dead and inactive storages total 600 acre-feet.

Deerfield Dam

DEVELOPMENT

Early History

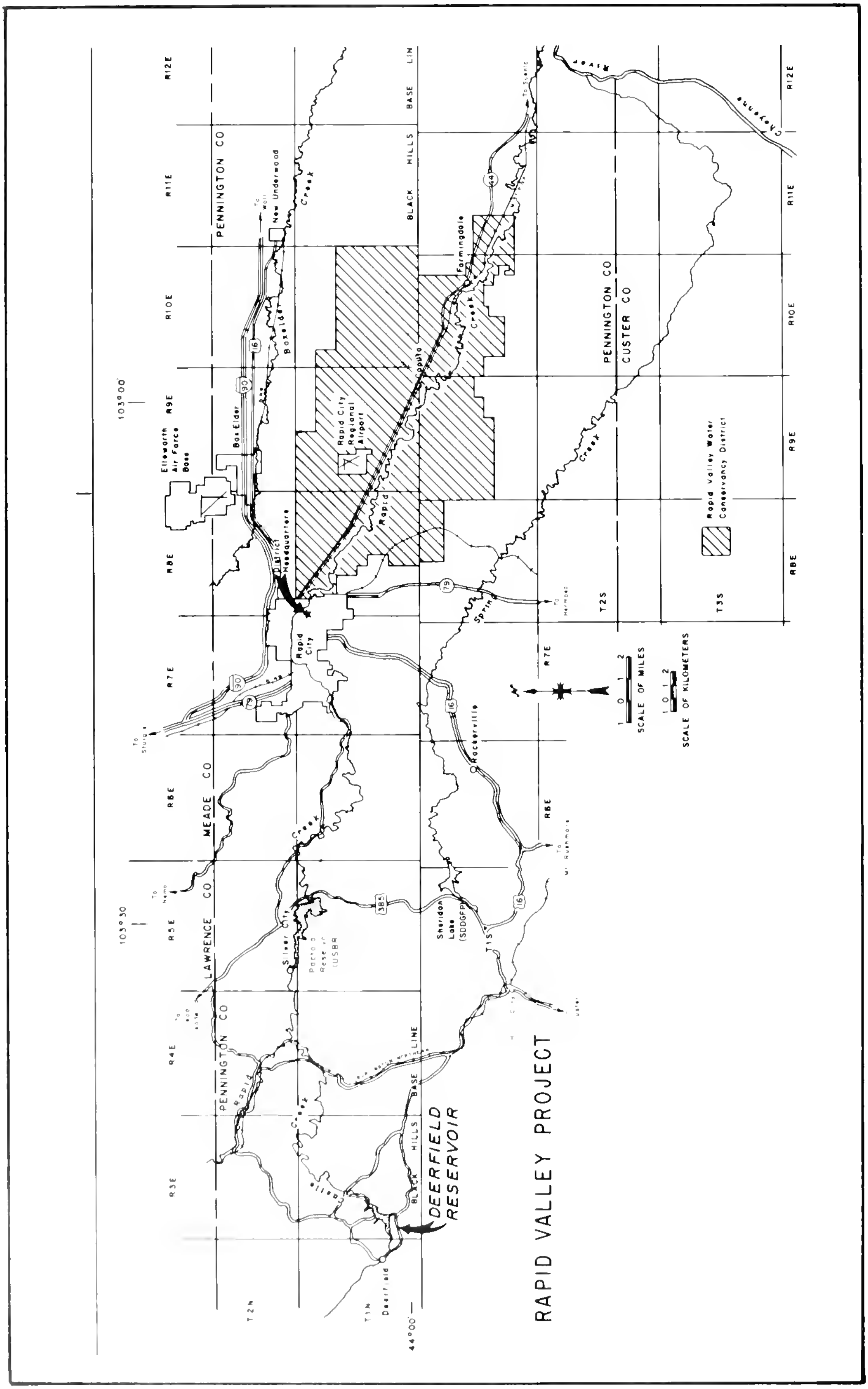
The area in and around Rapid Valley, except for that served by the Iowa Canal Extension, has had irrigation in some form for many years. Until 1930, there was usually a sufficient flow in Rapid Creek to take care of irrigation needs. After 1930, the water supply became inadequate for full irrigation development. Only those crops that could be grown without full water requirement were planted on most farms, except for lands with full water rights.

Investigations

The Dakota Power Company of Rapid City hired consulting engineers in 1915 and 1928 to investigate the possibilities of irrigation and power development along Rapid Creek. In 1937, the Bureau of Reclamation made investigations and prepared a report which presented plans for storage and related facilities.

Authorization

The President approved construction of the project in 1939 and funds were allotted from the Interior Department appropriation for 1940. That allotment was withdrawn because of delays in negotiations, and the project was resubmitted for approval as a Water Conservation and Utilization Project and approved by the President in 1940. Both authorizations provided for construction of Pactola Dam. Subsequently, the plan for building Pactola Dam was abandoned in favor of the Deerfield Dam site. The new plan was approved in 1942.



Rapid Valley Project

Construction

Construction was started on July 7, 1942, by the Farm Security Administration and was later continued by the Civilian Conservation Corps and the Civilian Public Service Camp under the Works Projects Administration during World War II. The facilities were completed by the Bureau of Reclamation in 1947. Minor construction, cleanup work, and disposal of excess equipment were accomplished in 1949. Water first became available from Deerfield Reservoir storage on May 1, 1948.

Operating Agency

Deerfield Dam and Reservoir are operated and maintained by the Bureau of Reclamation on a pooled storage basis with Pactola Reservoir, which is located downstream from Deerfield Dam on Rapid Creek.

BENEFITS

Irrigation

A supplemental supply of stored water is available to the 8,900 acres of irrigated land within the Rapid Valley Water Conservancy District. The integrated irrigated-dryland farms in the district produce corn, alfalfa, small grains, pasture, and livestock. The principal products are used to provide a stable feed supply for stockcow herds and fattening of cattle.

Municipal and Industrial Water

Municipal water needs for Rapid City, including the Ellsworth Air Force Base, are supplemented with stored water from Deerfield Reservoir.

Recreation and Fish and Wildlife

Outdoor recreation facilities at Deerfield Reservoir include picnic grounds, campgrounds, and fishing access. The recreation areas are administered by the Forest Service. Visitor days reported for 1977 totaled 166,800. The combined cold- and warm-water fishery at the reservoir is maintained by the South Dakota Department of Wildlife, Parks and Forestry.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	8,900	acres
Number of irrigated farms	56	

Climatic Conditions

Annual precipitation	17.4	in
Temperature:		
Maximum	107	°F
Minimum	−34	°F
Mean	47	°F
Growing season	150	days
Elevation of irrigable area	3000.0	ft

Facilities in Operation

Storage dams	1

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	299
Municipal water service	43,800
Total	44,099

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	7,000	297,040
1969	7,100	373,955
1970	7,400	496,230
1971	7,500	378,250
1972	7,200	311,265
1973	7,448	529,165
1974	7,265	930,600
1975	7,160	659,878
1976	7,324	880,851
1977	7,203	871,906

ENGINEERING DATA

Water Supply

CASTLE CREEK

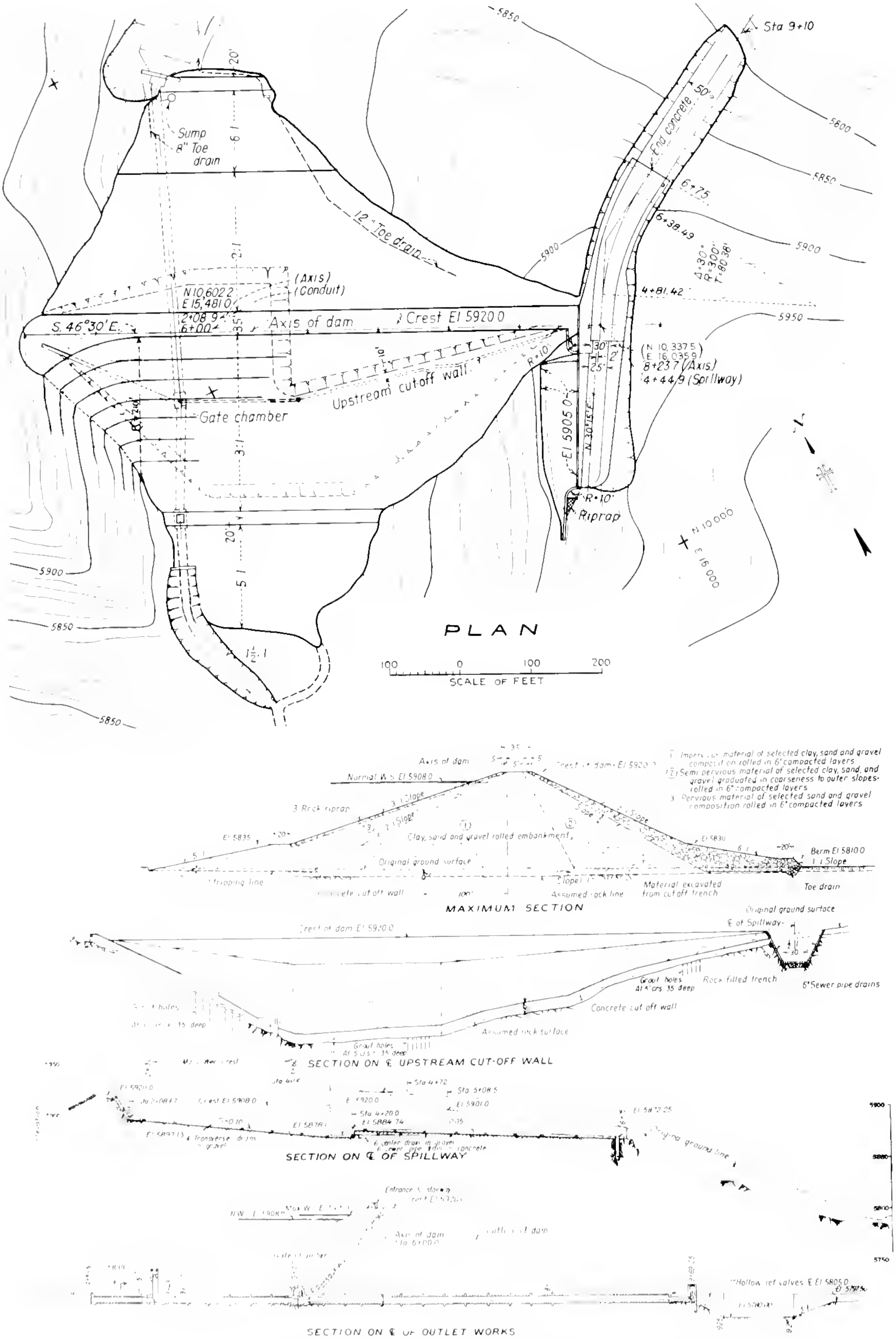
Drainage area above Deerfield Dam	96	mi²
Annual discharge at Deerfield Dam:		
Maximum (1965)	66,400	acre-ft
Minimum (1961)	10,900	acre-ft
Average	29,300	acre-ft

Storage Facilities

DEERFIELD DAM

Type: Zoned earthfill
Location: On Castle Creek, 25 mi west of Rapid City, S. Dak.
Construction period: 1942-46
Date of closure (first storage): December 3, 1945

Reservoir, Deerfield:		
Total capacity at El. 5915	15,700	acre-ft
Active capacity, El. 5839-5908	15,200	acre-ft
Surface area	414	acres
Dimensions:		
Structural height	133	ft
Hydraulic height	100	ft
Top width	35	ft
Maximum base width	770	ft
Crest length	825	ft
Crest elevation	5920.0	ft
Total volume	607,000	yd³
Spillway: Uncontrolled concrete-lined side-channel at right abutment.		
Crest length	190	ft
Crest elevation	5908.0	ft
Capacity at El. 5915	16,700	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by two 27-in hollow-jet valves.		
Capacity at El. 5908	275	ft³/s

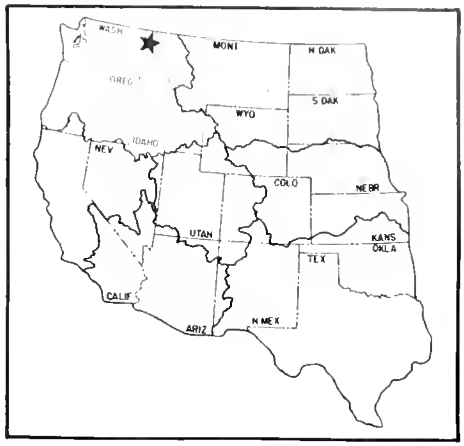


Deerfield Dam, Plan and Sections

Rathdrum Prairie Project

Idaho: Kootenai County

Pacific Northwest Region
Water and Power Resources Service



The Rathdrum Prairie Project area extends about 12 miles north and 13 miles west of Coeur d'Alene in the panhandle of Idaho. The project consists of the Post Falls, Hayden Lake, and East Greenacres Units, totaling 10,274 acres of irrigable land.

Major facilities of the Post Falls Unit consist of a pumping plant, 3,000 feet of discharge pipe, 9 miles of canal, and 20 miles of laterals.

Hayden Lake facilities consist of a pumping plant, 2 miles of 27-inch-diameter discharge pipe, a 10,026-cubic-foot storage tank, and a 32-mile pipe distribution system. Primary facilities of the East Greenacres Unit include 14 wells in 3 well complexes, a 43,446-cubic-foot regulating reservoir, and 45.4 miles of pipe distribution system.

PLAN

The Post Falls Pumping Plant has two pumps, each with a capacity of 30 cubic feet per second. Water is pumped from the Spokane River through a 3,000-foot-long, 42-inch-diameter steel discharge line into the 9-mile-long Main Canal. The distribution system consists of 20 miles of both open and piped laterals serving 3,357 irrigable acres.

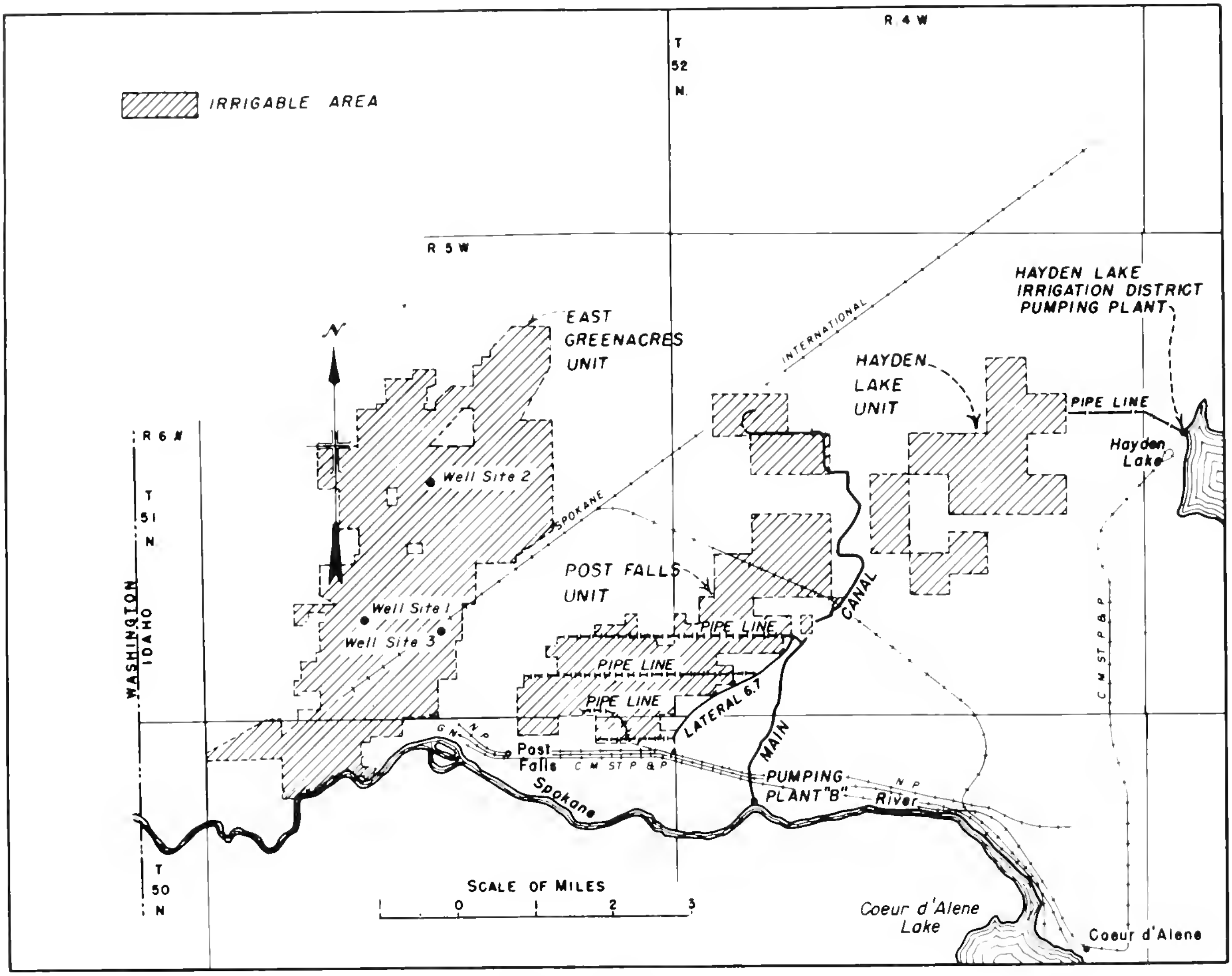
In July 1973, inspection of the Post Falls facilities revealed that the original 3,000-foot wooden discharge line was in imminent danger of failure. Under emergency fund procedures, the line was replaced with the present steel pipe.

The Hayden Lake Pumping Plant has two pumps, each with a capacity of 10 cubic feet per second at 225-foot dynamic head. Water is pumped from Hayden Lake at the shoreline plant through a discharge line that for 8,600 feet is concrete pipe; the remainder is steel pipe. A 10,026-cubic-foot tank, elevated 160 feet above ground, is incorporated in the main discharge line to equalize and provide pressure. Lateral pipe ranging from 4 to 24 inches in diameter distributes water throughout the 1,577 irrigable acres within the unit. Smaller piping is asbestos-cement and larger diameter pipe is steel with mortar lining.

Canals, discharge lines, pressure pipe laterals, pumping plants, and related facilities of the Post Falls and Hayden Lake Units were rehabilitated by the Bureau of Reclamation.

Irrigation and domestic water for the East Greenacres Unit is furnished by ground water from seven 20-inch-diameter and seven 16-inch-diameter wells ranging from 230 to 330 feet deep. Pump capacities for 14 pumps at the well sites range from 0.47 to 8.2 cubic feet per second, and horsepower ratings from 30 to 500 for each unit. Water is pumped to a 43,446-cubic-foot underground concrete regulating reservoir and carried from the reservoir through 45.2 miles of buried pressure pipe ranging from 6 to 36 inches in diameter. The 6- to 24-inch-diameter pipe is asbestos-cement; all pipe over 24 inches is pretensioned concrete cylinder. This multipurpose pipeline system was constructed by the Bureau of Reclamation for year-round use. It was built to serve 5,340 acres of irrigable land with 248 metered domestic turnouts 1-inch in diameter and 357 irrigation turnouts

East Greenacres Unit



Rathdrum Prairie Project

from 1 to 6 inches in diameter. The system replaces a gravity system that originated at Twin Lakes and served 1,420 acres. Existing outlet works at Twin Lakes were modified by installation of two new gates, concrete head-walls, and electric gate actuators with semiautomatic flood controls.

DEVELOPMENT

Early History

First efforts to irrigate the Rathdrum Prairie date back to 1889, when three filings for water were made as part of a plan to irrigate about 6,000 acres of the prairie from Hayden, Twin, and Hauser Lakes. The Spokane Valley Irrigation Company and the Valley Improvement Company were formed and surveys were made, but little in the way of construction was accomplished.

One of the first projects built was that of the Interstate Irrigation District, predecessor of the Hayden Lake Irrigation District, which undertook development of 2,000 acres in 1906. The Post Falls Irrigation District was organized about 1910, and four other small systems—Avondale, Dalton Gardens, East Greenacres, and East Farms—were built about the same time. The East Farms area, straddling the Idaho and Washington boundary, is a private irrigation development related to the Spokane Valley Farms Canal Company. The other systems are operated by irrigation districts.

Investigations

Originally, the Post Falls Irrigation District obtained its water supply from Hayden Lake. A canal 3,300 feet long conducted the water by gravity to a pumping plant, where it was lifted sufficiently to flow to the farms through a pipe distribution system. However, in 1921, the water level of the lake fell below the elevation of the outlet ditch, so that pumping from the lake into the canal was necessary to get water to the main pumping plant.

Financial and water-supply difficulties were experienced for many years and the irrigated area shrank to less than 1,000 acres. In 1940, bonded debt and delinquent interest were retired through agreement with bondholders by a token payment. Nevertheless, continuing water-supply difficulties and deterioration of the system finally forced abandonment of irrigation.

By 1946, deterioration of the 8,600-foot-long wooden discharge pipe in the Hayden Lake Irrigation District threatened to prevent further operation. The Bureau of Reclamation, after an investigation made at the request of local interests, recommended rehabilitation of this main supply line to serve 1,050 irrigable acres.

Because of the deteriorated condition of the pumping plant and the low-pressure pipe distribution system, Reclamation made an investigation in 1955-56 to determine the best plan and estimated cost for complete rehabilitation of the project, which resulted in authorization of the work.

East Greenacres Irrigation District was formally organized in about 1910 after its inception around 1905. The area originally planned was nearly 3,000 acres, but was later reduced to 1,500 acres. A changing economy, the inadequate water supply system originating at Twin Lakes, and costly maintenance of a water conveyance and distribution system with extremely high water losses were all instrumental in bringing about investigations to improve the project. Studies by the Bureau of Reclamation began in 1958, but were halted in 1960 by litigation between the Lakeshore Owners Association, interested in using the lake for recreation, and the Irrigation District regarding operating levels of Twin Lakes. Following settlement, project investigation was resumed in 1963. At a public meeting in February 1964, potential water users voted almost unanimously in favor of the project plan. Feasibility was documented in a report dated May 1966 that recommended a ground-water supply serving both domestic and irrigation requirements for some 5,300 acres through a closed pipe pressure system.

Authorization

Finding of feasibility for the Post Falls Unit was made by the Secretary of the Interior on December 24, 1943, and approved by the President on January 29, 1944, under the terms of the Water Conservation and Utilization Act of August 11, 1939, as amended. Replacement of the wooden discharge line was authorized by the 1974 Public Works Appropriation Act dated August 16, 1973, Public Law 93-97 (87 Stat. 318).

For the Hayden Lake Unit, finding of feasibility and authorization was made by the Secretary on June 9, 1947, under the Reclamation Project Act of 1939. Emergency rehabilitation was authorized under Interior Department Appropriation Act, 1948 (61 Stat. 473), by the First Deficiency Appropriation Act of May 10, 1948 (62 Stat. 221). Later, rehabilitation of the district works was authorized by Public Works Appropriation Act, 1957, approved July 2, 1956 (Public Law 641; 70 Stat. 474). Further emergency pipe rehabilitation was authorized by act of September 22, 1961 (75 Stat. 588).

East Greenacres Unit was authorized by act of June 23, 1970, Public Law 91-286 (84 Stat. 319).

Construction

Instead of pumping water from Hayden Lake for the Post Falls Unit, a plant was installed to pump from the Spokane River at a point much closer to the project lands. This reconstruction, performed in 1945, made the Post Falls system the first unit of the Rathdrum Prairie Project. The 3,000-foot wooden discharge line was replaced with a steel pipeline. Construction work began in the fall of 1973 and was completed in the spring of 1974.

Emergency repairs were made to the main supply line of the Hayden Lake Unit by the Bureau of Reclamation from May 1948 to April 1949. Major rehabilitation of the project, authorized in 1956, was completed in 1958. Emergency pipe rehabilitation work began in 1962 and was completed in 1963.

Construction on the East Greenacres Unit began in 1972 and was completed in 1976.

Operating Agencies

The Post Falls Irrigation District assumed the obligation of operation and maintenance of the Post Falls Unit at the beginning of the 1949 irrigation season.

The Hayden Lake Irrigation District retained the operation and maintenance of the Hayden Lake Unit during construction and continues to operate the system.

Operation and maintenance of the East Greenacres Unit was assumed by the East Greenacres Irrigation District on December 31, 1976. Operation and maintenance of Twin Lakes was assumed by Kootenai County in January 1977.

BENEFITS

Irrigation

Although fruit production was the major enterprise during the early years of the Post Falls and Hayden Lake Units, major crops in all three units are grain, hay, pasture, and seed (grass and potatoes). Many of the farm units are operated on a part-time basis and are used to produce food for the family or as rural homesites.

Domestic, Municipal, and Industrial Water

Domestic water service on the East Greenacres Unit is available through the multipurpose pipeline system to the area within the boundaries of the irrigation district. There were 248 domestic turnouts provided during construction of the project facilities, and the water supply is sufficient to provide additional turnouts to serve future homesites.

Recreation and Fish and Wildlife

Modification of the outlet works at Twin Lakes will help stabilize the water level, enhance the recreation areas around the lake, and improve fish and wildlife habitat.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	10,274	acres
Number of irrigated farms	367	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,308	428,326
1969	4,156	424,422
1970	4,165	382,929
1971	4,238	402,328
1972	3,786	359,293
1973	3,916	758,465
1974	3,931	591,673
1975	3,462	598,317
1976[1]	6,174	1,016,401
1977	4,825	880,510

[1]East Greenacres Unit included beginning in 1976.

Facilities in Operation

Canals	9	mi
Laterals	100	mi
Pumping plants	5	
Irrigation, domestic, municipal, and industrial wells	14	

Climatic Conditions

Annual precipitation	16.0	in
Temperature:		
Maximum	103	°F
Minimum	−25	°F
Mean	47	°F
Growing season	179	days
Elevation of irrigable area	2200-2300.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,202
Other water service[2]	2,479
Total	3,681

[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

POST FALLS UNIT, SPOKANE RIVER

Drainage area at gaging station on Spokane River near Post Falls, Idaho	3,840	mi²
Annual discharge:		
Maximum (1974)	8,408,000	acre-ft
Minimum (1977)	1,551,000	acre-ft
Average	4,758,000	acre-ft
Average annual diversion (1963-77)	11,600	acre-ft

HAYDEN LAKE UNIT, HAYDEN LAKE

Drainage area at Hayden Lake	62.3	mi²
Estimated average annual inflow to lake	45,000	acre-ft
Average annual diversion (1963-77)	2,250	acre-ft

EAST GREENACRES UNIT, WELLS

Average annual diversion (1976-77)	7,270	acre-ft

Carriage Facilities (Post Falls Unit)

MAIN CANAL

Location: From Post Falls Unit Pumping Plant on the Spokane River about 3 mi east of Post Falls, Idaho.
Construction period: 1945-46

Length	9	mi
Diversion capacity	60	ft³/s
Typical maximum section, compacted clay lining:		
Bottom width	7	ft
Side slopes	2:1	
Water depth	3.2	ft
Lining thickness:		
Compacted clay	6	in
Gravel blanket	6	in
Length	2	mi

PUMPING PLANT DISCHARGE LINE

Location: From Post Falls Unit Pumping Plant north.
Construction period: 1974
Description: Steel pipe

Length	3,000	ft
Diameter	3.5	ft
Capacity	60	ft³/s

Note: Hayden Lake Unit 2-mile discharge line is included in the project lateral system.

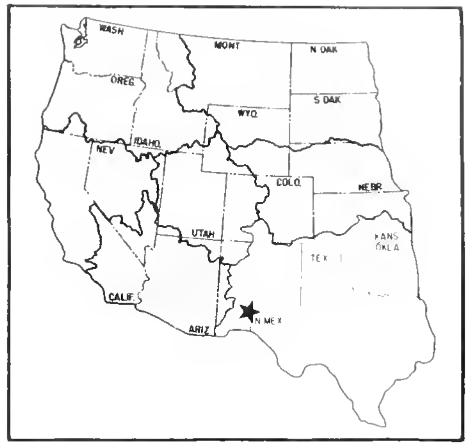
PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Post Falls Unit	2	60	150	1,350
Hayden Lake Unit	2	20	225	700
East Greenacres Unit	14	87	430	5,430

Rio Grande Project

New Mexico: Dona Ana, Sierra, and Socorro Counties
Texas: El Paso County

Southwest Region
Water and Power Resources Service



The Rio Grande Project furnishes a full irrigation water supply for about 178,000 acres of land and electric power for communities and industry in the area. Drainage water from project lands provides a supplemental supply for 18,330 acres in Hudspeth County, Tex. Project lands occupy the river bottom land of the Rio Grande Valley in south-central New Mexico and west Texas. About 60 percent of the lands receiving water are in New Mexico; 40 percent are in Texas.

Physical features of the project include Elephant Butte and Caballo Dams, 6 diversion dams, 141 miles of canal, 462 miles of laterals, 457 miles of drains, and a hydroelectric powerplant. The project is operated as two divisions: The Water and Land Division, and the Power and Storage Division.

PLAN

Storage for the project is provided in the Elephant Butte and Caballo Reservoirs. Water used for winter power generation at Elephant Butte is held in Caballo Reservoir for irrigation use during the summer. Diversions for project irrigation are made at four points on the Rio Grande below the storage reservoirs.

Mesilla Diversion Dam

Elephant Butte Dam, Reservoir, and Powerplant

Elephant Butte Dam and Reservoir (originally called Engle Dam) on the Rio Grande, 125 miles north of El Paso, Tex., can store 2,220,610 acre-feet[1] of water to provide irrigation and year-round power generation. This is a concrete gravity dam 301 feet high and 1,674 feet long including the spillway. It contains 629,500 cubic yards of concrete. The dam was completed in 1916, but storage operation began in 1915.

The power system consists of a 24,300-kilowatt hydroelectric powerplant at Elephant Butte Dam. A system consisting of 490 miles of 115-kilovolt transmission line and 11 substations totaling 81,750 kilovolt-amperes, which was developed and operated by the Rio Grande Project until 1977, has been sold to a private electric company.

Caballo Dam and Reservoir

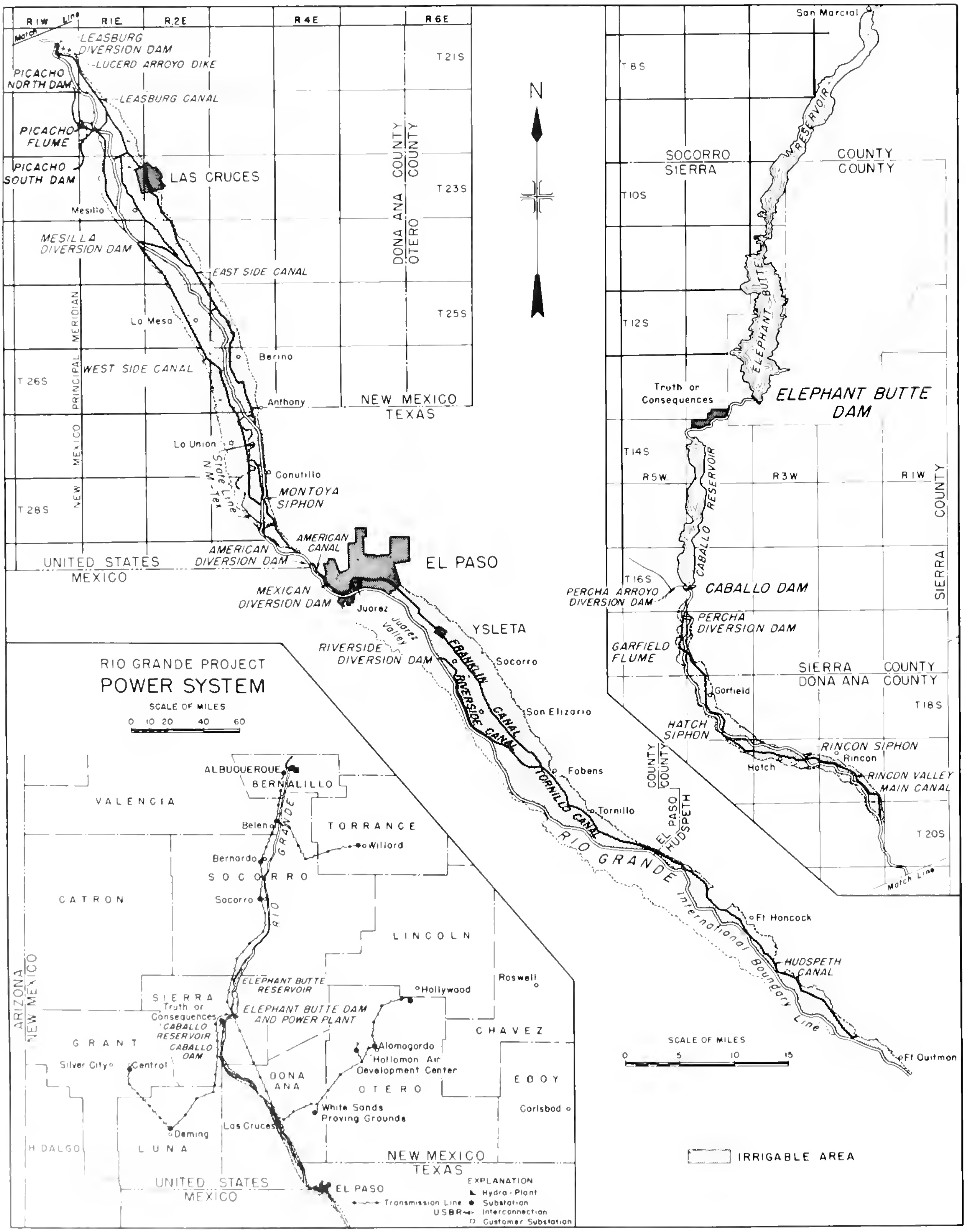
The Caballo Dam and Reservoir are on the Rio Grande 25 miles downstream from Elephant Butte Dam. The dam is an earthfill structure 96 feet high and 4,558 feet long, and has a capacity of 343,990 acre-feet of water. Water discharged from the Elephant Butte Powerplant during winter power generation is impounded at Caballo Dam for irrigation use during the summer.

Percha Diversion Dam and Canal System

Percha Diversion Dam is on the Rio Grande, 2 miles downstream from Caballo Dam. It diverts water into the Rincon Valley Main Canal. The dam is a concrete ogee weir with embankment wings.

The Rincon Valley Main Canal carries water for the irrigation of 16,260 acres in the Rincon Valley, is 27.1

[1] 1974 silt survey correction.



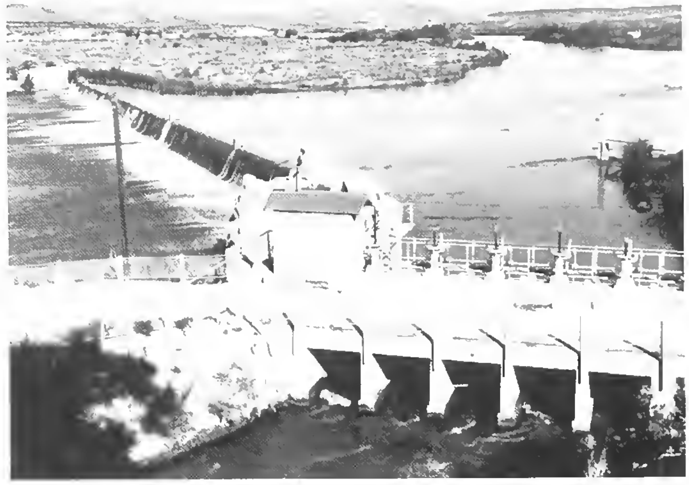
Rio Grande Project

miles long, and has an initial capacity of 350 cubic feet per second. The canal crosses over the Rio Grande in the Garfield Flume and under the river in the Hatch and Rincon Siphons.

Leasburg Diversion Dam and Canal System

Leasburg Diversion Dam, on the Rio Grande 62 miles north of El Paso at the head of Mesilla Valley, is a concrete ogee weir with embankment wings. This structure diverts water into the Leasburg Canal for the upper 31,600 acres of the Mesilla Valley irrigation system.

Leasburg Canal, which conveys irrigation water to Mesilla Valley, is 13.7 miles long and has an initial capacity of 625 cubic feet per second. Picacho North and Picacho South Dams provide flood protection to part of the Leasburg Canal system by blocking two arroyos northwest of Las Cruces, N. Mex.



Leasburg Diversion Dam

Mesilla Diversion Dam and Canal System

Mesilla Diversion Dam, on the Rio Grande 40 miles north of El Paso, is a low concrete weir, radial gate structure, 22 feet high, flanked by levees. This structure diverts water into the East Side and West Side Canals for the lower 53,650 acres of the Mesilla Valley irrigation system.

East Side Canal is 13.5 miles long and has an initial capacity of 300 cubic feet per second. West Side Canal is 27.9 miles long and has an initial capacity of 650 cubic feet per second. Near its terminus, the West Side Canal system crosses under the Rio Grande in the Montoya Siphon.

American Diversion Dam and Canal System

American Diversion Dam, on the Rio Grande 2 miles northwest of El Paso and immediately above the point where the river becomes the international boundary line, diverts irrigation water to El Paso Valley. The 18-foot-high dam is a radial-gate structure between earthfill dikes. It is operated by the American Section of the International Boundary and Water Commission to regulate delivery of water to Mexico in accordance with treaty provisions.

American Canal, also constructed and operated by the American Section of the International Boundary and Water Commission in connection with the American Diversion Dam, carries water 2.1 miles from the dam to the head of Franklin Canal. The canal capacity is 1,200 cubic feet per second.

Franklin Canal, which conveys water to El Paso Valley, is 30.5 miles long, has an initial capacity of 325 cubic feet per second, and serves 17,000 acres in the upper portion of the valley. It was privately constructed about 1889, and was acquired by the Bureau of Reclamation in 1912 to become one of the project's main canals.

Riverside Diversion Dam and Canal System

Riverside Diversion Dam, the southernmost project diversion point, is on the Rio Grande 15 miles southeast of El Paso, and diverts water into the Riverside Canal. This 17.5-foot-high, radial-gate concrete structure has a flood bypass weir and is flanked by river levees.

Riverside Canal is 17.1 miles long, has an initial capacity of 900 cubic feet per second, serves 39,000 acres in the lower portion of the valley, and carries any available surplus through to the Hudspeth District. Tornillo Canal, a continuation of Riverside Canal, is 12 miles long and has an initial capacity of 325 cubic feet per second.

DEVELOPMENT

Early History

There is evidence that the mild climate, rich soil, and easily accessible irrigation water of the Rio Grande Valley have attracted human habitation for many hundreds of years. When the Spanish explorers arrived in the valley in the first half of the 16th century, the Pueblo Indians were irrigating crops, using primitive methods which continued until the early part of the 20th century.

Between 1840 and 1850, various areas of the valley were irrigated by constructing canals and simple diversion structures at strategic points along the Rio Grande. These structures could not withstand the river in flood,

Caballo Dam

and were a source of continual annoyance until they were supplanted by more modern diversion structures.

Investigations

About 1890, extensive settlement and irrigation development in southern Colorado, in addition to that which had already taken place in central New Mexico, depleted the normal summer flow of the Rio Grande, causing the river to be dry at El Paso for more frequent and longer periods. Several small and local storage developments were proposed, but conflicting interests, including Mexico's claims for loss of water based on ancient prior right, prevented the culmination of any of them. These conflicting interests were resolved in 1904 when it was reported that a reservoir could be created by construction of a dam at Elephant Butte which would provide sufficient water to meet all requirements.

Riverside Diversion Dam

The Rio Grande Project was among the first to receive attention after the passage of the Reclamation Act in 1902. Investigation surveys were begun on the project in 1903 and a feasibility report was made in 1904.

Authorization

Construction of the Rio Grande Project was authorized by the Secretary of the Interior on December 2, 1905, under the provisions of the Reclamation Act, and funds were allocated to initiate construction of the first diversion unit. The Reclamation Act was extended to the entire State of Texas on June 12, 1906, following a partial extension for Engle (Elephant Butte) Dam in 1905.

Congress authorized the construction of Elephant Butte Dam on February 25, 1905, and on May 4, 1907, $1 million of nonreimbursable funds were appropriated as the State Department's share for allocation by treaty of 60,000 acre-feet of water annually to Mexico. Additional project works authorized under congressional action include Caballo Dam, a combined flood-control and power-reglating structure, and the Elephant Butte power development.

Construction

Construction was begun in 1906 on Leasburg Diversion Dam and Canal. The dam and 6 miles of canal were completed in 1908.

Construction of Elephant Butte Dam was begun in 1908 but progress was delayed when difficulty in obtaining reservoir land developed. Construction of the dam began again in 1912 and was completed in 1916; storage operation began in January 1915.

The Franklin Canal was constructed in 1889-90 by El Paso Irrigation Company, was purchased by the Bureau of Reclamation in 1912, and was enlarged in 1914-15. Additional project works, consisting of Mesilla Diversion Dam and the East Side and West Side Canals, Percha Diversion Dam and Rincon Valley Canal, and an extension of Leasburg Canal were constructed during 1914-19.

In 1917-18, contracts were entered into for the construction of distribution laterals and a drainage system in addition to storage and diversion works. A critical seepage condition had developed because of the rising groundwater table, and construction of the drainage system, which was begun in 1916, was expedited. During 1918-29, reconstruction and extension of old community ditches, and construction of new laterals to form a complete irrigation distribution and drainage system were in progress. Improvements have been added from time to time since 1930.

Elephant Butte Dam

Caballo Dam was included as a flood control unit in the Rio Grande Rectification Project and part of its cost was allocated to that purpose. It made year-round power generation at Elephant Butte Dam possible and part of the cost was allocated to that purpose, but it also provided replacement for storage lost at Elephant Butte due to silt deposition. This dam was built in 1936-38, followed by construction of the Elephant Butte Powerplant in 1938-40. Construction of the power transmission system, begun in 1940, was completed in 1952.

Operating Agencies

Operation and maintenance in the New Mexico portion of the project is directed by the Elephant Butte Irrigation District. The Bureau of Reclamation as represented by the Rio Grande Project directs operation and maintenance in the Texas portion of the project. El Paso County Water Improvement District No. 1 is scheduled to assume the direction of the Texas portion of the project in time for the 1980 irrigation season.

BENEFITS

Irrigation

The project is divided into many small farming units. Principal crops are cotton, alfalfa, vegetables, pecans, and grain.

Recreation

Elephant Butte Reservoir has a surface area of 36,521 acres. Located midway between Albuquerque, N. Mex., and El Paso, Tex., in scenic semidesert mountain terrain, it is popular throughout the entire Southwest for boating, fishing, and swimming. Cabin sites, boat rental, and fishing tackle are available.

Caballo Reservoir has a surface area of 11,500 acres. In rough desert terrain 17 miles south of Truth or Consequences, N. Mex., it provides an all-year recreation program of picnicking, boating, and fishing.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	177,992	acres
Supplemental irrigation service provided from project drainage water under Warren Act contract	18,546	acres
Total	196,538	acres
Number of irrigated farms	4,736	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	147,512	41,077,177
1969	152,369	38,958,946
1970	155,416	35,112,513
1971	148,650	38,442,856
1972	139,956	42,005,232
1973	148,270	59,410,412
1974	150,723	62,409,624
1975	151,162	66,879,431
1976	152,727	88,025,016
1977	147,012	86,560,215

Facilities in Operation

Storage dams	2	
Diversion dams	6	
Canals	141	mi
Laterals	462	mi
Drains	457	mi
Powerplants	1	

Climatic Conditions

Annual precipitation	7.8	in
Temperature:		
Maximum	111	°F
Minimum	−16	°F
Mean	64	°F
Growing season	247	days
Elevation of irrigable area	3500-4100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	19,113
Municipal water service (est)	365,000
Other water service[2]	32,378
Total	416,491

[2]Urban and suburban, residential, commercial, and industrial lands.

Power Generation

Fiscal Year	Elephant Butte Powerplant (kWh)
1968	45,935,670
1969	47,097,560
1970	68,094,700
1971	53,871,190
1972	20,850,580
1973	44,992,490
1974	81,518,480
1975	58,636,220
1976	73,154,270
Transition Qtr	19,509,950
1977	33,816,030

ENGINEERING DATA

Water Supply

RIO GRANDE

Drainage area at San Marcial, N. Mex.	24,760	mi²
Elephant Butte Reservoir	25,960	mi²
Caballo Reservoir	27,260	mi²
Annual discharge at San Marcial, N. Mex.:		
Maximum (1941)	2,831,000	acre-ft
Minimum (1951)	114,100	acre-ft
Average	905,700	acre-ft
Average annual diversion, 1938-78[3]	617,000	acre-ft

[3]Normal annual release from Caballo Reservoir in accordance with Rio Grande Compact is 790,000 acre-ft.

Storage Facilities

ELEPHANT BUTTE DAM[4]

Type: Concrete gravity
Location: On the Rio Grande 4 mi east of Truth or Consequences, N. Mex.
Construction period: 1912-16. Spillway channel below dam added in 1921 and modified in 1947, service outlet deflectors added in 1944, powerplant added in 1940.
Date of closure (first storage): 1915
Reservoir, Elephant Butte:

Average annual inflow, 1895-1955	905,700	acre-ft
Total capacity to El. 4407[5]	2,109,423	acre-ft
Active capacity	2,109,423	acre-ft
Surface area	36,521	acres
Dimensions:		
Structural height	301	ft
Hydraulic height	193	ft
Top width	18	ft
Maximum base thickness	228	ft
Crest length	1,674	ft
Crest elevation	4414.0	ft
Total volume	629,500	yd³

Spillway: Uncontrolled concrete ogee weir and concrete-lined chute at right end of dam, with four 10-ft-diameter circular openings through base of weir, each controlled by one cylindrical gate.

Crest length	295	ft
Crest elevation	4407.0	ft
Capacity at El. 4415:		
Weir	26,000	ft³/s
Conduits	8,750	ft³/s

Outlet works: All located through dam near left abutment.
Service: Four conduits, each controlled by one 60-in balanced valve.
Sluicing: Two conduits, each controlled by one 47- by 60-in slide gate.
Power: Six penstock openings leading to 73-in steel penstocks that join in pairs at the face of the dam to form three 96-in penstocks leading to powerplant.

Capacity at El. 4407:		
Service	5,300	ft³/s
Sluicing	3,100	ft³/s
Power	2,400	ft³/s

Foundation: Hard, sound, fissured sandstone in irregular beds, containing pockets and interbedded strata of friable shale and numerous small springs throughout foundation area.

[4]All elevations refer to project datum; add 43.3 feet for sea level.
[5]Original total constructed capacity 2,634,800 acre-ft.

Special treatment: Cement grout curtain beneath upstream cutoff trench, special grouting of fissures and springs.

Mass concrete: Crushed rock and rock screenings blended with sand for aggregate; cement a blend of portland (52%) and pulverized sandstone (48%); natural temperature control; quarried stones amount to 15% of total volume.

Volume excluding spillway	605,200	yd^3
Maximum size aggregate	3.5	in

Massive rock, maximum weight 8 tons per piece placed in green concrete.

Average net water-cement ratio by weight:		
Interior concrete	0.80	
Exterior concrete	0.65	
Cement content:		
Interior concrete	1.0	bbl/yd^3
Exterior concrete	1.4	bbl/yd^3

Contraction joints: Transverse joints spaced at 80- to 160-ft intervals below and 35 to 56.5 ft above El. 4312; faces coated with heavy oil, alternate blocks poured after initial cooling of adjacent blocks.

Caballo Dam[4]

Type: Zoned earthfill
Location: On the Rio Grande 17 mi south of Truth or Consequences, N. Mex.
Construction period: 1936-38
Date of closure (first storage): 1938

Reservoir, Caballo:		
Average annual inflow, 1938-55	739,340	acre-ft
Total capacity to El. 4182	343,990	acre-ft
Active capacity	343,990	acre-ft
Surface area	11,613	acres
Dimensions:		
Structural height	96	ft
Hydraulic height	78	ft
Top width	35	ft
Maximum base width	660	ft
Crest length	4,558	ft
Crest elevation	4190.0	ft
Total volume	1,244,000	yd^3

Spillway: Concrete-lined open channel in left abutment, controlled by two 50- by 22.5-ft radial gates.

Elevation top of gates (includes 1.5-ft splash plate)	4183.5	ft
Crest elevation	4161.0	ft
Capacity at El. 4182	33,200	ft^3/s

Outlet works: Concrete-lined tunnel through left abutment controlled by two 6- by 7.5-ft high-pressure slide gates. A 30-in-diameter steel pipe located below tunnel invert and extending from gate chamber, controlled by one 30-in gate valve, serves the Bonita Lateral.

Capacity at El. 4182	5,000	ft^3/s

Foundation: Gorge cut in compact red clay-bound conglomerate refilled with river deposits.

Special treatment: Cement grout curtain beneath cutoff walls; supplemental grouting of abutments.

Picacho North Dam

Type: Zoned earthfill
Location: On the North Branch of Picacho Arroyo about 5 mi northwest of Las Cruces, N. Mex.
Construction period: 1953

Reservoir, Picacho North:		
Total capacity	790	acre-ft
Dimensions:		
Height above original ground surface	42	ft
Top width	20	ft
Maximum base width	209	ft
Crest length	1,610	ft
Crest elevation	3942.0	ft
Total volume	149,000	yd^3

Spillway: Open cut spillway, emergency only, about 500 ft west of south end of dam.

Crest length	200	ft
Crest elevation	3938.0	ft

Outlet works: Uncontrolled concrete conduit through base of dam.

Capacity at El. 3938	283	ft^3/s

Picacho South Dam

Type: Zoned earthfill
Location: On the South Branch of Picacho Arroyo about 5 mi northwest of Las Cruces, N. Mex.
Construction period: 1953-54

Reservoir, Picacho South:		
Total capacity	460	acre-ft
Dimensions:		
Height above original ground surface	29	ft
Top width	15	ft
Maximum base width	145	ft
Crest length	1,624	ft
Crest elevation	3945.0	ft
Total volume	86,920	yd^3

Spillway: Emergency spillway consists of uncontrolled, riprap-lined open channel in right end of dam.

Crest length	100	ft
Crest elevation	3942.0	ft

Outlet works: Uncontrolled concrete conduit through base of dam.

Capacity at El. 3941	170	ft^3/s

Lucero Dike

Type: Random earthfill
Location: On the Lucero Arroyo 14 mi north of Las Cruces, N. Mex.
Construction period: 1951

Capacity	475	acre-ft
Dimensions:		
Height above original ground surface	19	ft
Top width	12	ft
Maximum base width	93	ft
Crest length	4,845	ft
Crest elevation	3934.0	ft
Total volume	102,000	yd^3

Spillway: Rectangular chute at west end of dike.

Crest length	10	ft
Crest elevation	3930.0	ft

Outlet works: Uncontrolled concrete conduit through base of dike.

Capacity at El. 3930	140	ft^3/s

Diversion Facilities

Percha Arroyo Diversion Dam[6]

Type: Rock-faced earthfill
Location: On Percha Arroyo, 1 mi west of Caballo Dam.
Year completed: 1939

[6]Dike constructed to divert storm runoff into Caballo Reservoir: no direct connection with irrigation system.

Dimensions:

Structural height	29 ft
Hydraulic height	19 ft
Total crest length	2,489 ft
Crest elevation	4200.0 ft
Volume	193,000 yd³

Spillway: None

Headworks: Flood diversion channel, no gates, highway bridge and drop chute into Caballo Reservoir.

Diversion capacity	30,000 ft³/s

PERCHA DIVERSION DAM

Type: Concrete ogee weir, embankment wings

Location: On the Rio Grande, about 2 mi south of Caballo Dam.

Year completed: 1918

Dimensions:

Structural height	18.5 ft
Hydraulic height	8 ft
Weir crest length	350 ft
Total crest length	2,720 ft
Crest elevation	4103.0 ft
Volume	43,200 yd³

Spillway: Overflow weir, 2 radial sluice gates, each 20- by 8-ft.

Headworks: Rincon Valley Main Canal headworks at west abutment: 8 slide gates, each 4.3 by 3.75 ft.

Diversion capacity	350 ft³/s

LEASBURG DIVERSION DAM

Type: Concrete ogee weir, embankment wings.

Location: On the Rio Grande, about 15 mi northwest of Las Cruces, N. Mex.

Year completed: 1907. Crest raised 1.25 ft in 1919.

Dimensions:

Structural height	10 ft
Hydraulic height	7 ft
Total crest length, dam, including weir	2,865 ft
Weir crest length	600 ft
Weir crest elevation	3922.25 ft
Volume	22,500 yd³

Spillway: Overflow weir, 3 slide sluice gates, each 5 by 8 ft.

Capacity[7]	17,000 ft³/s

Headworks: Leasburg Canal headworks at abutment; 7 slide gates 5 by 6.75 ft.

Diversion capacity	625 ft³/s

MESILLA DIVERSION DAM

Type: Concrete weir, radial gate structure

Location: On the Rio Grande, 6 mi south of Las Cruces, N. Mex.

Year completed: 1916. Crest raised 1.66 ft in 1940.

Dimensions:

Structural height	22 ft
Hydraulic height	10 ft
Weir crest length	303 ft
Crest elevation	3819.83 ft
Volume	2,900 yd³

Spillways: Nine radial gates, each 21.58 by 6 ft; 4 radial gates, each 21.58 by 8.42 ft.

Capacity[7]	15,000 ft³/s

Headworks: Canal headworks at each abutment. 8 slide gates, each 4.33 by 3.75 ft at west end; 6 slide gates, each 4.33 by 3.75 ft at east end.

Diversion capacity

West side	650 ft³/s
East side	300 ft³/s

AMERICAN DIVERSION DAM[8]

Type: Radial gate structure between river levees

Location: On the Rio Grande at El Paso, Tex.

Year completed: 1938

Dimensions:

Structural height	18 ft
Hydraulic height	5 ft
Weir crest length	286 ft
Crest elevation	3683.5 ft
Volume	2,900 yd³

Spillway: Thirteen radial gates, each 20 by 7.5 ft

Capacity[7]	12,000 ft³/s

Headworks: American Canal headworks at east abutment; 2 radial gates, each 20 by 11 ft.

Diversion capacity	1,200 ft³/s

RIVERSIDE DIVERSION DAM

Type: Concrete weir, radial gate structure

Location: On the Rio Grande, 15 mi southeast of El Paso.

Year completed: 1928

Dimensions:

Structural height	17.5 ft
Hydraulic height	8 ft
Weir crest length	267 ft
Crest elevation	3621.07 ft
Volume	2,500 yd³

Spillway: Six radial gates, each 16 by 8.17 ft, overflow weir.

Capacity[7]	11,000 ft³/s

Headworks: Riverside Canal headworks at east abutment; 5 radial gates, each 16 by 6 ft.

Diversion capacity	900 ft³/s

[7]These are the flood discharges which the International Boundary and Water Commission is using for the Rio Grande Channelization Project at the indicated points and are not necessarily the maximum which the dams will pass safely, nor which they were designed to pass.

[8]American Diversion Dam and Canal constructed and operated by American Section, International Boundary and Water Commission, United States-Mexico, for the diversion and allocation of water in accordance with treaty between the United States and Mexico.

Carriage Facilities

RINCON VALLEY MAIN CANAL

Location: From Percha Diversion Dam generally southeast along Rio Grande.

Construction period: 1916-19

Length	27.1 mi
Diversion capacity	350 ft³/s
Typical maximum section in earth:	
Bottom width	22 ft
Side slopes	2:1
Water depth	4.2 ft
Typical maximum section, concrete lined:	
Bottom width	14 ft
Side slopes	1.5:1
Water depth	4.2 ft
Lining thickness	4 in

GARFIELD FLUME (RINCON VALLEY MAIN CANAL)

Location: Rio Grande, about 4 mi south of Percha Diversion Dam.

Description: Steel truss structure carrying twin barrels.

Construction period: 1917-18

Length	800 ft

Diameter: No. 156 Hess flume

Capacity	320 ft³/s

HATCH SIPHON (RINCON VALLEY MAIN CANAL)

Location: Rio Grande, about 13 mi south of Percha Diversion Dam.
Description: Reinforced concrete
Construction period: 1918

Length	650 ft
Diameter	6 ft
Capacity	200 ft³/s

RINCON SIPHON (RINCON VALLEY MAIN CANAL)

Location: Rio Grande, 21 mi south of Percha Diversion Dam.
Description: Reinforced concrete
Construction period: 1918-19

Length	550 ft
Diameter	5 ft
Capacity	150 ft³/s

LEASBURG CANAL

Location: From Leasburg Diversion Dam on the Rio Grande about 15 mi northwest of Las Cruces, N. Mex., generally southeast along the river.
Construction period (first 6 mi): 1906-08. Extended to 11 mi in 1915-16. Constructed to present length and capacity in 1921-22.

Length	13.7 mi
Diversion capacity	625 ft³/s
Typical maximum section in earth:	
Bottom width	34 ft
Side slopes	1:1
Water depth	4 ft

EAST SIDE CANAL

Location: From Mesilla Diversion Dam on the Rio Grande about 6 mi south of Las Cruces, generally southeast along the river.
Construction period (first 10.5 mi): 1914-15. Constructed to present length and capacity in 1918-19.

Length	13.5 mi
Diversion capacity	300 ft³/s
Typical maximum section in earth:	
Bottom width	24 ft
Side slopes	1.5:1
Water depth	3.2 ft

WEST SIDE CANAL

Location: From Mesilla Diversion Dam on the Rio Grande about 6 mi south of Las Cruces, generally southeast along the river.
Construction period (first 14.4 mi): 1914-15. Constructed to present length and capacity in 1920.

Length	27.9 mi
Diversion capacity	650 ft³/s
Typical maximum section in earth:	
Bottom width	52 ft
Side slopes	1.5:1
Water depth	3 ft
Typical maximum section, concrete lined:	
Bottom width	52 ft
Side slopes	1.5:1
Water depth	3 ft
Lining thickness	4 in

AMERICAN CANAL

Location: From American Diversion Dam near El Paso, southeast along the Rio Grande to beginning of Franklin Canal.
Construction period: 1937-38

Length	2.1 mi
Diversion capacity	1,200 ft³/s
Typical maximum section, concrete lined:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	8.75 ft
Lining thickness	3 in

FRANKLIN CANAL

Location: From end of American Canal, near El Paso, generally southeast along the Rio Grande.
Construction period: Privately constructed in 1889-90. Purchased by Reclamation in 1912 and enlarged in 1914-15.

Length	30.5 mi
Diversion capacity	325 ft³/s
Typical maximum section in earth:	
Bottom width	24 ft
Side slopes	1.5:1
Water depth	5 ft
Typical maximum section, concrete lined:	
Bottom width	16 ft
Side slopes	0.5:1
Water depth	5 ft
Lining thickness	4 in

RIVERSIDE CANAL

Location: From Riverside heading on the Rio Grande near Ysleta, Tex., generally southeast along the river.
Construction period: 1927-40

Length	17.1 mi
Diversion capacity	900 ft³/s
Typical maximum section in earth:	
Bottom width	84 ft
Side slopes	1.5:1
Water depth	4 ft

TORNILLO CANAL

Location: From end of Riverside Canal near Fabens, Tex., generally southeast along the Rio Grande.
Construction period: 1923-24

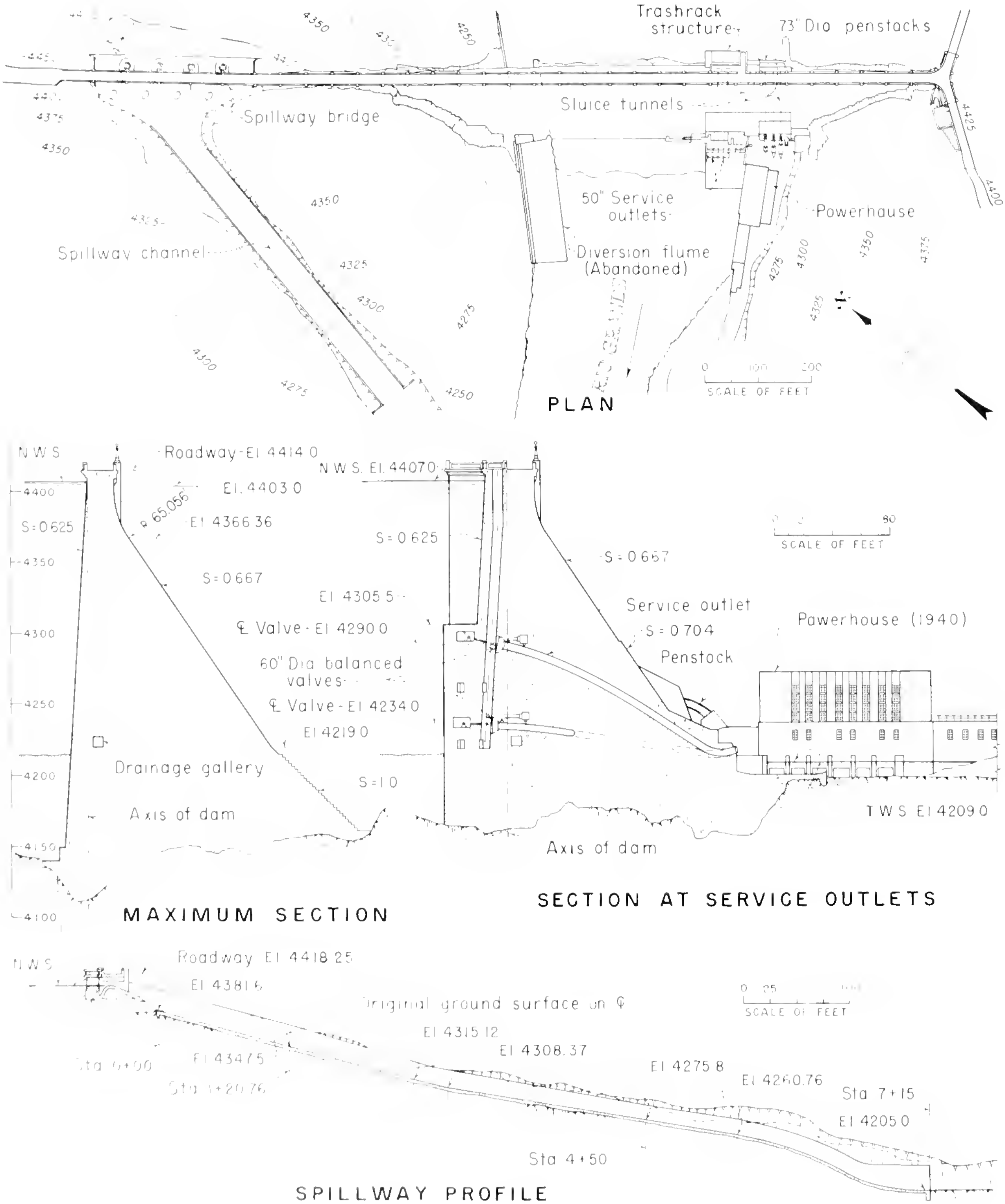
Length	12 mi
Diversion capacity	325 ft³/s
Typical maximum section in earth:	
Bottom width	26 ft
Side slopes	1.5:1
Water depth	5.4 ft

Power Facilities

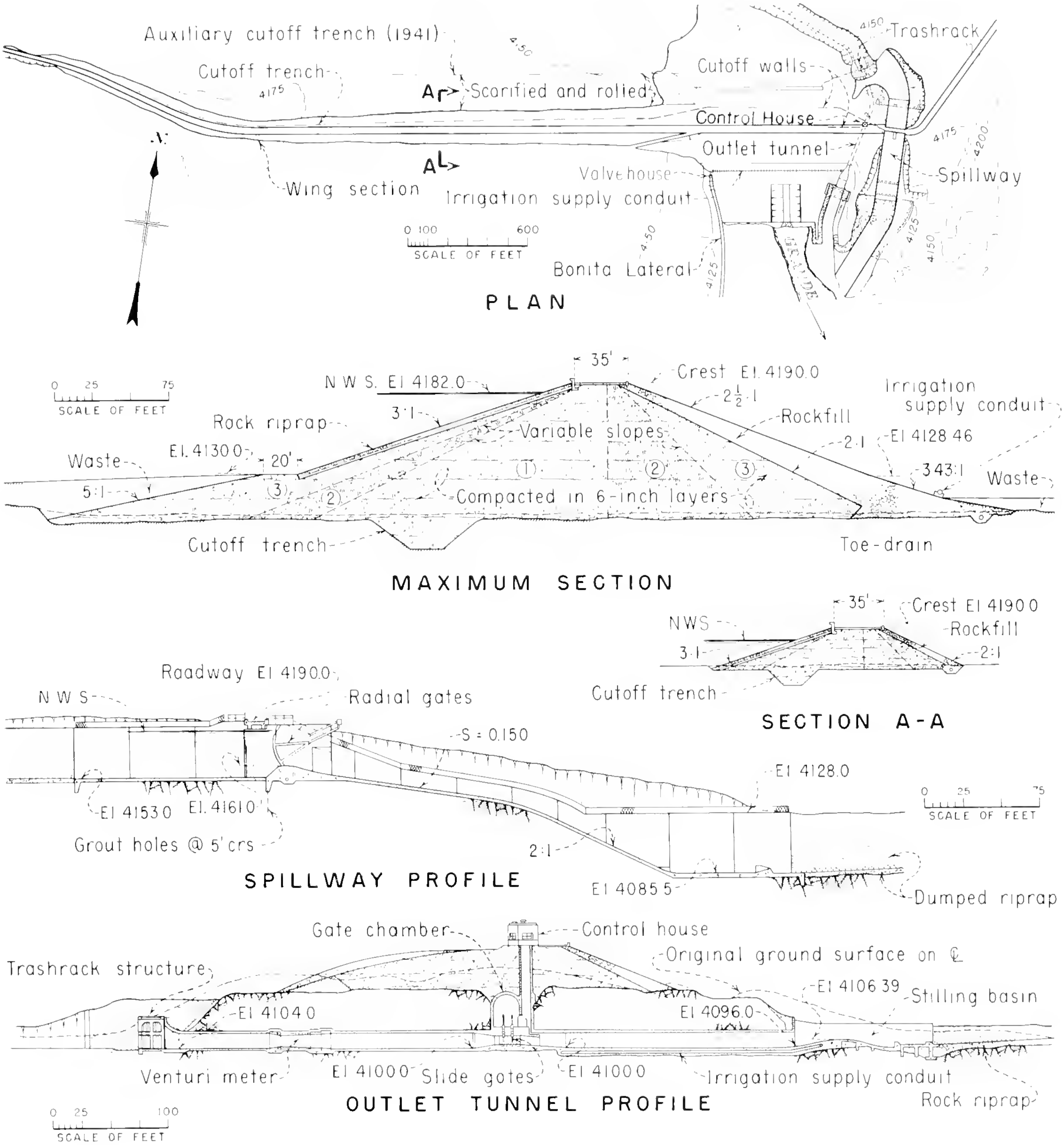
ELEPHANT BUTTE POWERPLANT

Location: At toe of Elephant Butte Dam.
Year of initial operation: 1940
Year last generator placed in operation: 1940

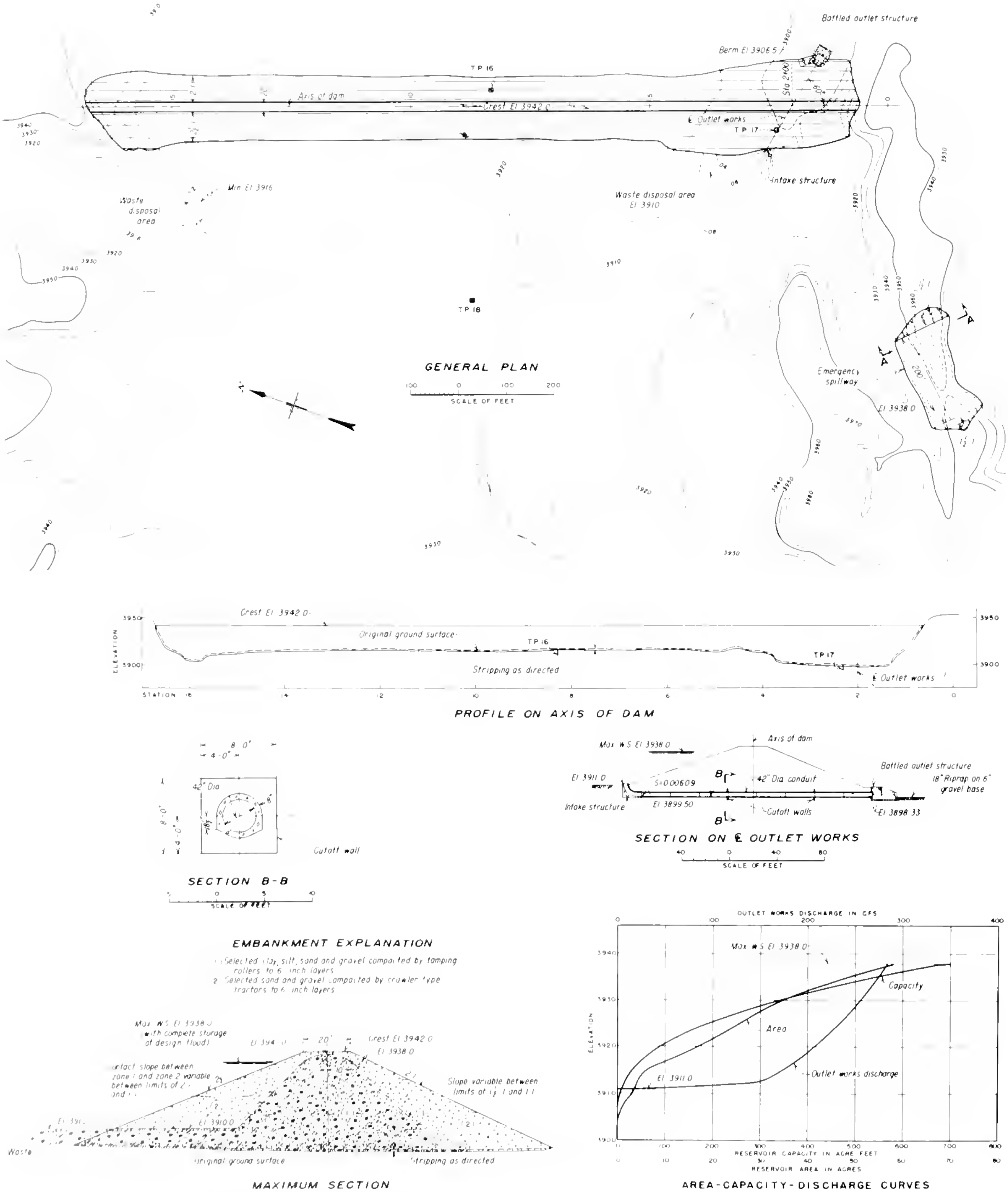
Nameplate capacity	24,300 kW
Number and capacity of generators (3)	8,100 kW
Maximum head	203 ft



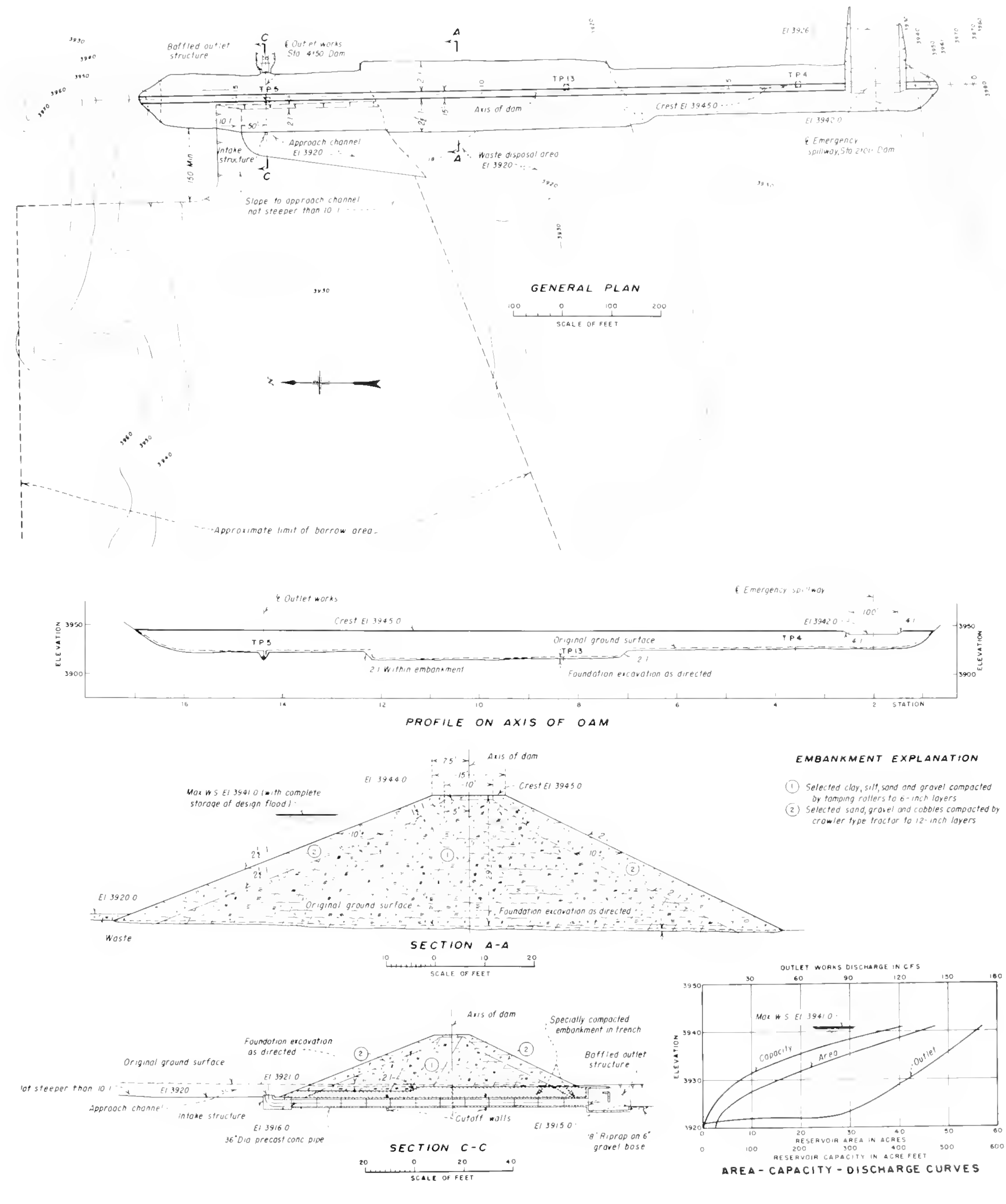
Elephant Butte Dam, Plan and Sections



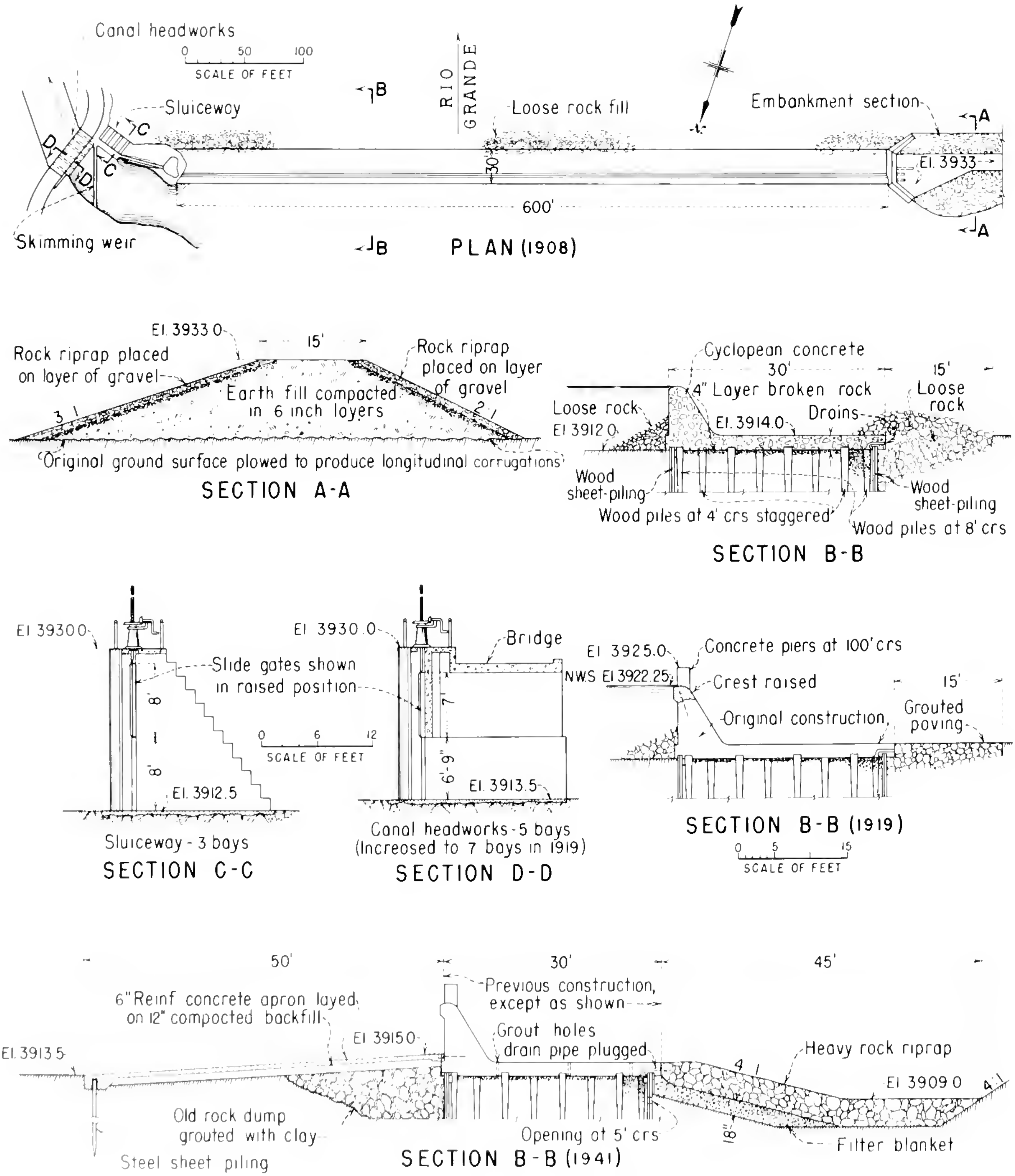
Caballo Dam, Plan and Sections



Picacho North Dam, Plan and Sections



Picacho South Dam, Plan and Sections

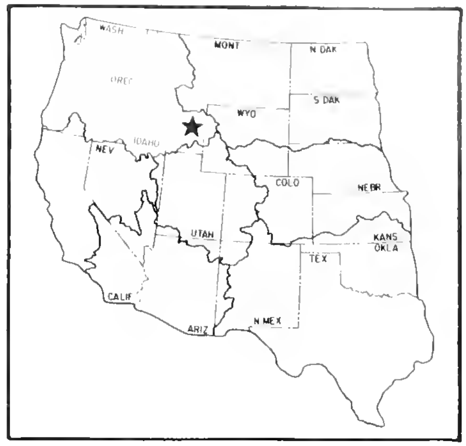


Leasburg Diversion Dam, Plan and Sections

Ririe Project

Idaho: Bonneville County

Pacific Northwest Region
Water and Power Resources Service



The Ririe Project was constructed to impound and control the waters of Willow Creek, a Snake River tributary in eastern Idaho, for flood control, irrigation, and recreation. Significant fish and wildlife protection measures also are included. Major features include Ririe Dam and Lake, and a floodway bypass outlet channel.

PLAN

Ririe Lake, formed by construction of Ririe Dam, serves a principal purpose of flood control on the lower reaches of Willow and Sand Creeks. Out of a total reservoir capacity of 100,500 acre-feet, 80,500 acre-feet serves both flood control and irrigation, 10,000 acre-feet is dead storage space that can serve conservation, and the top 10,000 acre-feet is held exclusively for emergency flood control operations.

Ririe Dam and Lake

Ririe Dam is located on Willow Creek, a minor tributary of the Snake River, in Bonneville County of eastern Idaho. The dam is 15 miles northeast of the city of Idaho Falls and about 4 miles southeast of the town of Ririe. Constructed by the Corps of Engineers, the dam is an earth and rockfill structure, 253 feet high and 1,070 feet long. The reservoir impounded by the dam has an active capacity of 90,500 acre-feet.

Ririe Dam

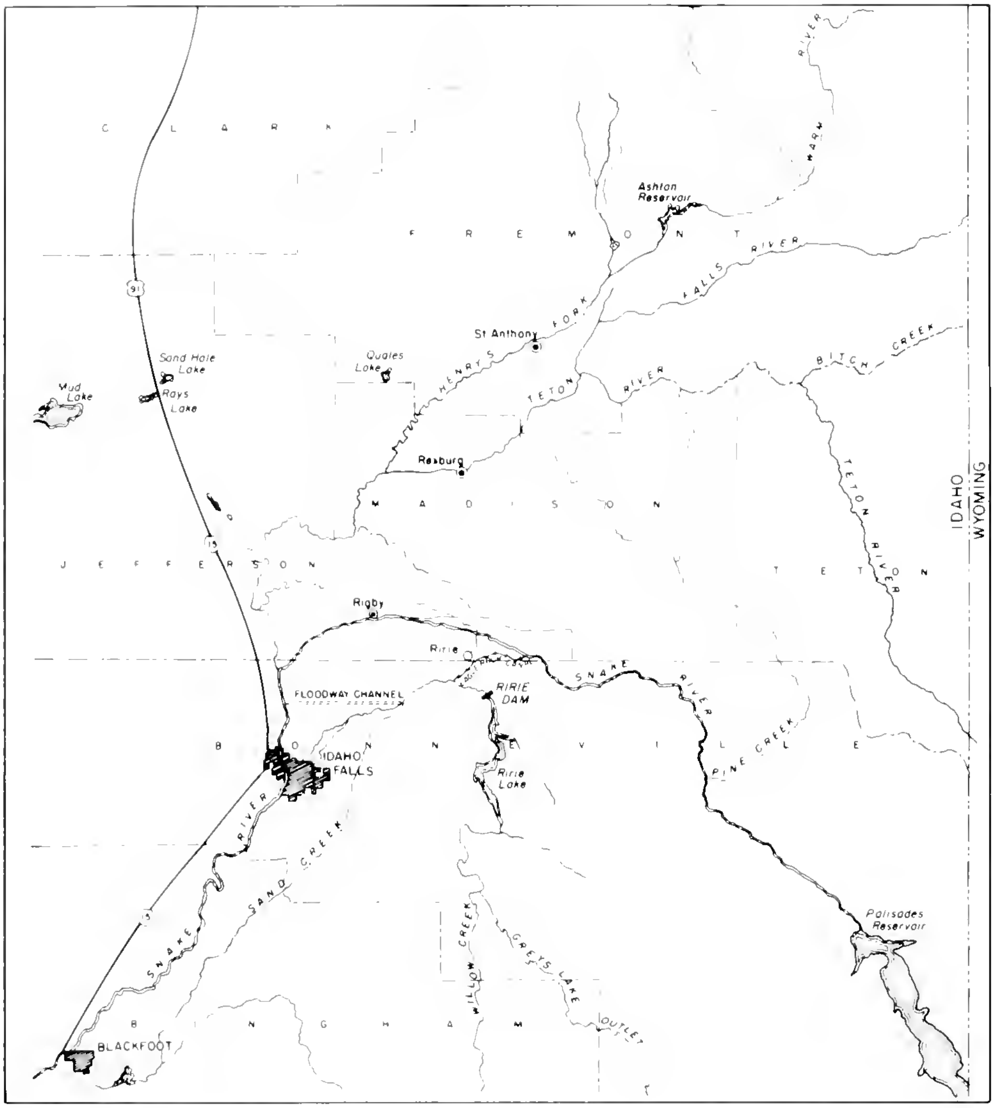
Floodway or Outlet Channel

The floodway or outlet channel is a structure to control the waterflow in Willow Creek below the dam, especially that section flowing through Idaho Falls and the area northeast of the city. Also controlled is Sand Creek as it flows east and southeast of Idaho Falls. Required releases of 1,900 cubic feet per second from Ririe Lake can be carried adequately in the natural channel to the point where the stream divides into Willow and Sand Creeks. The floodway bypass begins on Willow Creek just downstream from the point where Sand Creek branches from Willow Creek and extends directly west 7.8 miles to enter the larger natural channel of the Snake River 4.5 miles north of Idaho Falls. The bypass is gated at the Willow Creek intake to control initial inflow. The north bank of the channel was constructed at ground level to permit surface inflow of floodwaters along its course. Sand Creek can adequately carry 1,000 cubic feet per second and the floodway bypass channel was designed to carry 900 cubic feet per second, thereby providing the required additional capacity to control water flows.

DEVELOPMENT

Early History

Since 1911, at least eight spring floods and nine winter floods have caused considerable damage in the area of Ririe and Idaho Falls. The largest known floods were those of 1917 and 1962. The 1917 flood was a spring snowmelt flood augmented by rainfall peaking at 4,200 cubic feet per second in Willow Creek near Ririe. Some 3,000 acres of land were inundated for 2 to 3 weeks. The



Ririe Project

1962 flood was a winter rain flood augmented by frozen ground and snowmelt, peaking at 5,080 cubic feet per second in Willow Creek above its confluence with Sand Creek. About 54,000 acres were inundated for 2 to 3 days. Flows above 2,000 cubic feet per second that occurred about 3.5 miles below the present damsite would cause flooding conditions.

Investigations

The review report on "Columbia River and Tributaries," dated June 1949, prepared by the Corps of Engineers and printed as House Document 531, 81st Congress, 2nd session, summarized field studies for storage and channel works on Willow Creek and indicated that flood control works were not economically feasible at that time. The Upper Snake River Basin report of 1961, prepared jointly by the Corps of Engineers and the Bureau of Reclamation, indicated that Ririe Dam and Reservoir warranted early construction. Interim Report No. 3, dated March 1962 and prepared by the Corps, presented additional information on structures and costs, economic analysis, and operating procedures. This report included a brief summary of the February 1962 flood, with comments on the control of such a flood by storage at the Ririe site.

Authorization

Construction of Ririe Dam and Reservoir was authorized by the Flood Control Act of October 23, 1962, Public Law 87-874 (76 Stat. 1193). House Document No. 562 served as the basis for that authorization.

Construction

Project construction was performed under the jurisdiction of the Corps of Engineers. Construction of the dam began in January 1970 and was completed in November 1977. Floodway channel work began in June 1975. Recreation area work was started in May 1977.

Operating Agency

The authorizing act through House Document No. 562 provided for the Bureau of Reclamation to operate and maintain the project. Formal transfer of the project from the Corps of Engineers to the Bureau of Reclamation was consummated by a memorandum of agreement effective October 14, 1976.

BENEFITS

Flood Control

Coordinated operation of Ririe Dam and the floodway bypass channel will control the flows in Willow and Sand Creeks to help alleviate flood damages such as those previously experienced in the city of Idaho Falls and on surrounding farmlands. The devastating floods of 1917 and 1962 were created by flows more than double the 2,000-cubic-foot-per-second capacity of Willow Creek. With the present control structures, Willow Creek can be contained at 1,900 cubic feet per second.

Irrigation

Irrigation benefits will be realized from the eventual use of water for crop production. Space in the reservoir for the joint use of flood control and irrigation totals 80,500 acre-feet. None of the reservoir space has been sold for irrigation purposes; however, marketing studies and repayment contract negotiations are underway. Crops raised in the area where the water will be used consist principally of hay, grain, pasture, and potatoes.

Recreation and Fish and Wildlife

Four recreation areas have been developed to meet projected initial demands. Juniper Park, adjacent to the project headquarters visitor center, is the major recreation site. Both overnight camping and day-use facilities are available, including a floating fishing dock and a boat-launching ramp. Blacktail Park, on the lake, includes a swimming area and other day-use facilities. Benchland Park is also on the lake, but is accessible only by boat and has limited day-use facilities. Creekside Park has day-use facilities and access to Willow Creek just downstream from the dam. Ririe Lake will be stocked annually with rainbow trout and the minimum reservoir pool will provide winter habitat for fish survival and growth. A minimum flow of 25 cubic feet per second will be maintained downstream in Willow Creek to provide stream fishing habitat. Deer and elk use the area as winter range, so a large area around the south half of Ririe Lake will be developed as rangeland for support of these animals during the critical winter months.

PROJECT DATA

Facilities in Operation

Storage dams	1	
Floodway or outlet channel	1	

Climatic Conditions

Annual precipitation	10.9	in
Temperature:		
Maximum	100	°F
Minimum	−33	°F
Mean	43	°F

ENGINEERING DATA

Water Supply

WILLOW CREEK

Drainage area above Ririe Lake (excluding Grays Lake)	487	mi²
Annual discharge:		
Maximum (1971)	202,900	acre-ft
Minimum (1977)	34,300	acre-ft
Average	122,600	acre-ft

Storage Facilities

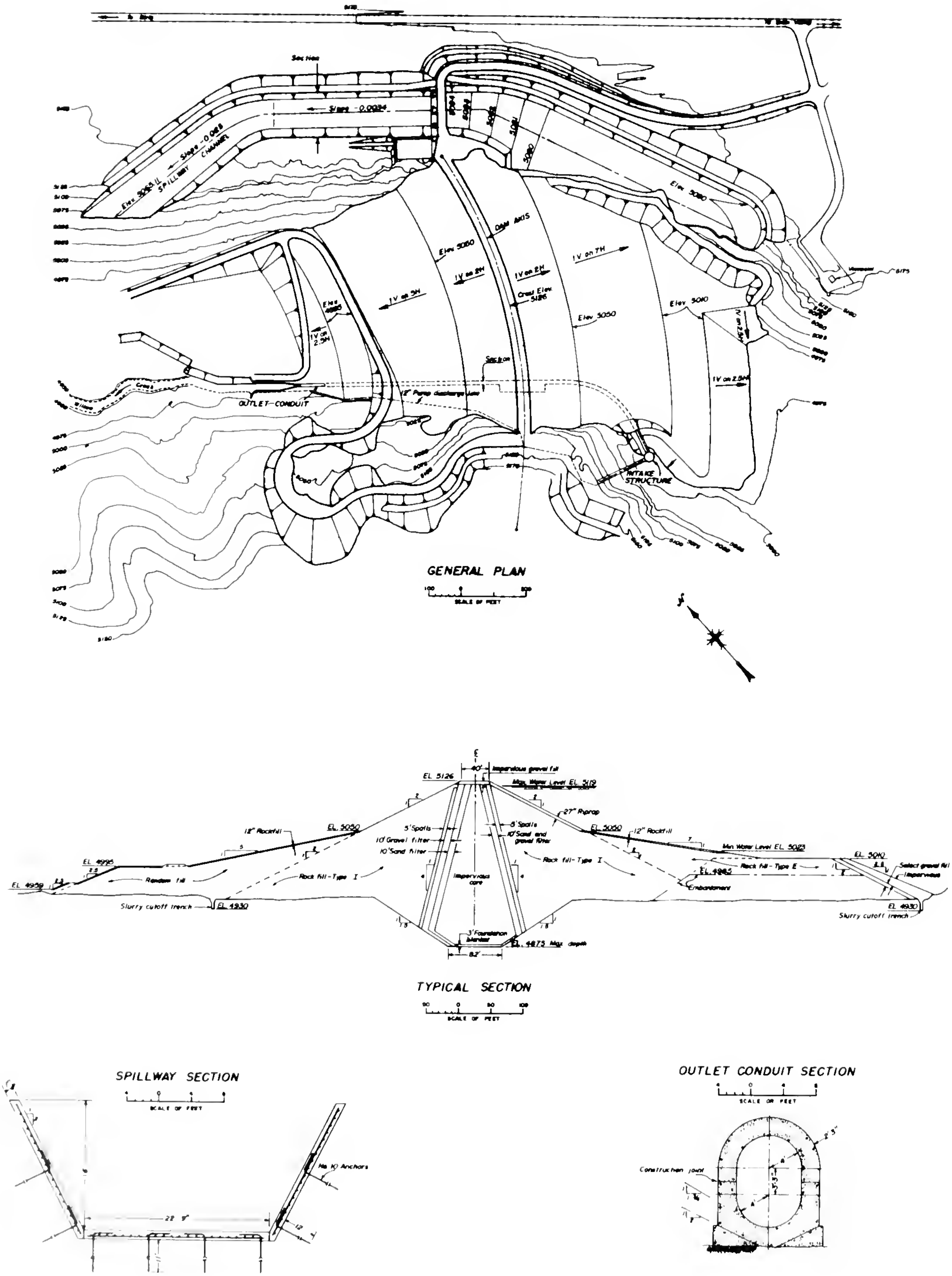
RIRIE DAM

Type: Earth and rockfill		
Location: On Willow Creek, near Idaho Falls, Idaho.		
Construction period: 1970-77		
Date of closure (first storage): 1976		
Reservoir, Ririe Lake:		
Total capacity to El. 5119	100,500	acre-ft
Active capacity, El. 5023 to 5112.8	90,500	acre-ft
Surface area at El. 5119	1,560	acres
Dimensions:		
Structural height	253	ft
Hydraulic height	169	ft
Top width	34	ft
Maximum base width	1,100	ft
Crest length	1,070	ft
Crest elevation	5128.0	ft
Total volume	2,676,000	yd³
Spillway: Concrete-lined chute 1,000 ft long at right abutment. Total width 111 ft. Gated width at floor 91 ft. Controlled by two 40.5- by 27.32-ft gates.		
Capacity at El. 5119	40,000	ft³/s
Outlet works: Concrete-lined horseshoe tunnel 1,150 ft long. Controlled by two slide gates opening to common tunnel.		
Total capacity at El. 5119	4,250	ft³/s

Carriage Facilities

FLOODWAY OR OUTLET CHANNEL

Location: From Willow Creek west to the Snake River 4.5 mi north of Idaho Falls.		
Construction period: 1975-78		
Length	7.8	mi
Diversion capacity	900	ft³/s
Typical section in earth, riprap lined:		
Bottom width	8	ft
Top width	50	ft
Side slopes	1:2	
Channel depth	10	ft

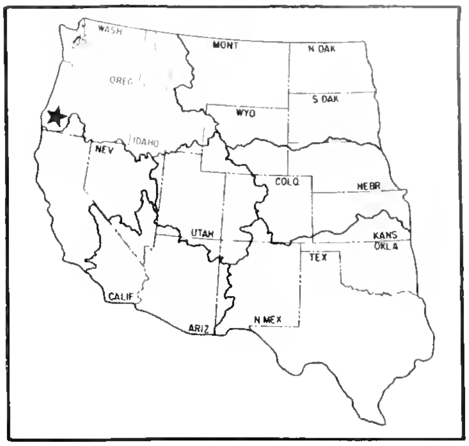


Ririe Dam, Plan and Sections

Rogue River Basin Project
Talent Division

Oregon: Jackson County

Pacific Northwest Region
Water and Power Resources Service



The Talent Division of the Rogue River Basin Project is in the northeastern part of the Klamath River Basin in southwestern Oregon. Work on the division consisted of construction, rehabilitation, and improvement of the irrigation facilities of three privately owned irrigation districts in the vicinity of Medford, Oreg., and the provision for supplemental water for these lands. The work on the Medford and Rogue River Valley Irrigation Districts included rehabilitation and betterment of Fourmile Lake Dam, Fish Lake Dam, and the numerous structures which are a part of the Main and Medford Canals. Rehabilitation work on the Talent Irrigation District included enlargement and extension of the distribution system. An extensive collection, diversion, storage, and conveyance system was constructed to carry excess waters of the Rogue River and Klamath River Basins to the irrigated lands.

The Talent Irrigation District consists of 15,054 irrigable acres. Medford Irrigation District has a water supply for 11,500 acres, and Rogue River Valley Irrigation District has a water supply for 8,310 acres. Additionally, the Talent Division provides electric power from a 16,000-kilowatt hydroelectric powerplant.

Principal features of the Talent Division include Howard Prairie Dam, Howard Prairie Delivery Canal, Keene Creek Dam, Green Springs Powerplant, the enlarged Emigrant Dam and Lake, and Agate Dam and Reservoir.

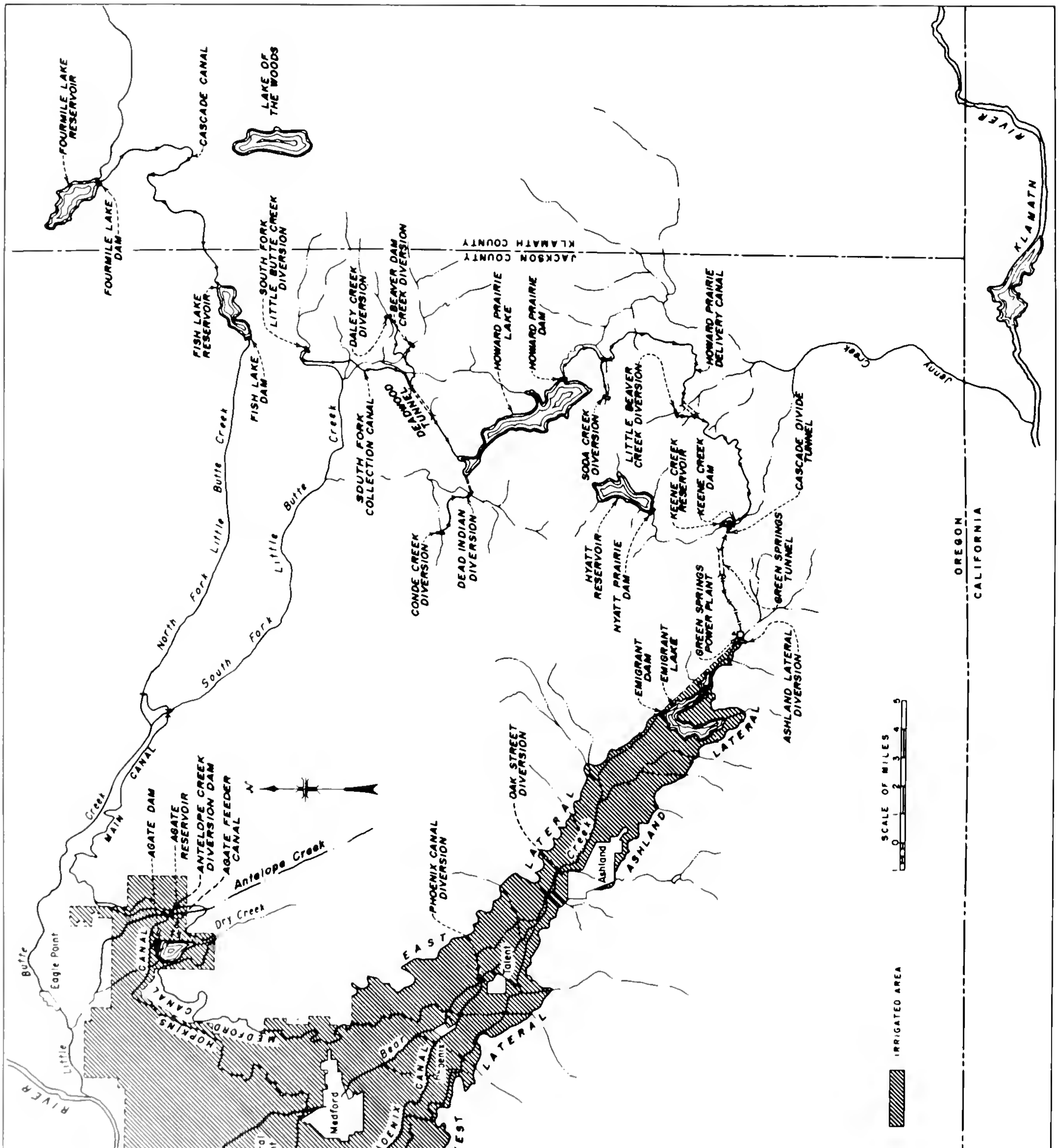
PLAN

Supplemental water for the Medford and Rogue River Valley Irrigation Districts is diverted through the facilities of the Talent Irrigation District, which adjoins the Medford district on the southeast. The Medford district diverts its supplemental water at Phoenix Diversion Dam, and the Rogue River Valley district diverts its share from a dam at Medford, Oreg.

To supply water to lands in the Talent Irrigation District and supplemental water to the Medford and Rogue River Valley districts, a collection canal system has been constructed to divert surplus flows of the South Fork of Little Butte Creek through a tunnel beneath the Cascade Divide from the Rogue River Basin to Howard Prairie Lake in the Klamath River Basin. Howard Prairie Dam stores collection canal diversions and Beaver Creek

Howard Prairie Dam and Reservoir

Hyatt Dam and Reservoir



Rogue River Basin Project

runoff. Howard Prairie delivery canal conveys the water from the storage reservoir to Keene Creek Regulating Reservoir, which also regulates releases from Hyatt Reservoir. Water from Soda and Little Beaver Creeks is diverted into the delivery canal by Soda Creek Diversion Dam and Little Beaver Creek Diversion Dam. From Keene Creek Reservoir, a tunnel and conduit carry the water across the Cascade Divide and down to Green Springs Powerplant on Emigrant Creek. Emigrant Dam reregulates powerplant discharges for irrigation. Storage in Agate Reservoir on Dry Creek is enhanced by diverting water from Antelope Creek and Little Butte Creek.

Howard Prairie Dam and Lake

Howard Prairie Dam is a zoned earthfill structure, with a height of 100 feet and a crest length of 1,040 feet, that contains 416,000 cubic yards of material. The reservoir created by the dam has a total capacity of 62,100 acre-feet. The dam is on Beaver Creek, 18 miles east of Ashland, Oreg.

Keene Creek Dam and Reservoir

This 78-foot-high, 558-foot-long earthfill dam is 16 miles east of Ashland, Oreg., on Keene Creek. Behind the dam is the 340-acre-foot Keene Creek Reservoir, which has sufficient water for the weekly cycle of powerplant operation for peaking power production of Green Springs Powerplant. The purpose of Keene Creek Dam is to reregulate releases from Howard Prairie and Hyatt Reservoirs to provide forebay pondage for Green Springs Powerplant.

Green Springs Powerplant

The Green Springs Powerplant, placed in operation in 1960, is an outdoor-type plant with a capacity of 16,000 kilowatts and a penstock discharge of 133 cubic feet per second operating under 1,800 feet of rated head.

Fish Lake and Fourmile Lake Dams and Canals

Rehabilitation at Fish Lake Dam included constructing a new spillway, riprapping the upstream face of the dam, and placing fine fill and grading work on the dam crest.

Fourmile Lake Dam rehabilitation consisted of constructing a parapet wall along the crest of the dam, replacing the old spillway with a new concrete structure, constructing a small dike on the right abutment, replacing existing fish screens with a new concrete structure, and repairing the concrete outlet conduit.

Extensive rehabilitation of the Main Canal included replacing three metal flumes with two concrete siphons and a concrete bench flume.

Emigrant Dam and Lake

The enlarged Emigrant Dam and Lake reregulate powerplant discharges for irrigation. The original 110-foot-high thin-arch concrete dam was incorporated into a 204-foot-high earthfill structure.

Agate Dam and Reservoir

Agate Dam is a zoned earthfill structure about 11 miles northeast of Medford, Oreg., on Dry Creek. The reservoir behind the dam has an active capacity of 4,670 acre-feet.

DEVELOPMENT

Early History

Soon after gold was discovered in California, miners came into the project area. Jacksonville, the first town in southern Oregon, was founded in 1851. Agricultural possibilities were recognized and permanent settlers located along the small streams of the valley. These early settlers raised common field crops and livestock, using adjacent hills and mountains for rangeland.

The earliest filing for water was in 1851 from a tributary of Bear Creek, and the first land was actually irrigated in 1852. Numerous other filings were made to utilize unregulated streamflow. The Southern Pacific Lines Railroad, which traverses the area, was constructed from Portland to California during 1868-89. This brought ready access to markets and hastened development of agriculture, lumbering, and mining, all of which increased migration into the region.

Investigations

Recognition of the paramount importance of the Rogue River Basin water resources has led to a series of investigations and proposals dating back about 40 years. The Federal Government first investigated potential irrigation development in the basin in 1913 under a cooperative contract with the State of Oregon. In 1915, under terms of this contract and under the authority of Chapter 87, "Laws of Oregon for 1913," the State Engineer withdrew all of the unappropriated direct flow of Rogue River and its tributaries above Raygold for purposes of irrigation, power, domestic use, and storage. Certain tributaries of the Klamath River which could be diverted to the Rogue River Basin also were withdrawn. These withdrawals are still in effect.

Investigations begun in April 1915 resulted in a report, dated February 1916, by the Reclamation Service in cooperation with the State of Oregon. This report, in

Fourmile Lake

addition to a survey of other areas in the basin, covered the upper portion of Bear Creek Valley. Several features mentioned in the report have been constructed and are in use by the Medford, Rogue River Valley, and Talent Irrigation Districts. Subsequently, more detailed studies have been authorized and carried out. In 1938, the Medford and Rogue River Valley Irrigation Districts made financial contributions to provide for more detailed irrigation studies. In 1939, the State legislature appropriated funds to supplement contributions by Josephine and Jackson Counties for studying the irrigation and multiple-purpose possibilities of the basin. These investigations, which were preliminary in scope, led to the Bureau of Reclamation Project Investigation Report No. 27, April 1940, and also led to investigations of a basinwide nature. A public hearing was held in Medford on June 8 and 9, 1948, to ascertain the wishes of the people of the Rogue River Basin concerning development and use of water in the Rogue River watershed. Further investigation by the Bureau of Reclamation led to authorization of the Talent Division and rehabilitation and betterment of the Rogue River Valley and Medford Irrigation Districts' facilities.

Authorization

Authorization for the Talent Division was Public Law 606, 83d Congress, 2d session, approved August 20, 1954, (68 Stat. 752). The work of rehabilitation on the Medford and Rogue River Valley Irrigation Districts' features under the act of October 7, 1949, (63 Stat. 724), also was authorized by Public Law 606. The construction of Agate Dam and Reservoir was authorized by the act of October 1, 1962, Public Law 87-727, (76 Stat. 677).

Construction

Rehabilitation work on structures of the Medford and Rogue River Valley Irrigation Districts was carried out in 1955-56. Construction of the Talent Division was done in 1957-61, and Agate Dam in 1965-66.

BENEFITS

Irrigation

With development of the Talent Division, agricultural production has increased, and activity stimulated in other basic industries. Irrigated farms specialize in fruit, principally pears, some specialty crops, hay, pasture, and grain.

Rehabilitation of the Medford and Rogue River Valley Irrigation Districts made possible their continued operation at full efficiency.

Hydroelectric Power

Construction and operation of the 16,000-kilowatt hydroelectric powerplant have helped meet expanding power demands in southern Oregon and northern California.

Flood Control

A schedule of joint-use storage at Emigrant Reservoir provides flood control benefits along Bear Creek. Flood control regulation is based upon regulating Bear Creek at Medford to a flow of 3,000 cubic feet per second. When the flow in Bear Creek at Medford exceeds or is forecasted to exceed 3,000 cubic feet per second, the release at Emigrant Reservoir is restricted to 50 cubic feet per second.

Recreation and Fish and Wildlife

Jackson County Parks has been developing Agate Reservoir in conjunction with their nearby Sportsman's Park. The reservoir provides non-motor boating as well as many recreation facilities that include a swimming beach, picnic areas, a model airplane runway, and eight baseball diamonds, all near the town of Medford.

Emigrant Lake, close to Ashland, is the location of the beautiful and popular Emigrant Lake Park, administered by Jackson County Parks. This park has overnight camping, picnic areas, swimming beaches, and play fields. The lake is popular for water skiing.

Hyatt and Howard Prairie Lakes are surrounded by the pine and fir forests of the Cascade Mountains. Resorts provide groceries, boat rentals, gasoline, and trailer hookups for campers. At Hyatt Lake, the Bureau of Land Management has constructed a campground and day use area that spread out through the trees near the dam. At Howard Prairie Lake, Jackson County Parks has constructed six campgrounds, one each for specifically organized groups, youth groups, and horseback riders, and the other three for the general public. Boating and water skiing are especially good at Howard Prairie Lake.

All the project reservoirs provide habitat for fish. Dry Creek was an intermittent stream that could not support fish before Agate Dam was built. Agate Reservoir is now a favorite fishing lake. Emigrant Lake supports an excellent bass fishery as well as trout in the different arms of the lake. The other reservoirs, with their higher elevations and cooler temperatures, have provided increased trout habitat.

Ducks are raised at each reservoir every year and geese nest at Howard Prairie Lake. Goose production has been increased by the addition of nesting platforms.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	34,180	acres
Number of irrigated farms	1,155	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	25,536	5,891,537
1969	26,355	9,166,561
1970	26,822	6,262,159
1971	27,171	9,592,372
1972	26,295	4,968,214
1973	26,079	12,124,379
1974	26,453	12,010,179
1975	25,060	11,616,680
1976	25,175	12,416,406
1977	24,725	11,365,996

Facilities in Operation

Storage dams	7	
Diversion dams	20	
Canals	250	mi
Laterals	197	mi

Climatic Conditions

Annual precipitation	19.7	in
Temperature:		
Maximum	109	°F
Minimum	−6	°F
Mean	54	°F
Growing season	206	days
Elevation of irrigable area	1200-2300.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	3,651
Municipal water service	17,500
Other water service[1]	16,778
Total	37,929

[1]Urban and suburban, residential, commercial, and industrial lands.

Power Generation

Fiscal year	Green Springs Powerplant, kWh	Fiscal year	Green Springs Powerplant, kWh
1968	66,981,000	1973	68,233,000
1969	62,654,000	1974	71,179,000
1970	71,075,000	1975	74,824,000
1971	76,992,000	1976	[2]91,784,000
1972	73,744,000	1977	67,528,000

[2]15-month period. Transitional quarter July-Sept. 1976 included. Fiscal year changed from July-June to October-September.

ENGINEERING DATA

Water Supply

Fourmile Lake

Drainage area	10	mi²
Annual discharge:		
Maximum (1974)	14,400	acre-ft
Minimum (1976)	2,500	acre-ft
Average	8,800	acre-ft

Fish Lake

Drainage area	20	mi²
Annual discharge:		
Maximum (1972)	49,400	acre-ft
Minimum (1968)	15,000	acre-ft
Average	28,400	acre-ft

Hyatt Reservoir

Drainage area	12	mi²
Annual discharge:		
Maximum (1971)	16,700	acre-ft
Minimum (1977)	1,800	acre-ft
Average	9,200	acre-ft

Emigrant Lake

Drainage area	64	mi²
Annual discharge:[3]		
Maximum (1974)	126,600	acre-ft
Minimum (1976)	31,600	acre-ft
Average	65,400	acre-ft

Howard Prairie Lake

Drainage area	79	mi²
Annual discharge:[4]		
Maximum (1971)	49,300	acre-ft
Minimum (1977)	9,500	acre-ft
Average	34,600	acre-ft

Keene Creek Reservoir

Drainage area	111	mi²
Annual discharge:[5]		
Maximum (1971)	44,600	acre-ft
Minimum (1977)	37,100	acre-ft
Average	40,800	acre-ft

Agate Reservoir

Drainage area (Dry Creek only)	13	mi²
Annual discharge:[6]		
Maximum (1971)	13,000	acre-ft
Minimum (1968)	6,000	acre-ft
Average	8,900	acre-ft
Average annual diversions by project (1963-77)	109,770	acre-ft

[3]Includes water diverted from Klamath Basin through Cascade Divide Tunnel.
[4]Includes transbasin interception from South Fork Little Butte Creek and tributaries.
[5]Discharge includes water from Howard Prairie and Hyatt Reservoirs. Computed from water through Green Springs Powerplant only.
[6]Includes some water diverted from Antelope Creek and Little Butte Creek.

Storage Facilities

Fourmile Lake Dam[7]

Type: Rockfill, concrete facing
Location: At outlet to Fourmile Lake 33 mi northeast of Medford, Oreg.
Construction period: Non-Reclamation construction. Spillway rehabilitated, concrete parapet wall constructed at crest, and rockfill dike constructed at right abutment in 1955-56.

Reservoir, Fourmile Lake:		
Total capacity to El. 6002.5	15,600	acre-ft
Active capacity	15,600	acre-ft
Surface area	960	acres
Dimensions:		
Structural height	25	ft
Top width	10	ft
Maximum base width	50	ft
Crest length	660	ft
Crest elevation	6005.0	ft
Total volume	2,000	yd³
Spillway: Partially lined open channel at left abutment with removable stoplog control.		
Crest length	60	ft
Elevation, top of flashboards	6002.5	ft
Crest elevation	6000.0	ft
Capacity at El. 6002	500	ft³/s
Outlet works:		
Capacity at El. 6004.5	85	ft³/s

Fish Lake Dam[7]

Type: Earthfill and rockfill
Location: At outlet to Fish Lake 26 mi east of Medford, Oreg.
Construction period: 1908. Rebuilt 1922-23. Non-Reclamation construction. Crest raised and spillway constructed by Reclamation in 1955-56.

Reservoir, Fish Lake:		
Total capacity to El. 4641.5	7,956	acre-ft
Active capacity	7,900	acre-ft
Surface area	415	acres
Dimensions:		
Structural height	49	ft
Top width	10	ft
Maximum base width	230	ft
Crest length	960	ft
Crest elevation	4648.0	ft
Total volume	128,000	yd³
Spillway: Uncontrolled concrete-lined side channel spillway at left abutment.		
Crest length	40	ft
Crest elevation	4641.5	ft
Capacity at El. 4643	500	ft³/s
Outlet works:		
Capacity at El. 4641.5	490	ft³/s

Hyatt Dam[8]

Type: Earth and rockfill
Location: At outlet to Hyatt Prairie Lake on Keene Creek in Klamath River Basin, 18 mi east of Ashland, Oreg.
Construction period: 1922. Non-Reclamation construction. Fish screens and recreation facilities constructed by Reclamation in 1960-61.

Reservoir, Hyatt:		
Total capacity to El. 5016	16,200	acre-ft
Active capacity	16,200	acre-ft
Surface area	880	acres
Dimensions:		
Structural height	53	ft
Top width	20	ft
Crest length	775	ft
Crest elevation	5025.0	ft
Total volume	73,000	yd³
Spillway:		
Crest length	50	ft
Crest elevation	5016.0	ft
Capacity at El. 5020.4	1,660	ft³/s

Emigrant Dam[8]

Type: Zoned earthfill
Location: On Emigrant Creek about 8 mi southeast of Ashland, Oreg.
Construction period: 1958-60. Existing 110-ft concrete thin-arch dam was of non-Reclamation construction, completed in 1924, incorporated into a larger earthfill dam by Bureau of Reclamation.

Reservoir, Emigrant Lake:		
Total capacity to El. 2241	40,500	acre-ft
Active capacity	39,000	acre-ft
Surface area	806	acres
Dimensions:		
Structural height	204	ft
Top width	35	ft
Maximum base width	1,100	ft
Crest length[9]	750	ft
Crest elevation	2254.0	ft
Total volume (including dikes)	1,563,000	yd³
Spillway:		
Crest length	350	ft
Crest elevation	2241.0	ft
Capacity at El. 2245.7	12,300	ft³/s
Outlet works:		
Capacity at El. 2248.6	600	ft³/s

Howard Prairie Dam[8]

Type: Zoned earthfill
Location: On Beaver Creek, 18 mi east of Ashland, Oreg.
Construction period: 1957-58

Reservoir, Howard Prairie Lake:		
Total capacity to El. 4526.6	62,100	acre-ft
Active capacity	60,600	acre-ft
Surface area	1,900	acres
Length	5	mi
Dimensions:		
Structural height	100	ft
Top width	30	ft
Maximum base width	412	ft
Crest length	1,040	ft
Crest elevation	4539.0	ft
Volume	416,000	yd³
Spillway: Concrete-lined chute in left abutment.		
Capacity	1,600	ft³/s
Outlets: 3-ft-diameter concrete conduit controlled by a 2.25-ft-square high-pressure gate, and a 6.5-ft-diameter concrete horseshoe conduit containing a 30-in steel pipe, controlled by a 2.25-ft-square high-pressure gate.		
Capacity	60	ft³/s

Keene Creek Dam[8]

Type: Zoned earthfill
Location: On Keene Creek, 16 mi east of Ashland, Oreg.

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[7]Medford and Rouge River Valley Irrigation Districts.
[8]Talent Irrigation District.
[9]Crest length is 3,090 ft including dikes.

Construction period: 1957-59
Reservoir, Keene Creek:

Total capacity to El. 4403.5	340	acre-ft
Active capacity	260	acre-ft
Surface area	15	acres

Dimensions:

Structural height	78	ft
Top width	30	ft
Maximum base width	520	ft
Crest length	558	ft
Crest elevation	4412.5	ft
Volume	171,000	yd³

Spillway: Concrete-lined chute on left abutment.

Capacity	2,650	ft³/s

Agate Dam

Type: Zoned earthfill
Location: On Dry Creek, about 11 mi northeast of Medford, Oreg.
Construction period: 1965-66
Reservoir, Agate:

Total capacity to El. 1510	4,780	acre-ft
Active capacity	4,670	acre-ft
Surface area	216	acres

Dimensions:

Structural height	86	ft
Hydraulic height	68	ft
Top width	25	ft
Crest length	3,800	ft
Crest elevation	1520.0	ft
Volume	421,000	yd³

Spillway: Concrete-lined chute on left abutment.

Capacity at El. 1514	3,500	ft³/s

Diversion Facilities

Antelope Creek Diversion Dam

Type: Stream drop inlet
Location: On Antelope Creek, about 12 mi northeast of Medford, Oreg.
Construction period: 1966
Dimensions:

Height above streambed	7	ft
Crest length	104	ft
Crest elevation	1524.0	ft
Volume	1,000	yd³
Diversion capacity	50	ft³/s

Ashland Lateral Diversion Dam

Type: Concrete ogee weir, earth dike
Location: On Emigrant Creek, 8 mi southeast of Ashland, Oreg.
Construction period: 1959
Dimensions:

Height above streambed	5	ft
Weir crest length	71	ft
Crest elevation	2410.5	ft
Volume (concrete)	500	yd³
Volume (total)	2,600	yd³
Overflow weir capacity	1,000	ft³/s

Sluiceway: One 10- by 9-ft radial gate.
Headworks: Concrete structure controlled by one 72- by 18-in slide gate.

Diversion capacity at El. 2410	18	ft³/s

Beaver Dam Creek Diversion Dam

Type: Rockfill, concrete core wall
Location: On Beaver Dam Creek near Ashland, Oreg.
Construction period: 1960
Dimensions:

Height above streambed	4	ft
Weir crest length	75	ft
Crest length	168	ft
Crest elevation	4670.5	ft
Volume	1,100	yd³
Overflow weir capacity	1,500	ft³/s

Headworks: Concrete structure with one 4- by 3-ft slide gate.

Diversion capacity	65	ft³/s

Conde Creek Diversion Dam

Type: Concrete and rockfill weir
Location: On Conde Creek about 5 mi northeast of Ashland, Oreg.
Construction period: 1958
Dimensions:

Height above streambed	4	ft
Crest length	109	ft
Crest elevation	4567.4	ft
Volume	950	yd³

Spillway: Overflow weir

Capacity at water surface El. 4570	750	ft³/s

Headworks: Conde Creek Collection Canal headworks controlled by 30-in slide gate.

Capacity	25	ft³/s

Daley Creek Diversion Dam

Type: Rockfill, timber core wall
Location: On Daley Creek near Ashland, Oreg.
Construction period: 1960
Dimensions:

Height above streambed	4	ft
Weir crest length	30	ft
Crest length	112	ft
Crest elevation	4692.5	ft
Volume	1,300	yd³
Overflow weir capacity	540	ft³/s

Headworks: Concrete structure with one 3- by 2-ft slide gate.

Diversion capacity	25	ft³/s

Dead Indian Diversion Dam

Type: Concrete and rockfill weir
Location: On Dead Indian Creek about 4 mi east of Ashland, Oreg.
Construction period: 1958
Dimensions:

Height above streambed	4	ft
Crest length	131	ft
Crest elevation	4538.0	ft
Volume	1,560	yd³

Spillway: Overflow weir

Capacity at water surface El. 4540.98	1,100	ft³/s

Headworks: Dead Indian Canal

Capacity	86	ft³/s

Little Beaver Creek Diversion Dam

Type: Concrete core wall and rockfill
Location: On Little Beaver Creek about 4 mi east of Lincoln, Oreg.
Construction period: 1959
Dimensions:

Height above streambed	9	ft
Crest length	80	ft
Crest elevation	4433.0	ft
Volume	1,300	yd³

Spillway: Overflow weir		
Crest elevation	4438.76	ft
Headworks: Little Beaver Creek Feeder Canal		
Capacity at normal water surface El. 4438.76	24	ft³/s

OAK STREET DIVERSION DAM

Type: Concrete weir, stoplogged crest
Location: On Bear Creek just north of Ashland, Oreg.
Construction period: 1961
Dimensions:

Height above streambed	5	ft
Crest length	133	ft
Crest elevation	1710.96	ft
Volume	3,000	yd³
Diversion capacity	75	ft³/s

PHOENIX CANAL DIVERSION DAM

Type: Concrete weir, stoplogged crest
Location: On Bear Creek near Ashland, Oreg.
Construction period: 1960
Dimensions:

Height above streambed	5	ft
Weir crest length	119	ft
Crest length	180	ft
Crest elevation	1548.0	ft
Volume (concrete)	250	yd³
Volume (total)	1,520	yd³
Overflow weir capacity	7,560	ft³/s
Headworks: Concrete with two 48- by 42-in control gates.		
Diversion capacity	102	ft³/s

SODA CREEK DIVERSION DAM

Type: Earthfill
Location: On Soda Creek, 6 mi east of Lincoln, Oreg.
Construction period: 1959
Dimensions:

Height above streambed	13	ft
Crest length	430	ft
Crest elevation	4478.0	ft
Volume	10,250	yd³
Spillway: Overflow weir		
Crest elevation	4473.5	ft
Capacity at water surface El. 4475	280	ft³/s
Headworks: Soda Creek Canal		
Capacity	11	ft³/s

SOUTH FORK LITTLE BUTTE CREEK DIVERSION DAM

Type: Rockfill, timber core wall
Location: On South Fork of Little Butte Creek near Ashland, Oreg.
Construction period: 1960
Dimensions:

Height above streambed	4	ft
Weir crest length	100	ft
Crest length	400	ft
Crest elevation	4681.5	ft
Volume	4,650	yd³
Overflow weir capacity	1,950	ft³/s
Headworks: Concrete structure with one 4- by 3-ft slide gate.		
Diversion capacity	65	ft³/s

Carriage Facilities

MAIN CANAL

Location: From North and South Forks of Little Butte Creek 17 mi northeast of Medford, Oreg., westerly to Bradshaw Drop, 11 mi northeast of Medford.
Construction period: Non-Reclamation construction. Replacement of eight existing flumes with bench flumes and concrete siphons by Reclamation.

Length	17	mi
Diversion capacity	175	ft³/s

HOPKINS CANAL

Location: From Bradshaw Drop on Main Canal about 11 mi northeast of Medford, Oreg., generally northwest to a point 2.5 mi northwest of Central Point, Oreg.
Construction period: Non-Reclamation construction. Replacement of two flumes with concrete siphons by Reclamation.

Length	28.5	mi
Diversion capacity	50	ft³/s

MEDFORD CANAL

Location: From Bradshaw Drop on Main Canal about 11 mi northeast of Medford, Oreg., generally southwest to a point about 1 mi south of Phoenix, Oreg., where it crosses under Bear Creek and is fed into Phoenix Canal.
Construction period: Non-Reclamation construction. Replacement of two wooden siphons and one flume with concrete siphons by Reclamation.

Length	25	mi
Diversion capacity	125	ft³/s

PHOENIX CANAL

Location: From 1 mi south of Phoenix, Oreg., generally northwest to a point about 3.5 mi west of Central Point, Oreg.
Construction period: Non-Reclamation construction. Enlarged and improved by Reclamation as part of Talent Division construction.

Length	18.1	mi
Diversion capacity	102	ft³/s

HOWARD PRAIRIE DELIVERY CANAL

Location: From Howard Prairie Dam, south and west to near Pinehurst, Oreg.
Construction period: 1956-59

Length	18.7	mi
Diversion capacity	60	ft³/s
Typical maximum section, concrete lined:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	3	ft

SOUTH FORK COLLECTION CANAL

Location: About 25 mi east of Medford, Oreg.
Construction period: 1958-59

Length	12.7	mi
Diversion capacity	65	ft³/s
Typical maximum section in earth and rock:		
Bottom width	6	ft
Side slopes:		
Unlined	1.5:1	
Earth lined	2:1	
Water depth	3.4	ft

DALEY CREEK COLLECTION CANAL

Location: About 25 mi east of Medford, Oreg.
Construction period: 1958-60
Length:

At 25 ft³/s	2.7 mi
At 65 ft³/s	1.6 mi
Diversion capacity	25-65 ft³/s
Typical maximum section in earth and rock:	
Bottom width	4 ft
Side slopes:	
Unlined	1.5:1
Earth lined	2:1
Water depth	2 ft

ASHLAND LATERAL[10]

Location: From Emigrant Creek below Green Springs Powerplant 8 mi southeast of Ashland, Oreg., northwesterly to city limits of Ashland.
Construction period: Non-Reclamation construction in about 1923, diverting from Sampson Creek. Enlarged, improved, and extended 3.2 mi up Emigrant Creek by Reclamation as part of Talent Division construction.

Length	16.9 mi
Diversion capacity	48 ft³/s

EAST LATERAL[10]

Location: From Emigrant Reservoir about 4 mi southeast of Ashland, Oreg. Extends northwesterly on east side of Bear Creek for 11 mi to bifurcation structure for West Lateral, continues northwesterly for another 14 mi.
Construction period: Non-Reclamation construction in about 1925. Enlarged, improved, and extended by Reclamation as part of Talent Division construction.

Length	25 mi
Diversion capacity	132 ft³/s

WEST LATERAL[10]

Location: From mile 11 of East Lateral about 1 mi north of Ashland, crosses Bear Creek in a steel-pipe siphon 6,730 ft long, continuing northwesterly on west side of Bear Creek for about 23 mi.
Construction period: Non-Reclamation construction in about 1925. Siphon replaced in 1944. Enlarged, improved, and extended 8.4 mi by Reclamation as part of Talent Division construction.

Length (below bifurcation in East Lateral)	23.2 mi
Diversion capacity	39 ft³/s

TALENT LATERAL[10]

Location: From Bear Creek about 0.5 mi north of Ashland, extending northwesterly on east side of Bear Creek to 1,640-ft siphon across the creek, continuing northwesterly about 17 mi to 1.5 mi southeast of Jacksonville, Oreg.
Construction period: Non-Reclamation construction sometime prior to 1925. Enlarged and improved by Reclamation as part of Talent Division construction.

Length (exclusive of Lower East Lateral)	19.4 mi
Diversion capacity	65 ft³/s

DEADWOOD TUNNEL

Location: About 24 mi east of Medford, Oreg.
Construction period: 1956-58
Lining: Concrete
Section: Horseshoe

Diameter	6 ft
Length	3,553 ft
Capacity	130 ft³/s

BILLINGS SIPHON

Location: From a point on East Lateral to a point on West Lateral near Ashland, Oreg.
Construction period: 1959

Diameter	30 in
Length	1.27 mi
Capacity	38.7 ft³/s

GREEN SPRINGS POWER CONDUIT

Location: From Keene Creek Dam west to the beginning of the Green Springs Powerplant penstock.
Construction period: 1957-59

Pressure pipe:	
Diameter	60 in
Length	4,154 ft
Cascade Divide Tunnel:	
Diameter	6 ft
Lining: Concrete	
Length	2,100 ft
Green Springs Tunnel:	
Diameter	6 ft
Lining: Concrete	
Length	4,833 ft

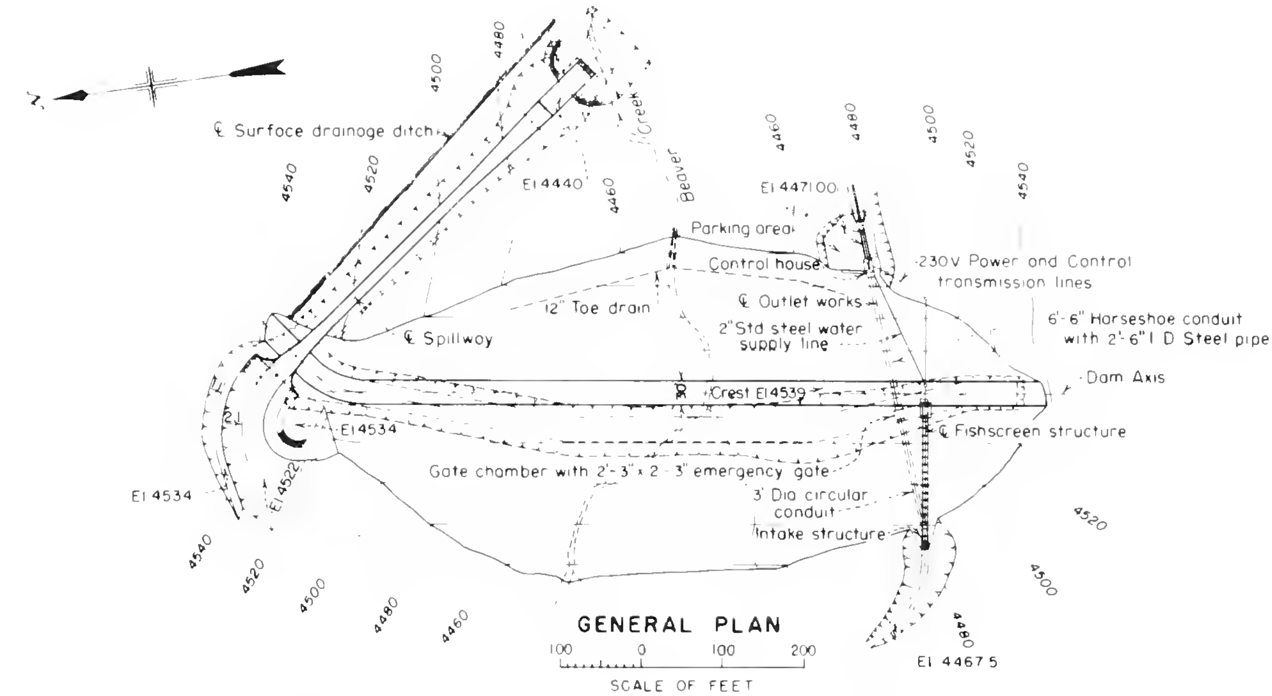
[10]Local usage designates canals diverting from Emigrant Reservoir or Bear Creek as laterals.

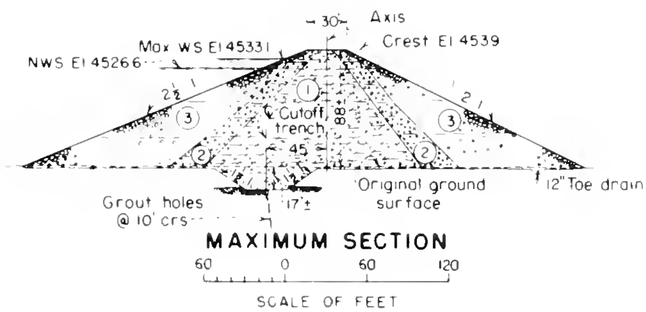
Power Facilities

GREEN SPRINGS POWERPLANT

Location: At discharge of Green Springs Power Conduit.
Year of initial operation: 1960

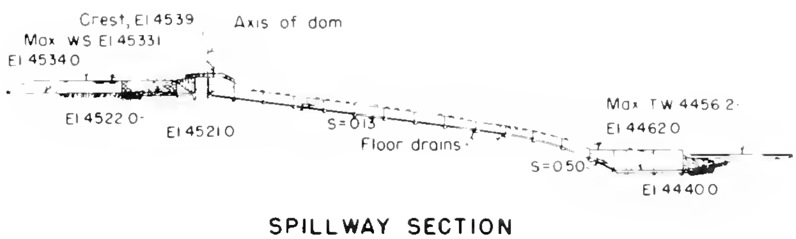
Nameplate capacity	16,000 kW
Number of generators	1
Substations:	
Number in operation	1
Capacity of transformers	18,000 kVA

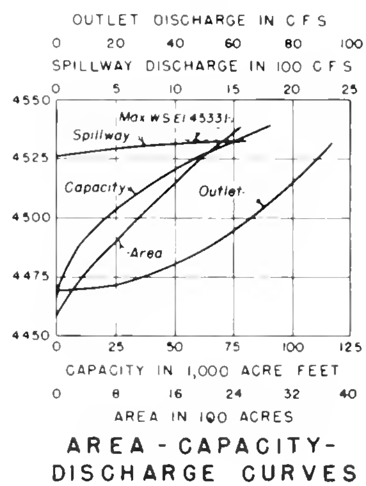


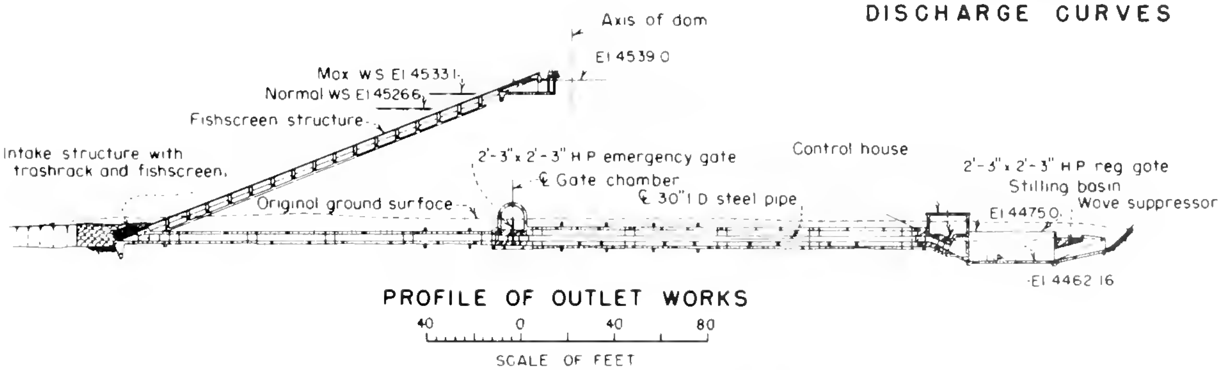


EMBANKMENT EXPLANATION

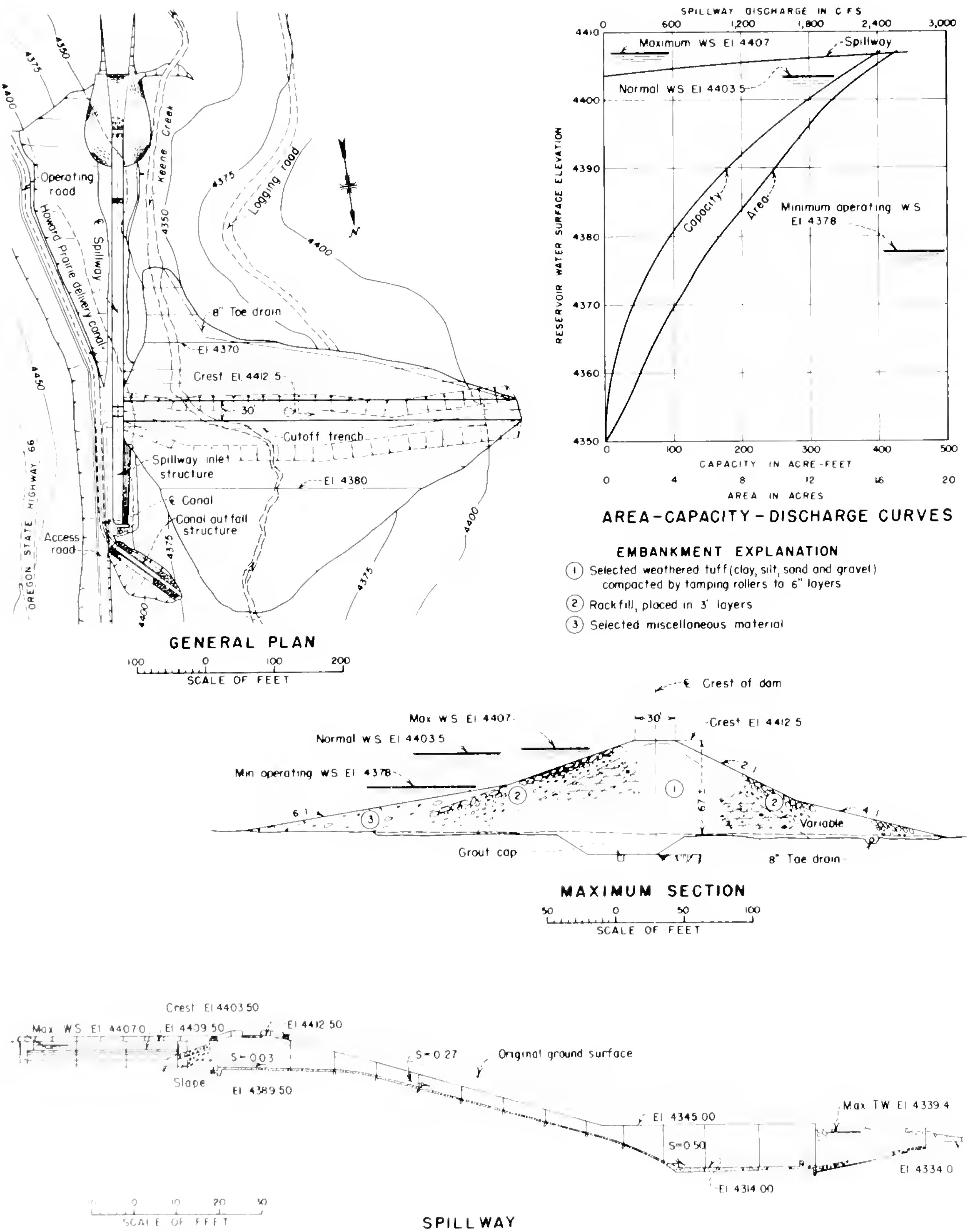
1. Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers
2. Selected rock fines compacted by crawler-type tractor to 12-inch layers
3. Rock fill placed in 3-foot layers



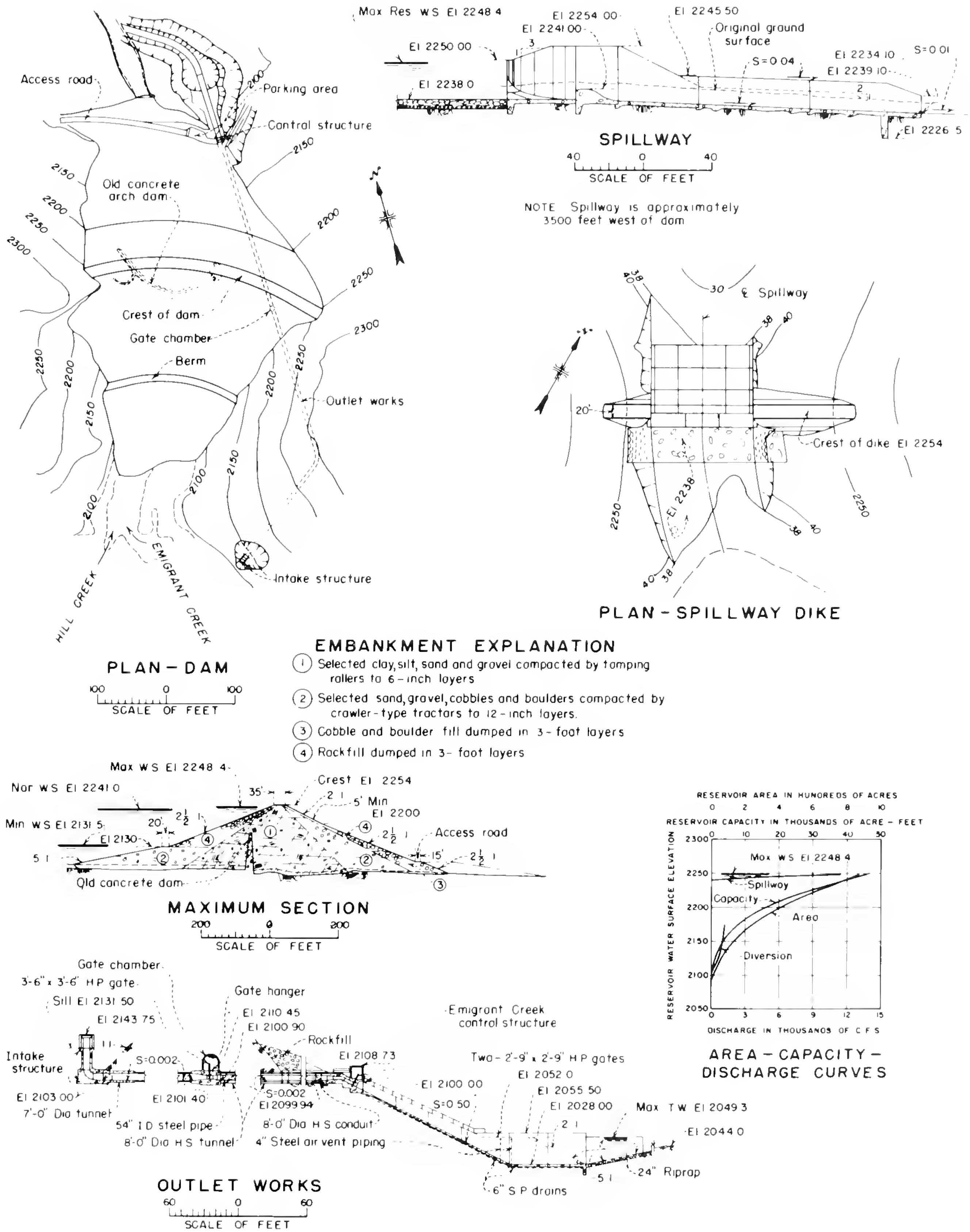




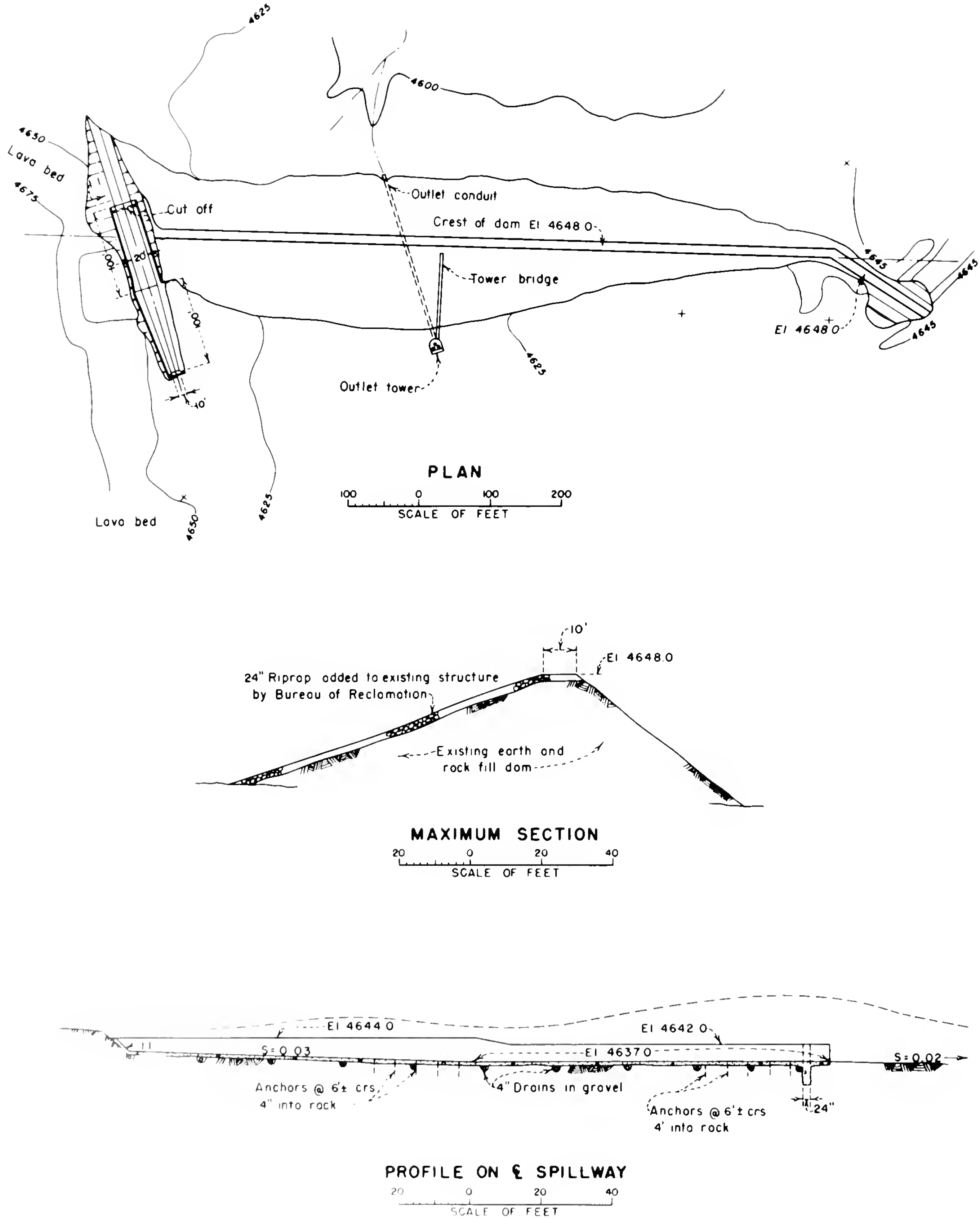
Howard Prairie Dam, Plan and Sections



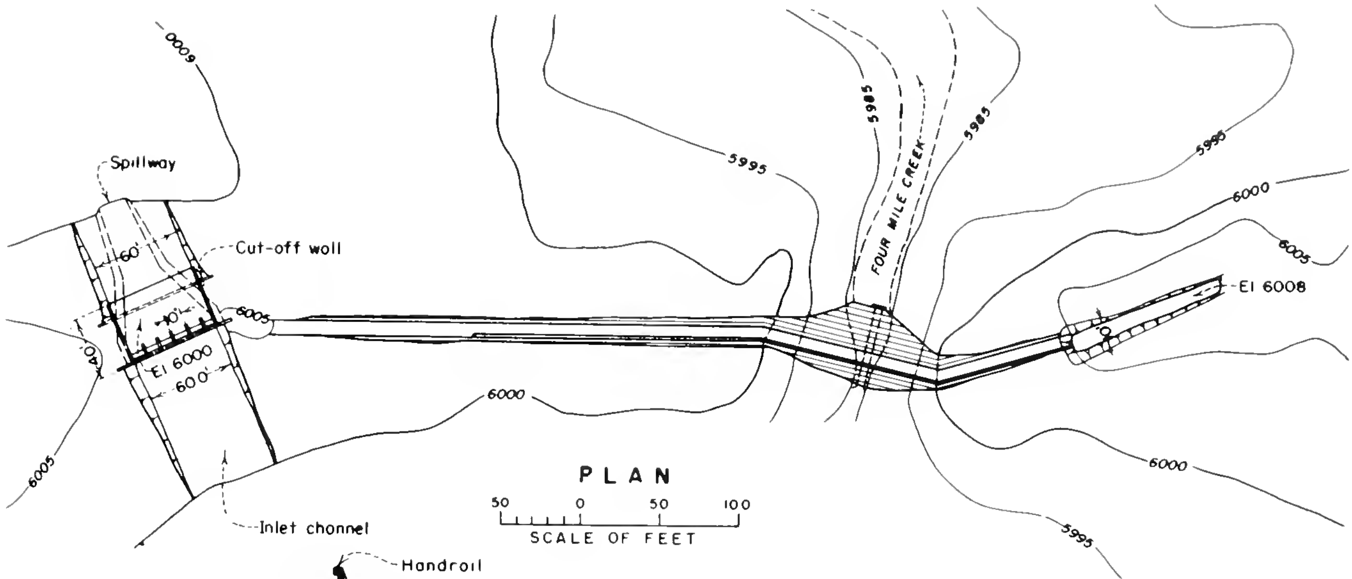
Keene Creek Dam, Plan and Sections



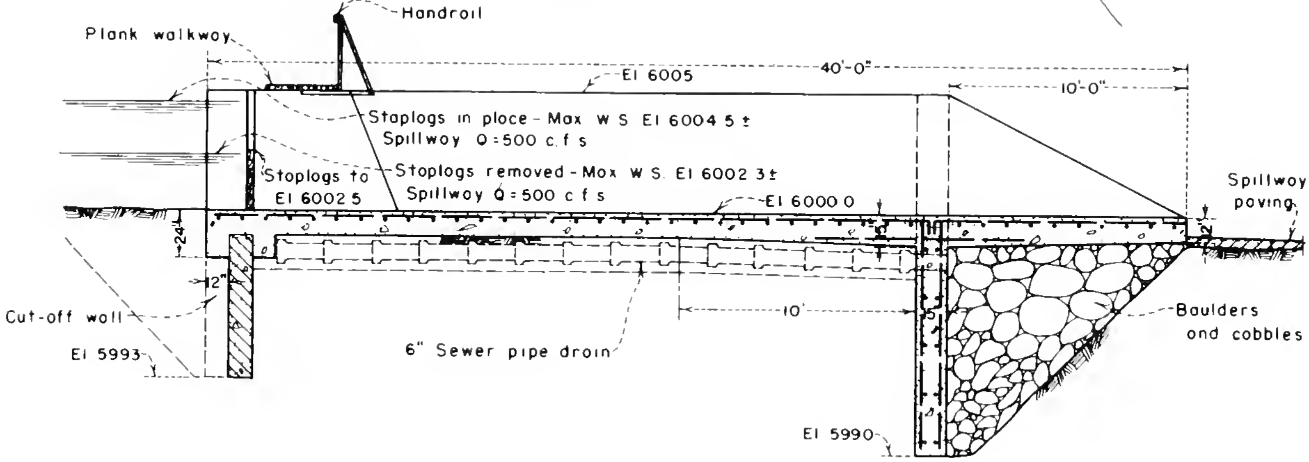
Emigrant Dam, Plan and Sections



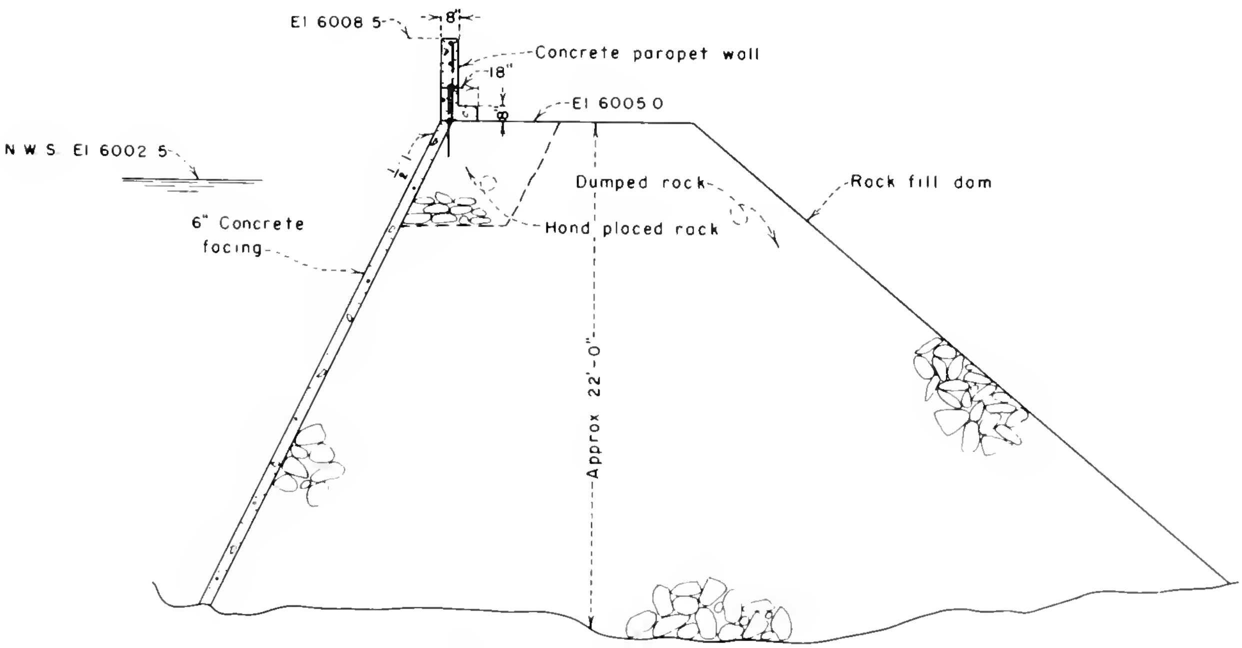
Fish Lake Dam, Plan and Sections



PLAN

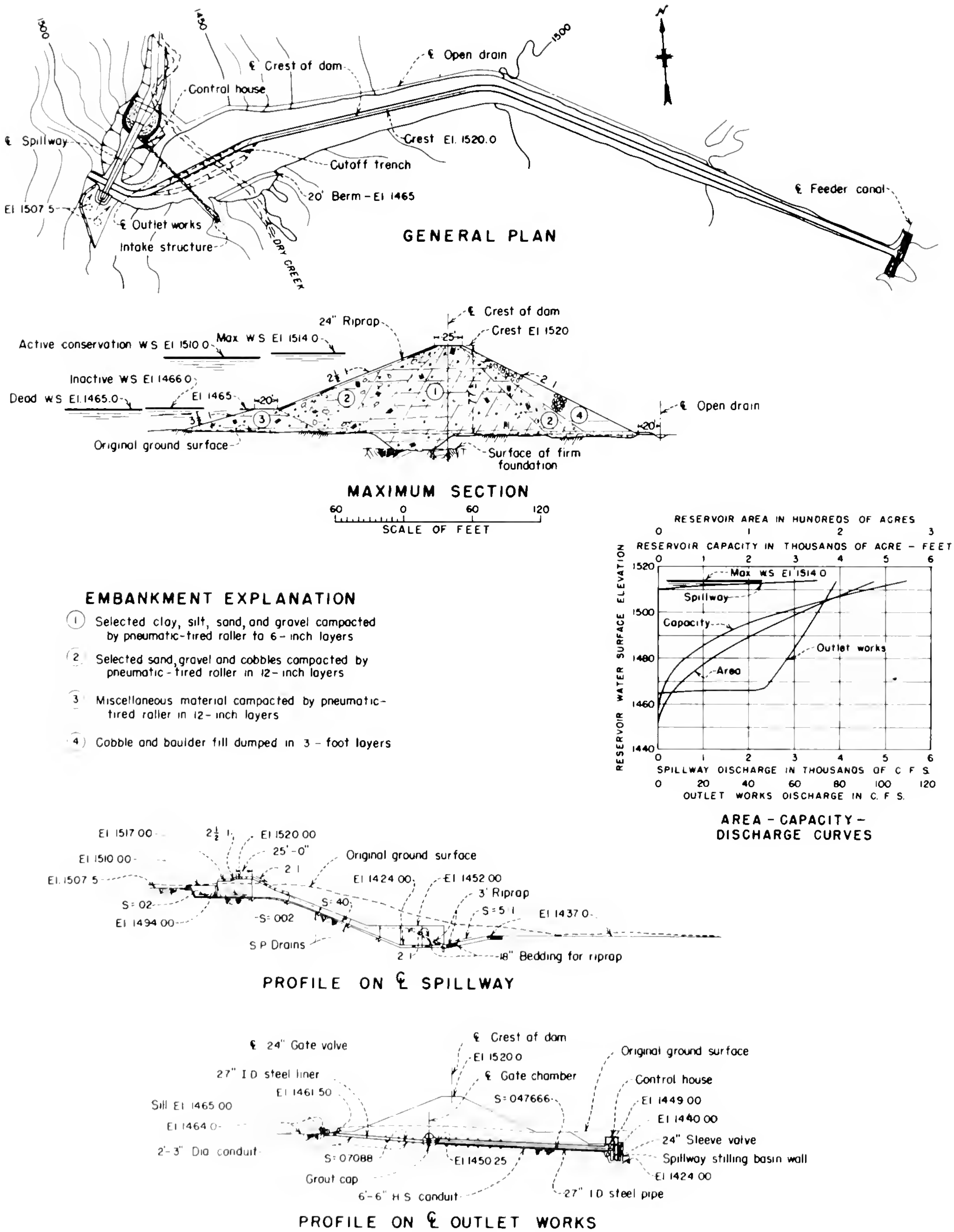


PROFILE ON ℄ SPILLWAY



MAXIMUM SECTION

Fourmile Lake Dam, Plan and Sections

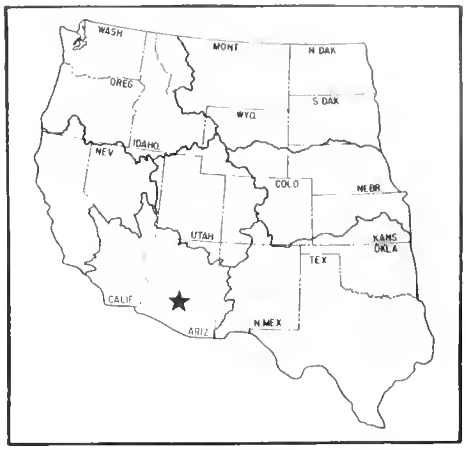


Agate Dam, Plan and Sections

Salt River Project

Arizona: Maricopa County

Lower Colorado Region
Water and Power Resources Service



The Salt River Project, located near Phoenix, Ariz., includes an area of about 250,000 acres. The land within the project is furnished a full irrigation water supply from the Salt and Verde Rivers and from 248 wells with motor-driven pumps; about 24,715 acres are furnished supplemental irrigation water. The rivers are controlled with six storage dams, two of which were constructed by the Bureau of Reclamation. A diversion dam constructed by Reclamation serves 1,259 miles of canals, laterals, and ditches of which 842 miles are lined and piped.

The power system includes five hydroelectric plants; three steam plants, two with separate combustion-turbine installations; and a combined cycle plant. In addition, the Salt River Project is participating in four existing coal-fired generating stations and is building another coal-fired station near St. Johns, Ariz. As of December 31, 1977, the power system also included 1,183 circuit miles of transmission lines, 4,985 circuit miles of overhead distribution lines, and 6,237 cable miles of underground distribution lines.

PLAN

Water is furnished by the Salt and Verde Rivers, which drain a watershed area of 13,000 square miles. The four storage reservoirs on the Salt River form a continuous chain of lakes almost 60 miles long. An important supplemental supply is obtained from well pumping units.

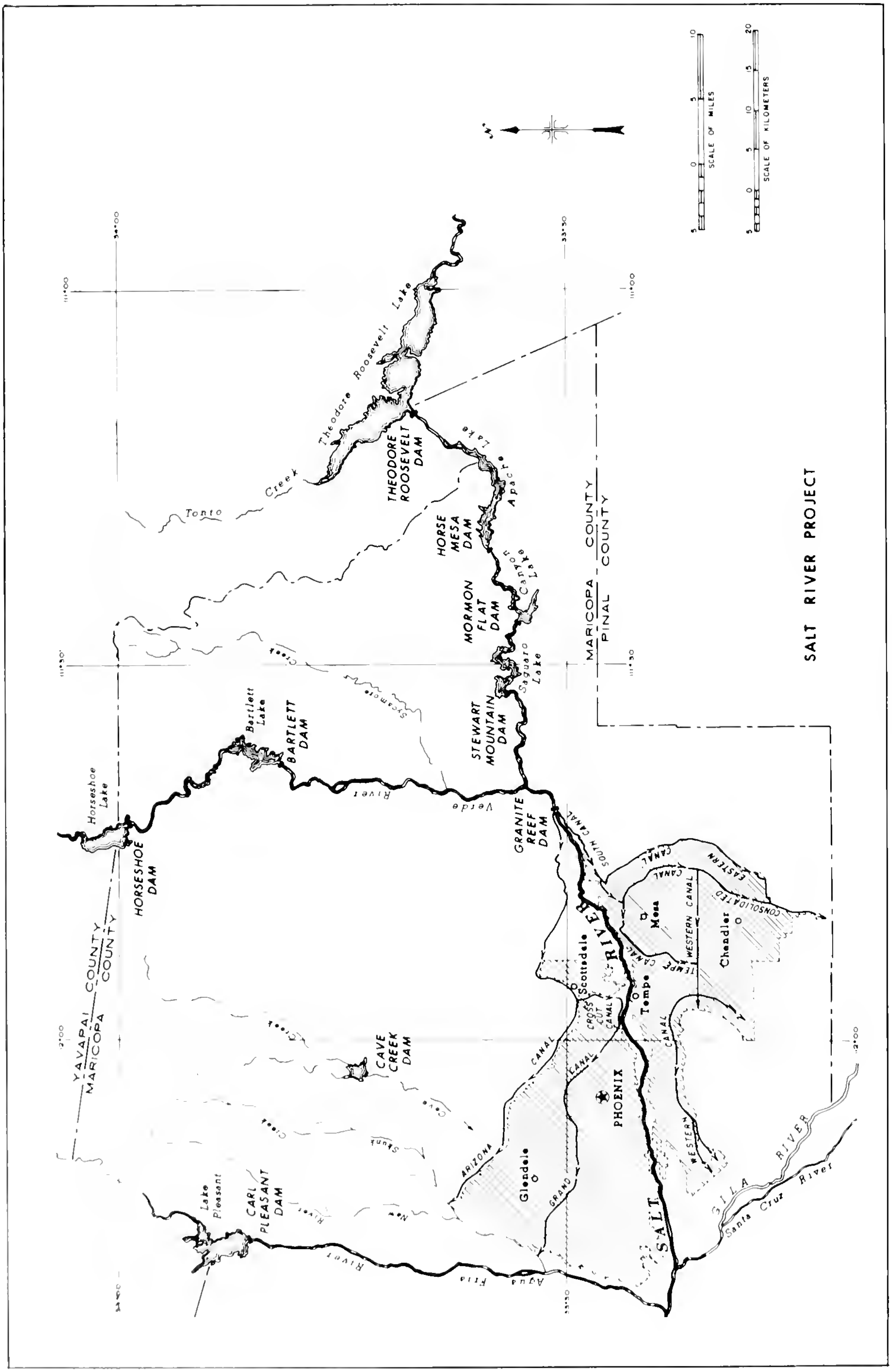
Irrigation flow is regulated by Bartlett Dam on the Verde River and Stewart Mountain Dam on the Salt River. Downstream of the confluence of the Verde and Salt Rivers, water is diverted to two main canals at the Granite Reef Diversion Dam. The Arizona Canal serves the north side of the project; the South Canal serves the south side. From the two main canals, water is diverted to secondary canals, then to laterals through which the water is delivered to farms and cities. Total storage capacity of Salt River reservoirs is 1,754,335 acre-feet. The combined storage capacity of the two reservoirs on the Verde River is 317,715 acre-feet.

Total hydroelectric generating capacity is 232 megawatts, including power from the pumped storage units at Horse Mesa and Mormon Flat Dams. Turbine generating units at these two dams produce power during periods of peak demands. The turbines can be reversed to pump water during offpeak periods from the lower reservoir back to the upper reservoir for repeated usage. As part of the same program, which began in 1969, existing units at the two dams were converted from 25 to 60 hertz, and one new 60-hertz unit replaced the former 25-hertz units at Theodore Roosevelt Dam. A hydroelectric unit located on the crosscut canal, which links the project's two major canals, provides additional hydroelectric capacity.

Theodore Roosevelt Dam and Reservoir

Theodore Roosevelt Dam, the first major structure constructed by the Bureau of Reclamation on the Salt River Project, is located about 76 miles northeast of Phoenix and 30 miles northwest of Globe, Ariz. The rubble-masonry thick-arch structure spans the Salt River to form a reservoir of 1,381,580 acre-feet. The dam is 280

Theodore Roosevelt Dam



Salt River Project

feet high, 723 feet long at the crest, and contains 355,800 cubic yards of masonry.

In 1936, the spillways were modified by lowering crests 6 feet to increase their capacities, and individual gate hoists, operating motors, and two 5-kilovolt-ampere gasoline-engine driven generators were installed.

Horse Mesa Dam and Reservoir

Located on the Salt River 65 miles northeast of Phoenix, Horse Mesa Dam is a concrete thin-arch structure 305 feet high. Constructed by the Salt River Valley Water Users' Association during 1924-27, the dam contains 162,000 cubic yards of concrete, and forms a 245,138-acre-foot reservoir.

Horse Mesa Dam and Apache Lake

The spillway, as modified in 1936 by the Bureau of Reclamation, included a 50,000-cubic-foot-per-second, concrete-lined auxiliary tunnel, 30 feet in diameter and 400 feet long; a regulating gate, gatehouse, and operating mechanism for controlling the tunnel; and a concrete discharge apron below the existing spillway. The piers on the radial-gate spillways were thickened, individual motor-driven gate hoists were installed, and two 15-kilovolt-ampere gasoline-engine driven generators were installed for emergency operation of the hoist motors.

Mormon Flat Dam and Reservoir

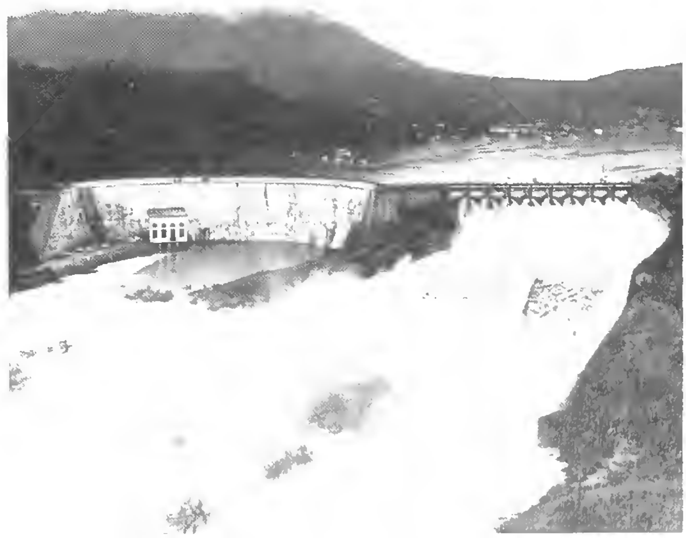
Mormon Flat Dam, a concrete thin-arch structure, 224 feet high, is on the Salt River 51 miles northeast of Phoenix. Constructed by the Salt River Valley Water Users' Association in 1923-26, it creates a reservoir with a capacity of 57,852 acre-feet.

Mormon Flat Dam

In 1938, the Bureau of Reclamation completed construction of a new gate structure and a concrete-lined spillway discharge channel, and installed two 50-foot-square stoney regulating gates, hoists, motors, two 25-kilovolt-ampere gasoline-engine driven generators, and a new road to the powerhouse.

Stewart Mountain Dam and Reservoir

Forty-one miles northeast of Phoenix, the Stewart Mountain Dam creates a reservoir with a capacity of 69,765 acre-feet. The dam is a concrete thin-arch structure, 207 feet high, with gravity abutments. Built by the Salt River Valley Water Users' Association in 1928-30, the dam has an open super-elevated channel spillway equipped with radial gates.



Stewart Mountain Dam and Saguaro Lake

Bartlett Dam

Horseshoe Dam

The spillway was modified by the Bureau of Reclamation in 1936. The work consisted of building a concrete-lined spillway discharge channel, 450 feet long by 265 feet wide, below the existing ogee spillway; reconditioning the hoisting equipment for the radial gates; and installing individual gate operating motors and two 10-kilovolt-ampere gasoline-engine driven generators.

Bartlett Dam and Reservoir

During 1936-39, Bartlett Dam was constructed by the Bureau of Reclamation on the Verde River 48 miles northeast of Phoenix. This multiple-arch dam is 287 feet high, contains 182,000 cubic yards of concrete, and creates a reservoir of 178,477-acre-foot capacity.

Horseshoe Dam and Reservoir

Horseshoe Dam, on the Verde River 58 miles from Phoenix, is an earthfill structure 194 feet high which creates a reservoir with a capacity of 139,238 acre-feet.

The dam was built during 1944-46 by the Phelps-Dodge Copper Products Corp. for the Salt River Valley Water Users' Association under a water exchange agreement.

Spillway gates were added to the dam in 1949 by the city of Phoenix to increase the domestic water supply.

Granite Reef Diversion Dam

Granite Reef Diversion Dam is located about 4 miles downstream of the confluence of the Salt and Verde Rivers and about 22 miles east of Phoenix. The dam was constructed between 1906 and 1908 by the Bureau of Reclamation to divert water released from storage to project canals.

Well Pumping Units

Pumps are installed on 248 wells to supplement the surface water supply. The total pumping capacity of these wells is 738,595 acre-feet. Several booster pumps were installed to lift water to canals and laterals through low lifts ranging from 3 to 40 feet.

Distribution and Drainage System

A total of 131 miles of irrigation canals, 878 miles of laterals, and 250 miles of drain ditches make up the water distribution system.

Granite Reef Diversion Dam

DEVELOPMENT

Early History

Irrigation of the Salt River Valley began about 1867. The riverflow was erratic, varying from a small stream to enormous floods. During years of drought, the supply of water at low river stages was inadequate for the land in cultivation. River flows in excess of immediate needs or canal capacities were lost, due to lack of storage facilities.

From 1867 to 1902, a number of diversion dams, canals, and laterals were constructed by private companies or through community effort. Difficulties caused by lack of water storage, inadequate diversion dams, and inequitable water distribution were so critical that many of the settlers left the valley. A committee was named to investigate the feasibility of a water storage system. A reservoir site located 80 miles from Phoenix, where Tonto Creek flowed into the Salt River, seemed the most practical.

Such a reservoir would cost from $2 to $5 million. As a territory of the United States, Arizona was prohibited from assuming such a large-scale debt; private investors could not be induced to take on the financial risk necessary to construct the dam.

The Salt River Valley Water Users' Association was incorporated on February 9, 1903, for the purpose of furnishing water, power, and drainage for the benefit of approximately 4,800 individual landowners.

Power Developments

When Phoenix and the surrounding communities began to grow, patterns of water distribution were affected. A great impact was also felt on electrical service provided by the Salt River Project.

In 1947, power sources included the hydroelectric facilities at the dams and on the Crosscut Canal and gas/oil-fired units at Crosscut. In 1952, the 104-MW Kyrene Steam Plant, south of Tempe, was placed in operation and in 1971-73, four combustion turbines were added, increasing the plant capacity from 104 to 300 MW.

In 1957, the 111-MW Agua Fria Steam Plant, located west of Glendale, was placed in operation. Since then, the station's capacity has been increased to 599 MW.

In 1969, the Salt River Project initiated its Hydroelectric Expansion and Frequency Unification (HEFU) program to increase hydroelectric generating capacity at facilities on the Salt River. This program included the installation of pumped storage units at Mormon Flat Dam in 1971 and at Horse Mesa Dam in 1972. The HEFU program also provided for converting the conventional hydroelectric generating facilities at the dams on the Salt River from the outmoded 25-hertz (Hz) to the modern frequency of 60 Hz and in 1973, a new 60-Hz, 36-MW generating unit was installed at Theodore Roosevelt Dam, which replaced the existing 25-Hz units.

In 1974-75, the four-unit combined-cycle Santan Generating Station was built near Gilbert, Ariz. This station has an installed capacity of 288 MW.

Salt River Project Participation in Power Projects

The Salt River Project and five Southwestern utilities have invested in the construction of two large coal-fired units at the Four Corners Generating Station near Farmington, N. Mex. The project has a 10-percent share of the 1,600-MW capacity. First power was received in 1969 and the second unit went on line in 1970.

In 1974-76, three coal-fired units were constructed at Navajo Generating Station near Page, Ariz. The Salt River Project manages the station and participates in 21.7-percent of its installed generation of 750 megawatts per unit.

In 1975, a second unit of the Hayden Generating Station at Hayden, Colo., was built. The Salt River Project receives 80 percent of the 260-MW coal-fired unit's capacity. It began operation in 1976.

The 1,580-MW Mohave Generating Station in southern Nevada, across the Colorado River from Bullhead City, Ariz., was built by a regional group of utilities. The project has a 10-percent interest in this station. Power from the first unit was delivered in 1970 and the second unit became operational in 1971.

Investigations

The project was investigated and found feasible by the Director of the Reclamation Service on March 7, 1903.

Authorization

The project was authorized by the Secretary of the Interior on March 14, 1903, in accordance with the act of June 17, 1902 (32 Stat. 338). Rehabilitation and betterment of the project works was authorized by the act of October 7, 1949 (63 Stat. 724), as amended.

Construction

Construction was started on August 24, 1903, and the first water was delivered in 1907.

The original project system, composed of Theodore Roosevelt Dam and Powerplant, Granite Reef Diversion Dam, and the improved main canals, was placed in service in 1909 and completed in 1911. The Salt River Valley Water User's Association built Horse Mesa, Stewart Mountain, and Mormon Flat Dams during 1923-30. On November 26, 1935, the association entered into a contract with the Bureau of Reclamation for the construction of Bartlett Dam, reconstruction or repairs to the spillways at Horse Mesa, Mormon Flat, Stewart Mountain, and Theodore Roosevelt Dams, and other improvements. All the work was started in 1936 and completed by 1939. In 1946, the Phelps-Dodge Corporation completed Horseshoe Dam on the Verde River under a water exchange agreement.

Operating Agencies

The Salt River Valley Water Users' Association has operated and maintained the irrigation and drainage system below Granite Reef Diversion Dam since November 1, 1917. Since 1937, the power features have been operated by the Salt River Project Agricultural Improvement and Power District.

BENEFITS

Irrigation

Irrigation has transformed a part of the Arizona desert into fertile farmland, where millions of dollars worth of crops are produced annually. Principal crops are wheat, grain sorghum, pasture, grain, alfalfa, barley, and citrus.

Power

The Salt River Project provides electric service to residential, commercial, industrial, and agricultural power users in a 2,900-square-mile service area in parts of Maricopa, Gila, and Pinal Counties.

Recreation and Fish and Wildlife

All reservoirs located on the Salt and Verde Rivers offer year-round boating and fishing for a variety of warm-water fish species. Waterfowl hunting is permitted in season. Theodore Roosevelt Lake contains a wildlife area and, as a wildlife refuge, is posted to permit hunting at certain times of the year.

Theodore Roosevelt and Apache Lakes offer year-round motel rental facilities. Canyon, Saguaro, and Bartlett Lakes offer a variety of camping, picnicking, swimming, and other outdoor recreation opportunities. The Salt River below Stewart Mountain Dam offers outstanding trout fishing during certain times of the year.

The first hard-surface bicycle path placed on Salt River Project right-of-way was completed in 1975. The 11.5-mile Papago Loop Bicycle Path was made possible through an agreement between the project and the cities of Phoenix, Tempe, and Scottsdale.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	238,220	acres
Supplemental irrigation service	24,715	acres
Total	262,935	acres
Number of irrigated farms	3,555	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	135,742	47,382,067
1969	136,701	45,974,249
1970	132,289	46,261,580
1971	129,074	49,881,659
1972	124,398	60,462,592
1973	120,136	90,096,423
1974	116,848	95,324,128
1975	111,105	86,596,868
1976	112,525	108,196,530
1977	126,606	91,851,836

Facilities in Operation

Storage dams	6	
Diversion dams	1	
Canals	131	mi
Laterals	876	mi
Pumping units for wells	248	
Hydroelectric powerplants	5	
Thermal powerplants	4	
Thermal powerplants (participant)	5	
Transmission lines	1,183	mi
Substations (distribution 122 - transmission 21)	143	

Climatic Conditions

Annual precipitation	7.7	in
Temperature:		
Maximum	116	°F
Minimum	27	°F
Mean	71	°F
Growing season	304	days
Elevation of irrigable area	900-1300.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	15,997
Municipal water service	1,098,700
Other water service[1]	5,090
Total	1,119,787

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

SALT RIVER

Drainage area at Roosevelt Dam	5,824	mi²
Annual discharge at Roosevelt Dam:		
Maximum (1916)	2,729,200	acre-ft
Minimum (1913)	496,500	acre-ft
Average	1,007,285	acre-ft
Annual discharge at Morman Flat Dam:		
Maximum (1928)	787,410	acre-ft
Minimum (1929)	549,750	acre-ft
Average	619,186	acre-ft
Annual discharge at Stewart Mountain Dam:		
Maximum (1973)	1,445,667	acre-ft
Minimum (1952)	248,125	acre-ft
Average	608,562	acre-ft
Average annual diversion (all sources) at Granite Reef 1913-77	1,177,661	acre-ft

VERDE RIVER

Drainage area at Bartlett Dam	6,160	mi²
Annual discharge at Bartlett Dam:		
Maximum (1973)	1,116,162	acre-ft
Minimum (1961)	126,291	acre-ft
Average	358,078	acre-ft

Storage Facilities

THEODORE ROOSEVELT DAM

Type: Cyclopean-masonry thick arch
Location: On the Salt River, about 76 mi northeast of Phoenix, Ariz.
Construction period: 1903-11. Spillways, outlets, and powerplant modified at various times between 1913-36.
Date of closure (first storage): 1910
Reservoir, Theodore Roosevelt Lake

Average annual inflow, 1913-77[2]	686,825	acre-ft
Total capacity to El. 2136	1,381,580	acre-ft
Surface area	17,315	acres
Dimensions:		
Structural height	280	ft
Hydraulic height	234	ft
Top width	16	ft
Maximum base width	184	ft
Crest length	723	ft
Crest elevation	2142.0	ft
Total volume	355,800	yd³

Spillway: Unlined open channel at each abutment, controlled by nineteen 20- by 15.9-ft radial gates.

Elevation top of gates	2136.0	ft
Crest elevation	2120.3	ft
Capacity at El. 2146	150,000	ft³/s

Outlet works:
River: Two steel pipes through right side of dam, each controlled by one 54-in butterfly valve. A third 54-in steel pipe has been plugged and abandoned; a 66-in ring jet valve acts as generator bypass for a 10-ft-diameter penstock.
Capacity at El. 2136:

54-in butterfly valves	1,560	ft³/s
66-in ring jet valve (when not generating)	1,600	ft³/s

Power: One 10-ft-diameter steel penstock through the base of the dam to the generator in the powerhouse and one 10-ft-diameter penstock from the abutment outlets serves the generator in the powerhouse. Two conduits in original diversion tunnel through left abutment and 7-ft-diameter penstock from power canal through left abutment outlet conduits have been plugged and abandoned.

[2]From 65-year mean statistical report accumulated monthly runoff.

HORSE MESA DAM

Type: Concrete thin arch
Location: On the Salt River, 65 mi northeast of Phoenix, Ariz.
Construction period: Constructed by Salt River Valley Water Users' Association in 1924-27. Spillways modified by Reclamation in 1936-37.
Reservoir, Apache Lake:

Total capacity to El. 1914	245,138	acre-ft
Surface area	2,656	acres
Dimensions:		
Structural height	305	ft
Hydraulic height	266	ft
Top width	8	ft
Maximum base width	57	ft
Crest length	660	ft
Crest elevation	1915.0	ft
With parapet	1920.0	ft
Total volume	162,000	yd³

Spillway: Concrete overall structures at each abutment, controlled by nine 26- by 23-ft radial gates, and a concrete-lined auxiliary tunnel spillway through right abutment, controlled by one 40- by 44.5-ft fixed-wheel gate.

	Service	*Auxiliary*
Elevation top of gates	1914.0 ft	1914.0 ft
Crest elevation	1891.0 ft	1869.5 ft
Capacity at El. 1920		150,000 ft³/s

Outlet works—Power: Three 8-ft-diameter penstocks and one 15.6-foot-diameter penstock through dam.

Capacity at El. 1914	7,000 ft³/s

MORMON FLAT DAM

Type: Concrete thin arch
Location: On the Salt River, about 51 mi northeast of Phoenix, Ariz.
Construction period: Constructed by Salt River Valley Water Users' Association in 1923-26. Spillway modified by Reclamation in 1937-38.
Reservoir, Canyon Lake:

Total capacity to El. 1660.5	57,852	acre-ft
Surface area	950	acres
Dimensions:		
Structural height	224	ft
Hydraulic height	142	ft
Top width	8	ft
Maximum base width	20	ft
Crest length	380	ft
Crest elevation	1666.0	ft
Total volume	59,900	yd³

Spillway: Concrete-lined channel at right abutment, controlled by two 50-ft-square fixed-wheel gates.

Elevation top of gates	1660.5	ft
Crest elevation	1610.5	ft
Capacity at El. 1671	150,000	ft³/s

Outlet works:
River: One 72-in-diameter penstock with upstream and downstream slide gates and one 72-in-diameter penstock with upstream slide gates only are used under low reservoir conditions. Three 54-in steel pipes

through dam have been plugged and abandoned. A needle valve is still attached to one of the 54-in pipes.
Power: Two 8-ft-diameter penstocks through dam leading to unit 1 and one 18-ft-diameter penstock leading to unit 2.

Stewart Mountain Dam

Type: Concrete thin arch
Location: On the Salt River, 41 mi northeast of Phoenix, Ariz.
Construction period: Constructed in 1928-30 by the Salt River Valley Water Users' Association. Spillway modified by Reclamation in 1936.

Reservoir, Saguaro Lake:		
Total capacity to El. 1529	69,765	acre-ft
Surface area	1,254	acres
Dimensions:		
Structural height	207	ft
Hydraulic height	116	ft
Top width	8	ft
Maximum base width	33	ft
Crest length	1,260	ft
Crest elevation	1530.0	ft
Total volume	120,000	yd³
Spillway: Concrete weir and concrete-lined open channel at left abutment, controlled by nine 27- by 23-ft radial gates.		
Elevation top of gates	1529.0	ft
Crest elevation	1506.0	ft
Capacity at El. 1535	140,000	ft³/s
Outlet works:		
River: One steel pipe through dam, controlled by one 84-in butterfly valve. A 96-in steel pipe, an 84-in steel pipe with a bifurcation, and two 54-in needle valves, penetrate the dam but have been sealed with semipermanent concrete bulkheads.		
Capacity at El. 1510	1,800	ft³/s
Power: 13.5-ft-diameter steel penstock through dam to powerplant.		

Bartlett Dam

Type: Concrete multiple arch
Location: On the Verde River, about 48 mi northeast of Phoenix, Ariz.
Construction period: 1936-39

Reservoir, Bartlett:		
Average annual inflow, 1948-77[3]	346,043	acre-ft
Total capacity to El. 1798	178,477	acre-ft
Surface area	2,775	acres
Dimensions:		
Structural height	287	ft
Hydraulic height	188	ft
Top thickness of arches	4	ft
Maximum buttress length	390	ft
Crest length	800	ft
Crest elevation	1799.5	ft
Total volume	182,000	yd³
Spillway: Concrete-lined channel at right abutment, controlled by three 50-ft-square crawler-type gates.		
Elevation top of gates	1798.0	ft
Crest elevation	1748.0	ft
Capacity at El. 1798	175,000	ft³/s
Outlet works: Five steel pipes through dam near left abutment, two controlled by 66-in needle valves, and three controlled by 6- by 7.5-ft slide gates (at low lake levels only).		
Capacity at El.1700	4,000	ft³/s

Foundation: Generally competent fine-grained granite fused to firm coarse-grained granite, with sheet and block joints; coarse-grained granite deeply disintegrated around islands of firm rock; inactive transverse faults with several branch faults in left abutment.
Special treatment: Cement grout curtain under upstream toe, shafts and trenches in faults filled with concrete, and faults grouted.

[3]From Verde River 30-year statistical report accumulated monthly runoff.

Horseshoe Dam

Type: Earthfill and rockfill
Location: On the Verde River, about 58 mi northeast of Phoenix, Ariz.
Construction period: 1944-46
Dam constructed by Phelps-Dodge Corp. Spillway gates installed in 1949 by agreement with the city of Phoenix.

Reservoir, Horseshoe:		
Average annual inflow, 1946-77	342,000	acre-ft
Total capacity to El. 2026	139,238	acre-ft
Surface area	2,762	acres
Dimensions:		
Structural height	194	ft
Hydraulic height	142	ft
Top width	39	ft
Maximum base width	619	ft
Crest length	1,140	ft
Crest elevation	2040.0	ft
Total volume	1,082,000	yd³
Spillway: Concrete-lined channel at right abutment, controlled by three 35- by 114-ft radial gates.		
Elevation top of gates	2026.0	ft
Crest elevation	2000.0	ft
Capacity at El. 2035.5	250,000	ft³/s
Outlet works: Circular outlet tower, 126 ft high behind left abutment, controlled by 9-ft-diameter cylinder valve.		
Capacity at El. 2026	2,200	ft³/s

Diversion Facilities

Granite Reef Diversion Dam

Type: Concrete ogee weir, embankment wings
Location: On the Salt River, 22 mi east of Phoenix, Ariz.
Year completed: 1908

Dimensions:		
Structural height	29	ft
Hydraulic height	18	ft
Weir crest length	1,000	ft
Total crest length	1,128	ft
Weir crest elevation	1310.0	ft
Volume	35,000	yd³
Sluiceway:		
North Side Canal: Four 15- by 9-ft slide gates.		
South Side Canal: Two 15- by 9-ft slide gates		
Headworks:		
North Side Canal: Eighteen 7- by 5-ft slide gates.		
South Side Canal: Nine 7- by 5-ft slide gates.		
Diversion capacity:		
North Side Canal	2,000	ft³/s
South Side Canal	1,600	ft³/s

Power Canal Diversion Dam[4]

Type: Concrete weir, embankment wings
Location: On the Salt River, near Livingstone, Ariz.

[4]The diversion dam is no longer in use and the headworks were sealed off in 1941.

Year completed: 1906. Reconstructed in 1936-37 and further modified in 1937-38.

Dimensions:

Structural height	12 ft
Hydraulic height	8 ft
Total crest length	862 ft
Weir crest length	500 ft
Weir crest elevation	2180.25 ft
Volume	16,000 yd³

Sluiceway: Four 7- by 9.75-ft slide gates.

Headworks: Three 7- by 5.25-ft slide gates.

Diversion capacity	220 ft³/s

Carriage Facilities

Arizona Canal

Location: Generally west from Granite Reef Diversion Dam, 22 mi east of Phoenix, Ariz.

Construction period: 1883-84. Enlarged by Reclamation, 1911-12.

Length	37.4 mi
Diversion capacity	2,000 ft³/s
Typical maximum section in earth:	
Bottom width	70 ft
Side slopes	1:1
Water depth	5.2 ft
Typical maximum section, concrete lined:	
Bottom width	80 ft
Side slopes	0.75:1
Water depth	6.8 ft
Lining thickness	1.5 in

Grand Canal

Location: From point on Arizona Canal, about 4 mi north of Tempe, Ariz., south to Tempe, then northwest through Phoenix to New River.

Construction period: 1878. Enlarged during 1907-13.

Length	21.4 mi
Diversion capacity	625 ft³/s
Typical maximum section in earth:	
Bottom width	35 ft
Side slopes	1:1
Water depth	5 ft
Typical maximum section, concrete lined:	
Bottom width	28 ft
Side slopes	0.75:1
Water depth	5 ft
Lining thickness	1.25 in

South Canal

Location: From Granite Reef Diversion Dam southwest to Mesa, Ariz., where the canal divides into the Consolidated and Tempe Canals.

Construction period: 1889

Length	11.3 mi
Diversion capacity	1,700 ft³/s
Typical maximum section, concrete lined:	
Bottom width	63 ft
Side slopes	1:1
Water depth	8 ft
Lining thickness	1.25 in

Consolidated Canal

Location: Generally south from South Canal division gates near Mesa, Ariz.

Construction period: 1894. Lined and enlarged, 1925-27.

Length	18.1 mi
Diversion capacity	525 ft³/s
Typical maximum section in earth:	
Bottom width	40 ft
Side slopes	1:1
Water depth	5 ft
Typical maximum section, concrete lined:	
Bottom width	60 ft
Side slopes	0.75:1
Water depth	8 ft
Lining thickness	1.5 in

Eastern Canal

Location: East of and generally paralleling the Consolidated Canal south from South Canal at South Consolidated Powerplant.

Construction period: 1889. Lined in 1925-27.

Length	14.2 mi
Diversion capacity	360 ft³/s
Typical maximum section, concrete lined:	
Bottom width	31 ft
Side slopes	0.75:1
Water depth	4.2 ft
Lining thickness	1.25 in

Tempe Canal

Location: Generally southwest from South Canal at division gates near Mesa, Ariz.

Construction period: 1871. Enlarged 1926-27.

Length	9.3 mi
Diversion capacity	600 ft³/s
Typical maximum section in earth:	
Bottom width	45 ft
Side slopes	1:1
Water depth	4 ft
Typical maximum section, concrete lined:	
Bottom width	34 ft
Side slopes	0.75:1
Water depth	4 ft
Lining thickness	2 in

Western Canal

Location: West from Tempe Canal near Tempe, Ariz.

Construction period: 1911-13

Length	14.4 mi
Diversion capacity	500 ft³/s
Typical maximum section in earth:	
Bottom width	35 ft
Side slopes	1:1
Water depth	4.5 ft
Typical maximum section, concrete lined:	
Bottom width	35 ft
Side slopes	0.75:1
Water depth	4 ft
Lining thickness	1.25 in

Cross-Cut Canal

Location: From Arizona Canal south to Grand Canal near Tempe, Ariz.

Construction period: 1912-13

Length	3.4 mi

Diversion capacity .... 400 ft³/s
Typical maximum section in earth:
Bottom width .... 38 ft
Side slopes 1:1
Water depth .... 4.1 ft
Typical maximum section, concrete lined:
Bottom width .... 16 ft
Side slopes 1:1
Water depth .... 6 ft
Lining thickness .... 4.5 in

POWER CANAL (Abandoned 1941)

Location: From Power Canal Diversion Dam on Salt River about 60 mi east of Phoenix, Ariz., west along Theodore Roosevelt Reservoir to Theodore Roosevelt Dam.
Construction period: 1902-03. Enlarged in 1911-12.
Length .... 19.3 mi
Diversion capacity .... 225 ft³/s
Typical maximum section in earth:
Bottom width .... 15 ft
Side slopes 0.25:1
Typical maximum section, concrete lined:
Bottom width .... 10 ft
Side slopes 0.75:1
Lining thickness .... 2 in

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Average lift, ft	Installed horse-power
Well pumping divisions:[5]				
Northside	130	437.79	280	21,385
Southside	115	546.95	324	29,355
P&H	3	21.97	125	450
Booster plants:				
Highline	8	125.0	42	1,500
Distribution	8	50.17	5	160

[5]All data based on 1977 summer tests. Where none are available, last prior test used.

Power Facilities

THEODORE ROOSEVELT POWERPLANT[6]

Location: At Theodore Roosevelt Dam, 76 mi northeast of Phoenix, Ariz.
Year of initial operation: 1909
Year last generator placed in operation: 1973[7]
Nameplate capacity .... 36,018 kW
Number and capacity of generator .... (1) 36,018 kW
Maximum head .... 225 ft

HORSE MESA POWERPLANT[8]

Location: At Horse Mesa Dam, 65 mi northeast of Phoenix, Ariz.
Year of initial operation: 1927
Year last generator placed in operation: 1972
Nameplate capacity .... 126,000 kW
Number and capacity of generators:
Conventional[9] .... (3) 11,000 kW
Pumped storage[9] .... (1) 93,000 kW
Maximum head:
Conventional .... 251 ft
Pumped storage .... 279 ft

MORMON FLAT POWERPLANT

Location: At Mormon Flat Dam, 51 mi northeast of Phoenix, Ariz.
Year of initial operation: 1926
Year last generator placed in operation: 1971
Nameplate capacity .... 54,000 kW
Number and capacity of generators:
Conventional[10] .... (1) 10,000 kW
Pumped storage[10] .... (1) 44,000 kW
Maximum head:
Conventional .... 140.5 ft
Pumped storage .... 151.5 ft

STEWART MOUNTAIN POWERPLANT

Location: At Stewart Mountain Dam, 41 mi northeast of Phoenix, Ariz.
Year of initial operation: 1930
Year last generator placed in operation: 1930
Nameplate capacity .... 13,000 kW
Number of generators[11] 1
Maximum head .... 107.5 ft

CROSSCUT POWERPLANT[12] (HYDRO)

Location: At the Grand Canal, southeast of of the junction of Washington and Van Buren Streets, Tempe, Ariz.
Year of initial operation: 1939
Number and capacity of generators .... (1) 3,000 kW
Maximum head .... 111 ft

SUBSTATIONS:

SALT RIVER TRANSMISSION SUBSTATIONS

Number in operation 21
Total kilovolt-ampere capacity 8,275,960
(Includes all bulk power stations and Salt River Project participation in jointly owned projects.)

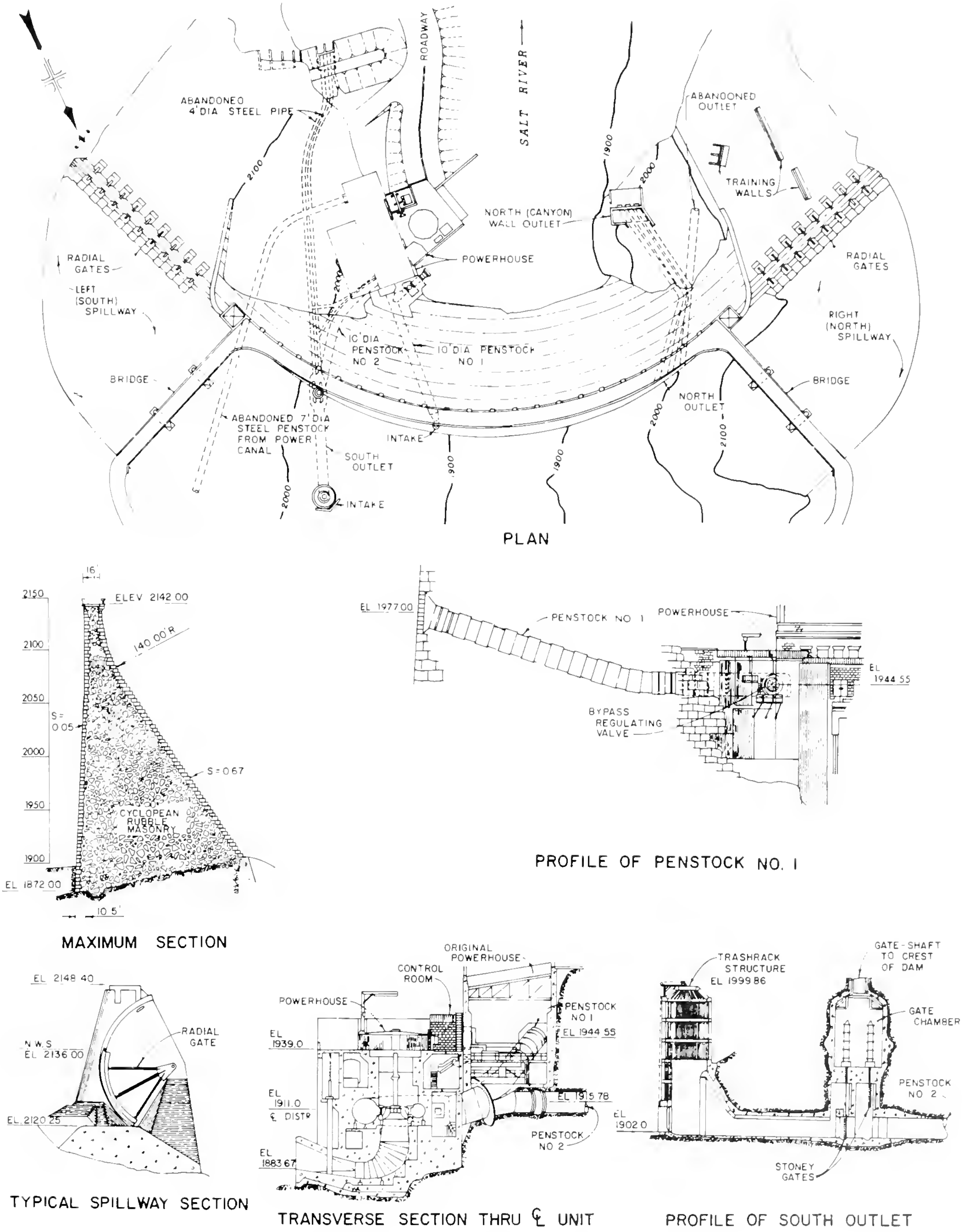
SALT RIVER PROJECT DISTRIBUTION SUBSTATIONS

Number in operation 122
Total kilovolt-ampere capacity 3,280,055

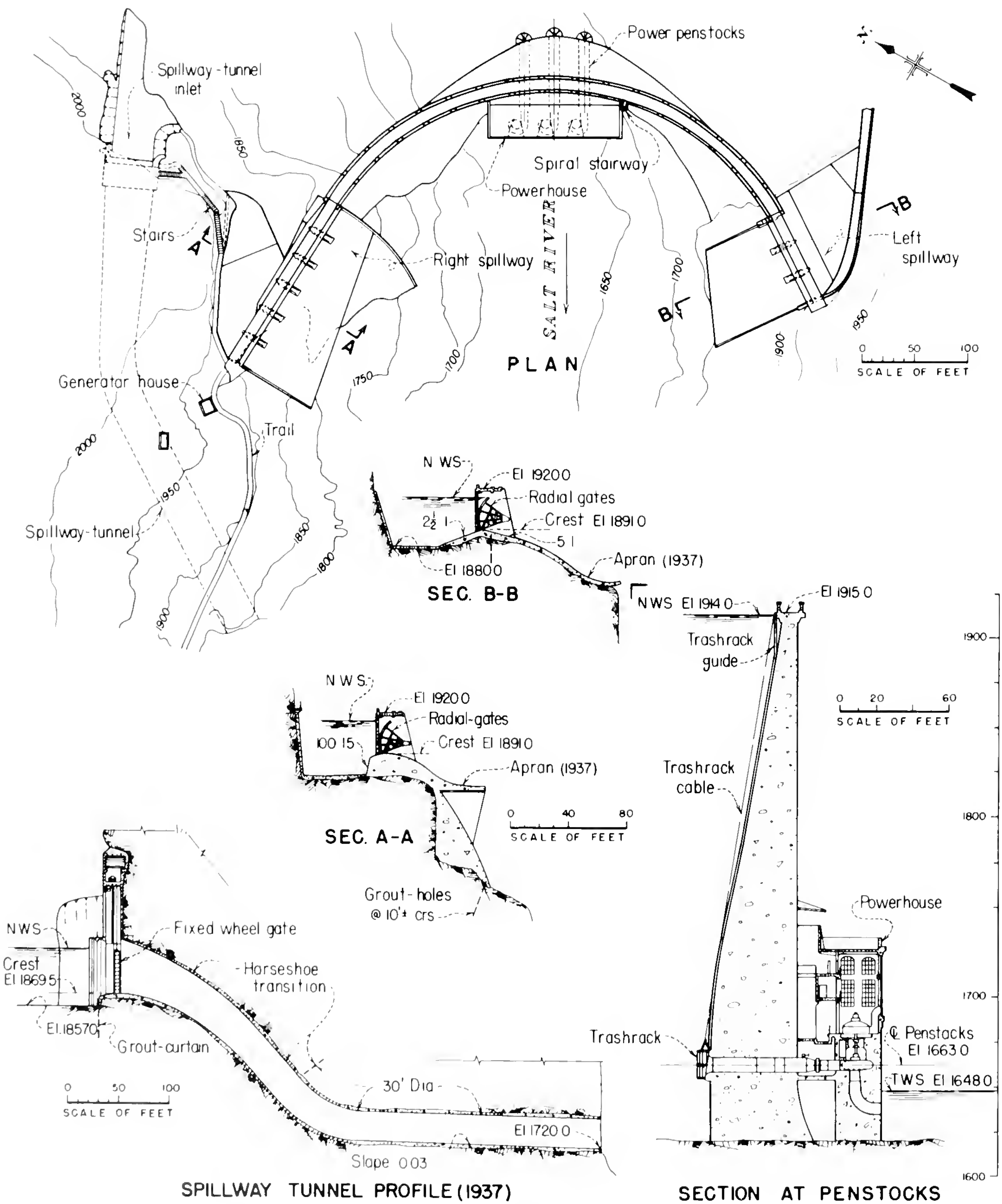
TRANSMISSION LINES

Transmission lines (circuit miles):
500 kV (includes participation) 194.67
230 kV (includes participation) 177.85
115 kV 293.47
69 kV 516.87
Total circuit miles 1,182.86
Distribution lines - primary and secondary:
Overhead (circuit miles) 4,985
Underground (cable miles) 6,237

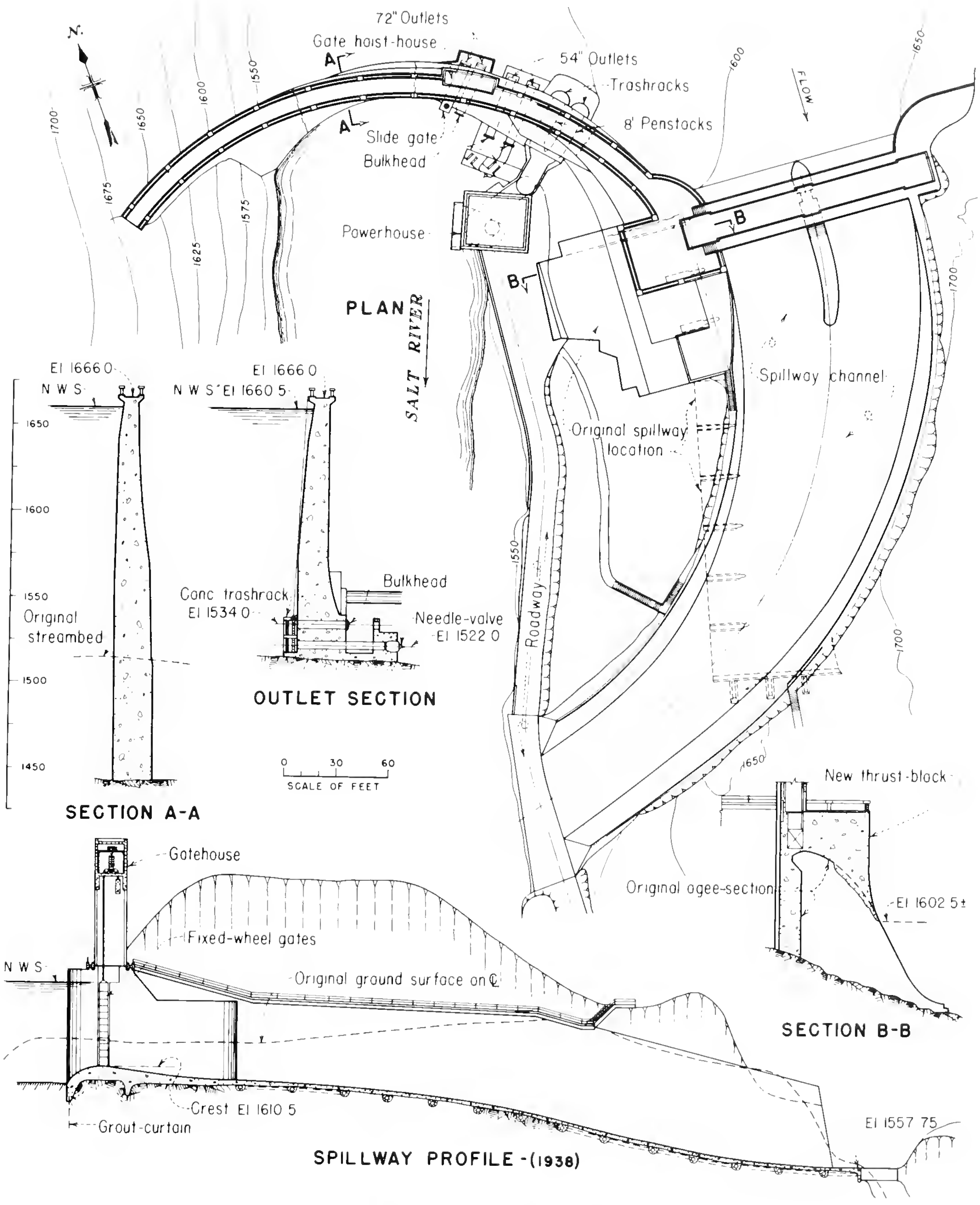
[6]Constructed by Bureau of Reclamation. Operated by Salt River Project Agricultural Improvement and Power District.
[7]The original plant consisted of seven 25-Hz generators with a total nameplate capacity of 19,290 kW. In 1973, these generators were replaced with one 60-Hz generator with a nameplate capacity of 36,018 kW.
[8]Constructed by Salt River Valley Water Users' Association and operated by the Salt River Project Agricultural Improvement and Power District.
[9]Converted from 25 to 60 Hz and pumped storage unit installed in 1972.
[10]Converted from 25 to 60 Hz and pumped storage unit installed in 1971.
[11]Converted from 25 to 60 Hz in 1962.
[12]Constructed by the Bureau of Reclamation with Salt River Valley Water Users' Association funds. Operated by Salt River Project Agricultural Improvement and Power District.



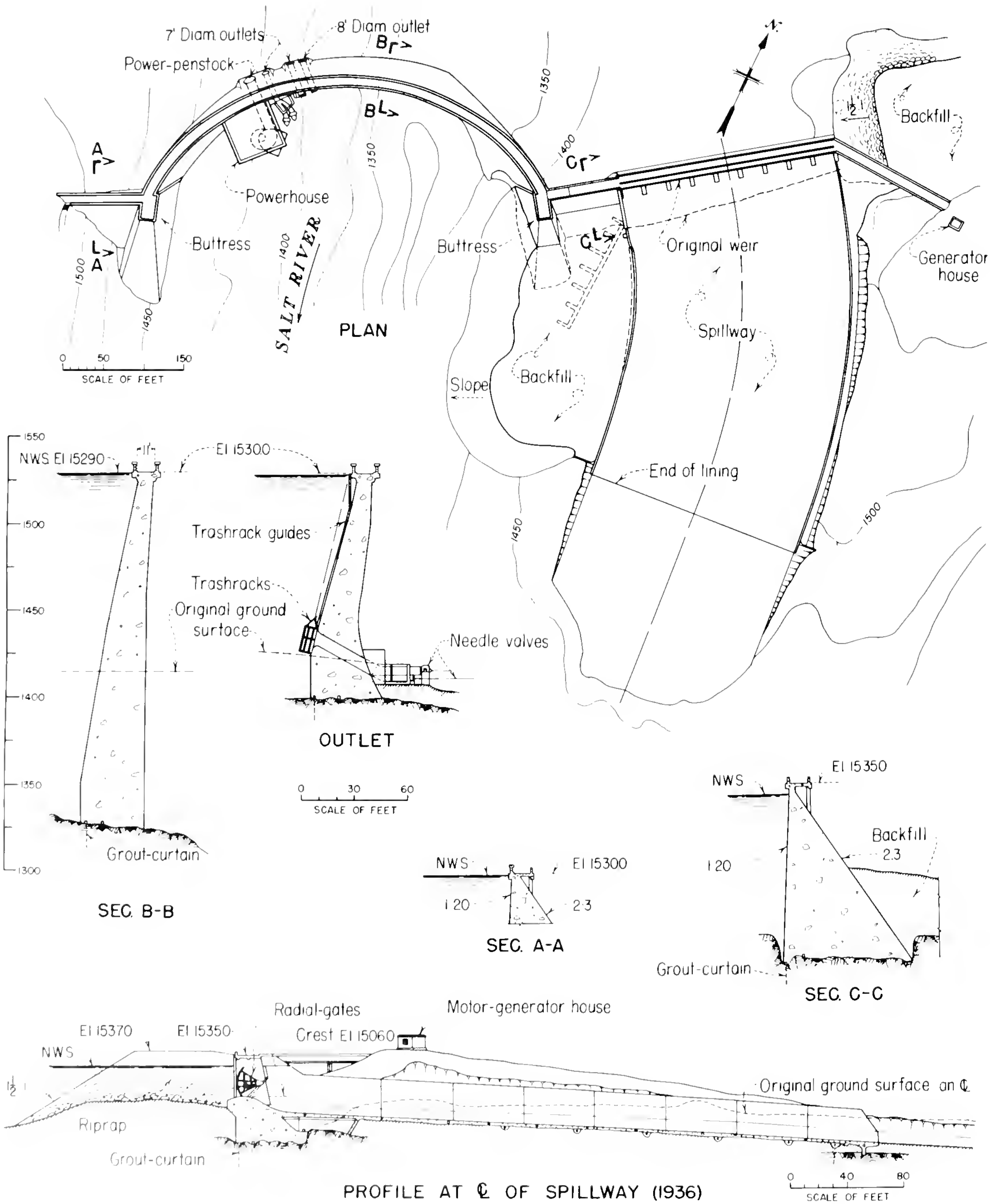
Theodore Roosevelt Dam and Powerplant, Plan and Sections



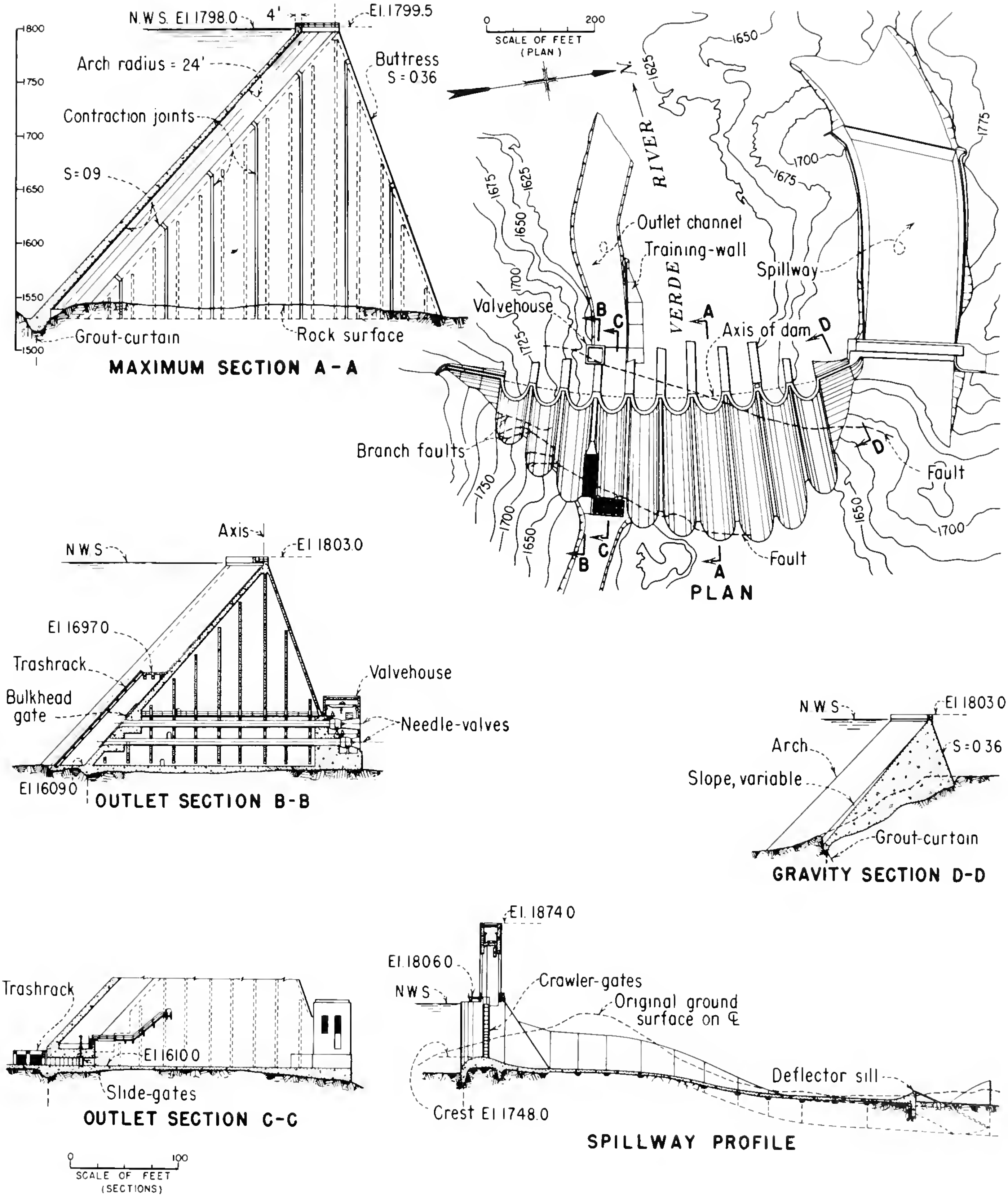
Horse Mesa Dam and Powerplant, Plan and Sections



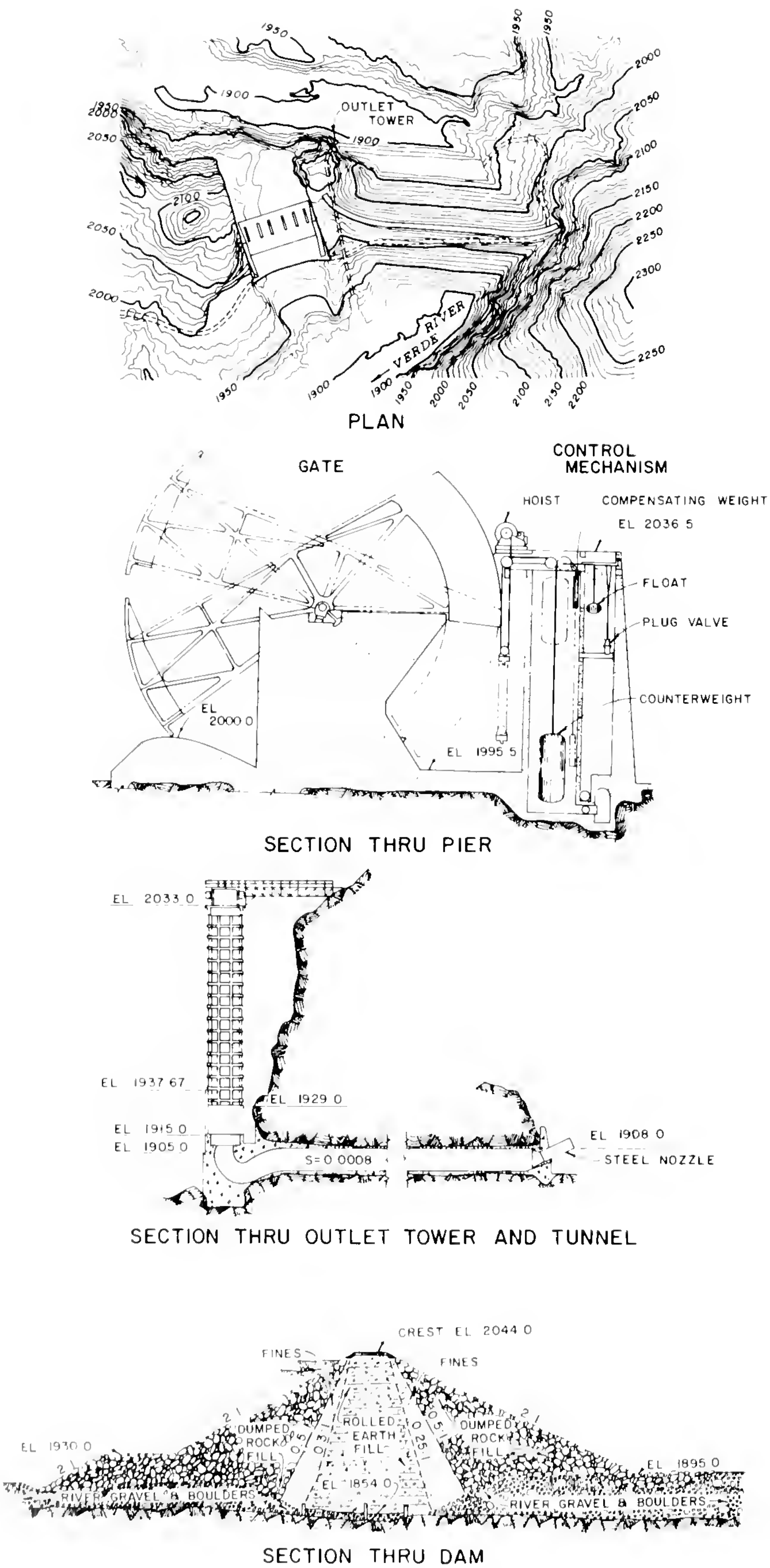
Mormon Flat Dam, Plan and Sections



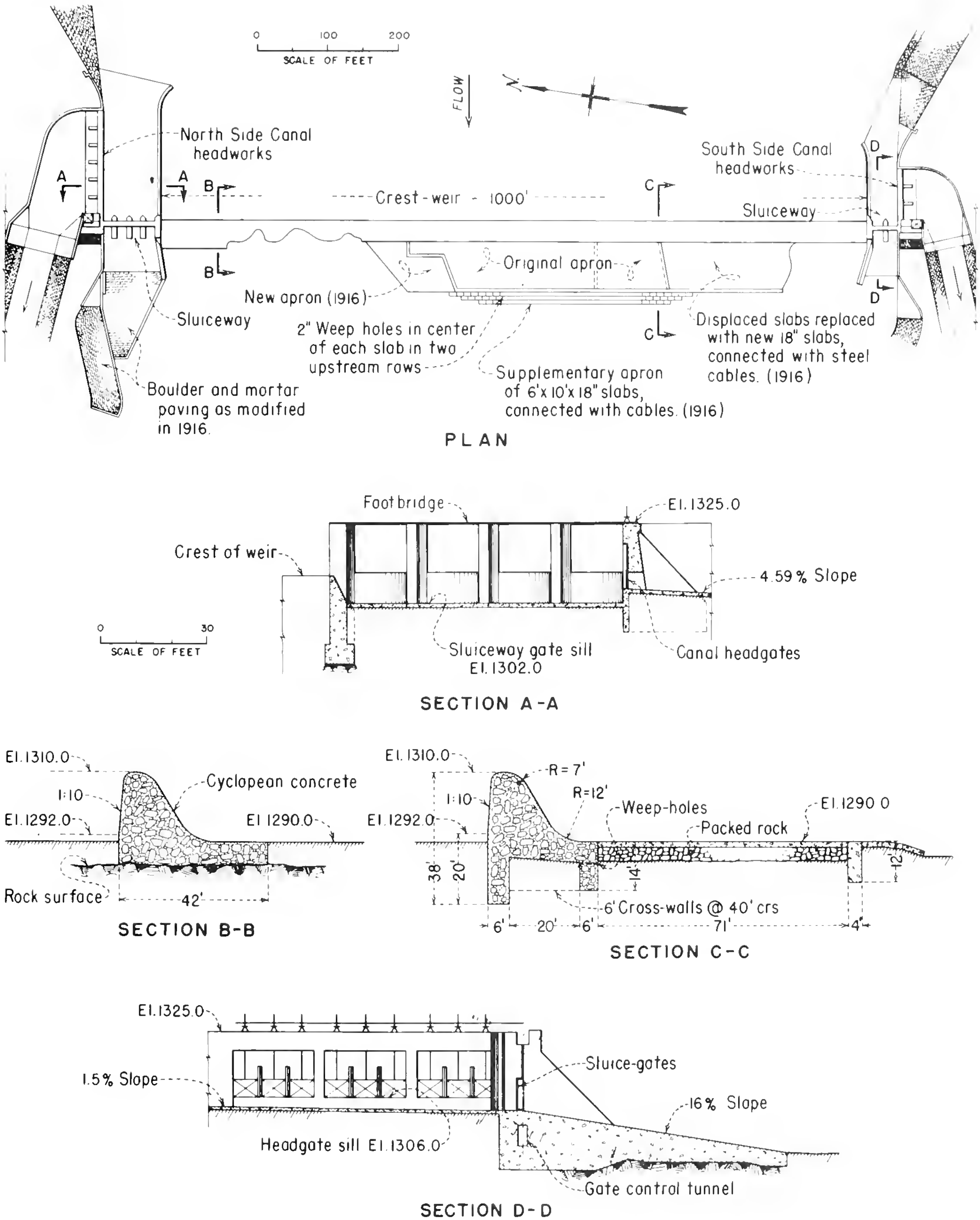
Stewart Mountain Dam, Plan and Sections



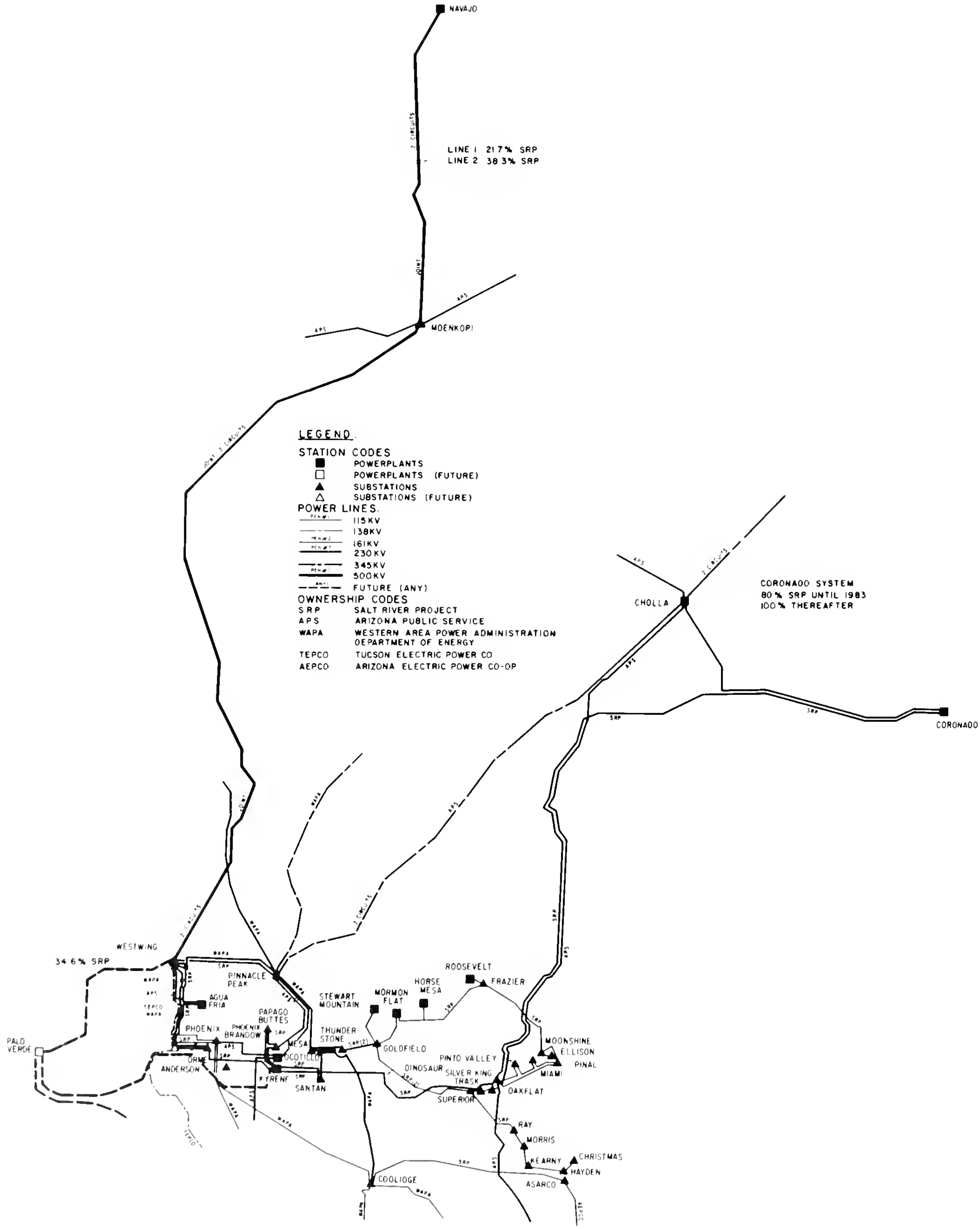
Bartlett Dam, Plan and Sections



Horseshoe Dam, Plan and Sections



Granite Reef Diversion Dam, Plan and Sections

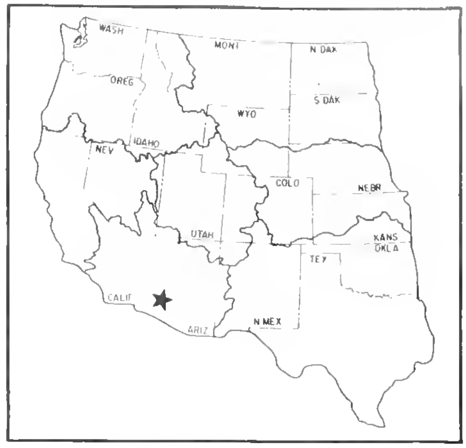


Salt River Project Transmission Line Grid

Salt River Project
(Rehabilitation and Betterment)

Arizona: Maricopa County

Lower Colorado Region
Water and Power Resources Service



The original irrigation facilities of the Salt River Project are located in the Salt River Valley in Maricopa County, Arizona. The project, one of Reclamation's first, serves about 240,000 acres of land with a surface-water supply from storage on the Salt and Verde Rivers. Supplemental water is obtained from 248 electrically pumped wells.

Surface water is conserved by six storage dams, four on the Salt River and two on the Verde River, with a combined storage capacity of 2,389,725 acre-feet. A diversion dam diverts water to 1,259 miles of canals, laterals, and ditches, which in turn deliver water to farms and cities.

PLAN

The general nature and purpose of the Salt River Project rehabilitation and betterment program is to reduce operation and maintenance costs, improve the irrigation facilities, increase operating efficiency, and conserve available water supplies.

The plan provides for lining certain sections of canals, replacing laterals with underground pipe, repairing and replacing gates, checks, and other irrigation structures, rehabilitating project water wells and undertaking repair and betterment work on some of the major storage facilities.

DEVELOPMENT

History

Construction of the Salt River Project was begun by the Bureau of Reclamation in 1903. The original features of the project consisted of Theodore Roosevelt Dam and Powerplant, Granite Reef Diversion Dam, and an improved canal system. These features were installed in 1911. In cooperation with the Bureau of Reclamation, the Salt River Project initiated a rehabilitation and betterment program in 1950. Contracts covering the work under the original program, supplemented by a congressionally approved extended program, were executed annually between the United States and the Salt River Valley Water Users' Association from the time the program was initiated in 1950 until 1958. Beginning July 1, 1958, the rehabilitation and betterment work has been covered by a contract through June 30, 1967, with repayable amounts computed for each fiscal year. The contract has been extended and is now scheduled to terminate June 30, 1982.

Investigations

In 1947, investigations of a rehabilitation and betterment program for the Salt River Project were initiated. Preliminary studies indicated that a complete rehabilitation of the project's irrigation system and other works would be needed to bring the project up to modern standards. A favorable feasibility report on the program was completed by the Bureau of Reclamation in 1948. The program was reviewed in 1964. A report was prepared recommending continuation of the rehabilitation and betterment work, which is the basis for the current program.

Authorization

The Salt River Project rehabilitation and betterment program was authorized pursuant to the act of October 7, 1949 (63 Stat. 724), and funds for the start of construction were appropriated in 1950.

Construction

Construction began in 1950. The work is being performed by the Salt River Valley Water Users' Association, using funds advanced by the Bureau of Reclamation. Plans developed by the association are approved by the Bureau of Reclamation. Work accomplished includes the lining the 42 miles of canals, 213 miles of laterals, 278 miles of lateral pipelines, and the rehabilitation of 8,259 structures.

Construction work underway includes about 505,000 square feet of concrete canal lining, 1.5 miles of concrete lateral lining, the installation of 1.1 miles of lateral pipelines, and the rehabilitation of 20 structures.

Operating Agencies

The irrigation and drainage system is operated and maintained by the Salt River Valley Water Users' Association. The power system of the project is operated by the Salt River Project Agricultural Improvement and Power District.

BENEFITS

Benefits to the Salt River Project from the rehabilitation and betterment program include reduced operation and maintenance costs, water conservation, increased crop production, and the elimination of neighborhood safety hazards.

PROJECT DATA

See the Salt River Project.

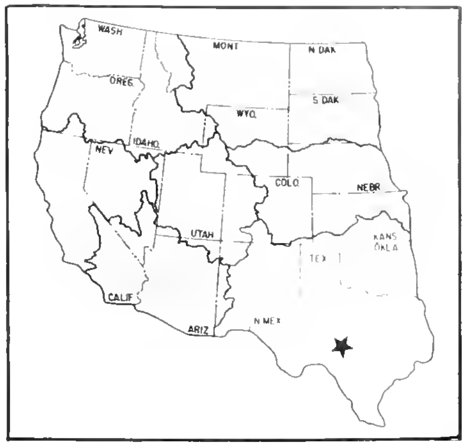
ENGINEERING DATA

See the Salt River Project.

San Angelo Project

Texas: Tom Green County

Southwest Region
Water and Power Resources Service



The San Angelo Project is in the immediate vicinity of the city of San Angelo in west-central Texas. Bureau of Reclamation development provided for the construction of Twin Buttes Dam and Reservoir, a headworks at Nasworthy Reservoir, and an irrigation and distribution system to serve a project area of 10,000 acres. The project provides for the integrated operation of Twin Buttes Reservoir with the existing O. C. Fisher Dam and Lake[1] and Nasworthy Reservoir to meet the municipal water requirements of San Angelo; permits irrigation of the project lands and provides flood protection, recreation, and fish and wildlife benefits.

PLAN

Twin Buttes Dam and Reservoir is immediately upstream from the existing Nasworthy Reservoir, about 6 miles southwest of San Angelo. Twin Buttes Dam controls the flows of the South and Middle Concho Rivers and Spring Creek.

Irrigation water is released from Twin Buttes Reservoir into Nasworthy Reservoir, where it is diverted by the new headworks into the 16-mile-long Main Canal. To assure the uninterrupted delivery of municipal water, irrigation releases are made from Twin Buttes Reservoir only when the water in storage exceeds 50,000 acre-feet. Water for municipal use is released as required from O. C. Fisher Lake or Twin Buttes Reservoir to flow down the river channels for diversion within the city limits.

Twin Buttes Dam and Reservoir

Twin Buttes Dam is a 134-foot-high zoned earthfill structure with a crest width of 30 feet and a crest length of over 8 miles. The embankment contains 21,465,854 cubic yards of material. An equalizing channel with a bottom width of 250 feet was excavated between the South Concho River and Spring Creek drainage areas. The outlet works for the dam, located near the left abutment, include an approach channel from the Middle Concho River, a concrete intake structure, 3-barreled concrete conduit with gate chamber and shaft, chute, and stilling basin. The spillway structure, also near the left abutment, is an uncontrolled ogee weir 200 feet in width. A concrete chute section, 320 feet long, extends from the crest to a stilling basin. Water from the stilling basins of both the spillway and outlet works discharges into a common channel.

Twin Buttes Reservoir has a total capacity of 640,580 acre-feet with a surface area of 23,508 acres. Active capacity of the reservoir is 632,210 acre-feet.

Headworks and Main Canal

The Main Canal headworks was constructed on the eastern edge of Lake Nasworthy. The headworks consists of a semicircular intake structure containing ten 4.5- by 5.5-foot intake openings with fish screens leading into a 5- by 6-foot concrete conduit, and outlet transition connecting to the concrete-lined Main Canal. Flows are controlled by a 5-foot-square motor-driven slide gate mounted at the upstream end of the conduit.

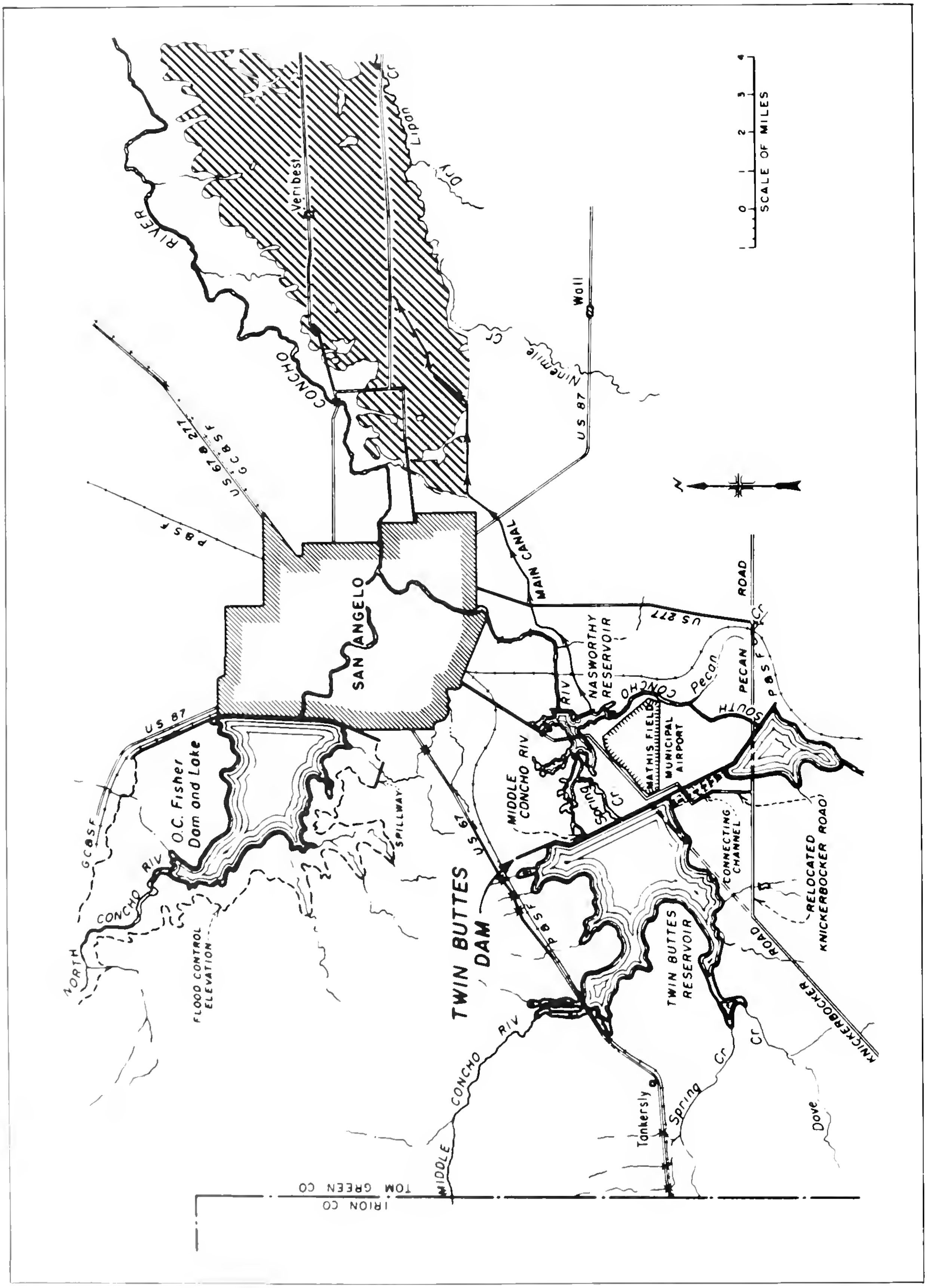
The 16-mile-long Main Canal has an initial capacity of 165 cubic feet per second. The canal follows an easterly and northeasterly direction to the project lands east of San Angelo. A 39-mile system of concrete-lined laterals completes the distribution of irrigation water.

DEVELOPMENT

Early History

The Concho River area was first settled about 1870 by cattlemen, who were followed by farmers. Although much of the area is still devoted primarily to grazing, most of the land now cultivated was first broken and farmed between 1880 and 1910. The last of the State-owned lands went into private ownership soon after 1910.

[1]San Angelo Dam was constructed by the Corps of Engineers in 1952 for flood control. The San Angelo Dam and Reservoir was designated "O. C. Fisher Dam and Lake" by Public Law 93-634, 93rd Congress, January 3, 1975 (88 Stat. 2173).

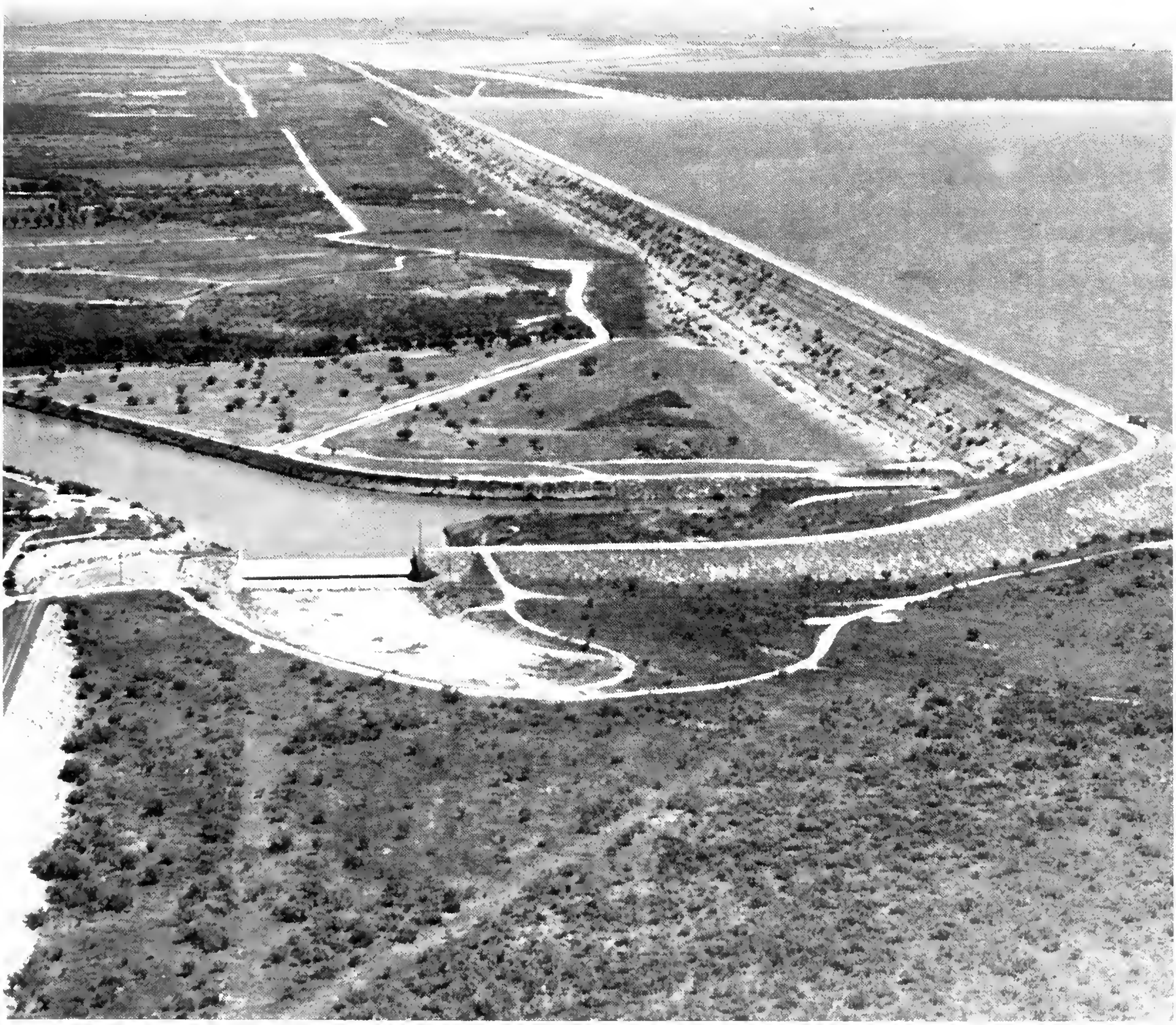


San Angelo Project

Except for the city of San Angelo, the Concho River watershed is sparsely settled. The city owes its origin to the establishment in 1868 of a military post, Fort Concho, for protection against Indians. At the same time, the settlement which became San Angelo was developed across the river on the North Concho.

Investigations

In 1939, the Corps of Engineers reported favorably upon the construction of the O. C. Fisher Dam and Reservoir on the North Concho River for the primary purpose of flood control. Construction of the reservoir by the Corps of Engineers was authorized by the Congress in the Flood Control Act of August 18, 1941, and construction of the reservoir was completed in 1952. Subsequent to the 1939 report by the Corps of Engineers, the Bureau of Reclamation initiated investigations for developing an irrigation plan for using Concho River water in excess of the municipal and industrial needs of the area.



Twin Buttes Dam and Reservoir

The Bureau of Reclamation completed a draft of a report on the North Concho Unit of the San Angelo Project in July 1946. This report set forth a plan for irrigating 12,000 acres of land. During the discussions of this plan with local interests and the Corps of Engineers in June and July 1946, the city of San Angelo requested that a portion of the conservation storage be reserved to furnish municipal and industrial water to the city. The investigations by the Bureau of Reclamation were then directed primarily toward determining the amount needed by the city and the water supply that would remain available for irrigation use.

In September 1954, the San Angelo Water Supply Corporation, acting for the city, asked the Bureau of Reclamation to reopen the investigations of the water resources potential of the Concho River to recognize recent local developments.

These studies proposed a dam and reservoir on Middle and South Concho Rivers at the Twin Buttes site that could offer virtually full regulation of the South and Middle Concho watershed above Nasworthy Reservoir. The reservoir would yield, when operated jointly with the O. C. Fisher Reservoir, sufficient water to meet all foreseeable municipal requirements and would provide water to irrigate 10,000 acres of land. On the basis of these findings, the project was authorized for construction.

Authorization

The project was authorized by Public Law 85-152 on August 16, 1957 (71 Stat. 372).

Construction

Construction of Twin Buttes Dam was begun in 1960 and completed in 1963. Construction on the Main Canal and laterals was done at the same time; all facilities were completed in 1963.

Following completion of construction, severe drought conditions prevailed in the Twin Buttes Dam watershed until April through August 1971, when above normal rains broke the drought and brought substantial inflow to Twin Buttes Reservoir. The storage amounts in the reservoir resulted in increased seepage below the dam. Studies of the seepage data resulted in a pilot grouting contract which was awarded in June 1976 and completed in March 1977. Additional foundation grouting is planned to control the foundation seepage as required.

BENEFITS

Irrigation

The San Angelo Project brings 10,000 acres of land under irrigation; however, because of the severe drought conditions experienced following completion of construction, it was not possible to start irrigating until March 1972, when the development period began. Following the development period, bringing irrigation water to project lands will increase the yield per acre and will increase the variety of crops that can be grown. Principal crops are cotton, alfalfa, grain sorghum, oats, pasture, and grain.

Municipal and Industrial Water

San Angelo has grown rapidly since 1940 and is the most important population center in the Concho River Basin. The San Angelo Project assures an adequate water supply for the city until the year 2010, based on estimated population growth.

Flood Control

The North and South Concho Rivers, which join in the city of San Angelo, have produced numerous floods that resulted in extensive damage. The floods have occurred primarily as high peak, flash floods and have not been subject to forecast. Twin Buttes Reservoir provides flood control storage capacity of 454,370 acre-feet plus surcharge capacity of 446,950 acre-feet for regulation of floodflows. This flood storage, combined with spillway and outlet works capacities, is sufficient to protect against an inflow design flood having a peak of 725,000 cubic feet per second and a 3-day volume of 825,000 acre-feet.

Streamflow regulation provided by the project reduces agricultural losses in crops, livestock, and farm improvements, minimizes land damage, and protects recreation facilities. Damage to urban and suburban property is reduced or eliminated.

Recreation and Fish and Wildlife

The arid, relatively barren nature of the area minimizes recreation opportunities. Consequently, surface-water impoundments suitable for fish and wildlife and for recreational uses make an important contribution. Twin Buttes Reservoir also will permit maintaining Nasworthy Reservoir at a relatively constant level, enhancing its recreation value.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	10,000	acres
Number of irrigated farms	120	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1972	8,049	474,685
1973	7,349	982,991
1974	6,500	882,896
1975	8,500	1,808,400
1976	9,000	1,791,147
1977	10,000	1,353,580

Facilities in Operation

Storage dams	1	
Canals	16	mi

Climatic Conditions

Annual precipitation	21	in
Temperature:		
Maximum	111	°F
Minimum	6	°F
Mean	65	°F
Growing season	234	days
Elevation of irrigable area	1820.0	ft

ENGINEERING DATA

Water Supply

South Concho and Middle Concho Rivers and Spring Creek drainage area above Twin Buttes Dam	2,472	mi²
Annual discharge:		
Maximum (1936)	489,600	acre-ft
Minimum (1952)	7,400	acre-ft
Average	88,200	acre-ft

Storage Facilities

TWIN BUTTES DAM

Type: Zoned earthfill
Location: On South and Middle Concho Rivers and Spring Creek, just upstream from their confluence, about 6 mi southeast of San Angelo, Tex.
Construction period: 1960-63
Reservoir, Twin Buttes:

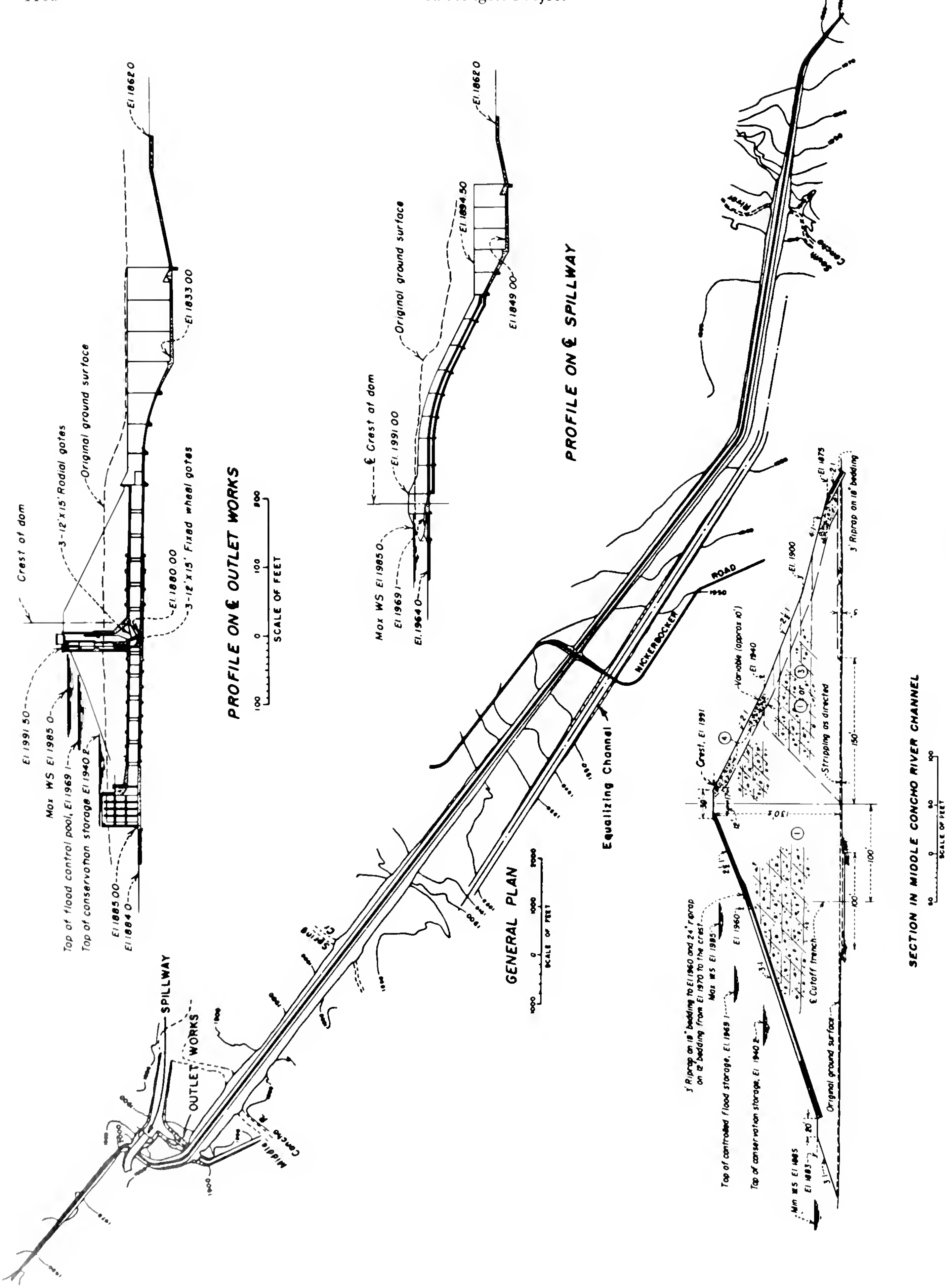
Dead capacity—Middle Concho River-Spring Creek arm, streambed to El. 1885	3,750	acre-ft
South Concho River arm, streambed to El. 1925	4,610	acre-ft
Active conservation capacity—El. 1885 to 1940.2	177,850	acre-ft
Exclusive flood control capacity—El. 1940.2 to 1969.1	454,370	acre-ft
Surcharge capacity—El. 1969.1 to maximum reservoir water surface at El. 1985	446,950	acre-ft
Total capacity at El. 1969.1	640,580	acre-ft
Surface area at El. 1969.1	23,508	acres
Dimensions:		
Structural height	134	ft
Top width	30	ft
Maximum base width	780	ft
Crest length	42,460	ft
Crest elevation	1991.0	ft
Total volume	21,442,000	yd³
Equalizing channel:		
Connects the South Concho River arm of the reservoir to the North Concho River-Spring Creek arm of the reservoir.		
Channel width	250	ft
Channel invert elevation	1925.0	ft
Spillway: Inlet channel, uncontrolled ogee weir, a chute with underlying drainage gallery, stilling basin and outlet channel, located near the left abutment.		
Crest length	200	ft
Crest elevation	1969.1	ft
Capacity at El. 1985, maximum water surface	47,300	ft³/s
Outlet works: Inlet channel, box-type inlet with trashracks, 3-barrel upstream pressure conduit with 15.5-ft-diameter circular tubes, gate chamber housing three 12- by 15-ft fixed-wheel gates and three 12- by 15-ft radial gates, gate structure rising from gate chamber and surmounted by a control house, downstream free-flow conduit with three 16-ft-diameter flat-bottomed tubes, chute, stilling basin, and outlet channel located near the left abutment. The fixed-wheel gates each contain a 2-ft-square regulating gate mounted within the larger gate for conservation releases.		
Capacity at El. 1940.2, top of conservation	25,000	ft³/s

Carriage Facilities

MAIN CANAL

Location: Headworks south of Nasworthy Dam to project lands east of San Angelo, Tex.
Construction period: 1961-63

Length	16	mi
Initial capacity	165	ft³/s
Typical maximum section, concrete lined:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	5	ft
Lining thickness	2.5	in

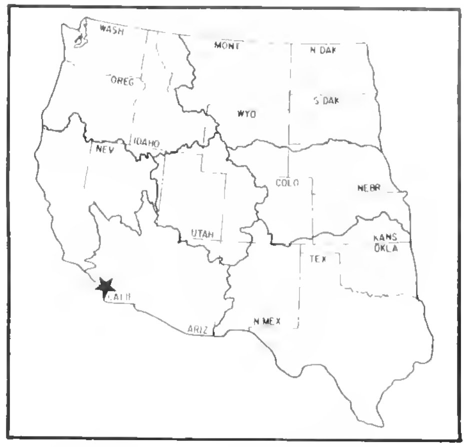


Twin Buttes Dam, Plan and Sections

San Diego Project

California: Riverside and San Diego Counties

Lower Colorado Region
Water and Power Resources Service



The San Diego Project consists of the First and Second San Diego Aqueducts. These two aqueducts, with two branch lines, make up the backbone of the San Diego County Water Authority System. The First Aqueduct consists of Pipelines 1 and 2, which extend from the Metropolitan Water District's Colorado River Aqueduct near San Jacinto, Calif., to the city of San Diego's San Vicente Reservoir, approximately 15 miles northeast of San Diego, Calif. Pipeline 1, designed by the Bureau of Reclamation, was constructed by the Navy Department to relieve the water supply emergency in San Diego County. Pipeline 2, roughly paralleling the first, was designed and constructed by the Bureau of Reclamation. The two pipelines share common tunnels and inverted siphons. They are operated as single units.

The Second Aqueduct consists of Pipelines 3 and 4. Although these pipelines are in common right-of-way for most of their length, they do not share any facilities south of Skinner Lake and are operated separately. Pipeline 3 extends from the Metropolitan Water District's Colorado River Aqueduct near Hemet, in Riverside County, to San Diego's Lower Otay Reservoir. Pipeline 4 terminates at San Diego's Alvarado Treatment Plant near Lake Murray. The Metropolitan Water District (MWD), of which the San Diego County Water Authority (Authority) is a constituent member, constructed the northerly 35 miles of the Second Aqueduct to a major delivery point of the Authority, located about 6 miles south of the Riverside-San Diego County line. The MWD owns and operates this section of the aqueduct. The Authority constructed the remaining 59 miles of the aqueduct, and owns and operates it.

The 12.5-mile Fallbrook-Ocean Branch originates from the First Aqueduct at Rainbow and extends to Morrow Reservoir. The La Mesa-Sweetwater Branch also originates from the First Aqueduct at Slaughterhouse Canyon, and extends through Lakeside and El Cajon to Sweetwater Reservoir.

A number of connecting pipelines have been constructed to provide flexibility in operating the system. One pipeline runs from the Second Aqueduct at Twin Oaks Valley to refill the First Aqueduct north of Escondido with untreated water after the agencies to the north have utilized the original capacity of the aqueduct. An interconnection upstream from Twin Oaks Valley permits transfer of flows between Pipeline 3 and Pipeline 4.

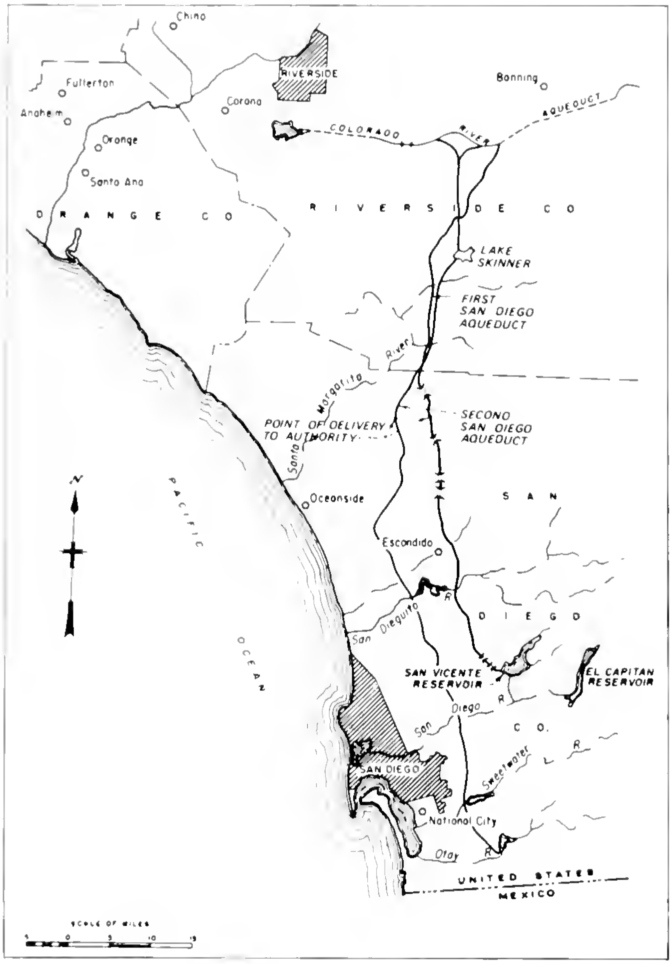
PLAN

The MWD of Southern California diverts water from the Colorado River at Lake Havasu and conveys it through the Colorado River Aqueduct to its terminus at Lake Mathews. Reach Five of the MWD Inland Feeder System comprises the First and Second San Diego Aqueducts. The four San Diego pipelines of the two aqueducts have a combined capacity of 826 cubic feet per second. Included in this reach of the inland feeder system is Lake Skinner, a regulating and storage reservoir, and the Robert A. Skinner Filtration Plant.

The MWD's San Diego Canal receives California State Water Project water from the Casa Loma Canal. Flow in the San Diego Canal is normally diverted into Lake Skinner and then routed to San Diego Pipelines 3 and 4 or into the Robert A. Skinner Filtration Plant through the outlet works. Water from Lake Skinner is routed directly into the filtration plant; treated water from the plant is diverted into San Diego Pipeline 3. Untreated water from the lake is diverted directly into Pipeline 4 after passing through the Auld Valley Control Structure. This structure controls the flow of water either from Lake Skinner, or directly from the San Diego Canal through the reservoir bypass pipeline. Lake Skinner has a total capacity of 44,000 acre-feet; its elevation is 1479.0 feet.

In 1977, the Skinner Filtration Plant, located near Lake Skinner, had a capacity of 150 million gallons per day. An expansion of the plant, scheduled for completion in 1979, will increase the capacity to 240 million gallons per day.

The San Jacinto Regulating Reservoir of the First San Diego Aqueduct was taken out of service on October 24, 1974, because of a requirement of the State of California Division of Safety of Dams. Water for Pipeline 2 was



San Diego Project

subsequently taken from Pipeline 1 at Rainbow Pass and Pipeline 1 receives water directly from the San Diego Canal at their crossing near San Jacinto.

No storage facilities are owned or operated by the Authority. However, it has contractual rights to store up to 40,000 acre-feet in San Diego's San Vicente Reservoir, terminus of the First Aqueduct. The Authority also has an agreement with the city of San Diego which permits storage of up to 2,500 acre-feet in Lower Otay Reservoir, terminus of Pipeline 3. Lake Jennings is used to store as much as 2,000 acre-feet, under terms of an agreement with Helix Water District. The Authority has agreements to store up to 1,800 acre-feet in the city of Escondido's Dixon Reservoir and 3,855 acre-feet in the Sweetwater Reservoir of the California American Water Company.

The First San Diego Aqueduct is about 70 miles long and water flows by gravity from an intake at elevation 1500 to the San Vicente Reservoir at elevation 760. The first 2 miles, the tunnels, and certain other sections not readily accessible were built to full capacity during construction of the first pipeline. The remaining sections, approximately 60 miles, compose a double pipeline. The separate pipelines are precast concrete pipe. The design capacity of the First San Diego Aqueduct is 196 cubic feet per second.

There are seven tunnels ranging in length from 500 to 5,700 feet. These tunnels, together with the diversion line to the regulating reservoir and the short reaches of full capacity pipeline, total about 14 percent of the length of the aqueduct.

The 94-mile-long Second San Diego Aqueduct flows by gravity from MWD's takeoff point to the Otay Reservoir through Pipelines 3 and 4. Pipeline 3 consists of a 500-cubic-foot-per-second, 16-mile canal. The remaining section, from Lake Skinner to its terminus, is composed of a combination of prestressed concrete pipe and steel pipe, and has an initial capacity of 250 cubic feet per second. At the Otay Reservoir, the pipeline's capacity is 144 cubic feet per second. Pipeline 4 is composed of 99-inch-diameter prestressed concrete pipe with an initial capacity of 380 cubic feet per second.

DEVELOPMENT

Early History

Over a period of years, the city of San Diego developed a domestic water supply by acquisition or construction of a number of dams. To obtain a dependable, uniform supply of water, the city contracted for storage in Lake Mead, the reservoir formed by Hoover Dam, of a quantity of water not to exceed 112,000 acre-feet annually. On October 2, 1934, the city entered into a contract with the Bureau of Reclamation which provided for the city's participation in construction of Imperial Dam and the All-American Canal under the Boulder Canyon Project Act. Under that contract, a capacity of 155 cubic feet per second in the All-American Canal was provided for the city.

On November 29, 1944, the President directed the Bureau of Reclamation to complete plans and specifications for a one-half capacity aqueduct for the MWD connection and directed the Navy's Bureau of Yards and Docks to perform the construction. In addition, the Bureau of Reclamation, with the Navy Department cooperating, was asked to construct additional works needed to bring the aqueduct to its ultimate capacity for carrying San Diego's allotted water.

A contract dated October 4, 1946, changed the point of delivery of Colorado River water to which San Diego had contractual rights from Imperial Dam to Parker Dam. Under a contract dated October 4, 1946, San Diego assigned its Colorado River water rights to the MWD.

On December 17, 1947, the San Diego County Water Authority was formally annexed to the MWD of Southern California, thereby becoming entitled to Colorado

River water from the MWD system for distribution to the Authority's member agencies in San Diego County.

When construction was completed in 1947 and Pipeline 1 of the First Aqueduct was placed in operation, the San Diego County Water Authority recommended that the aqueduct immediately be enlarged to full capacity to safeguard the area from critical water shortages. The Bureau of Reclamation was requested to make the necessary survey and reports. In January 1951, a report was submitted which proposed the enlargement of the aqueduct to full capacity by the addition of Pipeline 2 to the conduit of the same capacity as that previously designed and constructed. The Authority selected the parallel location as recommended for Pipeline 2.

In 1956, the California State Legislature appropriated funds for a study to determine the most practical route by which Northern California water might be brought into San Diego County. The report recommended that a canal section, about 30 miles long, with a capacity of 1,000 cubic feet per second, be constructed as the northerly portion of the aqueduct, beginning at the west portal of the San Jacinto Tunnel of MWD's Colorado River Aqueduct and extending to the vicinity of Auld Valley in Riverside County. The remainder of the proposed aqueduct, beginning at the end of the canal, was recommended to have a capacity ranging from 432 cubic feet per second at the upper end to 98 cubic feet per second at the terminus at Otay Reservoir. In January 1957, the Authority adopted the route of the Second San Diego Aqueduct, as recommended by the State.

The State of California commenced construction of the Second San Diego County Feeder Line, which is the northerly portion of the Second San Diego Aqueduct, from the West Portal of the San Jacinto Tunnel to a delivery point and connection to the Authority's system, located about 6 miles south of the Riverside-San Diego County line. The district adopted a canal capacity of 500 cubic feet per second instead of the 1,000 cubic feet per second recommended by the State and a pipeline capacity of 250 cubic feet per second instead of the 432 cubic feet per second recommended by the State.

It was recognized in the 1950's that additional water supply sources for the Southern California area would be required by the early 1970's. On November 4, 1960, the MWD entered into a contract with the State of California for 1,500,000 acre-feet annually from the State Water Project. As a result of the United States Supreme Court decision in the case of Arizona v. California, MWD was subject to the loss of about half its 1,212,000 acre-feet entitlement from the Colorado River. In view of this condition, the MWD-State of California contract was amended to increase MWD entitlement to State water to 2,011,500 acre-feet per year.

The California Aqueduct, the key feature of the State Water Project, was dedicated on May 18, 1973. The terminal storage reservoir of the California Aqueduct is Lake Parris.

Investigations

In May 1943, the Bureau of Reclamation was requested to investigate feasibility of a conduit connecting the west end of the San Jacinto Tunnel on MWD's Colorado River Aqueduct to the San Diego area, and a conduit connecting the All-American Canal to the San Diego area. A preliminary report on these investigations was submitted by the Bureau of Reclamation in September 1944. In 1945, an interdepartmental committee was appointed by the President of the United States to study the water supply of the City of San Diego and to recommend a plan for securing a supplemental supply. The report of the President's Committee was published as Senate Document No. 249, 78th Congress, 2d session. Recommended in the report was the immediate construction by the Government of an aqueduct connecting with the Colorado River Aqueduct near San Jacinto.

Investigations leading to the preparation of a feasibility report by the Bureau of Reclamation on the San Diego Project, Metropolitan Connection Enlargement (Pipeline 2 of the First San Diego Aqueduct), September 1951, were made and construction of Pipeline 2 began on March 23, 1953.

On February 9, 1956, the Authority proceeded with preliminary plans for the construction of the Second San Diego Aqueduct. The State of California provided funds for investigations to determine the most practical route by which Feather River water might be brought into San Diego County and delivered to the Authority.

The 1956 California State Legislature appropriated funds and instructed the Department of Water Resources to make detailed studies to determine the most feasible route by which Feather River water could be brought into San Diego County and delivered to the Authority for distribution. On January 15, 1957, the Authority approved the report on these investigations and proceeded with construction plans and specifications for Pipeline 3 of the Second San Diego Aqueduct.

On September 18, 1956, the MWD initiated the preparation of plans and specifications for construction of the Second San Diego County Feeder Line, which is the northerly portion of the Second Aqueduct.

In June 1966, the Authority contracted with MWD to provide engineering services on the Parris to Costa Loma Aqueduct and Pipeline 4 of the Second Aqueduct. At the end of the year, the first reach of MWD's section of the pipeline was under construction, and the Authority was in the process of making preliminary investigations of its section of Pipeline 4. In May 1968, the Authority commenced the final designs of its portion of Pipeline 4.

Authorization

Construction of the initial portion of the aqueduct was authorized by the President on November 29, 1944, as a wartime expedient, and ratified by the Congress on April 15, 1948.

The 82d Congress authorized the construction of the second barrel of the San Diego Aqueduct by the Secretary of the Navy under Public Law 171, on October 11, 1951.

On June 7, 1966, voters throughout Metropolitan Water District and San Diego County approved bond issues which provided authorization and funds for the construction of the Second San Diego Aqueduct. Under this authorization, construction of the Second San Diego Aqueduct was accomplished by MWD and the Authority.

Construction

Construction of Pipeline 1 of the First Aqueduct by the Navy began in 1945 and was completed in 1947. Pipeline 2 was constructed by the Bureau of Reclamation during 1952-54. Construction of the Second Aqueduct began in 1957. The MWD section of Pipeline 3 was completed in May 1960, and the Authority's section in November 1960. Construction of the MWD section of Pipeline 4 of the Second Aqueduct started 1968 and was completed in 1971. The Authority started construction of its section of Pipeline 4 in 1969. Construction of the first three phases was completed in 1973. Construction of the fourth phase of the pipeline is scheduled for completion in 1979.

Operating Agencies

The San Diego County Water Authority is responsible for the operation and maintenance of the First and Second Aqueducts south from MWD's point of delivery. MWD is responsible for the operation and maintenance of the aqueducts north of the delivery point.

BENEFITS

The Colorado River Aqueduct supplies more than 90 percent of all the water used in San Diego County. Over 98 percent of the population of San Diego County, which exceeds 1.6 million people, live within the Authority service area. The total water supply of the Authority comes through the facilities of the First and Second San Diego Aqueducts. The system provides a means for importing water for municipal, domestic, and other beneficial uses.

ENGINEERING DATA

Water Supply

The MWD obtains water for distribution to its member agencies from two sources. The Colorado River Aqueduct, owned and operated by the MWD, transports water from the Colorado River to its terminus at Lake Mathews. In 1978, the MWD was entitled to 1,212,000 acre-feet per year from this source. With the completion of the Central Arizona Project in the 1980's, this entitlement would be reduced to 550,000 acre-feet per year. MWD's second source of water is the State Water Project, which is owned and operated by the California State Department of Water Resources. Water from this source is transported from the delta at the confluence of the Sacramento and San Joaquin Rivers to an MWD delivery point. The district's ultimate contractual entitlement from the State is 2,011,500 acre-feet per year.

State Water Project water is transported from the State's system through Reach 4 of the Inland Feeder System which extends from the Parris Control Facility to the Casa Loma area in San Jacinto Valley. Connections at Casa Loma permit delivery of water from the Inland Feeder directly into the San Diego Canal or into the Colorado River Aqueduct. The San Diego Canal transports State Project water as well as Colorado River water to Lake Skinner, from which deliveries are made to MWD's member agencies in southern Riverside County and San Diego County via the San Diego pipelines.

Supplies for San Diego County Authority are diverted from MWD's Colorado River Aqueduct near the west portal of San Jacinto Tunnel into the First San Diego Aqueduct (Pipelines 1 and 2). Pipelines 1 and 2 enter and traverse San Diego County without going through any other major MWD facilities. The San Diego Canal, which received California State Water Project water from the Casa Loma Canal, terminates at Lake Skinner. A portion of the water from Lake Skinner flows directly into Pipeline 4, while another part is processed through the Skinner Filtration Plant before entering Pipeline 3. This operational procedure may be reversed in the future.

California State Water Project water is blended with Colorado River water at the Casa Loma Turnout as both supplies flow south in the San Diego Canal to Lake Skinner.

Storage Facility

LAKE SKINNER (AULD VALLEY RESERVOIR)

Type of dam: Earthfill
Location: In Auld Valley, Riverside County, about 8 mi south of Winchester at the southerly end of the San Diego Canal.

Construction period: Constructed by MWD - 1970-72
Date of first storage: April 16, 1973
Reservoir, Lake Skinner:

Total capacity	44,000	acre-ft
Dimensions:		
Structural height	100	ft
Crest length	5,280	ft
Crest elevation	1479.0	ft

Carriage Facilities

San Diego Aqueduct

Description: Consists principally of two parallel reinforced concrete pipelines. Includes 3.6 mi of steel pipeline (total in both pipelines), and 9.7 mi of single pipeline (full capacity) and tunnels.
Location: From the end of the San Jacinto Tunnel of the Colorado River Aqueduct (MWD of Southern California) near San Jacinto, Calif., south to San Vicente Reservoir, about 15 mi northeast of San Diego, Calif.
Construction period: 1945-47 (Pipeline 1), 1952-54 (Pipeline 2)

Length	71.1	mi
Diameter	96-48	in
Design capacity of the First Aqueduct (includes Pipelines 1 and 2)	196	ft³/s

Second San Diego Aqueduct (Pipeline 3 - MWD Section)

Description: Consists of 16 mi of open canal that discharges blended Colorado River and California State Water Project water into Lake Skinner and 19.3 mi of 72-in-diameter pipe from the Robert A. Skinner Filtration Plant to the Authority's delivery point.
Location: Extends from the Colorado River Aqueduct, near San Jacinto, to about 6 mi inside San Diego County, the MWD point of delivery to the Authority.
Construction period: 1957-60

Length:[1]		
Open canal	16	mi
Pipeline	19.3	mi
Diameter	72	in
Capacity:		
Open canal	500	ft³/s
Pipeline	250	ft³/s

Second San Diego Aqueduct (Pipeline 3 - Authority's Section)

Description: The first 10.6 mi of the pipeline, extending from MWD's delivery point to the Twin Oaks Vent about 5 mi north of San Marcos, consists of 72- and 75-in-diameter steel pipe. In reaches of the pipeline where heads exceed 600 ft, the pipe was cement-mortar lined and coated. The reach of the pipe from Twin Oaks Vent to Black Mountain Vent, 18.2 mi, is 75-, 72-, 69-, and 66-in prestressed concrete pipe and cement-mortar coated and lined steel pipe.

[1]Total length of Pipeline 3 is about 94 mi; about 35 mi are owned and operated by MWD.

Location: Extends from the MWD delivery point to the terminal structure at Lower Otay Reservoir.
Construction period: 1957-60

Length	59	mi
Diameter:		
MWD's delivery point to Twin Oaks (10.6 mi)	72-75	in
Twin Oaks to Black Mountain (18.2 mi)	66, 69, 72, 75	in
Capacity:		
MWD delivery point to Miramar Reservoir (34 mi)	250-175	ft³/s
Miramar Reservoir to Otay Reservoir (25 mi)	157-144	ft³/s

Second San Diego Aqueduct (Pipeline 4 - MWD's Section)

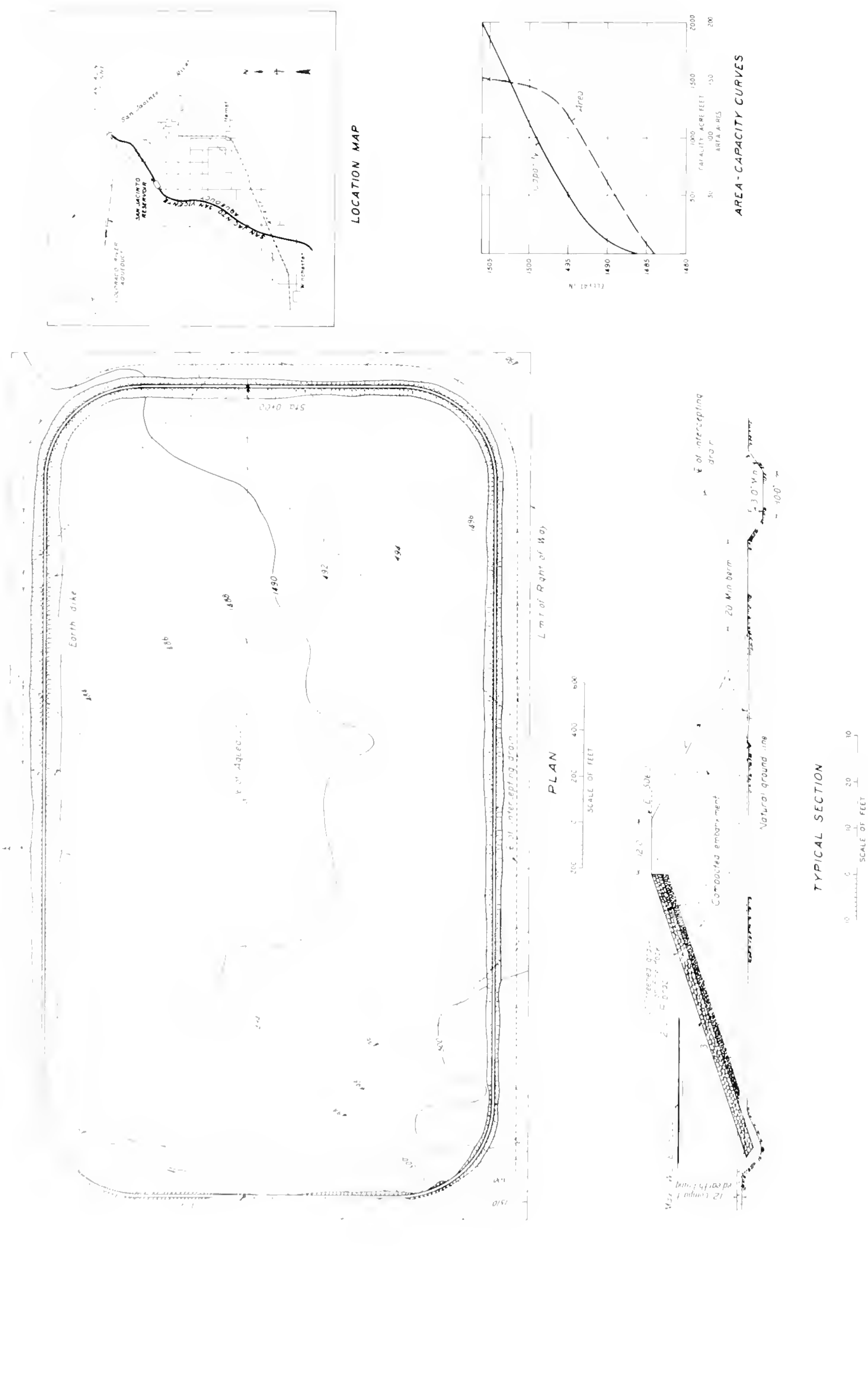
Description: The pipeline in the first reach of MWD's section consists of 9.5 mi of 99-in-inside-diameter, prestressed concrete cylinder pipeline. The second reach consists of 9.8 mi of 89-in-inside-diameter, mortar-lined and coated, welded-steel pipe.
Location: The first reach of the MWD's section of Pipeline 4 starts at Lake Skinner, where it receives water either from the lake or from the end of the San Diego Canal near Auld Valley and extends 9.5 mi south to the town of Temecula. The second reach starts at a point south of U.S. Highway 395, near Temecula, and extends to the Authority's delivery point about 9.8 mi south of the Riverside-San Diego County line.
Construction period: 1968-69 (first reach), 1969-71 (second reach)

Total length	19.3	mi
Diameter:		
Auld Valley to Temecula	99	in
Temecula to delivery point	88	in
Capacity	380	ft³/s

Second Aqueduct (Pipeline 4 - Authority's Section)

Description: Pipeline 4 was constructed in four phases. Phase I consists of 10.6 mi of 88-in-prestressed concrete pipe. Phase II is composed of 11.23 mi of 96-in-mortar-lined and coated, welded-steel pipe. Phase III consists of 12 mi of 96-, 72-, and 69-in prestressed concrete pipe. Phase IV consists of 6.59 mi of 84-, 72-, and 54-in prestressed concrete cylinder pipe.
Location: Phase I extends from Rainbow to the Crossover Aqueduct diversion structure near San Marcos. Phase II, from the Crossover Aqueduct to Escondido Mountain. Phase III, from Escondido Mountain to Miramar Reservoir. The Pomerade Pipeline (Phase IV) includes an extension of Pipeline 4 from Miramar Reservoir to Shepherd Canyon and a section of pipeline in shepherd Canyon to the intersection of Clairemont Mesa Boulevard and Santo Road in San Diego.
Construction period: First 3 phases, 1969-73. Phase IV extension, 1979.

Length	40.42	mi
Diameter:		
Phase I	88	in
Phase II	96	in
Phase III (varies)	96, 72, 69	in
Phase IV (varies)	84, 72, 54	in

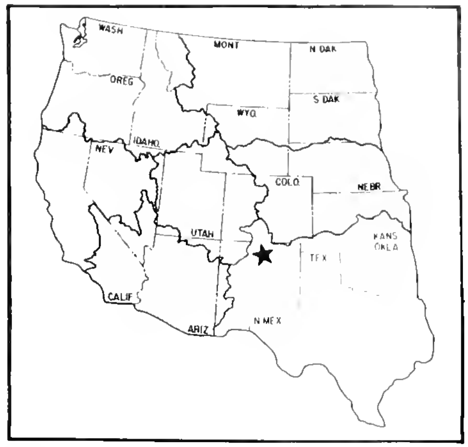


San Diego Project. Plan and Sections

San Juan-Chama Project

Colorado: Archuleta and Mineral Counties
New Mexico: Rio Arriba and Santa Fe Counties

Southwest Region
Water and Power Resources Service



The San Juan-Chama Project, authorized as a participating project of the Colorado River Storage Project, provides an average annual diversion of about 110,000 acre-feet of water from the upper tributaries of the San Juan River for use in the Rio Grande Basin, New Mexico.

The additional water is used for municipal, domestic, and industrial purposes: In the city of Albuquerque, 48,200 acre-feet; city and county of Santa Fe, 5,605 acre-feet; city of Los Alamos, 1,200 acre-feet; village of Los Lunas, 400 acre-feet; Twining Water and Sanitation District, 15 acre-feet; and city of Espanola, 1,000 acre-feet. Supplemental water is provided for irrigation of 89,711 acres in the Middle Rio Grande Conservancy District and 2,768 acres in the Pojoaque Valley Irrigation District. An annual allocation of 5,000 acre-feet of water is made available for fish and wildlife and recreation purposes at Cochiti Reservoir (a Corps of Engineers Project). There is an allocated but as yet uncontracted supply of 18,450 acre-feet.

PLAN

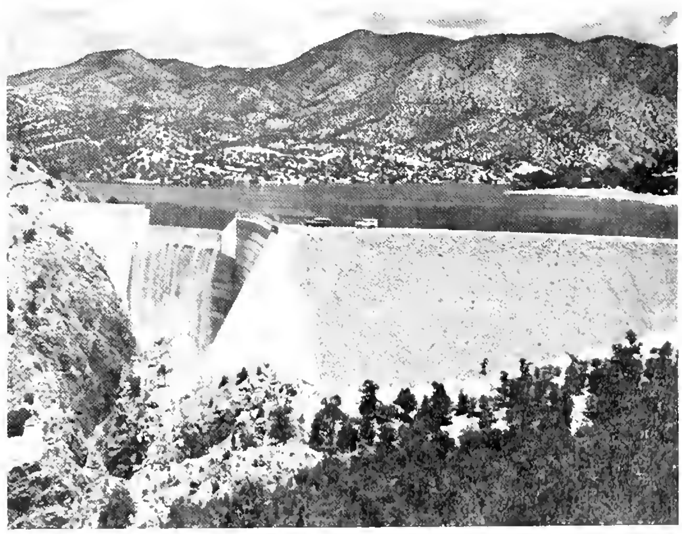
Blanco Diversion Dam on Rio Blanco diverts water to the Blanco Feeder Conduit, a closed conduit of 520 cubic feet per second capacity which conveys the water to Blanco Tunnel. Blanco Tunnel is a concrete-lined structure with 520 cubic feet per second capacity to carry water 8.64 miles from Rio Blanco to Little Navajo River. Little Oso Siphon, a concrete siphon with a capacity of 520 cubic feet per second, carries water under Little Navajo River to Oso Tunnel. Little Oso Diversion Dam on the Little Navajo River upstream from the Little Oso Siphon diverts water from the Little Navajo River through the Little Oso Feeder Conduit, a closed conduit with a capacity of 150 cubic feet per second, to the Oso Tunnel.

The Oso Tunnel is a concrete-lined structure with a capacity of 550 cubic feet per second and a length of 5.05 miles. It carries water from Little Navajo River to Navajo River. The 550-cubic-foot-per-second Oso Siphon conveys water under the Navajo River when the Oso Diversion Dam diverts water to the Oso Feeder Conduit. This conduit, with a capacity of 650 cubic feet per second, extends from Oso Diversion Dam to Azotea Tunnel.

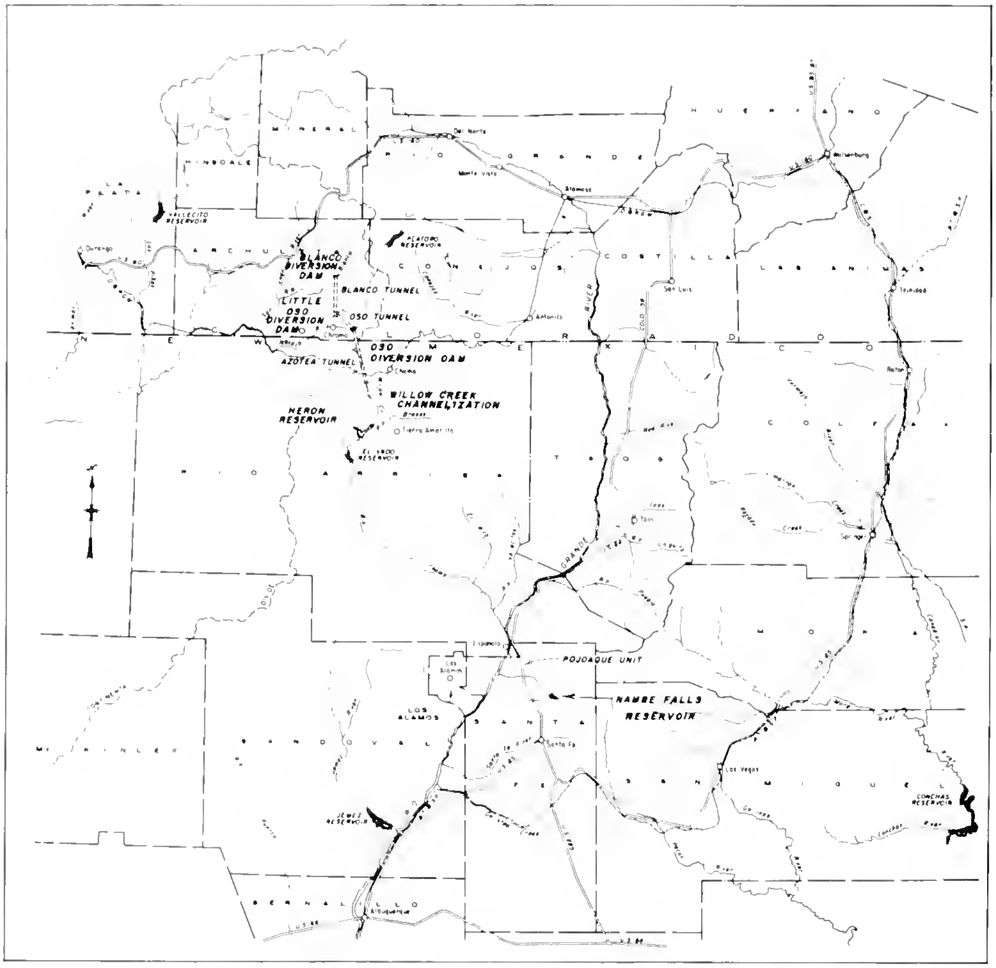
The 12.8-mile-long concrete-lined Azotea Tunnel, with a capacity of 950 cubic feet per second, conveys water from Navajo River to Azotea Creek in the Rio Grande Basin. These imported waters flow down Azotea and Willow Creeks 11.78 river miles to Heron Reservoir.

The regulating and storage reservoir is formed by Heron Dam on Willow Creek just above the point where Willow Creek enters the Chama River. The dam is an earthfill structure 275 feet high which forms a reservoir with a capacity of 401,320 acre-feet and a surface area of 5,950 acres. The spillway has a capacity of 660 cubic feet per second, and the outlet works has a capacity of 4,160 cubic feet per second.

The outlet works for El Vado Dam were enlarged in 1965-66 so that San Juan-Chama Project releases from Heron Reservoir could be passed unimpeded through El Vado Reservoir. The capacity of the outlet works is 6,600 cubic feet per second.



Nambe Falls Dam



San Juan-Chama Project

Nambe Falls Dam and storage reservoir provide supplemental irrigation water for the Pojoaque Valley Irrigation District and Indian pueblos of San Ildefonso, Nambe, and Pojoaque. The dam is a concrete and earth embankment structure 150 feet high which forms a reservoir with a capacity of 2,023 acre-feet.

DEVELOPMENT

Early History

Through prehistoric Indian activity at Sandia Cave northeast of Albuquerque, pueblo communities established before 600 A.D., Spanish settlement in 1598, and the homesteading development in the late 1840's, the Rio Grande Valley has accommodated and nurtured man. The waters provided by the San Juan-Chama Project flow to the descendants of these cultures, helping to continue the varied lifestyles represented.

Along the upper San Juan River drainage, the project's water source, a similar settlement pattern, with variations, developed. A desert culture base underlay the Anasazi development, but climatic conditions and the influx of the ancestors of the modern Navajo and Ute Indians limited pueblo development. Spanish exploration in the area is known as early as the search for gold in 1765, with settlement later in the century. Reports by trappers in the 1820's brought prospectors and miners, and eventually permanent settlers.

Investigations

Studies of the possibility of diverting San Juan River Basin waters into the Rio Chama, a tributary of the Rio Grande, began immediately following the first World War, but surveys of the features involved began in 1933, with the Bunger Survey. This survey was resumed in 1936, as a part of the Rio Grande Joint Investigations, to determine the need for the project.

The investigations established the basis for recognizing, in the Rio Grande Compact, the possibility of a transmountain diversion to bring water from the San Juan River into the Rio Grande Basin. The Colorado River Basin report, issued by the Bureau of Reclamation in 1946, established the quantity of water that was considered for the transmountain diversion during the negotiation of the Upper Colorado River Basin Compact.

In 1950, in the interest of coordination, the Secretary of the Interior appointed a committee known as the San Juan River Technical Committee. A summary report was prepared in May 1950, and the committee presented progress reports in 1951 and 1952.

Field work on the San Juan-Chama Project was resumed at the beginning of 1951, and interim reports were prepared by the Bureau of Reclamation through 1955, when a feasibility study was prepared. This study was supplemented in 1957 and was followed by authorization of the project. Volume 1 of the definite plan report, covering the diversion and regulation elements of this project, was approved on August 10, 1964.

Construction

Construction of Azotea Tunnel began on April 22, 1964, and was completed on November 11, 1970. Other construction included Blanco Diversion Dam and Tunnel, awarded on May 11, 1965, and completed May 22, 1969; Little Oso and Oso Diversion Dams and Oso Tunnel, awarded on February 1, 1966, and completed on November 11, 1970; Azotea Creek Channelization, awarded on August 14, 1967, and completed on December 6, 1968; Willow Creek Channelization, awarded on March 20, 1969, and completed on August 2, 1970; Heron Dam and relocation of State Highway 95, awarded August 8, 1967, and completed June 9, 1971.

Construction also included the enlargement of the outlet of existing El Vado Dam so Heron Reservoir releases could be bypassed through El Vado Reservoir. The contract was awarded on July 22, 1965, and completed December 29, 1966.

Construction of Nambe Falls Dam, first part of the tributary irrigation element, was awarded on June 13, 1974, and completed June 28, 1976. Additional construction may be required for other irrigation units.

BENEFITS

The project provides a supplemental water supply for various communities, supplemental supply for irrigation, and substantial fish and wildlife and recreation benefits have been created at Heron and Nambe Falls Reservoirs and at Cochiti Reservoir.

PROJECT DATA

Land Areas (1977)

Irrigable area, initial authorization:		
Full irrigation service	2,768	acres
Supplemental irrigation service	89,711	acres
Total	92,479	acres

Climatic Conditions

Annual precipitation	8-30	in
Temperature:		
Maximum	105	°F
Minimum	−30	°F
Growing season	141-208	days
Elevation of irrigable area:		
Rio Grande	4500-5200.0	ft
Tributary irrigation units	5600-8000.0	ft

ENGINEERING DATA

Storage Facilities

HERON DAM

Type: Earthfill		
Location: On Willow Creek immediately at its confluence with Rio Chama about 9 mi west of Tierra Amarilla, N. Mex.		
Construction period: 1967-71		
Reservoir, Heron:		
Storage capacity	401,320	acre-ft
Active capacity to El. 7190.8	399,980	acre-ft
Surface area	5,950	acres
Dimensions:		
Structural height	275	ft
Top width	40	ft
Maximum base width	1,535	ft
Crest length	1,220	ft
Crest elevation	7199.0	ft
Total volume	3,031,121	yd³
Spillway: (part of Heron Dike)		
Outlet works: Concrete intake structure to Rio Chama controlled by four 4- by 6-ft outlet gates and one 12-in jet-flow gate.		
Maximum discharge capacity	4,160	ft³/s

HERON DIKE

Type: Earthfill		
Location: 1 mi northwest of Heron Dam.		
Construction period: 1967-71		
Dimensions:		
Structural height	94	ft
Top width	30	ft
Maximum base width	390	ft
Crest length	2,405	ft
Crest elevation	7199.0	ft
Total volume	421,192	yd³
Spillway: On left abutment, consisting of an approach channel, concrete crest structure at El. 7190.8, and an open 500-ft-long chute.		
Discharge capacity	660	ft³/s

NAMBE FALLS DAM

Type: Prestressed concrete thin-arch dam, concrete thrust block, and a curved axis earth fill embankment		
Location: On the Rio Nambe 25 mi north of Santa Fe, N. Mex.		
Construction period: 1974-76		
Reservoir, Nambe Falls:		
Total capacity to El. 6826.6	2,023	acre-ft
Active capacity	1,665	acre-ft
Surface area	59	acres
Dimensions — concrete arch dam:		
Structural height	150	ft
Top width	5	ft
Maximum base width	15	ft
Crest length	320	ft
Crest elevation (without camber)	6840.0	ft

Dimensions — thrust block:

Structural height	108	ft
Structural width	78.5	ft
Structural length	280	ft

Dimensions — earth embankment dam:

Structural height	144	ft
Top width	25	ft
Maximum base width	289	ft
Crest length	673	ft
Crest elevation	6844.0	ft
Volume	200,000	yd^3

Spillway: Uncontrolled concrete crest in arch of dam.

Crest length	110	ft
Crest elevation	6826.6	ft
Capacity at El. 6826.6	2,023	ft^3/s

Outlet works: Two 14-in and one 6-in jet-flow gates.

Diversion Facilities

Blanco Diversion Dam

Type: Concrete ogee weir, with embankment wings
Location: On the Rio Blanco about 16 mi southeast of Pagosa Springs, Colo.
Year completed: 1969
Dimensions:

Structural height	41	ft
Hydraulic height	17.9	ft
Crest length	200	ft
Crest elevation	7867.0	ft
Volume	23,360	yd^3

Spillway: Concrete overflow
Headworks: One 3-ft-square and one 30-in-square motor-operated slide gate; one 16-by 7-ft and one 5- by 17-ft motor-operated radial gate.

Little Oso Diversion Dam

Type: Concrete ogee weir
Location: On the Little Navajo River about 3 mi northeast of Chromo, Colo.
Year completed: 1970
Dimensions:

Height above streambed	16.2	ft
Hydraulic height	14.3	ft
Crest length	295	ft
Crest elevation	7756.6	ft
Volume	7,400	yd^3

Spillway: Concrete overflow
Headworks: One 24-in-square and one 72-in-square motor-operated slide gate.

Oso Diversion Dam

Type: Concrete ogee weir with embankment wings
Location: On the Navajo River about 6 mi east of Chromo, Colo.
Year completed: 1970
Dimensions:

Structural height	51	ft
Hydraulic height	23.5	ft
Crest length	790	ft
Crest elevation	7677.7	ft
Volume	32,100	yd^3

Spillway: Concrete overflow
Headworks: One 36-in-square, one 48-in-square, and one 72-in-square motor-operated slide gate and one 13- by 10-ft motor-operated radial gate.

Carriage Facilities

Blanco Tunnel

Location: Rio Blanco southerly to Little Navajo River.
Construction period: 1965-69

Length	8.64	mi
Capacity	520	ft^3/s
Cross section: Circular	103	in
Diameter lining: Unreinforced concrete	6.5	in

Oso Tunnel

Location: Little Navajo River southeasterly to Navajo River.
Construction period: 1966-70

Length	5.05	mi
Capacity	550	ft^3/s
Cross section: Circular	103	in
Diameter lining: Unreinforced concrete	6.5	in

Azotea Tunnel

Location: From Navajo River southeasterly and under the Continental Divide to Azotea Creek.
Construction period: 1964-70

Length	12.8	mi
Capacity	950	ft^3/s
Cross section: Circular	131	in
Diameter lining: Unreinforced concrete	8	in

Little Oso Siphon

Location: Between Blanco and Oso Tunnels—carries water under the Little Navajo River.
Construction period: 1966-70
Type: Precast concrete pipe

Length	345	ft
Diameter	96	in
Capacity	520	ft^3/s

Oso Siphon

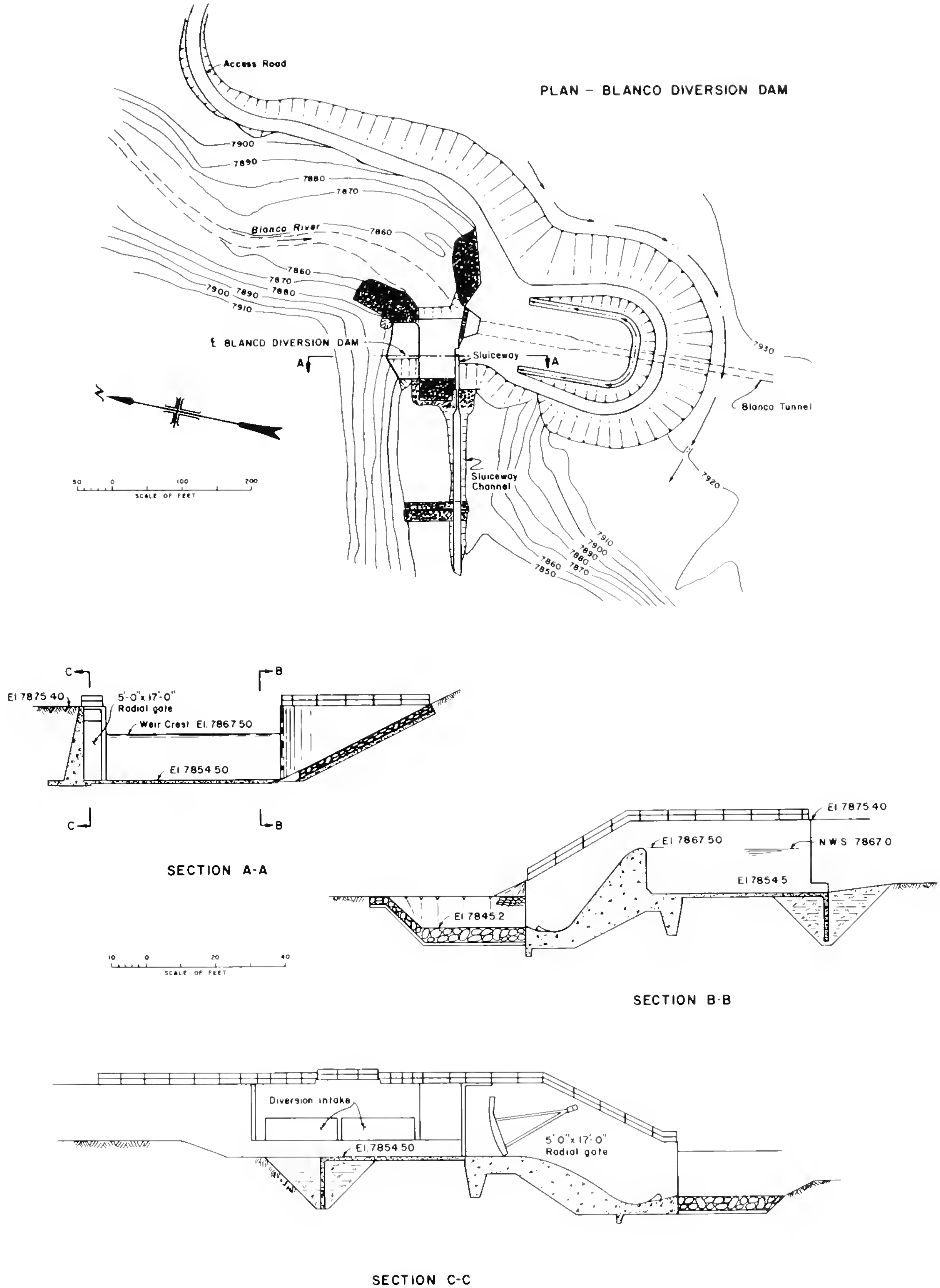
Location: Between Oso Tunnel and Azotea Tunnel—carries water under the Navajo River.
Construction period: 1966-70
Type: Precast concrete pipe

Length	899	ft
Diameter	96	in
Capacity	550	ft^3/s

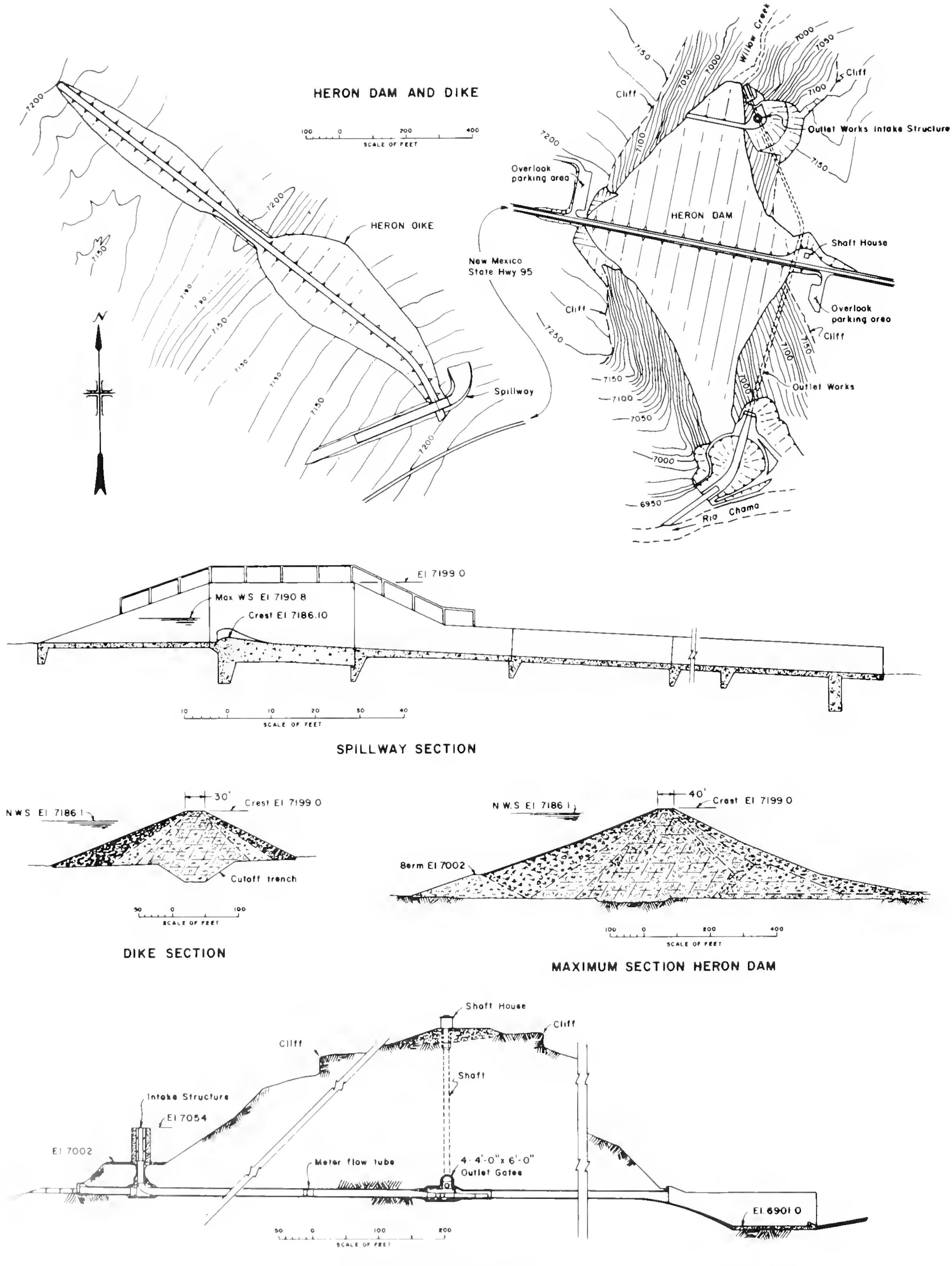
Azotea Creek and Willow Creek Conveyance Channels

Location: Southwest of Chama, N. Mex. on Azotea Creek between outlet of Azotea Tunnel and confluence of Willow Creek and along Willow Creek to the head of Heron Reservoir.
Type: Open channel with three baffled concrete drop structures

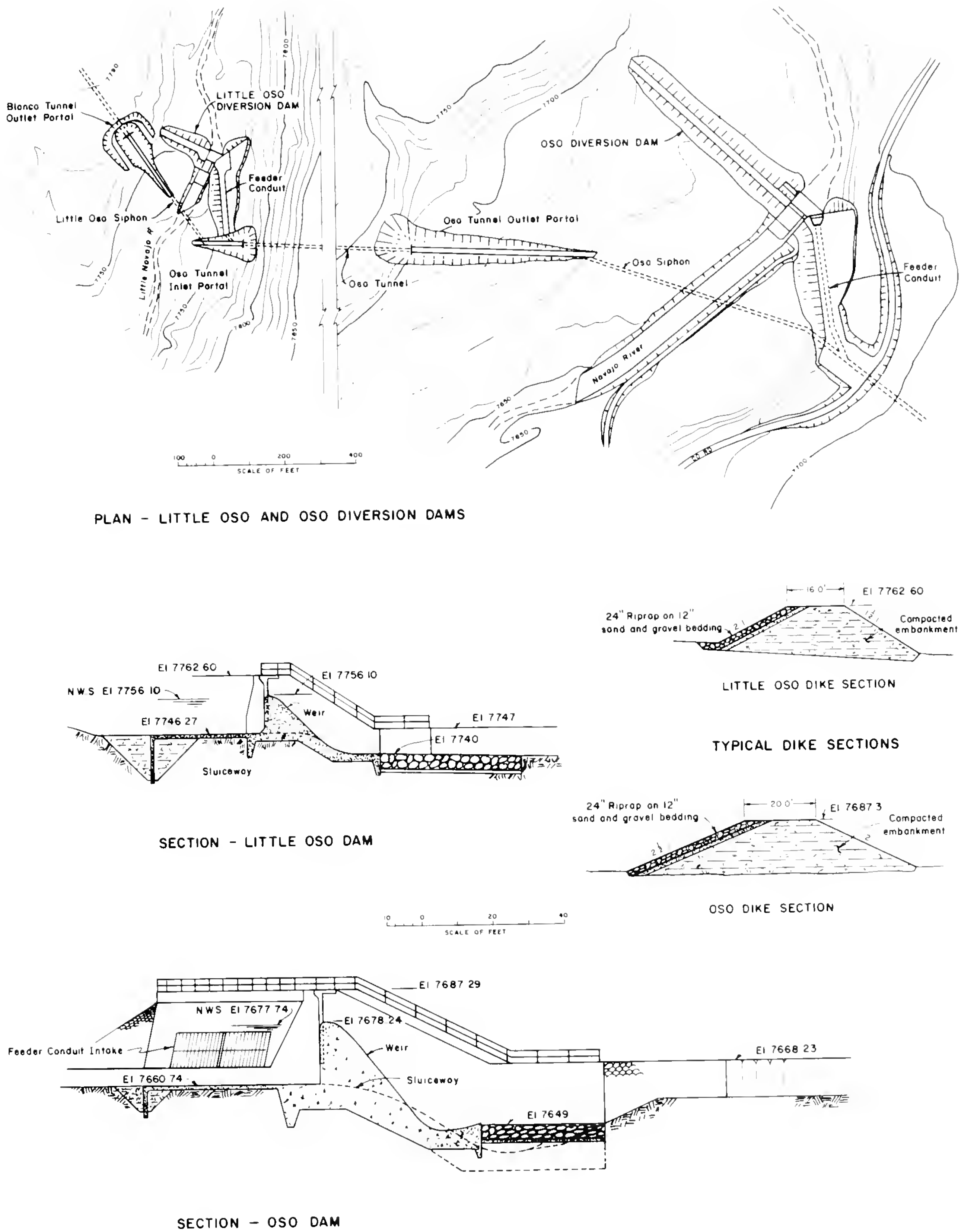
Length	11	mi
Width	28-65	ft
Side slopes	2:1	



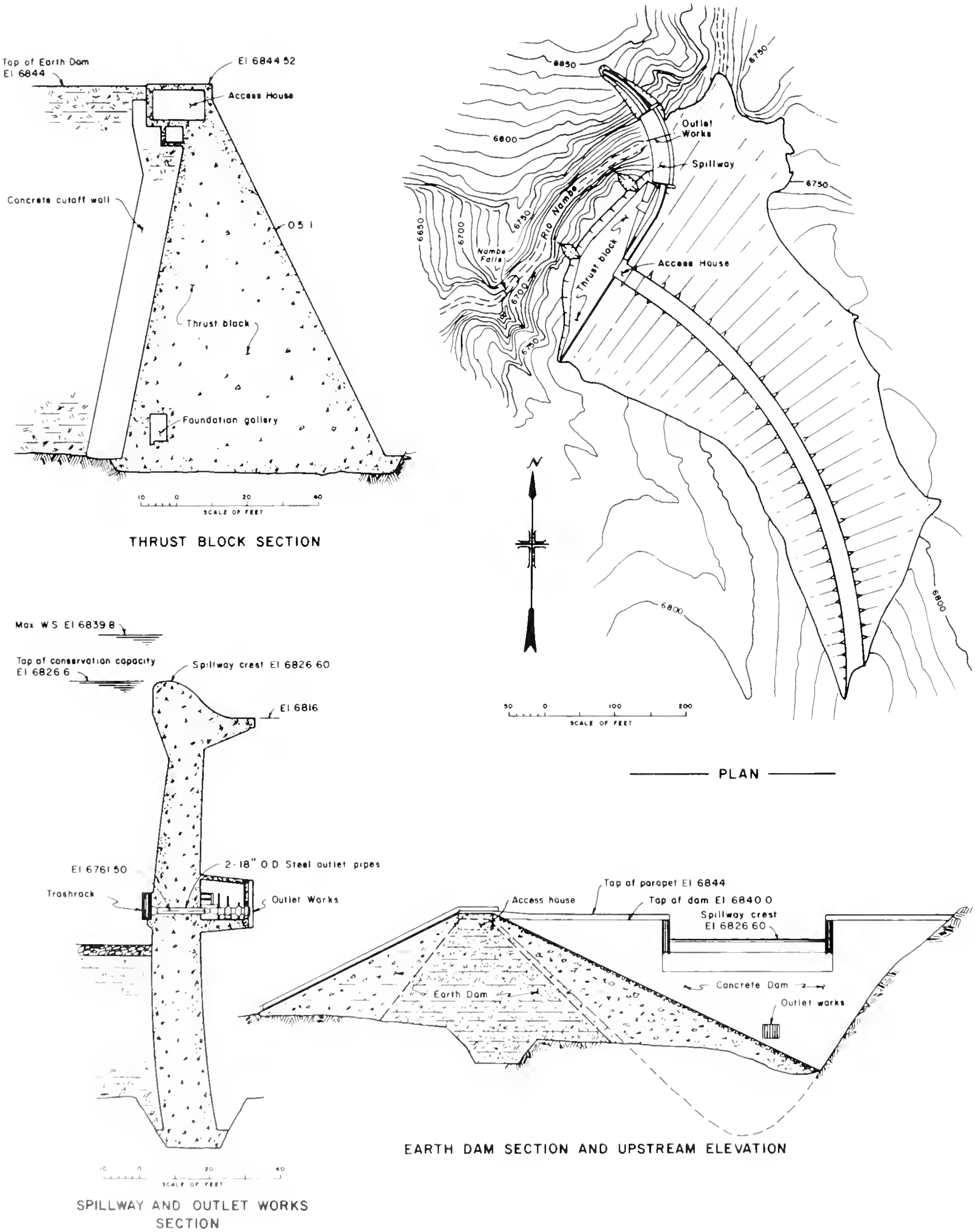
Blanco Diversion Dam, Plan and Sections



Heron Dam, Plan and Sections



Oso Dams, Plans and Sections

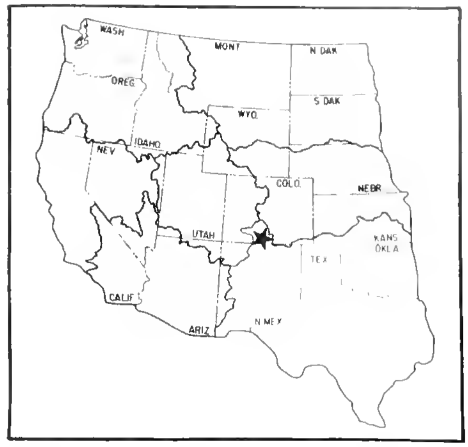


Nambe Falls Dam, Plan and Sections

San Luis Valley Project

Colorado: Alamosa, Conejos, Costilla, Rio Grande, and Saguache Counties

Southwest Region
Water and Power Resources Service



The San Luis Valley Project is in the south-central portion of the State of Colorado. The authorized project includes the Conejos Division, which regulates the water supply for 81,000 acres of land irrigated in the Conejos Water Conservancy District, and the Closed Basin Division, which would salvage shallow ground water now being lost to evapotranspiration in the Closed Basin of San Luis Valley and deliver it to the Rio Grande for beneficial use in accordance with the Rio Grande Compact among the States of Colorado, New Mexico, Texas, and the Treaty of 1906 with the Republic of Mexico. A small amount of water would be made available to the Alamosa National Wildlife Refuge. The Conejos Division included the construction of Platoro Dam and Reservoir, which was completed in 1951. The Closed Basin Division is in the advance planning stage.

PLAN

Platoro Dam stores floodwaters of the Conejos River, a tributary of the Rio Grande, for release when the normal flow falls below irrigation requirements. The plan includes no diversion or distribution works because the existing facilities of the district are adequate.

The Closed Basin Division facilities will deliver into the Rio Grande that water now being lost to evapotranspiration within the Closed Basin.

Platoro Dam and Reservoir

Platoro Dam is on the Conejos River about 1 mile above the town of Platoro, Colo. It is an earthfill structure consisting of a main embankment and a dike section, separated by a rock knoll in which the spillway is excavated. The maximum embankment height is 165 feet, and the dam contains 912,000 cubic yards of material. The reservoir formed by the dam has a capacity of 59,570 acre-feet, 6,060 acre-feet of which are for flood control and 53,510 acre-feet for joint use. The spillway is an open rock cut with a concrete control section having a capacity of 3,000 cubic feet per second. The outlet works, with a capacity of 710 cubic feet per second, is located in the right abutment.

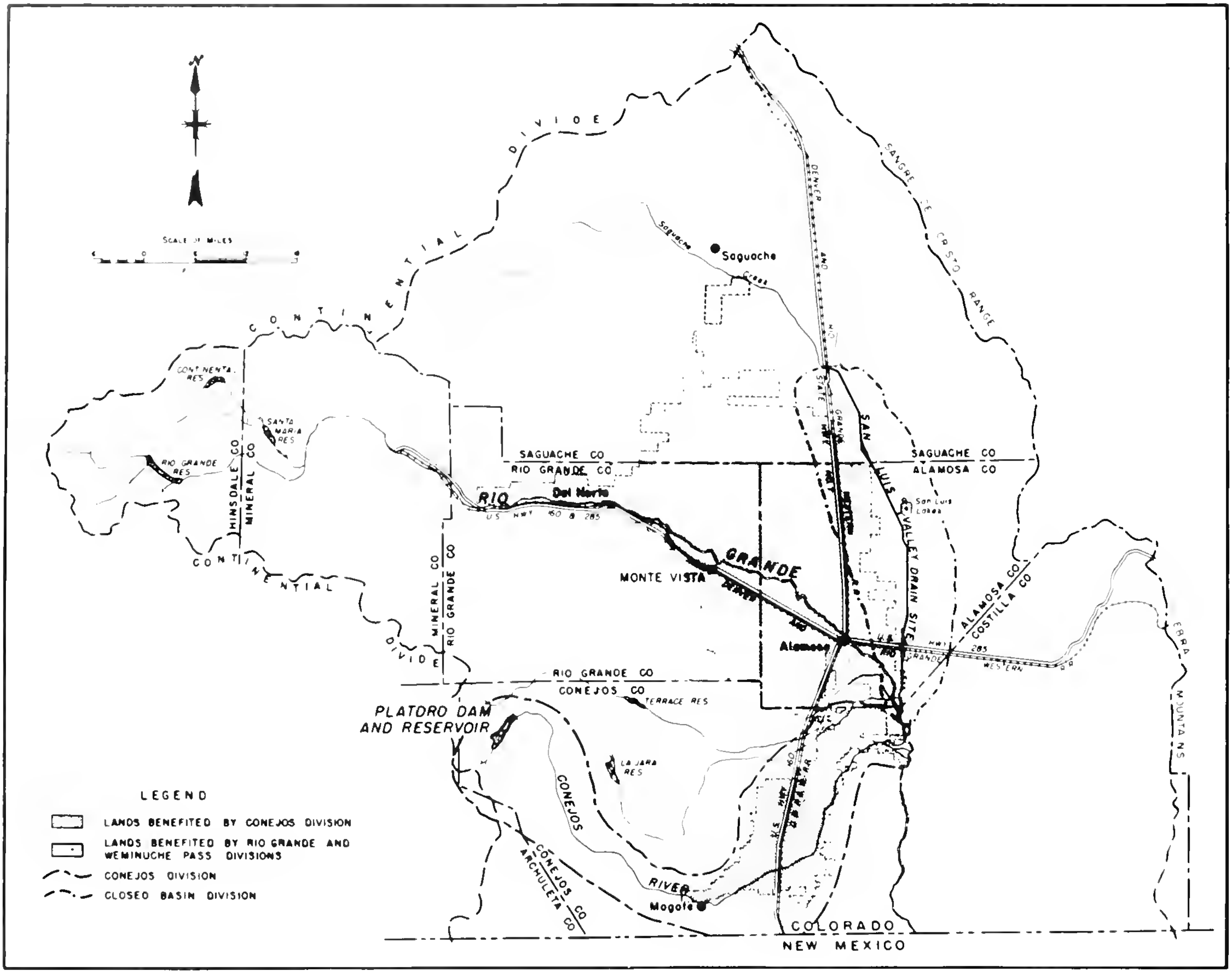
Closed Basin Division

The Closed Basin Divison is in the advance planning stage. The plan for development provides for installation of a system of wells, pumping plants, laterals, and a canal to salvage ground water within the Closed Basin for delivery to the Rio Grande. The plan further provides for the preservation and enhancement of existing wildlife habitat and provides desirable fishing and recreation benefits. It includes maintenance of an essentially constant storage level in San Luis Lake and construction of basic recreation facilities.

DEVELOPMENT

Early History

The early settlers in the area, recognizing the necessity for irrigation to sustain agriculture, began to tap the rivers and creeks by means of small canals and ditches. The first priority for diversion of water from the Conejos River, dated March 1, 1855, was granted to Irrigation District No. 1, which built and operated the Guadalupe Main Ditch. Agricultural development of the county and of the project area received its greatest impetus with the arrival of a group of settlers in 1878. This group and those following began the construction of canals and the establishment of towns and villages. The canals and ditches constructed in the project area were generally community enterprises, each obtaining water by direct diversion from the Conejos River without storage to satisfy late season requirements. As is common in most irrigation areas not having storage facilities, the result has been peak diversion in the spring and early summer months and critical shortages in late season. With this condition limiting the crops, together with the availability of public grazing lands and native meadows, land use closely related to the livestock industry evolved.



San Luis Valley Project

After 1880, large canal construction increased rapidly, and by 1900 the greatest practicable amount of natural streamflow had been diverted. Water users then began to construct water storage facilities on the Rio Grande. Two reservoirs in the Upper Rio Grande watershed were completed in 1913 by private capital. These were the Rio Grande (Farmers Union) and the Santa Maria, with capacities of 51,000 and 43,500 acre-feet, respectively. The Continental Reservoir, on a tributary of the Rio Grande, with a capacity of 27,000 acre-feet, was completed in 1928. La Jara and Terrace Reservoirs on La Jara Creek and Alamosa River were completed in 1910 and 1912, respectively. These have a combined capacity of approximately 31,000 acre-feet. By 1910, a rising water table was causing serious damage to the valley lands. This seeped condition was accelerated by large irrigation diversions. Drainage to reclaim seeped lands began about 1911, and by 1921 eight drainage systems serving about 90,000 acres of land had been constructed. These drainage systems have reclaimed a considerable amount of land in the western area of the Closed Basin, but large areas to the east remain to be reclaimed.

Investigations

Comprehensive engineering investigations in the San Luis Valley Project were initiated by the Bureau of Reclamation in 1936, which resulted in the authorization of the project.

Authorization

The project was originally authorized by the Secretary of the Interior on February 1, 1940, under section 9 of the Reclamation Act of 1939. A supplemental finding of feasibility and authorization for Platoro Dam and Reservoir was submitted by the Secretary on March 7, 1949.

The Closed Basin Division was authorized by Public Law 92-514, 92nd Congress, October 20, 1972, (86 Stat. 964).

Construction

Construction of the Platoro Dam and Reservoir was started in 1949 and completed in 1951. Construction of Closed Basin Division facilities is to be initiated in fiscal year 1980.

Operating Agency

Platoro Dam and Reservoir is operated and maintained by the Bureau of Reclamation. The authorizing act provides that the Secretary of the Interior is authorized to operate and maintain the Closed Basin Division.

BENEFITS

Irrigation

The increased water supply is of benefit to about 10,000 people living on the farms and in the six villages of the Conejos River area. Principal crops produced are alfalfa, clover, wheat, oats, barley, potatoes, and vegetables.

Water Salvage

A major impact of the Closed Basin Division will be the improvement the salvaged water supply will make in administration of the Rio Grande Compact and the United States-Republic of Mexico Treaty of 1906. This will benefit all the Rio Grande Compact States and the Ciudad Juarez Valley area of the Republic of Mexico. Some additional benefits may accrue to the agricultural economy of the Middle Rio Grande Project, New Mexico, and the Rio Grande Project, New Mexico-Texas.

Recreation

Platoro Reservoir is in a beautiful mountain setting at a high elevation. It is an excellent recreation feature for the local people and for tourists who seek relief from the heat during summer months. Excellent fishing and boating are provided by the reservoir during seasons when water is in storage.

The Closed Basin Division facilities will provide a dependable source of water for stabilizing the storage level in San Luis Lake. The lake is well located with reference to the valley population distribution, as well as to paths of tourists and vacation travel. Appreciable recreation benefits will be provided by the division facilities.

PROJECT DATA

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	7.2	in
Temperature:		
Maximum	100	°F
Minimum	−30	°F
Growing season	90-120	days
Elevation of irrigable area	7450-8200.0	ft

ENGINEERING DATA

Water Supply

CONEJOS RIVER

Drainage area above Platoro Dam	40	mi²
Annual discharge below Platoro Dam:		
Maximum (1965)	96,240	acre-ft
Minimum (1972)	44,750	acre-ft
Average	64,580	acre-ft

Storage Facilities

PLATORO DAM AND DIKE

Type: Zoned earthfill. Dike closes older river channel near left end of dam.
Location: On the Conejos River, 1 mi west of Platoro, Colo.
Construction period: 1949-51
Date of closure (first storage): July 17, 1950
Reservoir, Platoro:

Total capacity to El. 10,034	59,570	acre-ft
Active capacity	59,570	acre-ft
Surface area at El. 10,034	948	acres
Dimensions:		
Structural height	165	ft
Hydraulic height	131	ft
Top width	35	ft
Maximum base width	1,100	ft
Crest length (dam)	885	ft
Crest length (dike)	590	ft
Crest elevation	10,048.0	ft
Total volume	909,884	yd³

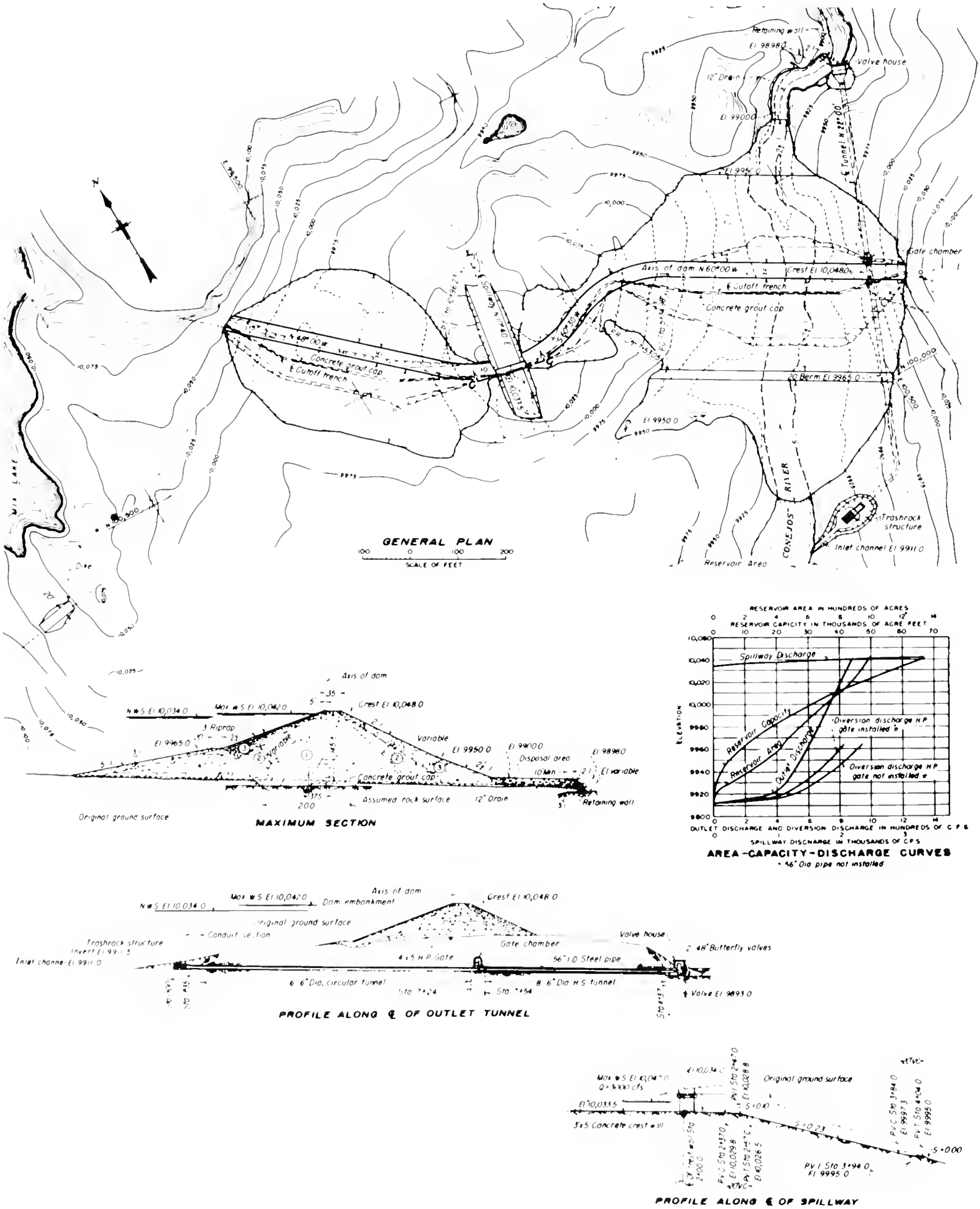
Spillway: Uncontrolled concrete crest and unlined open-cut channel at left abutment of dam.

Crest length	50	ft
Crest elevation	10,033.5	ft
Capacity at El. 10,042	3,000	ft³/s

Outlet works: Concrete-lined tunnel through right abutment, controlled by two 48-in butterfly valves.

Capacity at El. 9963	710	ft³/s

Foundation: Severely fractured, relatively fresh and unweathered andesite, with three principal fault zones.
Special treatment: Cement grout curtain beneath cutoff trench

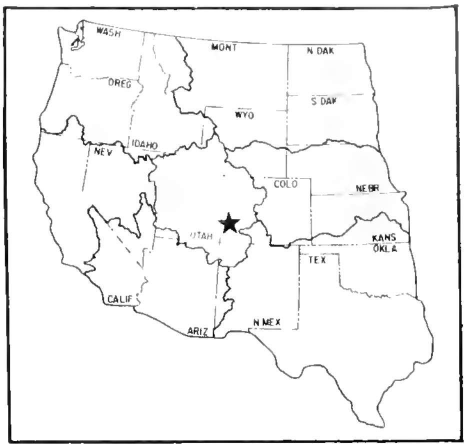


Platoro Dam, Plan and Sections

San Miguel Project
(Proposed)

Colorado: San Miguel and Montrose Counties

Upper Colorado Region
Water and Power Resources Service

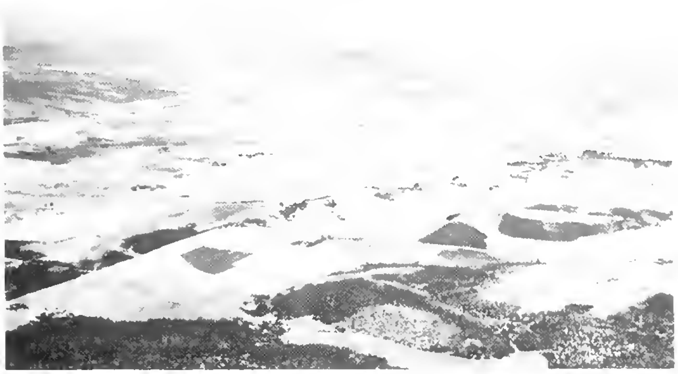


The San Miguel Project, in Montrose and San Miguel Counties in southwestern Colorado, would regulate flows of the San Miguel River. Principal towns near the proposed project area are Norwood, Nucla, and Naturita.

PLAN
(Preliminary)

The project would be a multiple-purpose water resource development that would regulate flows of the San Miguel River for irrigation, municipal and industrial use, fish and wildlife, recreation, and flood control.

The project would develop approximately 28,000 acre-feet of irrigation water for 19,000 acres of land and 14,000 acre-feet of water for municipal and industrial uses. An additional 21,000 acre-feet of water would be used by exchange from an existing water supply stored in Gurley, Cone, and Lilylands Reservoirs. Flows of the San Miguel River would be regulated by the proposed Saltado Reservoir, and releases would be made for municipal and industrial uses along the river. Municipal and industrial water for Wrights Mesa would be provided by exchange from the existing Gurley Reservoir. Irrigation water for Wrights Mesa would be released into a 9-mile-long pipeline acting as an inverted siphon that would follow the river downstream. At the end of the pipeline, a pumping plant would lift the water onto Wrights Mesa. Irrigation water for Wrights Mesa, East Lilylands, and Dry Creek Basin would be conveyed through the Basin Canal. Sprinkler irrigation is proposed on all project lands.



San Miguel Project

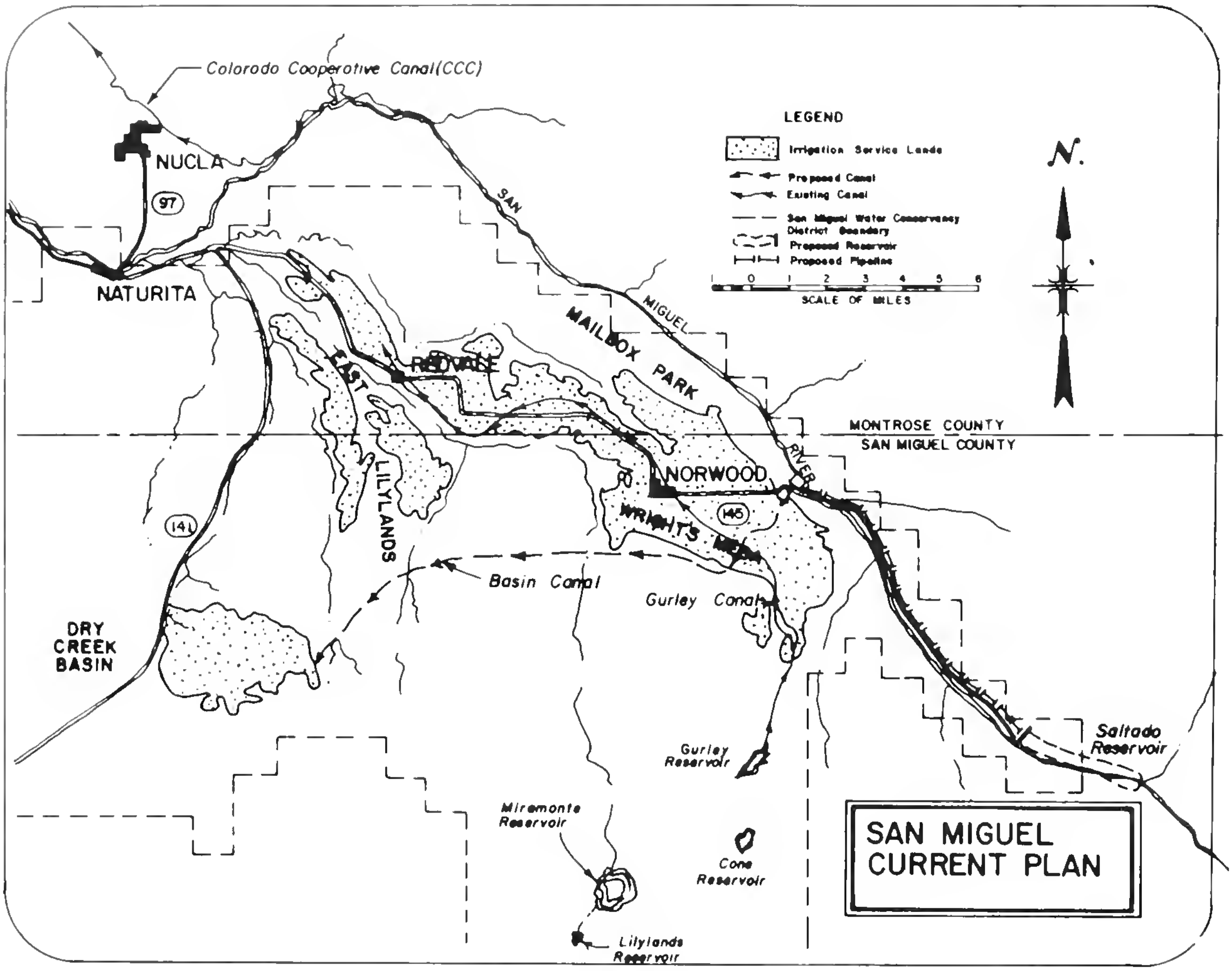
DEVELOPMENT

Early History

Mining communities along the San Miguel River were established in the 1870's primarily for gold, silver, copper, lead, and zinc. Naturita, in the San Miguel River Canyon, started vanadium development during World War I. Uranium mining started in the 1950's with the expanded development of uranium and vanadium areas. A strip coal mine is located near Nucla. Transportation problems were a deterrent to development in the area until the 1950's when some hard-surfaced roads were constructed. Agriculture is second to mining as the chief source of income in the project area. The majestic mountain scenery attracts many visitors to the scenic communities of Cortez, Telluride, Placerville, Ouray, Silverton, and Durango. Other recreation opportunities, such as touring old mining haunts, and hunting and fishing, bring an increasing number of visitors to the area each year.

Investigations

The Bureau of Reclamation first reported on the San Miguel Project in a March 1946 report entitled *The Colorado River.* The report inventories potential projects in the Colorado River Basin. In March 1953, a status report was prepared. Feasibility investigations were initiated in July 1959 and completed in 1966. Advance planning studies were initiated in 1972 to appraise the changes occurring after completion of the feasibility studies. During 1974, the Office of Management and Budget curtailed all planning pending a review of the project's effects on salinity increases in the Colorado River. Planning studies



Proposed site for San Miguel Project

were resumed shortly thereafter. Completion of a definite plan report is scheduled for 1981.

Authorization

The San Miguel Project was authorized by the Colorado River Basin Project Act of September 30, 1968, as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485).

Operating Agency

The San Miguel Water Conservancy District was formed in 1957 by local farmers, ranchers, and businessmen to stimulate interest in project development and to serve as the administrative and contracting organization for the project.

BENEFITS

Irrigation

About 28,000 acre-feet of water developed for irrigation would be available for full and supplemental service to 19,000 acres.

Municipal and Industrial Water

A supply of 14,000 acre-feet would be provided each year for municipal and industrial uses.

Recreation and Fish and Wildlife

Facilities would be provided for recreational activities and for fish and wildlife protection.

Flood Control

Regulation of San Miguel River flows would prevent flood damage.

PROJECT DATA

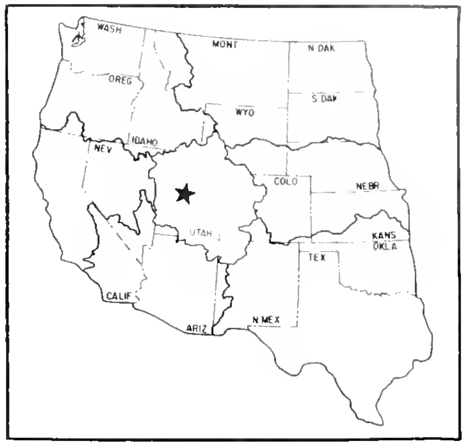
Land Areas

Irrigable area:	
Supplemental service	12,400 acres
Full service	6,600 acres
Total	19,000 acres

Sanpete Project

Utah: Sanpete County

Upper Colorado Region
Water and Power Resources Service



The Sanpete Project in central Utah includes the Ephraim Division near Ephraim and the Spring City Division in the vicinity of Spring City. Facilities constructed by the Bureau of Reclamation are the Ephraim and Spring City Tunnels. Water made available through these works is conveyed to project lands by privately constructed canals and laterals. The project furnishes a supplemental irrigation water supply to 7,661 acres in the Ephraim Division, and 7,085 acres in the Spring City Division.

PLAN

Water is fed into the Ephraim and Spring City Tunnels by feeder canals, built by the Civilian Conservation Corps, which collect water originating on the eastern slope of the southern range of the Wasatch Mountains. The tunnels convey the water to the western slope adjacent to project lands.

Tunnels

The Ephraim and Spring City Tunnels have lengths of 7,113 and 4,909 feet, respectively. Each tunnel is horseshoe in shape and is designed to carry 95 cubic feet per second of water. Unlined sections of the Ephraim Tunnel are 6.5 feet and lined sections are 5.5 feet in diameter. The Spring City Tunnel is lined and is 5.5 feet in diameter.

DEVELOPMENT

Early History

The settlement of the county was first attempted when an invitation to settlers was extended by Indian Chief Walker on June 14, 1849. In response to this invitation, 50 families from Salt Lake City were sent to Sanpete County in the fall of 1849. The Indians, however, regretted their solicitation for settlers and tension between the two groups finally resulted in the Blackhawk War, which continued until 1868. Following the war, settlers returned to the Sanpete Valley. After the town of Ephraim was incorporated in February 1868, growth was rapid, aided by the completion of the Denver and Rio Grande Western Railroad in 1890, and the Sanpete Railroad in 1893. Spring City was settled in 1850 by 15 families from Salt Lake City, but they were forced to leave in 1854 because of conflicts with the Indians. A new settlement was started in 1859 but was abandoned in 1866 until peace with the Indians was established. The town was incorporated in 1870.

Investigations

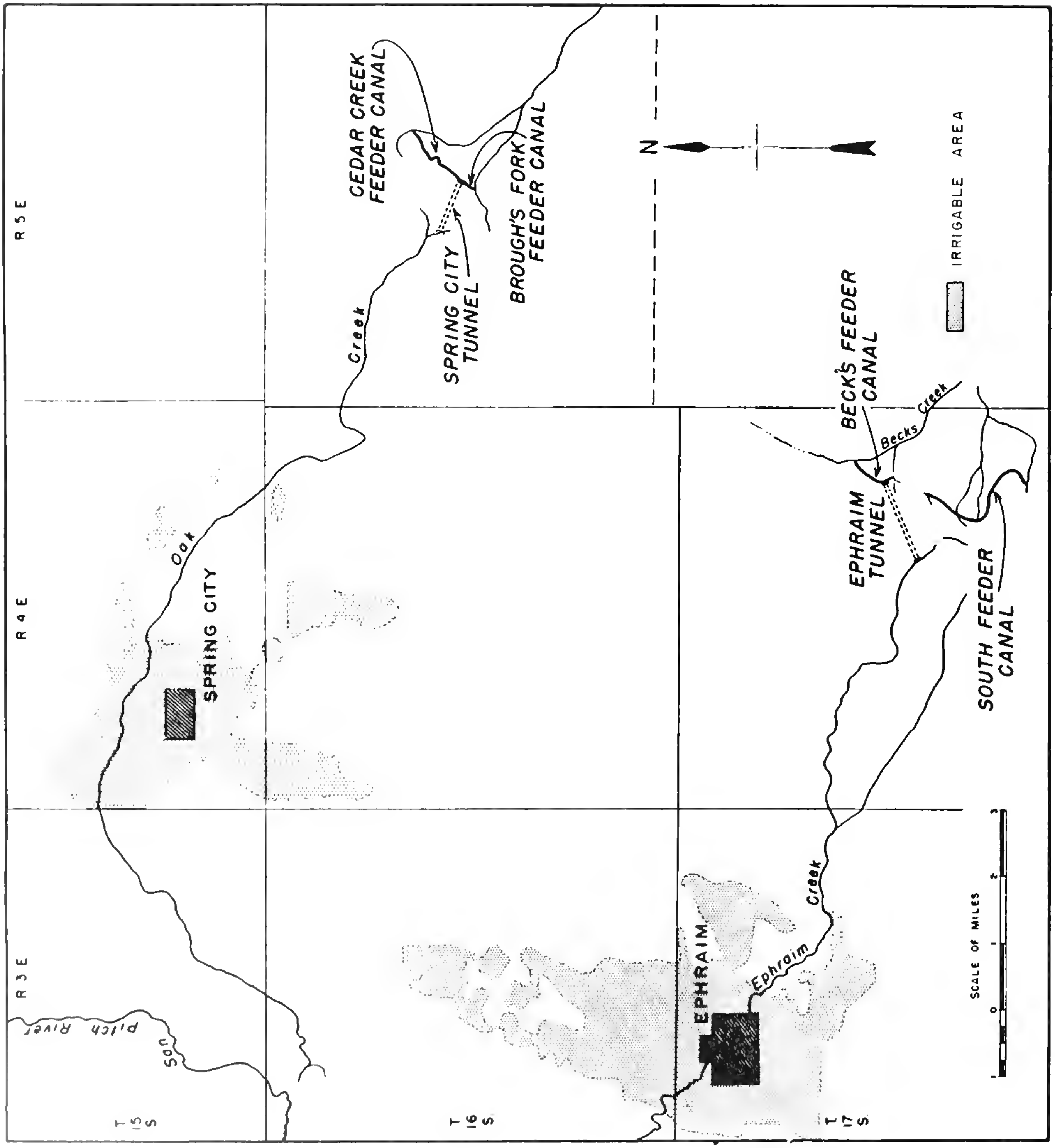
The available water supply from the San Pitch River and its tributaries was insufficient for a dependable full-season irrigation supply for nearby agricultural lands. The only other source of water was from the eastern slope of the mountains adjacent to the east side of the valley. The investigation of this source of water was begun, and a tunnel through the mountains for the Ephraim Division was started by private interests. However, construction of the tunnel was soon abandoned. The first investigation by the Bureau of Reclamation for development of this potential source of water commenced in 1931. The results of the investigation for tunnel sites and the study of the available water indicated that the project's water supply could be improved substantially by the diversion of water from the eastern slope of the mountains through tunnels to the western slope.

Authorization

Construction was approved by the President on November 6, 1935, under the terms of subsection B, section 4, act of December 5, 1924 (43 Stat. 701). The project was initiated under the provisions of the National Industrial Recovery Act of 1933.

Construction

Construction of the Ephraim Tunnel began in 1935; the Spring City Tunnel was started in 1937. The feeder



Sanpete Project

canals were constructed by Civilian Conservation Corps forces during 1934-35. All construction work in connection with the tunnels and feeder canals was completed by September 1939.

Operating Agencies

The Ephraim Division is operated and maintained by the Ephraim Irrigation Company. The Spring City Division is operated and maintained by the Horseshoe Irrigation Company.

BENEFITS

The project has benefited the livestock industry and has considerably stabilized irrigation for 211 farms comprising 14,746 acres. A substantial part of the yield would not have been possible without the supplemental water supply furnished by the project. Principal crops are alfalfa, wheat, barley, oats, and pasture. This transmountain diversion not only alleviated the threat of drought, which periodically hampered livestock and agricultural pursuits, but also increased the production of forage crops.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	14,746	acres
Number of irrigated farms	211	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	12,482	646,886
1969	12,227	610,680
1970	13,405	696,897
1971	13,083	1,261,300
1972	12,443	1,246,739
1973	13,360	1,494,393
1974	13,495	1,546,187
1975	13,405	1,835,860
1976	14,425	1,374,827
1977	12,970	1,096,429

Facilities in Operation

Canals	5.2	mi
Tunnels	2.3	mi

Climatic Conditions

Annual precipitation	12	in
Temperature:		
Maximum	107	°F
Minimum	−30	°F
Mean	47	°F
Growing season	125	days
Elevation of irrigable area	5700-6100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	740
Urban, suburban, and industrial service	1,732
Total	2,472

ENGINEERING DATA

Water Supply

COTTONWOOD CREEK

Drainage area:		
Tributary to Ephraim Tunnel	2.8	mi²
Tributary to Spring City Tunnel	2.9	mi²
Average annual diversion through tunnels:		
Ephraim Tunnel	3,300	acre-ft
Spring City Tunnel	1,630	acre-ft

Carriage Facilities

BROUGH'S FORK FEEDER CANAL

Location: From Brough's Fork northeast to Spring City Tunnel inlet about 10 mi southeast of Spring City, Utah.
Construction period: 1935-39

Length	0.4	mi
Diversion capacity	32	ft³/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	1.4	ft

CEDAR CREEK FEEDER CANAL

Location: From Cedar Creek southwest to Spring City Tunnel inlet about 10 mi southeast of Spring City, Utah.
Construction period: 1935-39

Length	1.3	mi
Diversion capacity	66	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	1.7	ft

SOUTH FEEDER CANAL

Location: From Seely Creek northeast to Ephraim Tunnel inlet about 10 mi southeast of Ephraim, Utah.
Construction period: 1934-35

Length	2.9	mi
Diversion capacity	60	ft³/s
Typical maximum section in earth:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	2.4	ft

BECK'S FEEDER CANAL

Location: From Beck's Creek southwest to Ephraim tunnel about 10 mi southeast of Ephraim, Utah.
Construction period: 1934-35

Length	0.6	mi
Diversion capacity	94	ft³/s
Typical maximum section in earth:		
Bottom width	6	ft
Side slopes	1.5:1	
Water depth	2.8	ft

Spring City Tunnel

Location: From ends of Brough's Fork and Cedar Creek Feeder Canals northwest to Oak Creek, about 10 mi southeast of Spring City, Utah.
Construction period: 1937-39

Length	1,909 ft
Capacity	95 ft^3/s

Cross section: Horseshoe

Diameter	5.5 ft

Lining: Concrete

Ephraim Tunnel

Location: From Beck's and South Feeder Canals southwest to Ephraim Creek, about 10 mi southeast of Ephraim, Utah.
Construction period: 1935-37

Length	7,113 ft
Capacity	95 ft^3/s

Cross section: Horseshoe

Diameter lined section	5.5 ft
Diameter unlined section	6.5 ft

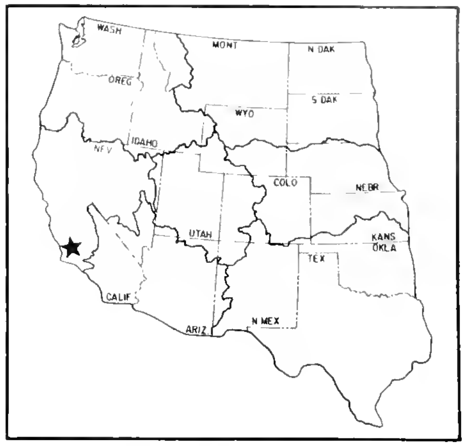
Lining: Gunite and concrete

Thickness	3-4 in

Santa Maria Project

California: Santa Barbara and San Luis Obispo Counties

Mid-Pacific Region
Water and Power Resources Service



The Santa Maria Project is located about 150 miles northwest of Los Angeles, Calif. Authorized in 1954, this joint water conservation and flood control project consists of Twitchell Dam and Reservoir, formerly called Vaquero Dam and Reservoir, constructed by the Bureau of Reclamation, and a system of river levees constructed by the Corps of Engineers.

PLAN

The Cuyama River, with its principal tributaries Alamo Creek and Huasna River, is the main source of water for the project. The drainage basin, comprising approximately 1,135 square miles above Twitchell Dam, lies along the southern boundary of San Luis Obispo County and the northern edge of Santa Barbara County.

Twitchell Dam is located on the Cuyama River about 6 miles upstream from its junction with the Sisquoc River. The multiple-purpose Twitchell Reservoir, with a total capacity of 240,000 acre-feet, stores floodwaters of the Cuyama River which are released as needed to recharge the ground-water basins to prevent salt water intrusion. All water used within the area is obtained by pumping from the ground-water reservoir.

The objective of the project is to release regulated water from storage as quickly as it can be percolated into the Santa Maria Valley ground-water basin. Therefore, Twitchell Reservoir is empty much of the time, and recreation and fishing facilities are not included in the project.

Twitchell Dam and Reservoir

Twitchell Dam is an earthfill structure, has a structural height of 241 feet, of which 216 feet are above streambed, a crest length of 1,804 feet, and contains approximately 5,833,000 cubic yards of material. The dam regulates flows along the lower reaches of the Cuyama River and impounds surplus flows for release in the dry months to help recharge the ground-water reservoir underlying the Santa Maria Valley, thus minimizing water waste.

DEVELOPMENT

Early History

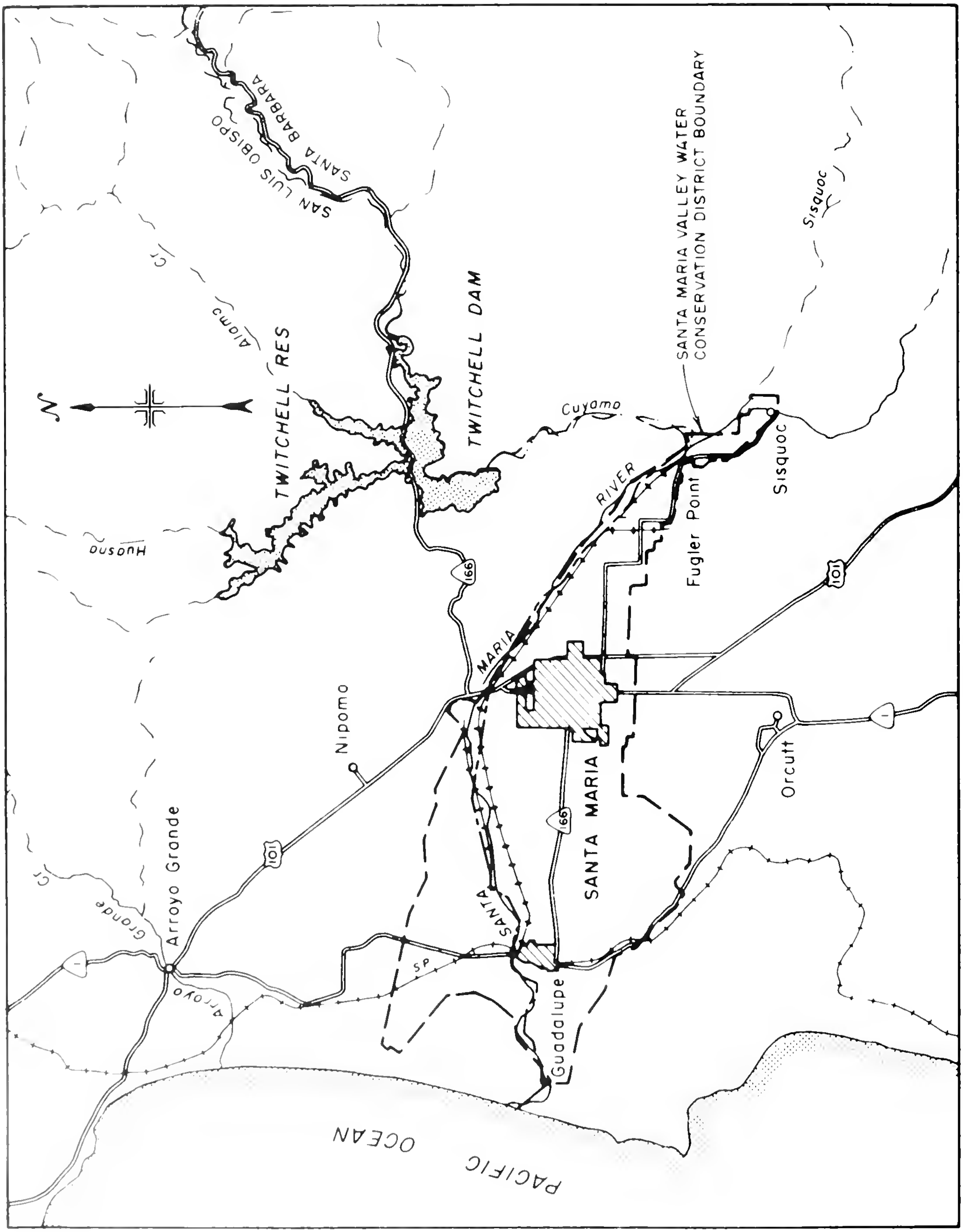
The area was devoted to cattle ranching until the great droughts of 1862-64 caused a decline in the industry. In about 1867, settlers arrived and introduced new types of agriculture. Grain production soon developed into an important industry, and fruit and bean crops were started. By 1900, fruit production began to decline, due primarily to unfavorable climatic factors. Cattle raising continued to be prominent since a major part of the watershed was suitable for grazing.

Irrigation was introduced in 1897 when the Union Sugar Company of San Francisco began growing sugar beets near Betteravia. Development of artesian wells to irrigate the beets offered new opportunities, which led gradually to the establishment of intensive vegetable growing. In 1898, a company was organized to take water from the Sisquoc River and transport it east by gravity canal to the city of Santa Maria and adjacent lands. Several years later a flood destroyed the dam and headgates, discouraging further efforts in this method of irrigation. During the 1920's, the crop pattern shifted from beans and grain to vegetables and flower seeds. Irrigated agriculture is now attained by pumping from wells.

Investigations

The first hydrologic report on the area was submitted to the county of Santa Barbara in 1931. This report discussed the feasibility of storage reservoirs on the Cuyama and Sisquoc Rivers. Results of other flood control investigations are contained in reports of the Corps of Engineers and the U.S. Department of Agriculture.

Bureau of Reclamation activities in the Santa Maria area were initiated under a cooperative contract dated July 1, 1941, between the Santa Barbara County Supervisors and Reclamation.



Santa Maria Project

In 1942, a land classification survey was made, followed by a report on the Santa Maria Basin as part of the county water resources investigations. This report, issued in 1946, was made in cooperation with the County Board of Supervisors.

The investigation, which resulted in construction of the project, was given impetus at a conference with the Corps of Engineers in November 1949, where an agreement was made to investigate a joint conservation and flood control project for the basin.

During this investigation, a reconnaissance geologic survey was made of 14 damsites, and a more detailed study was made of 7 of the most promising sites. A total of 68 miles of river profile was surveyed and detailed topographic maps made of 5 sites. Three foundation explorations were made before the Vaquero site was selected.

The resulting report was sent to the Bureau of Reclamation in November 1951. After approval by the Commissioner, the Secretary of the Interior, and the Bureau of the Budget, it was printed as House Document 217, 83d Congress, 1st session, dated July 29, 1953.

Authorization

The project was authorized on September 3, 1954, by act of Congress (Public Law 774, 83d Congress, ch. 1258, 2d session, 68 Stat. 1190).

Construction

Construction of Twitchell Dam was started in July 1956 and completed in October 1958. During the construction period, the name of Vaquero Dam and Reservoir was changed to Twitchell Dam and Reservoir through the efforts of the Santa Maria Valley Water Conservation District and Board of Supervisors of Santa Barbara County, with the concurrence of the Board of Geographic Names and the Bureau of Reclamation.

Twitchell Dam and Reservoir

As part of the project, the Corps of Engineers constructed a series of levees and channel improvements along the Santa Maria River to protect the city of Santa Maria and the Santa Maria Valley.

Operating Agency

Upon completion of construction, operation was transferred to the Santa Barbara County Water Agency for physical operation by the Santa Maria Valley Water Conservation District.

BENEFITS

Irrigation

Twitchell Reservoir impounds winter floodwaters for later release down the river channel at a predetermined rate for maximum percolation into the ground-water reservoir. Individual landholders pump water from this reservoir.

The principal irrigated products of the project area are field crops, including lettuce, beans, broccoli, carrots, and potatoes; vegetable and flower seeds; and irrigated pasture.

Flood Control

Flood control benefits are achieved through storage of winter floodwaters in Twitchell Dam.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	35,200	acres
Number of irrigated farms	158	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	30,500	64,873,673
1969	30,500	29,602,631
1970	30,500	29,605,586
1971	30,500	30,023,842
1972	30,500	32,685,082
1973	30,500	52,300,154
1974	30,500	71,510,013
1975	30,500	50,706,938
1976	30,500	56,721,056
1977	30,500	57,716,551

Facilities in Operation

Storage dam	1	

Climatic Conditions

Annual precipitation	11.5	in
Temperature:		
Maximum	104	°F
Minimum	21	°F
Mean	57	°F
Growing season	365	days
Elevation of irrigable area	350.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	12,000
Urban suburban irrigation service	35,000
Total	47,000

ENGINEERING DATA

Water Supply

CUYAMA RIVER

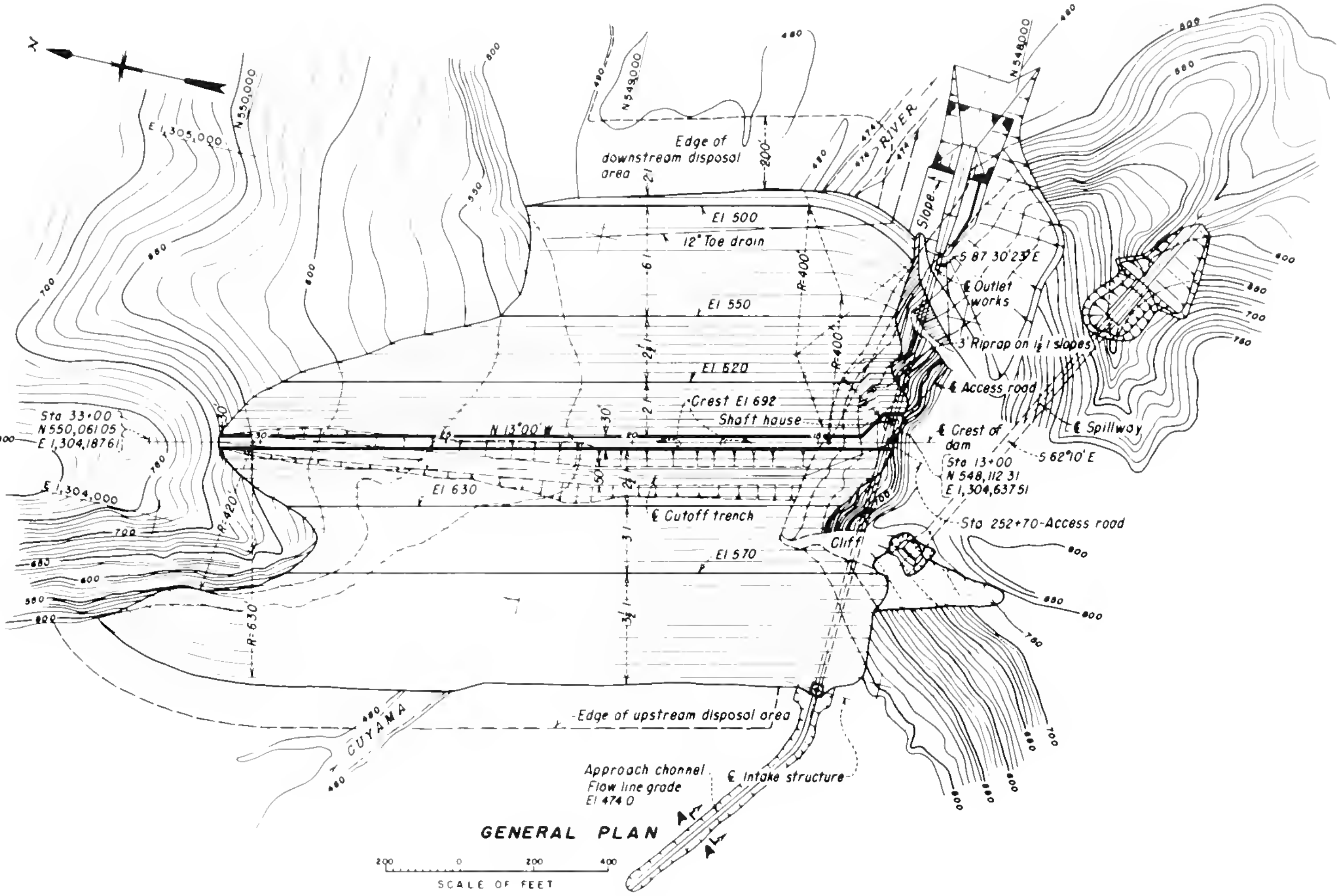
Drainage area above Twitchell Dam	1,135	mi²
Annual discharge at Twitchell Dam:		
Maximum (1941)	164,700	acre-ft
Minimum (1948)	2,800	acre-ft
Average	10,400	acre-ft

Storage Facilities

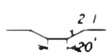
TWITCHELL DAM

Type: Zoned earthfill
Location: On the Cuyama River 7 mi northeast of Santa Maria, Calif.
Construction period: 1956-58

Reservoir, Twitchell:		
Average annual inflow, 1932-45	45,300	acre-ft
Total capacity to El. 686.5	240,000	acre-ft
Active capacity, El. 686.5	240,000	acre-ft
Surface area	3,700	acres
Dimensions:		
Structural height	241	ft
Hydraulic height	176	ft
Top width	30	ft
Maximum base width	1,328	ft
Crest length	1,804	ft
Crest elevation	692.0	ft
Total volume	5,833,000	yd³
Spillway: Uncontrolled concrete crest and concrete-lined tunnel through right abutment.		
Crest elevation	651.5	ft
Capacity, El. 686.5	26,350	ft³/s
Outlet works: Concrete conduit and concrete-lined tunnel through right abutment controlled by two 7- by 12-ft slide gates.		
Capacity at El. 686.5	12,700	ft³/s



GENERAL PLAN



SECTION A-A

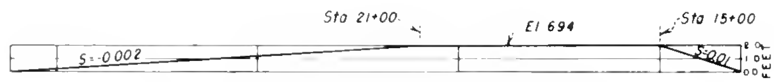
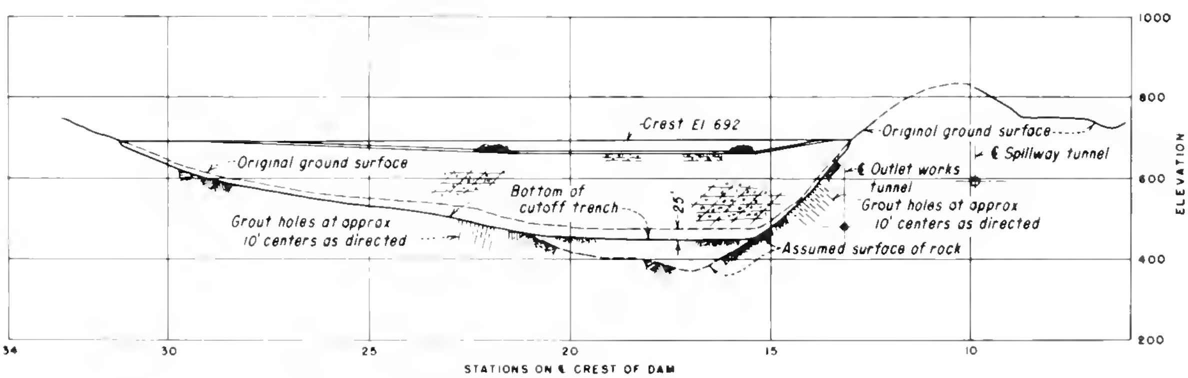


DIAGRAM FOR CAMBER ON CREST OF DAM



PROFILE ON € CUTOFF TRENCH

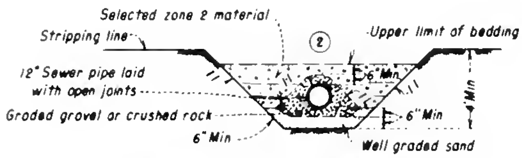
Twitchell Dam, Plan and Profile

RESERVOIR STORAGE ALLOCATION

PURPOSE	ELEVATION	STORAGE ACRE-FEET
Flood Control	623 to 651.5	89,000
Conservation	474 to 623	150,000*

Surcharge of 158,000 A F (Max W S El. 686.5) in combination with spillway capacity of 26,350 c f s and outlet capacity of 12,700 c f s is provided to protect against the inflow design flood having a peak of 120,000 c f s and 5 day volume of 426,000 A F

*Capacity of 150,000 A F between elevations 474 and 623 includes an allowance of 40,000 A F for sediment



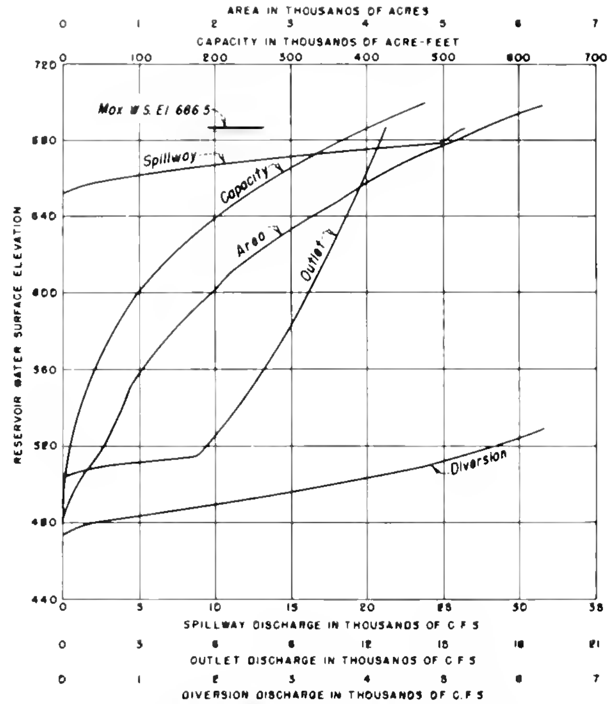
EMBANKMENT TOE DRAIN DETAIL

EMBANKMENT EXPLANATION

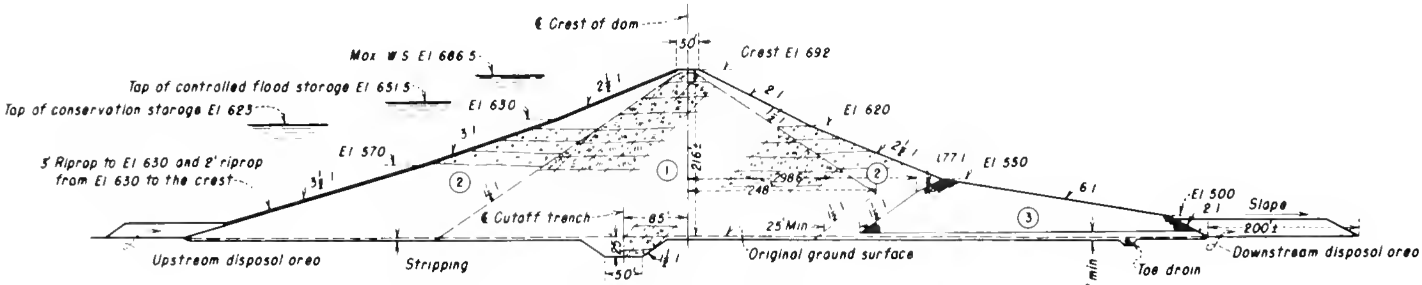
① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers

② Selected sand, gravel, and cobbles compacted by crawler-type tractor to 12-inch layers

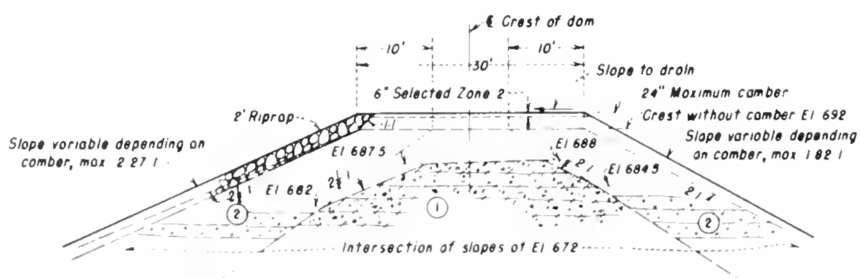
③ Selected miscellaneous material compacted by equipment travel in 12-inch layers



AREA CAPACITY-DISCHARGE CURVES



MAXIMUM SECTION



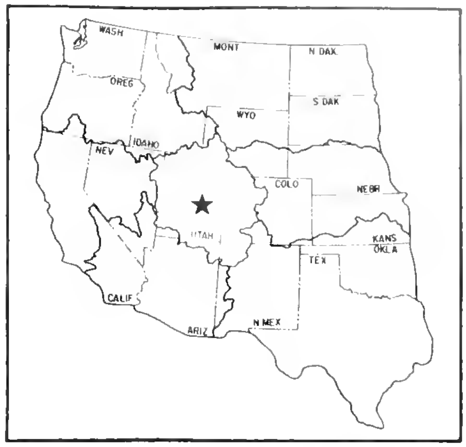
CREST DETAILS
MAXIMUM CAMBER

Twitchell Dam, Sections

Scofield Project

Utah: Carbon and Emery Counties

Upper Colorado Region
Water and Power Resources Service



Scofield Dam is on the Price River, a tributary of the Green River, about 22 miles northwest of Price, Utah, and is the principal feature of the Scofield Project.

The project provides seasonal and long-term regulation of the Price River for supplemental irrigation of about 26,000 acres of land, protection from floods, and water for fish propagation.

PLAN

Water is stored in Scofield Reservoir and released as needed into the Price River. Privately built distribution systems deliver the water to project lands.

Scofield Dam and Reservoir

Scofield Dam is a zoned earthfill structure with a structural height of 125 feet. It contains 204,000 cubic yards of material. The spillway is a free overflow concrete chute on the right abutment of the dam. The outlet works consists of an inlet structure, a concrete conduit through the base of the dam, and a gate chamber housing two gates, one for emergency operation and the other for regulation of reservoir outflow.

DEVELOPMENT

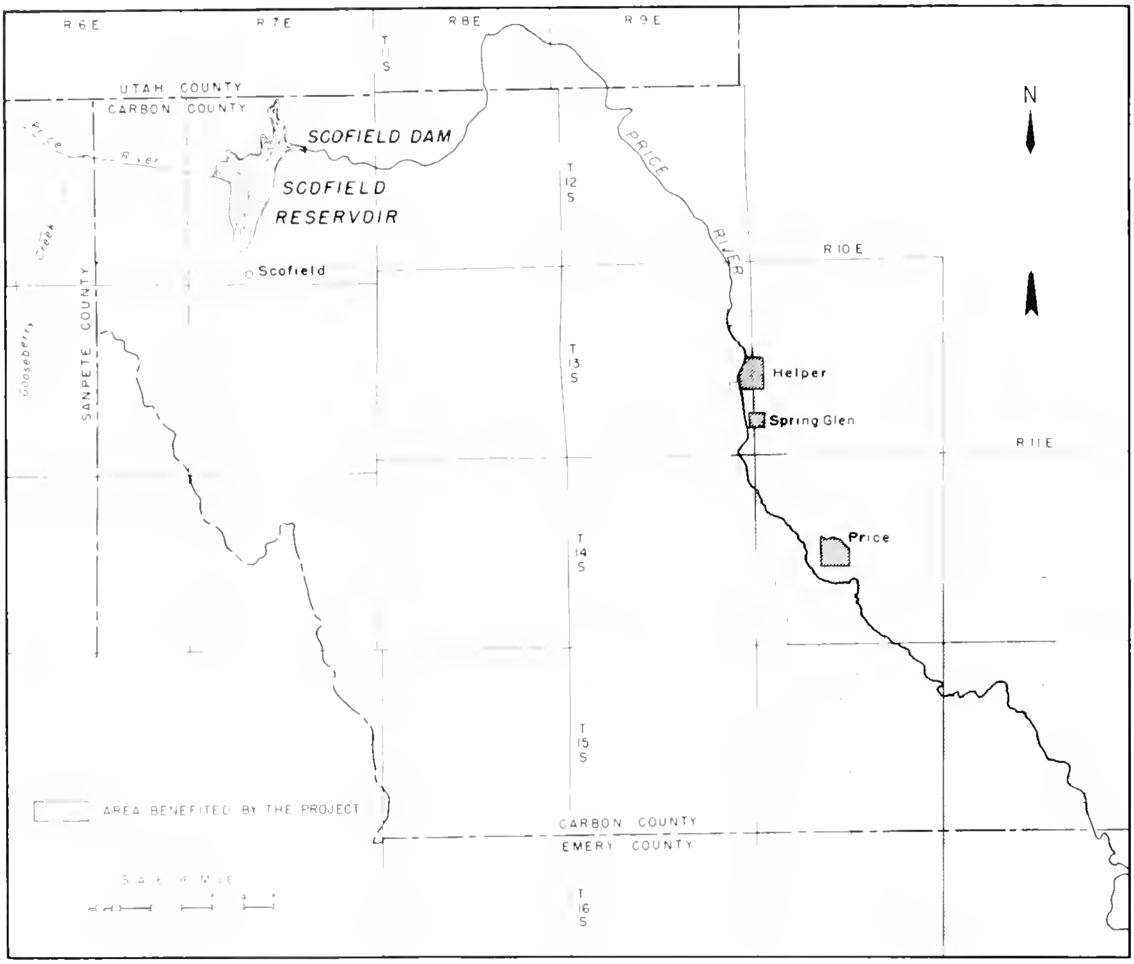
Early History

Irrigation development of lands served by the Scofield Project began in 1883. Ditch companies were organized, and the water was diverted from the natural flow of the Price River. From time to time, canal systems were combined and extended until it was found that natural flow of the river was inadequate to supply irrigation demands fully.

The Mammoth Reservoir Co. was incorporated and made filings on the floodwaters of the Price River in 1896. In 1900, a group of Sanpete County farmers secured the rights of the company for storing water and conveying it by transmountain diversion to their lands. During 1902, the Sanpete group had financial difficulties and the project passed into the hands of the Irrigated Lands Co. The latter company abandoned the idea of watering Sanpete County lands and made plans to irrigate 25,000 acres near Price, Utah. The company, in cooperation with the State of Utah, proceeded with construction of Mammoth Dam. After going through considerable financial difficulty, the Irrigated Lands Co. was reorganized in 1911 to form the Price River Irrigation Co., which developed the project as rapidly as financial conditions and demand for water would permit. The dam failed June 25, 1917, when it was only partly completed, releasing 11,000 acre-feet of water and causing flood damage estimated at $1 million to railroad and mining property. The dam was never rebuilt.

The Price River Water Conservation District, a municipal corporation, was organized in 1921 for developing storage facilities in the Price River watershed to replace the destroyed Mammoth Dam. Under the district's direction, Scofield Dam was constructed during 1925-26. The reservoir formed behind the dam had a capacity of 61,000 acre-feet. In May 1928, with the reservoir practically filled for the first time, the dam partially failed.

Scofield Dam and Reservoir



Scofield Project

Emergency repairs, together with rapid evacuation of storage water through the outlet tunnel, were effective in preventing complete failure and a devastating flood. Numerous attempts at placing the dam in a safe operating condition were unsuccessful. In view of the apparent weakness of the dam, storage in Scofield Reservoir was strictly limited to a maximum of 30,000 acre-feet.

Investigations

The Bureau of Reclamation investigated the development of the Scofield and Gooseberry Projects in accordance with a cooperative contract between the United States and the State of Utah. Results of Reclamation's studies led to the adoption of the plan to replace the unsafe Scofield Dam with a completely new and larger structure to be erected about 800 feet downstream from the existing dam.

Authorization

The project was authorized by the President on June 24, 1943, under the terms of the Water Conservation and Utilization Act of August 11, 1939 (53 Stat. 1418), as amended.

Construction

Construction of the new storage works was undertaken during World War II to prevent possible flood damage to the main line of the Denver and Rio Grande Western Railroad, the State highway, the telephone and telegraph lines, and the coal mines, all of which were important to the war effort.

The Carbon Water Conservancy District was organized in 1943, under the Utah Water Conservancy Act of 1941, for negotiating a contract with the United States for construction of the new dam. Contract negotiations between this district, the Price River Water Conservation District, and the United States were completed in 1943. Construction of the new dam began in 1943 and was completed June 15, 1946.

Operating Agency

Operation of the project was transferred from the Bureau of Reclamation to the Carbon Water Conservancy District on April 1, 1949.

BENEFITS

Irrigation

In an isolated area of Utah, the project furnishes water for growing livestock feed to stabilize the economy of a thriving industry. Principal crops are alfalfa, beans, barley, wheat, corn, potatoes, oats, and some late fruits.

Flood Control

By controlling the flow of the Price River, damage to the railroads and the many coal mines in the area is prevented. Possible failure of the old dam, which the Reclamation dam replaced, is no longer a threat to life and property.

Recreation

Scofield Reservoir has become increasingly popular for boating. Boat races are held on it annually. For many years the reservoir has provided good fishing for native and rainbow trout and is a valuable source of native trout eggs. Privately operated fishing camps with cabins and boats for rent are located near the reservoir, and private cabins are located along its shores. The Utah Division of Parks and Recreation operates and maintains the recreation area. Visitation in 1977 totaled 70,319.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	26,050	acres
Number of irrigated farms	410	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	13,168	1,322,770
1969	13,170	1,430,494
1970	12,945	1,163,804
1971	13,083	1,261,300
1972	12,443	1,246,739
1973	14,332	1,552,089
1974	22,267	3,672,419
1975	22,267	3,163,558
1976	22,765	3,074,140
1977	[1]9,686	[1]1,515,005

[1]Area irrigated was reduced because of the 1976-77 drought.

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	10.1	in
Temperature:		
Maximum	103	°F
Minimum	−31	°F
Mean	49	°F
Growing season	136	days
Elevation of irrigable area	5500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,640
Urban, suburban, and industrial service	9,500
Municipal service to Price City	8,650
Municipal service to Helper City	2,000
Total	21,790

ENGINEERING DATA

Water Supply

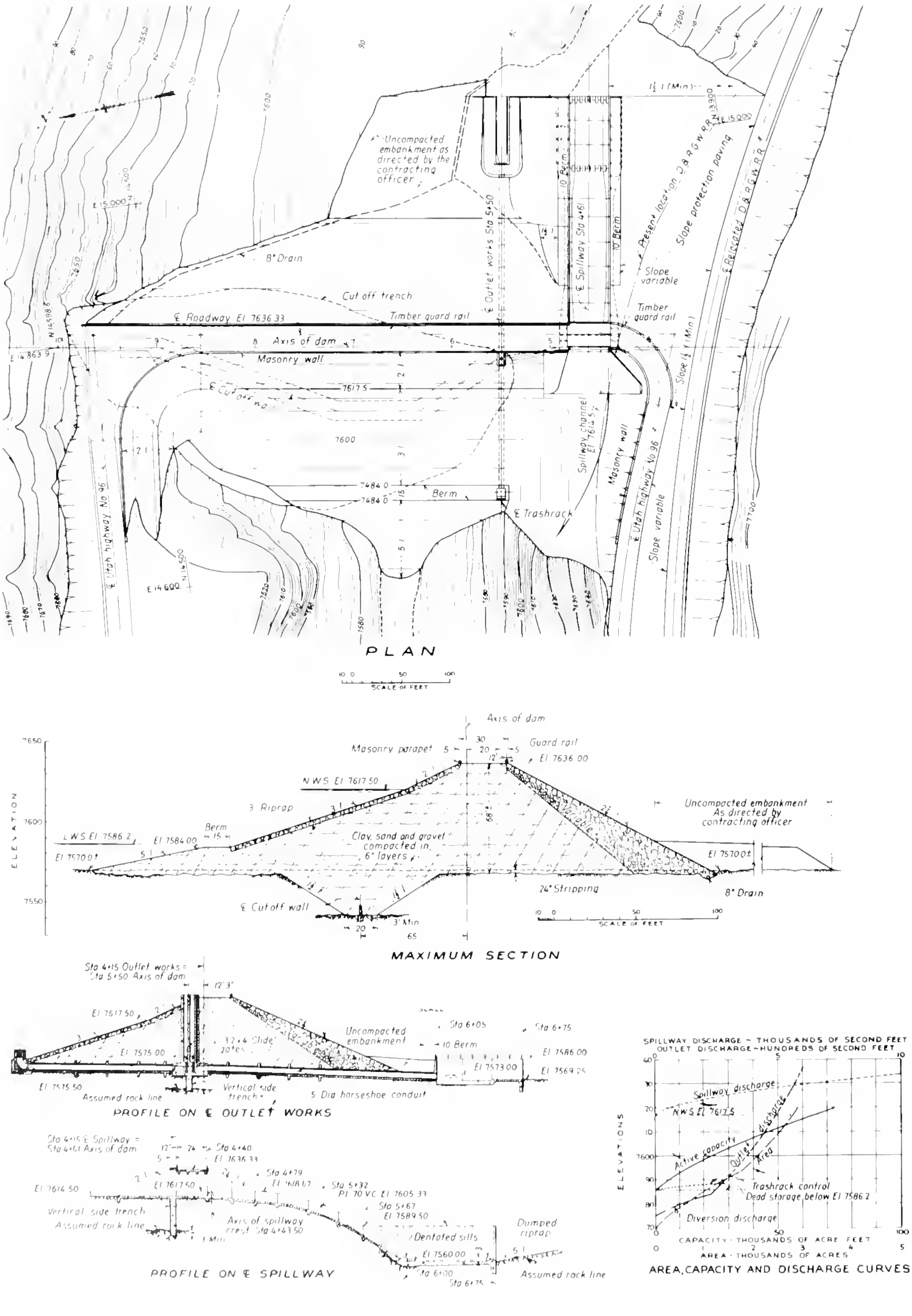
PRICE RIVER

Drainage area at Scofield Dam	163	mi²
Annual discharge at Scofield Dam:		
Maximum (1952)	96,600	acre-ft
Minimum (1977)	11,469	acre-ft
Average	43,229	acre-ft
Average annual diversion	62,800	acre-ft

Storage Facilities

SCOFIELD DAM

Type: Zoned earthfill		
Location: On the Price River, about 10 mi northeast of Scofield, Utah.		
Construction period: 1943-46		
Date of closure (first storage): November 8, 1945		
Reservoir, Scofield:		
Average annual inflow	57,600	acre-ft
Total capacity to El. 7616.5	73,600	acre-ft
Active capacity to El. 7586-7617.5	65,800	acre-ft
Surface area	2,810	acres
Dimensions:		
Structural height	125	ft
Hydraulic height	55	ft
Top width	30	ft
Maximum base width	400	ft
Crest length	575	ft
Crest elevation	7630.0	ft
Total volume	204,000	yd³
Spillway: Uncontrolled concrete crest and concrete-lined chute at right abutment.		
Crest length	40	ft
Crest elevation	7617.5	ft
Capacity at El. 7630	6,200	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by one 3.2- by 4.0-ft slide gate.		
Capacity at El. 7630	500	ft³/s
Foundation: Alternate layers of horizontally bedded sandstone and shale.		
Special treatment: Cement grout curtain under cutoff trench.		

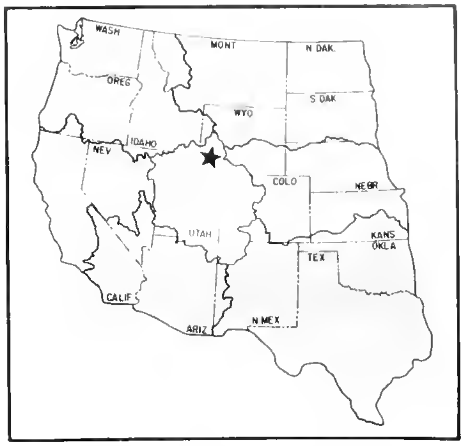


Scofield Dam, Plan and Sections

Seedskadee Project

Wyoming: Lincoln and Sweetwater Counties

Upper Colorado Region
Water and Power Resources Service



The Seedskadee Project, a participating project of the Colorado River Storage Project, is in the Upper Green River Basin in southwestern Wyoming. It provides storage and regulation of the flows of the Green River for power generation, municipal and industrial use, fish and wildlife, and recreation. The basin contains vast mineral resources of coal, trona, oil and gas, and oil shale that provide the basis for extensive existing and potential industrial development. Towns in the area are Rock Springs, Green River, and Kemmerer.

PLAN

Principal features of the project are the Fontenelle Dam, Powerplant, and Reservoir. The reservoir is operated for municipal and industrial water use, power production, flood control, and downstream fishery and wildlife refuge.

Fontenelle Dam, Powerplant, and Reservoir

The Fontenelle Dam is located on the Green River 24 miles southeast of La Barge, Wyo. A zoned earthfill structure, the dam is 139 feet high with a crest length of 5,421 feet, and a volume of 5,265,000 cubic yards of material. The spillway consists of an uncontrolled crest, open chute, and stilling basin with a design capacity of 20,000 cubic feet per second. Fontenelle Powerplant is located adjacent to the toe of the dam, with the power penstock branching from the river outlet works. The powerplant consists of one 10,000-kilowatt generator and one 16,000-horsepower hydraulic turbine.

The reservoir has an active capacity of 150,500 acre-feet and a total capacity of 345,400 acre-feet, with a surface area of 8,058 acres. The lake is 20 miles in length when full, and has a shoreline of approximately 56 miles.

DEVELOPMENT

Early History

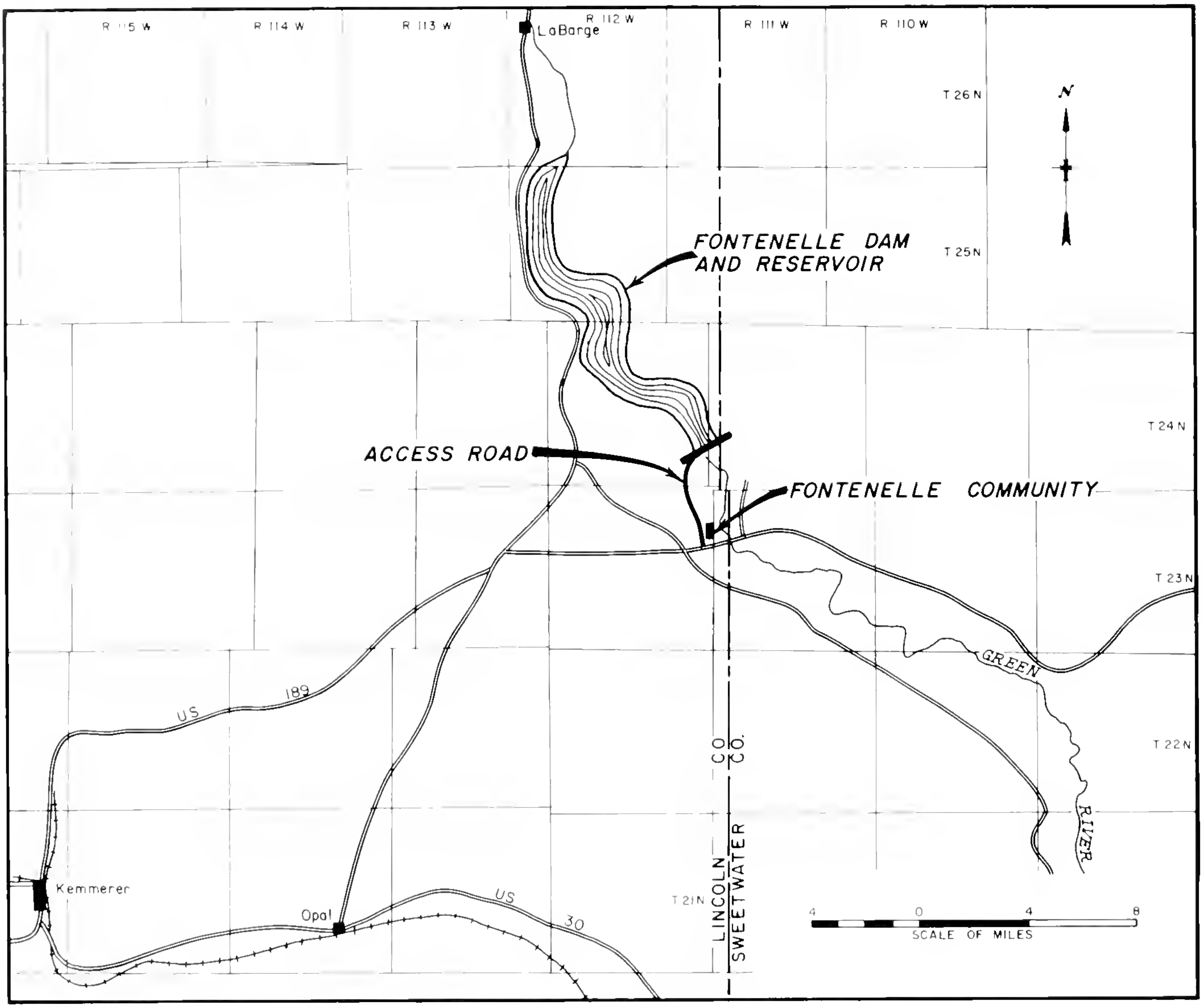
The Crow Indians called it the "Seeds-ke-dee-agie," meaning "Sage Hen River," but it was the "Rio Verde" to the Spaniards. To the mountain men it was simply the Green River. In 1812, South Pass was discovered by fur trappers. From 1825 until 1840, the Upper Green River Basin was the crossroads for the mountain men. After the trappers came, the covered wagons moved west along the Oregon Trail. Settlers began homesteading lands near the river in the 1880's.

Investigations

The Seedskadee Project was originally investigated by the Bureau of Reclamation as a unit of a plan for development in the Upper Green River Basin. This plan was presented in a 1946 report on the Colorado River Basin. The Bureau of Reclamation carried out investigations of the Seedskadee development as an independent project, and in November 1950 prepared a feasibility report on the Seedskadee Project, issued as a supplement to the December 1950 report on the Colorado River Storage Project and participating projects. These two reports were amended in October 1953 by a further supplement that brought construction cost and project benefit estimates up to date. This latter supplement was submitted to the Congress and was the basis for project authorization.

The definite plan report was prepared in April 1959, and in February 1961 was modified to provide for future municipal and industrial water needs. Under the provisions of Title III of the Water Supply Act of 1958 (72 Stat. 319), the Wyoming legislature authorized the Wyoming Natural Resource Board to negotiate a contract for additional capacity in the Fontenelle Reservoir for municipal and industrial water, thus increasing the total capacity of the reservoir to 345,400 acre-feet, with 150,500 acre-feet of active capacity. Following reevaluation studies, the House Committee on Interior and Insular Affairs approved construction of the powerplant and associated works.

On May 21, 1962, the Commissioner of Reclamation issued a stop-order suspending construction of irrigation



Seedskadee Project

features of the project until a review of Wyoming projects could be accomplished. In a program to find solutions to serious financial and economic problems encountered on high-altitude irrigation projects, and to provide guidelines for land development and water management, experimental crops were grown on 512 acres of land, using border dike, contour flooding, and circular sprinkling methods. As a result of these experimental farm studies, Fontenelle Dam, originally conceived as an irrigation storage dam, evolved toward storage of water for cities, industry, and fish and wildlife. Irrigation development has been indefinitely deferred.

Authorization

Seedskadee Project is one of the initial group of participating projects authorized with the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

Construction of Fontenelle Dam commenced in June 1961 and was completed in April 1964. In September 1965, after the reservoir had filled to capacity, water passing through relief cracks in the right abutment carried away part of the downstream embankment. The reservoir was evacuated and a repair program undertaken and completed in 1967. The reservoir was refilled in the winter and spring of 1968. Construction of Fontenelle Powerplant and appurtenant facilities was started in February 1963, and completed in January 1966. Power generation commenced in May 1968.

Operating Agencies

The Bureau of Reclamation operates the Fontenelle Reservoir and Powerplant, and is responsible for recreation facilities. The Fish and Wildlife Service manages the

Seedskadee National Wildlife Refuge. The Wyoming Game and Fish Commission manages the reservoir fishery and the fishery in the Green River below the reservoir. The development farm has been transferred to the Wyoming Game and Fish Commission for wildlife management purposes.

BENEFITS

Municipal and Industrial Water

Initial deliveries of municipal and industrial water to the State of Wyoming under the contract of June 14, 1962, began in 1974. Current negotiations are underway by the State to purchase the remaining allocations available for use in the burgeoning industrial development in the area.

Power

Commercial power generation commenced in May 1968. The powerplant and switchyard at Fontenelle Dam with transmission lines interconnect with the Colorado River Storage Project transmission system at the Flaming Gorge Powerplant.

Recreation and Fish and Wildlife

The Seedskadee National Wildlife Refuge was established by the Fish and Wildlife Service in 1965. The refuge lies along 35 miles of the Green River, approximately 6 miles below Fontenelle Dam and 20 miles northwest of the town of Green River. The refuge will provide habitat for waterfowl, and ultimately 18 wildlife management units will be developed. About 13,250 acres of Federal and private land have been acquired with plans to bring the refuge to a total of about 22,000 acres.

A substantial fishery has developed in the reservoir and in the stream between the reservoir and the Flaming Gorge Reservoir. Both the stream and reservoir are stocked with rainbow and brown trout. In the stream below the reservoir, a whitefish population is sustained as a result of natural spawning.

Recreation facilities constructed on the west shore of the reservoir near Fontenelle Creek include sites for camping and picnicking, a boat ramp, parking, sanitary facilities, and drinking water. Recreational use averages about 55,000 visitor days annually.

PROJECT DATA

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	8.8	in
Temperature:		
Maximum	104	°F
Minimum	−30	°F
Mean	44	°F
Growing season	106	days
Elevation of irrigable area	6200-6500.0	ft

ENGINEERING DATA

Water Supply

GREEN RIVER

Drainage area at Fontenelle Dam	4,200	mi²
Annual discharge:		
Maximum (1951)	1,844,000	acre-ft
Minimum (1934)	350,000	acre-ft
Average	1,227,000	acre-ft

Storage Facilities

FONTENELLE DAM

Type: Rolled earth and gravelfill
Location: On Green River, 24 mi downstream from La Barge, Wyo.
Construction period: 1961-64
Reservoir, Fontenelle:

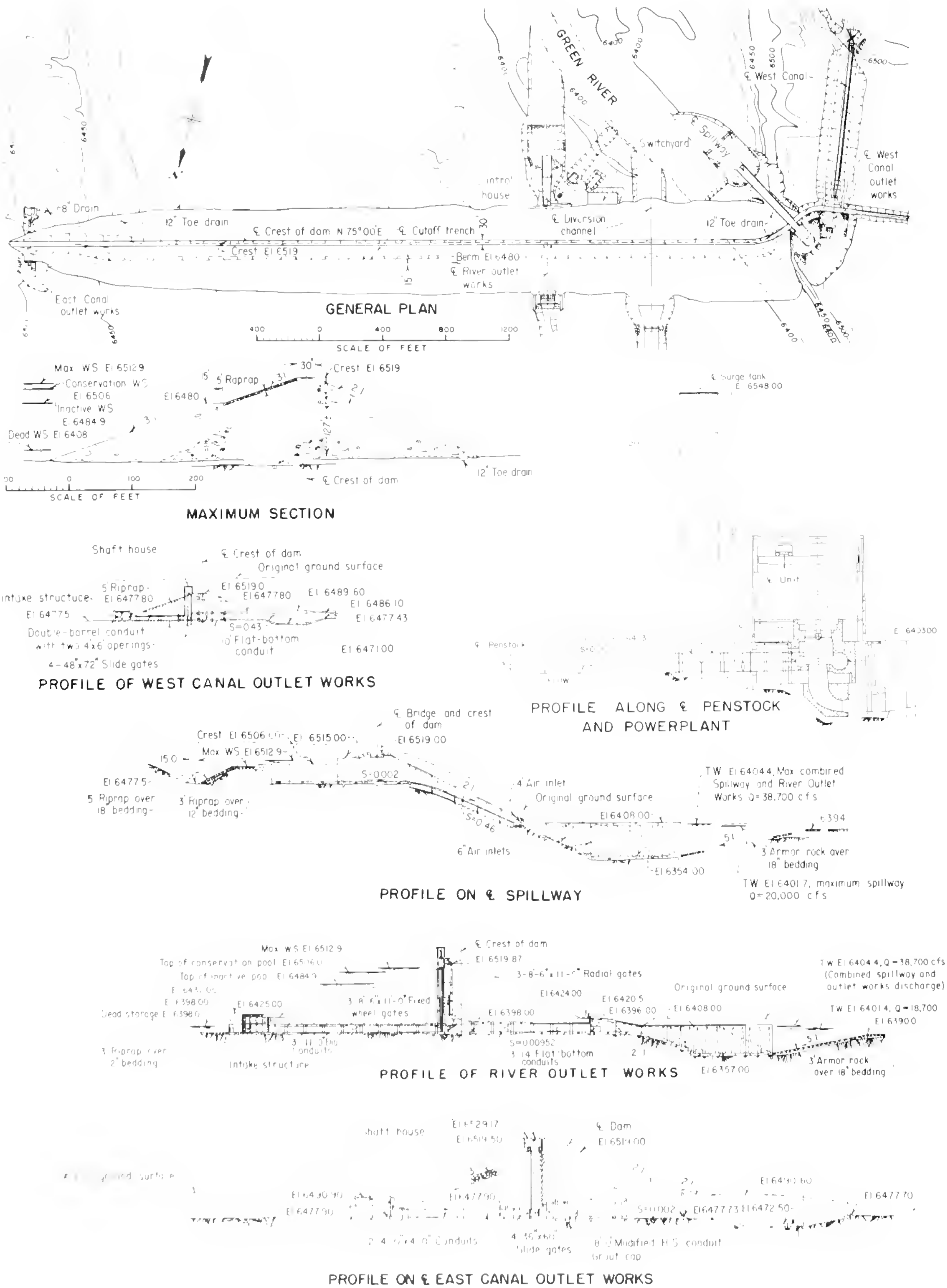
Total capacity to El. 6506	345,400	acre-ft
Active capacity	150,500	acre-ft
Surface area	8,058	acres
Dimensions:		
Structural height	139	ft
Top width	30	ft
Maximum base width	675	ft
Crest length	5,421	ft
Crest elevation	6519.0	ft
Volume	5,265,000	yd³
Spillway: Concrete, with inlet structure, chute, and stilling basin.		
Capacity	20,000	ft³/s
Outlet works:		
River outlet: Approach channel, concrete intake structure, three-barrel conduit, gate structure for three 8.5- by 11-ft fixed-wheel gates and three 8.5- by 11-ft radial gates, a chute, stilling basin, and outlet channel.		
Capacity: (Two barrels. One barrel used for power penstock)	18,700	ft³/s
East Canal outlet: Concrete intake structure, concrete conduit, gate structure for four 26- by 60-in slide gates, and stilling basin.		
Diversion capacity	585	ft³/s
West Canal outlet: Inlet channel, concrete intake structure, gate structure for four 48- by 72-in slide gates and stilling basin.		
Diversion capacity	780	ft³/s

Power Facilities

FONTENELLE POWERPLANT

Year of initial operation: 1968

Nameplate capacity	10,000	kW
Number and capacity of generators .... (1)	10,000	kW

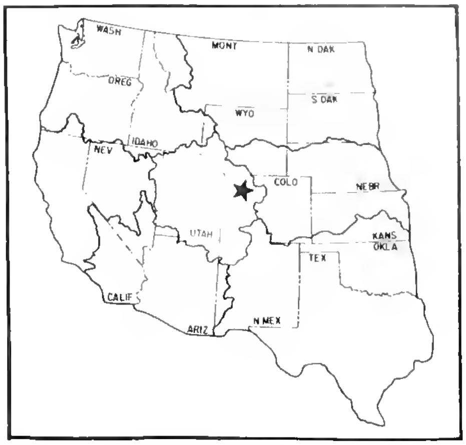


Fontenelle Dam, Plan and Sections

Silt Project

Colorado: Garfield County

Upper Colorado Region
Water and Power Resources Service



The Silt Project is in the west-central section of Colorado near the towns of Rifle and Silt. The project provides for storing the flows of Rifle Creek and pumping water from the Colorado River to increase the irrigation water for 6,591 acres of land. Principal features of the project are Rifle Gap Dam and Reservoir, a pumping plant, and a lateral system. Existing canals and laterals have been used and rehabilitated where necessary. Recreation facilities have been constructed at Rifle Gap Reservoir.

PLAN

Project storage is in Rifle Gap Reservoir, formed by Rifle Gap Dam on Rifle Creek. Reservoir exchange releases are made from Rifle Creek to existing ditches to meet downstream irrigation needs. Project water is released directly into Davie Ditch, which had been abandoned but has been rehabilitated to supply irrigation water to project lands on Davie Mesa.

Reservoir releases are made from Rifle Gap Reservoir to meet downstream diversion rights of nonproject lands. These releases allow additional diversions from East Rifle Creek upstream from Rifle Gap Reservoir for project use. Delivered through the Grass Valley Canal, this exchange water provides a full irrigation supply for new project lands and a supplemental supply to project lands previously irrigated with Harvey Gap Reservoir water and Grass Valley Canal diversions.

The Dry Elk Valley lateral carries water from the Grass Valley Canal to both full and supplemental service lands in Dry Elk Valley. Under project operation, Harvey Gap Reservoir, which previously filled and emptied each year, now stores and regulates water for a longer irrigation season.

The Silt Pumping Plant, with a capacity of 36 cubic feet per second, is located near the Colorado River about 2 miles east of the town of Silt. The 7.6-mile-long Silt Pump Canal extends northwest from the pumping plant discharge line, carrying irrigation water to land on the lower portion of Harvey Mesa. The pumped water is used as a supplemental supply, or as a replacement supply, for project land formerly irrigated with Colorado River water pumped at high cost from the Cactus Valley Ditch. It also is used as an exchange for nonproject water to replace Harvey Gap Reservoir water for project lands above the Silt Pump Canal.

Rifle Gap Dam and Reservoir

Rifle Gap Dam is constructed on Rifle Creek about 5.5 miles north of Rifle, Colo., at a point where the creek cuts through the Grand Hogback. The dam is a zoned earthfill structure with a height of 157 feet, a crest length of 1,450 feet, and a volume of 1,768,000 cubic yards of material.

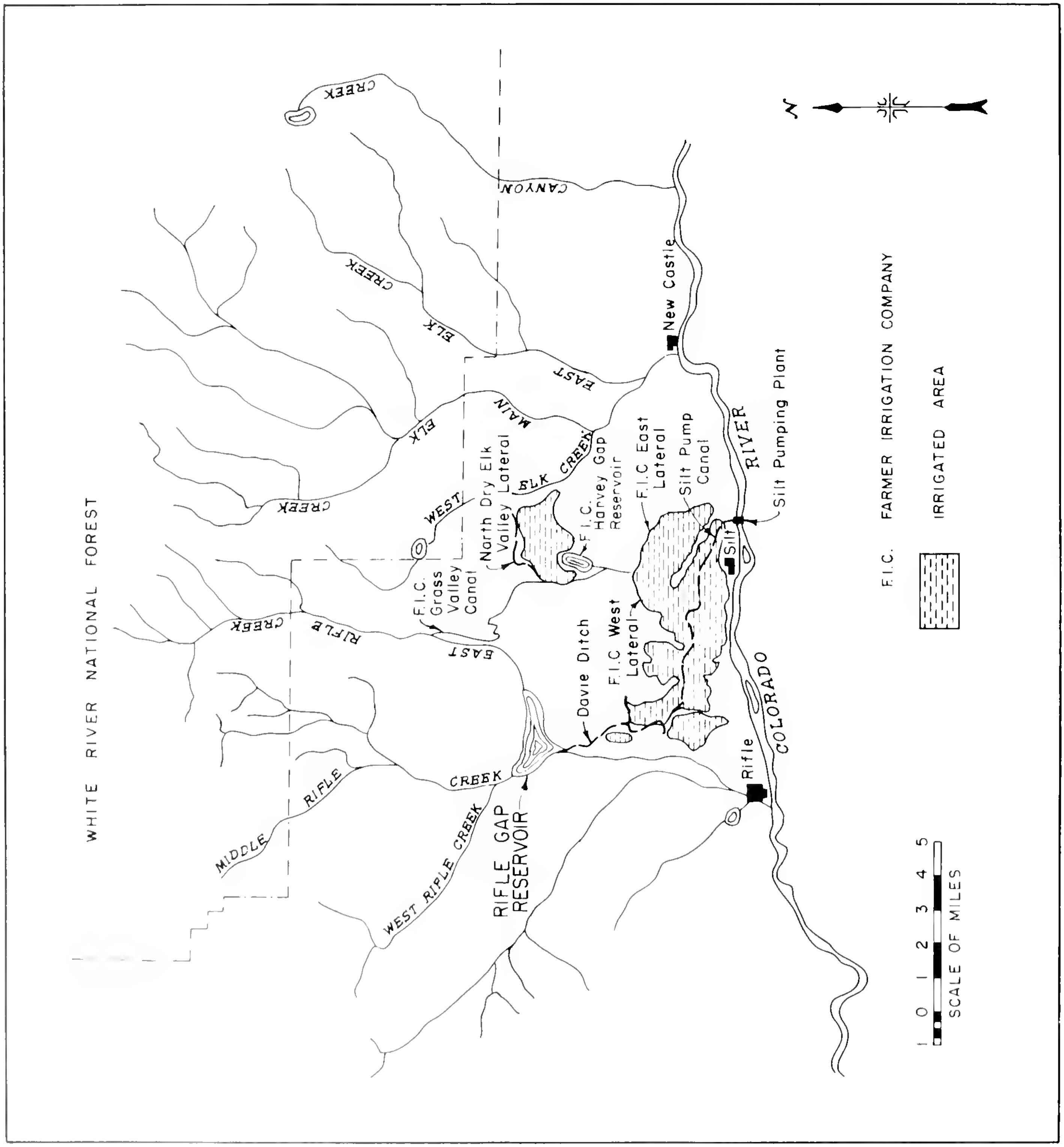
The spillway consists of a short approach channel, concrete inlet walls, concrete crest structure, and concrete chute and stilling basin. The outlet works consists of a concrete intake structure, a 6-foot upstream circular tunnel at the gate chamber with two 2.25-foot-square high-pressure gates. The river outlet diverts to a downstream 6-foot-diameter flat-bottom free-flow tunnel, which discharges into the spillway stilling basin. A 7-foot-diameter horseshoe tunnel branches from the gate chamber and contains a 30-inch steel pipe that conveys water to a concrete pipe that in turn discharges into Davie Ditch.

Rifle Gap Reservoir has a total capacity of 13,602 acre-feet and an active capacity of 12,168 acre-feet, with a surface area of 359 acres.

DEVELOPMENT

Early History

Most early settlers were miners and prospectors who turned to irrigated agriculture after being unsuccessful in mining attempts. In 1920, 40 families were brought from New York by the Midland Railroad Company to operate coal mines in the Silt area. When the railroad failed a short time later, the families remained and turned to farming in the vicinity.



Silt Project

Agriculture is the region's basic industry. Several thousand acres of rangeland and National Forest reserves surround the cultivated areas and are used for summer grazing. Most irrigated farmland is devoted to the production of alfalfa, grain, and native hay for livestock feed; a small acreage is used for production of fruit and truck crops.

Investigations

Investigations of the Silt Project by the Bureau of Reclamation began in 1936. A report on the Colorado River dated March 1946 briefly described a project plan that was similar to the present plan. The plan was described in greater detail in a January 1951 report on the Silt Project, which served as a supplement to the 1950 report on the Colorado River Storage Project and participating projects. The 1950 report was amended in 1953 and was the basis for authorization of the Silt Project. The December 1961 definite plan report presented the results of studies which generally confirmed the 1951 feasibility plan.

Authorization

The project is one of the initial participating projects authorized with the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

The construction contract for Rifle Gap Dam was awarded in August 1964. The project was completed in 1967.

Operating Agency

Operation and maintenance of the project was turned over to the Silt Water Conservancy District on January 1, 1968. The district also operates the private Farmers Irrigation Company facilities as part of the Silt Project.

BENEFITS

Irrigation

Major crops are alfalfa, small grain, and hay for livestock feed.

Fish and Wildlife and Recreation

Recreation is administered by the Colorado Division of Parks and Outdoor Recreation and consists of camping, picnicking, swimming, boating, and fishing. There were approximately 106,000 visitor days during 1977.

Rifle Gap Dam and Reservoir

PROJECT DATA

Land Areas (1977)

Irrigable area	6,591	acres
Number of irrigated farms	124	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,784	413,764
1969	5,062	600,750
1970	5,395	405,675
1971	5,422	645,521
1972	5,436	836,823
1973	5,483	914,693
1974	5,493	1,015,606
1975	5,513	862,717
1976	5,728	790,899
1977	5,962	781,868

Facilities in Operation

Storage dams	1	
Canals	12.5	mi
Grass Valley Canal (farmer owned, preproject)	13.5	mi
Laterals	1.98	mi
Pumping plants	1	

Climatic Conditions

Annual precipitation	11.1	in
Temperature:		
Maximum	104	°F
Minimum	−33	°F
Mean	48	°F
Growing season	160-165	days
Elevation of irrigable area	5500-6000.0	ft

ENGINEERING DATA

Water Supply

Rifle Creek

Drainage area at Rifle Gap Dam	142	mi^2
Annual discharge:		
Maximum (1958)	26,000	acre-ft
Minimum (1956)	14,800	acre-ft
Average	18,600	acre-ft

Storage Facilities

Rifle Gap Dam

Type: Zoned earthfill
Location: On Rifle Creek, 5.5 miles north of Rifle, Colo.
Construction period: 1964-67
Reservoir, Rifle Gap:

Total capacity to El. 5960	13,602	acre-ft
Active capacity	12,168	acre-ft
Surface area	359	acres
Dimensions:		
Structural height	157	ft
Hydraulic height	120	ft
Top width	30	ft
Maximum base width	800	ft
Crest length	1,450	ft
Crest elevation	5978.0	ft
Volume	1,768,000	yd^3

Spillway: Ungated ogee crest with concrete chute at left abutment.

Capacity at El. 5971.8	3,645	ft^3/s

Outlet works: Concrete tunnel through left abutment and gate chamber.
River: 6-ft-diameter tunnel discharging into spillway stilling basin, controlled by two 2.25-ft-square high-pressure gates.

Capacity at El. 5971.8	326	ft^3/s

Davie Ditch: 30-in steel pipe branching from gate chamber, controlled by one 2.25-ft-square high-pressure gate.

Capacity	18	ft^3/s

Carriage Facilities

Davie Ditch Canal

Location: From Rifle Gap Reservoir, extending south 4.9 mi.
Construction period: Rehabilitated by Reclamation, 1965-66

Length	4.9	mi
Initial capacity	18	ft^3/s
Bottom width	5	ft
Side slopes	2:1	
Water depth	1.4	ft

Grass Valley Canal

Location: From East Rifle Creek above Rifle Gap Reservoir, extending generally south and east to existing Harvey Gap Reservoir
Construction period: Rehabilitated by Reclamation, 1965-66

Length	1	mi
Initial capacity	60	ft^3/s
Bottom width	8	ft
Side slopes	2:1	
Water depth	3.5	ft

Silt Pump Canal

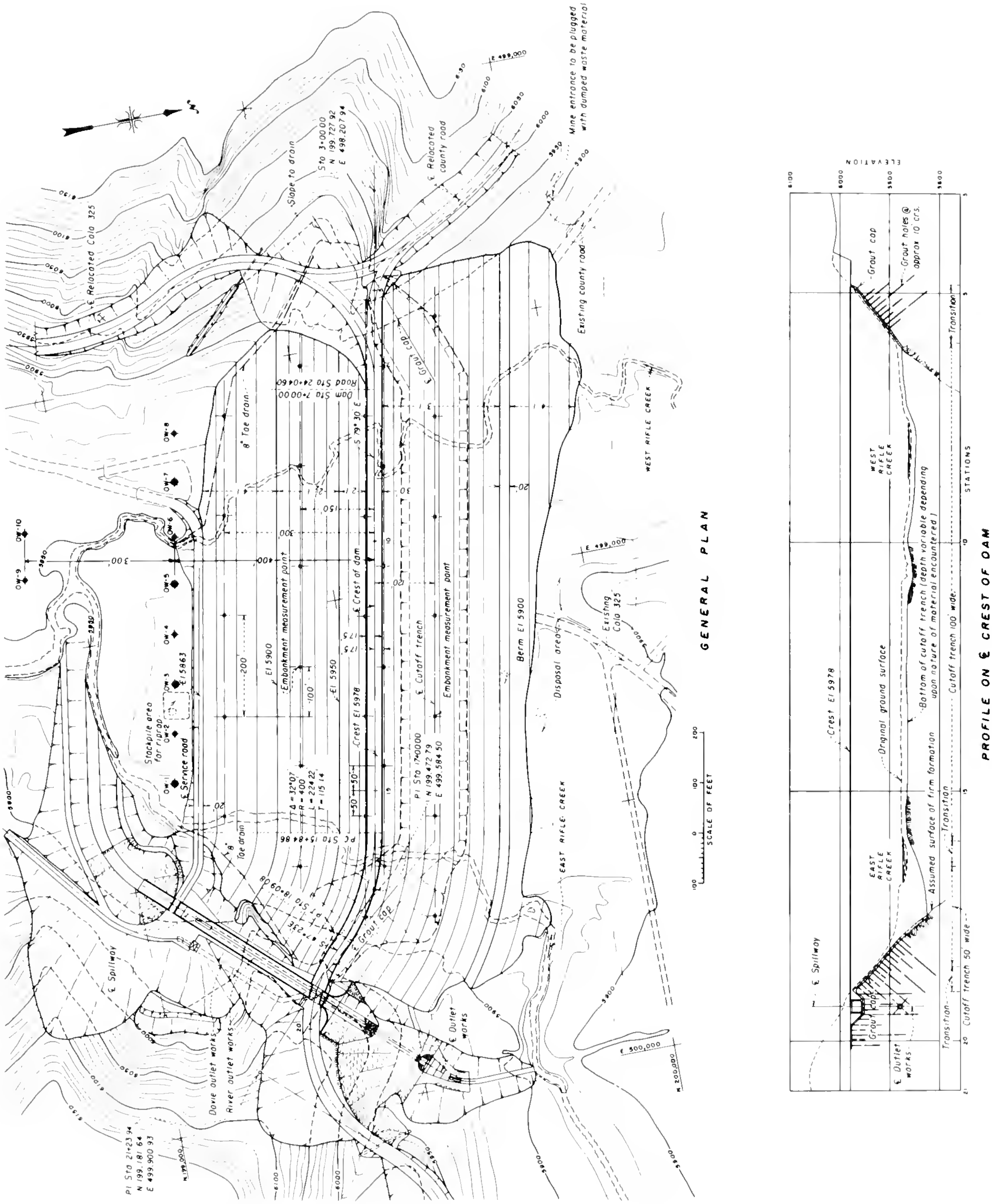
Location: At end of an inlet canal from the Colorado River about 2 mi east of Silt, Colo., extends to the northwest.
Construction period: 1965-66

Length	7.6	mi
Initial capacity	32	ft^3/s
Bottom width	6	ft
Side slopes	2:1	
Water depth	1.4	ft

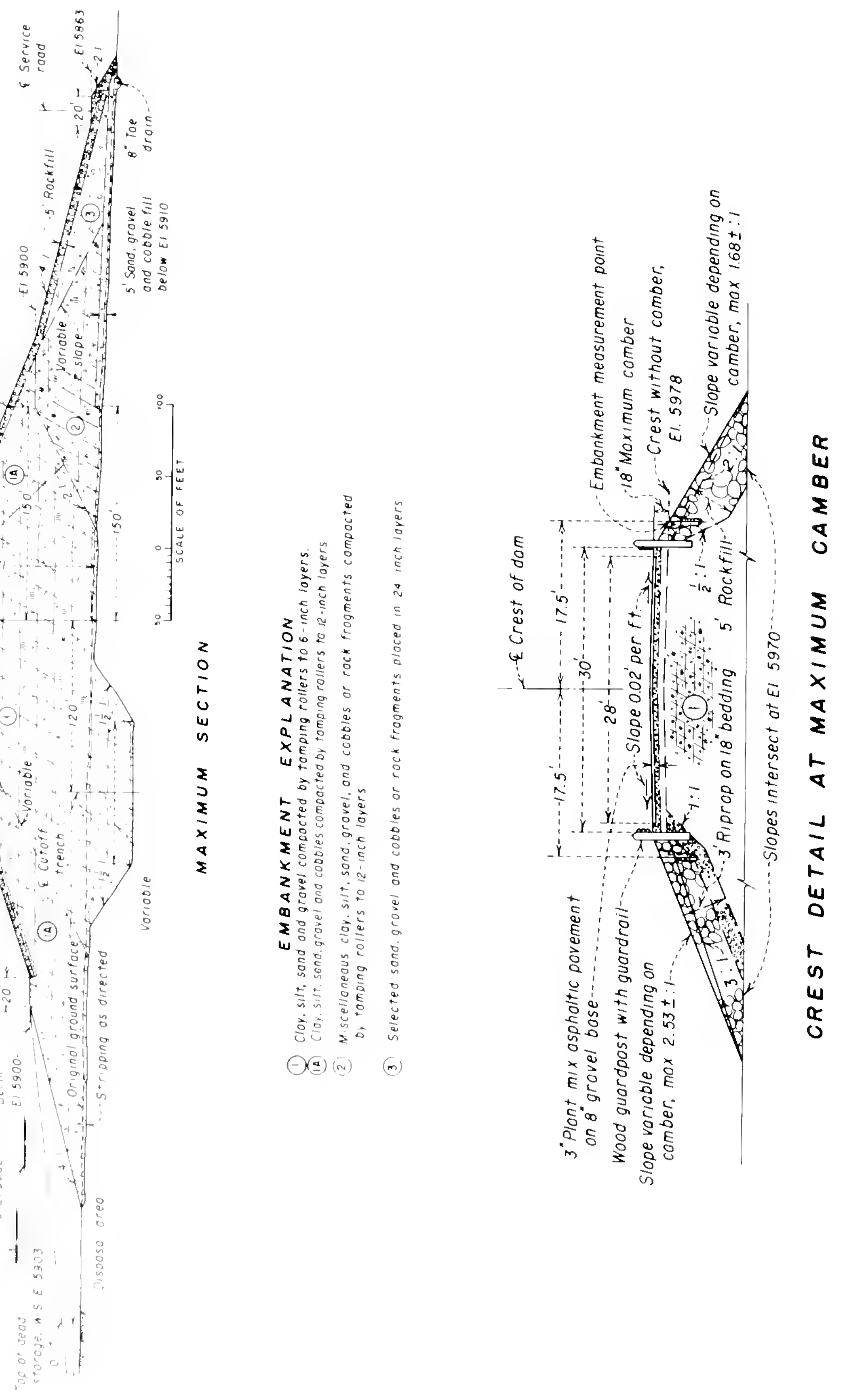
Silt Pumping Plant

Location: Near the Colorado River about 2 mi east of the town of Silt, Colo.

Number of units	4	
Total capacity	36	ft^3/s
Total dynamic head	225	ft
Total horsepower	1,275	



Rifle Gap Dam, Plan and Profile

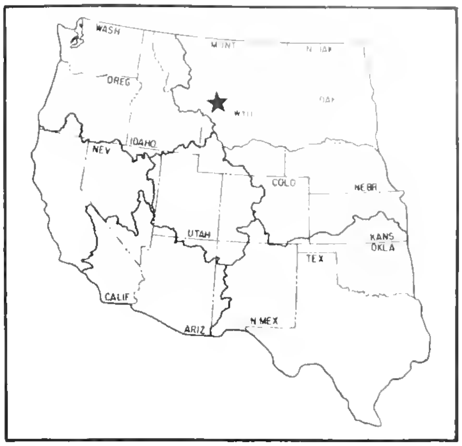


Rifle Gap Dam. Sections

Shoshone Project

Montana: Carbon County
Wyoming: Big Horn and Park Counties

Upper Missouri Region
Water and Power Resources Service



The Shoshone Project[1] is near Cody in northwestern Wyoming. Features of the project include Buffalo Bill Dam and Reservoir, Shoshone and Heart Mountain Powerplants, associated power transmission facilities, and a network of canals and laterals to deliver water to the project lands. A full irrigation water supply is available for 89,320 acres.

PLAN

Floodwaters of the Shoshone River are stored in Buffalo Bill Reservoir for later release for irrigation and power generation. The project comprises four irrigation divisions: Garland Division, with 35,853 irrigable acres; Frannie Division, 14,600; Willwood Division, 11,530; and Heart Mountain Division, 27,337.

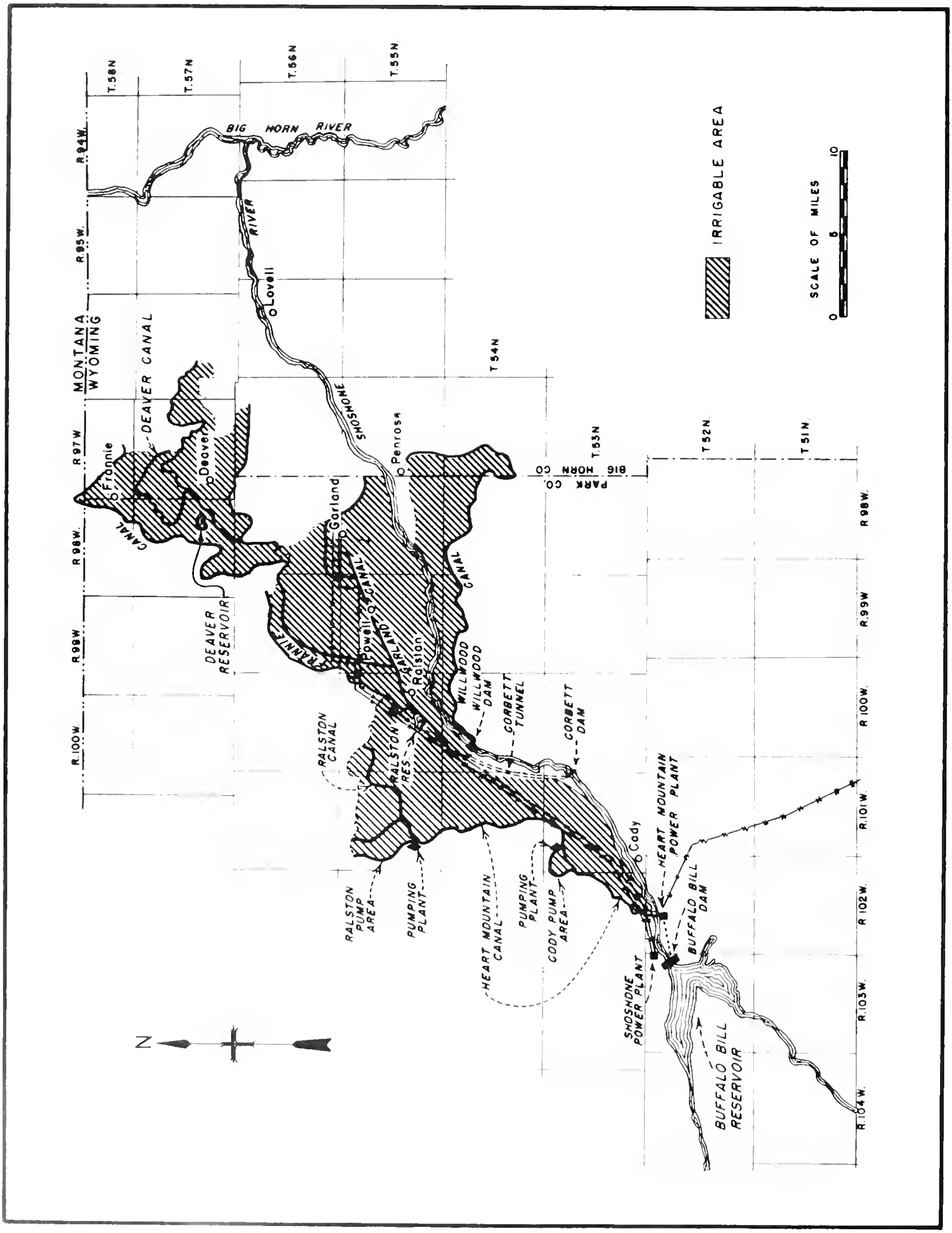
Power is developed at the Shoshone and Heart Mountain Powerplants. The system is interconnected with the West Division of the Pick-Sloan Missouri Basin Program. Transmission lines consist of 117.7 miles of 69-kilovolt and 14.0 miles of 34.5-kilovolt lines. The Shoshone Canyon Conduit, beginning at Buffalo Bill Dam, conveys water to the Heart Mountain Powerplant. This water then crosses the river through an inverted siphon into the Heart Mountain Canal for the Heart Mountain Division. Water for the Garland Division is diverted into the Garland Canal at Corbett Dam. The Frannie Canal serves the Frannie Division from the Garland Canal. Water for the Willwood Division is diverted into the Willwood Canal by Willwood Dam.

Buffalo Bill Dam and Shoshone Powerplant

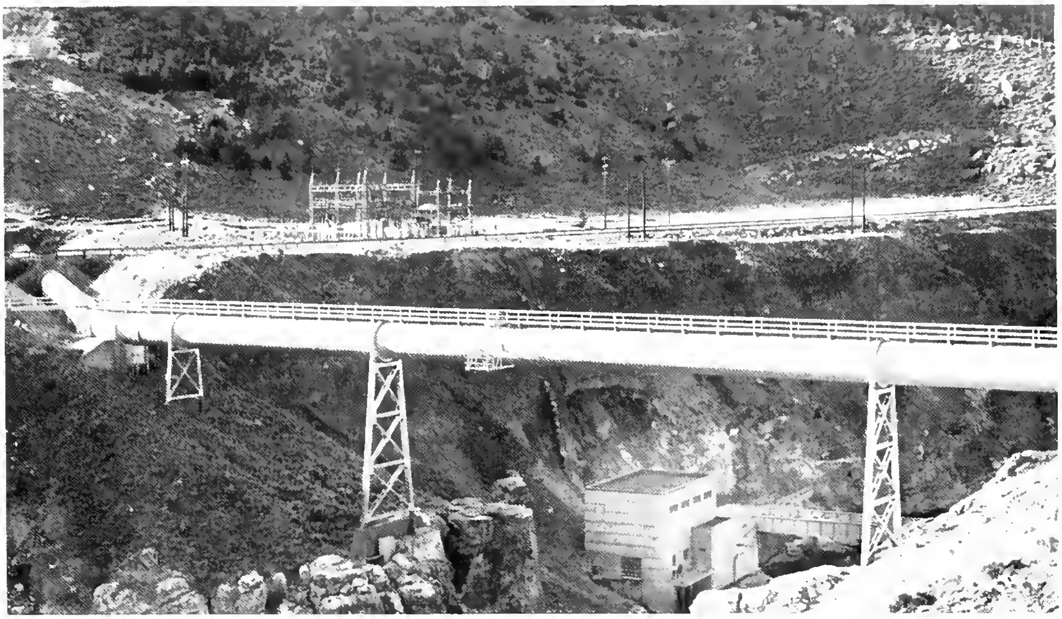
Buffalo Bill Dam, on the Shoshone River about 6 miles upstream from Cody, Wyo., is a concrete arch structure of constant radius. The structural height is 325 feet and the volume is 82,900 cubic yards. It is one of the first high concrete dams built in the United States. The reservoir impounds 423,970 acre-feet of water. The Shoshone Powerplant is near the base of Buffalo Bill Dam and has a capacity of 6,012 kilowatts.

Buffalo Bill Dam and Shoshone Powerplant

[1]Originally authorized as the Cody Project. Buffalo Bill Dam was formerly named Shoshone Dam.



Shoshone Project



Shoshone River Siphon and Heart Mountain Powerplant

Heart Mountain Powerplant

The Heart Mountain Powerplant is at the outlet of Shoshone Canyon Conduit about 4 miles southwest of Cody, Wyo. The capacity of the plant is 5,000 kilowatts.

Heart Mountain Irrigation System

The 26-mile-long Heart Mountain Canal begins at the outlet to Shoshone River Siphon, which spans the river below the Shoshone Canyon Conduit outlet. The initial capacity of the canal is 915 cubic feet per second. The siphon is part steel and part concrete, 1,640 feet long, and 10.25 feet in diameter.

Garland and Frannie Irrigation Systems

Corbett Dam is a reinforced concrete flat-slab-and-buttress weir with a short embankment wing. It is on the Shoshone River about 16 miles downstream from Buffalo Bill Dam. The hydraulic height is 12 feet. The outlet works is a concrete-lined horseshoe tunnel about 11 feet in diameter and 17,355 feet long.

The Garland Canal supplies the Garland and Frannie Divisions through the Frannie and Deaver Canals. Garland Canal heads at Corbett Dam and extends northeast about 18 miles. Its initial capacity is 1,000 cubic feet per second. Frannie Canal heads at the Garland Canal and is 44 miles long. The initial capacity is 550 cubic feet per second. Deaver Canal begins at the Frannie Canal. It is 24 miles long and has an initial capacity of 194 cubic feet per second.

Offstream storage is provided by Deaver Reservoir. This reservoir is on the Frannie Canal and has a capacity of 680 acre-feet. Ralston Reservoir on the Garland Canal is no longer used as an operational storage reservoir. It provides an emergency waste route during storms, and collects drainage water.

Willwood Irrigation System

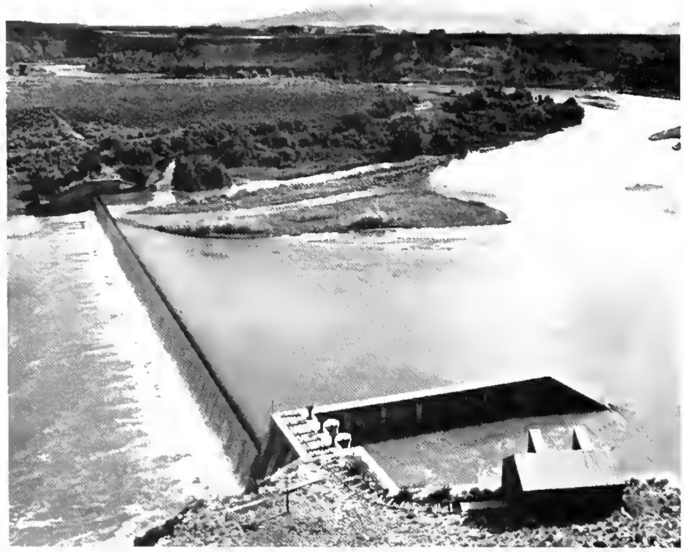
Willwood Dam, 8 miles downstream from Corbett Dam, is a concrete gravity structure with a hydraulic height of 41 feet. Willwood Canal heads at the diversion dam. The canal is about 25 miles long and the diversion capacity is 320 cubic feet per second.

DEVELOPMENT

Early History

Col. William F. "Buffalo Bill" Cody made the area now occupied by the Shoshone Project famous in the early days of the West. Buffalo Bill and his companions were the first to perceive the possibilities of turning the sagebrush flats of Wyoming's Bighorn Basin into a land of agricultural abundance through irrigation. In 1899, they acquired from the State of Wyoming, a right to appropriate waters from the Shoshone River for the irrigation of about 60,000 acres of public domain near Cody. As an initial step, they constructed a canal on the south side of the Shoshone River. In 1903, the Wyoming State Board of Land Commissioners, with Cody's approval, urged the Reclamation Service to complete the proposed irrigation development.

Willwood Dam



Corbett Dam

Investigations

Reclamation Service engineers investigated the proposed project and, to obtain the maximum benefit from the flow of the river, recommended construction of a dam on the Shoshone River at the upstream end of the sheer-walled canyon 7 miles west of Cody, Wyo.

Authorization

The project was authorized by the Secretary of the Interior on February 10, 1904, under authority of the Reclamation Act of June 17, 1902. Heart Mountain power development was found feasible and authorized by the Secretary on June 19, 1945, under the provisions of the Reclamation Project Act of 1939.

Construction

Construction began in early 1904. Ralston Dam and Corbett Dam were completed in 1908, making the first water available for irrigation. Buffalo Bill Dam began storing water in 1910. Deaver Dam was completed in 1918, and the Willwood Dam in 1924. The first lands open to settlement in the project were in the Garland Division in the vicinity of Powell, Wyo. Development of the Garland Division was virtually complete in 1918. Between 1917 and 1920, the Frannie Division, comprising lands principally between the towns of Frannie and Cowley, Wyo., was opened. The Willwood Division, lying south of the Shoshone River between Willwood Dam and Penrose, Wyo., was settled under successive openings between 1927 and 1938. The Heart Mountain Division, completed in 1917, extends along the north side of the Shoshone River from the vicinity of Cody, Wyo., to a point about 7 miles northwest of Ralston, Wyo.

Rehabilitation and Betterment (R&B) Program

The Shoshone Irrigation District, Garland Division, entered into a repayment contract with the United States on March 21, 1969, to repay the cost of the R&B Program. Construction work includes lining of canals with concrete or other materials; placing of canals, laterals, and drains in pipe; and replacement of minor and major structures. The district is in the third stage of the program. The expected program completion date is 1982.

Operating Agencies

The irrigation system for the Frannie Division is operated by the Deaver Irrigation District, the Garland Division by the Shoshone Irrivation District, the Willwood Division by the Willwood Irrigation District, and the Heart Mountain Division by the Heart Mountain Irrigation District. Buffalo Bill Dam and the powerplant are operated by the Bureau of Reclamation. The transmission system is operated by the Department of Energy.

BENEFITS

Irrigation

Principal crops grown are beans, alfalfa, pasture, oats, corn, barley, and sugar beets. As these are largely feed crops, the project assists materially in stabilizing the livestock industry in the area.

Hydroelectric Power

Power produced on the project is fed into a grid system which serves an area extending into three States.

Recreation

Buffalo Bill Dam and Reservoir are located in a rugged scenic canyon adjacent to a main highway which leads into Yellowstone National Park. The reservoir area provides camping, picnicking, swimming, boating, and good fishing for rainbow, brown, and mackinaw trout. Winter fishing is popular. In 1977, the area provided 170,400 visitor days of recreation.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	89,320	acres
Number of irrigated farms	774	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	66,618	6,772,988
1969	66,088	7,315,826
1970	81,446	7,783,613
1971	80,052	10,226,553
1972	80,382	11,937,157
1973	80,320	15,273,807
1974	81,252	24,757,928
1975	81,182	23,763,111
1976	81,080	18,580,595
1977	77,297	13,876,673

Facilities in Operation

Storage dams	2	
Diversion dams	2	
Canals	140	mi
Laterals	564	mi
Drains	673	mi
Powerplants	2	
Transmission lines	163.4	mi
Substations	4	

Climatic Conditions

Annual precipitation	9.6	in
Temperature:		
Maximum	111	°F
Minimum	−51	°F
Mean	46	°F
Growing season	158	days
Elevation of irrigable area	4500.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	3,260
Municipal water service	6,100
Other water service[2]	2,020
Total	11,380

[2]Urban and suburban, and industrial lands.

Net Power Generation

Fiscal year	Heart Mountain Powerplant, kWh	Shoshone Powerplant, kWh	Total kWh
1968	49,878,500	46,994,500	96,873,000
1969	49,658,900	47,592,800	97,251,700
1970	46,002,500	33,479,100	79,481,600
1971	20,537,800	42,525,300	63,363,100
1972	52,550,000	49,793,700	102,343,700
1973	51,929,000	48,657,600	100,586,600
1974	47,241,900	22,724,800	69,966,700
1975	48,150,400	10,365,400	58,515,800
1976	39,611,500	35,175,100	74,786,600
1977	35,837,000	23,167,100	59,004,100

ENGINEERING DATA

Water Supply

SHOSHONE RIVER

Drainage area at Buffalo Bill Dam	1,520	mi²
Annual discharge below Buffalo Bill Dam:		
Maximum (1928)	1,359,400	acre-ft
Minimum (1961)	445,600	acre-ft
Average	861,700	acre-ft

Storage Facilities

BUFFALO BILL DAM

Type: Concrete arch
Location: On the Shoshone River, 6 mi west of Cody, Wyo.
Construction period: 1905-10. Modified in 1915, 1922-23, and 1959.
Date of closure (first storage): May 16, 1910
Reservoir, Buffalo Bill:

Total capacity to El. 5360	423,970	acre-ft
Active capacity, El. 5259.6-5360	375,770	acre-ft
Surface area	6,720	acres
Dimensions:		
Structural height	325	ft
Hydraulic height	240	ft
Top width	10	ft
Maximum base width	108	ft
Crest length	200	ft
Crest elevation	5370.0	ft
Parapet elevation	5373.0	ft
Total volume	82,900	yd³

Spillway: Uncontrolled concrete side-channel weir upstream from left abutment and unlined tunnel through abutment to river

Crest length	298	ft
Crest elevation	5360.0	ft
Capacity at El. 5369	18,000	ft³/s

Outlet works: The new outlet works, completed in 1959, consists of a 20- by 17-ft horseshoe tunnel through the left abutment to an interior trashrack and bulkhead gate housing and then into a 7.5-ft concrete-lined tunnel terminating at a gatehouse immediately downstream from the dam at the left abutment. The gatehouse contains four 4- by 5-ft rectangular high-pressure gates, two acting as regulating gates and two as guard gates.

Capacity at El. 5365	3,130	ft³/s

Power outlet works consist of two 42-in conduits through base of dam, with 48-in balanced valves at lower end, continuing through 2 steel penstocks to 8.5-ft concrete-lined horseshoe tunnel 424 ft long in left canyon wall.

Diversion works (Shoshone Canyon Conduit): Concrete-lined tunnel through abutment, controlled by one 10-ft-diameter cylinder gate.

RALSTON DAM

Type: Earthfill
Location: Offstream on the Garland Canal, about 2 mi southwest of Ralston, Wyo.
Construction period: 1908
Reservoir, Ralston: Ralston Reservoir on the Garland Canal is no longer used as an operational storage reservoir. It provides an emergency waste route during storms, etc., and collects drainage water.
Dimensions:

Structural height	35	ft
Hydraulic height: Offstream		
Top width	10	ft
Maximum base width	205	ft
Crest length	2,200	ft
Crest elevation	4599.0	ft
Total volume	25,000	yd^3
Spillway: None		
Outlet works: Eight 4-ft-square slide gates.		
Capacity	850	ft^3/s

DEAVER DAM

Type: Homogeneous earthfill
Location: Offstream, 12 mi northeast of Powell, Wyo.
Construction period: 1918
Reservoir, Deaver: Inflow is from Frannie Canal.

Total capacity to El. 4305	680	acre-ft
Active capacity, El. 4295 - 4305	600	acre-ft
Surface area	80	acres
Dimensions:		
Structural height	14	ft
Hydraulic height: Offstream		
Top width	12	ft
Maximum base width	80	ft
Crest length	1,300	ft
Crest elevation	4309.0	ft
Total volume	30,000	yd^3

Spillway: None
Outlet works: 16-in cast iron pipe through dam.

Diversion Facilities

CORBETT DAM

Type: Concrete slab-and-buttress weir, embankment wing
Location: On Shoshone River, 16 mi downstream from Buffalo Bill Dam.
Year completed: 1908
Dimensions:

Structural height	18	ft
Hydraulic height	12	ft
Weir crest length	400	ft
Total crest length	938	ft
Weir crest elevation	4625.5	ft
Volume	10,200	yd^3
Spillway: Overflow weir		
Capacity	20,000	ft^3/s

Headworks: Concrete-lined horseshoe tunnel, about 11 ft in diameter, controlled by two 5- by 10-ft gates. Sluiceway controlled by three 4- by 5-ft slide gates.

Capacity of tunnel	1,000	ft^3/s

WILLWOOD DAM

Type: Concrete gravity ogee weir, embankment wing
Location: On Shoshone River, 8 mi downstream from Corbett Dam.
Year completed: 1924
Dimensions:

Structural height	70	ft
Hydraulic height	41	ft
Weir crest length	271	ft
Total crest length	476	ft
Weir crest elevation	4499.5	ft
Volume	22,100	yd^3
Spillway: Ogee overflow		
Capacity	25,000	ft^3/s
Headworks: Diversion channel, controlled by two 5.5- by 7-ft diversion gates.		
Capacity	320	ft^3/s

Carriage Facilities

SHOSHONE CANYON CONDUIT

Location: From Buffalo Bill Dam east along south side of Shoshone River Canyon to Heart Mountain Powerplant.
Construction period: 1935-40
Description: Consists principally of three tunnel sections connected by concrete conduit sections.

Length	2.8	mi
Capacity	1,200	ft^3/s
Cross section: Horseshoe		
Diameter	12	ft
Lining: Concrete		

SHOSHONE RIVER SIPHON (HEART MOUNTAIN CANAL)

Location: Across the Shoshone River from end of Shoshone Canyon Conduit, near Heart Mountain Powerplant.
Construction period: 1939

Description: Concrete siphon barrel	793	ft.
Steel siphon barrel	847	ft.
Length	1,640	ft
Diameter	123	in
Capacity	915	ft^3/s

HEART MOUNTAIN CANAL

Location: From Heart Mountain Powerplant generally north.
Construction period: 1937-47

Length	26.2	mi
Diversion capacity	915	ft^3/s
Typical maximum section in earth:		
Bottom width	32	ft
Side slopes	1.5:1	
Water depth	8.4	ft
Typical maximum section, concrete lined:		
Bottom width	8	ft
Side slopes	1.25:1	
Water depth	7.51	ft
Lining thickness	4	in

Garland Canal

Location: From lower end of Corbett Tunnel 3.25 mi below Corbett Dam on the Shoshone River about 6 mi northeast of Cody, Wyo., generally northeast to vicinity of Garland, Wyo.
Construction period: 1906-08

Length[3]	18.5 mi
Diversion capacity	1,000 ft³/s
Typical maximum section in earth:	
Bottom width	40 ft
Side slopes	2:1
Water depth	6.5 ft

Corbett Tunnel (Garland Canal)

Location: From Corbett Dam north to Ralston Reservoir.
Construction period: 1905-07

Length	17,355 ft
Capacity	1,000 ft³/s
Cross section: Rectangular arched roof	
Height	129 in
Width	138 in
Lining: Concrete	
Thickness	9 in

Frannie Canal

Location: From Garland Canal near Ralston, Wyo., generally northeast to vicinity of Frannie, Wyo.
Construction period: 1917-20

Length	44 mi
Diversion capacity	550 ft³/s
Typical maximum section in earth:	
Bottom width	36 ft
Side slopes	2:1
Water depth	4.5 ft

Deaver Canal

Location: From mile 14 on Frannie Canal, about 6 mi northeast of Powell, Wyo., generally northeast past Deaver Reservoir.
Construction period: 1916-17

Length	24 mi
Diversion capacity	194 ft³/s
Typical maximum section in earth:	
Bottom width	20 ft
Side slopes	1.5:1
Water depth	3.6 ft

Willwood Canal

Location: From Willwood Dam on the Shoshone River about 5 mi southwest of Ralston, Wyo., generally east to a point about 4.5 mi south of Penrose.
Construction period: 1924-27

Length	24.8 mi
Diversion capacity	320 ft³/s
Typical maximum section in earth:	
Bottom width	10 ft
Side slopes	1.5:1
Water depth	5 ft
Typical maximum section in rock:	
Bottom width	10 ft
Side slopes	0.75:1
Water depth	5 ft

[3]Exclusive of Corbett Tunnel.

Power Facilities

Heart Mountain Powerplant

Location: Shoshone River Canyon Conduit, about 4 mi southwest of Cody, Wyo.
Year of initial operation: 1948

Installed capacity	5,000 kW
Number of generators	1
Static head range	265-275 ft

Shoshone Powerplant

Location: About 300 ft downstream from Buffalo Bill Dam.
Year of initial operation: 1922
Year last generator placed in operation: 1931

Number of generators	3
Installed Capacity:	
(1)	1,212 kW
(2)	800 kW
(3)	4,000 kW
Static head range	120-227 ft

Substations

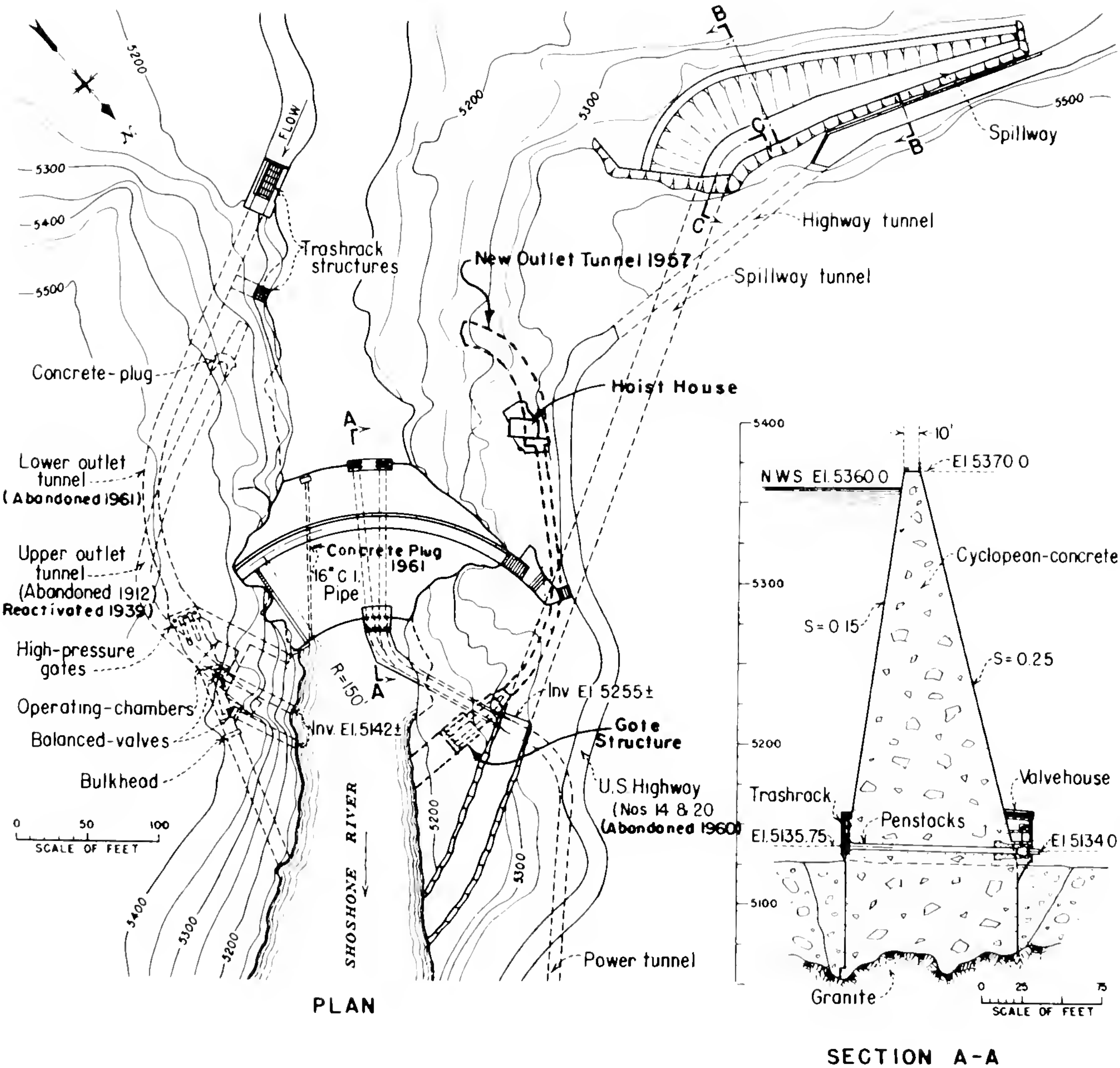
Number in operation	3
Total capacity of transformers	22,154 kVA

Substations	Rated voltage, kV	Year placed in service
Shoshone	33.0	1922
Heart Mountain	69.0	1948
Garland	69.0	1950

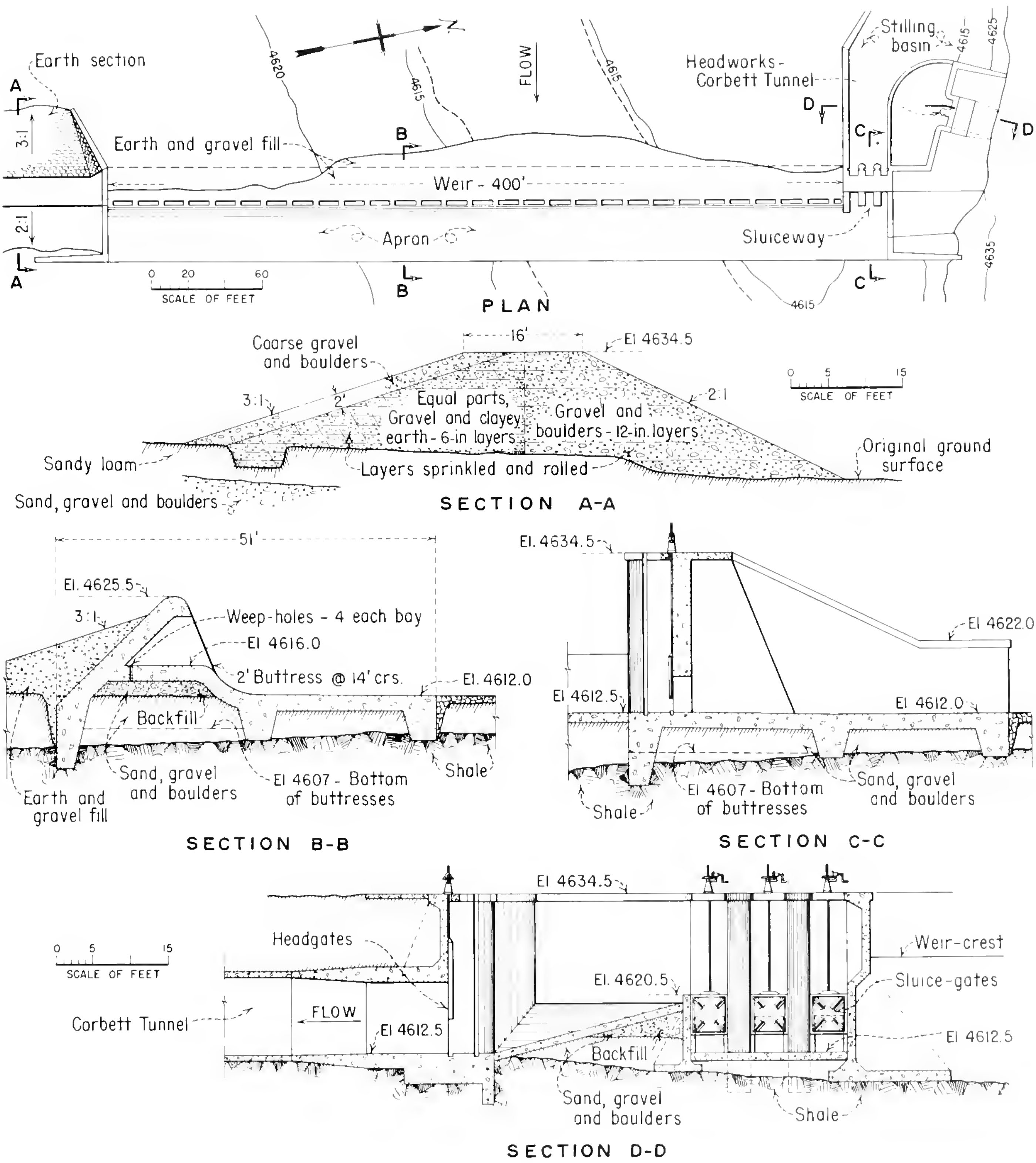
Transmission Lines

Total number of lines	9
Total circuit miles	133
69 kV	117.7 mi
34.5 kV	14.0 mi
12.5 kV	1.3 mi

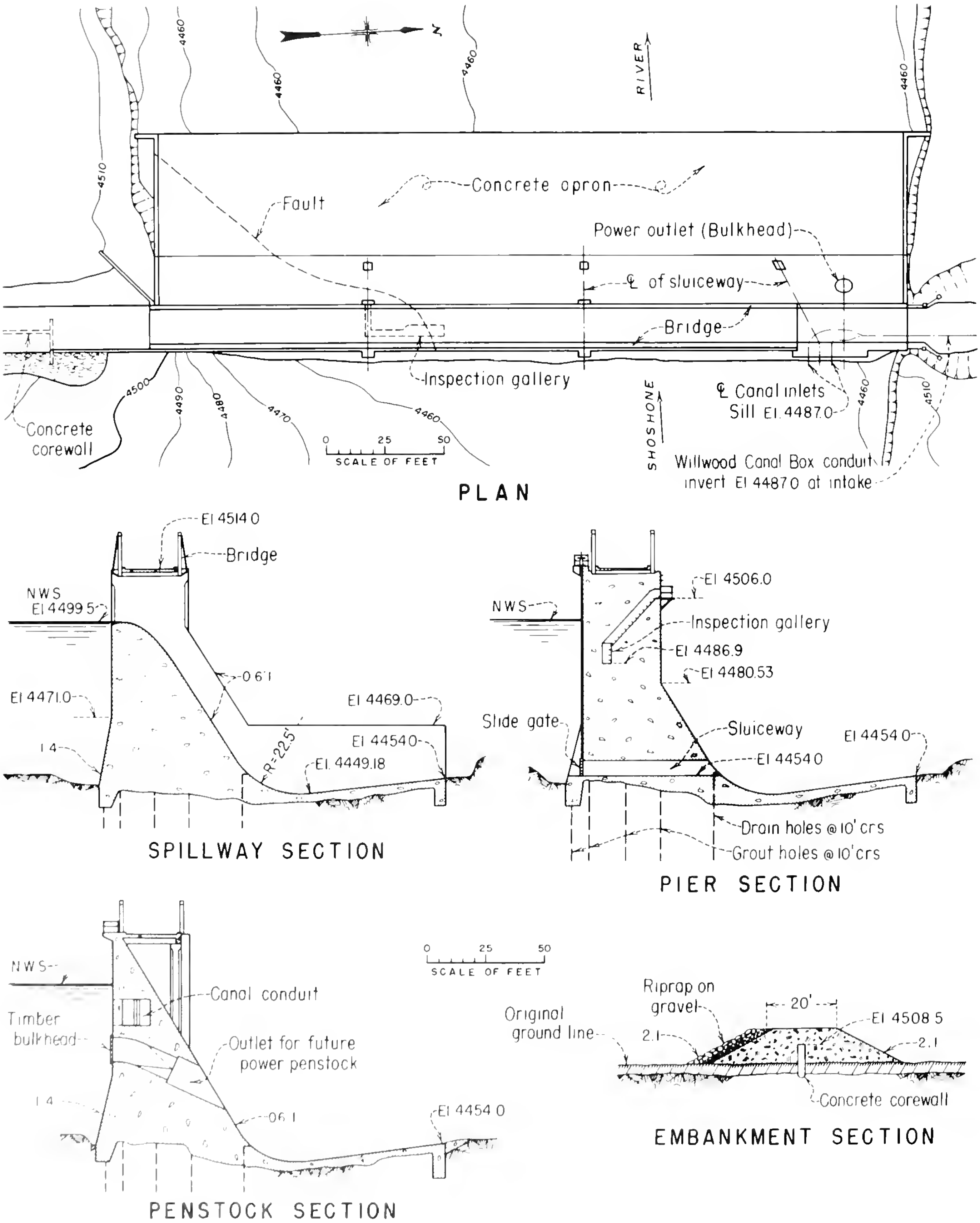
Transmission Lines	Voltage, kV	Circuit miles	Year placed in service
Shoshone—North Cody (Line No. 1)	34.5	6.36	1922
Willwood—Toward Powell	12.5	1.30	1924
Heart Mountain — North Cody	34.5	3.90	1930
Shoshone—Heart Mountain (Line No. 2)	34.5	2.66	1930
Heart Mountain — Thermopolis	69.0	80.50	1941
Shoshone—Heart Mountain (Line No. 1)	69.0	2.70	1941
North Cody — Cody	34.5	1.03	1942
Waltman — Thermopolis	69.0	0.57	1947
Heart Mountain — Lovell	69.0	33.90	1948



Buffalo Bill Dam, Plan and Section



Corbett Dam, Plan and Sections

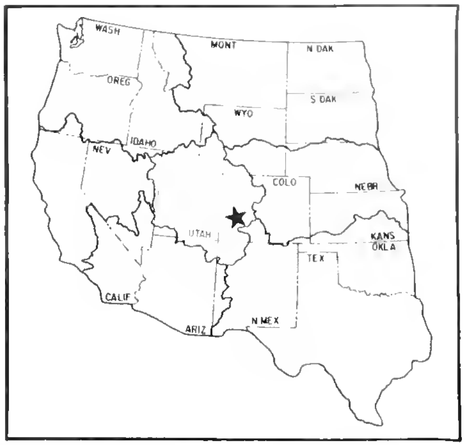


Willwood Dam, Plan and Sections

Smith Fork Project

Colorado: Delta and Montrose Counties

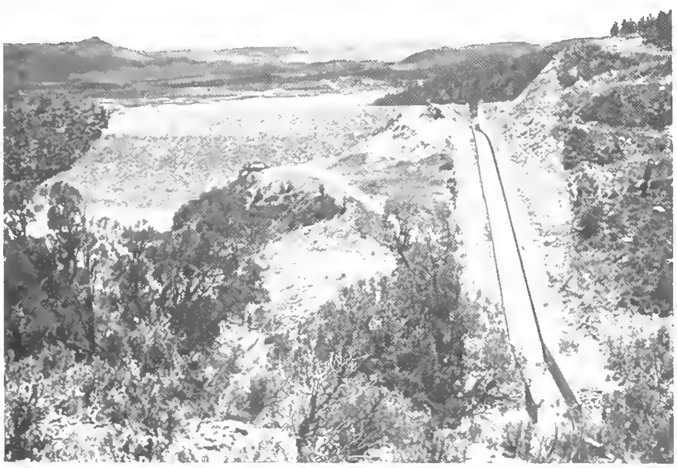
Upper Colorado Region
Water and Power Resources Service



Surplus flows of Smith Fork, Iron, Mud, and Alkali Creeks are regulated and utilized by Smith Fork Project in west-central Colorado. The project, 73 miles southeast of Grand Junction, supplements the irrigation water supply for 8,056 acres and provides a full water supply for 1,423 acres of land previously not irrigated. Construction features of the project include Crawford Dam and Reservoir, Smith Fork Diversion Dam, Smith Fork Feeder Canal, Aspen Canal, Clipper Canal, and recreation facilities.

PLAN

Crawford Dam is on Iron Creek, a tributary of the Smith Fork about 1 mile south of Crawford, Colo. The Crawford Reservoir regulates flows of Iron Creek and its tributaries as well as the surplus flows of the Smith Fork of the Gunnison River, diverted to the reservoir by the feeder canal. Small quantities of reservoir storage water are released to Iron Creek and diverted by several small private ditches. The remainder is released to Aspen Canal for conveyance to private ditches for distribution. Some of the storage releases through Aspen Canal replace former direct flow diversions from Smith Fork, permitting additional direct flow diversions for project land higher on the stream.



Crawford Dam

Crawford Dam and Reservoir

Crawford Dam is a zoned earthfill structure 162 feet high and 580 feet long, with a volume of 1,006,000 cubic yards. The uncontrolled overflow spillway is in the left abutment of the dam and has a design capacity of 1,400 cubic feet per second. The outlet works in the right abutment of the dam carries water through a 34-inch-diameter steel pipe controlled by four 2.25-foot-square high-pressure gates. Maximum discharge capacity to Aspen Canal is 125 cubic feet per second. Crawford Reservoir has a total capacity of 14,395 acre-feet and an active capacity of 14,064 acre-feet. The reservoir has a surface area of 406.2 acres.

Smith Fork Diversion Dam

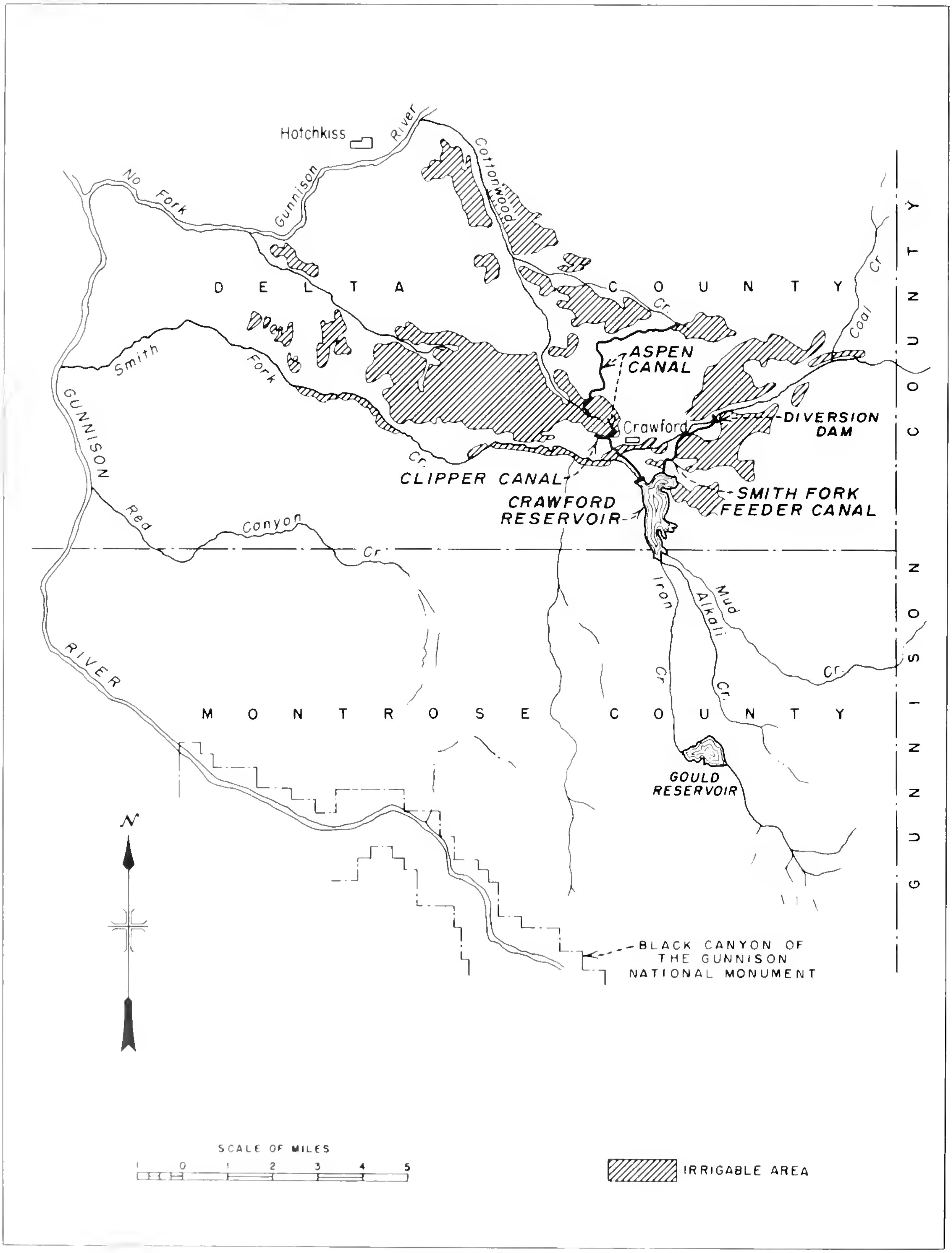
Smith Fork Diversion Dam at the head of Smith Fork Feeder Canal consists of a concrete ogee weir and embankment wings. It is about 3 miles northeast of Crawford. The dam stands 10 feet above streambed, has a total crest length of 790 feet, and a weir crest length of 34.5 feet. Diversion capacity of the structure is 80 cubic feet per second.

Smith Fork Feeder Canal

In the vicinity of Crawford, the earth-lined Smith Fork Feeder Canal originates at Smith Fork Diversion Dam and runs southwesterly to Crawford Reservoir. The 2.4-mile-long canal has an initial capacity of 80 cubic feet per second.

Aspen Canal

Aspen Canal heads at Crawford Dam and runs 5.8 miles in a northerly direction. The canal has an initial capacity of 125 cubic feet per second.



Smith Fork Project

Crawford Dam and Reservoir

Clipper Canal

Clipper Canal feeds from Aspen Canal and runs to the west a distance of about 0.5 mile. The initial capacity of the canal is 60 cubic feet per second.

DEVELOPMENT

Early History

Delta County, along with most of western Colorado, was originally inhabited by the Ute Indians. Early settlement of the area was retarded by hostility between the Indians and the immigrants. In 1881, a compromise agreement was reached between the Federal Government and the Ute Indians which required the Indians to locate in the Uintah Reservation in the Territory of Utah. After this agreement, settlement of the area progressed rapidly. Most of the impetus of the initial settlement period was provided by discoveries of rich deposits of gold, silver, and other minerals in the mountainous areas near the Continental Divide. Agricultural development proceeded at a slower rate but was much more uniform and stable. Farms were developed along the valleys, towns were established near the mines and the agricultural communities, and construction of railroads to the trade and mining centers was begun.

Investigations

The Smith Fork Project was mentioned briefly in Reclamation's basin-type report of March 1946 on the Colorado River. In 1951, Reclamation issued a detailed report on the Smith Fork Project as a supplement to the 1951 report on the Colorado River Storage Project and participating projects. This second report, amended in October 1953, was the basis on which the project was authorized.

Authorization

The project is one of the initial participating projects authorized with the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105).

Construction

Construction was begun on Crawford Dam in 1960 and on all other major features in 1961. All construction was completed in 1962.

Operating Agency

Operation and maintenance of the project was turned over to the Crawford Water Conservancy District on January 1, 1964.

BENEFITS

Irrigation

An improved irrigation supply permits new lands to be irrigated and permits better crop yields on lands previously inadequately watered. Predominant crops include alfalfa, grass hay, pasture, barley, oats, wheat, and corn. Feed production is used for livestock, primarily cattle and sheep.

Recreation

Recreation is administered by the Colorado Division of Parks and Outdoor Recreation and consists of fishing, boating, and camping. Visitor days generated by recreation facilities in 1977 reached a total of 61,071.

Boat launching ramp at Crawford Reservoir

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	1,423	acres
Supplemental irrigation service	8,056	acres
Total	9,479	acres
Number of farms irrigated	120	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	8,783	455,616
1969	8,898	536,607
1970	8,953	518,100
1971	8,924	609,941
1972	9,002	1,054,855
1973	8,924	1,310,066
1974	8,924	1,168,872
1975	8,924	919,957
1976	8,924	653,293
1977	9,089	[1]521,625

[1]Spring runoff in 1977 was the lowest in 61 years of record. In most areas of Colorado, precipitaton for the year was considerably below average, resulting in lower yields because of the extreme drought.

Climatic Conditions

Annual precipitation	10.8	in
Temperature:		
Maximum	93	°F
Minimum	−25	°F
Mean	46	°F
Growing season	137	days
Elevation of irrigable area	5450-7200.0	ft

ENGINEERING DATA

Water Supply

SMITH FORK CREEK

Drainage area near Crawford, Colo.	42	mi²
Annual discharge:[2]		
Maximum (1942)	52,600	acre-ft
Minimum (1954)	12,700	acre-ft
Average	32,000	acre-ft

IRON CREEK

Drainage area near Crawford, Colo.	74	mi²
Annual discharge:		
Maximum (1912)	18,300	acre-ft
Minimum (1954)[3]	7,000	acre-ft
Average	12,200	acre-ft

[2]Includes Saddle Mountain Ditch diversions which bypass the gage station.
[3]1977 minimum data not yet available.

Storage Facilities

CRAWFORD DAM

Type: Zoned earthfill
Location: On Iron Creek 1 mi south of Crawford, Colo.
Construction period: 1960-62

Reservoir, Crawford:		
Total capacity to El. 6553	14,395	acre-ft
Active capacity	14,064	acre-ft
Surface area	406.2	acres
Dimension:		
Structural height	162	ft
Top width	30	ft
Maximum base width	1,020	ft
Crest length	580	ft
Crest elevation	6578.0	ft
Total volume	1,006,000	yd^3
Spillway: Uncontrolled concrete crest and concrete-lined chute at left abutment.		
Crest length	15	ft
Crest elevation	6553.0	ft
Capacity at El. 6562	1,400	ft^3/s
Outlet works: Concrete circular and horseshoe tunnel with 34-in steel pipe with four 2.25-ft-square high pressure gates.		
Capacity to Aspen Canal	125	ft^3/s

Diversion Facilities

Smith Fork Diversion Dam

Type: Earth dike with concrete ungated ogee crest		
Location: On Smith Fork, 3 mi northeast of Crawford, Colo.		
Year completed: 1962		
Modified: 1967		
Sluiceway added (El. 6708—10-ft radial gate)	10	ft
Dimensions:		
Height above streambed	10	ft
Crest length (total)	790	ft
Crest length (weir)	34.6	ft
Crest elevation (weir)	6713.0	ft
Volume	5,900	yd^3
Headworks: One 5- by 4-ft slide gate and concrete box		
Capacity	80	ft^3/s

Carriage Facilities

Smith Fork Feeder Canal

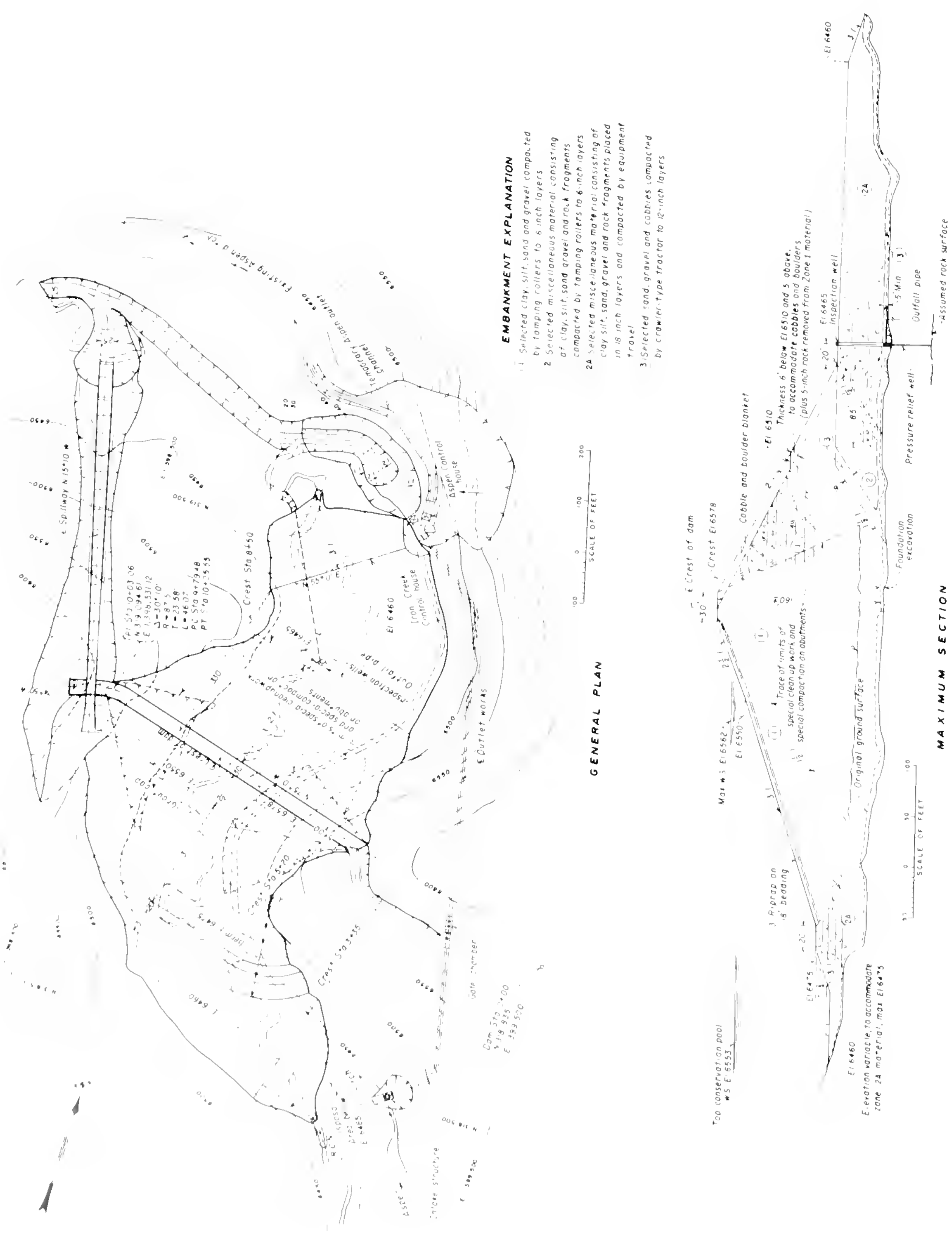
Location: Near Crawford, Colo., from Smith Fork Diversion Dam southwesterly to Crawford Reservoir.		
Construction period: 1961-62		
Length	2.4	mi
Initial capacity	80	ft^3/s
Typical maximum section, earth lined:		
Bottom width	8	ft
Side slopes	2:1	
Water depth	3	ft

Aspen Canal

Location: In the vicinity of Crawford, running northerly from Crawford Dam.		
Construction period: 1961-62		
Length	5.8	mi
Initial capacity	125	ft^3/s
Typical maximum section, earth lined:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	4	ft

Clipper Canal

Location: In the vicinity of Crawford, branching from Aspen Canal to the west.		
Construction period: 1961-62		
Length	0.45	mi
Initial capacity	60	ft^3/s
Typical maximum section, earth lined:		
Bottom width	7	ft
Side slopes	2:1	
Water depth	2.5	ft

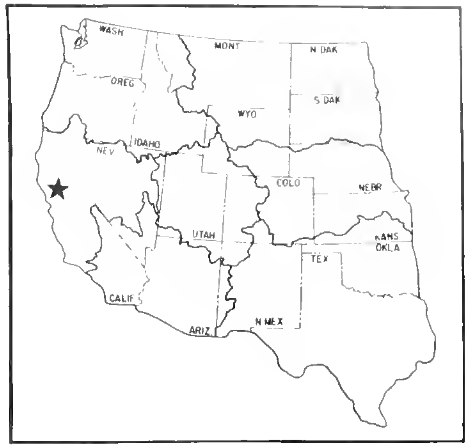


Crawford Dam, Plan and Sections

Solano Project

California: Napa and Solano Counties

Mid-Pacific Region
Water and Power Resources Service



The Solano Project is located mainly in Solano County, California, adjoining the northeast extremity of San Francisco Bay. The reservoir area behind Monticello Dam, the principal project feature, is in Napa County. Other important features are Putah Diversion Dam, Putah South Canal with a small terminal reservoir, and the necessary wasteways, laterals, and drainage works. The project was designed to irrigate approximately 96,000 acres of land. The project also furnishes municipal and industrial water to the principal cities of Solano County.

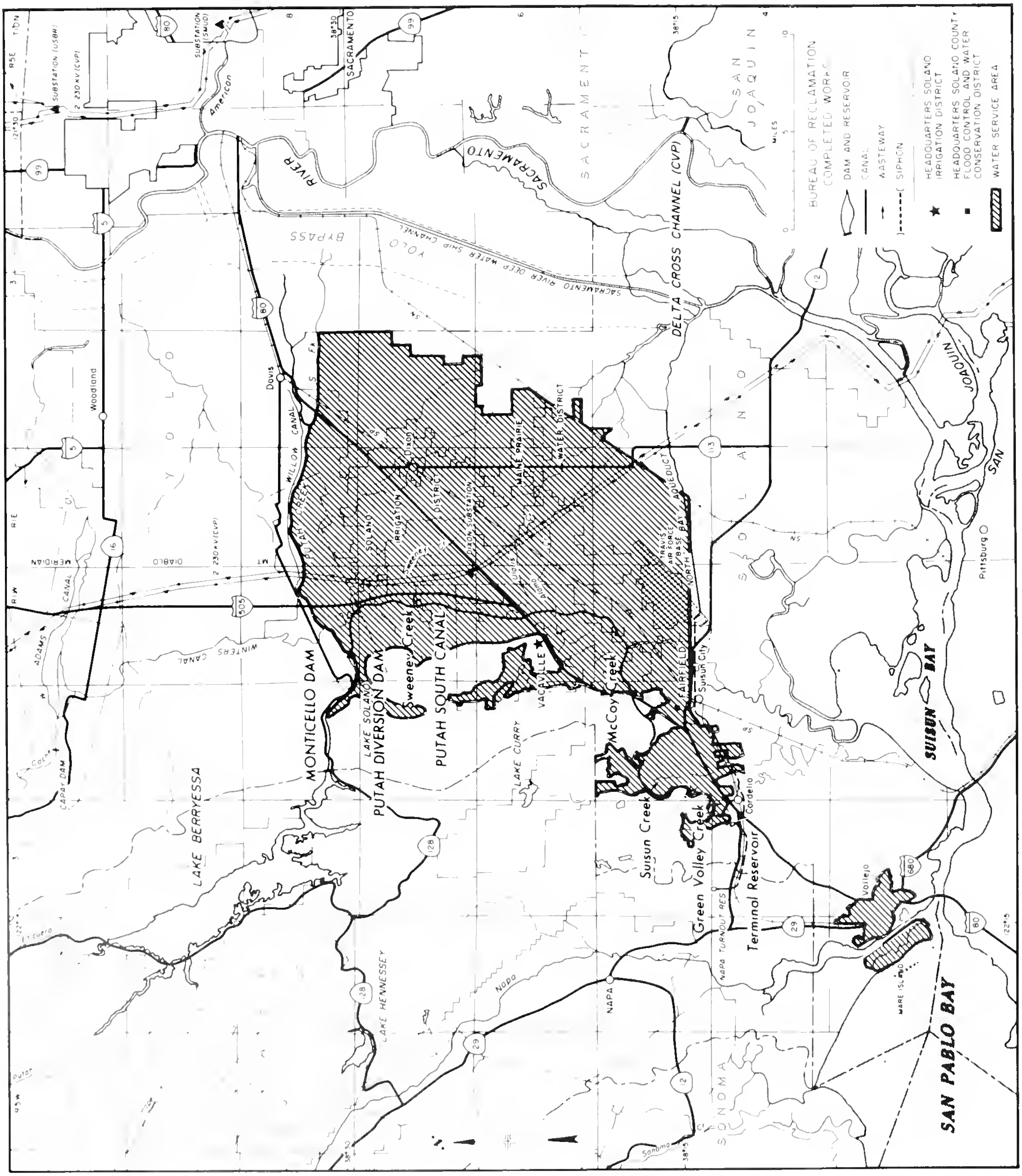
PLAN

Putah Creek is the source of water for the Solano Project. The drainage basin, comprising 576 square miles above Monticello Dam, lies to the northwest of Solano County on the eastern slope of the Coast Range in Napa and Lake Counties. In late summer the stream has little or no flow; in winter the runoff occurs almost immediately after precipitation due to the absence of snowpack and appreciable ground-water storage in the upper watershed.

Monticello Dam and Reservoir

Monticello Dam is located on Putah Creek where the stream crosses the eastern boundary of Napa County. The reservoir, Lake Berryessa, has a storage capacity of 1,602,000 acre-feet. It regulates flows along the lower

Monticello Dam and Lake Berryessa



Solano Project

Putah South Canal

reaches of Putah Creek and stores surplus water. The dam is a concrete, medium-thick arch structure with a height of 304 feet above the foundation and a crest length of 1,023 feet. Provisions were made in the initial construction for future power generating facilities.

Putah Diversion Dam

Putah Diversion Dam is located on Putah Creek approximately 6 miles below Monticello Dam. The dam is a gated concrete weir structure with an earthfill embankment wing, is 29 feet high, and has a crest length of 910 feet. The principal function of the dam is to divert water into Putah South Canal. The dam creates Lake Solano, which is about 1.5 miles long with a capacity of 750 acre-feet. The lake also provides recreation in an area already popular for picnicking, boating, swimming, and fishing.

Putah South Canal

Putah South Canal originates at Putah Diversion Dam and runs easterly for about 3 miles, then turns southward to follow the edge of the foothills for about 30 miles, terminating near Cordelia. The irrigable lands are mainly below the canal and are served by gravity. Irrigable lands above the canal are served by pumping directly from the canal. In addition to providing irrigation water, the canal conveys municipal and industrial water for Vacaville, Fairfield, Suisun, and Vallejo, as well as neighboring military installations. The canal is concrete lined, except for a 1-mile segment beginning at the Green Valley Siphon which is precast reinforced concrete pipe and designated as the Putah South Pipeline. The canal has a diversion capacity of 956 cubic feet per second with a terminal capacity of 116 cubic feet per second.

Terminal Dam and Reservoir

Terminal Dam is a compacted earthfill structure 24 feet high with a crest length of 870 feet. The 119-acre-foot reservoir is located at the end of Putah South Canal and serves as a terminal reservoir for the canal and a forebay from which water is delivered to Vallejo. This reservoir reregulates the terminal flows in the canal and provides a small carryover supply in case of an interruption in flow.

Green Valley Conduit

Green Valley Conduit, a high-pressure concrete pipeline ranging in size from 27 down to 18 inches in diameter, extends 8,400 feet from the Putah South Canal into Green Valley. Leading from this main pipeline, 4,000 feet of subconduits, 18 to 12 inches in diameter, carry water across the valley to the farmlands.

Distribution Systems

Local irrigation districts have the option of building their own distribution systems. Solano Irrigation District, pursuant to Public Law 130, has completed a $15-million distribution drainage system.

DEVELOPMENT

Early History

After gold was discovered in California, a vast migration passed through Solano County since it was on a direct route between San Francisco Bay and the goldfields. Communities grew rapidly, and agriculture expanded. An army post established at Benicia in 1849 was later turned into a major arsenal. In 1856, the U.S. Navy completed a shipbuilding and ship repair base at Mare Island opposite the city of Vallejo.

Following the severe drought in the 1860's, large-scale grain raising began, followed by a more diversified agriculture based on irrigation and dryland crops. Sheep and cattle raising continued to hold an important place in the economy of the area. Specialty crops came into prominence as demand for agricultural products in the San Francisco Bay area increased and water well capability was developed. With the increased irrigation and the municipal and industrial development of the county, the demand for water resulted in the utilization of all of the more readily available sources of supply.

Investigations

The problem of obtaining additional water to maintain the existing development became more and more critical.

About 1940, the Solano County Board of Supervisors organized the Solano County Water Council to study the areas in greatest need of additional water and to promote general water development in the county. The Solano Irrigation District was formed February 26, 1948, under the sponsorship of the council to obtain irrigation water from the proposed multiple-purpose Solano Project. To further the general water development, the Solano County Flood Control and Water Conservation District was authorized in 1951 by the State legislature and was activated on November 28, 1951, by the Solano County Board of Supervisors.

The Solano Project was included in the Bureau of Reclamation's comprehensive plan for development of water resources of the Central Valley Basin, California, as a part of the Yolo-Solano Project which is included in the plan under the West Side Sacramento Valley Area (Senate Document 113, 81st Cong., 1st sess.). A preliminary draft of the proposed report was prepared early in 1947 outlining the details for a combined Cache and Putah Creek development in accordance with the general Yolo-Solano Project plan referred to in the Central Valley Basin comprehensive report. A project planning report (House Document 65, 81st Cong., 1st sess., March 15, 1948) which outlined the plan of development of only Putah Creek resulted in the authorization of the present project.

Putah Diversion Dam and Reservoir

Authorization

The Solano Project was authorized by the Secretary of the Interior on November 11, 1948, under the terms of the Reclamation Project Act of 1939.

Construction

Construction of the project began in 1953. Monticello Dam and Putah Diversion Dam were completed in 1957 and Putah South Canal early in 1959.

Operating Agencies

Monticello Dam and Reservoir, Putah Diversion Dam, and Putah South Canal headworks are operated and maintained by the Bureau of Reclamation. The Putah South Canal (except headworks) and Green Valley Conduit are operated by the Solano Irrigation District under contract with the Solano County Flood Control and Water Conservation District.

BENEFITS

Irrigation

Principal crops are corn, wheat, sugar beets, tomatoes, fruits, nuts, and irrigated pasture.

Municipal and Industrial Water

The project supplies about 32,000 acre-feet annually to the cities of Vallejo, Vacaville, Fairfield, Benicia, and Suisun. Water is furnished through the city systems to Travis Air Force Base, Mare Island Naval Shipyard, and Benicia Arsenal.

Flood Control

It is estimated that flood damages amounting to $4.95 million were prevented by project facilities during 1957-77.

Recreation

The Lake Berryessa Recreation Area, administered by the Bureau of Reclamation, has seven developed concession resorts which offer boating, swimming, water skiing, fishing, camping, and picnicking. A two-lane public boat launch ramp and a day-use area are being constructed to augment the facilities offered by the concessionaires. Lake Solano Recreation Area, administered by the Solano County Parks Department, offers camping, picnicking, swimming, boating, and fishing.

Irrigated tomatoe field

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	96,068	acres
Number of irrigated farms	900	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	45,693	18,706,697
1969	48,772	18,437,877
1970	58,002	17,644,972
1971	52,168	16,487,217
1972	53,128	20,867,649
1973	53,365	30,969,085
1974	54,717	44,011,667
1975	58,599	43,933,532
1976	62,673	39,998,732
1977	56,701	35,639,895

Facilities in Operation

Storage dams	2	
Diversion dams	1	
Canals	32.3	mi
Pipelines	3.4	mi

Climatic Conditions

Annual precipitation	17.3	in
Temperature:		
Maximum	116	°F
Minimum	11	°F
Mean	60	°F
Growing season	244	days
Elevation of irrigable area	75.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	3,700
Urban/suburban irrigation service	450
Municipal and other water service	194,082
Total	198,232

ENGINEERING DATA

Water Supply

PUTAH CREEK

Drainage area at Monticello Dam	576	mi²
Annual discharge at Monticello Dam:		
Maximum (1941)	1,004,000	acre-ft
Minimum (1931)	34,800	acre-ft
Average	371,763	acre-ft
Annual diversion	162,971	acre-ft

Storage Facilities

MONTICELLO DAM

Type: Concrete medium thick arch
Location: On Putah Creek about 30 mi west of Sacramento, Calif.
Construction period: 1953-57
Reservoir, Lake Berryessa:

Average annual inflow, 1930-70	372,200	acre-ft
Total capacity to El. 455.5	1,602,000	acre-ft
Active capacity, El. 440	1,592,000	acre-ft
Surface area	20,700	acres
Shoreline	165	mi
Dimensions:		
Structural height	304	ft
Hydraulic height	239	ft
Top width	12	ft
Maximum base width	100	ft
Crest length	1,023	ft
Crest elevation	456.0	ft
Total volume	326,000	yd³

Spillway: Uncontrolled concrete morning-glory inlet and concrete-lined shaft and tunnel through right abutment.

Crest elevation	440.0	ft
Capacity, El. 455.5	48,400	ft³/s

Outlet works: Two pipes through the dam, each controlled by one 54-in hollow-jet valve.

Capacity at El. 455.5	2,580	ft³/s

Foundation special treatment: Cement-grout blanket over foundation area; grout curtain beneath upstream toe.
Mass concrete: Type II cement, 25 percent of pozzolan. Aggregate from Cache Creek, except materials 3 to 6 inches in size which were supplied from the American River.
Temperature control: Aggregates precooled; placed concrete cooled by circulating refrigerated water in embedded pipes.

TERMINAL DAM

Type: Compacted earthfill
Location: At the end of Putah South Canal near Cordelia, Calif.
Construction period: 1959
Reservoir, Terminal:
Dimensions:

Structural height	24	ft
Crest length	870	ft
Total volume	58,000	yd³

Diversion Facilities

PUTAH DIVERSION DAM

Type: Concrete ogee-gated weir, embankment wing
Location: On Putah Creek, 18 mi northeast of Napa, Calif.

Year completed: 1957

Dimensions:

Structural height	29	ft
Hydraulic height	10	ft
Crest length	910	ft
Crest elevation	136.25	ft
Volume	25,000	yd^3
Diversion capacity	956	ft^3/s

Carriage Facilities

Putah South Canal

Location: From Putah Diversion Dam generally southwest to vicinity of Cordelia, Calif.

Construction period: 1956-59

Length	32.3	mi
Capacity	956	ft^3/s

Section (initial reach):

Bottom width	12	ft
Side slopes	1.5:1	
Water depth	10 3	ft

Green Valley Conduit

Location: Extends from the Putah South Canal 8,400 ft into Green Valley, southwest of Fairfield, Calif.

Construction period: 1958-59

Length	2.4	mi
Capacity	14	ft^3/s

Type: Precast concrete

Diameter	12-27	in

Putah South Pipeline

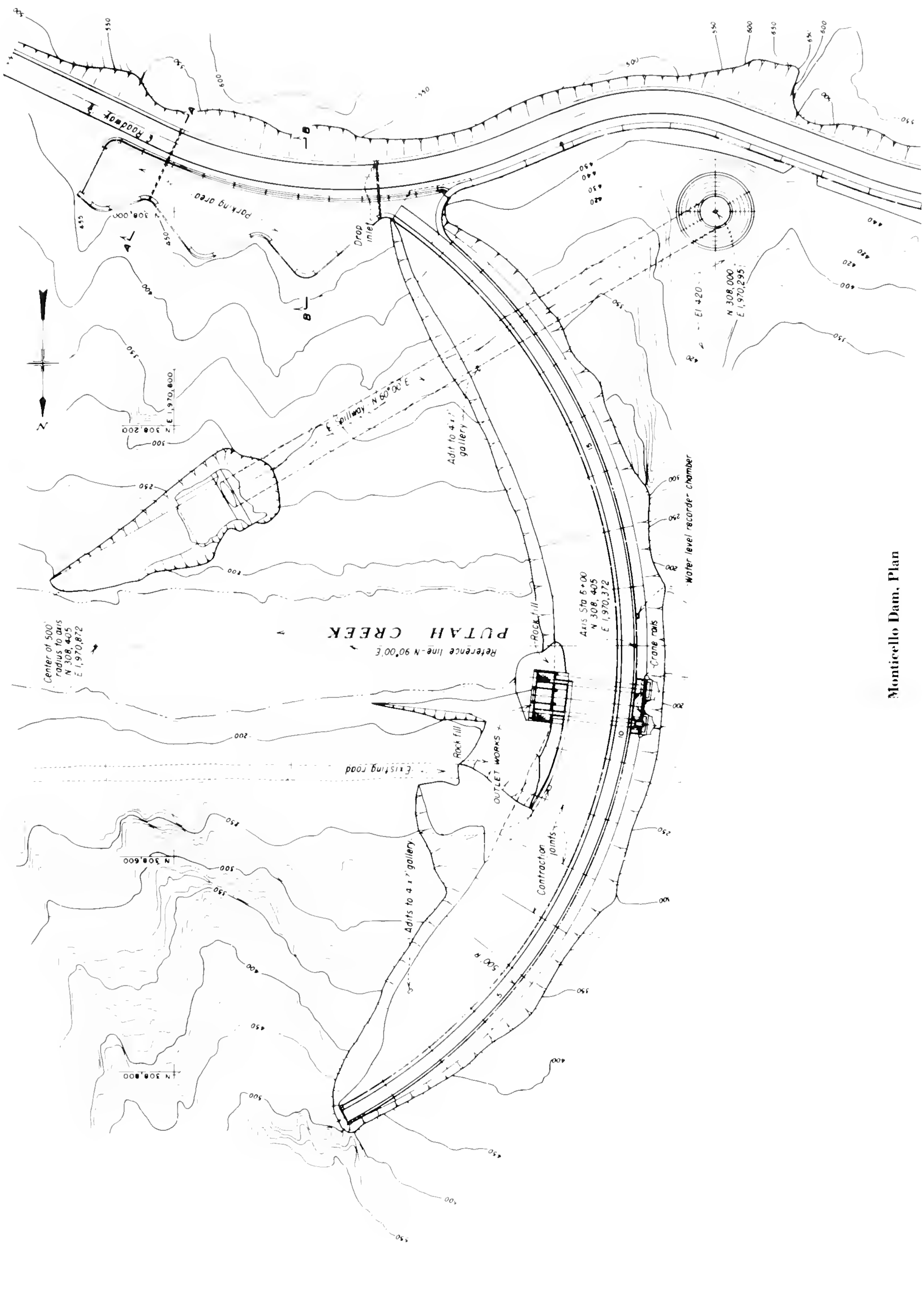
Location: An integral part of the Putah South Canal which extends from Putah Diversion Dam generally southwest to vicinity of Cordelia, Calif.

Construction period: 1958-59

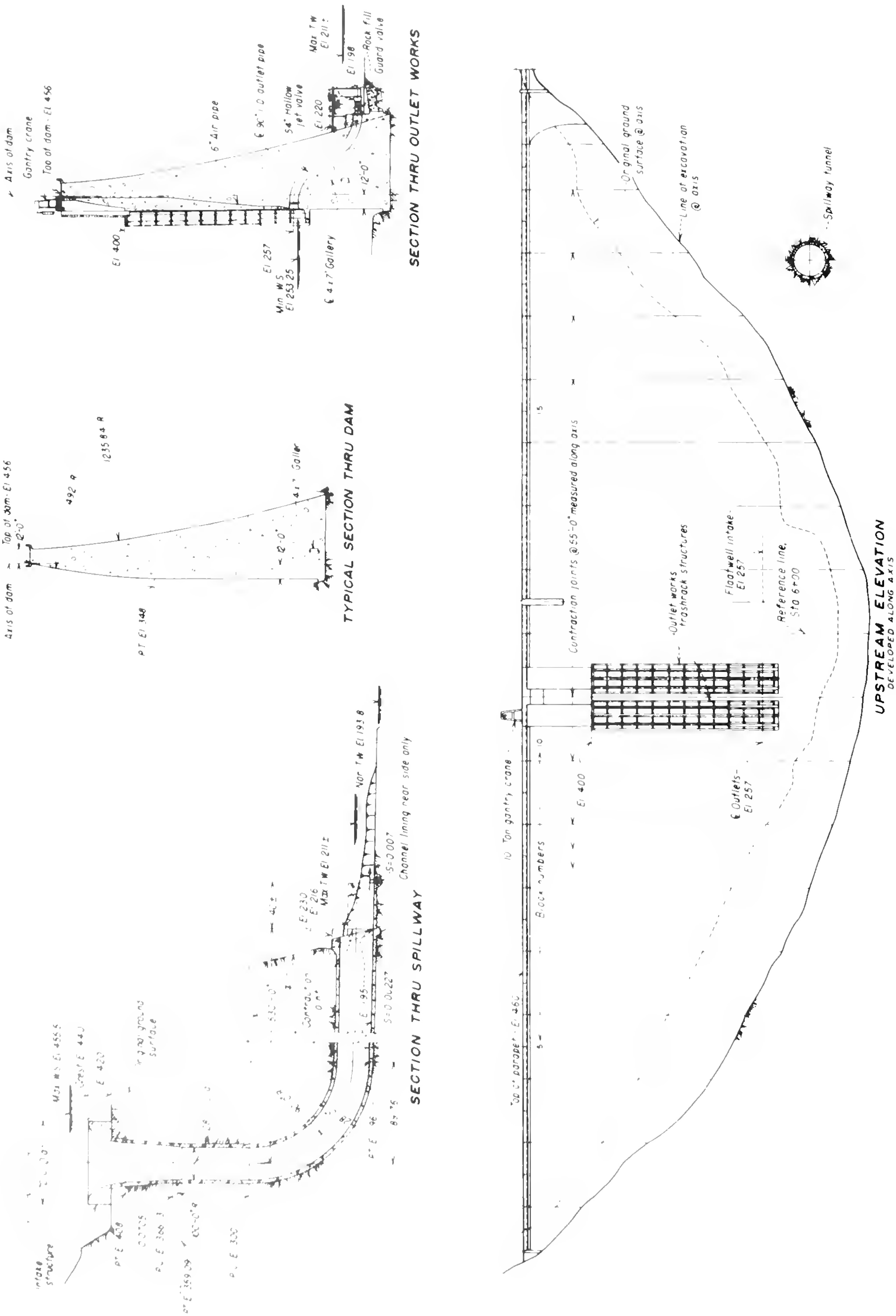
Length	1	mi
Capacity	180	ft^3/s

Type: Precast reinforced concrete

Diameter	72	in



Monticello Dam, Plan

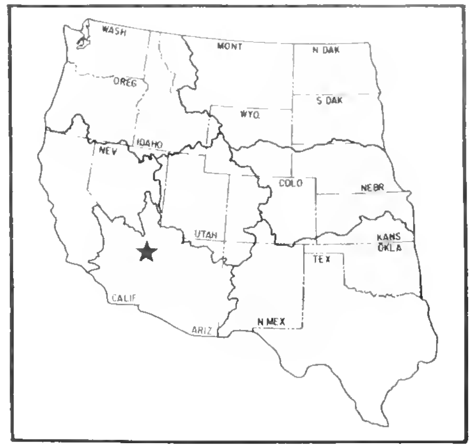


Monticello Dam. Sections

Southern Nevada Water Project
(First Stage in Operation)
(Second Stage Under Construction)

Nevada: Southern Clark County

Lower Colorado Region
Water and Power Resources Service



The Southern Nevada Water Project is a single-purpose project which will be capable of supplying 299,000 acre-feet of supplemental municipal and industrial water annually from Lake Mead to the service area of Las Vegas, North Las Vegas, Henderson, Boulder City, and Nellis Air Force Base in Nevada. The project is being constructed in two stages. The first stage became operational in November 1971, and is capable of providing 132,200 acre-feet of Lake Mead water annually to the project service area. Construction of the second stage of the project was initiated in 1977 and is scheduled to be completed in 1982.

PLAN

During the planning stage of the Southern Nevada Water Project, it was decided to construct the project in stages to provide flexibility in the timing of future installations, to allow for deviations from the projected future growth rates of population and industry. This plan has been proven valuable since it was impossible to foresee the dramatic 115 percent population increase between 1960 and 1970 and the shift in urban expansion to West Las Vegas.

The first stage is comprised of a main aqueduct, a 3.78-mile tunnel through the River Mountains, eight pumping plants, and 31.4 miles of pipeline. This stage has a peaking capacity of 26.7 million cubic feet of potable water a day.

The second stage will enlarge the first stage system by expanding some of the existing facilities. New features will include five pumping plants, the second barrel to the main aqueduct, and approximately 30 miles of pipeline and laterals with surge tanks, regulating tanks, and other delivery facilities. In conjunction with this stage, the State of Nevada will enlarge and modify the Alfred Merritt Smith water treatment facilities to accommodate additional water supplies.

The River Mountains Tunnel was constructed to full capacity in the first stage to accommodate both stages. The Saddle Island intake facilities were oversized to allow for the second stage requirement. The aqueduct system, when fully developed, will have the peaking capability of 53.4 million cubic feet of water per day.

FIRST STAGE
(Constructed 1968-71)

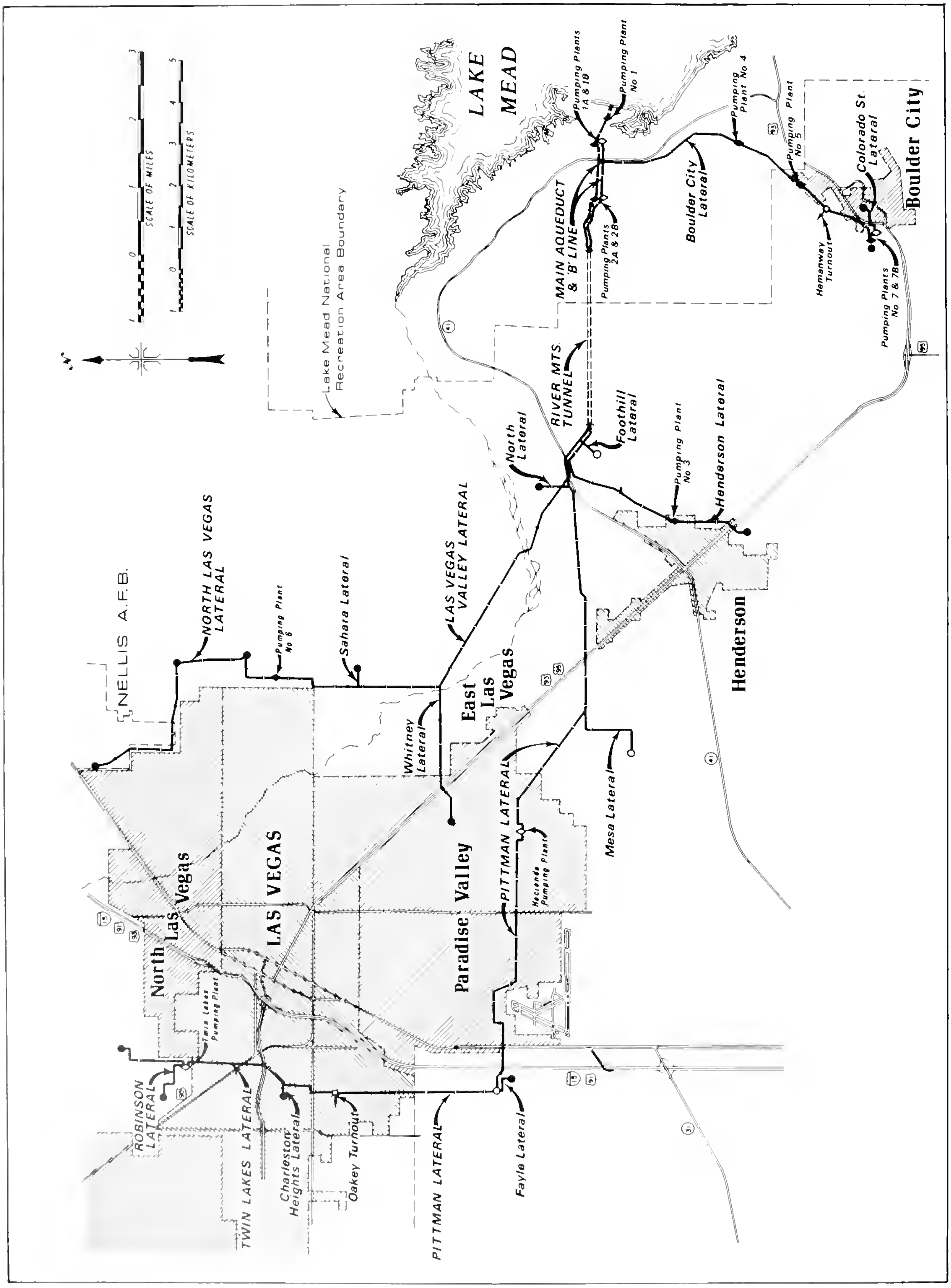
Saddle Island Intake Facilities

Lake Mead is tapped below the water level on the east side of Saddle Island in Las Vegas Bay and the water is conveyed through the island to the west through a 13-foot-diameter tunnel which terminates in a pump chamber below Pumping Plant No. 1. The tunnel is generally unlined and about 1,400 feet long. The pumping galley and vertical pump shafts were designed to accommodate the pumping requirements of both stages of the project.

Alfred Merritt Smith Water Treatment Facilities

Constructed by the State of Nevada, the Alfred Merritt Smith water treatment facilities are an integral part of

Southern Nevada Water Project Facilities



Southern Nevada Water Project

the Southern Nevada Water Project. They receive Colorado River water through the intake located in Lake Mead. After treatment, the water is returned to the water transmission system for delivery.

The first stage of the project, in tandem with the first stage of the water treatment facilities, collectively called the Southern Nevada Water System, can deliver up to 132,200 acre-feet of water annually to the project service area. Construction was begun in 1968 and the first water delivery was made on June 16, 1971.

Main Aqueduct

The Main Aqueduct extends 2.97 miles from Pumping Plant No. 1 to the River Mountains Tunnel. The first reach consists of 0.60 mile of 120-inch-diameter pipe, has an ultimate capacity of 585 cubic feet per second, and extends from Pumping Plant No. 1 to the Alfred Merritt Smith Water Treatment Plant. The second reach is composed of 2.37 miles of 96-inch-diameter pipe, has a capacity of 300 cubic feet per second, and extends from Pumping Plant No. 1A to Pumping Plant No. 2A on to the inlet portal of the River Mountains Tunnel.

River Mountains Tunnel

This tunnel was constructed during the first stage to accommodate second stage expansion. It is 3.78 miles long and was excavated through the River Mountains which lie between Las Vegas Valley and Lake Mead. The inside diameter of the concrete-lined tunnel is 121.5 inches, with an ultimate capacity of 608 cubic feet per second.

Las Vegas Valley Lateral

The Las Vegas Valley Lateral begins at the outlet portal of the River Mountains Tunnel. From the tunnel portal to the Henderson Bifurcation, a distance of 0.97 mile, it is a 96-inch-diameter pipe with a 289-cubic-foot-per-second capacity. From the Henderson Bifurcation and extending 6.02 miles to the Whitney Bifurcation where the lateral ends and the Whitney and North Las Vegas Laterals begin, the tunnel is constructed of 90-inch-diameter pipe with a 261-cubic-foot-per-second capacity.

North Las Vegas Lateral

The 10-mile North Las Vegas Lateral begins at the Whitney Bifurcation and terminates near Nellis Air Force Base. The lateral consists of 1.80 miles of 72-inch-diameter pipe with a capacity of 101 cubic feet per second, 3.07 miles of 66-inch-diameter pipe with a capacity of 86 cubic feet per second, 1.41 miles of 48-inch-diameter pipe with a capacity of 56 cubic feet per second, and 3.75 miles of 24- and 27-inch-diameter pipe with a capacity of 16 cubic feet per second at its terminus.

Whitney Lateral

This lateral begins at the Whitney Bifurcation and terminates at a receiving reservoir built by the Las Vegas Valley Water District near the intersection of Flamingo and Pecos Roads. The lateral includes 1.63 miles of 66-inch-diameter continuous steel pipe and 1.65 miles of 66-inch-diameter jointed steel pipe. The capacity is 160 cubic feet per second.

Sahara Lateral

This lateral begins at the Sahara Bifurcation on the North Las Vegas Lateral near the end of Sahara Avenue and extends eastward to the Sahara Flow Control Station. The lateral is constructed of 24-inch-diameter pipe and has a total length of 0.34 mile. The capacity is 15 cubic feet per second.

Henderson Lateral

The Henderson Lateral begins at the bifurcation with the Las Vegas Valley Lateral and terminates at a tank built by the city of Henderson. It is a gravity-flow lateral from its beginning to Pumping Plant No. 3. The pumping plant lifts the water the remaining distance to the terminal tank. The 28-cubic-foot-per-second-capacity lateral required 4.53 miles of 36-inch-diameter pipe.

Boulder City Lateral

Boulder City Lateral begins at Pumping Plant No. 1A and terminates at the twin 670,000-cubic-foot receiving tanks built by the city of Boulder City, Nev. The 36- and 27-inch-diameter pipe has a capacity of 30 cubic feet per second and a total length of 7.48 miles.

SECOND STAGE
(Under Construction, 1977)

Construction of the second stage will provide an additional annual delivery capability of 166,800 acre-feet of Colorado River water. Peak delivery capacity will be 53.4 million cubic feet per day. This will be accomplished through the addition of five new pumping plants, modifications to four existing pumping plants, a 2.39-mile-long second barrel to the main aqueduct installed next to the first stage barrel, approximately 30 miles of new aqueducts and pipelines, and a major expansion of the existing Alfred Merritt Smith water treatment facility. Since the Saddle Island intake facilities and the 3.78-mile tunnel through the River Mountains were sized during construction of the first stage to accommodate flows of the second stage, there will not be a need for new tunnel works.

Main Aqueduct "B" Line

The Main Aqueduct runs from Pumping Plant No. 1B to the River Mountains Tunnel inlet portal. The aqueduct consists of two sections. The first section, from Pumping Plant No. 1B to Pumping Plant No. 2B, consists of 1.35 miles of 96-inch-diameter pipe with a design capacity of 306 cubic feet per second. The second section, from Pumping Plant No. 2B to the River Mountains Tunnel inlet (Regulating Tank No. 2), consists of 0.82 mile of 96-inch-diameter pipe and 0.22 mile of 108-inch-diameter pipe with a design capacity of 306 cubic feet per second. The River Mountains Tunnel, as well as the Saddle Island Intake Tunnel and Pumping Chamber on Lake Mead, were initially constructed at full size and will not have to be enlarged to accommodate the design flows of the second stage.

Pittman Lateral

The Pittman Lateral begins at the outlet portal of the River Mountains Tunnel. From the tunnel portal to the Foothill Turnout, it will be 102-inch-diameter pipe, 0.31 mile in length, with a design capacity of 319 cubic feet per second. From the Foothill Turnout to the North Lateral Turnout, it will be a 102-inch-diameter pipe 1.05 miles in length, with a design capacity of 310 cubic feet per second. From the North Lateral Turnout to the Mesa Lateral Bifurcation, it is planned to be a 102-inch-diameter pipe, 5.21 miles in length, with a design capacity of 302 cubic feet per second. From the Mesa Lateral Bifurcation to the Hacienda Control Station, it is planned to be 2.04 miles of 96-inch-diameter pipe and 1.10 miles of 90-inch-diameter pipe with a capacity of 270 cubic feet per second. From the Hacienda Pumping Plant to the Valley View Regulating Tank, it is planned to be 6.45 miles of 96-inch-diameter pipe, with a peak capacity of 270 cubic feet per second. From the Valley View Regulating Tank to the Oakey Turnout, which is the end of the Pittman Lateral, it is planned to be 84-inch-diameter pipe, 3.71 miles in length, with a design capacity of 232 cubic feet per second. The Oakey Turnout will divert 150 cubic feet per second into the Oakey Forebay.

Hacienda Forebay and Pumping Plant

Hacienda Forebay and Pumping Plant will be a new facility located at the intersection of Annie Oakley Drive and Hacienda Avenue.

The pumps will lift water from a forebay to a regulating tank near the intersection of Tropicana Avenue and Valley View Boulevard. The plant is designed for six pumping units of 43.75 cubic feet per second each for a peak capacity of 250 cubic feet per second and a head of 365 feet. An extra pumping unit will be installed as a standby unit and will be required when a peak flow of 270 cubic feet per second is needed.

Fayle Lateral

The Fayle Lateral runs from Valley View Regulating Tank to Fayle Reservoir. It is planned to install 0.34 mile of 72-inch-diameter pipe placed parallel to the Pittman Lateral. The pipeline will have a peak capacity of 140 cubic feet per second.

Twin Lakes Lateral

The Twin Lakes Lateral will begin where Pittman Lateral ends at Oakey Turnout. From Oakey Turnout to the Carlton Square Reservoir, the lateral is planned to be a 54- and 48-inch-diameter concrete pipe, 1.14 miles in length with a design capacity of 82 cubic feet per second. From Carlton Square Reservoir to Twin Lakes Pumping Plant and Forebay, it is planned to be a 36-inch-diameter concrete pipe, 2.99 miles in length, with a design capacity of 42 cubic feet per second. From Twin Lakes Pumping Plant to the existing Carlton Square Reservoir, which is the end of the Twin Lakes Lateral, it is planned to be a 42-inch-diameter pipe, 1.39 miles in length, with a design capacity of 32 cubic feet per second.

Foothill Lateral

Foothill Lateral will begin at the foothill turnout on the Pittman Lateral. From the turnout to the Foothill Forebay, where the lateral ends, it is planned to be a 21-inch-diameter pipe, 0.20 mile in length, with a design capacity of 12 cubic feet per second.

North Lateral

The North Lateral will begin at the North Lateral Turnout on the Pittman Lateral. From the turnout to a reservoir to be built by the city of Henderson, the lateral is planned to be a 24-inch-diameter concrete pipe, 0.58 mile in length, with a design capacity of 11 cubic feet per second.

Mesa Lateral

Mesa Lateral will begin at the Mesa Lateral Bifurcation on the Pittman Lateral. From the bifurcation station to a receiving tank to be built by the city of Henderson, the lateral is planned to be a 42-inch-diameter pipe, 2.17 miles in length, with a design capacity of 46 cubic feet per second.

Charleston Heights Lateral

Charleston Heights Lateral will begin at the Charleston Bifurcation Station on the Twin Lakes Lateral. From the bifurcation station to the Las Vegas Valley Water District's existing tanks, it will be a 42-inch-diameter pipe, 0.14 mile in length, with a design capacity of 40 cubic feet per second.

Robinson Lateral

Robinson Lateral will begin at Twin Lakes Pumping Plant and Forebay. From the pumping plant to an existing water tank owned and operated by the city of North Las Vegas, which is the end point for the lateral, it is planned to be a 24-inch-diameter pipe, 1.52 miles in length, with a design capacity of 10 cubic feet per second.

Colorado Street Lateral

Beginning at Pumping Plant No. 7B, the Colorado Street Lateral will extend for a total length of 0.52 mile to Boulder City's west tank. The pipe, which will have a diameter of 24 inches and a capacity of 7.5 cubic feet per second, will be placed within the right-of-way of Colorado Street and existing water supply lines.

The Hemenway Turnout will be located on the existing Boulder City Lateral about 2,000 feet before the lateral reaches Pumping Plant No. 7B. The pipe, which will have a diameter of 8 inches, will have a capacity of 2.5 cubic feet per second. A sleeve valve will be installed at the location.

DEVELOPMENT

Early History

The first caravan of pioneers stopped in the Las Vegas area about 1832, en route to Los Angeles. In 1905, the San Pedro-Los Angeles Railroads (later the Southern Pacific Railroad) were linked and Las Vegas was established as a division point. The Las Vegas Land and Water Company was formed on May 2, 1905, to supply water to the locomotives and domestic water to the new town that was established by the railroad company. In 1931, thousands of workers moved into the area for the building of Hoover Dam. Boulder City was established as a construction camp.

By 1944, Las Vegas and the surrounding area were running out of ground water. In 1947, the Nevada State legislature passed a bill authorizing the establishment of the Las Vegas Valley Water District to purchase the Land and Water Company and to bring water into the Las Vegas Valley via pipeline from Lake Mead. The ownership of the company's facilities was transferred to the district in 1954.

On August 25, 1967, a contract was executed between the United States and the Colorado River Commission of Nevada for delivery of water and construction of project works. In 1969, the contract with the Government was revised to include the Las Vegas Valley Water District as a participant in the Southern Nevada Water Project.

Under the contract, the State committed 132,200 acre-feet of its allocated 300,000 acre-feet of Colorado River water to municipal and industrial use in Clark County, Nevada.

In November 1967, the Congress approved the first funding of the Southern Nevada Water Project, and work began in 1968. The Alfred Merritt Smith Water Treatment Plant was completed in 1970 and the first stage of the project was completed in 1971.

Forecasts made in the late 1960's and early 1970's of the water needs in the Las Vegas Valley indicated that, with the existing water supply systems, the first stage of the Southern Nevada Water Project would be able to meet the water requirements of the area until 1990. However, the economy of the area had entered a new era of rapid growth, which placed an unanticipated load on the system during the first 4 years of operation. New water demand projections indicated that the capacity of the first stage of the project will be used or exceeded in the early 1980's, which promoted the initiation of the construction of the second stage of the project in 1977. This stage, scheduled to be completed in 1982, will have the capability to deliver an additional 166,800 acre-feet of Colorado River water annually. It is forecast that the water developed will ensure the area an adequate water supply to about the year 2000.

Investigations

Appraisal field inspections were made by the Bureau of Reclamation in 1932 and 1944 of areas in Clark County, Nevada, that were considered to be irrigable with water from the Colorado River. The findings of the 1944 studies were included in a March 1946 report as the Las Vegas Pumping Project. A report on the preliminary investigations, March 1955, presented information on water supply and future requirements for the Las Vegas Valley area. During 1953-56, cooperative land classification and soil surveys were made of the Las Vegas Valley and Eldorado Valley subareas. The report covering these surveys was issued in February 1967. The potential of providing municipal, industrial, and agricultural water for developing Eldorado Valley near Boulder City, Nev., was given in an October 1959 report on reconnaissance investigations. The August 1963 feasibility report on the Southern Nevada Water Project, and the 1965 supplement to the report recommended authorization and construction of the project. The report and supplement were printed as House Document No. 177, 89th Congress, 1st session. Results of the advance planning studies for the first stage of the project were in the definite plan report on "Southern Nevada Water Project (First Stage)" in August 1967. The definite plan report on the second stage was prepared in October 1976 and the final environmental statement on the second stage was issued June 6, 1977.

Authorization

On October 22, 1965, the President signed Public Law 89-292, authorizing construction, operation, and maintenance of the project. Public Law 89-510, July 19, 1966, clarified water rights and amended Public Law 89-292.

Construction

Construction of the first stage started with the award of a contract for the construction of the River Mountains Tunnel and Outlet Portal on March 26, 1968, with the first water deliveries made to the Las Vegas Valley District on June 16, 1971. The first stage became operational November 1, 1971. Construction of the second stage of the project was started in June 1977. The initial water delivery is scheduled in September 1981 and all construction is scheduled for completion in 1982.

Operating Agency

The project is operated by the Division of Colorado River Resources for the State of Nevada.

BENEFITS

Municipal and Industrial Water

Benefits result from providing 299,000 acre-feet of Colorado River water annually to the Las Vegas Valley Water District, North Las Vegas, Henderson, Boulder City, and Nellis Air Force Base to supplement the municipal and industrial water supply.

PROJECT DATA

Facilities in Operation—First Stage

Storage dams[1]	0	
Saddle Island intake facility	1	
Main aqueduct	2.97	mi
River Mountains Tunnel	4	mi
Laterals	32.1	mi
Pumping plants	8	

[1]See Boulder Canyon Project statistics.

Facilities Under Construction—Second Stage

Main Aqueduct "B" Line	2.39	mi
Pittman Lateral	19.87	mi

Climatic Conditions

Annual precipitation	3.8	in
Temperature:		
Maximum	115	°F
Minimum	23	°F
Mean	68	°F
Elevation	2162.0	ft

ENGINEERING DATA

Water Supply

COLORADO RIVER
(See Boulder Canyon Project.)

Carriage Facilities (First Stage)

SADDLE ISLAND INTAKE FACILITIES
SADDLE ISLAND TUNNEL

Location: Extends from the east side of Saddle Island in Lake Mead through the island to the west, and terminates in a pump chamber below Pumping Plant No. 1.
Construction period: 1969-71

Length	0.27	mi
Capacity[2]	623	ft³/s
Cross section: Horseshoe		
Diameter	156	in
Elevation of inlet	1018.1	ft
Lining: Generally unlined		

Access adit: Provides access to the intake tunnel and pumping plant chamber through an inclined tunnel.

Length	600	ft
Width	14	ft
Type: Modified horseshoe		
Slope	0.17	

MAIN AQUEDUCT

Location: Extends from Pumping Plant No. 1 to the River Mountains Tunnel.
Construction period: 1970-71
Description: Prestressed circular concrete pipe

Length	2.97	mi
Diameter	120-96	in
Capacity	585-300	ft³/s

RIVER MOUNTAINS TUNNEL

Location: Excavated through the River Mountains, which lie between Las Vegas Valley and Lake Mead.
Construction period: 1968-70

Length	3.78	mi
Capacity	500-608	ft³/s
Cross section: Circular		
Diameter	121.5-156	in
Lining: Concrete	15-21	in

LAS VEGAS VALLEY LATERAL

Location: Begins at the outlet portal of the River Mountains Tunnel and runs to the Whitney Bifurcation.

[2]The tunnel was designed to provide capacity for both first and second stage operation.

Construction period: 1970-71
Description: Cylinder prestressed concrete (3.08 mi), steel pipe, mortar lined and coated (3.38 mi), and steel pipe, coal-tar coated 7-in mortar coating, field mortar lined (0.53 mi)

Length: From River Mountains Tunnel to Henderson Bifurcation (0.97 mi) from Henderson Bifurcation to Whitney Bifurcation (6.02 mi)	6.99	mi
Diameter	96-90	in
Initial capacity	289-261	ft³/s

North Las Vegas Lateral

Location: Begins at the Whitney Bifurcation and extends to a terminal reservoir near Nellis Air Force Base.
Construction period: 1970-71
Description: Steel pipe, coal-tar coated, 6 in mortar coating, field mortar lined (0.21 mi), steel pipe mortar lined and coated (8.42 mi), and pretensioned concrete (1.37 mi)

Length	10	mi
Diameter	72-24	in
Capacity	101-16	ft³/s

Whitney Lateral

Location: Begins at the Whitney Bifurcation and extends in an easterly direction to a terminal reservoir near the intersection of Flamingo Road and Pecos Road.
Construction period: 1970-71
Description: Steel pipe, coal-tar coated, 6-in mortar coating, field mortar lined (1.63 mi) and steel mortar lined and coated (1.65 mi)

Length	3.28	mi
Diameter	66	in
Capacity	160	ft³/s

Sahara Lateral

Location: Begins at the Sahara Bifurcation and extends eastward to the Sahara Flow Control Station.
Construction period: 1970-71
Description: Steel pipe, mortar lined and coated

Length	0.34	mi
Diameter	24	in
Capacity	15	ft³/s

Henderson Lateral

Location: Begins at the Henderson Bifurcation works on the Las Vegas Valley Lateral and extends in a southwesterly direction to the city of Henderson terminal tank.
Construction period: 1968-71
Description: Steel pipe, mortar lined and coated

Length	4.53	mi
Diameter	36	in
Capacity	28	ft³/s

Boulder City Lateral

Location: Begins at Pumping Plant No. 1A and terminated at the twin 5-receiving tanks near Boulder City, Nev.
Construction period: 1968-69
Description: Pretensioned concrete and steel-lined pipe

Length	7.48	mi
Diameter	36-27	in
Capacity	30	ft³/s

Alfred Merritt Smith Water Treatment Facilities

Location: Constructed by the State of Nevada near Pumping Plant 1A near the west shore of Lake Mead opposite Saddle Island.
Construction period: 1969-70
Description: The water treatment plant provides for pretreatment, aeration, taste and odor control, flocculation, filtration, chlorination, and corrosion control.

Capacity	53,400,000	ft³
Number of flocculation units	10	
Number of filters	20	
Surface area of filters	56,000	ft²
Filter rating at maximum flow	5	ft²
Filter media:		
Anthracite coal	20	in
Sand	10	in
Filter backwash rate	22.5	ft²

Chemical additives: Chlorine, sulfur dioxide, potassium permanganate, sodium silicate, activated silica, caustic soda, aluminum sulfate, activated carbon and polyelectrolyte.

Carriage Facilities (Second Stage)

Saddle Island Intake Facilities
(See First Stage.)

Main Aqueduct "B" Line

Location: Runs from Pumping Plant 1B to River Mountains Tunnel.
Construction period: 1977-(Under construction)
Description: Prestressed circular concrete pipe

Length	2.39	mi
Diameter	96-108	in
Initial capacity	306	ft³/s

River Mountains Tunnel
(See First Stage.)

Pittman Lateral

Location: Begins at the outlet portal of the River Mountains Tunnel and extends to the Oakey Forebay near Oakey Blvd.
Construction period: 1978- (Under construction)
Description: From the River Mountains Tunnel portal to the Mesa Lateral Bifurcation, a distance of 6.57 mi, of prestressed circular concrete pipe 8.5 ft in diameter. From the Mesa Lateral Bifurcation to the Valley View Regulating Tank, 9.59 mi, the aqueduct consists of prestressed concrete pipe, 8.0 and 7.5 ft in diameter. From the regulating tank to the Oakey Forebay at the end of the lateral, it is a 7.0-ft-diameter pipe, 3.71 mi in length.

Length	19.87	mi
Diameter	102-84	in
Initial capacity	319	ft³/s

Fayle Lateral

Location: From Valley View Regulating Tank to Fayle Reservoir.
Construction period: (Under construction)
Description:

Length	0.34 mi
Diameter	72 in
Capacity	140 ft³/s

Twin Lakes Lateral

Location: Begins at the Oakey Forebay, the end of the Pittman Lateral, and extends to Carlton Square Reservoir.
Construction period: (Under construction)
Description:

Length	5.52 mi
Diameter	54-30 in
Capacity	82-32 ft³/s

Foothill Lateral

Location: Begins at the Foothill Turnout on the Pittman Lateral and extends to the Foothill Forebay.
Construction period: (Under construction)
Description:

Length	0.20 mi
Diameter	21 in
Capacity	12 ft³/s

North Lateral

Location: Begins at the North Lateral Bifurcation on the Pittman Lateral and extends to a reservoir to be constructed by the city of Henderson at a site near the city's north boundary.
Construction period: (Under construction)
Description:

Length	0.58 mi
Diameter	24 in
Capacity	11 ft³/s

Mesa Lateral

Location: Begins at the Mesa Lateral Bifurcation on the Pittman Lateral and runs to a receiving tank to be built by the city of Henderson.
Construction period: (Under construction)
Description:

Length	2.17 mi
Diameter	42 in
Capacity	46 ft³/s

Charleston Heights Lateral

Location: Starts at a bifurcation on the Twin Lakes Lateral and terminates at the existing Las Vegas Valley Water District tanks.
Construction period: (Under construction)
Description:

Length	0.11 mi
Diameter	42 in
Capacity	40 ft³/s

Robinson Lateral

Location: Begins at the Twin Lakes Pumping Plant and Forebay and extends to an existing North Las Vegas water tank located in the vicinity of the North Las Vegas Air Terminal.
Construction period: (Under construction)
Description:

Length	1.52 mi
Diameter	24 in
Capacity	10 ft³/s

Colorado Street Lateral

Location: Extends from Pumping Plant No. 7B near first stage Pumping Plant No. 7 to Boulder City's existing west water tank.
Construction period: (Under construction)
Description:

Length	0.52 mi
Diameter	24 in
Capacity	7.5 ft³/s

Alfred Merritt Smith Water Treatment Facility
(See First Stage)

Pumping Plants

Designation	Number of units, Pumps	Standby	Total capacity, ft³/s	Average lift, ft	Installed horse-power
First Stage					
Pumping Plant No. 1	10		311	223	10,000
PP No. 1A (Main Aqueduct)	6	1	300	355	
PP No. 1A (Boulder City Lateral)	2	1	15	455	
No. 2A	6	1	300	355	
No. 3	3	1	28	230	
No. 4	2	1	15	455	
No. 5	2	1	15	455	
No. 6	3	1	90	182	
No. 7	3	1	15	78	
Second Stage[3]					
PP No. 1 (modifications)	10	0	312	223	10,000
PP No. 1A (Boulder City Lateral) (modifications)	2	0	15	445	1,200
PP No. 4 (modifications)	2	0	15	445	1,200
PP No. 5 (modifications)	2	0	15	445	1,200
PP No. 1B	6	1	306	355	18,000
PP No. 2B	6	1	306	355	18,000
PP No. 7B	3	1	7.5	[4]NA	225
Hacienda	6	1	250	365	
Twin Lakes-Robinson	3	1	10	[4]NA	930
Twin Lakes-Carlton	3	1	32	[4]NA	

[3]Subject to change pending final design.
[4]Pending final design.

Power Facilities

Southern Nevada Water Project—First Stage

Electrical power is supplied to all the pumping plants except Pumping Plant No. 7 from 69-kV transmission lines of Nevada Power Company. The company constructed approximately 10 miles of 69-kV line extensions to serve these pumping plants. Pumping Plant No. 7 is served from the 1.16-kV distribution system of the

Boulder City municipal system. Main equipment in the pumping plant switchyards consists of a main power transformer protected by a fused disconnecting switch or a fuse and disconnecting switch installed separately.

Switchyard
Number in operation 8
Capacity of transformers:

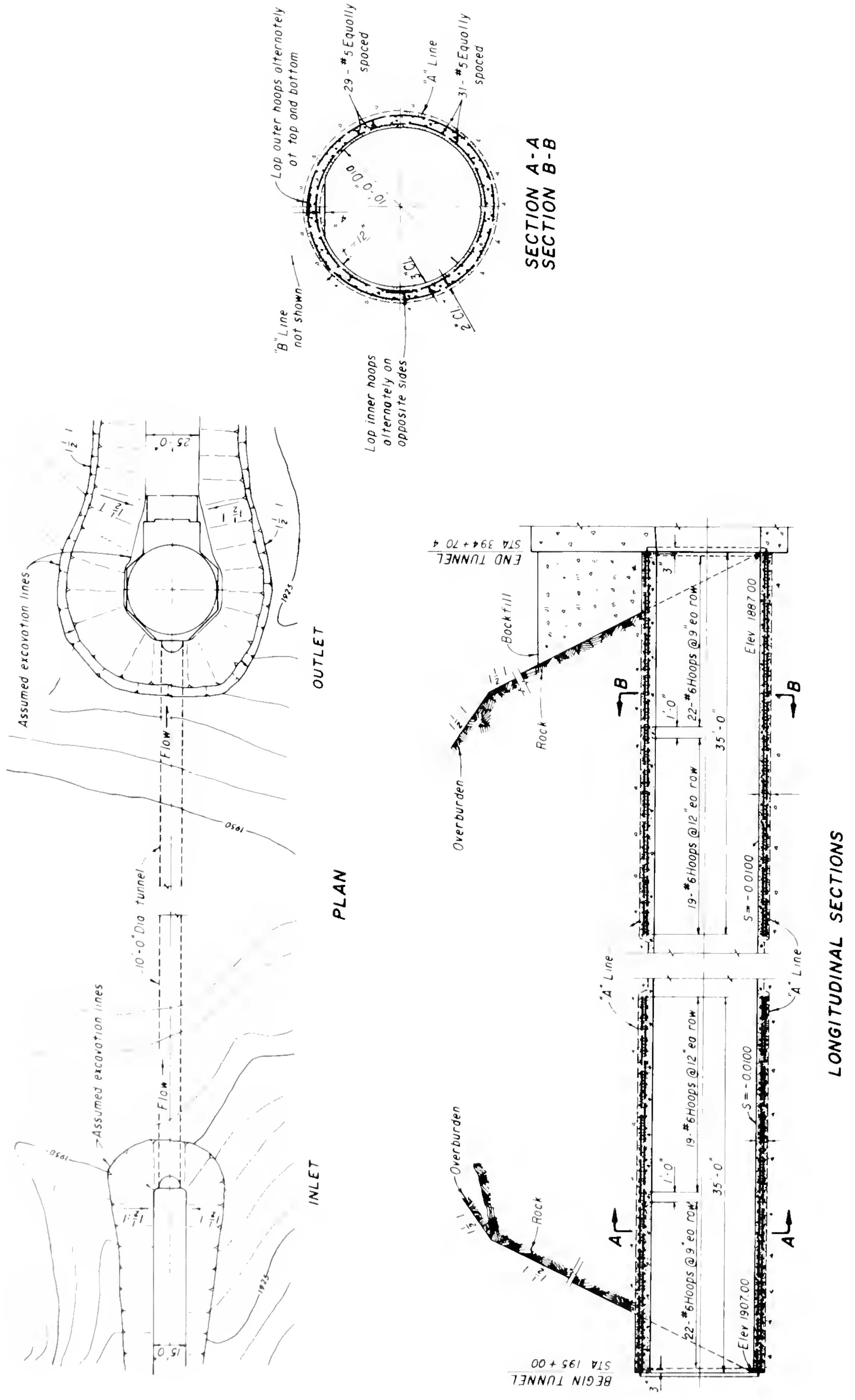
Designation	Voltage	Transformer Rating - kVA
Switchyard No. 1	69,000/4,160	8,100/10,125 OA/FA
Switchyard No. 1A	69,000/4,160	10,500/15,680/19,600 OA/FA/FOA
Switchyard No. 2	69,000/4,160	10,000/12,500 OA/FA
Switchyard No. 3	69,000/4,160	1,000 OA
Switchyard No. 4	69,000/4,160	2,200 OA
Switchyard No. 5	69,000/4,160	2,200 OA
Switchyard No. 6	69,000/4,160	2,500 OA
Switchyard No. 7	4,160/480	500

Southern Nevada Water Project—Second Stage

Electrical power will be supplied to all the pumping plants except Pumping Plant No. 7B from 12- and 69-kV transmission lines of Nevada Power Company. The company will construct approximately 7 miles of 69-kV line extensions to serve these pumping plants. This construction will include approximately 1 mile of 69-kV double-circuit line. The Twin Lakes Pumping Plant will be the only plant served from a 12-kV distribution line which is located adjacent to the pumping plant site. Pumping Plant No. 7B will be served from the distribution system of the Boulder City municipal system. Main equipment in the pumping plant switchyards will consist of a main power transformer protected by a breaker, interrupter switch, or fused disconnect.
Number under construction 6

Capacity of transformers:

Designation	Voltage	Transformer rating - kVA
Switchyard No. 1	69,000/4,160	8,100/10,125 OA/FA
Switchyard No. 1B	69,000/4,160	15,300/20,400/25,500 OA/FA/FOA
Switchyard No. 2B	69,000/4,160	10,800/14,400/18,000 OA/FA/FOA
Switchyard No. 7B	Not available	
Hacienda Switchyard	69,000/4,160	10,500/14,000/17,500 OA/FA/FOA
Twin Lakes Switchyard	Not available	

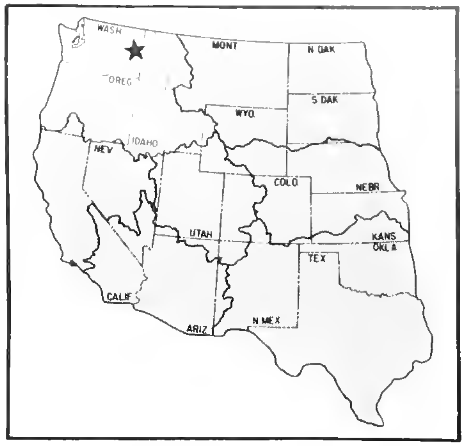


River Mountains Tunnel, Plan and Sections

Spokane Valley Project

Washington: Spokane County
Idaho: Kootenai County

Pacific Northwest Region
Water and Power Resources Service



The Spokane Valley Project provides an irrigation and domestic water supply for lands lying east of the city of Spokane, extending eastward to the Washington-Idaho boundary and on into Idaho for a short distance. The diversion dam on the Spokane River and the canal system previously used have been abandoned in favor of a pumping system from wells into a pressure pipeline system that now provides sprinkler irrigation and serves domestic, municipal, and industrial requirements.

PLAN

The Spokane Valley is a 57-square-mile lowland plain lying along both sides of the Spokane River. The valley is 6.5 miles wide at the Washington-Idaho boundary and narrows to 2.5 miles at the edge of Spokane. Reclamation-built project facilities are designed to serve 7,432 acres of irrigable land within the valley. The project is divided into six pressure zones or service areas: Carder, Corbin, Greenacres, West Farms, Otis Orchards, and East Farms. Project water is pumped from ground water into elevated steel-tank regulating reservoirs and distributed under pressure through an asbestos-cement pipe system for irrigation and domestic, municipal, and industrial purposes. The system of wells, pumping units, and distribution facilities has an adequate capacity for present and future requirements. The main trunk pipe system for each area is used for irrigation and as a source of supply for domestic water. Irrigation service connections to ownerships existing at the time of construction were provided as a part of the project cost. Power for project pumping is obtained from the Columbia River Federal Power System.

The water supply is obtained by pumping from 34 deep wells that are 16 to 22 inches in diameter, and 90 to 150 feet deep. The wells are located at 11 different sites in clusters of 3 wells at 10 sites and 4 wells at 1 site. Water from the well sites is lifted to eleven 6,684-cubic-foot elevated steel tanks that range in height from 125 to 187 feet, and are used as equalizing reservoirs. The wells are equipped with turbine pumps that range in capacity from 2.6 to 7.4 cubic feet per second, and motor sizes that range from 100 to 300 horsepower. Total dynamic head ranges from 241 to 309 feet at the 34 wells. The distribution system includes 102.8 miles of buried asbestos cement pipelines ranging in diameter from 6 to 24 inches, complete with sectionalizing valves and service connection accessories.

DEVELOPMENT

Early History

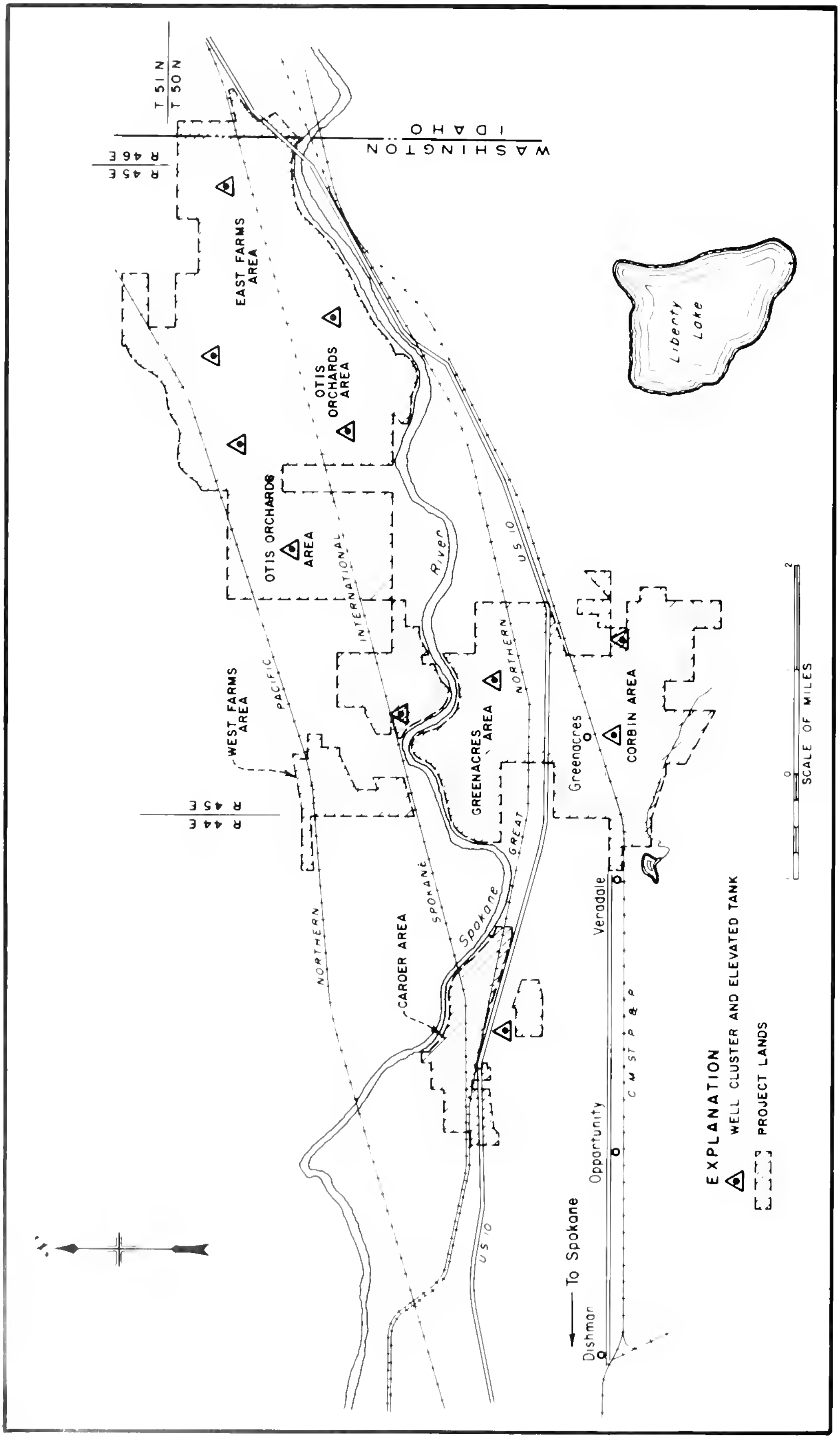
Settlement of the valley began about the turn of the century; irrigation developments date from about 1905. The growth of Spokane as a commercial and industrial center has led to subdivision of some of the irrigated land into homesites.

The Spokane Valley Land and Water Co., organized in 1903, irrigated about 22,000 acres of land. The company sold a block of its land in 1908 to finance construction of a canal system. By 1912, a canal along the north side of the river led from Post Falls, Idaho, to some of the lands. Seepage in the unlined canals, failure of wooden flumes and other structures, and the limited amount of water that could be diverted in August and September severely handicapped effective irrigated agriculture.

A new organization took over the water rights, irrigation facilities, and other assets in 1921, and two irrigation districts were formed in 1922. The South Branch Canal and lateral systems were built in 1923. In succeeding years additional irrigation districts were organized, the canal system was partially lined, and deteriorated wooden structures were replaced. Prior to the time the Bureau of Reclamation was requested to aid in construction, the distribution system was again in need of rehabilitation, and continued operation of gravity canals and laterals had become more difficult because of new residential subdivisions.

Investigations

In 1954, the Bureau of Reclamation published a reconnaissance report which outlined six alternative methods



Spokane Valley Project

Sprinkler irrigation

of rehabilitating the project. The seven irrigation districts concurred in selecting a plan to abandon the diversion dam and water conveyance systems and replace them by pumping from wells to be drilled at several points in the valley. The wells would serve the irrigated land through pressure pipeline systems.

This selection resulted in the publication of a feasibility report in August 1956 which detailed the chosen plan, computed benefits, and determined probable charges.

Authorization

The project was authorized by Public Law 86-276, approved September 16, 1959 (73 Stat. 561), as amended by Public Law 87-630, approved September 5, 1962 (76 Stat. 431).

Construction

Construction of project facilities began in 1963 and was completed in 1967.

Operating Agency

The project has been operated and maintained by Consolidated Irrigation District No. 19 since January 1, 1968.

BENEFITS

Irrigation

Uniform irrigation supplies make possible a more reliable crop yield in an area where only about 6 inches of natural precipitation fall during the growing season. Hay, pasture, grain, and vegetables are the principal agricultural products.

Domestic, Municipal, and Industrial Water

Extensive benefits are realized through the development of an adequate water supply for domestic, municipal, and industrial use. Because of urban growth, domestic service demand is increasing constantly.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	7,432	acres
Number of irrigated farms	136	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,369	627,231
1969	3,980	621,133
1970	3,743	543,362
1971	3,310	499,769
1972	2,604	456,331
1973	2,016	671,691
1974	1,896	795,028
1975	1,800	588,449
1976	2,754	940,200
1977	3,250	1,076,008

Facilities in Operation

Pressure pipelines	103	mi
Service connections (domestic, municipal, and industrial)	3,235	
Service connections (irrigation)	3,500	
Wells	34	
Pumping units	34	

Climatic Conditions

Annual precipitation	16	in
Temperature:		
Maximum	103	°F
Minimum	−25	°F
Mean	47	°F
Growing season	179	days
Elevation of irrigable area	1900-2100.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	560
Other water service[1]	8,790
Total	9,350

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

Ground-water supply from 34 wells, 16 to 22 inches in diameter.

Average annual diversions (1968-77) .... 20,280 acre-ft

Storage Facilities

Eleven elevated steel-tank regulating reservoirs, 6,680-ft^3 capacity each. Total capacity 73,500 ft^3.

Carriage Facilities

Pressure pipelines, asbestos-cement, ranging in diameter from 6 to 24 in, extending for 103 mi.

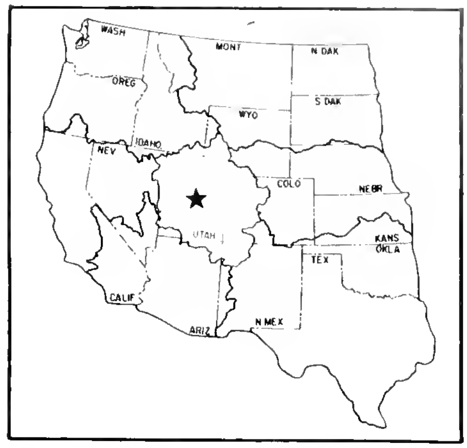
Pumping Units

Designation	Number of units	Total capacity, ft^3/s	Pump capacity range, ft^3/s	Motor horsepower
Well pump units	34	162	2.6-7.4	100-300

Strawberry Valley Project

Utah: Utah and Wasatch Counties

Upper Colorado Region
Water and Power Resources Service



The Strawberry Valley Project comprises about 45,000 irrigable acres centered around Spanish Fork, Utah. This project provided the first large-scale transmountain diversion from the Colorado River Basin to the Bonneville Basin. It also was one of the earliest Bureau of Reclamation projects to develop hydroelectric energy.

Project features include Strawberry Dam and Reservoir, Indian Creek Dike, Strawberry Tunnel, two diversion dams, three powerplants, a main canal system, and a portion of the lateral system. The remainder of the distribution system was privately constructed. Two of the powerplants were constructed by the water users association.

PLAN

The irrigation water is diverted from the Colorado River Basin to the Bonneville Basin. Water is stored in Strawberry Reservoir on the Strawberry River, a tributary of the Green River. The reservoir also receives water through feeder canals from Indian Creek, Trail Hollow Creek, and Currant Creek. The stored water is diverted into Bonneville Basin through the 3.8-mile Strawberry Tunnel under the Wasatch Divide. The water is discharged into Diamond Fork, a tributary of the Spanish Fork River, and diverted into the Strawberry Power Canal, which supplies the Springville-Mapleton Lateral to the north, the High Line Canal system to the south, the Upper and Lower Spanish Fork Powerplants, and the older privately built distribution system. Approximately 1,550 kilowatts of power are developed in three powerplants on the project.

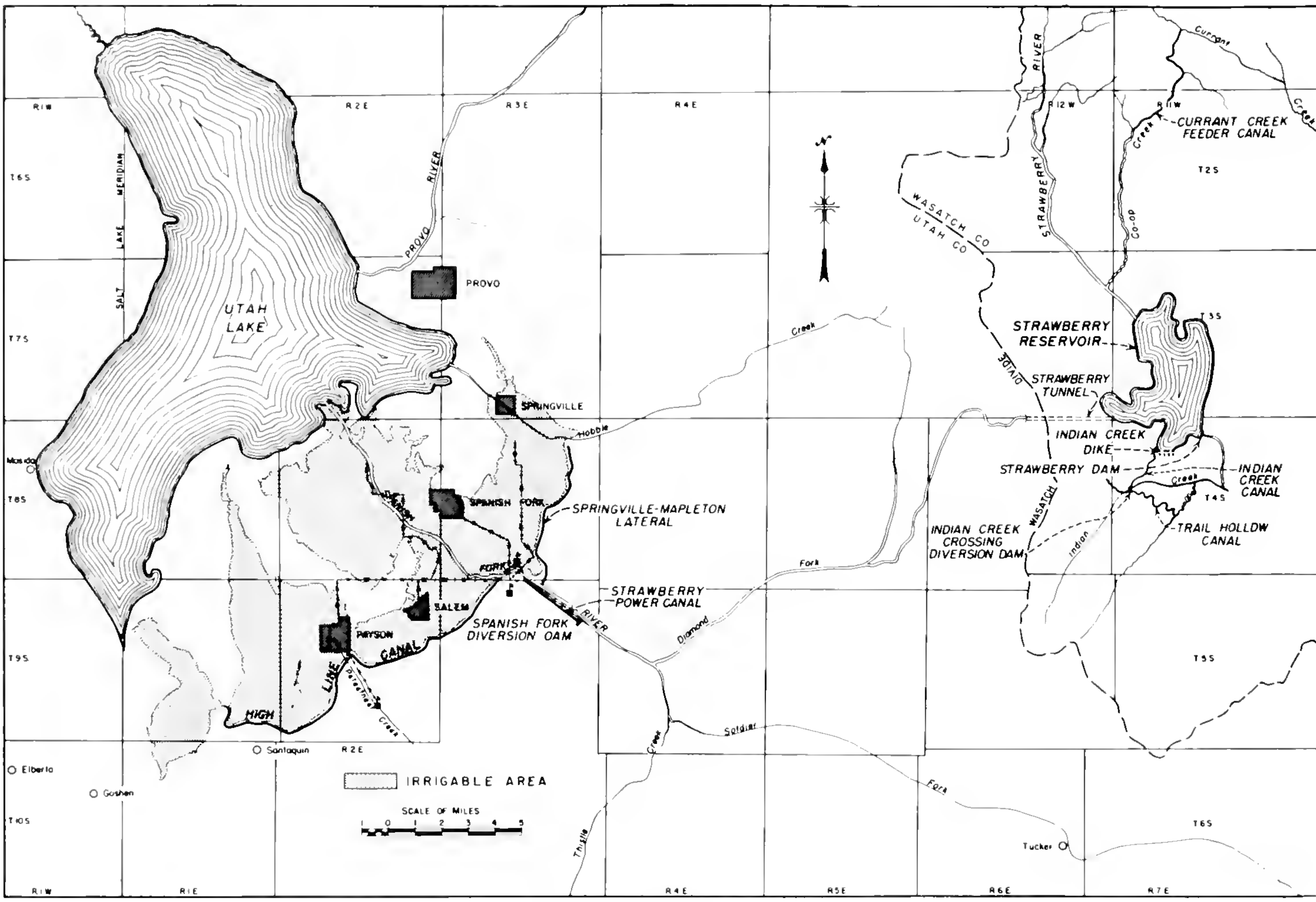
Strawberry Dam and Reservoir

Strawberry Dam, Reservoir, and Outlet Tunnel

Strawberry Dam is on the Strawberry River about 29 miles southeast of Provo, Utah. It is an earthfill structure, 72 feet high, and contains 118,000 cubic yards of materials. The spillway is a concrete-lined chute in the north abutment of the dam that has a capacity of 425 cubic feet per second. Indian Creek Dike closes a saddle in the south end of the reservoir. The dike is 37 feet high and has a volume of 114,000 cubic yards.

The 283,000-acre-foot reservoir also is fed by three feeder canals. The Indian Creek Crossing Diversion Dam diverts into the Indian Creek Feeder Canal. The dam is an earth structure 12 feet high. The 750-cubic-foot-per-second feeder canal is 2 miles long. The Trail Hollow Canal is 4 miles long, has a capacity of 125 cubic feet per second, and extends from Trail Hollow Creek to the Indian Creek Feeder Canal. The 110-cubic-foot-per-second Currant Creek Feeder Canal is nearly 5 miles long, diverting into Co-op Creek, a tributary of Strawberry River upstream of the reservoir.

The outlet for the reservoir is the Strawberry Tunnel, which takes water from the reservoir through the divide to Diamond Fork, a tributary of the Spanish Fork River. The concrete-lined tunnel is 7 feet wide and 9 feet high, and is 3.8 miles long. It has a capacity of 600 cubic feet per second. Inflow is controlled by two 3- by 5-foot gates.



Strawberry Valley Project

Soldier Creek Dam and Reservoir

Soldier Creek Dam, completed in 1974 as part of the Bonneville Unit of the Central Utah Project, is 7 miles downstream from Strawberry Dam. The reservoir created by Soldier Creek Dam eventually will raise the water surface of Strawberry Reservoir by about 45 feet. When this level is reached, the enlarged reservoir will have a capacity of 1,106,500 acre-feet and a surface area of 17,000 acres.

Spanish Fork Diversion Dam and Canal System

The Spanish Fork Diversion Dam has a concrete gravity ogee weir with a hydraulic height of 13 feet. The dam diverts Strawberry Reservoir releases into the Strawberry Power Canal, which supplies the Springville-Mapleton Lateral and the High Line Canal. The Power Canal extends 3.3 miles from the diversion dam to the Spanish Fork Powerplants. It has a diversion capacity of 500 cubic feet per second. The Springville-Mapleton Lateral branches from the Power Canal 2 miles below the diversion dam. The lateral is 6.75 miles long and has a diversion capacity of 100 cubic feet per second. The High Line Canal begins above the Spanish Fork Powerplants where the Power Canal ends, and extends 17.5 miles in a southwesterly direction. The diversion capacity is 300 cubic feet per second.

Water from these canals is distributed through privately constructed laterals.

Powerplants

The Upper Spanish Fork Powerplant, with two units, operates under a maximum head of 123 feet, and develops 900 kilowatts. The Lower Spanish Fork Powerplant has one unit operating under a maximum head of 48 feet and develops 250 kilowatts. The Payson Powerplant on Peteetneet Creek operates on a maximum head of 636 feet and develops 400 kilowatts. There are 42 miles of transmission lines to deliver the power to the consumers.

The Upper Spanish Fork Powerplant was constructed by the Bureau of Reclamation, the other two powerplants by the Strawberry Water Users Association. All plants are operated by the association.

DEVELOPMENT

Early History

Settlers began irrigating the lower part of the Utah Valley on the south side of the Spanish Fork River and the area adjacent to Utah Lake on the north side of the river prior to 1860. The low summer flow of the river limited development of the irrigable land, and the need for supplemental storage was evident long before 1900.

Investigations

The first reconnaissance and preliminary surveys for supplemental storage and investigation of the irrigable lands by the United States began in 1903, making the project one of the earliest investigated under the Reclamation Act. Following the complete investigation, construction of the project was recommended by a board of engineers on October 2, 1905.

Authorization

The project was authorized by the Secretary of the Interior on December 15, 1905, under the provisions of the Reclamation Act of 1902.

Construction

Excavation of the Strawberry Tunnel was started in 1906 and completed in 1912. Construction of the Spanish Fork Diversion Dam, Strawberry Power Canal, and Upper Spanish Fork Powerplant was completed in 1908. Electric power from these facilities was used at the Strawberry Tunnel and Dam during construction. Construction of Indian Creek Dike and Feeder Canal was completed in September 1912 and Strawberry Dam was finished in 1913. The High Line Canal and distribution system of approximately 77 miles, of which about 62 miles are concrete lined, was completed in 1916 and the Springville-Mapleton Lateral was completed in 1918. The entire project was completed by June 30, 1922.

Operating Agency

The Strawberry Water Users Association operates and maintains the project.

BENEFITS

Irrigation

Before 1900, the low summer flow of the river limited the development of the irrigable lands. Since 1922, all of the reservoir basin supply has been used for the benefit of the project. As a result of an adequate supply of water to the lands, stabilized crop returns and improvement in the economic conditions of the area have been realized. Principal crops are alfalfa, corn, small grains, fruit, and some vegetables.

Hydroelectric Power

From three small generating plants having a total capacity of 1,550 kilowatts, the project has realized revenues which have assisted materially in the repayment of construction costs. Generation and transmission of power on the project are handled entirely by the Strawberry Water Users Association.

Recreation and Fish and Wildlife

Strawberry Reservoir has a surface area of 8,400 acres at total capacity and will double when the new reservoir, resulting from construction of Soldier Creek Dam, is filled. The enlarged reservoir will cover 17,160 acres at maximum capacity.

A recreation master plan has been prepared for the enlarged reservoir. Initial development will consist of two major recreation sites, several fisherman access points, and a visitor station. The major recreation sites will be developed at Soldier Creek Bay and at Strawberry Bay. The sites will provide about 700 camping units which include flush toilets, electric power, shelters, tables, grills, fire circles, and a sewage collection and treatment system. Boat ramps, marinas, parking, and fish cleaning stations at each major site also are being planned. Administration of fish and wildlife activities as well as boating regulation will be the responsibility of the State of Utah. It is anticipated that the quality fishery, so popular at Strawberry Reservoir, will continue to be maintained. The reservoir has long been one of Utah's finest fisheries and is the primary source of eggs for native cutthroat trout used in fish hatcheries throughout the State. Visitor days to the area in 1977 totaled 231,294, lower than normal because of the 1977 drought (normal annual visitation is almost 400,000).

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	17,694	acres
Supplemental irrigation service	26,877	acres
Total	44,571	acres
Number of irrigated farms	1,562	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	40,132	3,976,063
1969	39,789	4,048,383
1970	40,175	4,194,042
1971	40,495	4,496,106
1972	40,436	4,484,445
1973	40,786	9,518,053
1974	40,979	10,456,283
1975	40,042	10,705,288
1976	41,108	11,212,013
1977	41,260	10,868,553

Facilities in Operation

Storage dams	1	
Diversion dams	2	
Canals	91	mi
Laterals	251	mi
Drains	96	mi
Tunnels	4	mi
Powerplants	3	
Transmission lines	42	mi

Climatic Conditions

Annual precipitation	16.9	in
Temperature:		
Maximum	106	°F
Minimum	−19	°F
Mean	51	°F
Growing season	150	days
Elevation of irrigable area	4500-4800.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	5,466
Urban, suburban, and industrial service	3,496
Total	8,962

ENGINEERING DATA

Water Supply

Strawberry River

Drainage area at Strawberry Dam	170	mi²
Annual discharge at Strawberry Dam:		
Maximum (1952)	182,900	acre-ft
Minimum (1934)	19,300	acre-ft
Average	74,085	acre-ft

Spanish Fork River

Drainage area at Castilla, Utah	670	mi²
Annual discharge at Castilla:		
Maximum (1952)	310,600	acre-ft
Minimum (1934)	62,300	acre-ft
Average	149,900	acre-ft
Average annual diversion from Strawberry Reservoir	54,800	acre-ft

Storage Facilities

Strawberry Dam and Indian Creek Dike

Type: Homogeneous earthfill
Location: Strawberry River, 29 mi southeast of Provo, Utah. Dike closes saddle in south end of reservoir.
Construction period: 1908-13
Date of closure (first storage): July 14, 1912
Reservoir, Strawberry:

Average annual inflow	61,800	acre-ft
Total capacity to El. 7558	283,000	acre-ft
Active capacity, El. 7512-7558	270,000	acre-ft
Surface area	8,400	acres

Dimensions:	*Dam*	*Dike*
Structural height	72 ft	37 ft
Hydraulic height	60 ft	25 ft
Top width	21 ft	20 ft
Maximum base width	366 ft	198 ft
Crest length	490 ft	1,311 ft
Crest elevation	7569.0 ft	7569.0 ft
Volume	118,000 yd³	114,000 yd³

Spillway: Uncontrolled concrete crest and concrete-lined chute at the left abutment of the dam.

Crest length	66	ft
Crest elevation	7558.0	ft
Capacity at El. 7560[1]	425	ft³/s

Outlet works: Control structure at inlet to Strawberry Tunnel is located on Strawberry Reservoir across from dam. Control is by two 3- by 10-ft slide gates.

Capacity	600	ft³/s

[1] In 1953, the 1.5-ft-high crest was removed from the two center sections of the spillway, increasing the discharge capacity to approximately 1,000 ft³/s. Since then, flashboards have been installed on the crest, restoring it to El. 7558.

Diversion Facilities

Spanish Fork Diversion Dam

Type: Concrete ogee weir
Location: On the Spanish Fork River, about 5 mi southeast of Spanish Fork, Utah.
Year completed: 1908
Dimensions:

Structural height	28	ft
Hydraulic height	13	ft
Weir crest length	38	ft
Crest length	74	ft
Crest elevation	4851.0	ft
Volume	1,000	yd³

Headworks: Concrete structure with six 4.5- by 8-ft openings controlled by slide gates.

Diversion capacity	500	ft³/s

Indian Creek Crossing Diversion Dam

Type: Earth dike
Location: On Indian Creek, about 25 mi east of Spanish Fork.
Year completed: 1913
Dimensions:

Structural height	12	ft
Hydraulic height	5	ft
Crest length	1,350	ft
Crest elevation	7577.0	ft
Volume	15,000	yd³

Headworks: Concrete structure with six hand-operated slide gates.

Diversion capacity	750	ft³/s

Carriage Facilities

Trail Hollow Canal

Location: From Trail Hollow Creek about 5 mi south of Indian Creek Dike, generally northwest to Indian Creek Feeder Canal.
Construction period: 1911-12

Length	4 mi
Capacity	125 ft³/s
Typical maximum section in earth:	
Bottom width	12 ft
Side slopes	1:1 and 1.5:1
Water depth	3.25 ft

Indian Creek Feeder Canal

Location: From diversion dam on Indian Creek generally northeast to reservoir at a point near west end of Indian Creek Dike.
Construction period: 1911-12

Length	2 mi
Capacity	750 ft³/s
Typical maximum section in earth:	
Bottom width	22 ft
Side slopes	1:1 and 1.5:1
Water depth	6.5 ft

Currant Creek Feeder Canal

Location: From Currant Creek about 14 mi north of east portal of Strawberry Tunnel, generally south to Co-op Creek.
Construction period: 1934-36

Length	4.7 mi
Capacity	110 ft³/s
Typical maximum section in earth:	
Bottom width	8 ft
Side slopes	1.5:1
Water depth	3 ft

Strawberry Tunnel

Location: From Strawberry Reservoir west.
Construction period: 1906-12

Length	3.8 mi
Capacity	600 ft³/s

Cross section: Rectangular with arched roof, 7 ft wide and 9 ft high.
Lining: Concrete

Strawberry Power Canal

Location: From Spanish Fork Diversion Dam on Spanish Fork River about 7 mi southeast of Spanish Fork, Utah, generally northwest along river to Spanish Fork Powerplant.
Construction period: 1907-08

Length	3.3 mi
Diversion capacity	500 ft³/s
Typical maximum section in earth:	
Bottom width	19 ft
Side slopes	1.5:1
Water depth	6.2 ft
Typical maximum section, concrete lined:	
Bottom width	4 ft
Side slopes	1:1
Water depth	7.2 ft
Lining thickness	6 in

High Line Canal

Location: From Strawberry Power Canal near powerplant, generally southwest along southern edge of irrigated area.
Construction period: 1915-18

Length	17.5 mi
Diversion capacity	300 ft³/s
Typical maximum section in earth:	
Bottom width	20 ft
Side slopes	1.5:1
Water depth	4.1 ft
Typical maximum section, concrete lined:	
Bottom width	6 ft
Side slopes	1:1
Water depth	4 ft
Lining thickness	4 in

Springville-Mapleton Lateral

Location: Generally north from point on Strawberry Power Canal about 2 mi downstream from diversion dam.
Construction period: 1918

Length	6.75 mi
Diversion capacity	100 ft³/s
Typical maximum section in earth:	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2.7 ft
Typical maximum section, concrete lined:	
Bottom width	4 ft
Side slopes	1.5:1
Water depth	2.55 ft
Lining thickness	4 in

Power Facilities

Upper Spanish Fork Powerplant[2]

Location: On Strawberry Power Canal about 3 mi southeast of Spanish Fork.
Year of initial operation: 1909
Year last generator placed in operation: 1908

Nameplate capacity	900 kW
Number and capacity of generators (2)	450 kW
Maximum head	123 ft

Lower Spanish Fork Powerplant[3]

Location: On Strawberry Power Canal about 3 mi southeast of Spanish Fork.
Year of initial operation: 1937

Nameplate capacity	250 kW
Number of generators	1
Maximum head	48 ft

Payson Powerplant[3]

Location: In Payson Canyon on Peteetneet Creek about 3 mi southeast of Payson, Utah.
Year of initial operation: 1941

Nameplate capacity	400 kW
Number of generators	1
Maximum head	636 ft

Transmission Lines

Total number of lines	6
Circuit miles:	
11-kV	28
44-kV	14
Total	42

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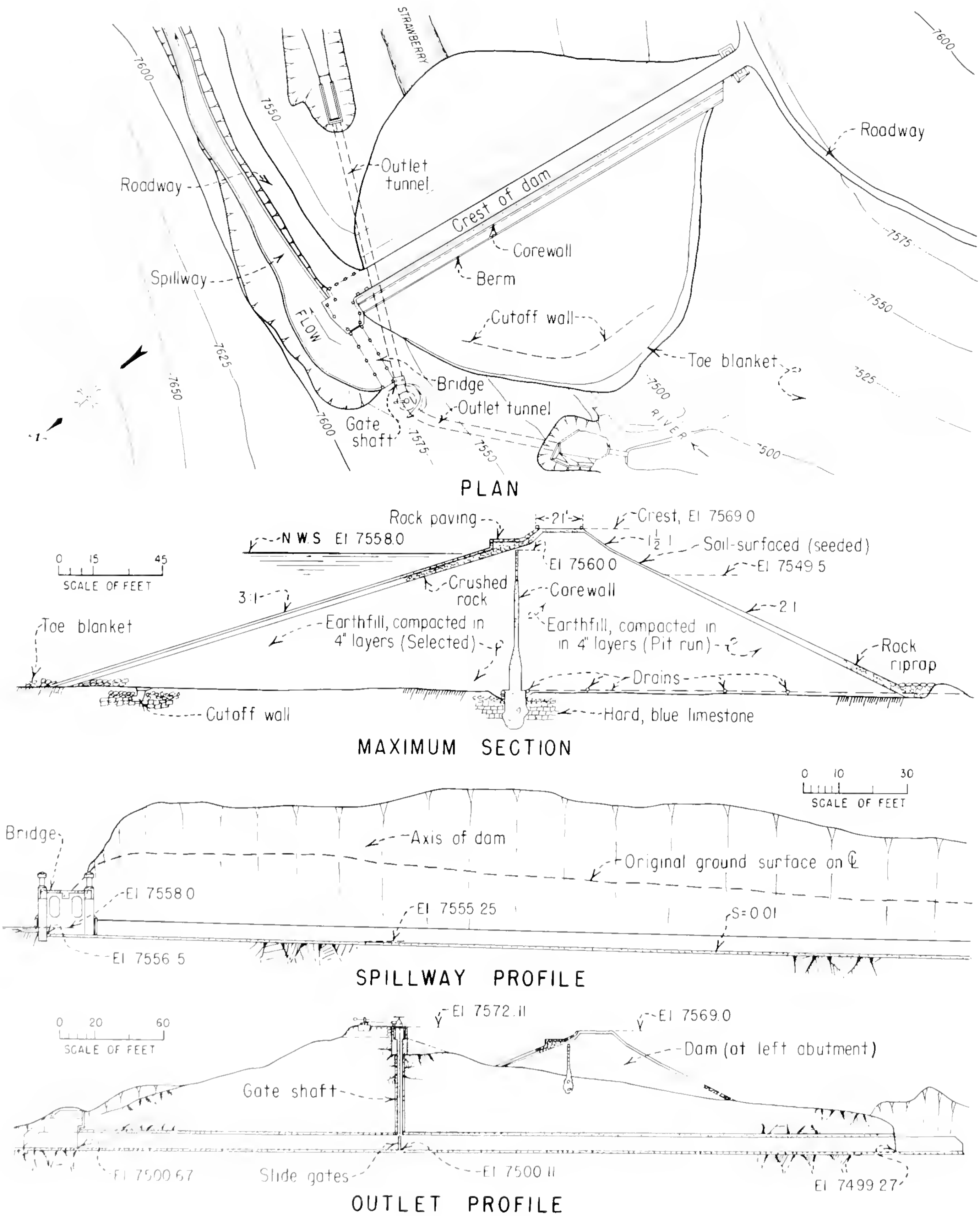
[2]Constructed by Bureau of Reclamation and operated by water users' association.
[3]Constructed and operated by water users' association.

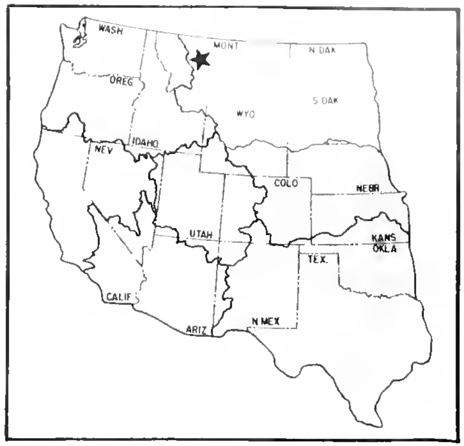


Strawberry Dam, Plan and Sections

Sun River Project

Montana: Cascade, Lewis and Clark, and Teton Counties

Upper Missouri Region
Water and Power Resources Service

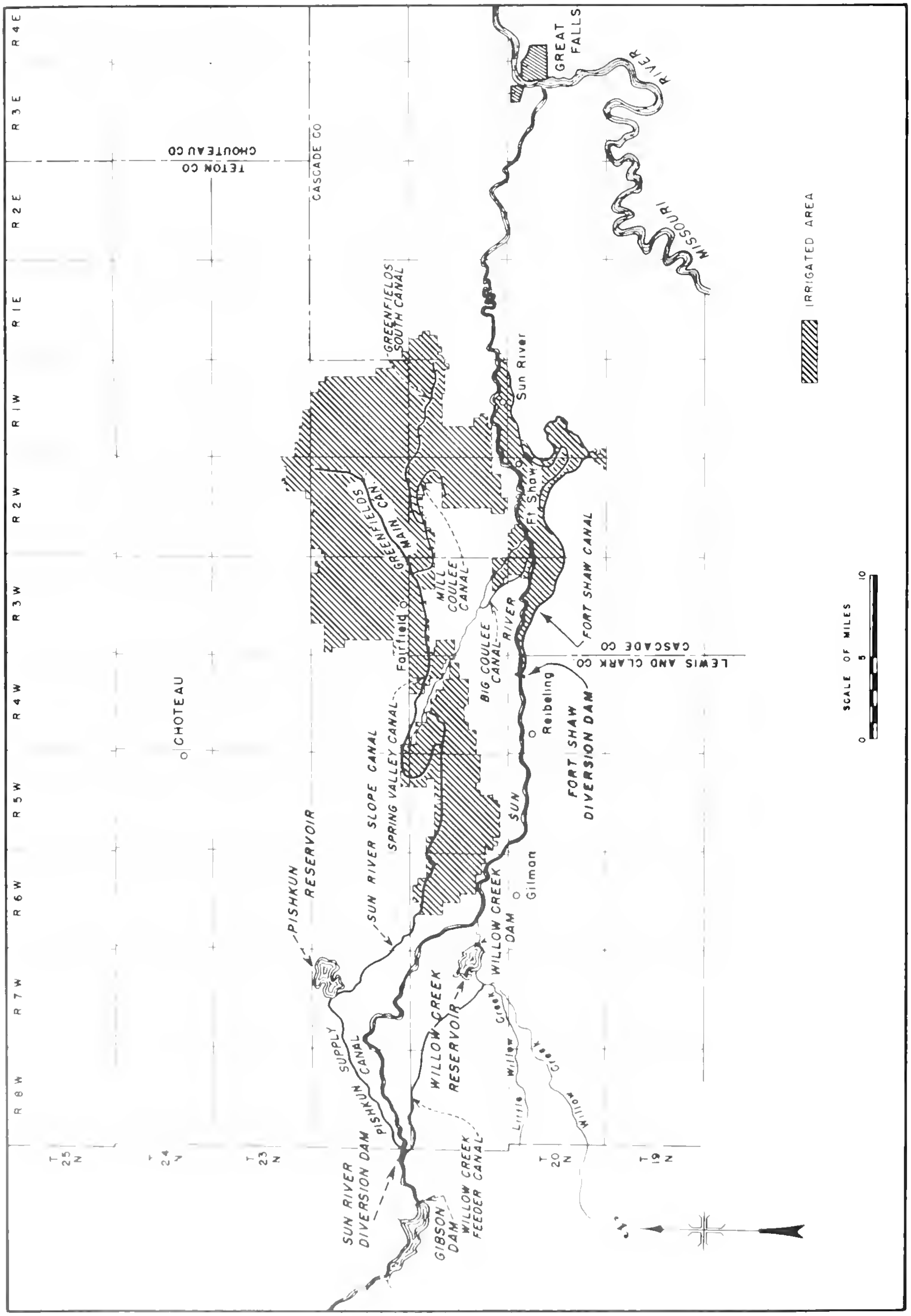


The Sun River Project is composed of the Greenfields and Fort Shaw Divisions in central Montana, west of the city of Great Falls. Principal features are Gibson Dam and Reservoir, Willow Creek Dam and Reservoir, Pishkun Dikes and Reservoir, Sun River Diversion Dam, Fort Shaw Diversion Dam, two supply canals, and six irrigation canals.

PLAN

The project uses the waters of the Sun River and tributaries, stored and regulated by Gibson, Pishkun, and Willow Creek Reservoirs, for irrigating 91,011 acres of land lying along the Sun River. Water stored in Gibson Reservoir is released into the river for diversion downstream into the Pishkun Supply Canal or into the Fort Shaw Canal. The Pishkun Supply Canal, heading at Sun River Diversion Dam, conveys water to Pishkun Reservoir or to the Willow Creek Reservoir through the Willow Creek Feeder Canal, which stems from the Pishkun Supply Canal and empties into a natural channel to the reservoir. Water released from Pishkun Reservoir enters the Sun River Slope Canal, which branches into several main canals for distribution to approximately 81,000 acres in the Greenfields Division. Storage in Willow Creek Reservoir is returned to the Sun River. Water for approximately 10,000 acres in the Fort Shaw Division is diverted directly from the river into the Fort Shaw Canal.

Gibson Dam



Sun River Project

Sun River Diversion Dam

Gibson Dam and Reservoir

Gibson Dam, the principal structure of the project, is on the Sun River, 70 miles west of Great Falls. It is a concrete arch dam 199 feet high and contains 167,500 cubic yards of concrete. A drop inlet spillway located just upstream from the north end of the dam has a capacity of 30,000 cubic feet per second. The entrance to the shaft and 29.5-foot-diameter tunnel is controlled by six 34- by 12-foot radial gates. Outlet structures for the dam are two 72-inch-diameter semisteel-lined conduits through the base of the dam. The maximum capacity of the outlets is 3,050 cubic feet per second. Gibson Reservoir has a total capacity of 99,100 acre-feet.

Pishkun Dikes and Reservoir

Pishkun Reservoir is an offstream storage reservoir, about 15 miles northeast of Gibson Dam, and has a capacity of 46,700 acre-feet. The reservoir is formed by eight earthfill dikes with heights ranging from 12 to 50 feet and an overall length of 9,050 feet. The outlet for the reservoir is a 12-foot-diameter, approximately semicircular, concrete conduit through Dike No. 4. The outlet structure has a maximum capacity of 1,600 cubic feet per second. There is no spillway for the reservoir.

Willow Creek Dam and Reservoir

Willow Creek Dam is an earthfill structure on Willow Creek about 15 miles southeast of Gibson Dam. In addition to storing water from Willow Creek, the reservoir is fed from the Sun River through the Willow Creek Feeder Canal. The structure is 93 feet high, has a crest length of 650 feet, and contains 275,000 cubic yards of material. An open spillway channel 700 feet wide at the ground surface has a capacity of 10,000 cubic feet per second. The outlet works tunnel runs through the right abutment. The reservoir has a capacity of 32,400 acre-feet of water.

Sun River Diversion Dam

The Sun River Diversion Dam, located 3 miles downstream from Gibson Dam, is a concrete arch structure with a structural height of 132 feet and a crest length of 261 feet. The dam contains 6,500 cubic yards of concrete. It is equipped with an overflow crest for a spillway. The outlet works tunnel runs through the canal wall of the right abutment. The capacity of the outlet works feeding the Pishkun Supply Canal is 1,400 cubic feet per second.

Pishkun Supply Canal

The Pishkun Supply Canal extends 12 miles from the Sun River Diversion Dam to the Pishkun Reservoir. A few hundred feet below the diversion dam, the canal crosses Sun River through a 1,400-cubic-foot-per-second-capacity monolithic siphon 700 feet long. The canal flows through two tunnels, 980 feet and 2,280 feet long, and numerous drain and control structures after it crosses Sun River.

Willow Creek Feeder Canal

Stemming from Pishkun Supply Canal a short distance below the river diversion, the Willow Creek Feeder Canal has a maximum capacity of 500 cubic feet per second and is 7.5 miles long to the point where it enters a natural channel to Willow Creek Reservoir.

Fort Shaw Canal

The Fort Shaw Canal inlet is on the main channel of the Sun River immediately upstream from the Fort Shaw Diversion Dam. The flow into the canal is regulated by a concrete headworks. The canal has a capacity of 225 cubic feet per second and is 12 miles long. It includes a monolithic siphon over Simms Creek and several drops and control structures. This canal supplies water for the entire Fort Shaw Division through approximately 85 miles of laterals.

Sun River Slope Canal System

The system furnishes water for the Greenfields Division. Sun River Slope and Spring Valley Canals combined extend 32 miles from Pishkun Reservoir to a drop at Fairfield. The diversion capacity is 1,600 cubic feet per second. Three major drops and various control structures and lateral turnouts are a part of the canals. Greenfields Main Canal heads at the end of Spring Valley Canal and extends 25.4 miles northeast. It has an initial capacity of 1,200 cubic feet per second but is gradually reduced in size to 10 cubic feet per second at its terminus. Greenfields South Canal is supplied by the Greenfields Main Canal at a point about 2 miles below the start of the main canal. The initial capacity is 425 cubic feet per second and the length is 16.7 miles. Mill Coulee Canal is supplied from the Greenfields South Canal. The initial capacity is 200 cubic feet per second and the length is 10.7 miles.

DEVELOPMENT

Early History

In 1870, Col. John Gibbons marched the Seventh U.S. Infantry into the Sun River Valley and took station at

Pishkun Reservoir

Fort Shaw, which had been established to protect the freighters, travelers, and miners against the Indians. Gold had been discovered in Alder Gulch, and miners, adventurers, and trappers were coming into the new country. Boats ran up the Missouri River to Fort Benton, and from there supplies were freighted into the placer diggings.

Soon after Colonel Gibbons' command settled down to routine garrison duty, company gardens were established. The post adjutant was directed to survey and build a ditch from Sun River to irrigate the post gardens located on the bench southwest of the fort. Thus began the first irrigation district, then considered a marvel in the engineering field and thought to be the largest ditch in the country. The capacity was about 15 cubic feet per second.

Early settlers developed lands between the Sun and Teton Rivers for grazing. Studies were made by the Geological Survey during the latter part of the 19th century, local interests formed several corporations to develop irrigation within the area, and some progress was made with private irrigation.

Investigations

In 1902, a number of settlers filed homestead and desert claims on Greenfield Bench and organized the Kilraven Cooperative Canal Company to irrigate the lands. They partially excavated 4 of the 14 miles of canal necessary to deliver the water; then, in 1903, they abandoned the work. On October 17, 1903, the newly organized Reclamation Service withdrew from entry all the lands pertaining to the cooperative company's system to incorporate them into the Sun River Project. The settlers holding desert entries on these lands claimed an extension of time to make proof on their entries, based on the

Willow Creek Dam and Reservoir

premise that withdrawal of these lands would preclude other settlers from taking up land and helping with the construction of the cooperative company's system. Extensions of time were granted in most cases from year to year. In the winter of 1905-06, the people of Choteau, Great Falls, and vicinity, realizing the importance of the Sun River Project, sent a joint committee to Washington to urge the Director and the Secretary to approve the project and make an early allotment of funds for beginning the work. When the bill opening the Fort Shaw lands to settlement was passed by the Congress, these lands were selected as the first unit of the Sun River Project.

Authorization

The project was authorized by the Secretary of the Interior on February 26, 1906, in accordance with the act of June 17, 1902 (Ch. 1093, 32 Stat. 388, 43 U.S.C. 391).

Construction

Construction work on the Fort Shaw Division began in May 1907, and the bulk of the work was completed by July 1908. The first water was delivered to the division lands in 1909. Construction of the Greenfields Division began in 1913; the first water was made available in 1920. The main storage dam, Gibson, was constructed during 1926-29. Since that time, construction work has been of a minor nature.

Rehabilitation and Betterment

Modification of Gibson Dam to ensure safe passage of an inflow design flood is planned. Proposed work will allow the dam to be safely overtopped by a water depth of 12 feet. A rehabilitation and betterment program on the Greenfields Division irrigation facilities is scheduled to be completed by 1987. This program includes lining portions of the main canals and laterals; replacement of several open laterals and buried pipe; installation of automatic and telemetric equipment for control of water regulating facilities at Gibson and Pishkun Dams and at storage points on the irrigation system; and repairing, updating, and replacing of various structures and measuring devices.

Operating Agencies

The Fort Shaw Divison is operated by the Fort Shaw Irrigation District. The Greenfields Division is operated by the Greenfields Irrigation District.

BENEFITS

Irrigation

The land is divided into farms. Principal crops are wheat, oats, barley, alfalfa, silage, and pasture.

Recreation

In 1977, Gibson, Pishkun, and Willow Creek Reservoirs were used 43,300 visitor days. Greenfields (Freezeout Lake) was used 13,600 visitor days. These reservoirs provide excellent boating and rainbow and brown trout fishing. Swimming, camping, and picnicking are enjoyed during the summer months.

PROJECT DATA

Land Areas (1977)

Irrigable area:	
Full irrigation service	91,011 acres
Number of irrigated farms	606

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	76,003	3,736,309
1969	75,793	3,578,955
1970	76,015	3,565,700
1971	79,065	4,341,334
1972	76,548	5,583,214
1973	80,154	8,091,715
1974	83,532	8,943,488
1975	82,266	8,082,647
1976	82,421	8,954,713
1977	82,887	8,954,854

Facilities in Operation

Storage dams and dikes	3
Diversion dams	2
Canals	131 mi
Laterals	562 mi
Drains	265 mi

Climatic Conditions

Annual precipitation	19	in
Temperature:		
Maximum	106	°F
Minimum	−49	°F
Mean	45	°F
Growing season	129	days
Elevation of irrigable area	3700.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,999
Municipal and industrial	91
Other water service[1]	23

[1]Urban, suburban, and industrial lands.

ENGINEERING DATA

Water Supply

North Fork, Sun River

Drainage area at Gibson Dam	559	mi²
Annual discharge near Augusta, Mont.:		
Maximum (1975)	592,200	acre-ft
Minimum (1977)	80,900	acre-ft
Average	319,800	acre-ft

Storage Facilities

Gibson Dam

Type: Concrete arch
Locaton: On the North Fork of Sun River, about 30 mi northwest of Augusta, Mont.
Construction period: 1926-29. Spillway modified in 1938.
Date of closure (first storage): December 1929

Reservoir, Gibson:		
Total capacity to El. 4724	99,100	acre-ft
Active capacity, El. 4557.5-4724	99,000	acre-ft
Surface area	1,296	acres
Dimensions:		
Structural height	199	ft
Hydraulic height	195	ft
Top width	15	ft
Maximum base width	117	ft
Crest length	960	ft
Crest elevation	4725.5	ft
Parapet elevation	4729.0	ft
Total volume	167,500	yd³
Spillway: Drop-inlet, discharging into shaft and tunnel in left abutment, controlled by six 34- by 12-ft radial gates.		
Elevation top of gates	4724.0	ft
Crest elevation	4712.0	ft
Capacity at El. 4724	30,000	ft³/s
Capacity at El. 4729	50,000	ft³/s
Outlet works: Two conduits through base of dam, each controlled by one 60-in jet-flow valve.		
Capacity at El. 4724	3,050	ft³/s

Foundation: Crystalline limestone in regular beds which strike crosswise of river.
Special treatment: Cement-grout curtain beneath upstream cutoff trench; spring in left abutment grouted.

Pishkun Dikes

Type: Zoned earthfill
Location: Eight dikes, located offstream about 16 mi southwest of Choteau, Mont.
Construction period: 1930-31. Enlarged in 1940.
Date of closure (first storage): January 1930

Reservoir, Pishkun:		
Total capacity to El. 4370	46,700	acre-ft
Active capacity, El. 4342-4370	30,400	acre-ft
Surface area	1,550	acres
Dimensions:		
Structural height	12-50	ft
Hydraulic height	38	ft
Top width	20	ft
Crest length, total all dikes	9,050	ft
Crest elevation	4380.0	ft
Total volume	599,000	yd³
Spillway: None		
Outlet works: Concrete conduit through Dike No. 4		
Capacity	1,600	ft³/s

Willow Creek Dam

Type: Modified homogeneous earthfill
Location: On Willow Creek, 5 mi northwest of Augusta, Mont. Four small earth dikes close low areas north of the dam.
Construction period: 1907-11. Crest raised 2 ft and spillway constructed in 1917; crest raised 12 ft in 1941.
Date of closure (first storage): March 1916

Reservoir, Willow Creek:		
Total capacity at El. 4142	32,300	acre-ft
Active capacity, El. 4085.3-4142	32,200	acre-ft
Surface area	1,470	acres
Dimensions:		
Structural height	93	ft
Hydraulic height	69	ft
Top width	30	ft
Maximum base width	456	ft
Crest length	650	ft
Crest elevation	4154.0	ft
Total volume (dam and dikes)	366,000	yd³
Spillway: Uncontrolled, open channel emergency spillway in Dike No. 5 about 3,600 ft north of dam, with concrete cutoff wall and rock paving at crest.		
Crest length	700	ft
Crest elevation	4144.0	ft
Capacity at El. 4147	10,000	ft³/s
Outlet works: Concrete-lined tunnel through right abutment, controlled by one 4.5-ft-square slide gate for service, and a similar emergency gate.		
Capacity at El. 4142	500	ft³/s

Diversion Facilities

Sun River Diversion Dam

Type: Concrete arch weir
Location: On the North Fork of Sun River, 17 mi northwest of Augusta, Mont., 3 mi downstream from Gibson Dam.
Year completed: 1915

Dimensions:		
Structural height	132	ft
Hydraulic height	114	ft
Crest width	7.5	ft
Base width	40	ft

Crest length	261	ft
Weir crest elevation	4474.0	ft
Volume	6,500	yd³

Spillway: Overflow crest

Capacity	34,000	ft³/s

Headworks: Concrete gate structure in right abutment, discharging into tunnel approximately 11 ft in diameter and 693 ft long. Two 5- by 10-ft steel slide gates, hand operated.

Diversion capacity	1,400	ft³/s

Fort Shaw Diversion Dam

Type: Rockfill overflow section
Location: On the Sun River, 12 mi upstream of Fort Shaw, Mont., 40 mi downstream from Sun River Diversion Dam.
Year completed: 1908
Dimensions:

Structural height	9	ft
Hydraulic height	9	ft
Crest length	400	ft
Approximate volume rockfill	3,000	yd³

Carriage Facilities

Pishkun Supply Canal

Location: From Sun River Diversion Dam, 3 mi downstream from Gibson Dam on the North Fork, Sun River, generally northeast to Pishkun Reservoir.
Construction period: 1913-20. Enlarged 1935-38.

Length	12	mi
Diversion capacity	1,400	ft³/s
Typical maximum section in earth:		
Bottom width	27	ft
Side slopes	1.5:1	
Water depth	12	ft

Sun River Crossing (Pishkun Supply Canal)

Location: On the Sun River near Sun River Diversion Dam.
Description: Monolithic concrete siphon

Length	700	ft
Diameter	10	ft
Capacity	1,400	ft³/s

Tunnels No. 2 and 3 (Pishkun Supply Canal)

Total length	3,260	ft
Capacity	1,400	ft³/s

Willow Creek Feeder Canal

Location: Southeast from Sun River Crossing entrance on Pishkun Supply Canal.
Construction period: 1938

Length	7.5	mi
Diversion capacity	500	ft³/s
Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	1.5:1	
Water depth	4.5	ft

Sun River Slope Canal

Location: From Pishkun Reservoir generally southeast.
Construction period: 1917-19

Length	18	mi
Diversion capacity	1,600	ft³/s
Typical maximum section in earth:		
Bottom width	36	ft
Side slopes	1.5:1	
Water depth	12.6	ft
Typical maximum section, concrete lined:		
Bottom width	12.33	ft
Side slopes	1:1	
Water depth	10.7	ft
Lining thickness	4	in

Spring Valley Canal

Location: East from a point on Sun River Slope Canal near its end, to vicinity of Fairfield, Mont.
Construction period: 1931-32

Length	14	mi
Diversion capacity	1,200	ft³/s
Typical maximum section in earth:		
Bottom width	40	ft
Side slopes	1.5:1	
Water depth	8	ft

Greenfields Main Canal

Location: From end of Spring Valley Canal near Fairfield, Mont., generally northeast.
Construction period: 1913-20. Enlarged 1940.

Length	25.4	mi
Diversion capacity	1,200	ft³/s
Typical maximum section in earth:		
Bottom width	38	ft
Side slopes	1.5:1	
Water depth	7.3	ft

Greenfields South Canal

Location: From point on Greenfields Main Canal near Fairfield, Mont., generally east.
Construction period: 1913-20. Enlarged 1940.

Length	16.7	mi
Diversion capacity	425	ft³/s
Typical maximum section in earth:		
Bottom width	24	ft
Side slopes	1.33:1	
Water depth	4	ft

Mill Coulee Canal

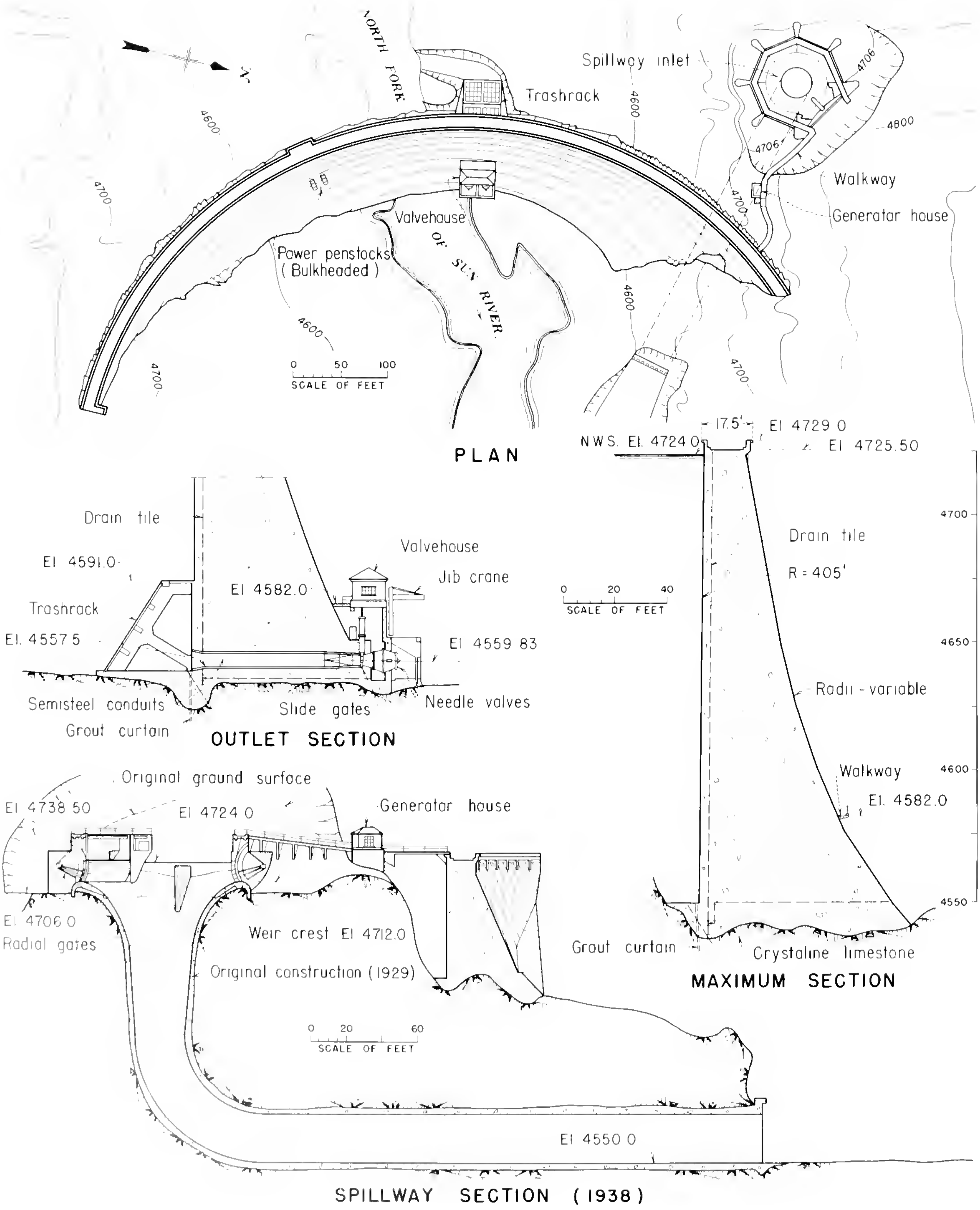
Location: East and south from Greenfields South Canal near Fairfield, Mont.
Construction period: 1913-20. Enlarged 1940.

Length	10.7	mi
Diversion capacity	200	ft³/s
Typical maximum section in earth:		
Bottom width	20	ft
Side slopes	1.5:1	
Water depth	3	ft

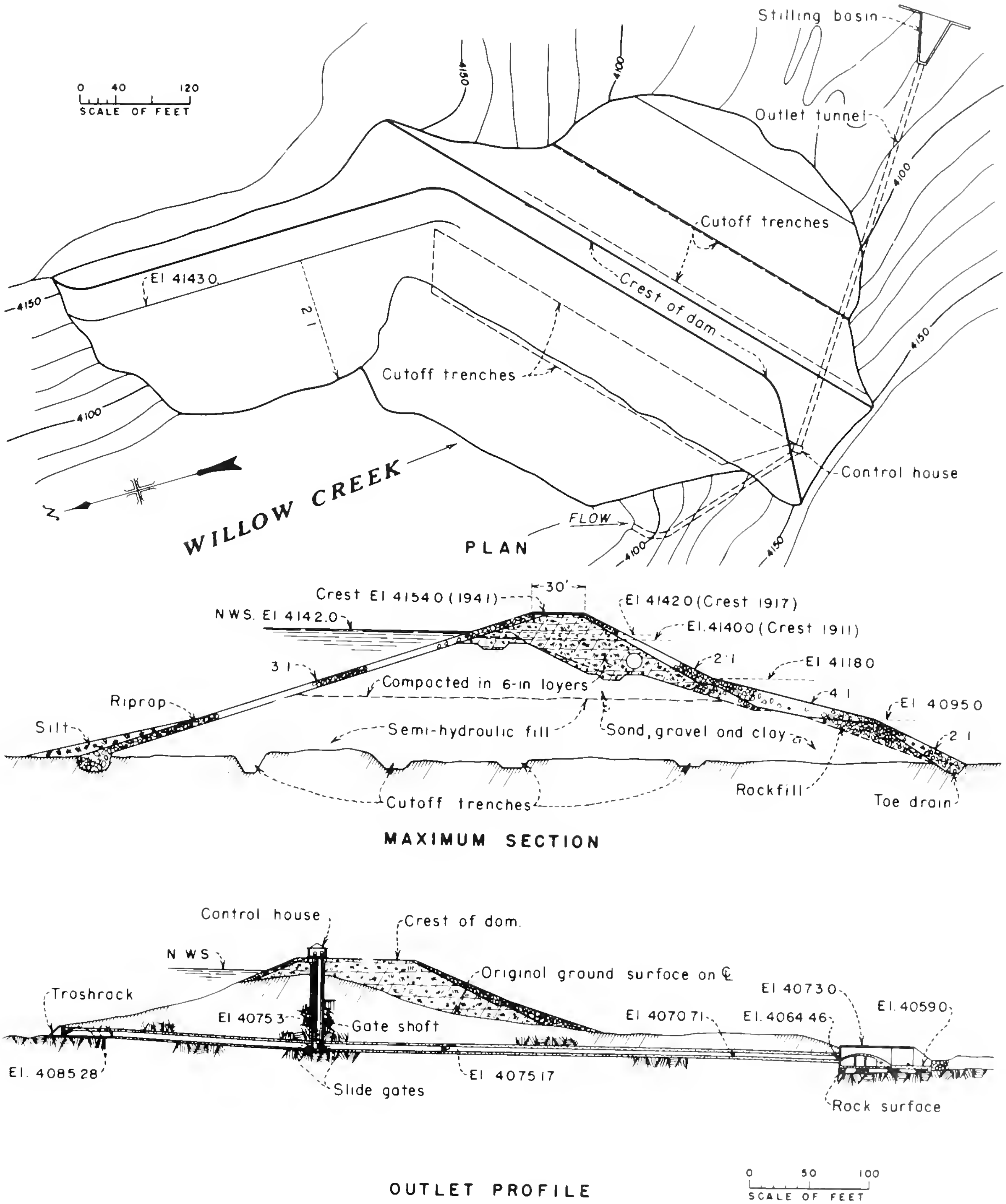
Fort Shaw Canal

Location: From diversion on the Sun River about 5 mi west of Simms, Mont., generally east to vicinity of Sun River, Mont.
Construction period: 1907-08

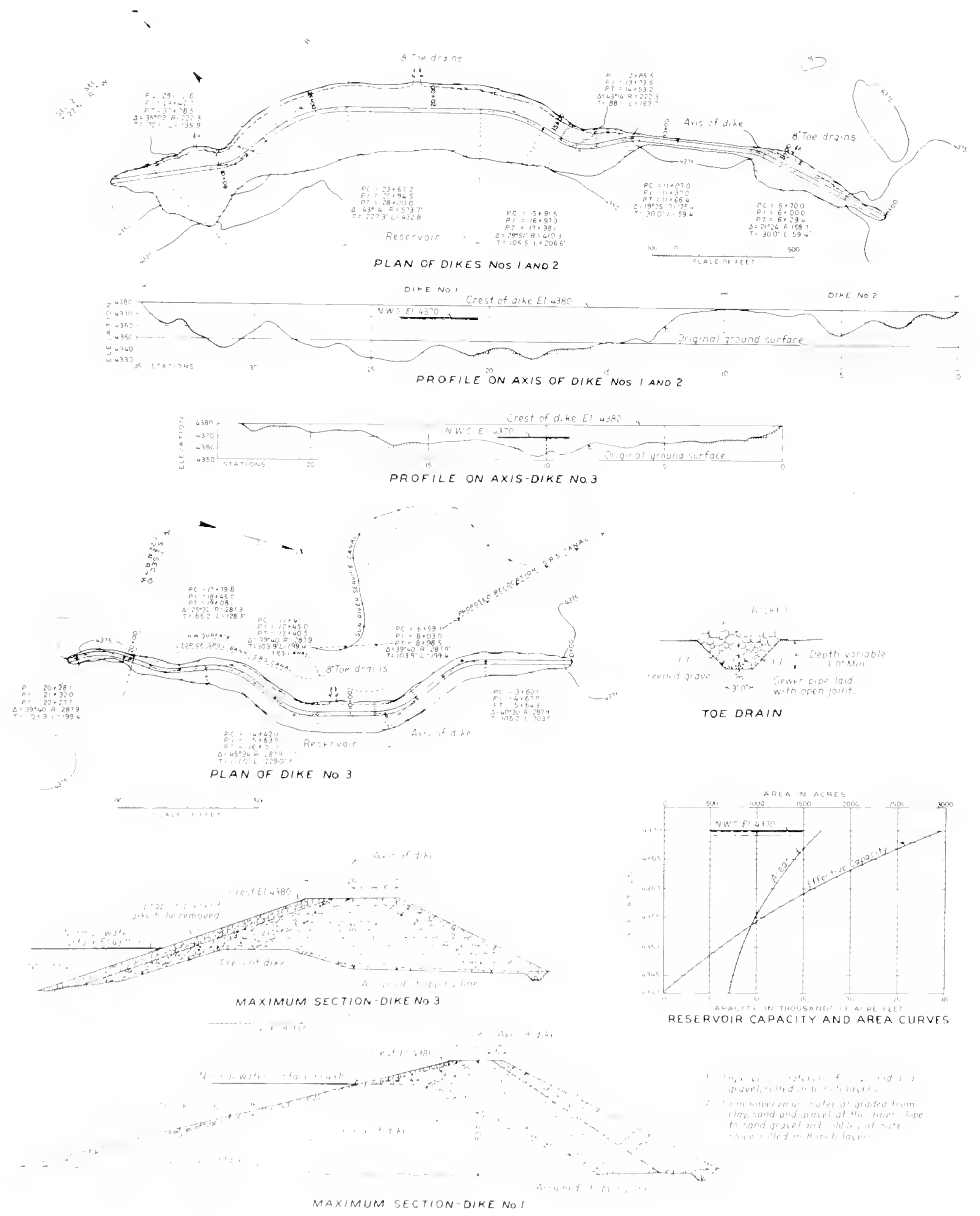
Length	12	mi
Diversion capacity	225	ft³/s
Typical maximum section in earth:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4	ft



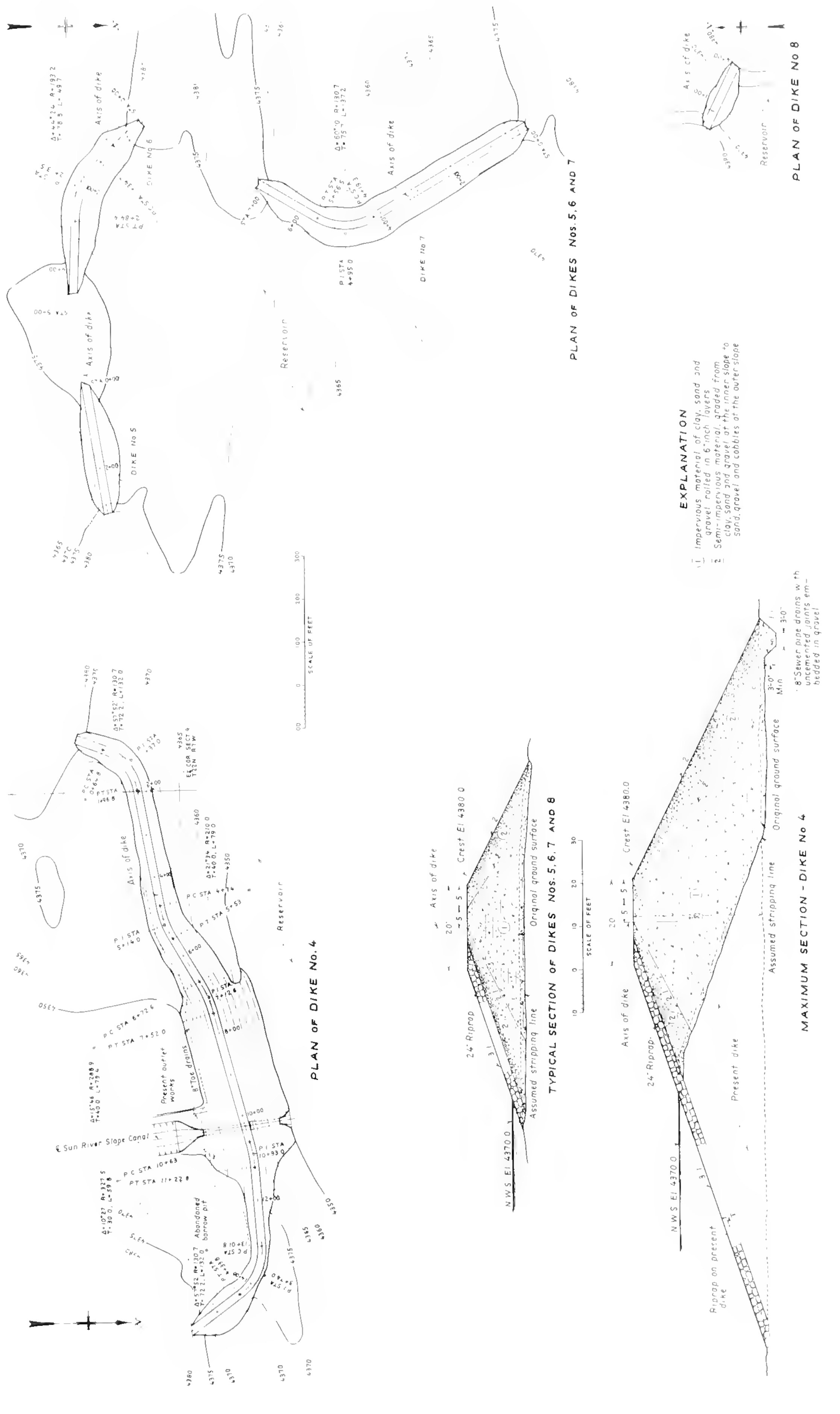
Gibson Dam, Plan and Sections



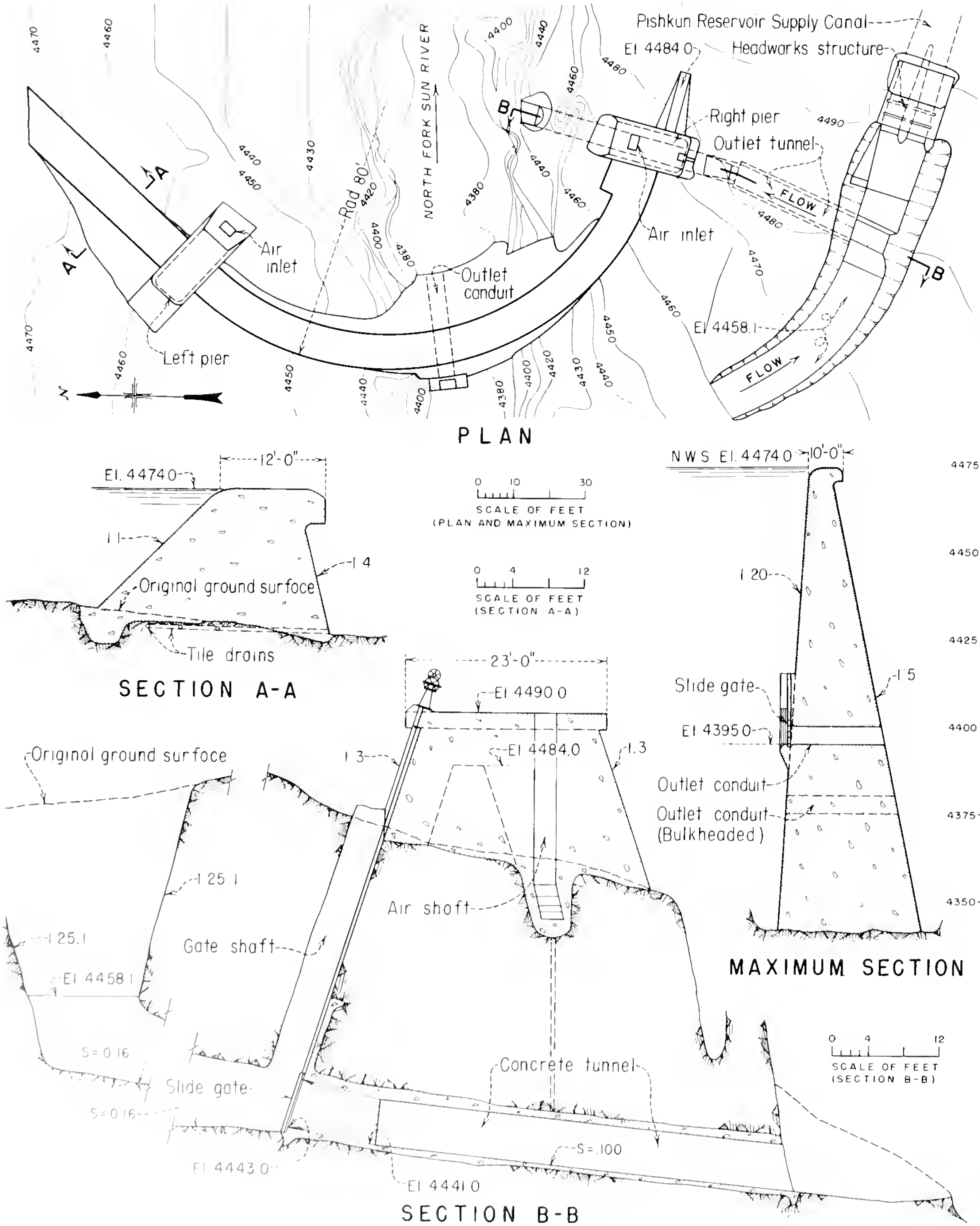
Willow Creek Dam, Plan and Sections



Pishkun Dikes Nos. 1, 2, and 3, Plan and Sections



Pishkun Dikes Nos. 4 through 8, Plan and Sections

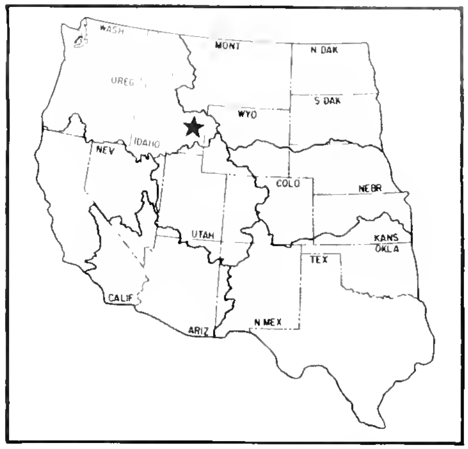


Sun River Diversion Dam, Plan and Sections

Teton Basin Project
Lower Teton Division

Idaho: Fremont, Madison, and Teton Counties

Pacific Northwest Region
Water and Power Resources Service



The Lower Teton Division of the Teton Basin Project was authorized for the purpose of storing water of the Teton River in eastern Idaho. Storage space would provide for supplemental and primary irrigation water, power production, flood control, and enhancement of fish and wildlife and recreation. Major features of the first phase of the Lower Division included Teton Dam and Reservoir, Teton Power and Pumping Plant, a switchyard, Fremont discharge and pump canal, Enterprise-East Teton feeder pipeline and canal, and 27 water-replacement wells.

Teton Dam, after being basically completed in November 1975, failed on June 5, 1976, and was completely inoperative after that date.

PLAN

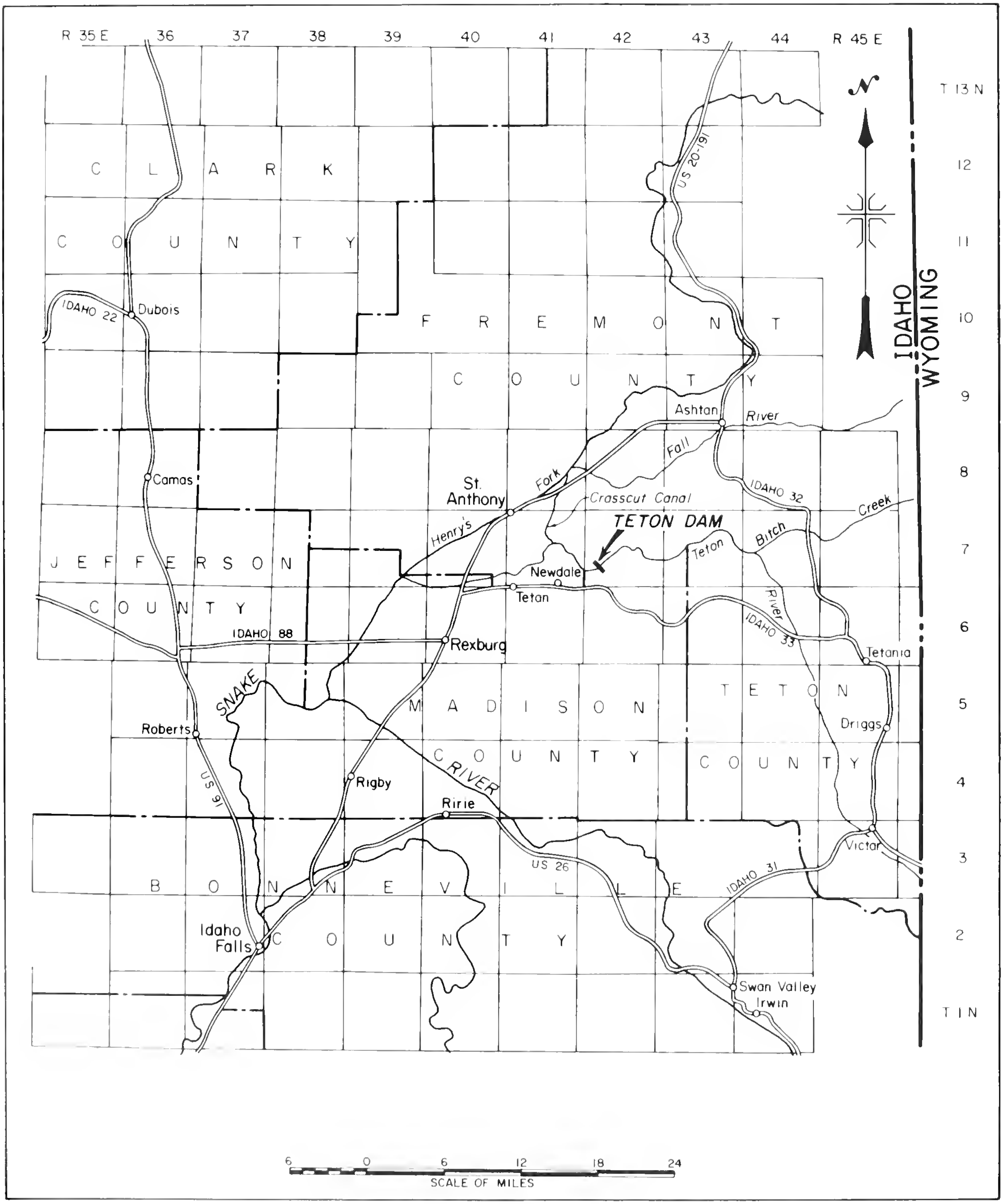
Teton Reservoir, formed by construction of Teton Dam, was to provide a supplemental water supply to 111,210 acres of land in the Fremont-Madison Irrigation District, local and downstream flood control benefits, water to operate a 16,000-kilowatt powerplant, and major recreation developments. Ground-water pumping in dry years would supplement the water supply when surface flows were fully appropriated. The reservoir also would have provided a full water supply to approximately 37,000 acres of land under the second phase of the project. The second phase would have required separate authorizing legislation.

Teton Dam and Reservoir

Teton Dam was located on the Teton River, a tributary of Henrys Fork of the Snake River in Fremont County of eastern Idaho. The dam, located 3 miles northeast of Newdale, Idaho, was a 305-foot-high zoned earthfill structure with a crest length of 3,100 feet including spillway, and a crest elevation of 5332.0 feet. Total impoundment capacity was 288,250 acre-feet, with an active capacity of 200,000 acre-feet. A three-gated, chute-type spillway was located on the right abutment, along with an auxiliary outlet works and access shaft. The main river outlet was located in a tunnel in the left abutment.

Teton Dam before failure

Teton Dam after failure



Teton Basin Project

Teton Power and Pumping Plant

The power and pumping plant were located in a steel-framed building at the base of the left abutment of the dam. The powerplant consisted of two 10,000-kilowatt generators with provision to install a third unit in the future. Pumping plant facilities included six pumping units, two rated at 7.35 cubic feet per second and four at 14.70 cubic feet per second. The rated head was 323 feet. Water from the pumping plant was to be delivered into the Fremont Pump Canal.

DEVELOPMENT

Early History

Shortages of irrigation water occur frequently in the Henrys Fork Valley. During a series of dry years such as occurred in the 12-year period from 1931 through 1942, shortages occurred in each of the 12 years in the Ashton area and in 10 of the 12 years in the St. Anthony-Rexburg area.

The Teton River is subject to flooding caused by ice jams in the early spring even though the discharge is quite low at that time. These ice jams occur frequently and occasionally raise the water surface elevation to flood heights.

Channel capacity in the lower reaches of the Teton River is about 2,000 cubic feet per second and general inundation occurs at 4,000 cubic feet per second. The maximum flood of record occurred on February 11 and 12, 1962, when unseasonably warm weather and rain rapidly melted snowpacks on the valley floor and foothills, and ice-jammed channels raised the peak flow to 7,000 cubic feet per second at the St. Anthony gage. Much of Sugar City and Rexburg and the lands between these towns were inundated. The previous flood of record was in 1893, with a peak discharge of 5,830 cubic feet per second. Floods in 1894 and 1918 are believed to have been larger than the 1893 flood, but no estimates were made of peak discharges.

Investigations

Twenty reservoir sites were investigated and surveyed by the Reclamation Service in the Henrys Fork area during 1902-05. Henrys Lake, Island Park, Grassy Lake, and sites on the Teton River were among those considered.

Field investigations were undertaken in the 1930's and 1940's on several damsites in the Upper Teton Basin. These sites were not considered feasible either because of unfavorable geological conditions or excessive cost per acre-foot of storage. Also, minimal flood control protection would result from smaller upstream reservoirs. A reconnaissance report dated October 1961 recommended that detailed studies begin immediately on the Lower Division, including Teton Dam and Reservoir, and that future studies on the Upper Division should be initiated when local interest and economic conditions indicated that a project was justifiable. In March 1962, a report on the Lower Teton Division was issued showing feasibility of the project which was later authorized for construction.

Authorization

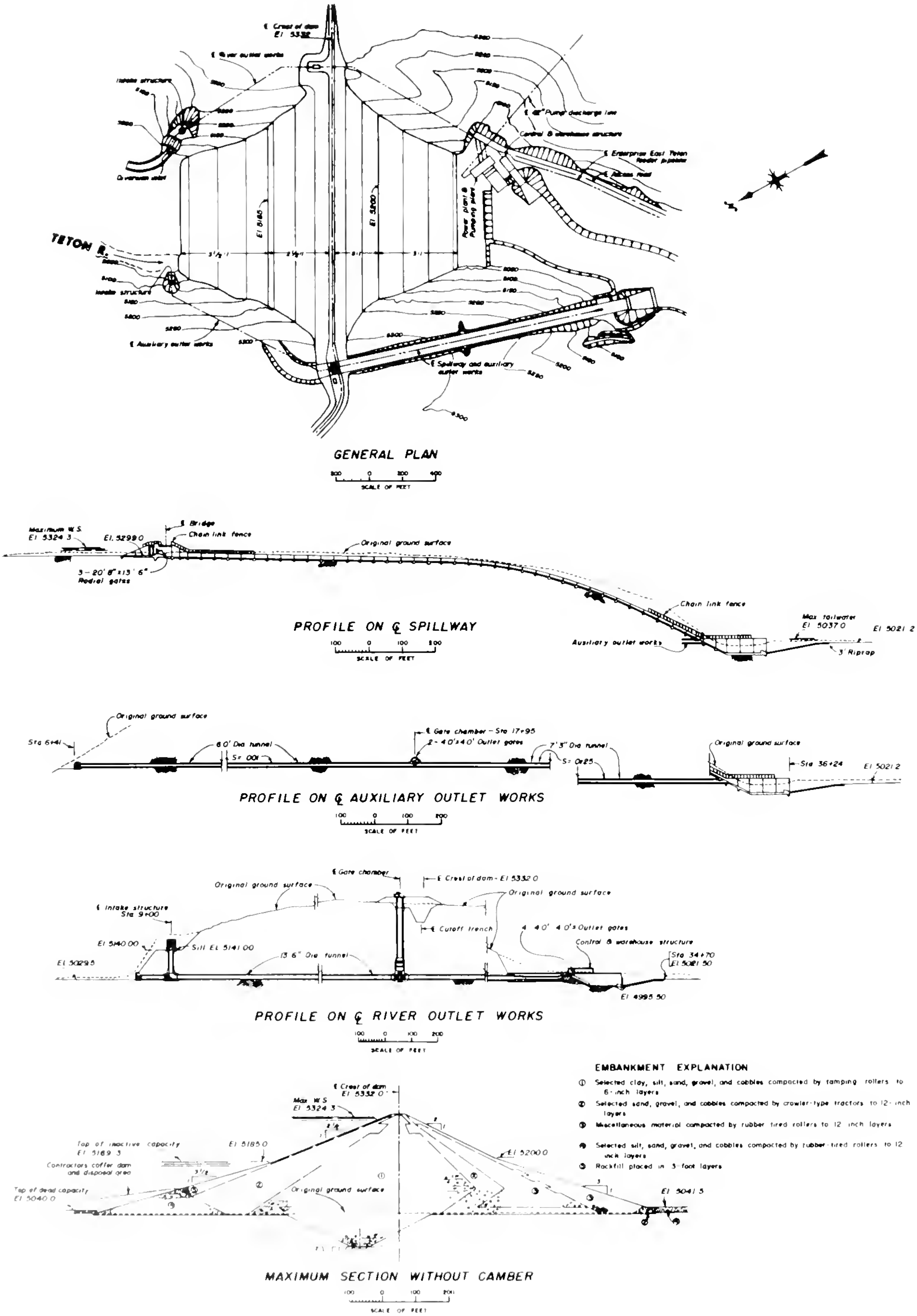
Construction of the Lower Teton Division of the Teton Basin Project was authorized by Public Law 88-583 dated September 7, 1964 (78 Stat. 925).

Construction

Construction of Teton Dam began in February 1972 and was basically completed in November 1975. At the time of dam failure on June 5, 1976, the two scheduled electrical generating units had been installed and were almost ready for testing. The pump units also were installed but were not ready for operation. First phase construction of the Fremont discharge and pump canal and the Enterprise-East Teton feeder pipeline and canal was partially completed.

Failure of Teton Dam

On June 5, 1976, the Teton Dam structure failed and was rendered completely inoperative. Reservoir elevation at the time of failure was 5301.7 feet; the reservoir was filling at about 3 feet per day. At full reservoir capacity of 288,250 acre-feet, the water surface elevation would have been 5320.0 feet.

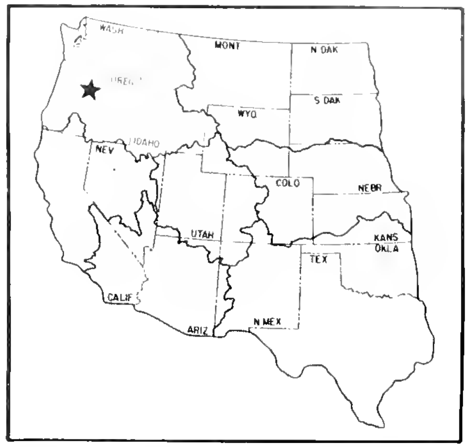


Teton Dam, Plan and Sections

The Dalles Project
Western Division

Oregon: Wasco County

Pacific Northwest Region
Water and Power Resources Service



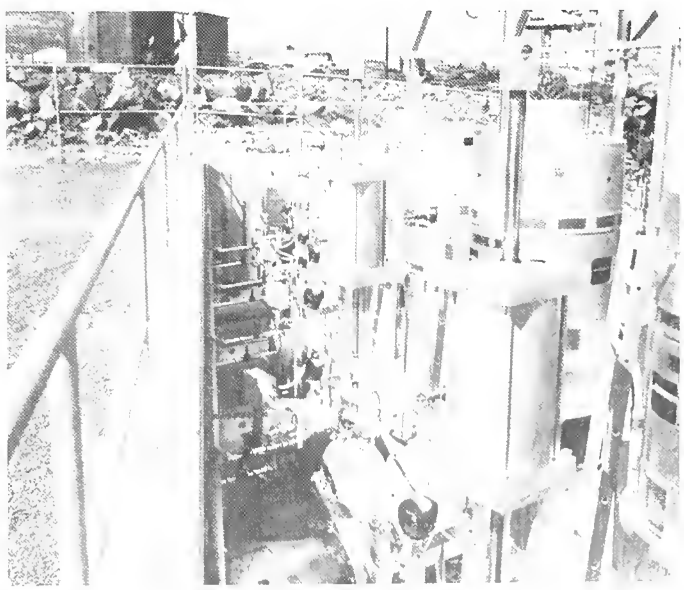
The Dalles Project Western Division is located about 80 miles east of Portland, adjacent to the city of The Dalles, Oreg., on the south side of the Columbia River. Principal features are the Mill Creek Pumping Plant, a booster pumping plant, seven relift pumping plants, three concrete-lined reservoirs, one elevated steel storage tank, five steel regulating tanks, and 46 miles of buried pressure pipe. The division provides water for 5,655 irrigable acres of land.

PLAN

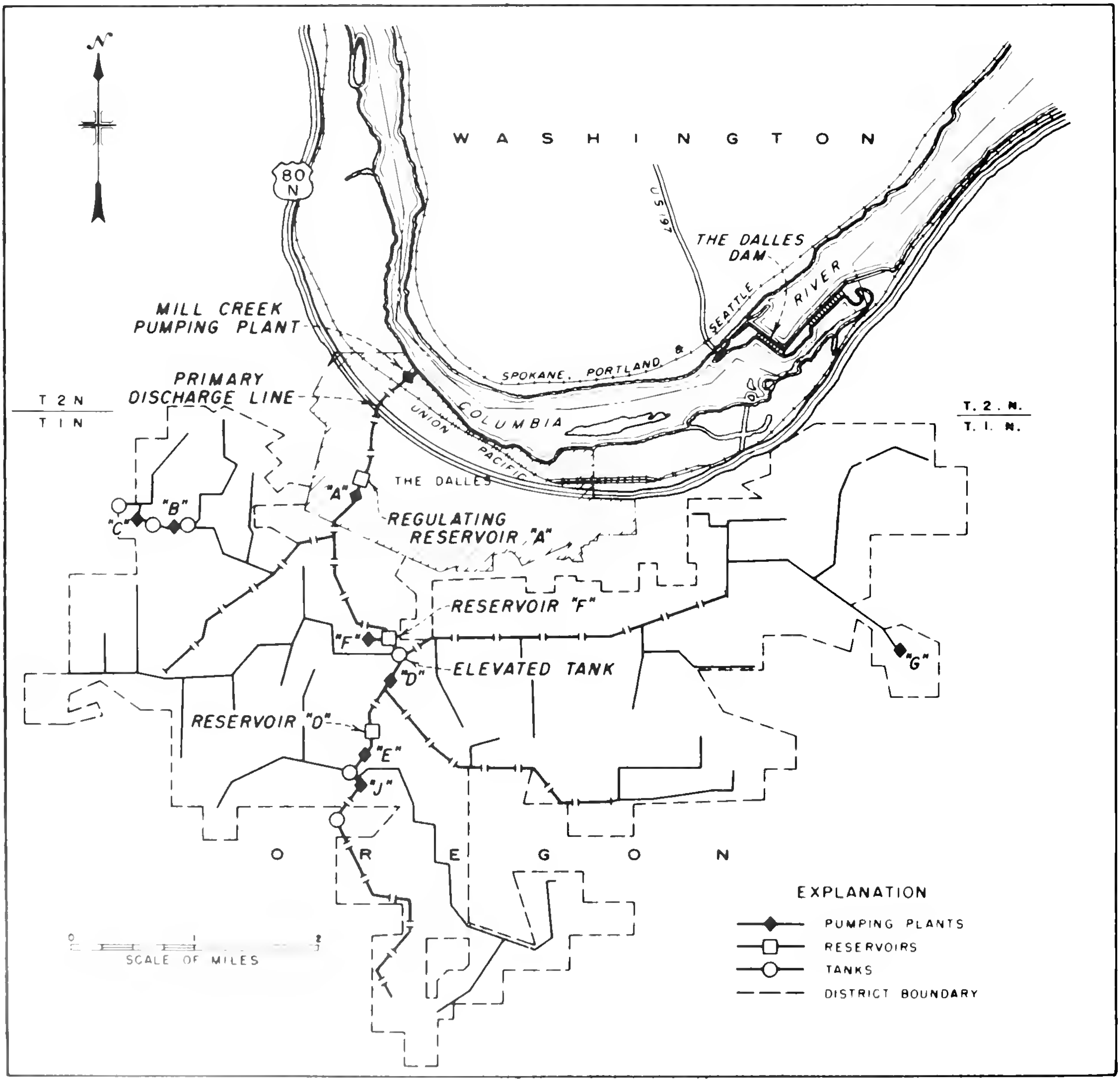
No storage for the project's water supply is required as the supply is pumped from the Columbia River about 4 miles downstream from The Dalles Dam, a Corps of Engineers dam. Lands of the Western Division are served by Mill Creek Pumping Plant, an outdoor-type installation with five pumps that have a total maximum capacity of 54.2 cubic feet per second. The 36-inch pretensioned concrete primary discharge line, which serves no turnouts directly, leads to Booster Pumping Plant "A", where five pumps lift 51 cubic feet of water per second against a dynamic head of 419 feet. Seven additional relift pumping plants with a total of 24 pumps raise water to serve project lands that reach an elevation of 1700.0 feet. The three reinforced concrete-lined surface reservoirs, one elevated steel tank, and five smaller steel regulating tanks provide minimal storage and pressure regulation for the distribution system. Three types of pipe, ranging in size from 36 to 4 inches in diameter, were used in constructing the 46-mile lateral distribution system. Pretensioned concrete cylinder pipe was used in sizes 36 through 14 inches in diameter. Mortar-lined and coated-steel pipe was predominately used in sizes 12 through 4 inches in diameter. Asbestos-cement pipe was used for the Lateral E-6 extension and Lateral F-8A in sizes ranging from 10 to 4 inches in diameter.

The only nonirrigation facilities on the project are the fish screens installed on the pump intakes at the Mill Creek Pumping Plant on the Columbia River. Ten fish screens are provided, two sets for each of the five pump bays. Each screen is 6.25 feet high by 8 feet wide, faced with 16-gage galvanized steel square mesh wire cloth.

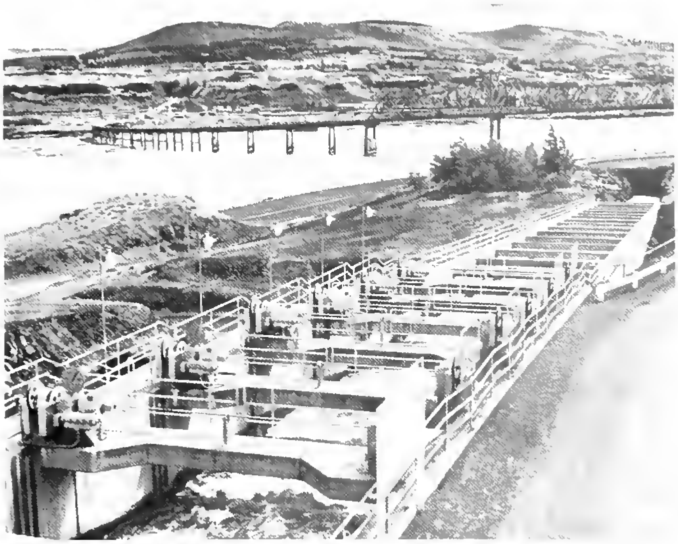
Cherry orchards on The Dalles Project



Mill Creek Pumping Plant



The Dalles Project



Fishladder at The Dalles Dam

DEVELOPMENT

Early History

The Dalles was settled because river transport in the early years of the 19th century had to be portaged around the Columbia River rapids. A water route southward toward California by way of the Deschutes River Gorge encouraged further growth. The settlement grew into a town because it had become an important transportation hub. Canning and processing fish, fruit, and vegetables constituted the first industry, later augmented by sawmills and an aluminum reduction plant. Some orchards have been irrigated in the project area for many years, using pumped ground water. A somewhat greater acreage is devoted to dryland orchards. The principal crop is sweet cherries.

Investigations

A rapidly falling water table, and the difficulty of successfully operating unirrigated orchards in a region of extremely limited rainfall have been responsible for several investigations and reports on the feasibility of irrigation in the Western Division area. The earliest of these reports outlined a project plan substantially the same as the one finally adopted. A feasibility report, prepared in December 1947, was issued as House Document No. 169, 81st Congress, 1st session, in May 1949, and incorporated in House Document No. 473, 81st Congress, 2d session, in March 1950. Lack of local interest in developing the project caused it to be held in abeyance until an alarming decline in the water table, that necessitated deepening most of the irrigation wells, led to resumption of investigations by the Bureau of Reclamation in 1958. A feasibility report dated November 1959 resulted from this investigation.

Authorization

Construction of the project was authorized by Public Law 86-745, dated September 13, 1960 (74 Stat. 882).

Construction

Construction began late in 1962 and was completed in 1966.

Operating Agency

Operation and maintenance of project facilities was assumed by The Dalles Irrigation District on March 24, 1966.

BENEFITS

Irrigation

All direct and indirect benefits from the project are attributable to irrigation. The project area is well adapted to high quality fruit production, principally cherries. About 75 percent of the area is devoted to orchards; grain, hay, and pasture are the principal crops of the remaining area. Screening the Mill Creek Pumping Plant intakes will alleviate harm to fish in the Columbia River.

Placing pipe for distribution system

Typical project pumping plant

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	5655	acres
Number of irrigated farms	146	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	5,124	2,139,425
1969	5,151	4,223,064
1970	5,336	4,342,366
1971	5,381	2,906,919
1972	5,371	4,138,121
1973	5,404	5,144,727
1974	5,505	4,913,814
1975	5,495	5,242,488
1976	5,424	5,624,938
1977	5,493	5,719,757

Facilities in Operation

Pumping plants	9	
Surface reservoirs, concrete lined	3	
Reservoirs, steel tanks (one elevated, five at ground level)	6	
Pressure pipeline	46	mi

Climatic Conditions

Annual precipitation	14.2	in
Temperature:		
Maximum	109	°F
Minimum	−9	°F
Mean	54	°F
Growing season	243	days
Elevation of irrigable area	200-1200.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	418
Other water service[1]	138
Total	556

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

COLUMBIA RIVER

Drainage area at The Dalles	237,000	mi²
Annual discharge:[2]		
Maximum (1972)	177,200,000	acre-ft
Minimum (1977)	87,500,000	acre-ft
Average	137,500,000	acre-ft
Average annual diversions (1966-77)	8,480	acre-ft

[2]Values have not been adjusted for upstream storage or diversions.

Storage Facilities

Reinforced concrete-lined regulating reservoirs:		
Reservoir A capacity	42,702	ft³
Reservoir D capacity	28,223	ft³
Reservoir F capacity	48,844	ft³
Steel tank regulating reservoirs:		
Elevated Tank F: Welded 36-ft-diameter steel spheroidal tank, 31 ft high, supported, 99-ft overall height.		
Capacity	30,147	ft³
Tanks A, B, C, E, and J: Welded steel cylindrical surface tanks, varying sizes.		
Total capacity (five tanks)	41,377	ft³

Carriage Facilities

PRIMARY DISCHARGE LINE

Pretensioned concrete pipe extending from Mill Creek Pumping Plant to Reservoir A at Pumping Plant "A" site.

Diameter	36	in
Length	6,283	ft
Capacity	54.2	ft³/s

DISTRIBUTION SYSTEM

Buried pipe system with pipes ranging in diameter from 36 to 4 inches, having a total length of 236,600 ft. Pretensioned concrete cylinder, mortar lined and coated steel, and asbestos-cement pipe used. Pressures ranging from 65 to 325 lb/in² are sufficient to operate sprinkler irrigation systems on individual tracts.

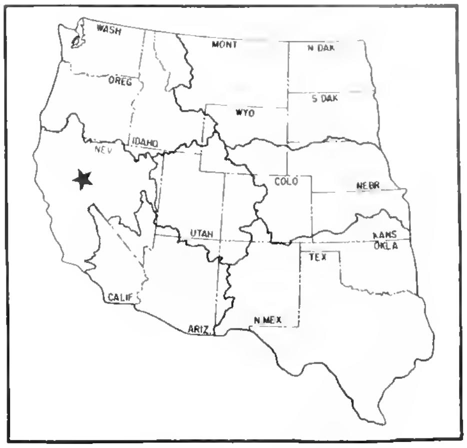
PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Mill Creek	5	54.20	228	1,800
"A"	5	51.00	419	2,500
"B"	3	5.00	256	275
"C"	2	1.64	203	80
"D"	5	17.00	207	620
"E"	4	9.80	158	250
"F"	5	42.85	307	2,150
"G"	2	1.66	150	60
"J"	3	3.60	110	70

Truckee Storage Project

California: Nevada County
Nevada: Washoe County

Mid-Pacific Region
Water and Power Resources Service



The Truckee Storage Project was constructed to provide a supplemental supply of irrigation water to approximately 29,000 acres of land in the Truckee Meadows surrounding Reno and Sparks, Nev.

PLAN

Supplemental irrigation water for the Truckee Storage Project is stored in Boca Reservoir on the Little Truckee River, while release of water from Lake Tahoe (operated by the Truckee-Carson Irrigation District) and Donner Lake is made to provide better regulation of the Truckee River according to the Truckee River Agreement. Diversion and delivery of irrigation water are made by the 33 ditch companies which form the Washoe County Water Conservation District, while control and administration is maintained through 7 subdistricts.

Boca Dam and Reservoir

Boca Dam and Reservoir on the Little Truckee River store water for Truckee River regulation and irrigation of lands on the Truckee Storage and Newlands Projects. The reservoir has an active capacity of 41,000 acre-feet. The dam, completed in 1939, is a zoned earthfill structure 116 feet high, with a crest length of 1,629 feet.

DEVELOPMENT

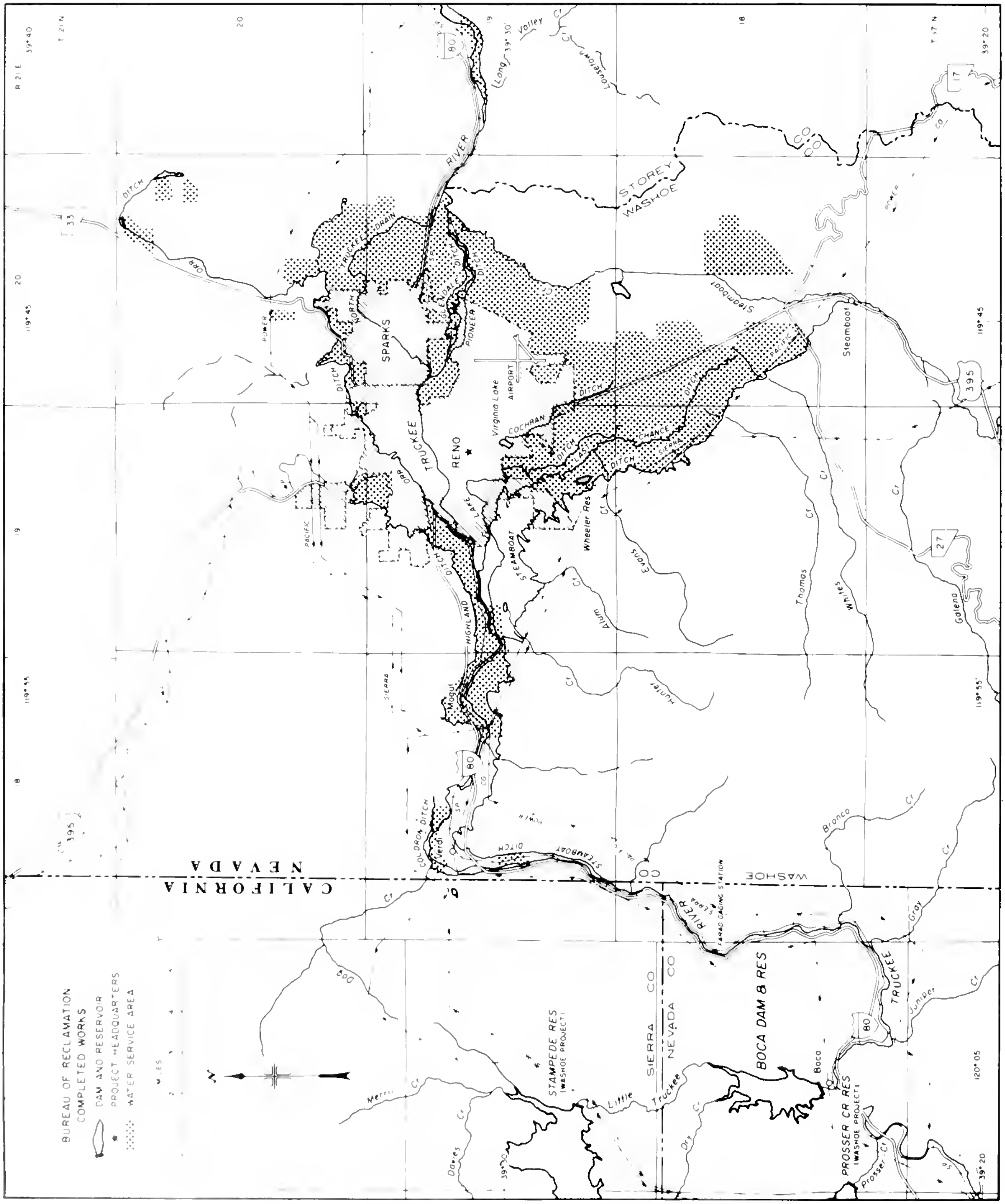
Early History

Irrigation of lands in the Reno Valley began as early as 1858 with diversions from small streams. Settlement and irrigation of the valley progressed on an individual or community effort basis until there were 31 separate diversions in 20 miles along the Truckee River, beginning about 13 miles above Reno. The demand for irrigation water after 1900 in western Nevada resulted in water appropriations in excess of summer flows of the river. Further development of the irrigable area of about 29,000 acres depended upon a supplemental storage supply. This necessity resulted in the construction of a small storage dam prior to 1920 by private parties at a location near the present dam.

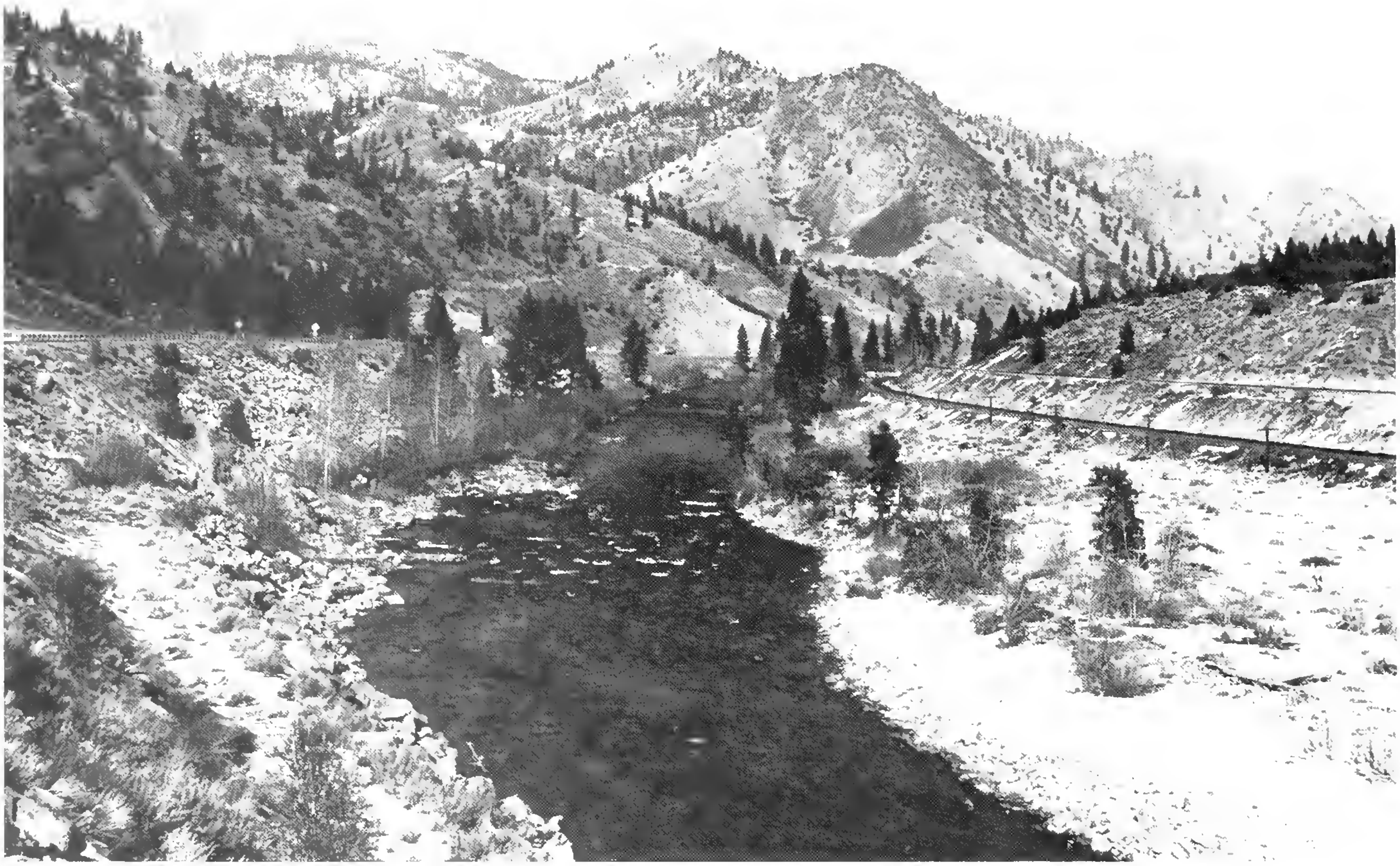
Investigations

The Federal Government made the first investigations for irrigation of the Reno Valley in connection with the project, then known as the Truckee-Carson Project. In 1927, the Bureau of Reclamation began investigations to determine the quantity of water available for storage development, and to locate a storage site. Further work followed that led to organizing the Washoe County Water Conservation District in June 1929, and consummation of the Truckee River Agreement on July 1, 1935. This agreement, through which water users from the Truckee River system sought to conserve the waters of Lake Tahoe and the Truckee River and its tributaries, established regulations for the maintenance of minimum rates of flow in the river during winter months, provided for development of pondage for reregulating fluctuations in streamflow occasioned by the operation of privately owned hydroelectric powerplants, and provided for development of a minimum of 40,000 acre-feet of supplemental storage on the Little Truckee River by the Washoe County Water Conservation District.

Boca Dam and Reservoir



Truckee Storage Project



Truckee River

Authorization

The President approved the project for construction on September 21, 1935, under section 4 of the act of June 25, 1910 (36 Stat. 835), and under subsection B of section 4 of the act of December 5, 1924 (43 Stat. 701). Funds for construction were made available under the provisions of the National Industrial Recovery Act.

Construction

Construction of Boca Dam began April 24, 1937, and was completed before the irrigation season of 1939.

Operating Agency

The project is operated by the Washoe County Water Conservation District.

BENEFITS

Irrigation

Alfalfa, meadow hay, and pasture are the most important crops grown on irrigated lands of the project in support of a thriving livestock and dairy industry. Next in importance are feed grains, followed by potatoes, onions, and truck crops.

Recreation and Fish and Wildlife

Boca Reservoir on the Little Truckee River provides public recreation facilities for camping, picnicking, boating, fishing, and hunting, along with other recreational activities. The area is under administration of the Forest Service.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	28,980	acres
Number of irrigated farms	200	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	19,328	1,178,547
1969	19,288	1,250,547
1970	19,246	1,353,589
1971	19,156	1,325,699
1972	19,156	1,329,559
1973	19,525	2,357,370
1974	18,970	2,431,460
1975	18,865	2,600,970
1976	18,865	4,076,465
1977	15,665	2,245,095

Facilities in Operation

Storage dams	1

Climatic Conditions

Annual precipitation	32.8	in
Temperature:		
Maximum	97	°F
Minimum	−45	°F
Mean	42	°F
Growing season	103	days
Elevation of irrigable area	4404.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,395
Urban/suburban irrigation service	120,000
Total	121,395

ENGINEERING DATA

Water Supply

LITTLE TRUCKEE RIVER

Drainage area at Boca Dam	172	mi^2
Average annual discharge at Boca Dam: 1939-76	139,000	acre-ft

Storage Facilities

BOCA DAM

Type: Zoned earthfill
Location: On the Little Truckee River, 27 mi southwest of Reno, Nev.
Construction period: 1937-39
Reservoir, Boca:

Average annual inflow, 1940-68	137,400	acre-ft
Total capacity to El. 5605	41,000	acre-ft
Active capacity, El. 5605	41,000	acre-ft
Surface area	1,000	acres
Dimensions:		
Structural height	116	ft
Hydraulic height	93	ft
Top width	35	ft
Maximum base width	778	ft
Crest length	1,629	ft
Crest elevation[1]	5615.0	ft
Total volume	912,000	yd^3

Spillway: Concrete-lined open channel at left abutment controlled by two 19- by 16-ft radial gates.

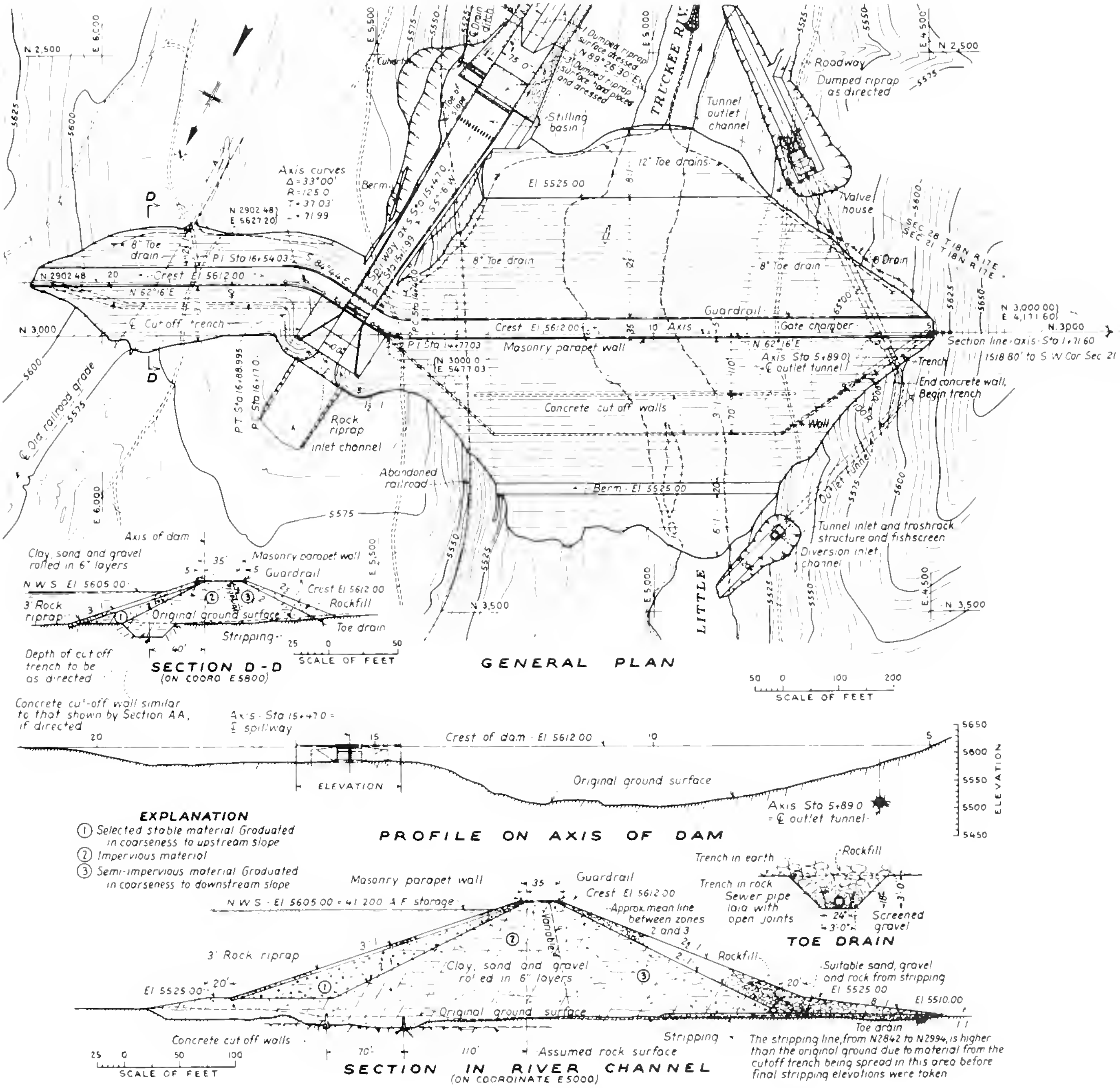
Elevation, top of gates	5605.0	ft
Crest elevation	5589.0	ft
Capacity, El. 5605	8,000	ft^3/s

Outlet works: Concrete-lined tunnel to gate chamber in right abutment, then two plate-steel outlet pipes controlled by two 42-in needle valves.

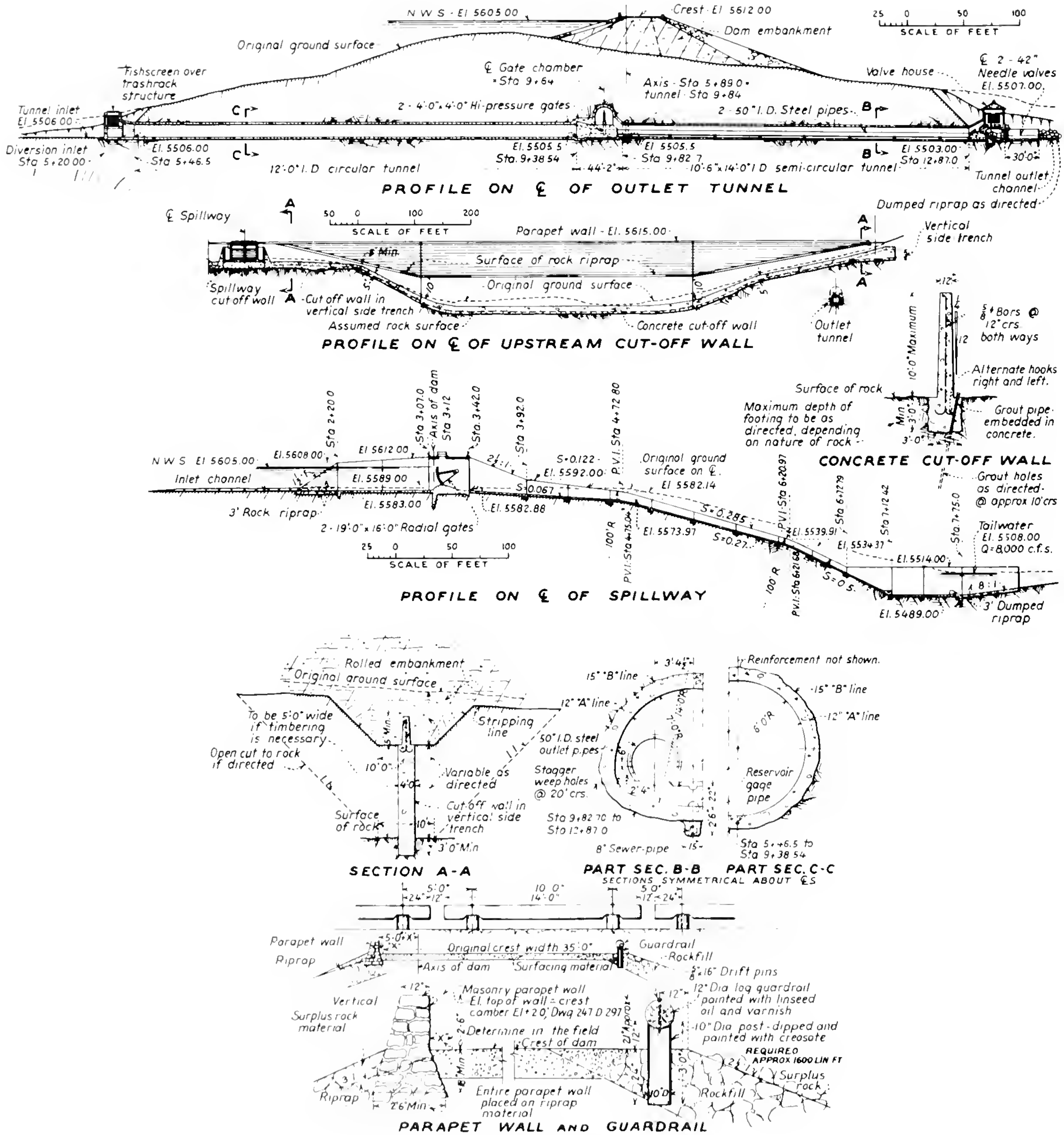
Capacity at El. 5605	900	ft^3/s

Foundation: Unconsolidated alluvial fill overlaying consolidated volcanic debris, mainly tuff and andesitic lava flows.
Special treatment: Cement grout curtain beneath cutoff walls.

[1]Elevation at top of 3-ft concrete parapet wall; actual crest elevation is 5612.0 ft.



Boca Dam, Plan and Sections

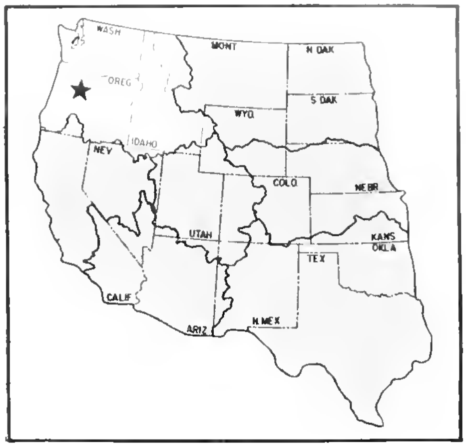


Boca Dam, Sections

Tualatin Project

Oregon: Washington, Yamhill, and Clackamas Counties

Pacific Northwest Region
Water and Power Resources Service



The Tualatin Project area lies primarily in Washington County in the northwest part of the Willamette Basin, west of and adjacent to the city of Portland, Oreg. Some 17,000 acres of land are furnished irrigation water. Several communities and an industrial corporation are furnished untreated water for municipal and industrial use, and for quality control purposes. Fish and wildlife enhancement, recreation, and flood control are also important project functions.

Principal features include Scoggins Dam, Henry Hagg Lake, Patton Valley Pumping Plant, Spring Hill Pumping Plant, 20 booster pumping plants, and 88 miles of piped lateral distribution system.

Patton Valley Pumping Plant

PLAN

Construction of Scoggins Dam and the formation of Henry Hagg Lake provided storage for water to supplement the natural streamflow of the Tualatin River and help meet the increasing water requirements of the area.

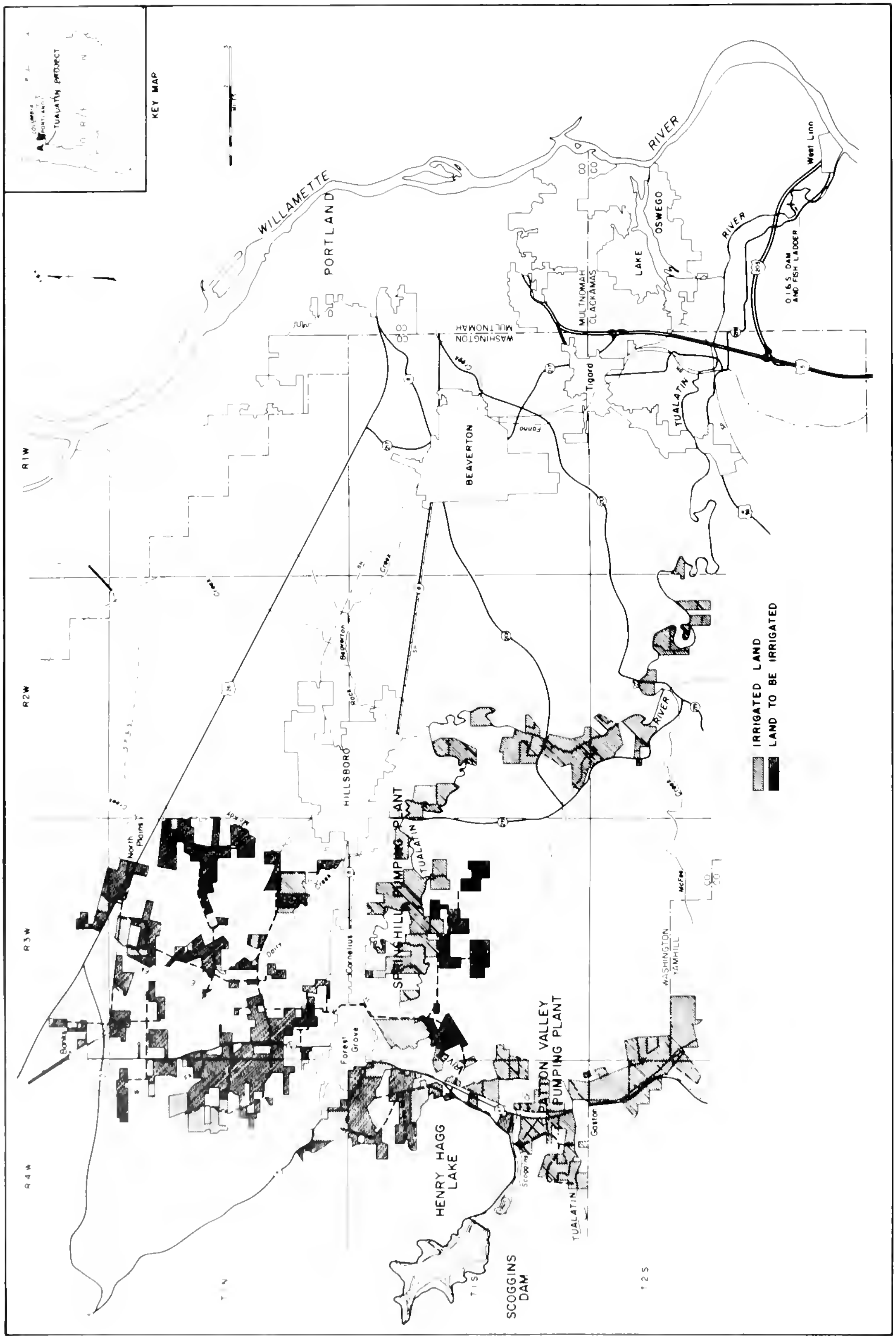
The 17,000 acres of irrigable land are located in an area about 15 miles wide and 17 miles long, west of the metropolitan area of Portland. The communities that receive water service are also in the area immediately west of Portland. Water stored in Henry Hagg Lake is released for normal riverflow and for all project functions by the outlet tunnel and spillway outlet channel into Scoggins Creek downstream from the dam.

Scoggins Dam and Henry Hagg Lake

Scoggins Dam is a 151-foot-high zoned earthfill structure that is 2,700 feet long at the crest and contains 4 million cubic yards of material. The upstream side of the dam is faced with rock riprap for protection against wave action; the downstream side is faced with topsoil and planted with grass. Total capacity of Henry Hagg Lake is 59,910 acre-feet.

Patton Valley Pumping Plant and Distribution System

Irrigation water released at the dam is pumped into the distribution system by two downstream pumping plants. Patton Valley Pumping Plant was constructed on the right bank of Scoggins Creek about 2.5 miles downstream from the dam. This is an outdoor plant with five vertical shaft turbine pumps having a combined capacity of 34.7 cubic feet per second. A traveling water screen is provided to prevent passage of fish into the pump sump. Water from the five pumping units is delivered a short distance to a 19,118-cubic-foot-capacity regulating tank by a 30-inch-outside-diameter steel discharge line. Some 3.5 miles of buried, gravity-fed pipeline serve about 1,900 acres of land. The main pipeline consists of over 6,000 feet of 30-inch-diameter reinforced plastic mortar pipe.



Tualatin Project

The remainder of the Patton Valley distribution system is asbestos-cement pipe ranging in size from 21 to 10 inches in diameter.

Spring Hill Pumping Plant and Distribution System

The Spring Hill Pumping Plant, a cooperative venture between the Bureau of Reclamation and the city of Hillsboro, is located on the right bank of the Tualatin River about 9 miles downstream from the dam and 3 miles south of Forest Grove, Oreg. Nine irrigation pumps with a combined capacity of 148.2 cubic feet per second deliver water through a 2,472-foot-long, 60-inch-diameter prestressed concrete cylinder pipe discharge line to a 84,900-cubic-foot capacity buried concrete regulating tank. The 84.5-mile-long buried pressure pipeline distribution system ranges in size from 54 to 6 inches in diameter and serves 10,300 acres at the rate of 0.014 cubic feet per second for each acre at a total dynamic head of 127 feet. Some 66.8 miles are asbestos-cement pipe, and the remaining 17.7 miles are reinforced concrete pipe. In addition to the acreage served by the Spring Hill and Patton Valley Pumping Plants, 4,800 acres are served by direct pumping of released storage water from Scoggins Creek and the Tualatin River.

The city of Hillsboro presently has three pumping units installed in the Spring Hill Pumping Plant, with a combined capacity of 32.24 cubic feet per second, that deliver water directly to the city's water treatment plant. There is space in the pumping plant for an additional unit to be installed as the requirement for more municipal water develops.

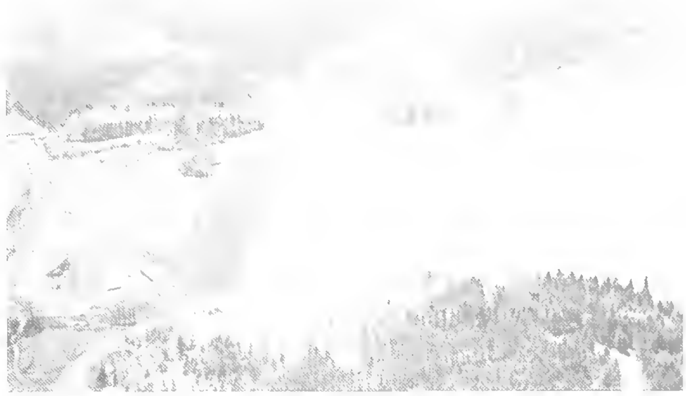
DEVELOPMENT

Early History

The project area was known as "Twality Plains" in the pioneer era and was one of the earliest farming settlements in Oregon. Agriculture developed quickly because there were numerous open areas that permitted cultivation without the expense and labor of clearing timber stands, and also because of the fertile soils in the Tualatin Valley. As the population increased, timbered tracts were cleared and more land came under cultivation. Hay, grain, and livestock production were the basis for the early agricultural economy and are still important in the economy of the area. From a small start in 1930, irrigation increased substantially; by the late 1950's, only about 6,000 acres in the Tualatin Basin were inadequately irrigated.

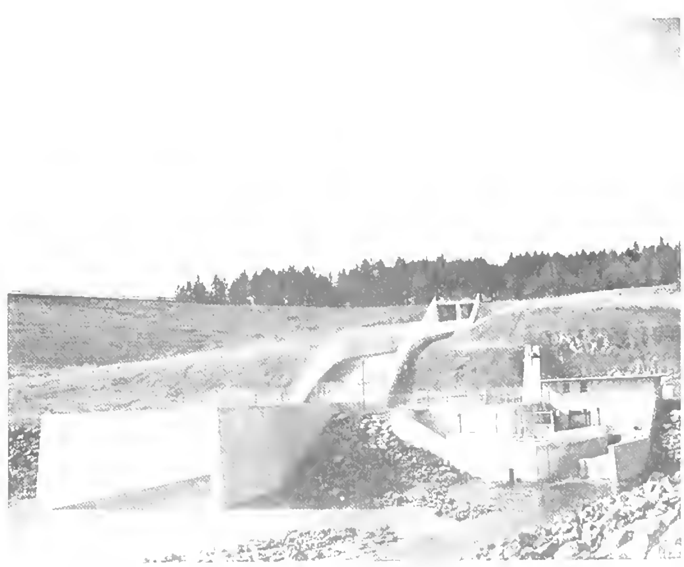
Investigations

Flood and drainage problems have been a source of concern since early settlement. During 1935-41, studies made by the Corps of Engineers centered around flood control storage and river channel improvement. Local interests were opposed to some features of the plan, such as straightening the river channel, and felt there was inadequate provision for irrigation storage in the proposed flood control reservoirs.



Scoggins Dam and Henry Hagg Lake

Studies of the Tualatin Project, as reported in the Bureau of Reclamation's interim report of July 1948, considered a plan for providing irrigation and drainage to 46,000 acres of potentially irrigable lands, flood control for low-lying lands adjacent to the streams, and a municipal water supply for the towns of the project area. In 1951, local residents held a series of meetings to formulate an opinion on the type of irrigation development best suited to the needs of the area. Both the Corps of Engineers and the Bureau of Reclamation cooperated in



Spillway, outlet works, and fishtrap facility at Scoggins Dam a study to provide basic data on present and long-range coordinated development.

Storage at the Scoggins Reservoir site was analyzed in Reclamation's report of November 1956, which gave consideration to irrigating 31,000 acres of potentially irrigable land and providing 4,500 acre-feet of supplemental municipal and industrial water for the local communities. Upon review of this report, it became apparent that there was a greater need for municipal and industrial water than originally anticipated and some of the owners of potentially irrigable lands were not sufficiently interested in the development plan to proceed further. In May 1963, a feasibility report was issued that proposed irrigation water for 17,000 acres of land, 14,000 acre-feet of municipal and industrial water, and water for fish and wildlife, recreation, quality control, and flood control benefits. On the basis of this plan, the project was authorized.

Authorization

Construction of the Tualatin Project was authorized under the provisions of Public Law 89-596, approved September 20, 1966 (80 Stat. 822).

Construction

Construction of project facilities began in 1972 and was completed in 1978.

Operating Agencies

Scoggins Dam, Henry Hagg Lake, and related recreation facilities are operated and maintained by the Bureau of Reclamation. Fish trapping facilities at the dam are operated by the Oregon Department of Fish and Wildlife.

Spring Hill Pumping Plant

The Patton Valley and Spring Hill Pumping Plants and related irrigation facilities are operated and maintained by the Tualatin Valley Irrigation District.

BENEFITS

Irrigation

Increased agricultural production from 17,000 acres has been obtained by making a dependable water supply available throughout the growing season, especially during the late summer period. Principal crops are grain, vegetables, berries, hay, and pasture. The raising of container-grown nursery stock is also significant in the project area.

Flood Control

The gated spillway at Scoggins Dam permits effective use of the top 20,300 acre-feet of reservoir space for flood control. Henry Hagg Lake can completely regulate a flood of the size which occurs about once in 50 years at the damsite. This regulation also will provide some significant flood stage reduction at downstream points on the Tualatin River.

Municipal and Industrial Water

The project provides 14,000 acre-feet of water for supplemental municipal and industrial purposes for four communities and an industrial corporation in one of the fastest growing areas of Oregon. In addition, 16,900 acre-feet of water are made available under an agreement with the Unified Sewerage Agency of Washington County to improve the water quality of the Tualatin River by scheduled releases of water in the summer when natural flows are low.

Recreation and Fish and Wildlife

The Scoggins Dam and Henry Hagg Lake area encompasses 2,581 acres and provides 1,132 acres of water surface with 11 miles of shoreline at full pool. Located in a forested setting only a short distance from Portland, the area is used both by local residents and visitors from the Willamette Valley. Boat launching and mooring facilities have been constructed and there are large day-use areas provided with picnic tables, shelters, and water and sanitary facilities.

Henry Hagg Lake is stocked annually with rainbow trout for excellent fishing. Minimum flows are provided in Scoggins Creek and a fish trap was built below Scoggins Dam to collect, for hatchery use, the anadromous fish blocked by the dam. Several dead trees were left in the reservoir to attract osprey, and portions of the reservoir area are managed to provide winter range for elk and black-tailed deer.

PROJECT DATA

Land Areas (1977)

Full irrigation service:		
In service	6,700	acres
Ultimate	17,000	acres
Number of irrigated farms	105	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1976	6,330	4,640,125
1977	6,466	6,121,862

Facilities in Operation

Storage dams	1	
Pumping plants	2	
Regulating tanks	2	
Laterals (piped)	88	mi

Climatic Conditions

Annual precipitation	44.4	in
Temperature:		
Maximum	108	°F
Minimum	−4	°F
Mean	53	°F
Growing season	229	days
Elevation of irrigable area	100-275.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	358
Other water service[1]	516
Total	874

[1]Residential, municipal, and industrial uses.

ENGINEERING DATA

Water Supply

Scoggins Creek

Drainage area above Scoggins Dam	39	mi²
Annual discharge at Scoggins Dam:		
Maximum (1974)	158,000	acre-ft
Minimum (1977)	29,000	acre-ft
Average	104,000	acre-ft
Average annual diversions by project (1976-77)	16,843	acre-ft

Storage Facilities

Scoggins Dam

Type: Zoned earthfill
Location: On Scoggins Creek about 5.5 mi southwest of Forest Grove, Oreg.
Construction period: 1972-75
Reservoir, Henry Hagg Lake:
First closure: 1974
Initial filling: April 30, 1975

Total capacity at El. 195-303.5	59,910	acre-ft
Active capacity at El. 235.3-303.5	53,600	acre-ft
Surface area	1,132	acres
Dimensions:		
Structural height	151	ft
Hydraulic height	111	ft
Top width	30	ft
Maximum base width	1,200	ft
Crest length	2,700	ft
Crest elevation	313.0	ft
Volume	4,000,000	yd³
Spillway: Concrete-lined chute-type channel at left abutment of dam controlled by two 19- by 20.5-ft radial gates.		
Capacity at El. 305.7	13,920	ft³/s
Outlet works: Reinforced 6-ft-diameter concrete tunnel with gate chamber controlled by one 4- by 5-ft high-pressure steel gate.		
Capacity at El. 305.7	220	ft³/s

Carriage Facilities

Primary Discharge Lines

Steel pipe from Patton Valley Pumping Plant to adjacent regulating tank:		
Diameter	30	in
Length	40	ft
Capacity	34.7	ft³/s
Prestressed concrete cylinder pipe from Spring Hill Pumping Plant to regulating tank:		
Diameter	60	in
Length	2,472	ft
Capacity	148.2	ft³/s

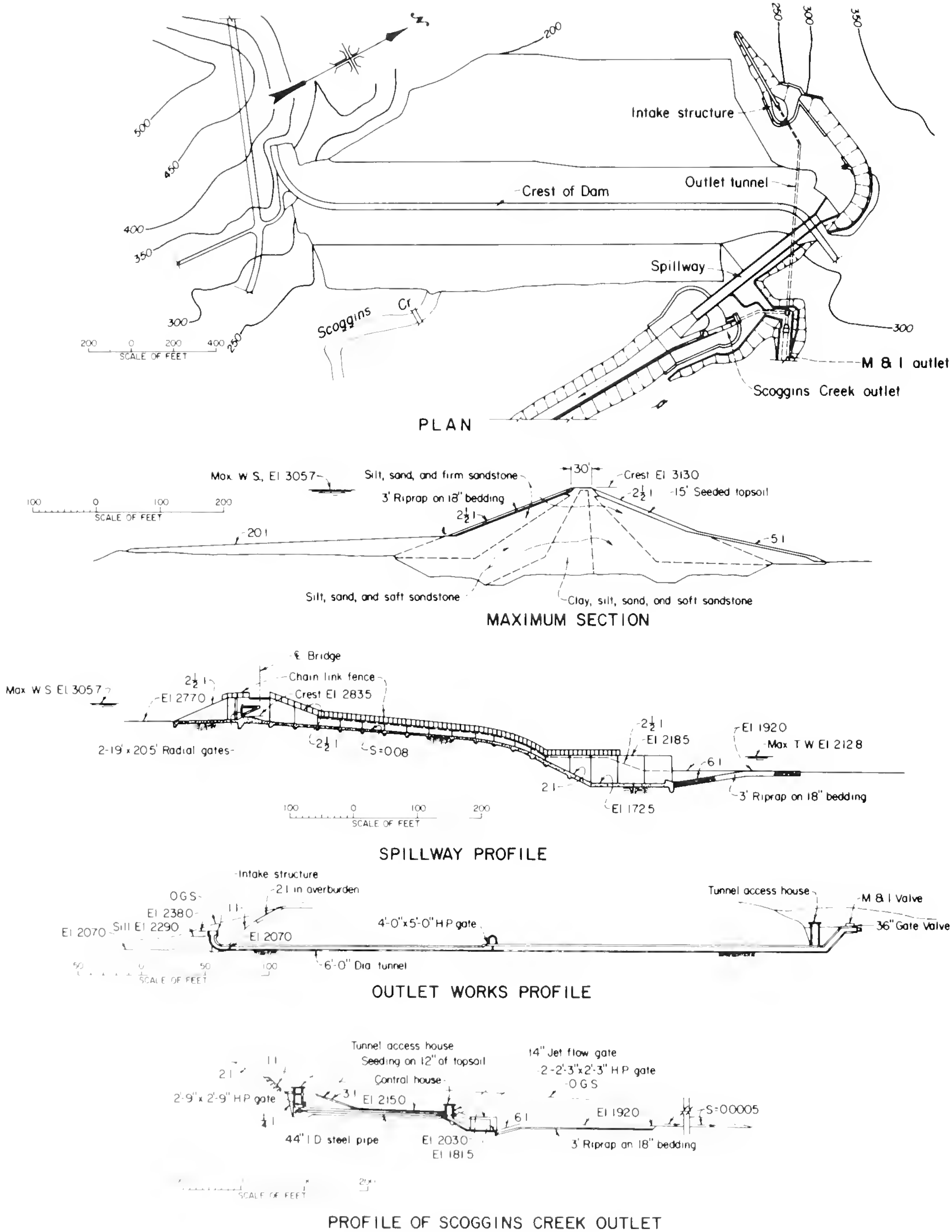
Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Patton Valley				
Units No. 1-3	3	26.04	80	375
Unit No. 4	1	5.78	80	75
Unit No. 5	1	2.88	80	40
Spring Hill				
City of Hillsboro (Municipal & Industrial)				
Unit No. 1	1	8.24	66	75
Units No. 2-3	2	24.00	85	250
USBR (Irrigation)				
Units No. 5-8	4	25.20	377	1,400
Units No. 9-13	5	123.00	377	7,700

Distribution System (Laterals)

Patton Valley: Buried gravity-fed pipe system ranging in size from 30- to 10-in diameter, 3.5 mi total length. 6,000 ft of 30-in pipe is reinforced plastic mortar. Remainder of system is asbestos-cement pipe ranging from 21- to 10-in diameter.

Spring Hill: Buried pressure-fed pipe system ranging in size from 54- to 6-in diameter, 84.5 mi total length. Asbestos-cement pipe used on 66.8 mi, and reinforced concrete pipe on 17.7 mi.

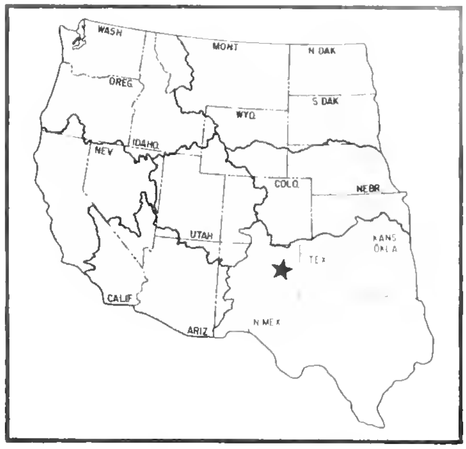


Scoggins Dam, Plan and Sections

Tucumcari Project

New Mexico: Quay and San Miguel Counties

Southwest Region
Water and Power Resources Service



The Tucumcari Project, in east-central New Mexico surrounding the city of Tucumcari, has about 41,000 acres of irrigable land. Project features include the Conchas Dam and Reservoir (constructed by the Corps of Engineers), Conchas and Hudson Canals, and a distribution and drainage system.

PLAN

Water stored in the Conchas Reservoir, 31 miles northwest of Tucumcari, is conveyed to the land in the Conchas Canal and its branch, the Hudson Canal. The canals deliver the water to the 171-mile distribution system which serves the project lands.

Conchas Dam

Conchas Dam, constructed by the Corps of Engineers on the Canadian River, is a concrete gravity section flanked by embankment wings. The dam has a structural height of 235 feet, a crest length of 6,230 feet, and a volume of 836,000 cubic yards of concrete and 887,000 cubic yards of earth. The main spillway is an overflow section 300 feet long in the main section of the dam. An emergency spillway, located on the north dike, is 3,000 feet long and is 17 feet higher than the main spillway. The irrigation outlet works is a circular pressure tunnel leading to the gate chamber, then into two steel penstocks in a horseshoe tunnel. The reservoir has a capacity of 528,951 acre-feet, of which 252,334 acre-feet are conservation storage.

Conchas Canal

The 84-mile Conchas Canal has an initial capacity of 700 cubic feet per second, 31 siphons aggregating 21,921 feet in length, and 5 tunnels with a cumulative length of 30,370 feet.

Hudson Canal

Commencing at mile 56.5 on the Conchas Canal, the Hudson Canal extends 26 miles through the project lands. The initial capacity is 384 cubic feet per second. The canal has one siphon 3,200 feet long.

DEVELOPMENT

Early History

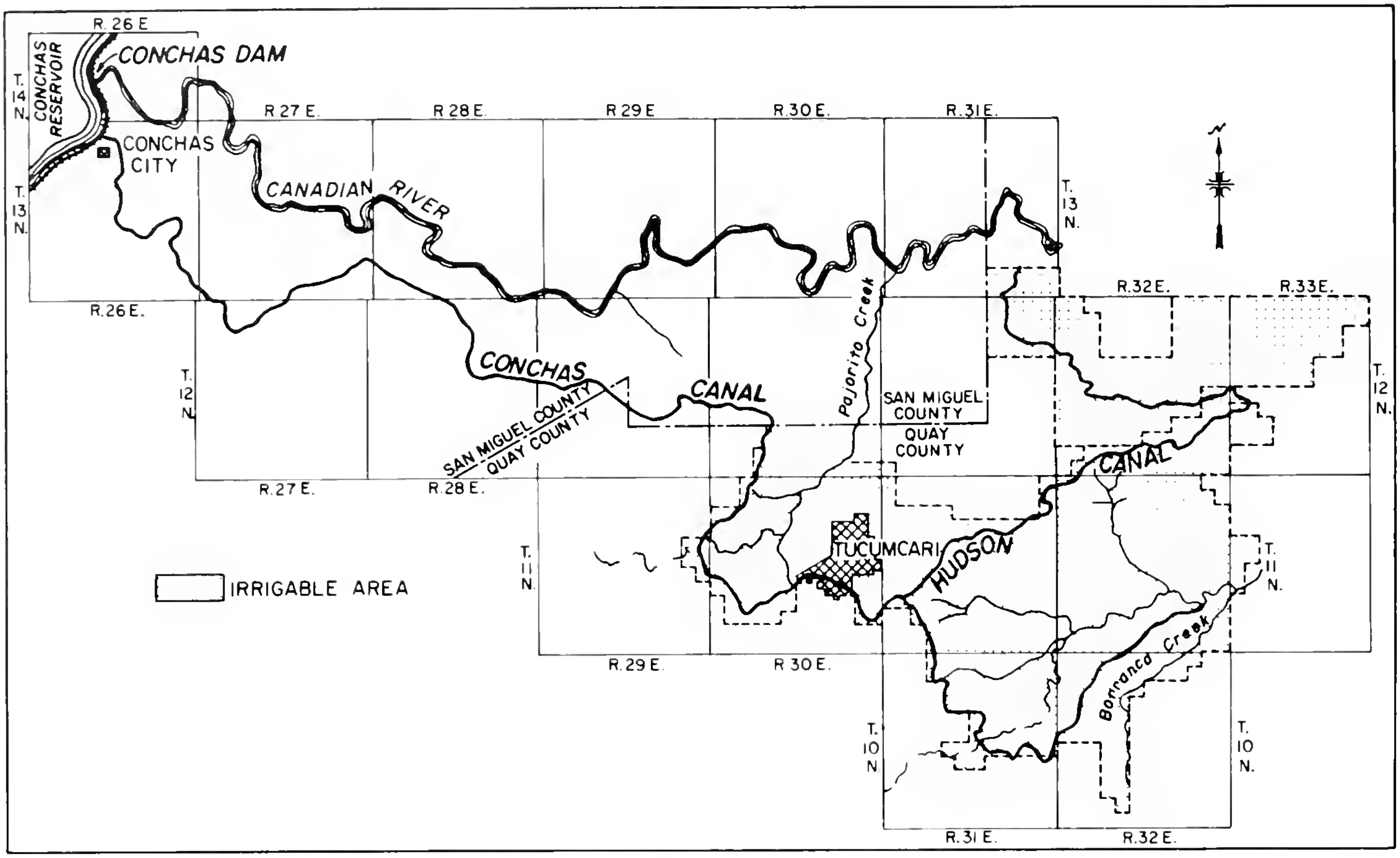
Some lands in the project area have been in cultivation for 145 years, but residents of Quay and San Miguel Counties primarily have been livestock producers. The first wagon train passed through the area in 1832. Quay County was formed in 1903, 2 years after the founding of Tucumcari. Extensive settlement occurred during the late 19th and early 20th centuries. To early settlers, the possibility of farming these semiarid lands depended on whether rainfall would be sufficient to produce crops.

Investigations

The first complete study of land and water resources was made by the Interstate Land Development Company. In 1925, the Canadian River Development Association was formed to foster a flood control and irrigation project by constructing storage facilities in the Canadian River Basin. On December 31, 1926, a compact was entered into by New Mexico, Texas, Oklahoma, and Arkansas setting forth an equitable distribution of these waters. New Mexico then completed a comprehensive survey and cost report for a project including diversion from the Canadian River combined with a storage reservoir on Pajarito Creek.

In 1934, the Secretary of the Interior created the Arkansas Basin Committee to make a complete investigation of the watersheds of the Arkansas River. Working in cooperation with the Corps of Engineers, the committee reported favorably on numerous projects throughout the basin. Among these were Conchas Dam on the Canadian River and its concomitant irrigation district.

Conchas Dam, initiated under the Emergency Relief Act of 1935, was authorized by the Congress in the Flood Control Act of June 22, 1936, and was completed in 1940



Tucumcari Project

by the Corps of Engineers. Incorporated in the Conchas Dam construction was a headworks structure for an irrigation canal. The Bureau of Reclamation and the Corps of Engineers, each under the authority of its separate department, set up a cooperative plan to regulate the reservoir storage capacity to best serve the requirements of irrigation and flood control.

In 1936, the Bureau of Reclamation was authorized to conduct investigations to ascertain the practicability and cost of a canal and distribution system to serve an area in the vicinity of Tucumcari, using the diversion headworks incorporated in the Conchas Dam structure. The final report, covering water supply, economic studies, and cost estimates, was completed in August 1937.

Authorization

The President approved the finding of feasibility on November 1, 1938. The Congress, by an act approved April 9, 1938 (Public Law 477, 75th Cong.), authorized the Bureau of Reclamation to build the project subject to this approval.

The basic repayment contract with the Arch Hurley Conservancy District was executed on December 27, 1938. Subsequent amendatory contracts provided for the emergency installation of pumps at Conchas Dam during the summer of 1953 and a rehabilitation and betterment program through drainage and canal lining beginning in 1961 and continuing to completion during 1976.

Construction

Construction of the irrigation system began in 1940 and continued to December 1942, when work was suspended by the War Production Board. The project was reauthorized in April 1944 as a war emergency food project. First water was delivered to project lands in 1946 and construction was essentially completed in 1950. Operation of the project disclosed a need for the drainage improvement work which was accomplished by construction contracts during 1952-54.

The Arch Hurley Conservancy District desired further improvement to the project distribution and drainage system, and in May 1961 district forces initiated a rehabilitation and betterment program which included the installation of about 86 miles of canal and lateral linings and the addition of about 23 miles of open drains. The program was completed during 1976.

Operating Agencies

Conchas Dam is operated and maintained by the Corps of Engineers. Tucumcari Project is operated and maintained by the Arch Hurley Conservancy District. Operation and maintenance responsibility was turned over to the district on January 1, 1954.

BENEFITS

Many crops grown on the project are used to sustain the area's livestock industry. Alfalfa hay, alfalfa seed, grain sorghum, cotton, and broom corn are the leading crops produced.

PROJECT DATA

Land Areas (1977)

Irrigable area:
Full irrigation service .... 41,386 acres
Number of irrigated farms 467

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	37,688	2,610,254
1969	36,300	2,918,998
1970	35,283	3,126,469
1971	34,822	2,812,866
1972	33,177	2,772,970
1973	36,353	4,005,765
1974	35,542	3,335,008
1975	33,752	3,106,673
1976	35,086	1,760,007
1977	37,417	1,875,559

Facilities in Operation

Storage dams[1] 1
Canals .... 110 mi
Laterals .... 171 mi
Pumping plants[2] 1
Drains .... 75 mi

[1]Constructed by the Corps of Engineers.
[2]Emergency installation at the irrigation outlet works structure, to permit pumping water from Conchas Reservoir below El. 4157.35.

Climatic Conditions

Annual precipitation .... 15 in
Temperature:
Maximum .... 108 °F
Minimum .... −16 °F
Mean .... 58 °F
Growing season .... 253 days
Elevation of irrigable area .... 4000.0 ft

Settlement

Number of persons served with project water (1977):
Farm irrigation service 570

ENGINEERING DATA

Water Supply

Canadian River

Drainage area .... 7,409 mi²

Average discharge at two gages above Conchas Reservoir:
Conchas River at Variadero, 523 mi² .... 11,590 acre-ft
Canadian River near Sanchez, 6,015 mi² ..... 146,300 acre-ft
Total both gages, 6,538 mi² .... 157,890 acre-ft
Average annual diversion (1950-75) .... 93,672 acre-ft

Storage Facilities

Conchas Reservoir

Total capacity to El. 4218 .... 528,951 acre-ft
Active conservation capacity, El. 4157.35-4201[3] .... 252,334 acre-ft
Surface area at El. 4218 .... 13,664 acres
Surface area at El. 4201 .... 9,692 acres

[3]Additional space available for 198,827 acre-ft of flood storage.

Carriage Facilities

Conchas Canal

Location: From Conchas Reservoir generally southeast about 7 mi from Tucumcari, N. Mex.
Construction period: 1939-48
Length .... 84 mi
Diversion capacity .... 700 ft³/s
Typical maximum section in earth:
Bottom width .... 24 ft
Side slopes 1.5:1
Water depth .... 8.7 ft

Conchas Canal Tunnels

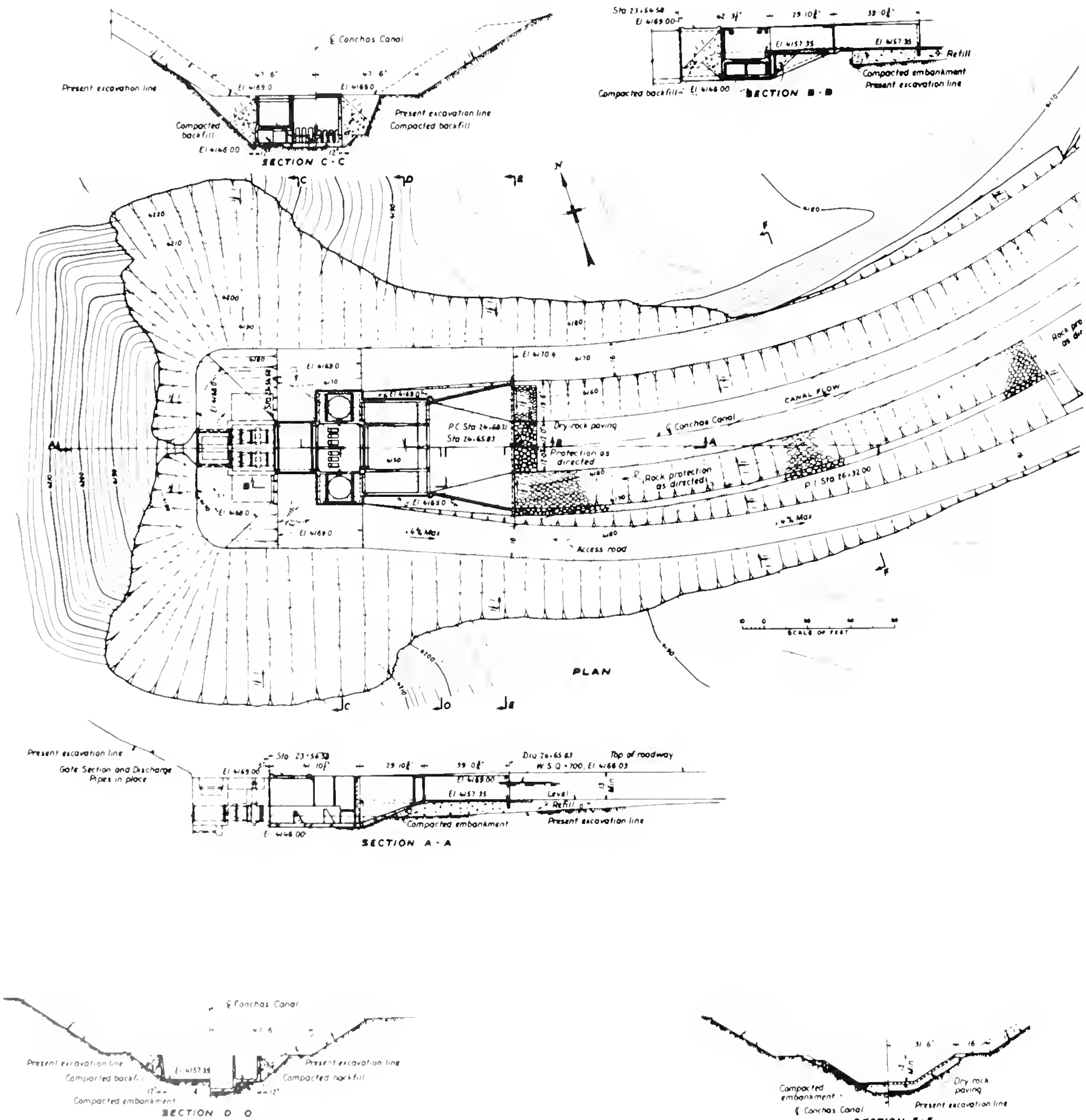
Location: At various points on Conchas Canal between Conchas Reservoir and southern boundary of project lands.
Number of tunnels 5
Total length .... 30,370 ft
Capacity .... 700 ft³/s
Cross section: Horseshoe
Diameter .... 11.5 ft
Lining: Concrete.

Conchas Canal Siphons

Location: At various points on Conchas Canal between Conchas Reservoir and southern boundary of project lands.
Number of siphons 31
Total length .... 21,921 ft
Capacity .... 700 ft³/s
Type: Concrete

Hudson Canal

Location: From a point on Conchas Canal about 1 mi south of Tucumcari, N. Mex., generally northeast.
Construction period: 1945-50
Length .... 26 mi
Diversion capacity .... 384 ft³/s
Typical maximum section in earth:
Bottom width .... 16 ft
Side slopes 1.5:1
Water depth .... 7 ft
Typical maximum section, heavy compacted earth lined:
Bottom width .... 16 ft
Side slopes 1.5:1
Water depth .... 7 ft
Lining thickness:
On bottom .... 1.5 ft
On side slopes (horizontally) .... 8 ft

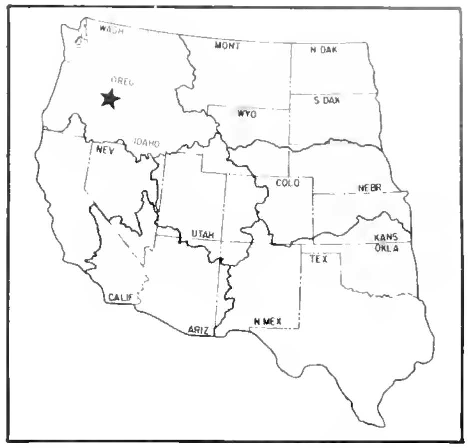


Conchas Canal Headworks, Plan and Sections

Umatilla Project

Oregon: Morrow and Umatilla Counties

Pacific Northwest Region
Water and Power Resources Service



The Umatilla Project furnishes a full supply of irrigation water to 17,348 acres and a supplemental supply to 13,235 acres. These lands, located in north-central Oregon, are divided into three divisions. The East Division is the Hermiston Irrigation District, the West Division is the West Extension Irrigation District, and the South Division includes the Stanfield and Westland Irrigation Districts. In addition, there are 3,568 acres not included in an irrigation district that are provided either a full or supplemental water supply from McKay Reservoir under individual storage contracts.

Project features of the East Division are Cold Springs Dam and Reservoir, Feed Canal Diversion Dam and Canal, and Maxwell Diversion Dam and Canal. Three Mile Falls Diversion Dam on the Umatilla River and the 27-mile West Extension Main Canal are the principal features of the West Division. McKay Dam and Reservoir are the only features in the South Division.

PLAN

The project plan provides for irrigation of lands in the lower Umatilla River Valley and along the south side of the Columbia River west of Umatilla, Oreg., with water from the Umatilla River. Storage is provided by Cold Springs Dam, to which water from the Umatilla River is conveyed through a feed canal, and by McKay Dam on McKay Creek. Three diversion dams on the Umatilla River divert into the Feed Canal, which supplies Cold Springs Reservoir, and into the West Extension and Maxwell Canals, each of which serve portions of the project lands.

Cold Springs Dam and Reservoir

Stanfield and Westland Irrigation Districts have each contracted for 30-percent ownership of the storage space in McKay Reservoir. Water is released from the reservoir on request from the districts. The Bureau of Reclamation is not responsible for the distribution of the stored water since the districts operate their own canal systems.

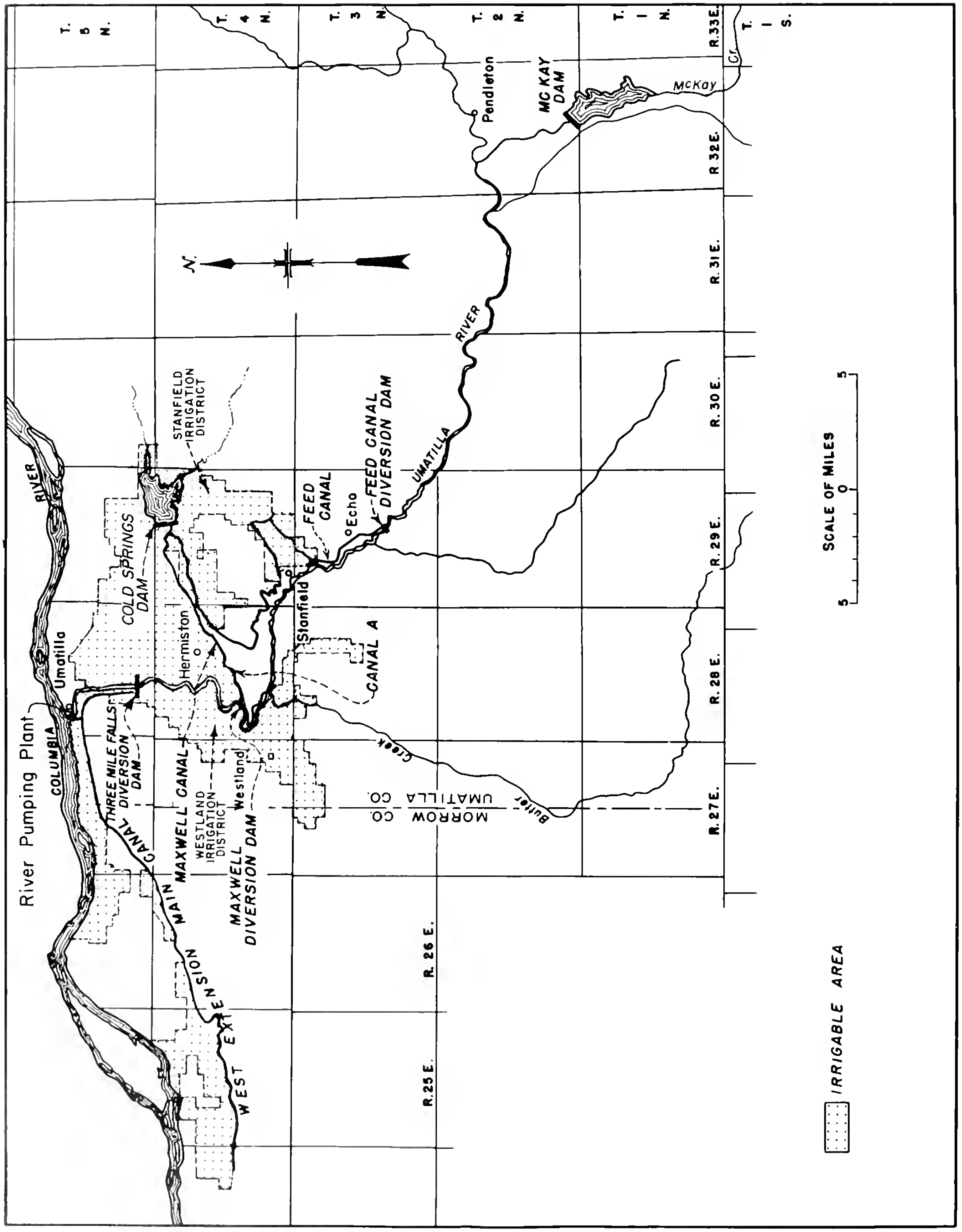
Cold Springs Dam and Reservoir

Cold Springs Dam is a zoned earthfill type with a structural height of 100 feet and a volume of 793,000 cubic yards. Cold Springs Reservoir is located offstream about 6 miles northeast of Hermiston, Oreg. Water is diverted to the reservoir from the Umatilla River by the Feed Canal Diversion Dam and Canal. The reservoir's active capacity is 50,000 acre-feet.

McKay Dam and Reservoir

Located on McKay Creek about 6 miles south of Pendleton, Oreg., McKay Dam was constructed to furnish a supplementary supply of water to Stanfield and Westland Irrigation Districts. The dam is an earthfill structure with a reinforced concrete paved upstream slope, is 165 feet high, and contains 2,364,000 cubic yards of material. The reservoir has an active storage capacity of 73,800 acre-feet.

McKay Dam was originally constructed during 1923-27. Modification of the spillway section was made in 1978-79 to increase the capacity from 10,000 to 27,000 cubic feet per second.



Umatilla Project

Feed Canal Diversion Dam and Canal

The Feed Canal Diversion Dam is located on the Umatilla River 1.5 miles southeast of Echo, Oreg. The dam, a concrete, rock, and timber weir with an embankment wing, raises the level of the water in the riverbed 4 feet to provide diversion into the 25-mile-long Feed Canal that extends to the Cold Springs Reservoir. This 350-cubic-foot-per-second canal and the reservoir provide water for late summer releases from the dam.

Maxwell Diversion Dam and Canal

The Maxwell Diversion Dam and Canal divert water from the Umatilla River and convey it to 10,829 acres of land in the East Division. The dam, located about 1 mile west of Hinkle, Oreg., is a concrete and timber-crib weir with an embankment wing. The dam permits diversion into the Maxwell Canal by raising the water surface 4 feet above the riverbed. The canal is 10 miles long and has an initial capacity of 140 cubic feet per second.

Three Mile Falls Diversion Dam and Canal

The Three Mile Falls Diversion Dam is a concrete multiple arch weir which diverts water to the West Division through the West Extension Main Canal. The dam is on the Umatilla River 3 miles south of Umatilla, Oreg., and has a structural height of 24 feet, a hydraulic height of 23 feet, and a crest length of 915 feet. The canal is 27 miles long and has a diversion capacity of 375 cubic feet per second. Water to irrigate 6,519 acres of project lands is supplied through this system.

River Pumping Plant

The West Extension Irrigation District installed the River Pumping Plant in 1968-69 to supply supplemental irrigation water to lands within the district and to serve an additional 2,000 acres outside the West Extension irrigable area. The plant is located on the Umatilla River 0.5 mile above its confluence with the Columbia River and discharges into the West Extension Main Canal 3 miles from Three Mile Falls Diversion Dam. Three vertical-turbine pumps, rated at 20 cubic feet per second each and driven by 600-horsepower motors, are installed in the plant.

DEVELOPMENT

Early History

In 1903, the Hinkle Ditch Company began irrigating land to the south and east of Hermiston. The point of diversion was about 0.5 mile above Echo and 0.75 mile below the diversion of the present Feed Canal. The company was taken over by the Western Land & Irrigation

McKay Dam and Reservoir

Company, which considerably enlarged and extended the main canal and laterals. During most years, water could be diverted as desired from the first of March until about the middle of June and occasionally until early in July. During years of short runoff, the last irrigation took place the latter part of May. Lack of water during the summer months greatly hindered development and the Westland Irrigation District was formed to cooperate with the Bureau of Reclamation in utilizing water stored in McKay Reservoir.

In 1905, the Furnish Ditch Company began construction of a system to irrigate 8,000 to 10,000 acres in the vicinity of Stanfield, Oreg. The point of diversion was about 6 miles above that of the present Feed Canal. During 1909, a small reservoir was built on the main stream between Echo and Pendleton to store between 4,000 and 5,000 acre-feet of water. The natural flow of the river usually provided sufficient water for irrigation between the first of March and the middle of June, and the stored supply generally would last until the first of August. Later, the Stanfield Irrigation District was organized to negotiate with the Bureau of Reclamation for storage in McKay Reservoir.

Investigations

In January 1903, the Reclamation Service began investigations to determine the possibility of irrigating lands on the lower Umatilla River by gravity flow from the Columbia and Snake Rivers. During 1903-04, the

Irrigated lands near Columbia River

Service surveyed the Umatilla River and its tributaries and mapped the more feasible reservoir sites. Subsequent investigations were made to find a reservoir site on the irrigable lands east of the river. The studies resulted in construction of Cold Springs Reservoir and the establishment of the Umatilla Project. In 1923, construction was started on McKay Dam and Reservoir. The project has been operating since 1927.

Inflow design flood studies in recent years on McKay Creek have indicated that the spillway capacity at McKay Dam would not be adequate under extreme flood conditions. Modifications to increase the spillway capacity were recommended in a report completed in April 1975.

Authorization

The East and West Divisions, which originally comprised all the project, were authorized on December 4, 1905, under provisions of the original Reclamation Act, section 4, (32 Stat. 388). Recommendations from the Board of Engineers with respect to construction of McKay Dam were approved by the Director of the Reclamation Service on March 3, 1923. Rehabilitation of Stanfield Irrigation District was accomplished with funds provided by the National Industrial Recovery Act of 1933. Modification of McKay Dam was authorized by Public Law 94-228, dated March 11, 1976 (90 Stat. 207).

Construction

Construction began on the project in 1906, and the first water was available for irrigation from the Cold Springs Reservoir on March 8, 1908. Construction began on McKay Dam in 1923 and was completed in 1927. Rehabilitation of the Stanfield Irrigation District began in 1933 and was completed in 1938.

Operating Agencies

In the South Division, McKay Reservoir is operated by the Bureau of Reclamation. Stanfield and Westland Irrigation Districts operate their own facilities. The East Division has been operated by the Hermiston Irrigation District since June 23, 1926, and the West Division by the West Extension Irrigation District since April 27, 1926.

BENEFITS

Irrigation

More than 34,000 acres of land benefit from the irrigation facilities of the project. Principal crops are alfalfa hay and pasture; other crops grown are grain, mint, and vegetables.

Flood Control

McKay Dam is operated on an informal basis for flood control and greatly reduces flows that otherwise would be very damaging. The spillway section modification that increased the capacity from 10,000 to 27,000 cubic feet per second will not prevent damaging flows downstream from the dam during an extreme flood inflow, but it will ensure against a catastrophic flood from dam failure. Releases during an extreme flood inflow would increase gradually, allowing time for warning and evacuation of those people living in the urban developed area between McKay Dam and the Umatilla River.

Recreation and Fish and Wildlife

Both the McKay and Cold Springs Reservoir areas are national wildlife refuges that are heavily used by migrating waterfowl. The McKay Reservoir area consists of 515 acres of land and almost 1,300 acres of water surface with 11 miles of shoreline. Some 275 acres of the reservoir area have been designated as public hunting grounds. There are boat launching facilities at the reservoir. Cold Springs Reservoir has about 1,600 acres of water surface and 12 miles of shoreline. The reservoir area includes over 1,000 acres of land, of which 900 acres have been designated as public hunting grounds. No recreation facilities have been constructed.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	17,348	acres
Supplemental irrigation service	13,235	acres
Subtotal, service to irrigation districts	30,583	acres
Individual storage contractors	3,568	acres
Total, all acres receiving service	34,151	acres
Number of irrigated farms[1]	746	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	21,878	1,489,609
1969	22,324	1,942,640
1970	22,717	2,079,731
1971	23,272	2,109,330
1972	24,045	2,553,697
1973	24,263	3,437,789
1974	24,541	3,807,288
1975	24,587	3,535,444
1976	25,002	4,063,776
1977	25,042	3,714,867

Facilities in Operation

Storage dams	2	
Diversion dams	3	
Canals	137	mi
Laterals	106	mi
Pumping plants	1	
Drains	14	mi

Climatic Conditions

Annual precipitation	8.2	in
Temperature:		
Maximum	108	°F
Minimum	−11	°F
Mean	53	°F
Growing season	187	days
Elevation of irrigable area	470.0	ft

Settlement

Number of persons served with project water (1977):[1]	
Farm irrigation service	2,283
Other water service[2]	9,155
Total	11,438

[1]Excludes individual storage contractors, for which detailed data were not available.
[2]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

UMATILLA RIVER

Drainage area at Yoakum, Oreg.	1,280	mi²
Annual discharge:		
Maximum (1974)	895,700	acre-ft
Minimum (1977)	179,300	acre-ft
Average	475,000	acre-ft

MCKAY CREEK

Drainage area at Pilot Rock, Oreg.	180	mi²
Annual discharge:		
Maximum (1974)	131,000	acre-ft
Minimum (1977)	19,500	acre-ft
Average	70,200	acre-ft
Average annual diversions by project (1963-77)	216,690	acre-ft

Storage Facilities

MCKAY DAM

Type: Earthfill with diaphragm, upstream slope paved with concrete.
Location: On McKay Creek, 6 mi south of Pendleton, Oreg.

Drainage area	186	mi²
Construction period: 1923-27. Spillway modified 1978-79.		
Reservoir, McKay:		
Average annual inflow, 1963-77	70,200	acre-ft
Active capacity, El. 1182-1322	73,800	acre-ft
Surface area	1,290	acres
Length	4	mi
Dimensions:		
Structural height	165	ft
Hydraulic height	156	ft
Top width	23.5	ft
Maximum base width	650	ft
Crest length	2,700	ft
Crest elevation	1330.0	ft
Total volume	2,364,000	yd³
Spillway: Concrete-lined channel in right abutment. Side overflow inlet controlled by six 20- by 10-ft radial gates and a twin-barrel siphon.		
Crest elevation	1312.0	ft
Capacity at El. 1322	27,000	ft³/s
Outlet works: Concrete-lined tunnel through right abutment controlled by two 4-ft needle valves and one 10-in needle valve. The latter is used for direct diversion into the Marion-Jack Ditch.		
Capacity at El. 1322	1,500	ft³/s

COLD SPRINGS DAM

Type: Zoned earthfill
Location: Offstream about 6 mi northeast of Hermiston, Oreg.
Construction period: 1906-08
Reservoir, Cold Springs: Inflow from Umatilla River through Feed Canal.

Active capacity[3], El. 560-621.5	50,000	acre-ft
Surface area	1,550	acres
Dimensions:		
Structural height	100	ft
Hydraulic height	90	ft
Top width	20	ft
Maximum base width	460	ft
Crest length	3,450	ft
Crest elevation	630.0	ft
Total volume	793,000	yd³
Spillway: Uncontrolled concrete overflow weir and chute in right abutment.		
Crest length	200	ft
Crest elevation	623.0	ft
Capacity at El. 626	6,000	ft³/s
Outlet works: Concrete conduit through base of dam controlled by two 4-ft-square slide gates.		
Capacity at El. 623	600	ft³/s

[3]Further analysis of active capacity is being considered due to sediment deposition.

Diversion Facilities

Feed Canal Diversion Dam

Type: Concrete, rock, and timber weir with embankment wing
Location: On Umatilla River, 1.5 mi southeast of Echo, Oreg.
Year completed: 1907
Dimensions:

Structural height	8 ft
Hydraulic height	4 ft
Crest length	2,100 ft
Crest elevation	656.0 ft
Volume	14,100 yd³
Diversion capacity	350 ft³/s

Maxwell Diversion Dam

Type: Concrete and timber-crib weir with embankment wing
Location: On Umatilla River, 1 mi west of Hinkle, Oreg.
Year completed: 1912
Dimensions:

Structural height	14 ft
Hydraulic height	4 ft
Crest length	400 ft
Crest elevation	529.0 ft
Volume	500 yd³
Diversion capacity	140 ft³/s

Three Mile Falls Diversion Dam

Type: Concrete multiple arch weir
Location: On Umatilla River, 3 mi south of Umatilla, Oreg.
Year completed: 1914
Dimensions:

Structural height	24 ft
Hydraulic height	23 ft
Crest length	915 ft
Crest elevation	404.3 ft
Volume	5,100 yd³
Diversion capacity	375 ft³/s

Carriage Facilities

Feed Canal

Location: From Feed Canal Diversion Dam generally northwest along the Umatilla River about 8 mi, then northeast to Cold Springs Reservoir.
Construction period: 1906-07. Enlarged 1913-17.

Length	25 mi
Diversion capacity	350 ft³/s
Typical maximum section in earth:	
Bottom width	23 ft
Side slopes	1.5:1
Water depth	5.5 ft

West Extension Main Canal

Location: From Three Mile Falls Diversion Dam generally west about 20 mi along Columbia River.
Construction period: 1913-16

Length	27 mi
Diversion capacity	375 ft³/s

Maxwell Canal

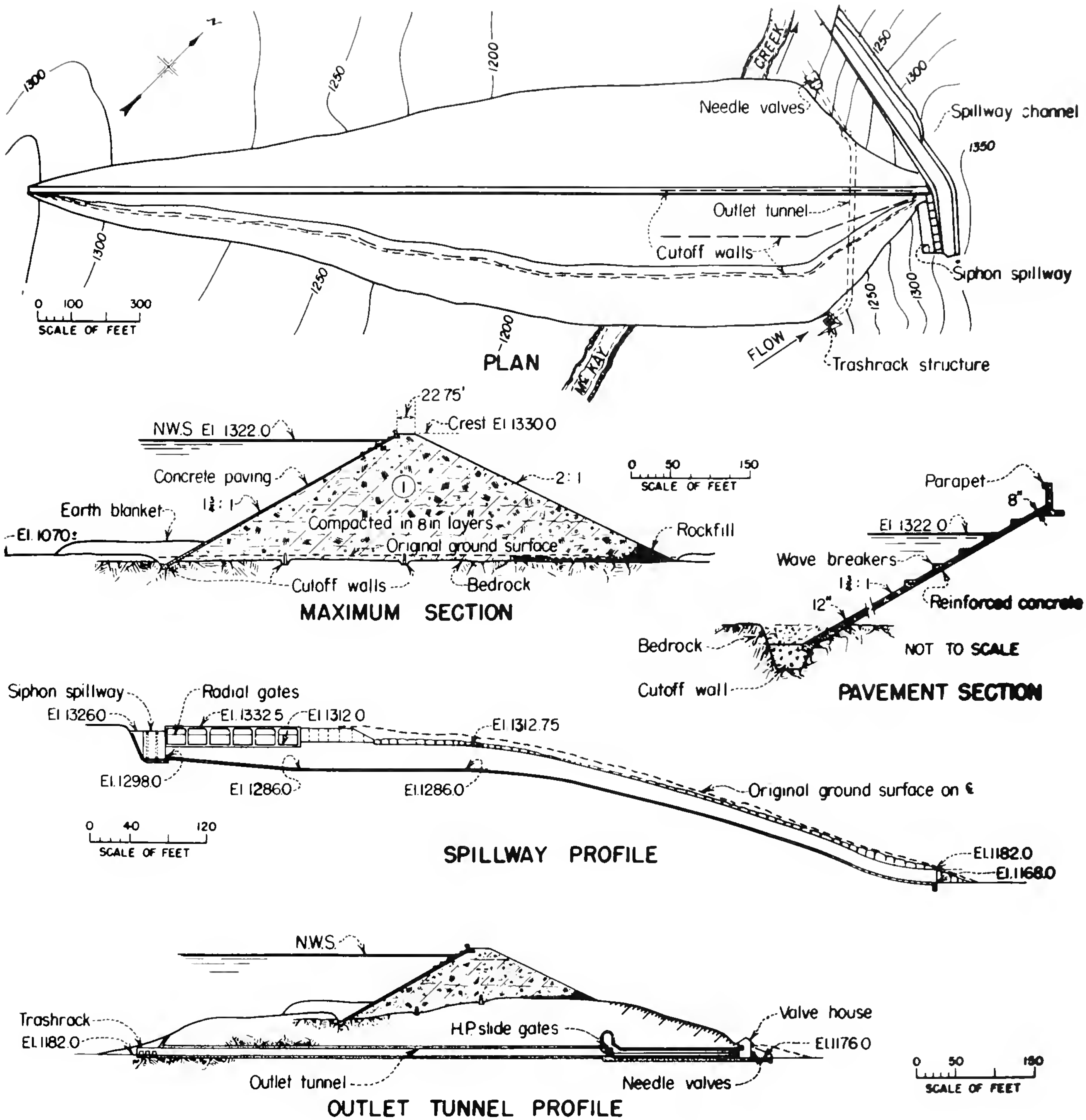
Location: From Umatilla River northeast to vicinity of Cold Springs Reservoir.
Construction period: Non-Reclamation construction. Enlarged in 1917 by Bureau of Reclamation.

Length	10 mi
Diversion capacity	140 ft³/s

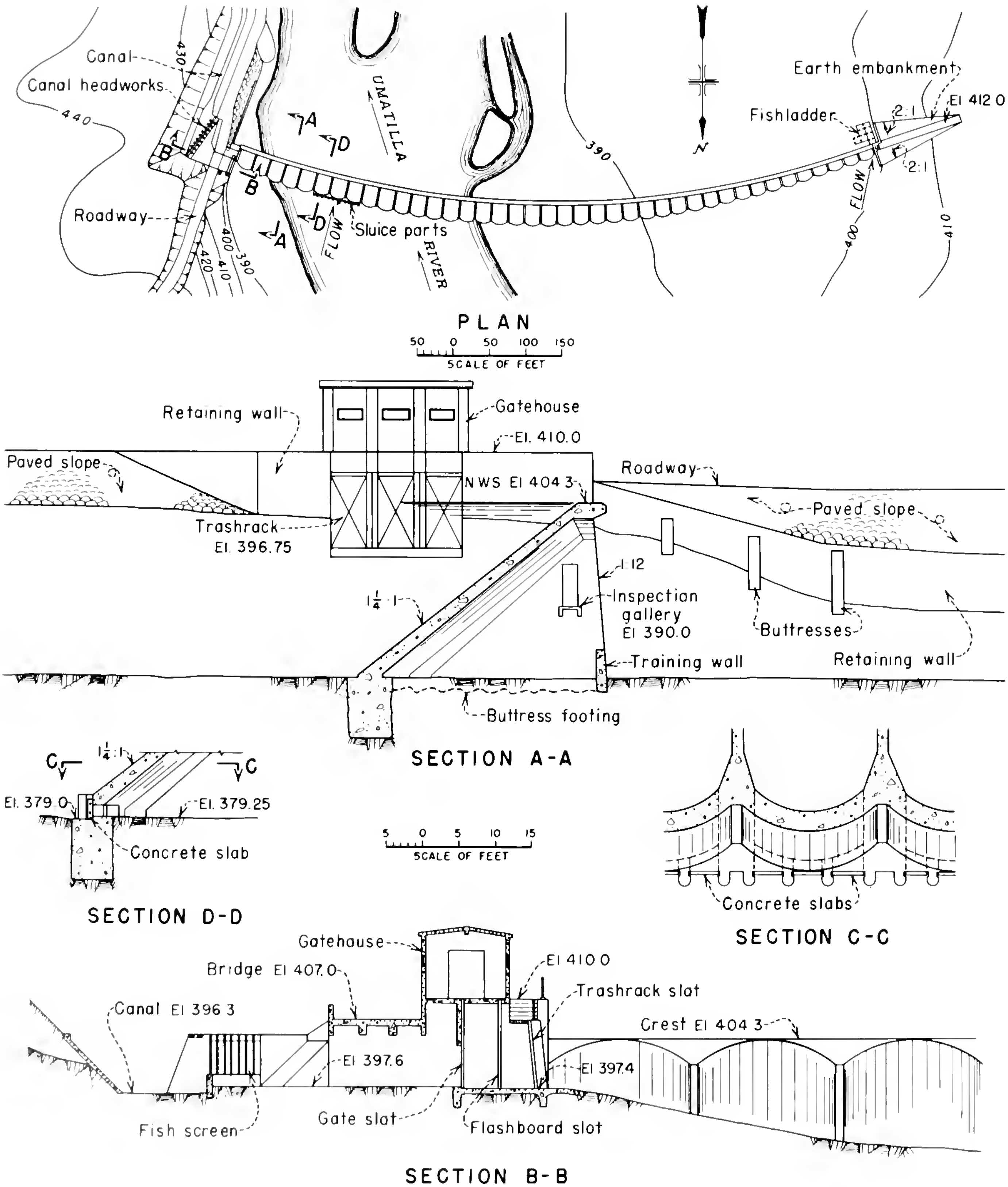
Pumping Plants

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
River Pumping Plant[1]	3	60	145	1,800

[1]Installed by West Extension Irrigation District.



McKay Dam, Plan and Sections

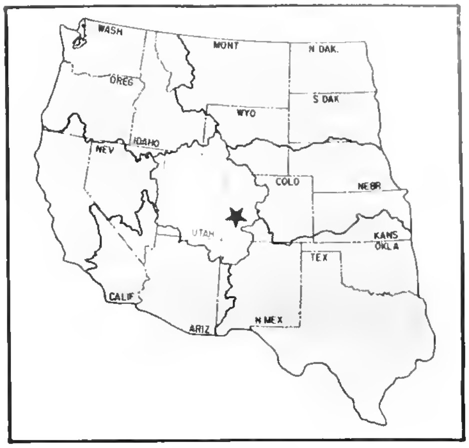


Three Mile Falls Diversion Dam, Plan and Sections

Uncompahgre Project

Colorado: Delta, Gunnison, and Montrose Counties

Upper Colorado Region
Water and Power Resources Service



The Uncompahgre Project is on the western slope of the Rocky Mountains in west-central Colorado. Project lands surround the town of Montrose and extend 34 miles along both sides of the Uncompahgre River to Delta, Colo. Project features include Taylor Park Dam and Reservoir, Gunnison Tunnel, 7 diversion dams, 128 miles of main canals, 438 miles of laterals, and 216 miles of drains. The systems divert water from the Uncompahgre and Gunnison Rivers to serve over 76,000 acres of project land.

PLAN

The project plan provides for storage in Taylor Park Reservoir on the Taylor River, which is a part of the Gunnison River Basin, and diversion of water from the Gunnison River by the Gunnison Diversion Dam through the Gunnison Tunnel and the South Canal to the Uncompahgre River.

To distribute the waters of the Gunnison and Uncompahgre Rivers, the South and West Canals were constructed and the larger existing private canals, that take water directly from the Uncompahgre River, were purchased, then enlarged and extended. Laterals were constructed to deliver water from the South Canal to project lands.

Taylor Park Dam and Reservoir

Taylor Park Dam is on the Taylor River, a tributary of the Gunnison River. The dam is a zoned earthfill structure 206 feet high, with a crest length of 675 feet and a volume of 1,115,000 cubic yards. It creates a reservoir with a storage capacity of 106,200 acre-feet. The spillway is an overflow-type weir crest 180 feet long with a capacity of 10,000 cubic feet per second. The outlet works is a horseshoe tunnel with a diameter of 10 feet, and a capacity of 1,500 cubic feet per second.

Gunnison Diversion Dam, Tunnel, and Canal System

The Gunnison Diversion Dam on the Gunnison River, about 12 miles east of Montrose, is a timber-crib weir with concrete wings and a removable crest. The dam has a structural height of 16 feet. It diverts Gunnison River direct flows, as well as releases from the Taylor Park Dam into the Gunnison Tunnel.

The Gunnison Tunnel was designed as a rectangular section 11 feet wide and 12 feet high, with an arch roof. A number of modifications have been made since the original construction. It is 5.8 miles long and has a capacity of 1,000 cubic feet per second.

The South Canal extends from the end of the Gunnison Tunnel generally southwest 11.4 miles to the Uncompahgre River. Part of the canal is concrete lined; the remainder is unlined. The canal has an initial capacity of 1,010 cubic feet per second.

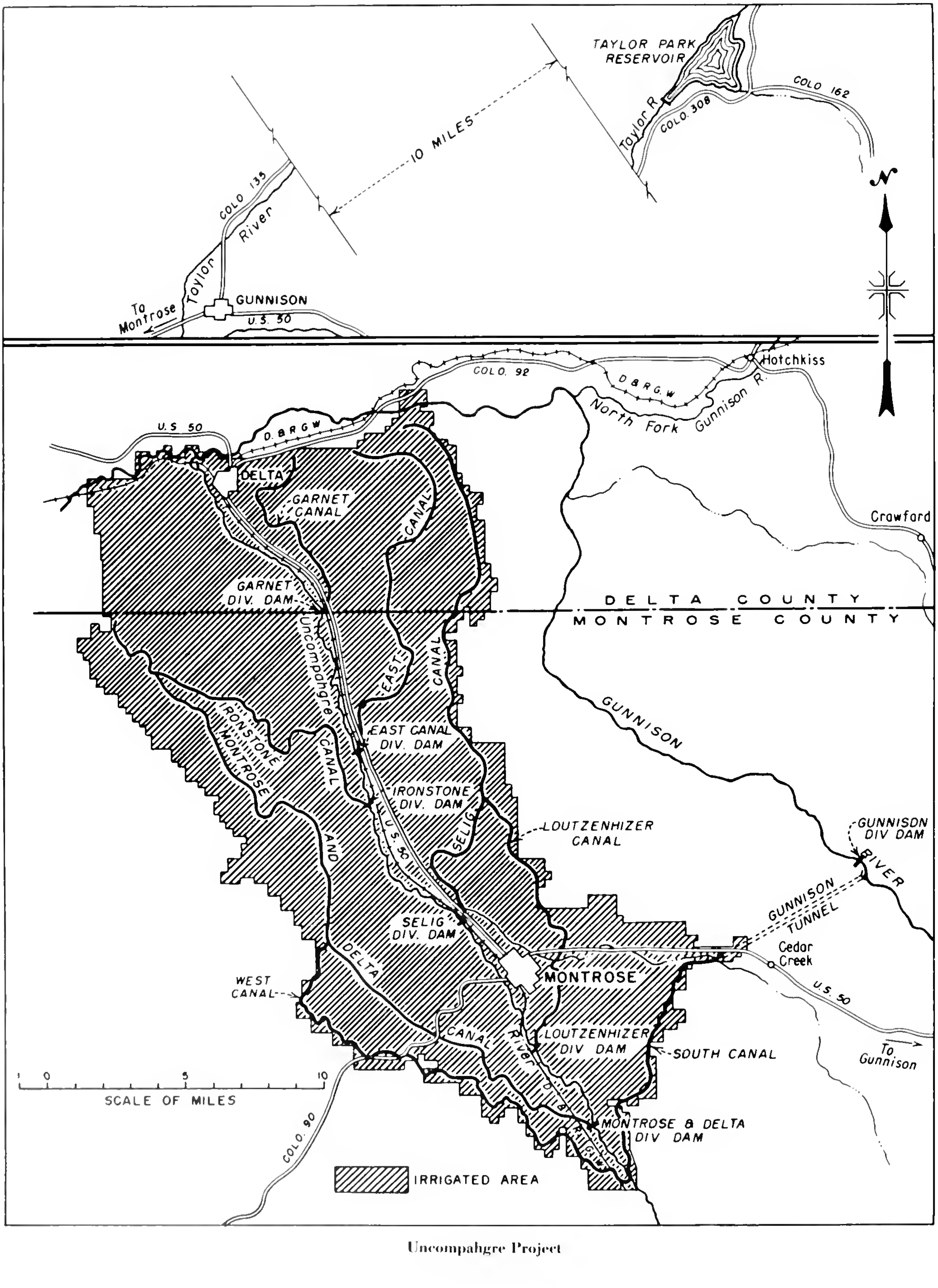
West Canal extends generally northwest about 21 miles from the Uncompahgre River beginning at the terminal structure of the South Canal with the river. This unlined canal has an initial capacity of 172 cubic feet per second. The West Canal is diverted directly from the South Canal and a timber and metal flume carries the canal across the Uncompahgre River. There is a small diversion for winter flows directly from the Uncompahgre River.

Montrose and Delta Diversion Dam and Canal

This diversion dam is on the Uncompahgre River about 8 miles south of Montrose. The dam is a concrete gate structure with radial control and sluiceway gates. The unlined canal extends generally northwest about 40 miles from the diversion point and had a diversion capacity of 563 cubic feet per second. The original dam and canal were privately constructed and later purchased and rehabilitated by Reclamation as part of the Uncompahgre Project. A new structure was built in 1963 with a diversion capacity of 550 cubic feet per second.

Loutzenhizer Diversion Dam and Canal

The diversion dam is on the Uncompahgre River about 2 miles south of Montrose. It was a pile-and-timber weir



Uncompahgre Project

with a concrete apron but was rebuilt by the water users into a concrete weir and apron with radial gates. The dam has a structural height of 24 feet. The canal extends generally northwest 14.5 miles from the diversion dam and has a diversion capacity of 120 feet per second. The original dam and canal were privately constructed and purchased by Reclamation in 1908.

Selig Diversion Dam and Canal

Selig Diversion Dam is on the Uncompahgre River about 5 miles northwest of Montrose. It has a timber-gated sluiceway with uncontrolled concrete overflow weir and concrete stilling basin. Its structural height is 25 feet. The canal extends generally north about 20 miles from the diversion dam. This unlined canal has a diversion capacity of 320 cubic feet per second. The original dam and canal were privately constructed and purchased by Reclamation in 1914.

Ironstone Diversion Dam and Canal

Located on the Uncompahgre River about 8 miles northwest of Montrose, the Ironstone Diversion Dam is a concrete structure with radial control and sluiceway gates with a concrete wing. The structural height is 7 feet. The unlined canal runs 14 miles northwest from the diversion dam. The diversion capacity is 400 cubic feet per second. The original dam and canal were privately constructed and were acquired by Reclamation in 1915.

East Canal Diversion Dam and Canal

Located on the Uncompahgre River about 10 miles northwest of Montrose, the East Canal Diversion Dam is

Taylor Park Dam and Reservoir

a concrete and timber weir with an earth embankment wing. The structural height is 16 feet. The unlined canal extends 10.6 miles north from the diversion dam. Its diversion capacity is 165 cubic feet per second. The original dam and canal were privately constructed and were acquired by Reclamation in 1911.

Garnet Diversion Dam and Canal

The diversion dam is on the Uncompahgre River about 15 miles northwest of Montrose. The dam is a concrete-surfaced rockfill weir, and has a structural height of 8 feet. Garnet Canal is unlined and extends 10.7 miles northwest from the diversion dam. Its diversion capacity is 75 cubic feet per second. The original dam and canal were constructed by private interests and purchased by the Bureau of Reclamation in 1914.

Lateral and Drainage Systems

There are 438 miles of laterals which distribute water to project lands. A system of subsurface drains totaling 216 miles has been constructed.

DEVELOPMENT

Early History

The lands comprising the project area were formerly part of the Ute Indian Reservation. Settlement rapidly followed cession of the land by the Indians to the United States. By 1903, about 30,000 acres in the Uncompahgre Valley were irrigated by private systems which included five diversion dams on the Uncompahgre River. As the possibilities for greater use of irrigation water were evident, a larger development by the State of Colorado was started in 1901 but was abandoned. Work by the Reclamation Service began in 1903.

Investigations

Active support for driving a tunnel from the Gunnison River to the Uncompahgre Valley to obtain additional water was solicited as early as 1890. In 1894, the Geological Survey completed a reconnaissance survey and found it was too expensive an undertaking for local interests, but in 1901 the State of Colorado appropriated $25,000 to start the tunnel. Only 900 feet were driven before the funds were exhausted. In 1901, construction surveys of the project were begun by the Geological Survey, and the general scheme of the project was outlined in its first report. After the passage of the Reclamation Act in 1902, the Uncompahgre Valley was selected for immediate development. The original surveys by the Geological Survey, plus the investigational work carried out by the Reclamation Service, served as a basis for authorization of the project in 1903.

Authorization

The project (originally called Gunnison Project) was authorized by the Secretary of the Interior on March 14, 1903, under the provisions of the Reclamation Act. Rehabilitation of the project and construction of Taylor Park Dam was approved by the President on November 6, 1935.

Construction

Construction began in July 1904, and the first water for irrigation was available during the season of 1908 from the Uncompahgre River. The Gunnison Tunnel was completed in 1909, and the Gunnison Diversion Dam was completed in January 1912. The project was transferred to the Uncompahgre Valley Water Users Association for operation and maintenance in 1932. Taylor Park Dam, built from funds allotted under the National Industrial Recovery Act, was completed in 1937. Other improvements made during the same period included enlargement, lining, and smoothing portions of the Gunnison Tunnel, constructing concrete and steel structures to replace some of the wornout wooden structures in the privately constructed irrigation systems, relining portions of the canals, and constructing a drainage system to relieve and prevent waterlogging of land.

Operating Agency

The project is operated and maintained by the Uncompahgre Valley Water Users Association.

BENEFITS

Almost 76,300 acres of land receive a full irrigation water supply from the facilities of the project. Principal crops are alfalfa, wheat, corn, oats, potatoes, beans, barley, onions, and fruit.

Recreation

Free camp and picnic grounds have been provided by the Forest Service at Taylor Park Reservoir. Cabins are available at privately owned resort developments in the area. Camping, picnicking, swimming, and boating are popular activities, and fishing is good for rainbow, brown, and Loch Leven trout. Some brook and native trout also are caught. Recreation facilities administered by the Forest Service had 43,570 visitor days in 1977. Visitation normally exceeds 60,000 but was less in 1977 because of the drought.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service	76,297	acres
Number of irrigated farms/tracts	1,800	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	65,127	8,272,866
1969	65,095	9,128,717
1970	65,415	8,221,250
1971	67,326	9,135,904
1972	68,095	12,671,242
1973	68,056	16,835,754
1974	68,012	19,139,043
1975	67,934	23,102,332
1976	67,843	17,798,457
1977	66,943	19,037,802

Facilities in Operation

Storage dams	1	
Diversion dams	7	
Canals	128	mi
Laterals	438	mi
Drains	216	mi

Climatic Conditions

Annual precipitation	9	in
Temperature:		
Maximum	109	°F
Minimum	−36	°F
Mean	51	°F
Growing season	150	days
Elevation of irrigable area	4950-6400.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service	7,000
Municipal water service	8,700
Other water service[1]	7,750
Total	23,450

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

Uncompahgre River

Drainage area at Colona, Colo.	437	mi²
Annual discharge:		
Maximum (1921)	331,200	acre-ft
Minimum (1954)	87,600	acre-ft
Average	194,100	acre-ft

Gunnison River

Drainage area at Gunnison Tunnel	3,980	mi²
Annual discharge:		
Maximum (1957)	2,066,000	acre-ft
Minimum (1954)	584,000	acre-ft
Average	1,284,000	acre-ft
Average annual diversion (1958-77)	483,415	acre-ft

Storage Facilities

Taylor Park Dam

Type: Zoned earthfill
Location: On the Taylor River, 30 mi northeast of Gunnison, Colo.
Construction period: 1935-37
Date of closure (first storage): 1937
Reservoir, Taylor Park:

Average annual inflow, 1939-72	142,800	acre-ft
Total capacity to El. 9330	106,200	acre-ft
Surface area	2,040	acres
Dimensions:		
Structural height	206	ft
Hydraulic height	153	ft
Top width	35	ft
Maximum base width	1,000	ft
Crest length	675	ft
Crest elevation	9344.0	ft
Total volume	1,115,000	yd³

Spillway: Uncontrolled concrete side-channel weir and concrete-lined chute in left abutment.

Crest length	180	ft
Crest elevation	9330.0	ft
Capacity at El. 9336	10,000	ft³/s

Outlet works: Concrete-lined, 10-ft-diameter tunnel through right abutment, controlled by two 48-in needle valves.

Capacity at El. 9330	1,500	ft³/s

Foundation: Competent, fine-grained phyllites and granitic intrusions in left abutment and river channel; firm, much-jointed, warped, and faulted sedimentary formations in right abutment. Major inactive fault with crush zone extends through right abutment.
Special treatment: Shaft excavated in fault zone beneath cutoff wall and backfilled with concrete; grout curtain beneath cutoff walls and supplementary grouting in foundation, abutments, and fault zone.

Diversion Facilities

Gunnison Diversion Dam

Type: Timber-crib weir, concrete wings, removable crest
Location: On the Gunnison River, about 12 mi east of Montrose, Colo.
Year completed: 1912. Supplemental construction in 1915.
Dimensions:

Structural height	16	ft
Hydraulic height	10	ft
Weir crest length	237	ft
Crest length	244	ft
Crest elevation	6542.5	ft
Volume	3,200	yd³

Headworks: Concrete gate structure with two 6.9- by 11.6-ft steel plate gates.

Diversion capacity	1,000	ft³/s

East Canal Diversion Dam

Type: Concrete weir, embankment wing
Location: On the Uncompahgre River, about 10 mi northwest of Montrose, Colo.
Year completed: 1915. Constructed by private interests, reconstructed in 1940.

Dimensions:

Structural height	16 ft
Hydraulic height	8 ft
Weir crest length	75 ft
Crest length	764 ft
Crest elevation	5403.0 ft
Volume	1,000 yd³

Headworks: Timber structure with ten 3- by 4-ft wooden gates with 24-in handwheel screw-type hoists.

Diversion capacity	330 ft³/s

LOUTZENHIZER DIVERSION DAM

Type: Concrete weir and apron with radial gates
Location: On the Uncompahgre River about 2 mi south of Montrose, Colo.
Year completed: 1883. Acquired by Reclamation in 1908, supplemental construction in 1908 and 1911, rehabilitated 1974.
Dimensions:

Structural height	24 ft
Hydraulic height	9 ft
Weir crest length	114 ft
Volume	400 yd³

Headworks: Concrete structure with radial gate controls and sluiceway operated by an electric motor.

MONTROSE AND DELTA DIVERSION DAM

Type: Concrete gate structure with radial control and sluiceway gates
Location: On the Uncompahgre River, about 8 mi south of Montrose, Colo.
Year completed: 1883. Constructed by private interests. Supplemental construction by Reclamation in 1908, 1911, 1912, and 1915. New structure built in 1963.
Dimensions:

Structural height	46 ft
Hydraulic height	10 ft
Weir crest length	65 ft
Volume	9,825 yd³

Headworks: Concrete structure, two radial gates operated by an electric motor

Diversion capacity	550 ft³/s

GARNET DIVERSION DAM

Type: Rockfill weir, concrete surfaced
Location: On the Uncompahgre River, about 15 mi northwest of Montrose, Colo.
Year completed: Acquired by Reclamation and rehabilitated in 1914.
Dimensions:

Structural height	8 ft
Hydraulic height	4 ft
Weir crest length	75 ft
Crest elevation	5170.0 ft
Volume	1,000 yd³

Headworks: Two 4- by 6-ft wooden gates.

Diversion capacity	75 ft³/s

IRONSTONE DIVERSION DAM

Type: Concrete gate structure, concrete wing
Location: On the Uncompahgre River, about 8 mi northwest of Montrose, Colo.
Year completed: Acquired by Reclamation in 1915, supplemental construction in 1935, rehabilitated in 1962.
Dimensions:

Structural height	17 ft
Hydraulic height	13 ft
Weir crest length	52 ft
Crest elevation	5433.65 ft
Volume	3,930 yd³

Headworks:
For Main Canal, nine 3- by 4-ft wooden gates.
For Satisfaction Canal, two 3- by 4-ft wooden gates.

Diversion capacity	400 ft³/s

SELIG DIVERSION DAM

Type: Timber-gated sluiceway with uncontrolled concrete overflow weir and concrete stilling basin
Location: On the Uncompahgre River, about 5 mi northwest of Montrose, Colo.
Year completed: Acquired by Reclamation, supplemental construction in 1914.
Dimensions:

Structural height	25 ft
Hydraulic height	10 ft
Weir crest length	94.5 ft
Crest length	96 ft
Crest elevation	5696.25 ft
Volume	500 yd³

Headworks: Timber structure, 12 gates, 3.17 ft wide by 4 ft high, operated by hand wheel hoists.

Diversion capacity	320 ft³/s

Carriage Facilities

GUNNISON TUNNEL

Location: From Gunnison Diversion Dam southwest to a point about 2 mi west of Cedar Creek, Colo.
Construction period: 1905-09. Rehabilitated 1966-67.

Length	5.8 mi
Capacity	1,000 ft³/s

Cross-section: Rectangular with arched roof, 11 ft wide, 12 ft high
Lining: Concrete

SOUTH CANAL

Location: From end of Gunnison Tunnel generally south-southwest to Uncompahgre River.
Construction period: 1904-09

Length	11.4 mi
Diversion capacity	1,010 ft³/s
Typical maximum section in earth:	
Bottom width	30 ft
Side slopes	2:1
Water depth	10 ft
Typical maximum section, concrete lined:	
Bottom width	25 ft
Side slopes	1:1
Water depth	4.5 ft
Lining thickness	6 in

WEST CANAL

Location: Generally northwest from the Uncompahgre River beginning at the terminal structure of South Canal.
Construction period: 1912

Length	21.2 mi
Diversion capacity	172 ft³/s
Typical maximum section in earth:	
Bottom width	200 ft
Side slopes	1:1
Water depth	2.5 ft

MONTROSE AND DELTA CANAL

Location: Generally northwest from Montrose and Delta Diversion Dam.
Construction period: Privately constructed. Purchased by Reclamation in 1908 and rehabilitated in 1908-12.

Length	40 mi
Diversion capacity	550 ft³/s
Typical maximum section in earth:	
Bottom width	26 ft
Side slopes	1:1
Water depth	4 ft

LOUTZENHIZER CANAL

Location: Generally north-northwest from Loutzenhizer Diversion Dam.
Construction period: Privately constructed. Purchased by Reclamation in 1908 and rehabilitated.

Length	14.5 mi
Diversion capacity	120 ft³/s
Typical maximum section in earth:	
Bottom width	16 ft
Side slopes	1:1
Water depth	2.5 ft

SELIG CANAL

Location: Generally north from Selig Diversion Dam.
Construction period: Privately constructed. Rehabilitated and enlarged by Reclamation in 1914.

Length	20 mi
Diversion capacity	320 ft³/s
Typical maximum section in earth:	
Bottom width	26 ft
Side slopes	1.5:1
Water depth	1.5 ft

IRONSTONE CANAL

Location: Generally northwest from Ironstone Diversion Dam.
Construction period: Privately constructed. Acquired by Reclamation in 1915.

Length	14 mi
Diversion capacity	400 ft³/s
Typical maximum section in earth:	
Bottom width	30 ft
Side slopes	1.5:1
Water depth	4 ft

EAST CANAL

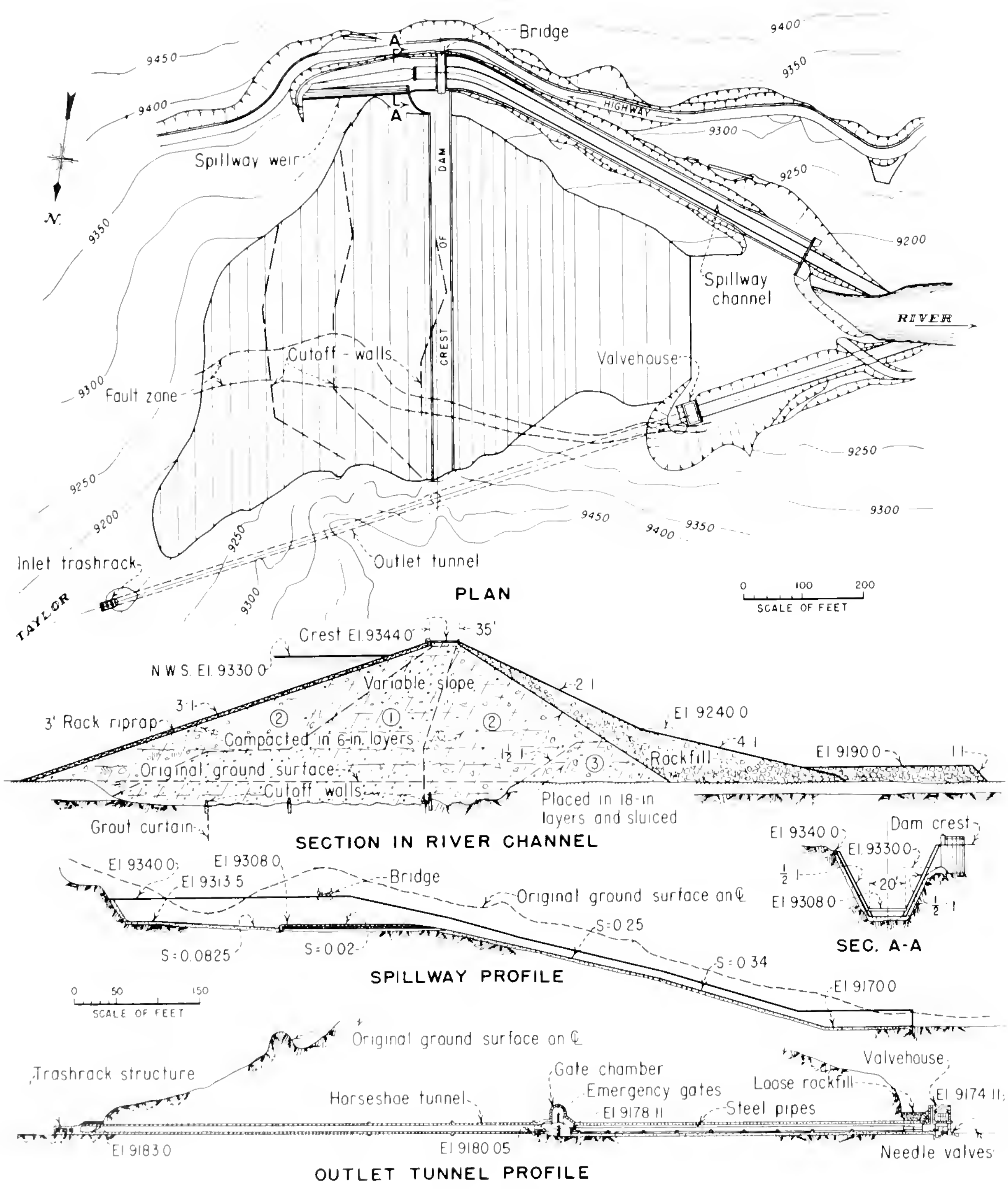
Location: Generally north from East Canal Diversion Dam.
Construction period: Privately constructed. Acquired by the Government in 1911, rehabilitated and extended.

Length	10.6 mi
Diversion capacity	165 ft³/s
Typical maximum section in earth:	
Bottom width	24 ft
Side slopes	1.5:1
Water depth	1.5 ft

GARNET CANAL

Location: North-northwest from Garnet Diversion Dam.
Construction period: Privately constructed. Rehabilitated by Reclamation in 1914.

Length	10.7 mi
Diversion capacity	75 ft³/s
Typical maximum section in earth:	
Bottom width	18 ft
Side slopes	1.5:1
Water depth	1.5 ft

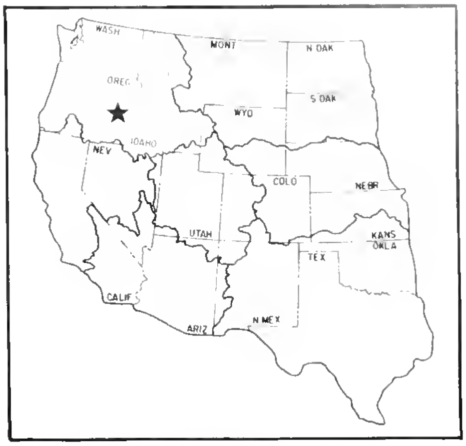


Taylor Park Dam, Plan and Sections

Vale Project

Oregon: Harney and Malheur Counties

Pacific Northwest Region
Water and Power Resources Service



The Vale Project lands are located along the Malheur River and Willow Creek in east-central Oregon, surrounding the town of Vale. The project furnishes irrigation water to 34,993 acres of land. Features include Agency Valley Dam and Beulah Reservoir, Bully Creek Dam and Reservoir, Harper Diversion Dam, Vale Main Canal, and a distribution and drainage system. To supplement project needs, the Federal Government purchased one-half of the storage rights in the Warm Springs Reservoir built by the Warmsprings Irrigation District.

PLAN

The project stores water in Warm Springs, Beulah, and Bully Creek Reservoirs. The stored water in Warm Springs and Beulah Reservoirs, together with natural streamflow, is diverted from the Malheur River by the Harper Diversion Dam to the Vale Main Canal. This water supplies lands on the west side of the Malheur River from Kime to Vale, and along Willow Creek from Vale to the vicinity of Jamieson, Oreg. A siphon, 1.5 miles southwest of Little Valley, conveys water to the Little Valley Canal, on the east side of the Malheur River in the vicinity of Little Valley. Excess water from the Malheur River is diverted to Bully Creek Reservoir through the Vale Main Canal, and through the Bully Creek Feeder Canal that delivers water from the Main Canal, heading about 8 miles west of Vale, Oreg. Water stored in Bully Creek Reservoir is delivered by two laterals, one beginning at the outlet works of the dam and the other at Bully Creek Diversion Dam about a mile downstream from the reservoir.

Warm Springs Dam and Reservoir

Warm Springs Dam is on the Middle Fork of the Malheur River about 13 miles southwest of Juntura, Oreg. The dam, constructed by the Warmsprings Irrigation District, is a 106-foot-high thin arch structure, and contains 19,500 cubic yards of concrete. The active capacity of the reservoir is 191,000 acre-feet. One-half of the storage in the reservoir was purchased for use on the Vale Project.

Agency Valley Dam and Beulah Reservoir

Located on the North Fork of the Malheur River near Beulah, Oreg., the Agency Valley Dam is a 110-foot-high zoned earthfill structure that contains 646,000 cubic yards of material. The capacity of the reservoir is 60,000 acre-feet.

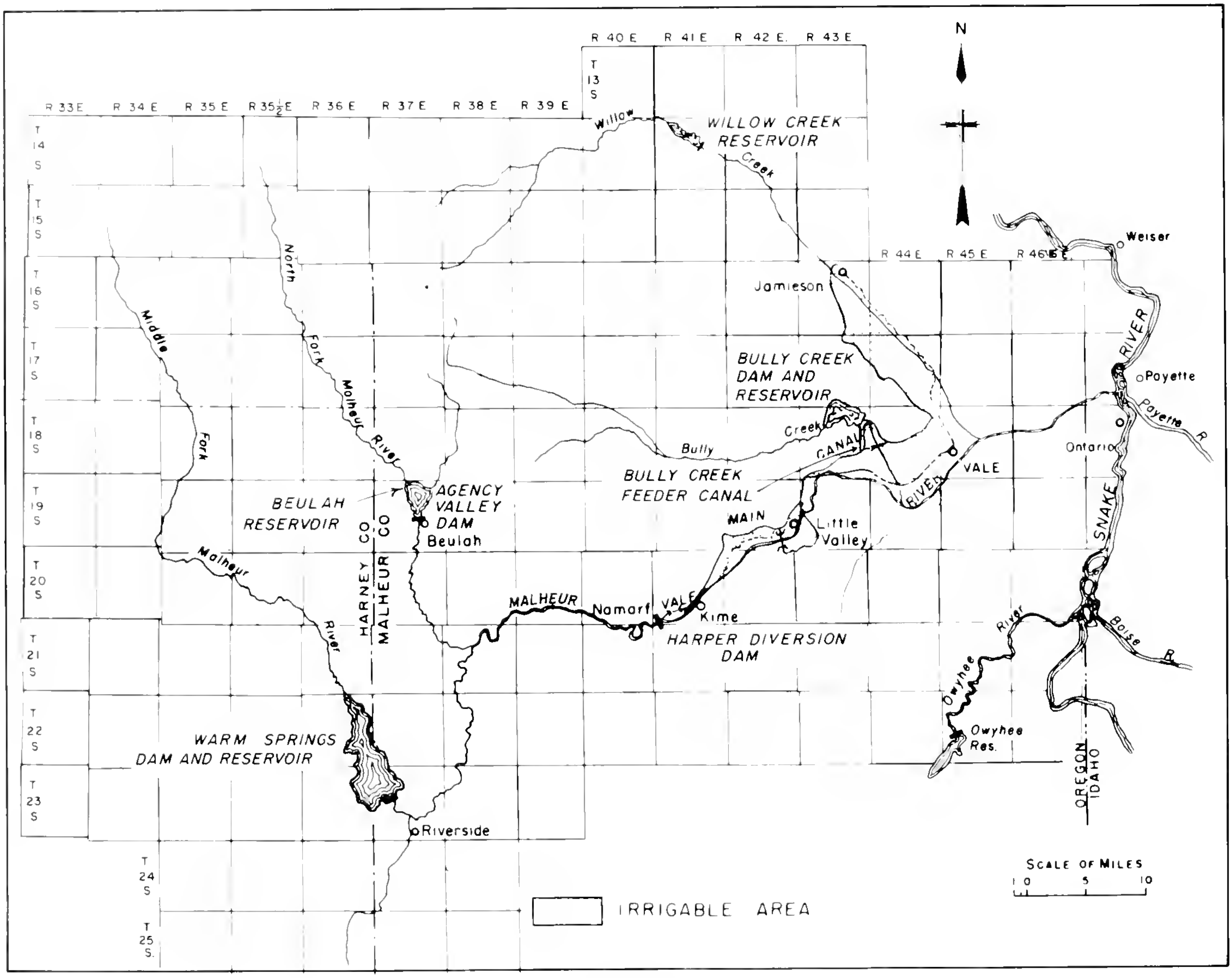
Bully Creek Dam and Reservoir

Bully Creek Dam is located on Bully Creek about 8 miles northwest of the creek's confluence with the Malheur River, and 9 miles northwest of Vale, Oreg. The dam is a zoned earthfill structure with a crest length of 3,070 feet and total height of 121 feet. The reservoir has an active capacity of 30,000 acre-feet.

Diversion Works, Canal, and Drainage Systems

Harper Diversion Dam, on the Malheur River 20 miles southwest of Vale, is a concrete slab with hinged steel

Warm Springs Dam and Reservoir



Vale Project

gates and an embankment wing. The dam raises the water level of the river 12 feet for diversion into Vale Main Canal.

Vale Main Canal extends 74 miles from the diversion dam to a point near Jamieson. The canal has an initial capacity of 662 cubic feet per second.

Bully Creek Diversion Dam on Bully Creek has a hydraulic height of 4 feet and a crest length of 213 feet. The dam is a rockfill structure with a timber cutoff.

Laterals with a cumulative length of 279 miles distribute the water to the land. There are 122 miles of drains on the project.

DEVELOPMENT

Early History

Lands now included in the Vale Project were irrigated in 1881 by settlers who built small distribution systems that diverted water directly from the Malheur River. Independent ditch companies were formed as irrigated acreages increased, and by 1929 more than 63,000 acres were being irrigated.

The Warmsprings Irrigation District was organized in 1919 to build the Warm Springs Dam with private capital raised through the sale of bonds. While it was recognized at the time the dam was built that the reservoir capacity of 191,000 acre-feet would be in excess of the needs of the district, it was evident that this capacity could be provided at the lowest cost per acre-foot of water stored. Overestimates of the irrigable lands in the district were also a factor. The resulting too-liberal use of the surplus water and the lack of adequate drainage caused the water table to rise and reduced the area which could be farmed. At the same time, overapplication of irrigation water increased the need for drainage.

Investigations

At the request of local interests, the Bureau of Reclamation began investigations in 1925 to determine the feasibility of developing a project in the area. A report was submitted which served as the basis for authorization of the initial project.

An irrigation project on Bully Creek was proposed about 1911 by private interests but proved infeasible. When investigations for the Bully Creek Extension were initiated by the Bureau of Reclamation in 1938, it was planned that the project would provide storage on Bully Creek at the Hendrix Reservoir site for about 7,045 acres of land within and adjacent to the existing Vale Project. Landowners in the Brogan area expressed a desire to be excluded from the project and, consequently, a revised 5,000-acre irrigation plan was approved by the Secretary of the Interior and sent to the President for approval in September 1943. The approval was not forthcoming because of the war emergency and scarcity of construction materials. In September 1957, the feasibility report on the extension that provided for increasing the project from 32,000 to 35,000 acres formed the basis for subsequent authorization.

Authorization

Construction of the Vale Project was authorized by the President on October 21, 1926. The Bully Creek Extension was authorized by Public Law 86-248, dated September 9, 1959 (73 Stat. 478).

Construction

A contract between the Federal Government and the Vale Oregon Irrigation District was signed October 22, 1926. The contract provided for the purchase of one-half interest in Warm Springs Reservoir by the Bureau of Reclamation, construction of a diversion dam, main canal, branch canals, structures in connection therewith, and construction of necessary drainage works for the Warmsprings Irrigation District. Construction began on March 3, 1927.

The first units of the Vale Project (Harper and Little Valley) were opened to irrigation in 1930. The last unit to receive irrigation water was the Willow Creek unit in 1938. On March 28, 1932, a supplemental contract was executed with the Vale Oregon Irrigation District that provided for construction of Agency Valley Dam on the North Fork of the Malheur River to add storage needed for an adequate water supply. The dam was completed in 1935.

Facilities of the Bully Creek Extension, primarily Bully Creek Dam and Reservoir, Feeder Canal, Diversion Dam, and laterals, were constructed during 1962-64.

Operating Agency

The project is operated and maintained by the Vale Oregon Irrigation District.

BENEFITS

Irrigation

Almost 35,000 acres of sagebrush and rangeland have been transformed into productive farmland. Principal crops produced are grain, hay, pasture, sugar beets, sweet corn, and potatoes.

Flood Control

Bully Creek Reservoir provides specific storage space for flood control purposes and is instrumental in reducing floods on the Malheur River that could cause considerable damage and losses, and in controlling flood damages along Bully Creek and on the Malheur River below the mouth of Bully Creek. The three reservoirs are operated on a coordinated forecast basis for flood control.

Recreation and Fish and Wildlife

Bully Creek Reservoir lies in a narrow, curving valley bounded on both sides by steep hills. With 7 miles of shoreline, it is the smallest of the three reservoirs. Recreation facilities include a campground, swimming beach, and boat launching and mooring facilities. The reservoir fishery provides excellent catches of white crappie, yellow perch, and black bass. The reservoir is used as a resting place by migratory waterfowl with some ducks remaining to nest. Sparse vegetative cover of sagebrush and grass provides habitat for small mammals and birds.

Beulah Reservoir is nestled in Agency Valley, almost filling the small triangular valley. There are campgrounds and facilities for launching and mooring boats at the reservoir, which has a stocked trout fishery. A wide variety of migrating waterfowl use the reservoir, with heavy use by Canada geese. The thick vegetative cover, composed of sagebrush, grass, and occasional juniper, provides excellent wildlife habitat for mule deer and elk in addition to the small mammals and birds that are residents of the reservoir area.

Warm Springs Reservoir lies against the tall, steep hills on the eastern side of a broad valley. There are no recreation facilities at the reservoir, so primary use is fishing for black bass, yellow perch, and rainbow trout. Migrating waterfowl use the reservoir, and it is a part of the winter range for mule deer. The area is not heavily used, due in part to the sparse vegetation, mainly sagebrush.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	34,993	acres
Number of irrigated farms	391	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	33,626	2,905,333
1969	33,754	2,920,998
1970	33,306	2,927,324
1971	33,711	3,256,730
1972	33,666	3,467,055
1973	34,385	4,772,333
1974	34,608	6,185,674
1975	34,446	5,888,733
1976	34,583	5,197,157
1977	34,236	4,168,837

Facilities in Operation

Storage dams	3	
Diversion dams	2	
Canals	86	mi
Laterals	279	mi
Drains	122	mi

Climatic Conditions

Annual precipitation	9.1	in
Temperature:		
Maximum	106	°F
Minimum	−27	°F
Mean	52	°F
Growing season	159	days
Elevation of irrigable area	2500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	1,297
Other water service[1]	70
Total	1,367

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

North Fork, Malheur River

Drainage area above Beulah Reservoir	440	mi²
Annual discharge at Beulah Reservoir:		
Maximum (1974)	194,100	acre-ft
Minimum (1977)	31,300	acre-ft
Average	105,400	acre-ft

Middle Fork, Malheur River

Drainage area above Warm Springs Reservoir	1,100	mi²
Annual discharge at Warm Springs Reservoir:		
Maximum (1965)	296,600	acre-ft
Minimum (1977)	25,600	acre-ft
Average	149,900	acre-ft

Bully Creek

Drainage area above Bully Creek Dam	547	mi²
Annual discharge at Bully Creek Dam:		
Maximum (1965)	76,200	acre-ft
Minimum (1966)	6,400	acre-ft
Average	35,100	acre-ft
Average annual diversions by Vale Oregon Irrigation District (1963-77)	174,120	acre-ft

Storage Facilities

Agency Valley Dam

Type: Zoned earthfill
Location: On the North Fork of Malheur River near Beulah, Oreg.
Construction period: 1934-35
Date of closure (first storage): January 1, 1936[2]

Reservoir, Beulah:		
Total capacity to El. 3340	60,000	acre-ft
Surface area	1,900	acres
Dimensions:		
Structural height	110	ft
Hydraulic height	83	ft
Top width	35	ft
Maximum base width	552	ft
Crest length	1,850	ft
Crest elevation	3348.0	ft
Total volume	646,000	yd³
Spillway: Concrete-lined channel in right abutment controlled by three 18- by 17-ft radial gates.		
Elevation, top of gates	3340.0	ft
Crest elevation	3323.0	ft
Capacity at El. 3340	10,000	ft³/s
Outlet works: Concrete-lined tunnel through right abutment controlled by two 36-in needle valves at outlet end.		
Capacity at El. 3340	600	ft³/s

Foundation: Shale; basalt flows at right abutment. Special treatment: Cement-grout curtain beneath cutoff walls; supplementary grouting at right abutment.

Warm Springs Dam

Type: Concrete thin arch
Location: On Middle Fork of Malheur River 35 mi southwest of Harper, Oreg.
Construction period: 1918-19
Privately constructed. Reclamation purchased half interest in dam and reservoir in 1926.

Reservoir, Warm Springs:		
Total capacity to El. 3406	192,400	acre-ft
Active capacity	191,000	acre-ft
Surface area	4,600	acres
Dimensions:		
Structural height	106	ft
Hydraulic height	92	ft
Top width	8	ft
Maximum base width	28	ft
Crest length	469	ft
Crest elevation	3409.0	ft
Total volume	19,500	yd³
Spillway: Overflow section in dam		
Crest length	324	ft
Crest elevation with 5-ft flashboards	3406.0	ft

[2]River diverted through outlet works on February 20, 1935.

Capacity at El. 3406[3]	12,000	ft³/s
Outlet works: Two openings through base of dam, each controlled by a 3.25- by 6-ft gate.		
Capacity at El. 3406	2,000	ft³/s
Foundation: Series of olivine basalt flows. Special treatment: Pressure grouting along downstream toe.		

Bully Creek Dam

Type: Zoned earthfill		
Location: On Bully Creek in Malheur County, Oreg., 8 mi northwest of Vale.		
Construction period: 1962-63		
Date of closure (first storage): February 1, 1963		
Reservoir, Bully Creek:		
Total capacity to El. 2516	31,600	acre-ft
Active capacity	30,000	acre-ft
Surface area	985	acres
Dimensions:		
Structural height	121	ft
Hydraulic height	99	ft
Top width	30	ft
Maximum base width	665	ft
Crest length	3,070	ft
Crest elevation	2529.0	ft
Total volume	1,017,210	yd³
Spillway: Concrete-lined in right abutment, 70 ft wide by 450 ft long, controlled by ten 48-in-square sluice gates.		
Elevation, top of gates	2516.0	ft
Capacity at El. 2516	4,970	ft³/s
Outlet works: Concrete conduit located in left abutment, 4.67 ft in diameter and 235.5 ft long, leading to gated chamber. Extending from gate chamber to bifurcation for Lateral 197-13 outlet and Bully Creek outlet.		
Capacity, Lateral 197-13 outlet	300	ft³/s
Capacity, Bully Creek outlet	280	ft³/s

[3]Capacity without flashboards.

Diversion Facilities

Harper Diversion Dam

Type: Concrete gate structure with embankment wing		
Location: On Malheur River, 20 mi southwest of Vale, Oreg.		
Year completed: 1929		
Dimensions:		
Structural height	21	ft
Hydraulic height	12	ft
Crest length	914	ft
Crest elevation	2647.0	ft
Volume	9,300	yd³
Spillway: Seven 20- by 10-ft hinged steel gates.		
Headworks: 10.5- by 13-ft canal radial headgate discharging into intake portal of a tunnel.		
Diversion capacity	662	ft³/s

Bully Creek Diversion Dam

Type: Rockfill with timber cutoff		
Location: On Bully Creek 1 mile downstream from Bully Creek Dam.		
Year completed: 1964		
Dimensions:		
Structural height	12	ft
Hydraulic height	4	ft
Crest length	213	ft
Crest elevation	2407.5	ft
Volume	3,760	yd³
Spillway: 10- by 6-ft radial gate in reinforced concrete sluiceway.		
Headworks: Two 5- by 3-ft steel slide gates discharging into Lateral 197-20.		
Diversion capacity: Present lateral limits diversion capacity to 26.7 ft³/s. Lateral section designed for, and can be enlarged to, a future capacity of 99 ft³/s.		

Carriage Facilities

Vale Main Canal

Location: From Harper Diversion Dam northeast to Vale, then northwest to Jamieson.		
Construction period: 1927-35		
Length	74	mi
Diversion capacity	662	ft³/s
Typical maximum section in earth:		
Bottom width	22	ft
Side slopes	1.5:1	
Water depth	7.6	ft
Typical maximum section, concrete lined:		
Bottom width	10	ft
Side slopes	1.5:1	
Water depth	7.3	ft
Lining thickness	3	in

Tunnel No. 1 (Vale Main Canal)

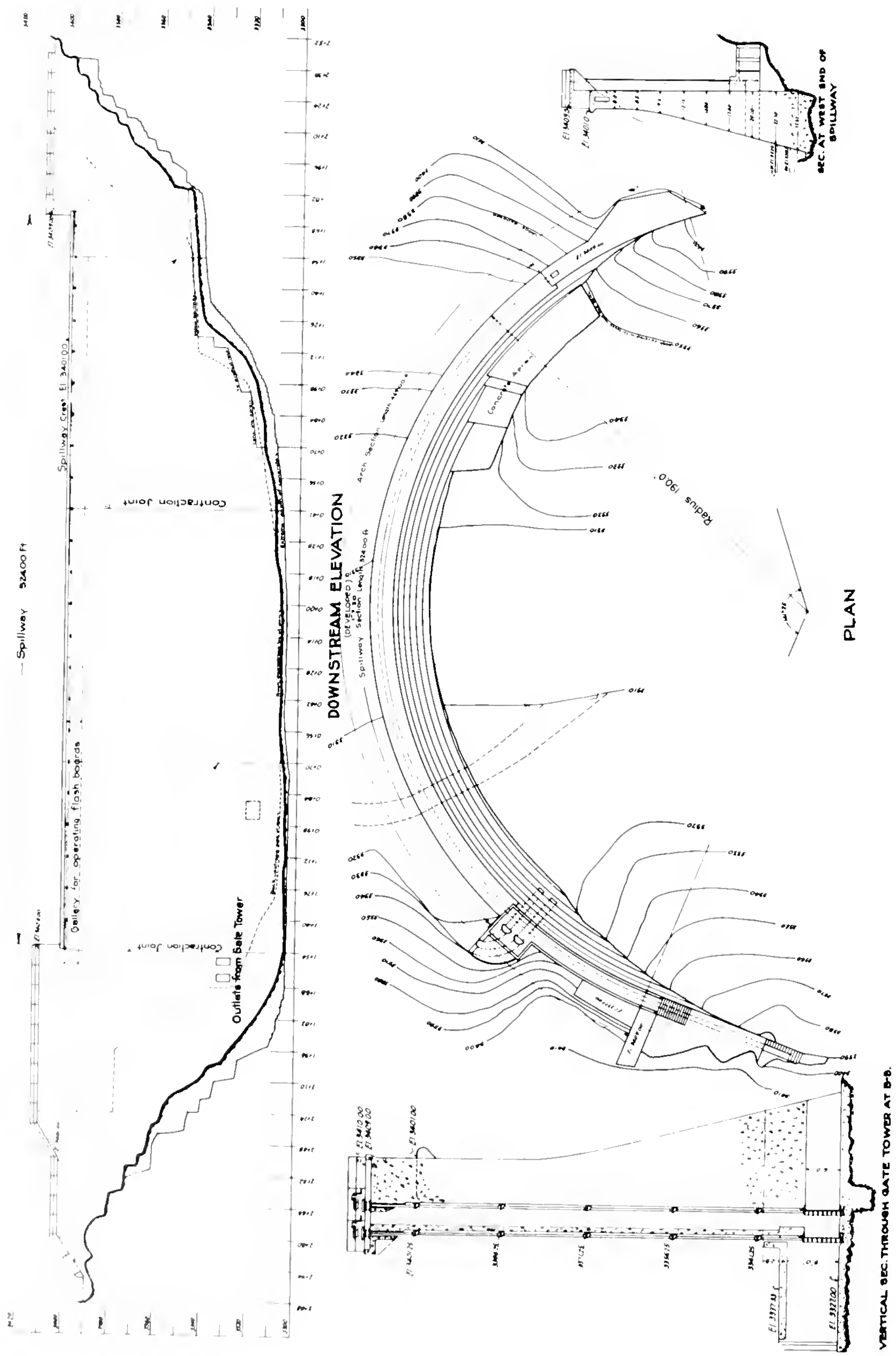
Location: At Harper Diversion Dam.		
Construction period: 1928-29		
Length	2,150	ft
Capacity	662	ft³/s
Cross section: Horseshoe		
Diameter	10.5	ft
Water depth	8.6	ft
Concrete lining	6-10	in

Little Valley Canal

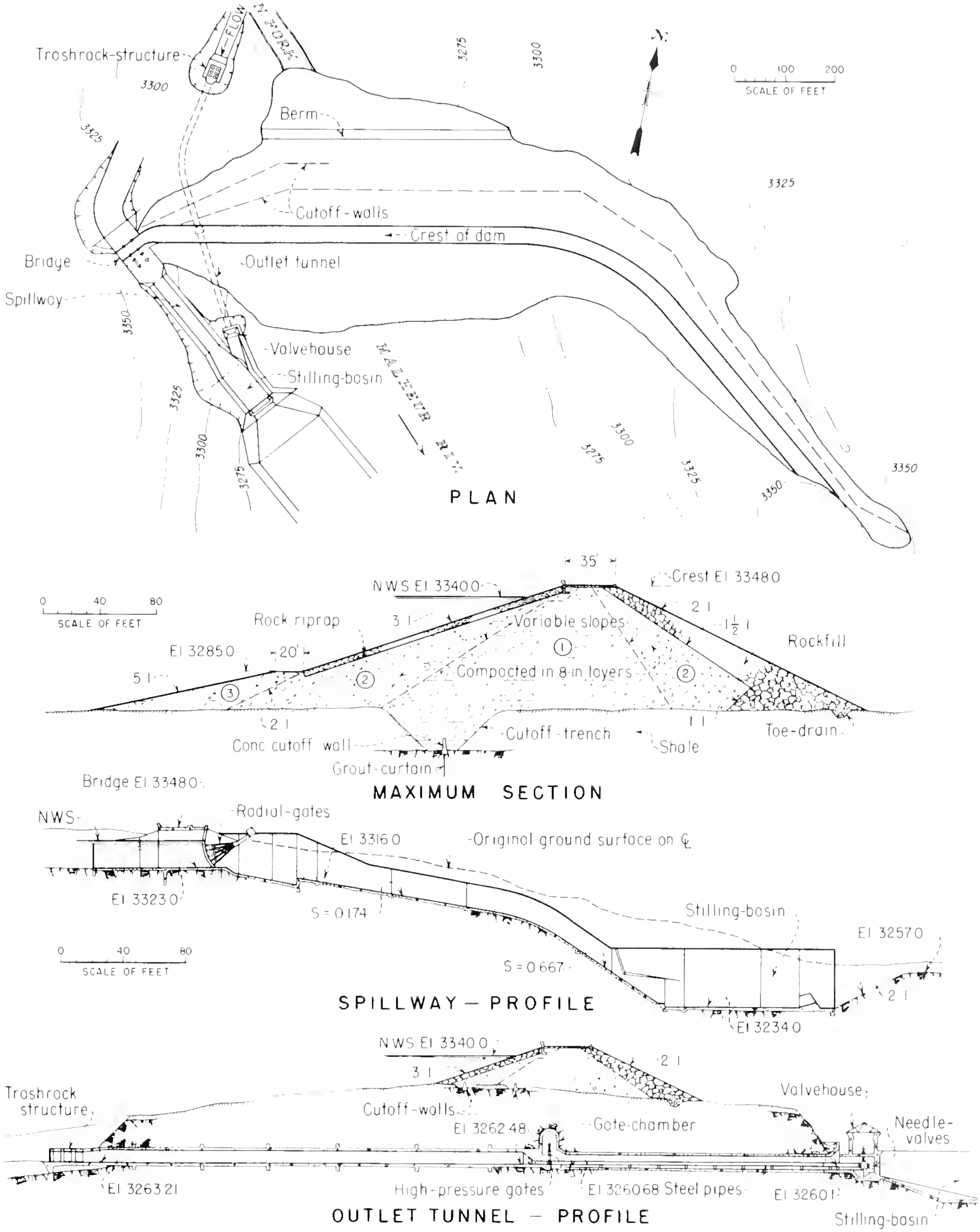
Location: About 5 mi east of Harper, Oreg.		
Construction period: 1929-30		
Length	8	mi
Diversion capacity	33.4	ft³/s
Typical maximum section in earth:		
Bottom width	4	ft
Side slopes	1.5:1	
Water depth	2.3	ft

Bully Creek Feeder Canal

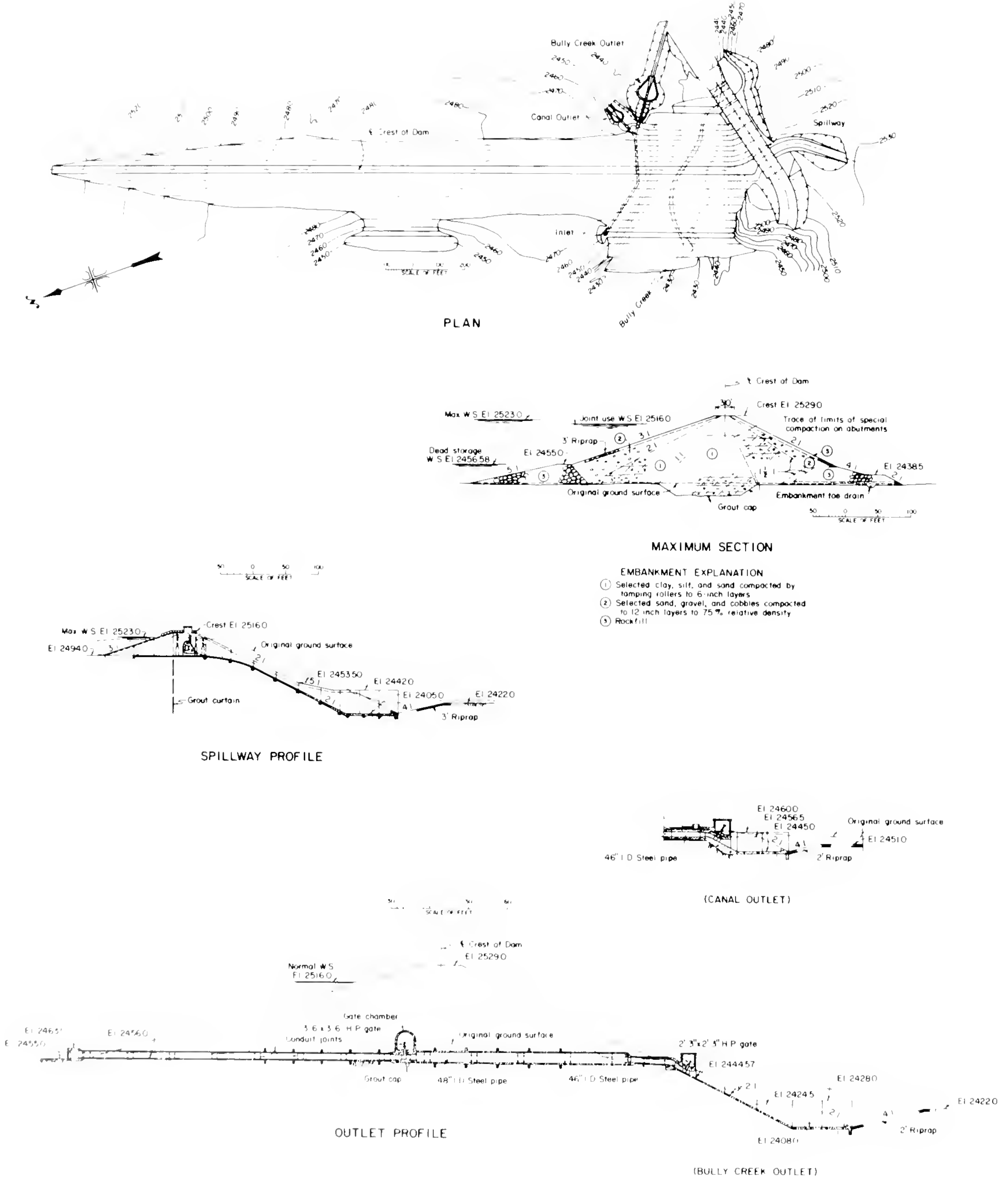
Location: From intake structure on Vale Main Canal about 8 mi west of Vale northwest to Bully Creek Reservoir.		
Construction period: 1962-63		
Length	2.5	mi
Diversion capacity	300	ft³/s
Typical maximum section:		
Bottom width	16	ft
Side slopes	1.5:1	
Water depth	5.5	ft



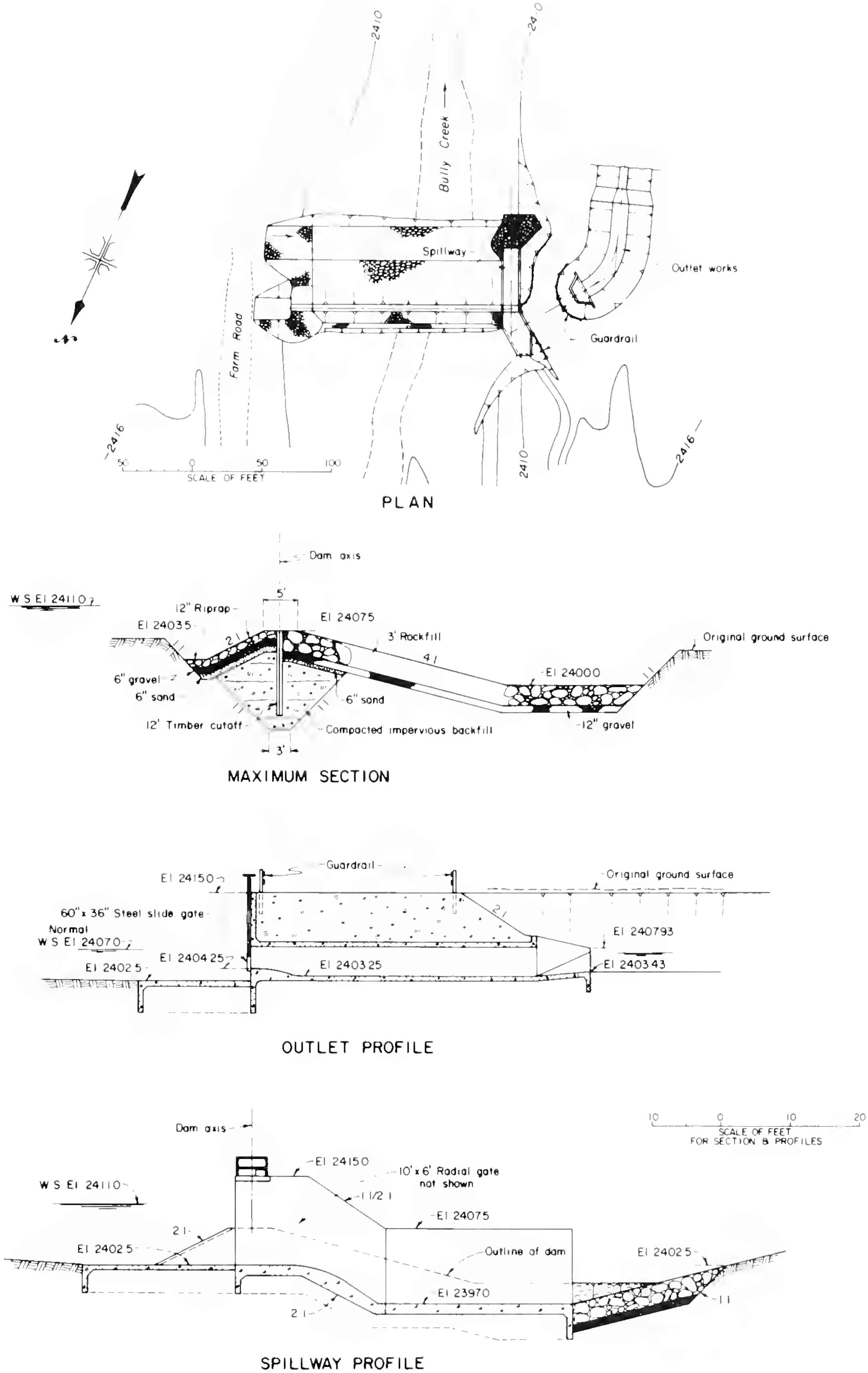
Warm Springs Dam, Plan and Sections



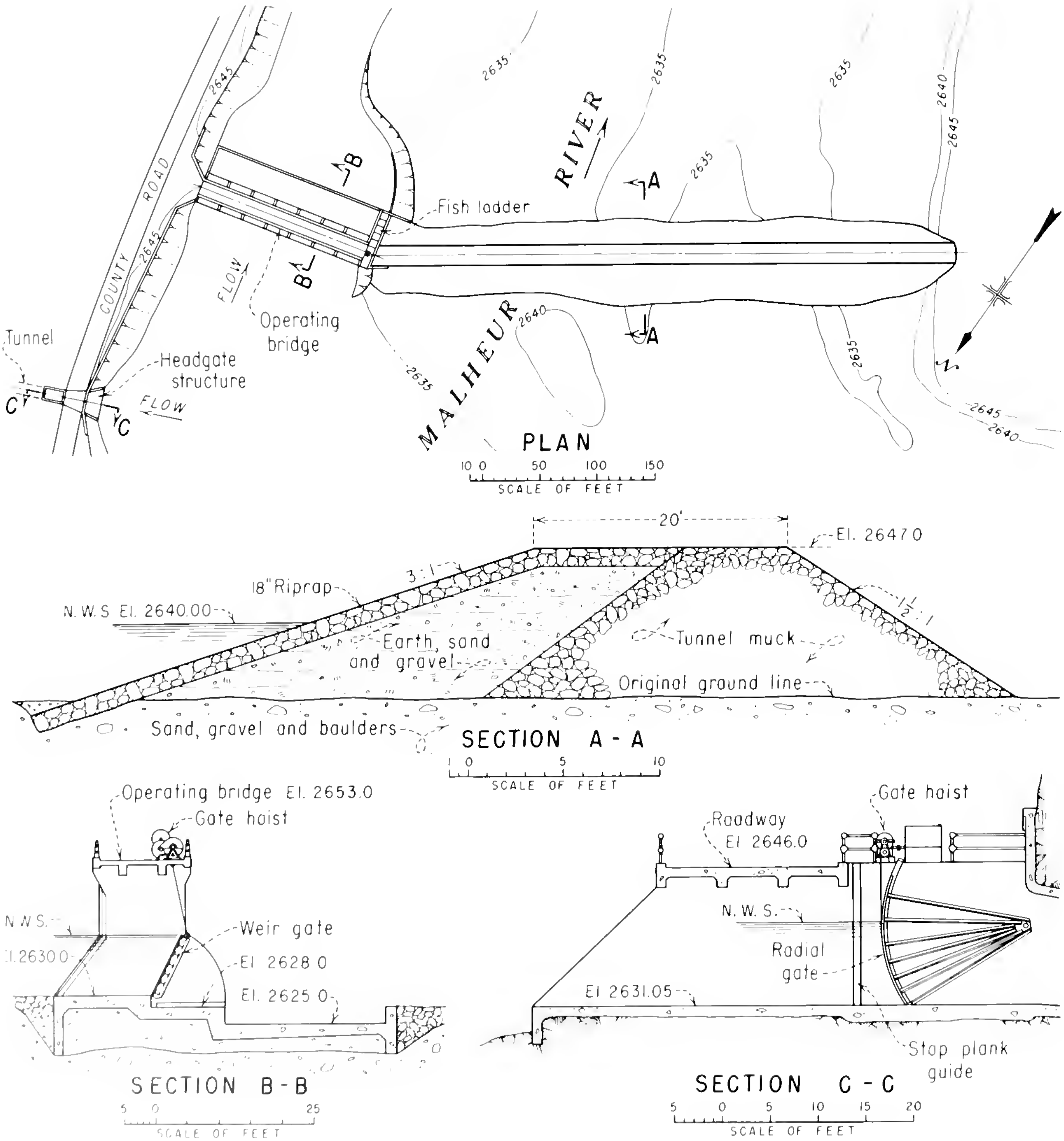
Agency Valley Dam, Plan and Sections



Bully Creek Dam, Plan and Sections



Bully Creek Diversion Dam, Plan and Sections

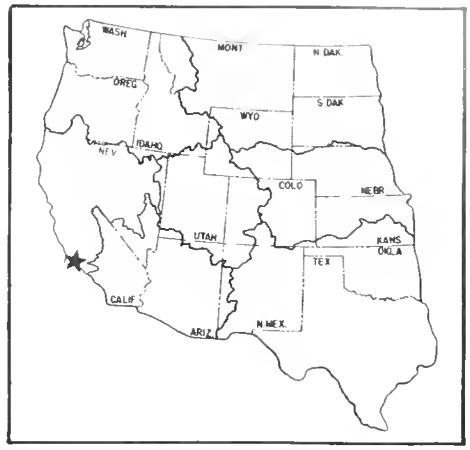


Harper Diversion Dam, Plan and Sections

Ventura River Project

California: Ventura County

Mid-Pacific Region
Water and Power Resources Service

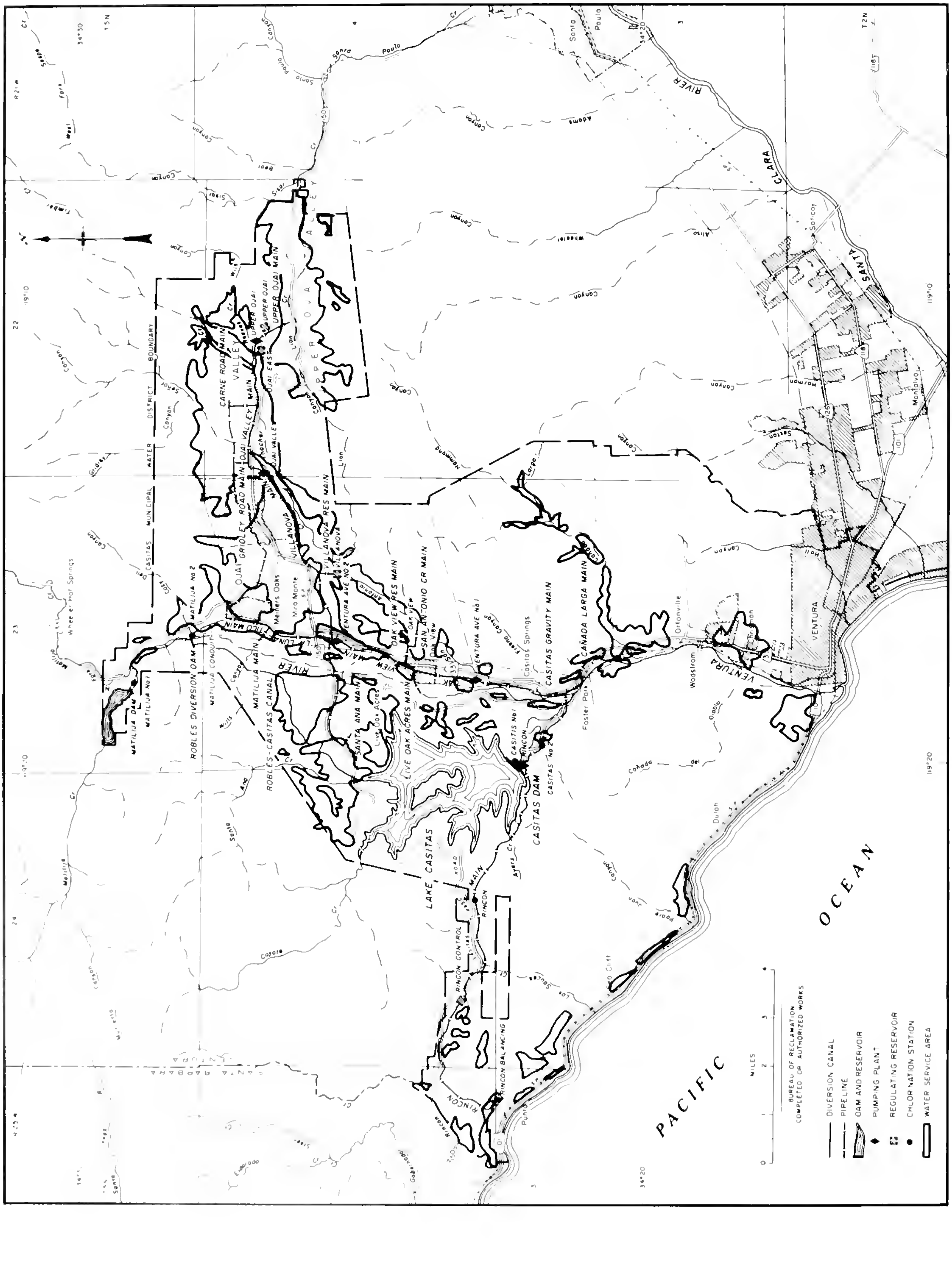


The Ventura River Project, in southern California about 60 miles northwest of Los Angeles, furnishes an irrigation water supply to about 13,200 irrigable acres of land, and municipal and industrial water to approximately 39,000 users in urban and suburban areas within the Casitas Municipal Water District (formerly the Ventura River Municipal Water District). The project was authorized in 1956. The Ventura River and its tributaries are the main water sources for the project.

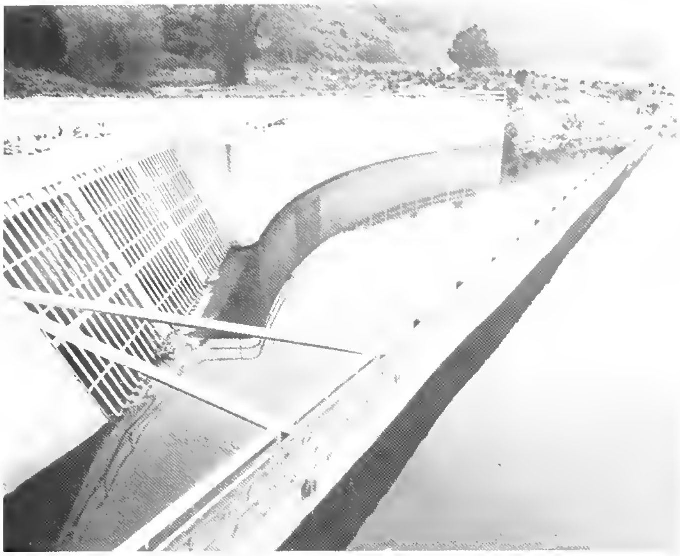
PLAN

The Ventura River Project comprises a storage reservoir on Coyote Creek, a diversion dam on the Ventura River, a canal to carry water from the diversion dam to the reservoir, and a high-pressure pipeline distribution system. The distribution system has pumping plants and balancing reservoirs to distribute the water from Lake Casitas to the various areas within the project for irrigation, municipal, and industrial uses. Use of waters from

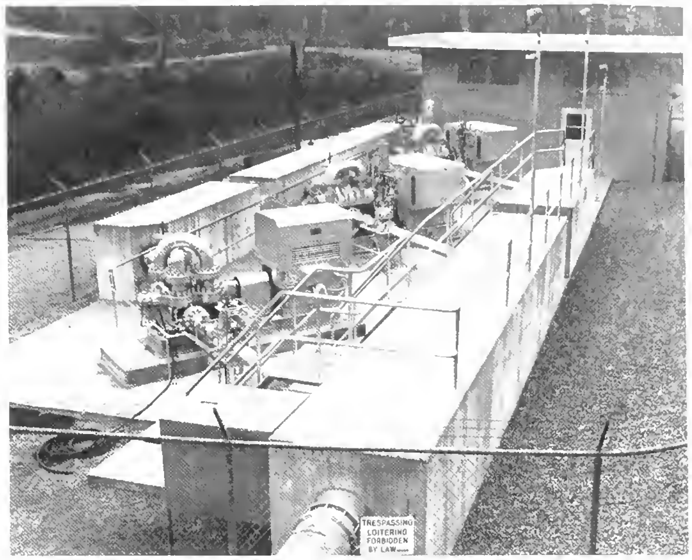
Casitas Dam and Reservoir



Ventura River Project



Robles Diversion Dam



Rincon Pumping Plant

Matilija Dam, built by Ventura County and placed in operation in 1948, is incorporated in the overall plan for operation of the project.

Casitas Dam and Reservoir

Casitas Dam is located on Coyote Creek about 2 miles above the junction of the creek and the Ventura River. The reservoir, which has a storage capacity of 254,000 acre-feet, regulates flows along the lower reaches of Coyote Creek and stores surplus water for irrigation and municipal purposes. The dam is a 334-foot-high earthfill structure that has a crest length of 2,000 feet and contains a total of 9,310,000 cubic yards of material.

Robles Diversion Dam

Robles Diversion Dam is located on the Ventura River about 1.5 miles downstream from the confluence of Matilija Creek and North Fork Matilija Creek. The dam has a height of 24 feet and a crest length of 530 feet. The structure is rockfilled with a timber cutoff wall and a rolled earth core. The dam diverts water into the headworks of the Robles-Casitas Canal.

Robles-Casitas Canal

Robles-Casitas Canal, with a total length of approximately 5.4 miles and a capacity of 500 cubic feet per second, conveys water from Robles Diversion Dam to Lake Casitas. There are 4.5 miles of concrete canal and 0.9 mile of 78-inch reinforced concrete pipe, called the Robles-Casitas Diversion Conduit.

Main Pipeline System

The main pipeline is a pressure-pipe system nearly 34 miles long that consists of reinforced concrete pipe and mortar-lined steel pipe ranging in size from 54 to 12 inches. The main conduit starts at Casitas Dam with a capacity of 121 cubic feet per second. After crossing the Ventura River, the conduit branches to serve the lower area to the west, including the city of Ventura, and the upper area to the north and east of Lake Casitas. The main conduit for the west coastal area has a capacity of 9.6 cubic feet per second at the dam; it passes through a pumping plant and traverses 9.7 miles in a westerly direction over Casitas Pass to the Rincon Balancing Reservoir near the coast.

Pumping Plants

Five pumping plants, Ventura Avenue No. 1 and No. 2, Ojai Valley, Upper Ojai, and Rincon, lift water from the storage level elevation in Lake Casitas to the elevations at the points of delivery.

Balancing Reservoirs, Chlorination Stations, and Distribution System

Six balancing reservoirs, Oak View, Villanova, Ojai East, Upper Ojai, Rincon Control, and Rincon Balancing, are filled from the main conduit during the off-peak hours and are used to help supply the full requirement of water during peak hours and as a carryover supply in case of an emergency. Five chlorination stations are provided, two downstream from the outlet of Lake Casitas, two downstream from the outlet of Matilija Dam, and one between the Rincon Pumping Plant and Rincon Control Reservoir. These stations are operated for the dual purpose of preventing algal growth in the pipelines to maintain their capacity for delivering water, and assuring the safety of the supply for domestic purposes. The Casitas Municipal Water District constructed and operates the distribution system within the project subareas.

DEVELOPMENT

Early History

The Ventura River Basin was visited in 1542 by the Spanish navigators who landed at Ventura Harbor. Agriculture did not become established in the area until about 1782, when the Mission Fathers dedicated San Buenaventura. During the mission days, agricultural activities were devoted to raising crops and livestock to supply the needs of surrounding settlements. Water was diverted from Ventura River near the mouth of Canada Larga. During Mexican rule, prior to the middle of the 19th century, the land was divided into large grants that were subdivided later and sold to settlers. By 1900, more intensive cropping practices had replaced most of the earlier grain farming, and there was a gradual reduction in the size of farms. Production of apples, apricots, and peaches was initiated at an early date. Citrus fruits were successfully introduced into the Ojai and Ventura River Valleys; commercial planting started in the early 1900's. Development of urban communities and population growth within the Ventura River Basin has been rapid, particularly since 1920.

Investigations

Future economic growth of the area was dependent upon obtaining an additional dependable water supply. The need for more water had been recognized for many years, and investigations of the project area had been made by several organizations. The investigations made by the Bureau of Reclamation were requested by the Board of Directors of the Ventura River Municipal Water District (now the Casitas Municipal Water District). Results of Reclamation's findings were published in a feasibility report dated December 1954, House Document 222, 84th Congress, 1st session, and used as a basis for authorization of the project.

Authorization

The project was authorized by act of the Congress (Public Law 423, 84th Cong., 2d session) approved March 1, 1956.

Construction

Construction of Casitas Dam began in July 1956 and was completed in March 1959; Robles Diversion Dam and five pumping plants were completed in 1959; other distribution works were started in 1957 and completed in 1959.

The Ventura River Municipal Water District advanced funds to the Bureau of Reclamation for investigations and design of the proposed Ventura Project. This permitted almost immediate issuance of specifications and an early start on construction as soon as authorization was given.

Robles-Casitas Canal

Robles-Casitas Canal

Operating Agency

The project is operated by the Casitas Municipal Water District.

BENEFITS

Irrigation

The principal products of the project area are citrus and other fruits. In addition, walnuts and berries contribute substantially to the agricultural produce of the area.

Municipal and Industrial Water

The water needs of 39,000 municipal and industrial users in the city of Ventura and vicinity are met by the project.

Recreation

Lake Casitas offers fishing, boating, camping, and picnicking activities. The Lake Casitas recreation area is under the management of the Casitas Municipal Water District.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	7,957	acres
Supplemental irrigation service	5,243	acres
Total	13,200	acres
Number of irrigated farms	174	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	3,172	3,620,239
1969	3,253	2,618,915
1970	3,396	2,748,110
1971	3,317	2,855,699
1972	3,268	3,618,359
1973	3,049	6,661,452
1974	4,192	7,055,027
1975	4,973	8,896,619
1976	5,081	8,093,562
1977	5,200	7,634,054

Facilities in Operation

Storage dams	1	
Diversion dams	1	
Canals	4.5	mi
Pumping plants	3	
Pipelines	34.8	mi

Climatic Conditions

Annual precipitation	14.2	in
Temperature:		
Maximum	119	°F
Minimum	13	°F
Mean	59	°F
Growing season	365	days
Elevation of irrigable area	1000.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	449
Urban/suburban irrigation service	6,800
Municipal and other water service	38,883
Total	46,132

ENGINEERING DATA

Water Supply

Ventura River

Drainage area at Robles Diversion Dam	76.4	mi²
Annual discharge at Robles Diversion Dam:		
Maximum (1969)	28,000	acre-ft
Minimum (frequently)	0	acre-ft
Average	13,660	acre-ft

Coyote Creek

Drainage area at mouth of Ventura River	41.2	mi²
Annual discharge at mouth of Ventura River:		
Maximum (1973)	930	acre-ft
Minimum (1951)	0	acre-ft
Average	302	acre-ft

Storage Facilities

Casitas Dam

Type: Zoned earthfill		
Location: On Coyote Creek about 6.5 mi northwest of Ventura, Calif.		
Construction period: 1956-59		
Reservoir, Lake Casitas:		
Average annual inflow, 1918-52	26,300	acre-ft
Total capacity	254,000	acre-ft
Active capacity	251,000	acre-ft
Surface area	2,700	acres
Shoreline	31	mi
Dimensions:		
Structural height	334	ft
Hydraulic height	261	ft
Top width	40	ft
Maximum base width	1,835	ft
Crest length	2,000	ft
Crest elevation	585.0	ft
Total volume	9,310,000	yd³
Spillway: Concrete chute on left abutment of dam.		
Capacity, El. 578.7	7,400	ft³/s
Outlet works: Concrete-lined 8-ft-diameter tunnel 800 ft long, and concrete-lined 8-ft horseshoe tunnel 1,000 ft long containing 51-in-diameter steel pipe. Controlled by one 4-ft-square high-pressure gate and one 48-in hollow-jet valve.		
Capacity at El. 567	570	ft³/s

Diversion Facilities

Robles Diversion Dam

Type: Rockfill weir, timber cutoff wall		
Location: On the Ventura River about 12 mi north of Ventura, Calif.		
Year completed: 1958		
Dimensions:		
Structural height	24	ft
Hydraulic height	13	ft
Crest length[1]	530	ft
Crest elevation	765.0	ft
Volume[2]	11,000	yd³
Diversion capacity	500	ft³/s

[1]Crest length of weir only.
[2]Volume of weir only.

Carriage Facilities

ROBLES-CASITAS CANAL

Location: From Robles Diversion Dam southwest to Casitas Reservoir.
Construction period: 1957-58

Length	4.5 mi
Capacity	500 ft³/s
Section (initial reach):	
Bottom width	7 ft
Side slopes	1.5:1
Water depth	5.6 ft

MAIN PIPELINE SYSTEM

Location: From Casitas Dam west to near Punta, Calif., northeast to the Upper Ojai Valley, and then south about 1 mi to Foster Park, Calif.
Construction period: 1957-59

Length	33.9 mi
Capacity	121 ft³/s
Diameter	54-12 in

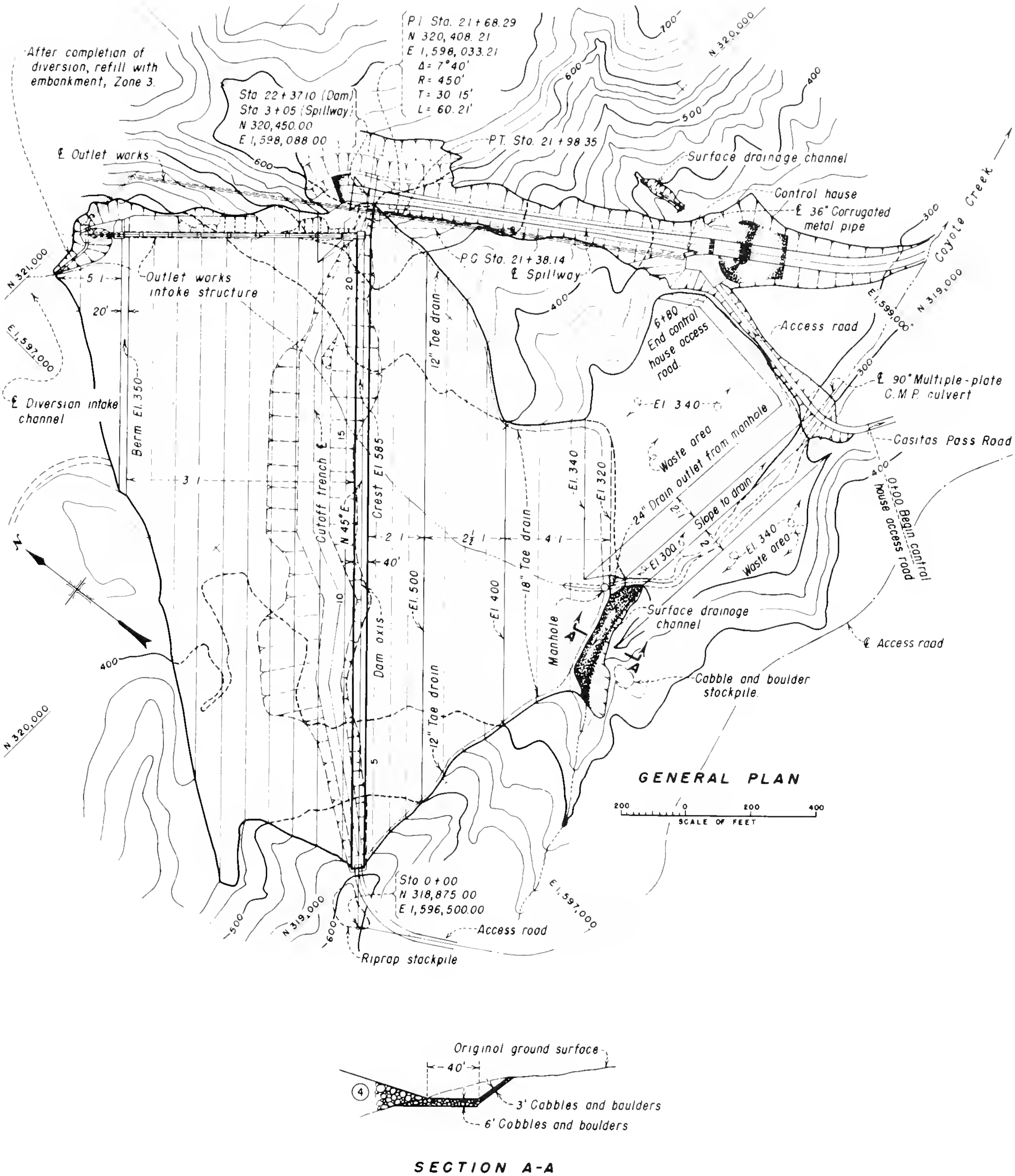
ROBLES-CASITAS DIVERSION CONDUIT

Location: An integral part of the Robles-Casitas Canal which extends from the Robles Diversion Dam to Casitas Reservoir.
Construction period: 1957-59

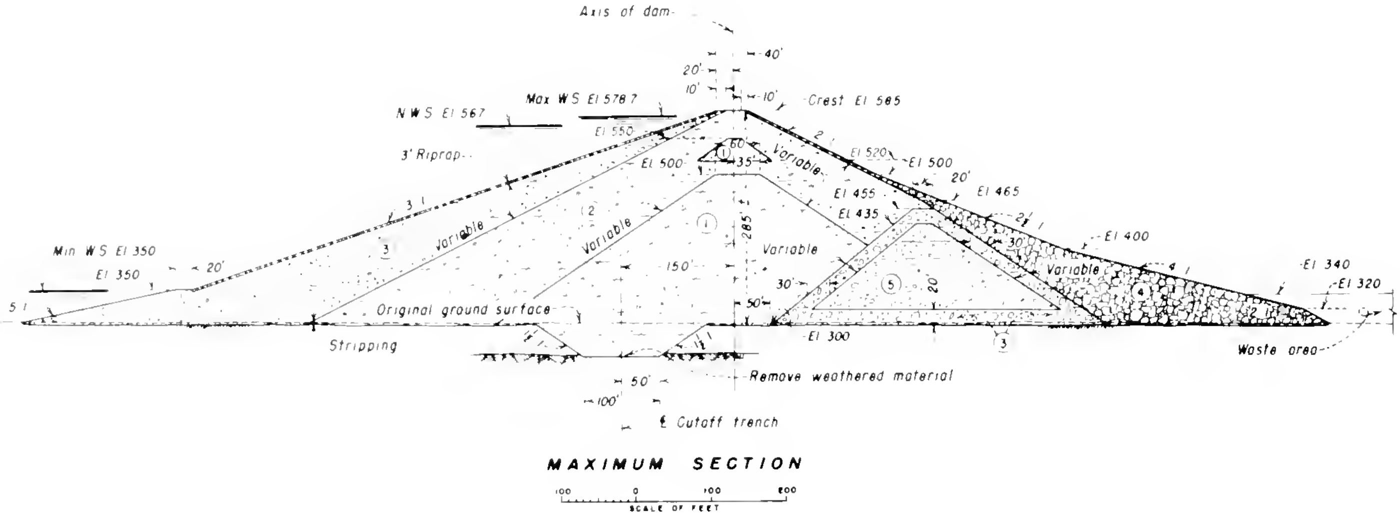
Length	0.9 mi
Capacity	500 ft³/s
Type: Reinforced concrete	
Diameter	78 in

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Rincon	2	6	900	1,040
Ventura Avenue No. 1	4	50	429	3,200
Ventura Avenue No. 2	3	48	220	1,800
Ojai Valley	3			900
Upper Ojai	2			560



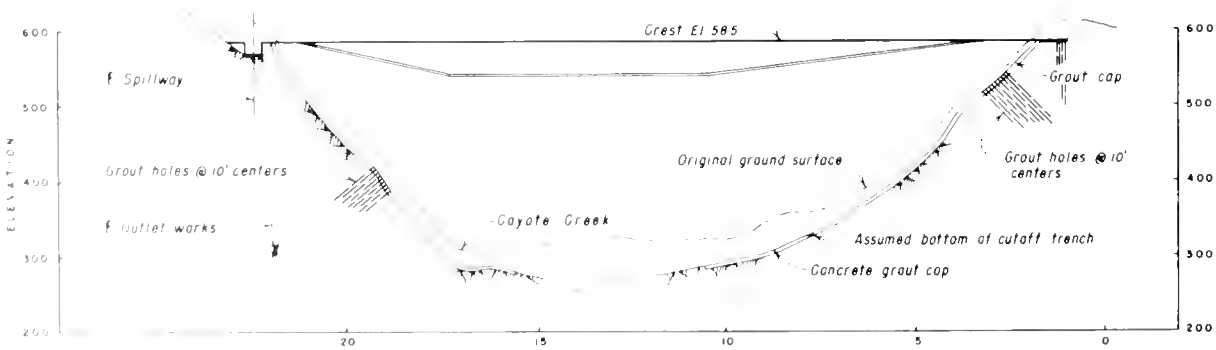
Casitas Dam, Plan



MAXIMUM SECTION

EMBANKMENT EXPLANATION

1. Selected clay, silt, and sand compacted by tamping rollers to 6-inch layers
2. Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers
3. Selected sand, gravel, and cobbles compacted by crawler-type tractor to 12-inch layers
4. Cobbles and boulders dumped in 3-foot layers
5. Selected miscellaneous material compacted by tamping rollers to 6-inch layers



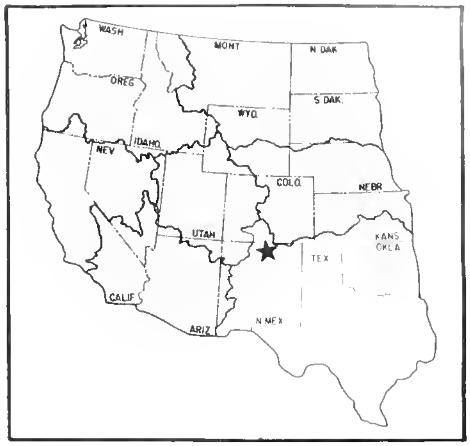
PROFILE ON ℄ OF CUTOFF TRENCH
AXIS STATIONS (PROJECTED)

Casitas Dam, Sections

Vermejo Project

New Mexico: Colfax County

Southwest Region
Water and Power Resources Service



The Vermejo Project, near Maxwell, N. Mex., includes Vermejo Diversion Dam, Vermejo Canal, Eagle Tail Heading, Eagle Tail Canal, Stubblefield Dam and Reservoir, Dams and Reservoirs No. 2, 12, 13, and 14, and a distribution system to serve 7,379 acres of land. The project was constructed by a private company, and rehabilitated by the Bureau of Reclamation. Stubblefield Dam and the Eagle Tail Canal Heading are essentially new structures.

PLAN

Water for the project is diverted from Vermejo River and Chico Rico Creek. Offstream storage reservoirs are used to store the water, which flows to the land through a privately constructed distribution system.

Vermejo Diversion Dam

The Vermejo Diversion Dam is the headworks for the Vermejo Canal. The 300-foot-long dam is a concrete weir structure with an embankment wing, and was constructed by one of the early irrigation companies. The Bureau of Reclamation rehabilitated the dam, and modified the canal headworks to provide a maximum diversion of 600 cubic feet per second into Vermejo Canal.

Vermejo Canal

Water is conveyed to Stubblefield Reservoir and Reservoir No. 2 through Vermejo Canal. The canal has an initial capacity of 600 cubic feet per second; the capacity is 300 cubic feet per second at the Stubblefield Bifurcation Works. With the canal flowing at full capacity at Stubblefield Bifurcation, 300 cubic feet per second pass through Stubblefield Inflow Chute and Canal into Stubblefield Reservoir, and 300 cubic feet per second continue to Reservoir No. 2.

Eagle Tail Heading and Canal

Located in the old Hebron Reservoir area, the Eagle Tail Heading diverts the flow of Chico Rico Creek into Eagle Tail Canal. Floods in excess of 300 cubic feet per second, the capacity of Eagle Tail Canal, are conveyed through a 1,000-foot unlined floodway section to the Canadian River.

The 15.5-mile Eagle Tail Canal delivers water to offstream storage reservoirs within the project area. The canal crosses and intercepts the entire flow of Willow and Curtis Creeks.

Stubblefield Dam and Reservoir

Water from Vermejo River is stored in this reservoir, which has an active capacity of 12,205 acre-feet. The reservoir is formed by a modified homogeneous earthfill dam 10,119 feet in length with a maximum height of 47 feet above streambed. A 300-foot-wide emergency spillway is located at the south end of the dam. The outlet for releasing water to Stubblefield Lateral is a concrete conduit controlled by a metal slide gate.

Dam and Reservoir No. 2

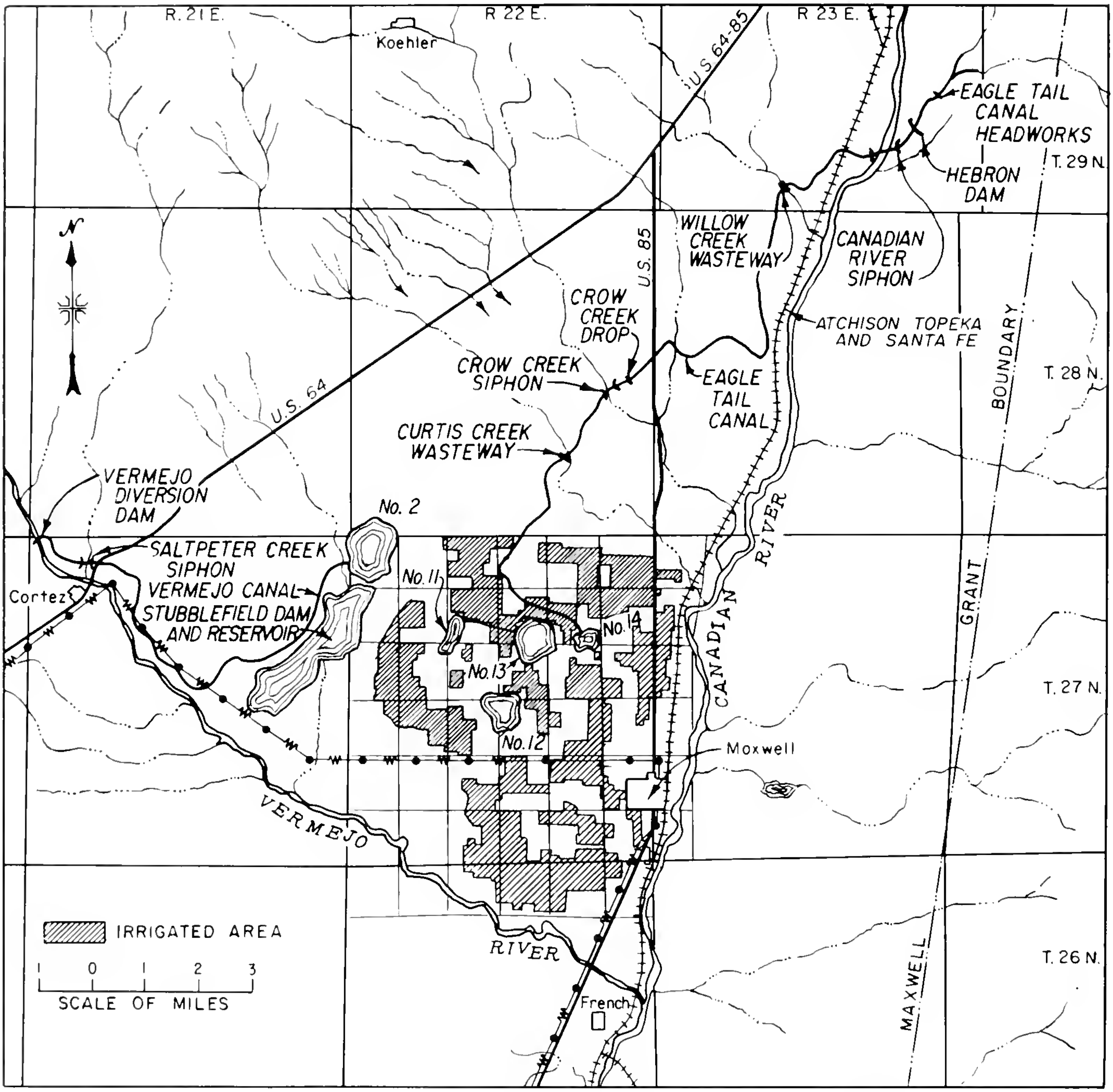
This homogeneous earthfill dam is 10,730 feet long and 12 feet high. The active capacity of 2,063 acre-feet of water is received from the Vermejo River. A 128-cubic-foot-per-second canal outlet on the east side of the reservoir releases irrigation water into the Laguna Lateral system.

Dam and Reservoir No. 13

The reservoir, with an active capacity of 4,783 acre-feet, is formed by an earthfill dam 8,003 feet long and 32 feet high. A 30-cubic-foot-per-second-capacity concrete conduit canal outlet releases water for the No. 13 lateral system.

Dam and Reservoir No. 12

Dam No. 12 was constructed during the earlier period of the irrigation development. The project plan provides for



Vermejo Project

rehabilitation of the dam and reservoir. However, work has been deferred until sediment accumulation in Reservoir No. 13 will necessitate additional storage.

Distribution System

This system of laterals, which range in capacities from 5 to 80 cubic feet per second and have a total length of about 65 miles, has the capacity to convey water from the storage reservoirs to 7,379 acres of irrigable land. Stubblefield, Eagle Tail, and Laguna Eagle Tail Laterals connect Stubblefield Reservoir and Reservoir No. 2 with Eagle Tail Canal, so water from Vermejo River can be used in the Eagle Tail system.

DEVELOPMENT

Early History

Development of the project area was first undertaken by the trustees of the Maxwell Land Grant Company in 1888. A supply ditch, known as the High Line Vermejo Canal, was constructed with its headgate on a branch of the Vermejo River near Dawson. This canal was abandoned when the river changed course away from the point of diversion. In 1891, the Low Line Vermejo Canal was constructed at the approximate location of the present Vermejo Canal.

The Vermejo Ditch Company was organized in 1903 and acquired title to water rights, the Vermejo Ditch System, and Reservoirs No. 2, 5, 7, 8, 12, 13, and 20. These reservoirs had been constructed in natural depressions within the project area. The system was successively owned and operated by various land development and water user companies until the formation of the Vermejo Conservancy District in February 1952.

Development and extension of the project facilities were continued during 1908-13. By the end of 1913, the Hebron Dam and Eagle Tail Canal had been constructed to supply the area with water from Chico Rico Creek in addition to the water from Vermejo River. By this time irrigation water was being supplied to approximately 18,000 acres.

Later, certain lands were abandoned because of seepage, location, or water shortages. Occasional floods did considerable damage to the irrigation system, and a flood in 1942 washed out the Hebron Dam on Chico Rico Creek. The irrigation system became badly deteriorated, and many of the farms were abandoned.

Investigations

In 1947, when less than 3,500 acres were being irrigated, the Bureau of Reclamation was requested to investigate and undertake the rehabilitation of the project.

Authorization

The project was authorized on September 27, 1950, by act of Congress (Public Law No. 848, 81st Cong., 2d sess. 64 Stat. 1072), as amended by the act of March 5, 1952 (Public Law No. 269, 82d Cong., 2d sess. 66 Stat. 13).

Construction

Construction began in 1953 and was completed in 1955. Rehabilitation and construction work on Dam No. 12 has been delayed until needed.

Operating Agency

The project is operated and maintained by the Vermejo Conservancy District.

BENEFITS

Irrigation

The project area has a definite marketing advantage for feed crops as it is located in the center of a range-livestock region. Principal crops produced are alfalfa, pasture, wheat, barley, and oats.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	7,379	acres
Number of irrigated farms	36	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	4,720	227,136
1969	6,294	206,364
1970	5,559	341,271
1971	5,094	226,318
1972	4,912	261,367
1973	5,083	291,757
1974	6,262	197,091
1975	5,422	78,520
1976	2,063	12,960
1977	665	12,756

Facilities in Operation

Storage dams[1]	3	
Diversion dams	1	
Canals	25	mi
Laterals	65	mi
Drains	9	mi

[1]Does not include Reservoirs 12 and 14, whose capacities are unknown.

Climatic Conditions

Annual precipitation	15	in
Temperature:		
Maximum	102	°F
Minimum	−25	°F
Mean	50	°F
Growing season	148	days
Elevation of irrigable area	6,000	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	125
Urban, residential	200

ENGINEERING DATA

Water Supply

VERMEJO RIVER

Drainage area at Vermejo Diversion Dam	317	mi²
Gage on Vermejo River near Dawson, N. Mex., (301 mi² of drainage area) is indicative of flow at diversion. Average annual discharge — 51 years of record (1915-17, 1919-20, 1927-75)	13,260	acre-ft

CHICO RICO CREEK

Drainage area at Eagle Tail Diversion	325	mi²
Estimated annual diversion	9,000	acre-ft

Storage Facilities

Stubblefield Dam and Dike

Type: Modified homogeneous earthfill. A dike, 5,545 ft long and 7 ft high, extends north from point near north end of dam.
Location: Offstream, 6 mi northwest of Maxwell, N. Mex.
Construction period: 1953-54. Dam built partially on existing Stubblefield Dike.

Reservoir, Stubblefield:		
Total capacity to El. 6133	16,170	acre-ft
Active capacity, El. 6101.8-6129.2	12,205	acre-ft
Surface area at El. 6129.2	904	acres
Dimensions:		
Structural height	47	ft
Hydraulic height: Offstream		
Top width	20	ft
Maximum base width	300	ft
Crest length	10,119	ft
Crest elevation	6137.0	ft
Total volume	827,000	yd³
Spillway: Uncontrolled open channel emergency spillway at southwest end of dam.		
Crest length	300	ft
Crest elevation	6133.0	ft
Outlet works: Concrete box conduit through base of dam controlled by one 4-ft-square slide gate, acting as combination canal and wasteway outlet.		
Capacity at El. 6129.2:		
To canal	150	ft³/s
To wasteway	300	ft³/s

Dam No. 2

Type: Homogeneous earthfill
Location: Offstream, 7 mi northwest of Maxwell, N. Mex.
Construction period: 1953-54. Dam built partially on existing Dam No. 2.

Reservoir, No. 2:		
Total capacity to El. 6147.8	2,874	acre-ft
Active capacity, El. 6135-6147.8	2,063	acre-ft
Surface area at El. 6147.8	418	acres
Dimensions:		
Structural height	12	ft
Top width	20	ft
Crest length	10,730	ft
Crest elevation	6152.0	ft
Total volume	206,000	yd³
Spillway: Uncontrolled riprapped emergency spillway near southwest end of dam.		
Crest length	300	ft
Crest elevation	6147.8	ft
Outlet works: 2 concrete box conduits through dam, 1 for canal releases and 1 for wasteway, each controlled by a 4-ft-square slide gate.		
Capacity at El. 6145.8:		
To canal	128	ft³/s
To wasteway	150	ft³/s

Dam No. 13

Type: Homogeneous earthfill
Location: Offstream, about 3 mi northwest of Maxwell, N. Mex.
Construction period: 1953-54
Dam built partially on existing Dam No. 13.

Reservoir, No. 13:		
Total capacity to El. 6046.5	4,949	acre-ft
Active capacity, El. 6020-6046.5	4,783	acre-ft
Surface area at El. 6046.5	336	acres
Dimensions:		
Structural height	32	ft
Hydraulic height: Offstream		
Top width	20	ft
Crest length	8,003	ft
Crest elevation	6052.0	ft
Total volume	248,000	yd³
Spillway: Uncontrolled open channel emergency spillway at northeast end of dam.		
Crest length	300	ft
Crest elevation	6046.5	ft
Outlet works: Concrete box conduit through base of dam, controlled by one 3-ft-square slide gate.		
Capacity at El. 6046	30	ft³/s

Diversion Facilities

Vermejo Diversion Dam

Type: Concrete slab and buttress weir, embankment wing
Location: On the Vermejo River, about 4 mi southeast of Dawson, N. Mex.
Year completed: 1910. Reconstructed by Bureau of Reclamation in 1955.

Dimensions:		
Structural height	17	ft
Hydraulic height	5	ft
Weir crest length	300	ft
Crest length	1,021	ft
Crest elevation	6182.94	ft
Volume	4,400	yd³
Headworks: Concrete, four 3- by 4-ft and five 4- by 7-ft cast iron slide gates.		
Diversion capacity	600	ft³/s

Carriage Facilities

Vermejo Canal

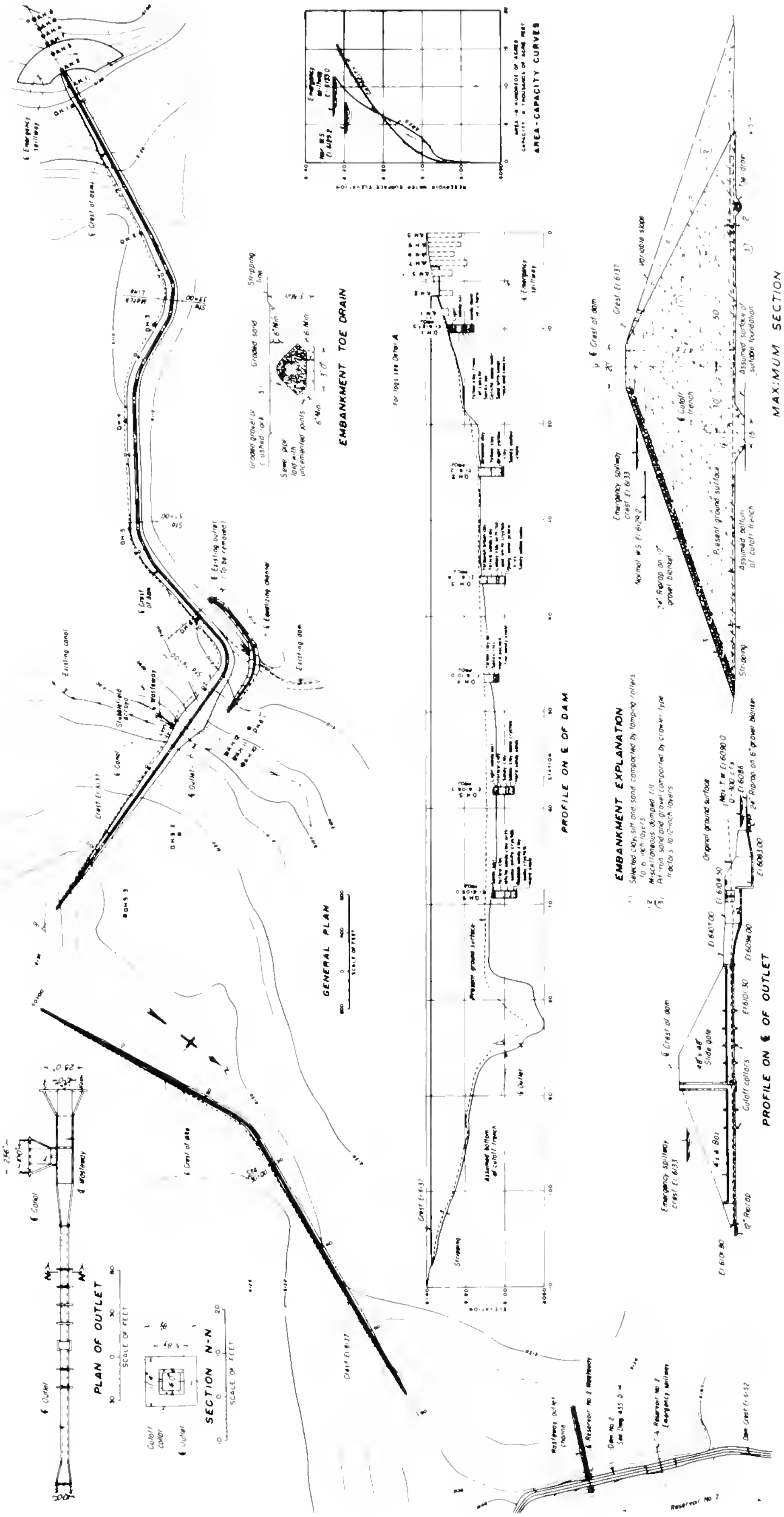
Location: From the Vermejo River about 12 mi northwest of Maxwell, N. Mex., generally southeast about 5 mi to Stubblefield Reservoir, then northeast about 4 mi.
Construction period: Privately constructed. Portions of canal enlarged and some new construction by Reclamation in 1954-55.

Length	9.5	mi
Diversion capacity	600	ft³/s
Typical maximum section in earth:		
Bottom width	30	ft
Side slopes	1.5:1	
Water depth	5.67	ft

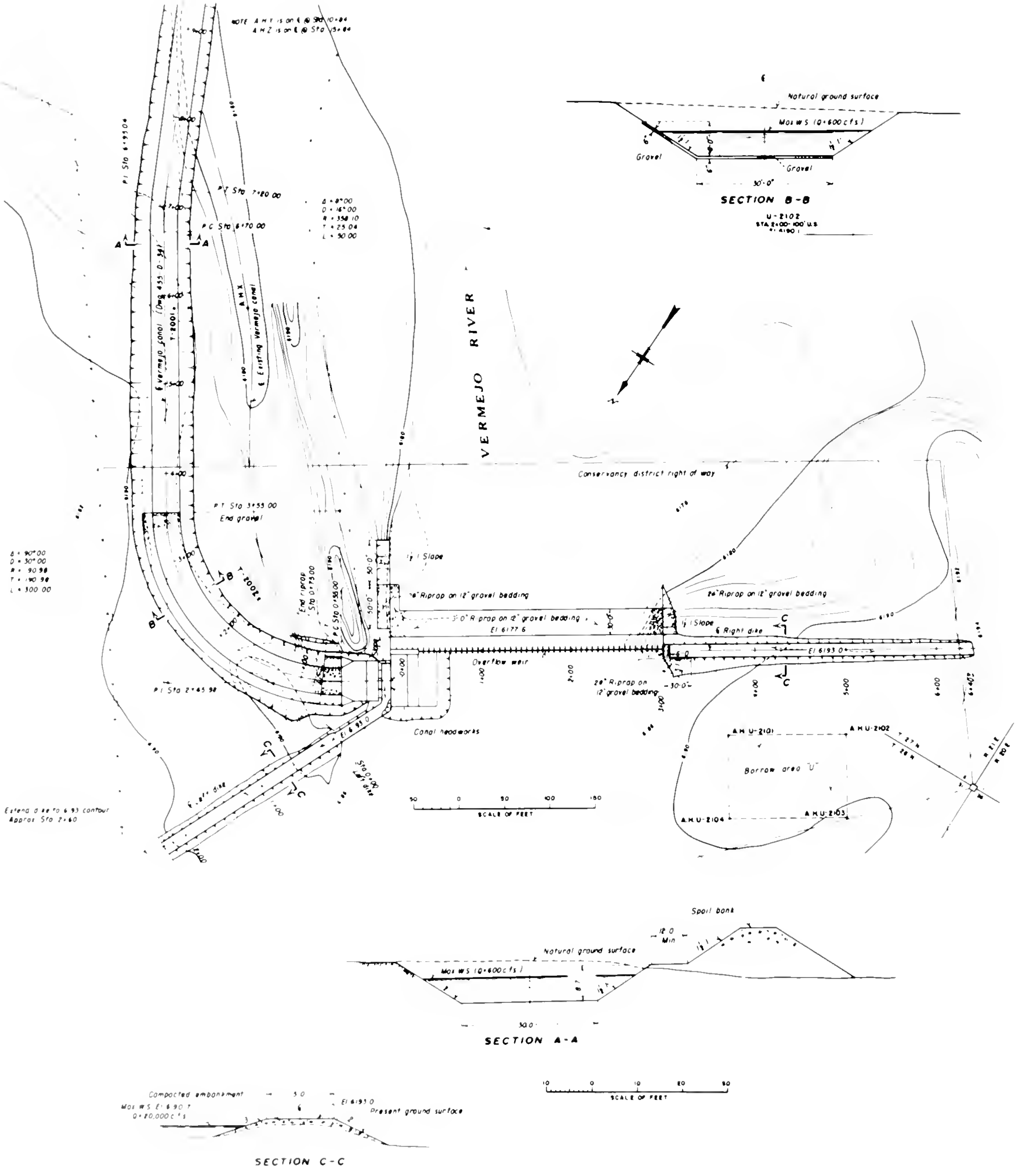
Eagle Tail Canal

Location: From heading on Chico Rico Creek about 13 mi northeast of Maxwell, N. Mex., generally southwest to irrigated area.
Construction period: Privately constructed. Rehabilitated by Reclamation in 1954-55.

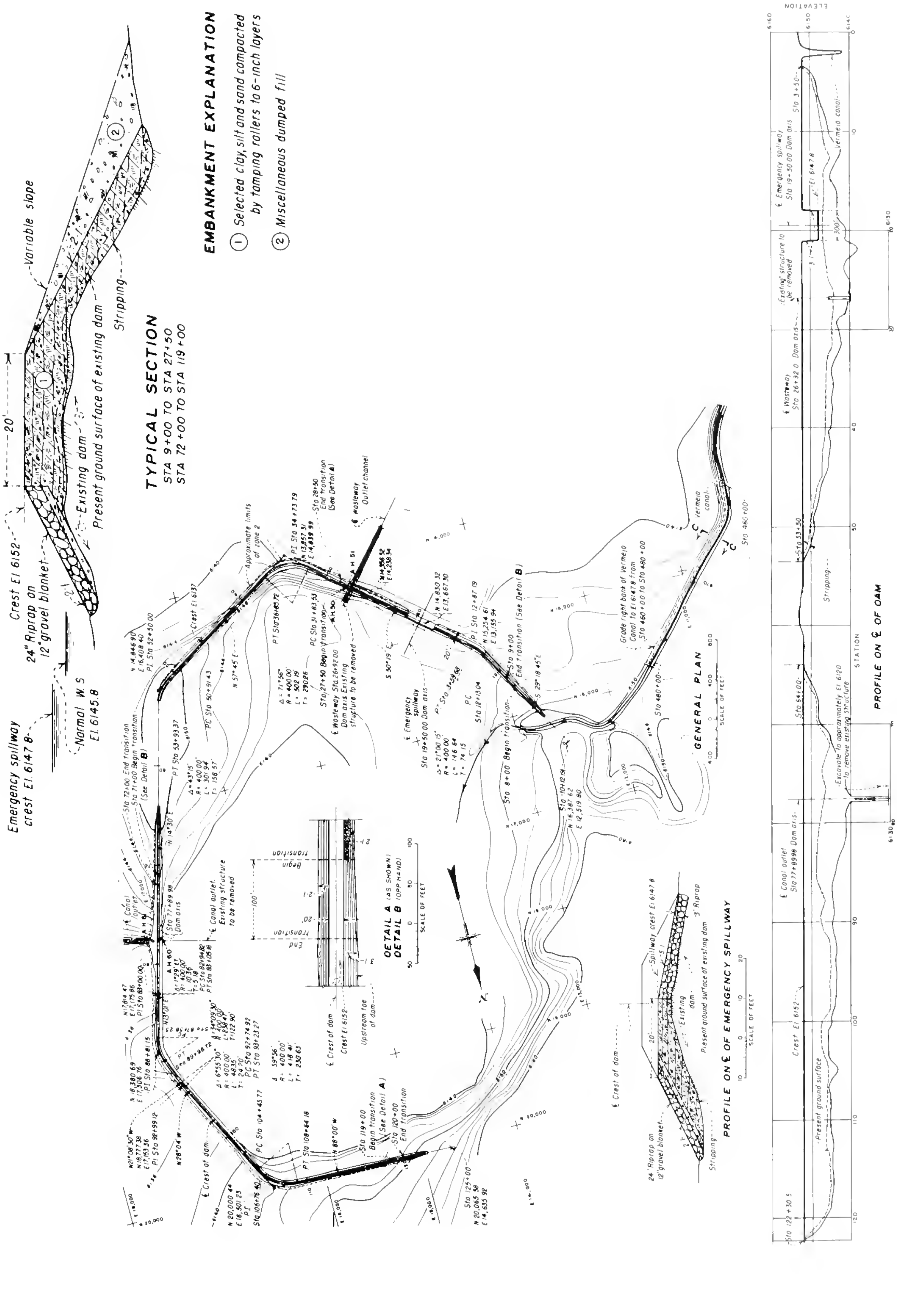
Length	15.5	mi
Diversion capacity	300	ft³/s
Typical maximum section in earth:		
Bottom width	18	ft
Side slopes	1.5:1	
Water depth	4.31	ft



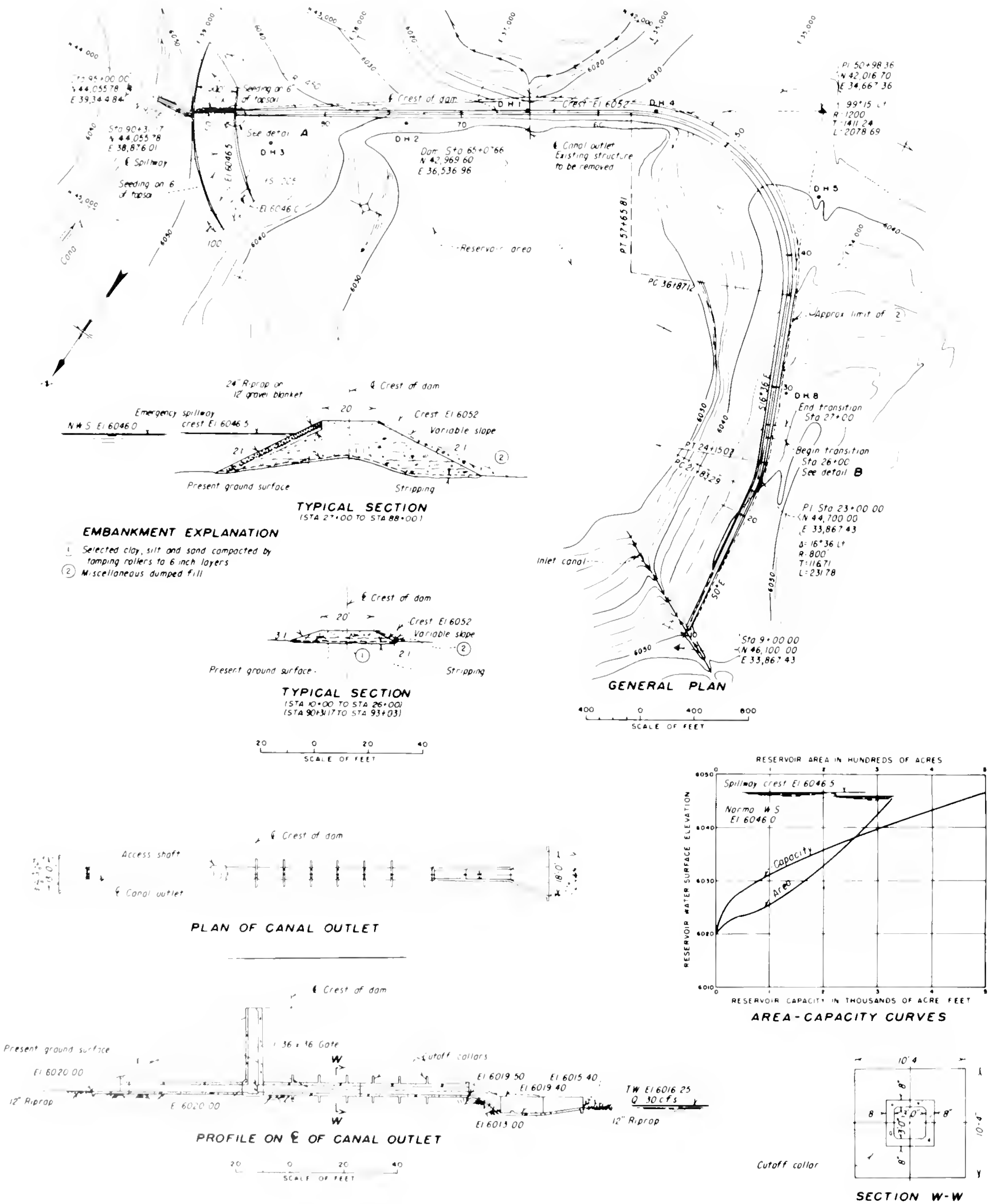
Stubblefield Dam, Plan and Sections



Vermejo Diversion Dam, Plan and Sections



Dam No. 2, Plan and Sections

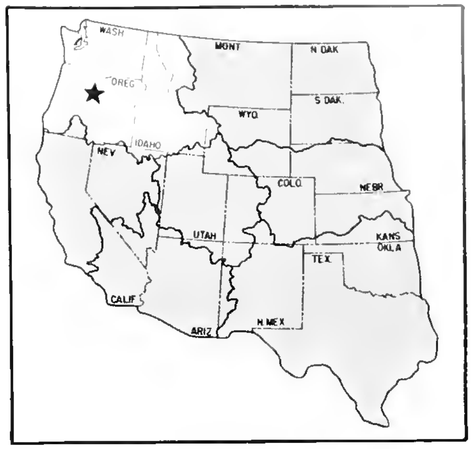


Dam No. 13, Plan and Sections

Wapinitia Project

Oregon: Wasco County

Pacific Northwest Region
Water and Power Resources Service



The Wapinitia Project, Juniper Division, is on Juniper Flat in north-central Oregon. Juniper Flat is a plateau, 3 to 6 miles wide and approximately 17 miles long, between the Deschutes and White Rivers. Some 2,108 acres over a scattered area receive supplemental irrigation service from the project. The principal construction feature is Wasco Dam on Clear Creek, 0.5 mile below the outlet of Clear Lake, a natural lake in a mountain valley.

PLAN

Project water is stored in Clear Lake behind Wasco Dam, about 35 miles west of Maupin, Oreg. Existing diversion structures, canals, and other distribution facilities that were formerly in operation have been used without rehabilitation or extension by the project. A diversion structure on Clear Creek, located about 3 miles downstream from Wasco Dam, diverts the water into a delivery canal, through which it is conveyed about 12 miles to be discharged into McCubbin Gulch. After flowing about 4 miles down the gulch, the water is rediverted into the distribution system. The main distribution canal extends the full length of Juniper Flat north of Wapinitia Creek. Two smaller canals with separate diversions from McCubbin Gulch serve a small area south of Wapinitia Creek.

Wasco Dam and Clear Lake

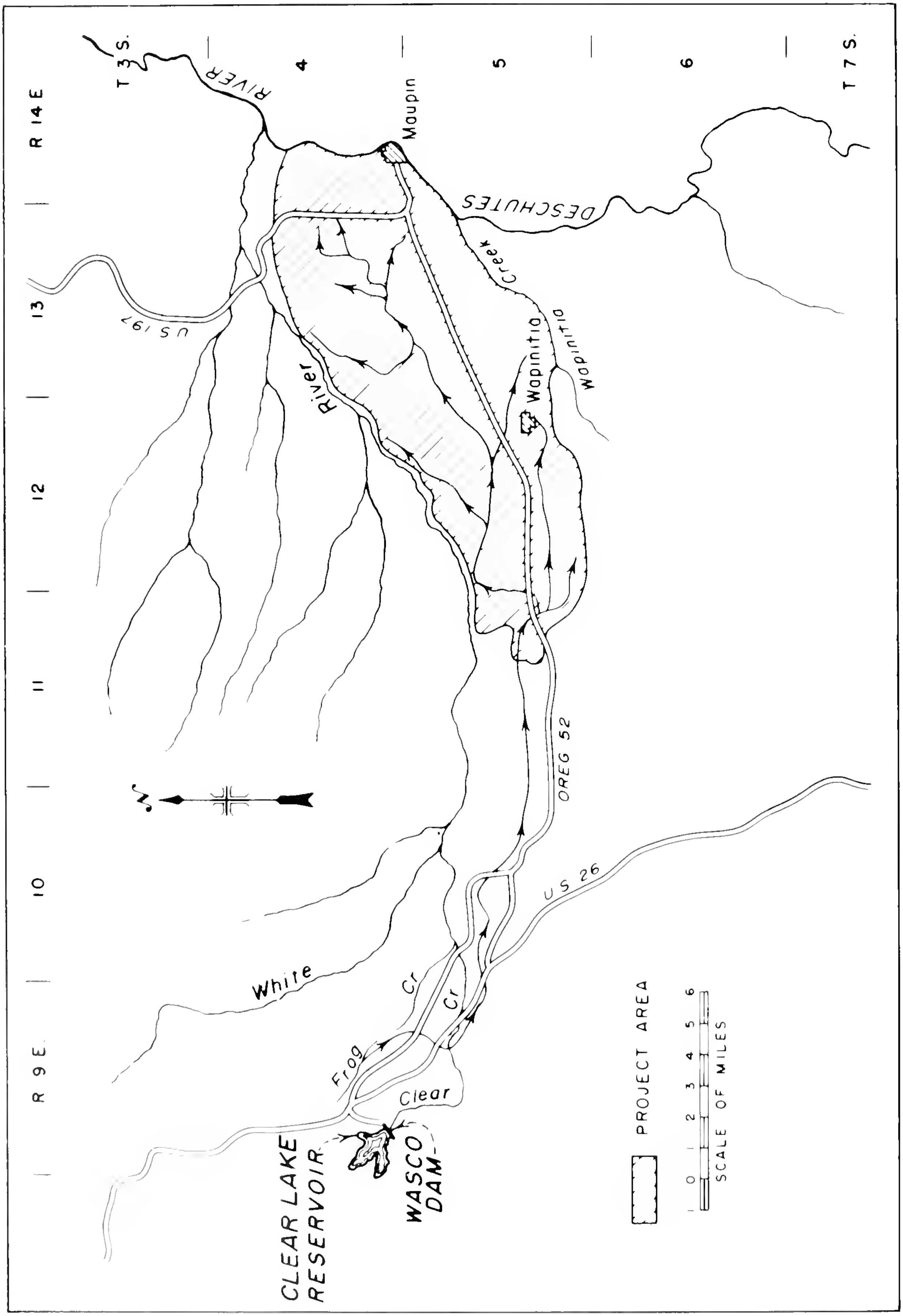
Wasco Dam and Clear Lake

Wasco Dam is a 59-foot-high zoned earthfill structure that contains 57,000 cubic yards of material. The crest is 20 feet wide and 415 feet long. The reservoir behind the dam has a total capacity of 13,060 acre-feet and a surface area of 557 acres. The outlet works consists of 20-foot-wide approach and outlet channels, a submerged vertical intake structure, a single rectangular 4- by 5-foot conduit, a gate chamber with two 3-foot-square slide gates and two overflow weirs, and a 56-foot-long stilling basin. The slide gates are operated manually by two lifts on top of the gate chamber structure at the crest of the dam. The emergency spillway, crossing the left abutment, consists of an unlined channel with a base width of 30 feet. A concrete overflow grade wall is in the spillway 10 feet upstream of the axis of the dam.

DEVELOPMENT

Early History

Many of the early immigrants to the West settled in the White River Basin. Demands of the increasing population in Oregon and Washington led to the establishment of large grazing herds. Extensive dryland wheat farming, following completion of the transcontinental railroad in 1880, later complemented the livestock industry. Some of



Wapinitia Project

the large sheep and cattle herds were gradually broken up, and thousands of acres, once used as rangeland, were homesteaded and brought under cultivation. Years of above-average rainfall promoted a "wheat boom." Succeeding years of very low rainfall forced the abandonment of many farms. The farmers who stayed diverted water for irrigation to grow alfalfa. However, irrigation developed slowly due to limited financial means, limited surface water supplies, and costly facilities.

Investigations

The first investigation of irrigation possibilities in the area was made in 1910. The primary considerations of this investigation were to provide storage on Clear Lake and construct a V-shaped flume to transport logs to a sawmill 6.5 miles downstream. A supplementary purpose of the investigation was to determine the practicability of furnishing irrigation water to lands on Juniper Flat. A report prepared in 1916 by the Reclamation Service and the State Engineer contained reconnaissance information on the general area and indicated some 46,000 acres as potentially irrigable, contingent upon storage in Clear Lake, diversion of White River water, and purchase or control of the White River Powerplant. An unpublished report on the White River Basin was made by the Bureau of Reclamation in 1945, based essentially upon the same considerations as the 1916 report. A more detailed investigation, begun in the summer of 1952, was made to find means of stabilizing the water supply for lands under the Juniper Flat District Improvement Company. The report of this investigation was the basis for congressional authorization of the project.

Authorization

The Juniper Division of the Wapinitia Project was authorized on June 4, 1956, when the President signed Public Law 559, 84th Congress, 2d session (70 Stat. 244).

Construction

The contract for construction of Wasco Dam was awarded in May 1958, and the completed structure was accepted by the Bureau of Reclamation in November 1959.

Operating Agency

The project is operated and maintained by the Juniper Flat District Improvement Company.

BENEFITS

Irrigation

Stored irrigation water has made possible the production of crops every year in an area that previously produced good crops only during infrequent wet years. Irrigated pasture, hay, and wheat are the principal crops.

Outlet works stilling basin at Wasco Dam

Recreation

Clear Lake as a natural lake was a popular recreation center. Construction of Wasco Dam increased the surface area to 557 acres and provided 8 miles of shoreline. There are 1,374 acres of land surrounding the lake that are available for recreation. Located entirely within the Mt. Hood National Forest, the lake is about 13 miles south of Mt. Hood and lies in a small, forested valley. Recreation facilities for camping and boat launching are available, and the lake has a very good trout fishery.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	2,108	acres
Number of irrigated farms	55	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	1,921	99,854
1969	1,997	151,353
1970	1,941	147,175
1971	1,795	140,788
1972	1,824	159,880
1973	1,880	218,758
1974	1,867	321,154
1975	1,867	312,405
1976	1,879	349,407
1977	1,820	197,663

Facilities in Operation

Storage dams	1	
Canals	38	mi
Laterals	63	mi

Climatic Conditions

Annual precipitation	17.9	in
Temperature:		
Maximum	103	°F
Minimum	−21	°F
Mean	49	°F
Growing season	160	days
Elevation of irrigable area	1700-2200.0	ft

Settlement

Number of persons served with project water (1977):		
Farm irrigation service	113	

ENGINEERING DATA

Water Supply

CLEAR CREEK

Drainage area above Wasco Dam	8	mi^2
Annual discharge:		
Maximum (1972)	30,400	acre-ft
Minimum (1970)	21,500	acre-ft
Average	24,600	acre-ft
Average annual diversions (1963-77)	5,020	acre-ft

Storage Facilities

WASCO DAM

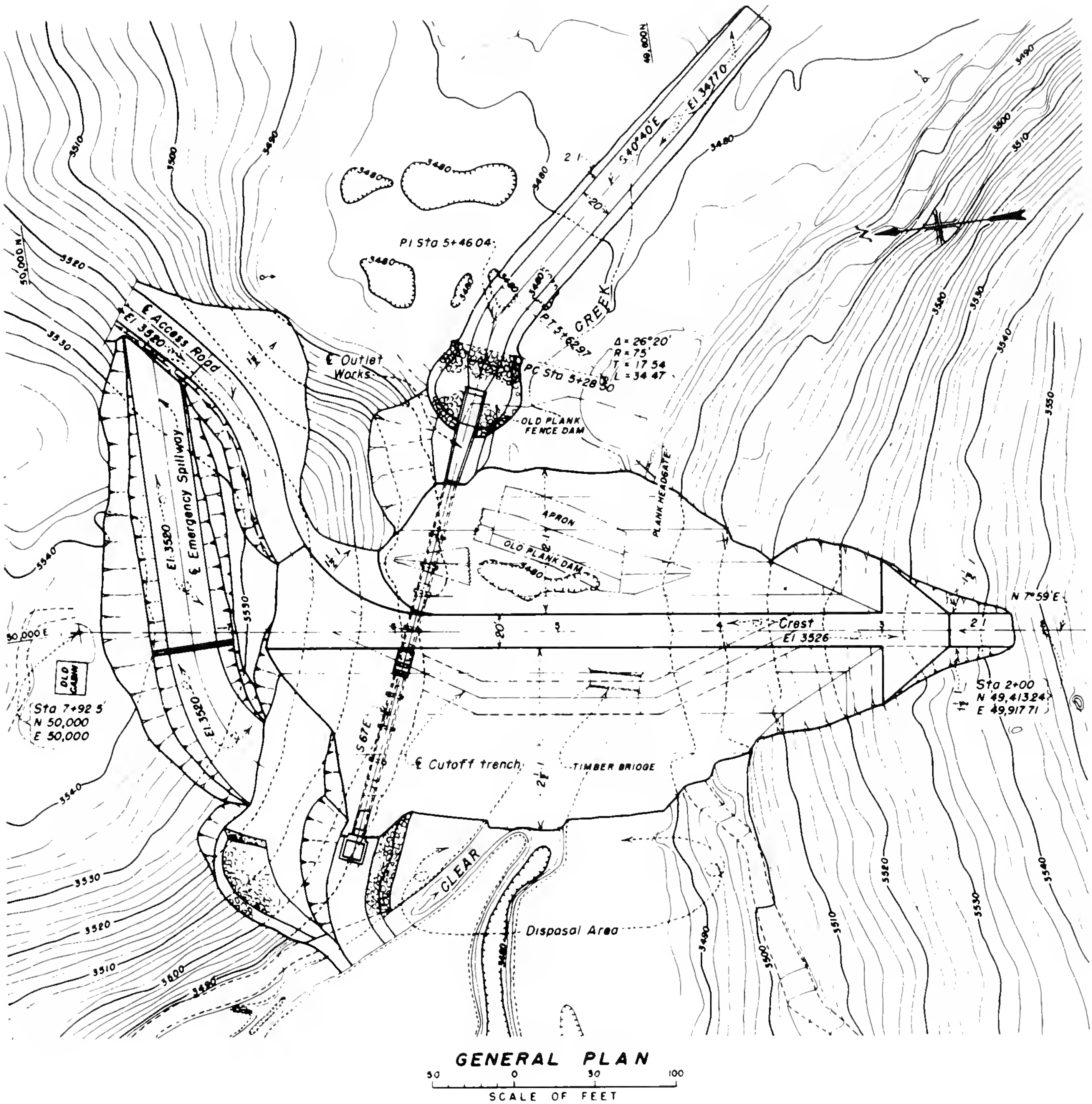
Type: Zoned earthfill
Location: On Clear Creek, about 35 mi west of Maupin, Oreg.
Construction period: 1958-59

Reservoir, Clear Lake:		
Total capacity to El. 3514.4	13,060	acre-ft
Active capacity, El. 3455-3514.4	11,860	acre-ft
Surface area	557	acres
Dimensions:		
Structural height	59	ft
Hydraulic height	40	ft
Top width	20	ft
Maximum base width	227	ft
Crest length	415	ft
Crest elevation	3526.0	ft
Volume	57,000	yd^3

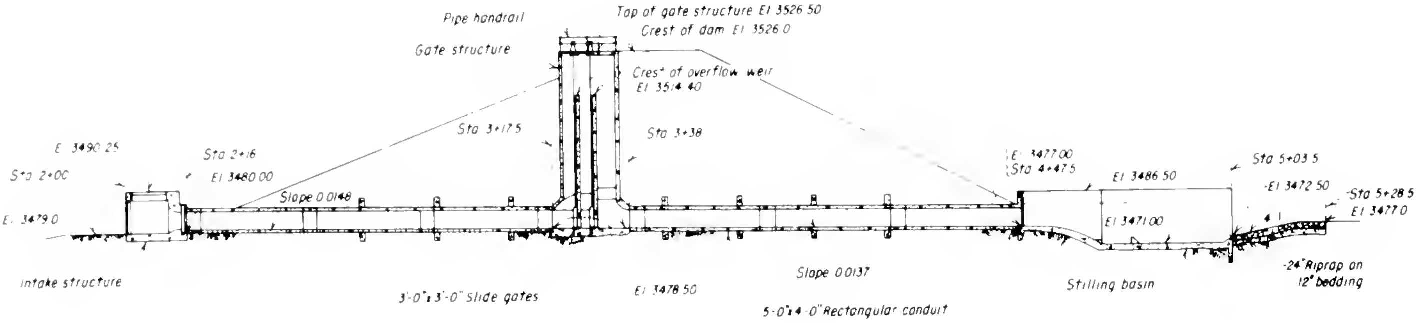
Spillway: Uncontrolled concrete overflow weir and unlined channel on left abutment of dam.

Outlet works: Concrete conduit controlled by two 3-ft-square slide gates and overflow weir.

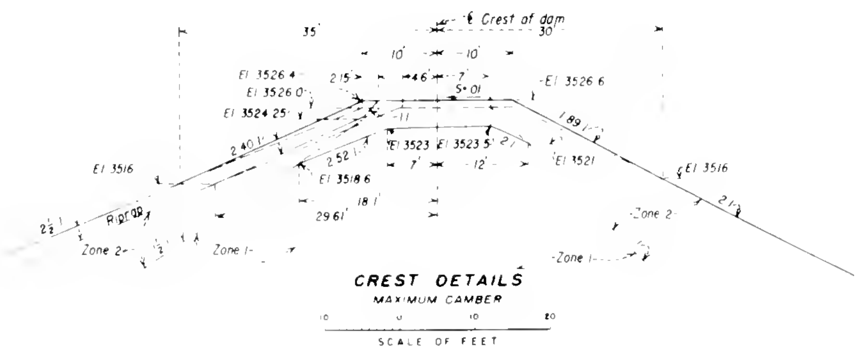
Capacity, water surface El. 3520:		
Outlet gates	320	ft^3/s
Overflow weir	170	ft^3/s



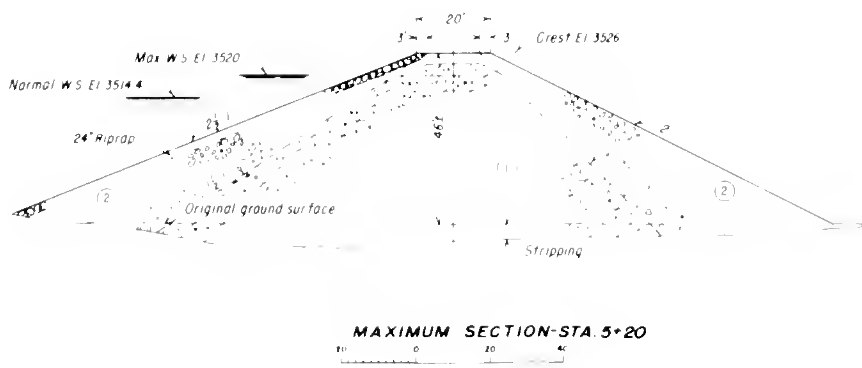
Wasco Dam, Plan



PROFILE ON ℄ OUTLET WORKS



CREST DETAILS
MAXIMUM CAMBER



MAXIMUM SECTION-STA. 5+20

EMBANKMENT EXPLANATION

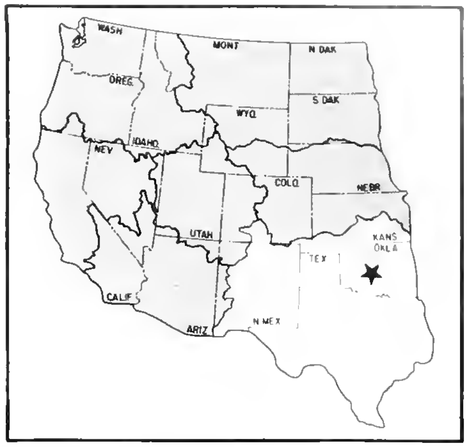
Selected clay, silt, and sand compacted by tamping rollers to 6 inch layers
2 Cobble and rockfill

Wasco Dam, Sections

Washita Basin Project

Oklahoma: Caddo, Grady, Custer, Washita, and Kiowa Counties

Southwest Region
Water and Power Resources Service



The Washita Basin Project is in the Washita River Basin in southwestern Oklahoma. Principal features of the project are Foss Dam and Reservoir, Fort Cobb Dam and Reservoir, and appurtenant works to provide a domestic, municipal, and industrial water supply for several cities and towns in that section of the State. The project also contributes flood control, recreation, and fish and wildlife benefits.

PLAN

Foss Dam and Reservoir, on the Washita River in Custer County, provide regulation of the river flows and municipal and industrial water supplies for the cities of Clinton, Cordell, Hobart, and Bessie, Okla. The water is transported from the reservoir to the project cities through 50.8 miles of aqueduct and laterals, three pumping plants, and chlorination and other facilities.

Fort Cobb Dam and Reservoir are on Pond (Cobb) Creek, a tributary of the Washita River in Caddo County. The facilities regulate runoff to furnish surface water supplies for the municipal and industrial water requirements of the city of Anadarko and the Western Farmers Electric Cooperative near Anadarko. Water is conveyed from the reservoir through a 20.9-mile-long gravity-flow aqueduct system.

Foss Dam and Reservoir

The authorizing act for Washita Basin Project, Public Law 419, 84th Congress, included provision for the storage, regulation, and distribution of irrigation water for 26,000 acres of land, limited to a 10-year period from the commencement of delivery of municipal water from the reservoir on which the irrigation unit is dependent. Repayment negotiations for irrigation development downstream of Fort Cobb and Foss Reservoirs have not been successful; therefore, no irrigation facilities have been constructed.

Foss Dam and Reservoir

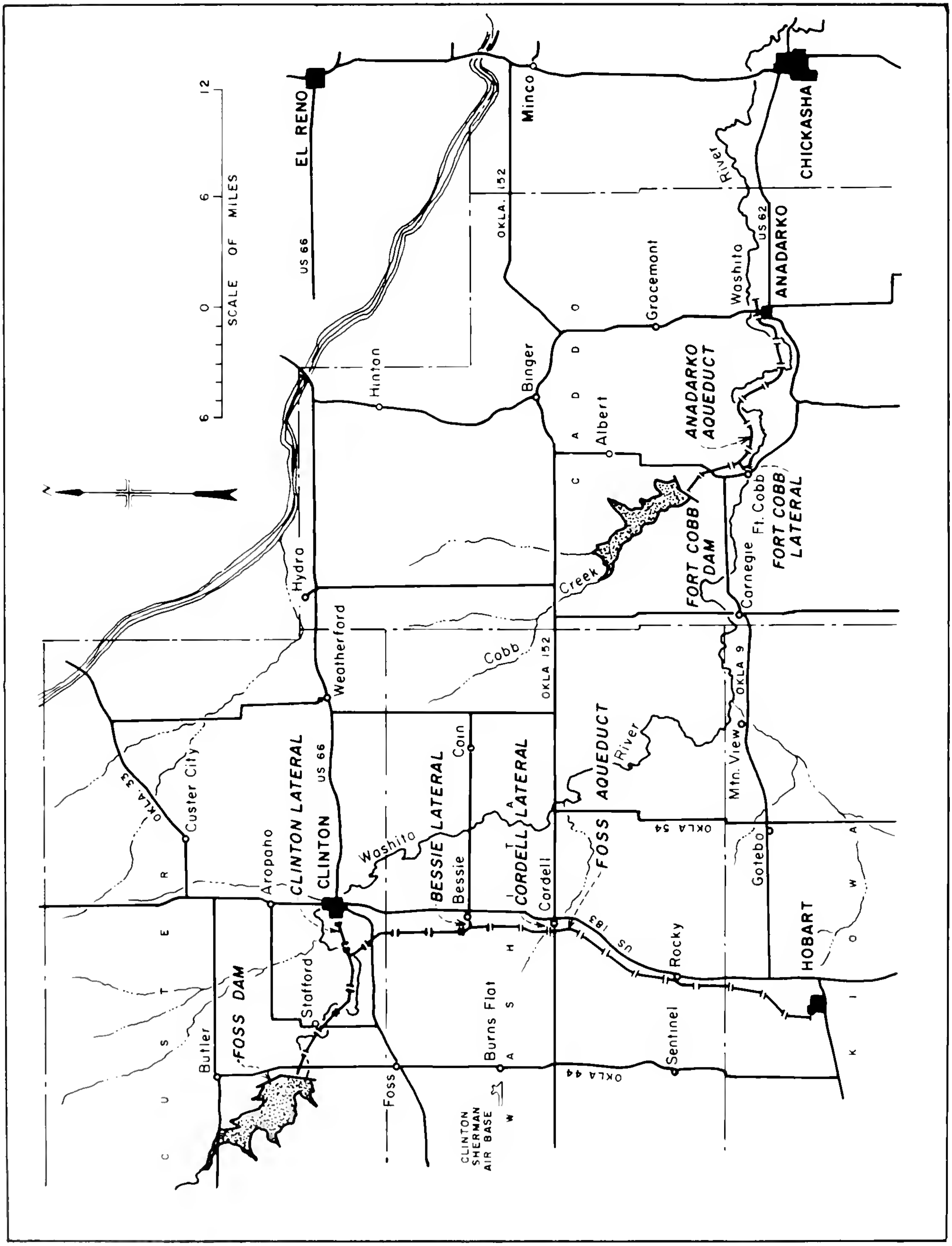
Foss Dam is on the Washita River approximately 15 miles west of Clinton, Okla. It is a zoned earthfill structure with a crest width of 30 feet and a crest length of 18,130 feet. The structural height is 142 feet with 10,537,000 cubic yards of embankment, at top of flood pool level.

Foss Reservoir has an area of 13,141 acres. Total capacity of the reservoir is 436,900 acre-feet. The uncontrolled morning-glory spillway is at the right abutment of the dam.

Fort Cobb Dam and Reservoir

Fort Cobb Dam is on Pond (Cobb) Creek about 5 miles north of Fort Cobb, and roughly 5 miles above the confluence of Cobb Creek with the Washita River. The dam is a zoned earthfill structure containing 3,520,000 cubic yards of embankment. The crest width is 30 feet, and the crest length is 9,900 feet. The structural height of the dam is 122 feet.

Fort Cobb Reservoir has a total capacity of 143,740 acre-feet and covers an area of 5,956 acres at top of flood pool level. The uncontrolled morning-glory spillway in the left abutment consists of a concrete intake structure, concrete conduit, and concrete chute and stilling basin.



Washita Basin Project

DEVELOPMENT

Early History

The first non-Indian settlements in the area were small scattered trading posts and military posts. Fort Washita was founded in 1842 on the east bank of the river about 22 miles above its mouth, Fort Arbuckle in 1851 near Wildhorse Creek in southern Murray County, and Fort Cobb in 1859 at the mouth of Pond (Cobb) Creek. About 1865, the cattle industry became a factor in settlement of the area. During the Civil War, vast herds of cattle had accumulated in Texas and at the end of the war many were driven across Oklahoma to shipping points in Kansas. One of the principal routes for these drives was the famous Chisholm Trail, which originally extended from Anadarko, Okla., to Wichita, Kans. The men conducting the cattle drives became interested in the large areas of grazing lands in this territory and leased from the Indians extensive acreages on which ranch operators and their crews became established. Following passage of the Organic Act of 1890, the Oklahoma Territory was organized. The Cheyenne and Arapahoe Tribes were given allotments of land, and unallotted lands in Roger Mills, Custer, and Washita Counties were opened to entry in 1892.

Investigations

Irrigation in the Washita River Basin has been practiced for at least 30 years. The irrigated acreage in 1945-46 was approximately 15 percent of that irrigated during the 1934-40 drought period. With the wet years of the 1940's, irrigation declined. Surveys were made of the water supply facilities of 35 towns and cities in or immediately adjacent to the Washita River Basin.

A survey conducted in 1946 and another in 1951 showed that 27 of these municipalities obtained their water supply from ground-water sources, 4 derived supplies from relatively small reservoirs on tributary streams, 2 pumped directly from the unregulated flow of the Washita River, and 2 used both underground sources and surface water stored in tributary reservoirs. The report on the Washita River Basin issued by the National Resources Planning Board in May 1943 outlined the basin's water resources rather than the specific project work necessary for developing those resources. The report indicated that an extensive system of multiple-purpose reservoirs was the basic form of improvement required to provide for existing and prospective needs for flood control, irrigation, municipal and industrial water supply, and to afford important benefits in the form of sediment control, recreation, and fish and wildlife conservation. The report specifically recommended construction of a multiple-purpose reservoir at the Foss site. The Bureau of Reclamation began investigations in 1945 to establish a

Fort Cobb Dam and Reservoir

plan for further development of the land and water resources consistent with the basin problems and needs.

Authorization

The project was authorized by Public Law 419, 84th Congress, 2d session, approved February 25, 1956 (70 Stat. 28).

Construction

Foss Dam was constructed during 1958-61, and Fort Cobb Dam was built in 1958-59.

The Foss Aqueduct was constructed during 1960-62 and the Anadarko Aqueduct was constructed during 1959-61.

BENEFITS

Municipal and Industrial Water

Seven Oklahoma towns receive a municipal and industrial water supply as a result of the Washita Basin Project. Additionally, water is furnished to Western Farmers Electric Cooperative, and to carpet mills which have been established near Anadarko.

The original project cities in the Foss Division of the Washita Basin Project, through cooperative efforts with the Foss Reservoir Master Conservancy District, have constructed a central water treatment plant at Foss Reservoir. The treated water supply is conveyed through the project aqueduct system to each of the cities.

The Fort Cobb Division of Washita Basin Project delivers municipal and industrial water to the city of Anadarko, and to the Western Farmers Electric Cooperative, from Fort Cobb Reservoir through the project-constructed Anadarko Aqueduct.

Recreation and Fish and Wildlife

Fort Cobb Reservoir provides over 2,000 acres of land and some 2,300 acres of water surface areas for recreation and includes 1,800 acres of land and 1,800 acres of water surface area for wildlife management. This reservoir provides some 45 miles of shoreline at top of conservation pool. The recreation areas are administered by the Oklahoma Tourism and Recreation Department and the wildlife management area is administered by the Oklahoma Department of Wildlife Conservation. Since reservoir releases are primarily for municipal and industrial demands and flood control, the reservoir is maintained at full conservation pool elevation and does not normally experience drastic drawdowns.

Foss Reservoir provides over 1,500 acres of land and over 5,000 acres of water surface for recreation purposes and some 4,500 acres of land and over 3,700 acres of water surface in the Washita National Wildlife Refuge for wildlife management. Foss Reservoir provides some 63 miles of shoreline at top of conservation pool elevation. The recreation areas are administered by the Oklahoma Tourism and Recreation Department. The Washita National Wildlife Refuge in the upper reaches of the reservoir is administered by the Fish and Wildlife Service.

Recreation at Fort Cobb and Foss Reservoirs includes sightseeing, picnicking, camping, swimming, boating, fishing, hunting, golfing, and water skiing. Annual visitation to the two reservoirs exceeds 500,000 visitor days. The State of Oklahoma has established State parks at both reservoirs, enhancing the opportunities for the public to enjoy these outdoor water-oriented activities and scenic areas.

Flood Control

The Washita River Basin is long and narrow. The river flows generally from northwest to a southeast, perpendicular to the axis of the major frontal storms. This basin shape and orientation results in the generation of damaging floodflows. It is not unusual for several consecutive flood crests to follow within comparatively short periods.

Operations at Foss and Fort Cobb Reservoirs provide continuing flood control benefits to downstream areas previously subjected to floodflows and resulting loss of life and damage to land areas and improvements. Flood control operations require close coordination among the conservancy districts, the Corps of Engineers, and the Bureau of Reclamation. These reservoirs have been operated for flood control since the initial filling of the conservation pools.

PROJECT DATA

Facilities in Operation

Storage dams	2	
Aqueducts	71.7	mi

Climatic Conditions

Average annual precipitation	23	in
Temperature:		
Maximum	120	°F
Minimum	−15	°F
Mean	60	°F

ENGINEERING DATA

Water Supply

WASHITA RIVER

Drainage area above Foss Dam	1,454	mi²
Annual discharge:		
Maximum (1941)	209,700	acre-ft
Minimum (1953)	6,400	acre-ft
Average	64,800	acre-ft

COBB CREEK

Drainage area above Fort Cobb Dam	315	mi²
Annual discharge:		
Maximum (1949)	56,050	acre-ft
Minimum (1954)	7,490	acre-ft
Average	24,750	acre-ft

Storage Facilities

FOSS DAM

Type: Zoned earthfill
Location: Washita River, 12 mi west of Clinton, Okla.
Construction period: 1958-61
Reservoir, Foss:

Dead capacity—Streambed to El. 1597.2	12,400	acre-ft
Active conservation capacity—El. 1597.2 to 1652	244,000	acre-ft
Exclusive flood control capacity—El. 1652 to 1668.6	180,500	acre-ft
Surcharge capacity—El. 1668.6 to 1691	380,000	acre-ft
Total capacity to El. 1668.6	436,900	acre-ft
Surface area at El. 1668.6	13,141	acres
Dimensions:		
Structural height	142	ft
Top width	30	ft
Maximum base width	1,340	ft
Crest length	18,130	ft
Crest elevation	1697.0	ft
Volume	10,537,000	yd³

Spillway: Morning-glory inlet structure with ungated crest having a diameter of 22.33 ft joining a circular concrete conduit of 9.5 ft diameter, concrete chute and stilling basin.

Capacity	3,150	ft³/s

River outlet works: Tower-type trashracked intake structure, an 11-ft diameter circular concrete pressure conduit, a gate chamber housing two 6- by 7.5-ft high-pressure emergency gates, two 6- by 7.5-ft high-pressure regulating gates, shaft, gate chamber and shaft house, a 15-ft-diameter free-flow modified horseshoe conduit and stilling basin.		
Capacity	4,450	ft^3/s
Canal outlet works: Box-type trashracked intake structure, a 5-ft-diameter circular concrete pressure conduit, a gate chamber housing two 2.75-ft-square high-pressure emergency gates and two 2.75-ft-square high-pressure regulating gates, an 8-ft-diameter free-flow modified horseshoe conduit, and a stilling basin.		
Capacity: No water is to be released until canal system is built. Future canal capacity	180	ft^3/s
Municipal outlet works: Four trashracked intake structures with sills at El. 1597, 1612, 1627, and 1642 (for selective withdrawal of water for quality), four concrete encased 24-in-outside-diameter steel outlet pipes, a gate chamber housing four 24-in wedge gate valves, a downstream 5.17 ft wide concrete conduit with walkway and 26-in-outside-diameter steel outlet pipe, and a control house.		
Capacity: (El. 1605)	25	ft^3/s

FORT COBB DAM

Type: Zoned earthfill
Location: Pond (Cobb) Creek, 5 mi north of Fort Cobb, Okla.
Construction period: 1958-59
Reservoir, Fort Cobb:
Storage space in Fort Cobb Reservoir is allocated as follows:

Dead capacity—Streambed to El. 1300	1,664	acre-ft
Active conservation capacity—El. 1300 to 1342	78,346	acre-ft
Exclusive flood control capacity—El. 1342 to 1354.8	63,730	acre-ft
Surcharge capacity—El. 1354.8 to 1374.4	148,650	acre-ft
Total capacity to El. 1354.8	143,740	acre-ft
Surface area at El. 1354.8	5,956	acres

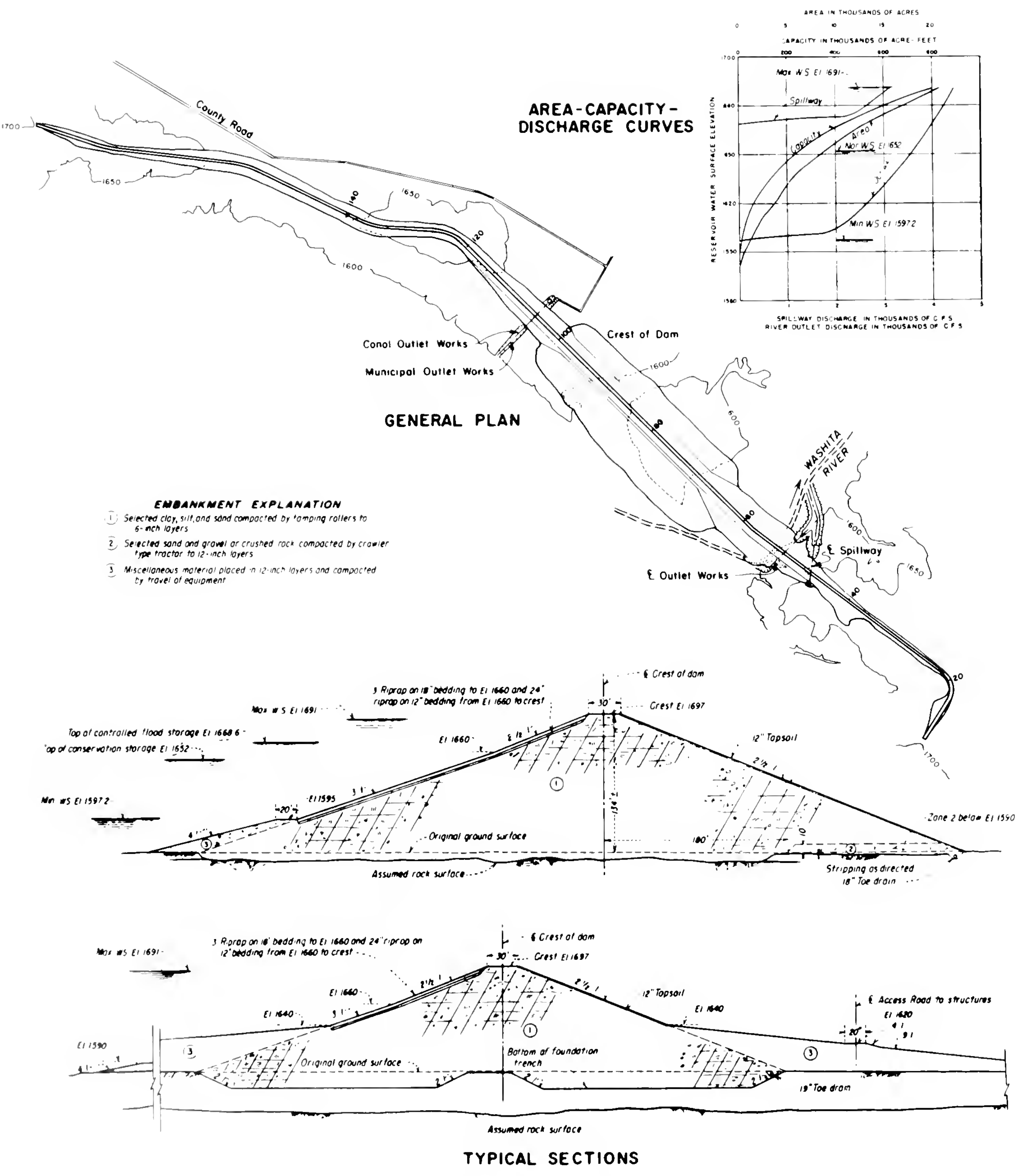
Dimensions:

Structural height	122	ft
Top width	30	ft
Maximum base width	747	ft
Crest length	9,900	ft
Crest elevation	1380.0	ft
Volume	3,520,000	yd^3
Spillway: Morning-glory inlet structure with ungated crest having a diameter of 22.33 ft joining a circular concrete conduit of 9.5-ft-diameter, concrete chute and stilling basin.		
Capacity	3,050	ft^3/s
Outlet works: Tower-type trashracked intake structure, a 9-ft-diameter circular concrete pressure conduit, a gate chamber housing two 5-ft-square high-pressure emergency gates and two 5-ft-square high-pressure regulating gates; a 13-ft-diameter modified free-flow conduit, a 5.17- by 7-ft access conduit adjacent to the free-flow conduit; a control house and a stilling basin.		
The outlet works also contains a municipal water outlet consisting of an intake (integral with outlet works intake structure), two 26-in-diameter steel outlet pipes encased in concrete alongside the outlet works pressure conduit; two 24-in gate valves, housed in the gate chamber; a 26-in-diameter steel outlet pipe which extends through the access conduit and control house and terminates at a stilling well (constructed integrally with the right wall of the outlet works stilling basin), and a 24-in sleeve regulating valve.		
Capacity: Two 5-ft-square high-pressure gates	2,560	ft^3/s

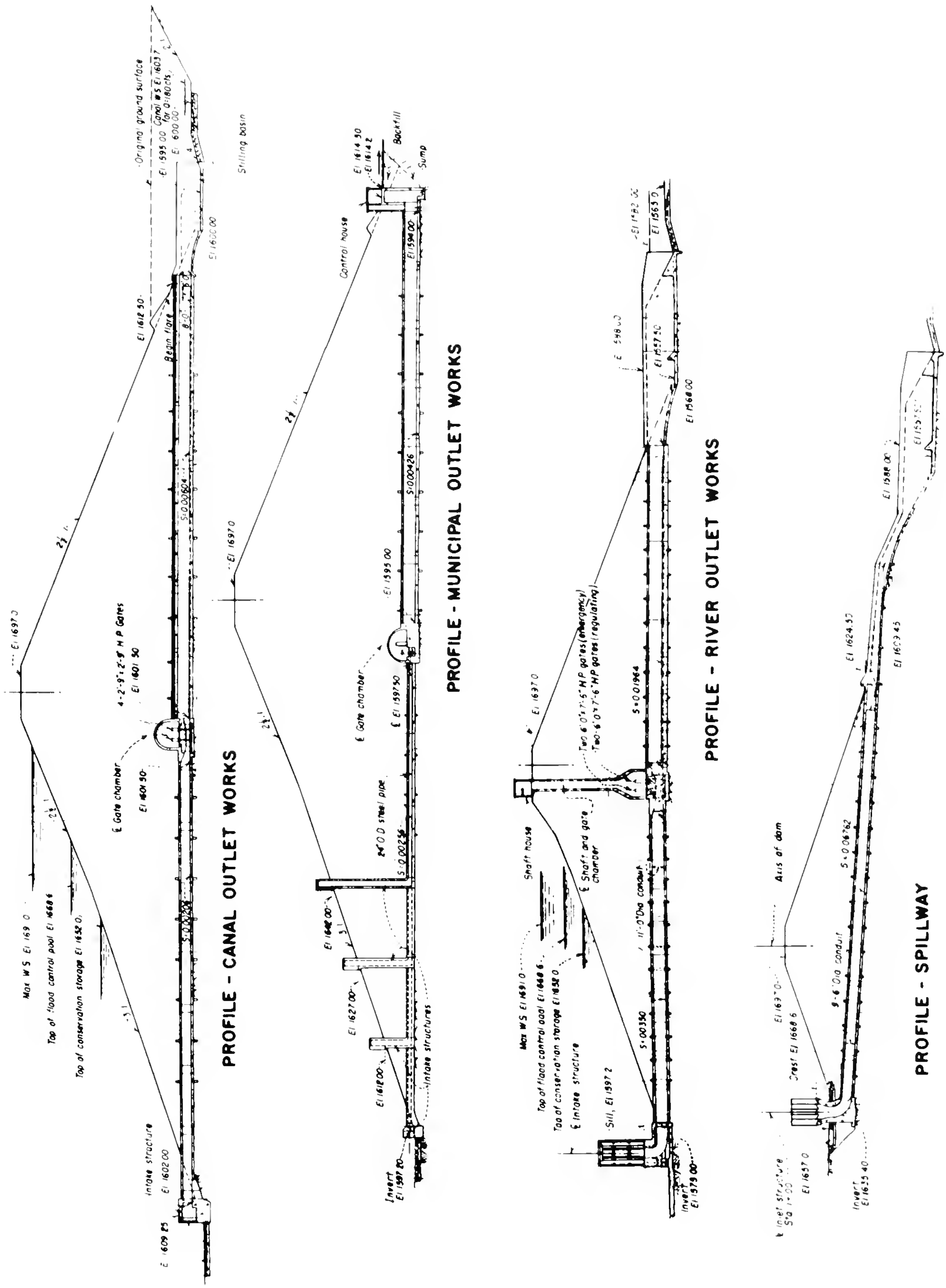
Carriage Facilities

PUMPING PLANTS: FOSS DIVISION

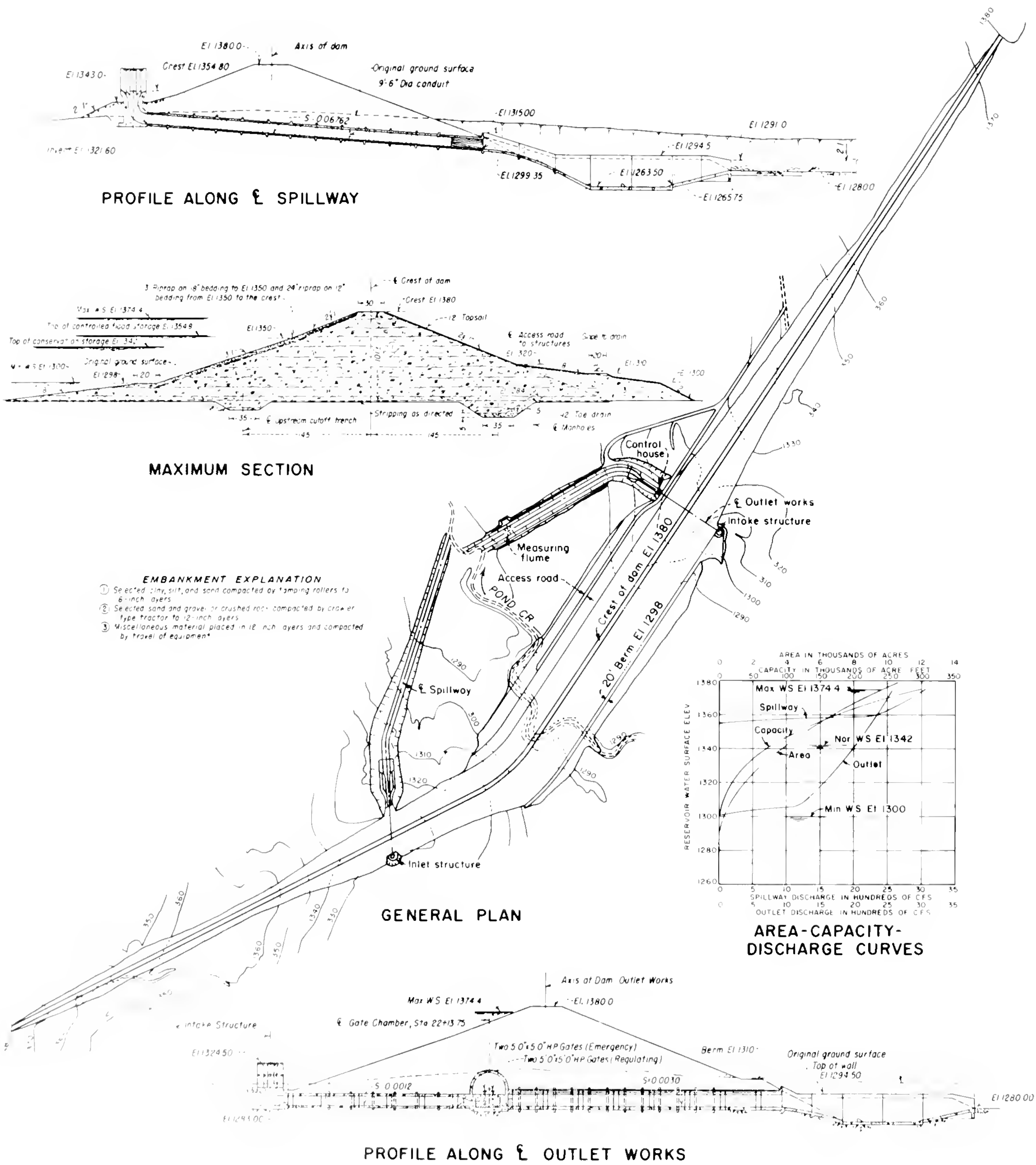
Designation	Number of units	Total capacity, ft^3/s	Total dynamic head, ft	Total horsepower
Number 1	3	23.25	52	180
Number 2	3	9.0	81	120
Number 3	3	6.0	122	120



Foss Dam, Plan and Sections



Foss Dam, Outlet Works and Spillway

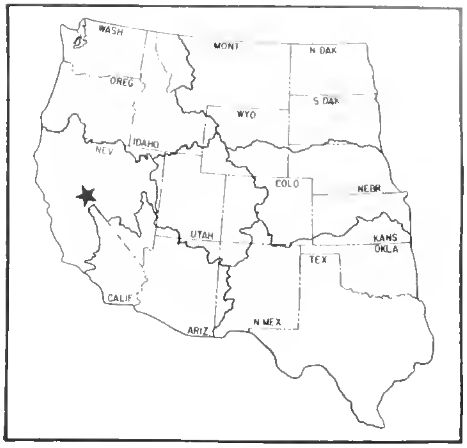


Fort Cobb Dam, Plan and Sections

Washoe Project

Nevada: Washoe, Storey, Lyon, Douglas, and Churchill Counties; and Carson City
California: Alpine, Sierra, Nevada, Placer, and El Dorado Counties

Mid-Pacific Region
Water and Power Resources Service



The Washoe Project, a part of the Lahontan Basin development plan, comprises the drainage basins of the Truckee and Carson Rivers. The project covers an area in west-central Nevada that includes the cities of Reno, Sparks, and Carson City, and the communities of Fallon, Fernley, Minden, Gardnerville, and Dayton. The project also covers a small portion of east-central California in the vicinity of Lake Tahoe, including the cities of Truckee, Tahoe City, and South Lake Tahoe. The project was designed to improve the regulation of runoff of the Truckee and Carson River systems, and to provide supplemental irrigation water and drainage for presently irrigated lands, as well as water for municipal and industrial and fishery uses, flood protection, fish and wildlife benefits, and recreation development.

The Truckee and Carson Rivers and their tributaries are the principal streams in the project area. The rivers drain the eastern slope of the Sierra Nevada and are fed primarily by melting snow. The flows are high in the spring but drop sharply after midsummer.

Major features of the project include Prosser Creek, Stampede, and Marble Bluff Dams, and Pyramid Lake Fishway, now in operation; and the proposed Stillwater Wildlife Area Improvement Facilities, and the Watasheamu Dam, Reservoir, and related facilities.

Prosser Creek Dam and Reservoir

PLAN

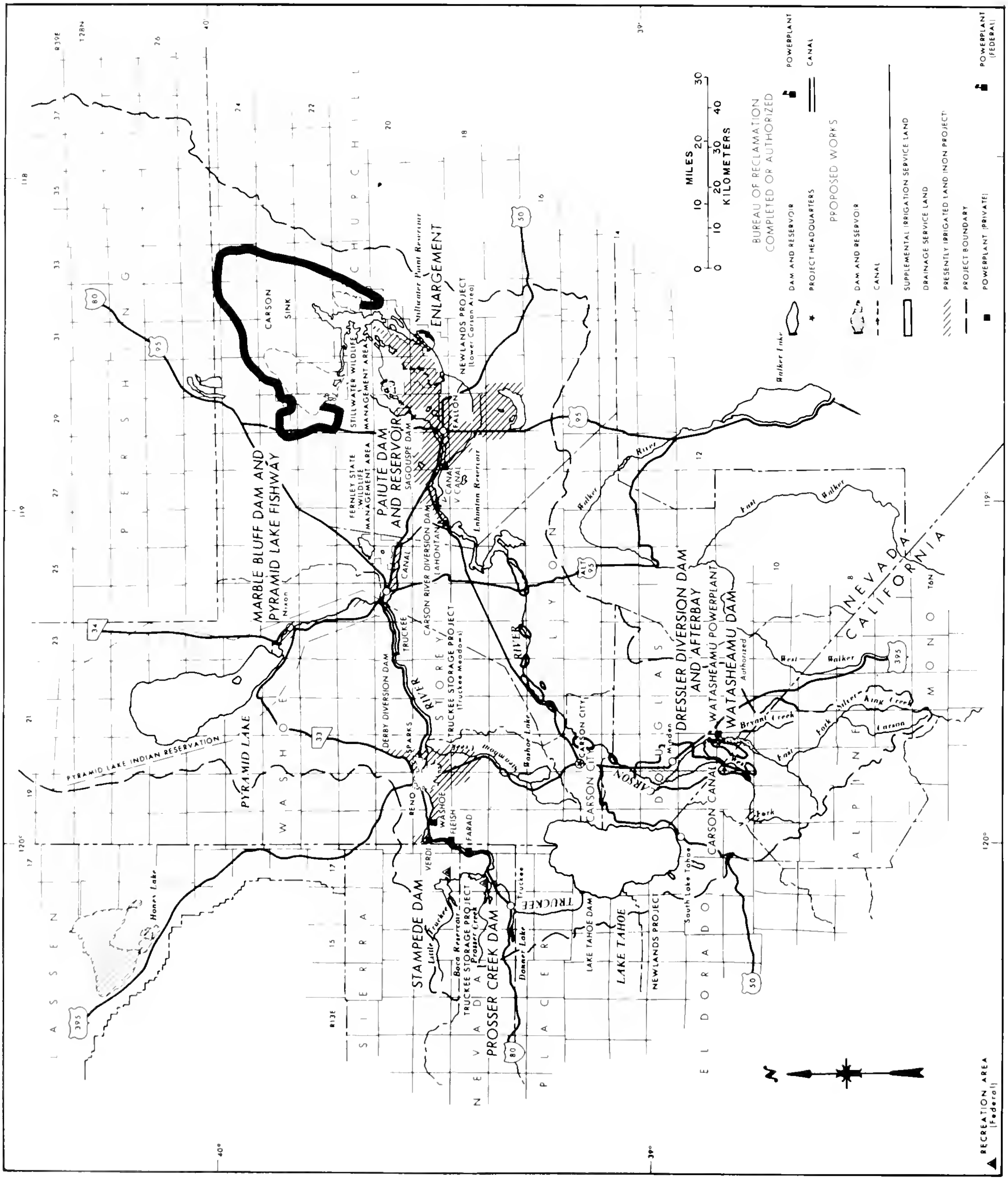
The Washoe Project was designed to develop water supplies to meet additional needs by conserving excess runoff in project reservoirs, and by saving water now lost to nonbeneficial evaporation and transpiration. The plan also calls for the use of storage capability to regulate flows for such nonconsumptive purposes as flood control, fishery improvement, and power production.

Prosser Creek Dam and Reservoir

Prosser Creek Dam and Reservoir, completed in 1962, are located on Prosser Creek approximately 1.5 miles above the confluence of Prosser Creek and the Truckee River. The dam, a zoned earthfill structure, has a height of 163 feet and a crest length of 1,830 feet. The reservoir has a capacity of 30,000 acre-feet, which provides for flood control. Water stored in the reservoir is used in an exchange of releases with Lake Tahoe to improve fishery flows in the Truckee River, principally in the reach from Lake Tahoe to the mouth of Donner Creek. Sites in the reservoir vicinity have been developed for recreational use and the reservoir provides a new fishery.

Stampede Dam and Reservoir

Completed in 1970, Stampede Dam and Reservoir are located on the Little Truckee River immediately below the mouth of Davies Creek and approximately 8 miles above the confluence of the Little Truckee and Truckee Rivers. The dam is a zoned earthfill structure with a height of 239 feet, a crest length of 1,511 feet, and an embankment volume of 4.5 million cubic yards. The reservoir, with a capacity of 226,500 acre-feet, provides flood control, recreation, a new reservoir fishery, and other fishery improvements on the main Truckee River, Little Truckee River, and Boca Reservoir.



Washoe Project

Marble Bluff Dam and Pyramid Lake Fishway

Marble Bluff Dam and Pyramid Lake Fishway, completed in 1975, are located on the Truckee River about 3 miles upstream from Pyramid Lake. The dam is a zoned earthfill structure with a height of 35 feet and a crest length of 1,622 feet. It serves as a heading for flow through the Pyramid Lake Fishway and also functions to check headward downcutting of the river channel and to halt erosion of lands on the Pyramid Lake Indian Reservation. The fishway extends from Marble Bluff Dam about 3 miles to Pyramid Lake. With a capacity of 50 cubic feet per second, the fishway provides a passageway for Pyramid Lake fish to move up into the Truckee River for spawning and return to the lake. Water developed by the Stampede Division of the project will provide supplemental flows to facilitate functioning of the fishway during years of low streamflow.

Stillwater Wildlife Area Improvement Facilities

These facilities will be constructed in the Stillwater Wildlife Management Area of the lower Carson River Basin to improve the water supply for waterfowl habitat. New reservoir capacity to regulate available water supplies will be provided by enlarging the capacity of Stillwater Point Reservoir by about 6,000 acre-feet and by constructing Paiute Dam and Reservoir with a capacity of about 4,000 acre-feet. A Paiute Reservoir supply canal will be constructed to take Newlands Project drain water and Carson River spills from the lower Carson River to Paiute Reservoir. Other conveyance facilities will be constructed to improve distribution and movement of drain and spillwaters to the management area.

Watasheamu Dam and Reservoir

Watasheamu Dam and Reservoir will be located on the East Fork of the Carson River approximately 10 miles south of Gardnerville, and are planned to develop an additional irrigation water supply. Releases from the reservoir also will be used for power generation. The reservoir will provide flood control and a new recreation site, and possibly water to meet municipal and industrial needs.

Watasheamu Powerplant

Watasheamu Powerplant will be located near the toe of Watasheamu Dam on the East Fork of the Carson River and will be operated by natural flow and storage releases from Watasheamu Reservoir. A switchyard will be constructed at the powerplant to increase the voltage of the power generated, and transmission lines will be constructed from the switchyard to existing facilities near Minden, Nev.

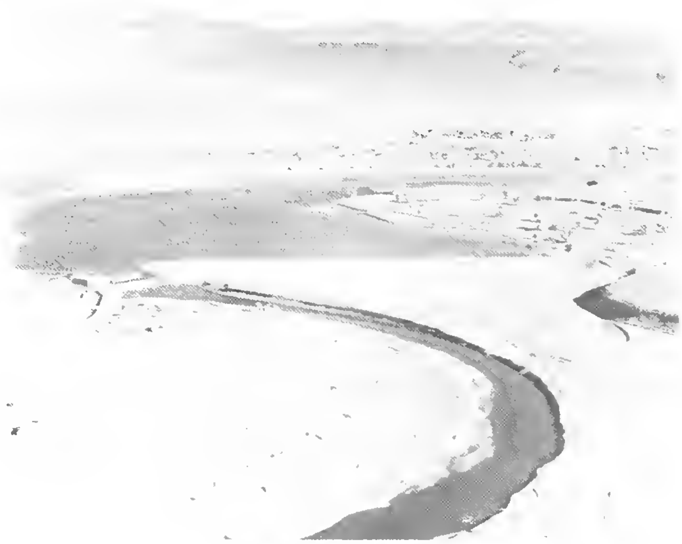
Pyramid Lake Fishway

Dressler Diversion Dam and Afterbay

Dressler Diversion Dam and Afterbay will be located on the East Fork of the Carson River about 4.5 miles downstream from Watasheamu Dam. This facility will provide a diversion heading for the proposed Carson Canal and an afterbay to regulate the discharge of Watasheamu Powerplant for irrigation use.

Carson Canal

Carson Canal will extend approximately 8 miles from the proposed Dressler Diversion Dam and Afterbay on the East Fork of the Carson River to about 2 miles beyond the West Fork of the Carson River. The canal will convey natural flows of the East Carson River and Watasheamu Reservoir storage to provide supplemental irrigation for West Fork lands in Alpine County, California, and Douglas County, Nevada.



Marble Bluff Dam

Stampede Dam and Reservoir

DEVELOPMENT

Early History

Irrigation in the Reno Valley was initiated by settlers in 1861. Soon after 1900, the demand for irrigation water in western Nevada resulted in water appropriations exceeding summer flows.

Agricultural enterprises have been made possible by numerous small reclamation developments constructed by private interests, and by the Newlands and Truckee Storage Projects constructed by the Bureau of Reclamation. Existing Reclamation developments have contributed materially to the progress of the project area. The natural distribution of the water supply, however, is still a serious problem and a deterrent to future growth. Despite water surpluses in certain areas, large acreages of farmland receive water only in the spring and suffer severe shortages in the summer months. Spring runoff and heavy rains often cause disastrous floods by the Truckee and Carson Rivers. These floods damage property, are a source of pollution in the cities of Reno and Sparks, destroy property along the Lake Tahoe shoreline, and curtail production by inundating farmlands.

Investigations

Establishment of streamgaging stations on the Truckee River and its tributaries by the Powell irrigation investigation in 1899 was one of the first steps toward investigating the overall potential water supplies of the area. The Bureau of Reclamation issued a status report in December 1952 summarizing results of reconnaissance investigations made in the Washoe Project area. The report compared three possible plans for obtaining comprehensive development of the Truckee and Carson

Rivers and served as a basis for selecting the adopted development plan. The adopted plan was outlined in a feasibility report of September 1954.

Authorization

The project was authorized by Public Law 858, 84th Congress, 2d session, August 1, 1956, as amended August 21, 1958, by Public Law 85-706.

Construction

Construction of Prosser Creek Dam, the initial feature of the Washoe Project, began in May 1960 and was completed in November 1962. Work began in early November 1966 on Stampede Dam and Reservoir and was completed in February 1970. Marble Bluff Dam and Pyramid Lake Fishway construction work was started in December 1973 and completed in October 1975.

The proposed Stillwater Wildlife Area Facilities, Stampede Powerplant, Watasheamu Dam, Reservoir, and Powerplant, and related facilities including Dressler Diversion Dam and Afterbay and Carson Canal, have not been constructed.

Operating Agencies

Prosser Creek, Stampede, and Marble Bluff Dams are operated by the Bureau of Reclamation. The Pyramid Lake Fishway is operated by the Fish and Wildlife Service.

Outlet works intake structure at Stampede Dam

Little Truckee River below Stampede Dam

BENEFITS

Irrigation

The project was planned to provide a supplemental irrigation water supply to 43,380 acres.

Municipal and Industrial Water

The project will provide additional water to meet foreseeable future increases in municipal and industrial needs in the Reno-Sparks area, the Truckee River Basin in California, and other possible points of use in the project area.

Hydroelectric Power

The project was planned to provide 40 million kilowatt-hours of power annually.

Recreation and Fish and Wildlife

Stampede and Prosser Creek Reservoirs offer swimming, boating, fishing, and camping. In addition, picnicking facilities are available at Stampede Reservoir. Recreation facilities at both reservoirs are administered by the Forest Service.

A water supply will be provided for fishery purposes in the lower Truckee River Basin. The fishery water will supplement flows in the river below Derby Dam in periods of low runoff to help maintain stream conditions and will augment Pyramid Lake Fishway flows that will enable Pyramid Lake fish to spawn in the lower Truckee River.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Supplemental irrigation service	43,380	acres
Number of irrigated farms	0	

Facilities in Operation

Storage dams	2	
Diversion dams	1	

Climatic Conditions

Annual precipitation	4.2	in
Temperature:		
Maximum	107	°F
Minimum	−27	°F
Mean	54	°F
Growing season	104	days
Elevation of irrigable area	4730.0	ft

Settlement

Number of persons served with project water (1977)	0	

ENGINEERING DATA

Water Supply

Prosser Creek

Drainage area at Prosser Creek Reservoir	50	mi^2
Annual discharge at Prosser Creek near Boca, Calif.:		
Maximum (1952)	117,700	acre-ft
Minimum (1961)	27,600	acre-ft
Average	63,030	acre-ft

Truckee River

Drainage area at Lake Tahoe at Tahoe City	500	mi^2
Annual discharge:		
Maximum (1907)	656,900	acre-ft
Minimum (1931)	4,700	acre-ft
Average	180,400	acre-ft

Storage Facilities

Prosser Creek Dam

Type: Zoned earthfill
Location: On Prosser Creek about 1.5 mi above the confluence of Prosser Creek and the Truckee River.
Construction period: 1959-62
Reservoir, Prosser Creek:

Average annual inflow, 1964-68	56,100	acre-ft
Total capacity to El. 5741.2	30,000	acre-ft
Active capacity, El. 5660.6	29,000	acre-ft
Surface area	734	acres
Shoreline	11	mi
Dimensions:		
Structural height	163	ft
Hydraulic height	119	ft
Top width	30	ft
Maximum base width	728	ft
Crest length	1,830	ft
Crest elevation	5761.0	ft
Total volume	1,804,000	yd^3

Spillway: Concrete chute at left abutment

Crest elevation	5741.2	ft
Capacity, El. 5754.5	2,750	ft^3/s

Outlet works: Concrete conduit through dam near left abutment with two pairs of 3- by 6.5-ft high-pressure gates in chamber near center, controlled from shaft house on dam crest.

Capacity at El. 5754.5	1,900	ft^3/s

Stampede Dam

Type: Zoned earthfill
Location: On the Little Truckee River about 8 mi above junction with the main Truckee River and about 11 mi northeast of Truckee, Calif.
Construction period: 1966-70
Reservoir, Stampede:

Average annual inflow, 1939-77	135,000	acre-ft
Total capacity	226,500	acre-ft
Active capacity	221,400	acre-ft
Surface area	3,450	acres
Shoreline	25	mi
Dimensions:		
Structural height	239	ft
Hydraulic height	225	ft
Top width	40	ft
Maximum base width	1,395	ft
Crest length	1,511	ft
Crest elevation	5970.0	ft
Total volume	4,517,000	yd^3

Spillway: Concrete chute on right abutment

Crest elevation	5948.7	ft
Capacity, El. 5963.3	3,060	ft^3/s

Outlet works: Concrete-lined tunnel through right abutment, 12 ft in diameter, upstream of gate chamber with 6- by 7.5-ft emergency gate.

Capacity at El. 5963.3	2,740	ft^3/s

Diversion Facilities

Marble Bluff Dam

Type: Zoned earthfill
Location: About 3 mi from the terminus of the Truckee River on the Pyramid Lake Indian Reservation.
Year completed: 1975
Dimensions:

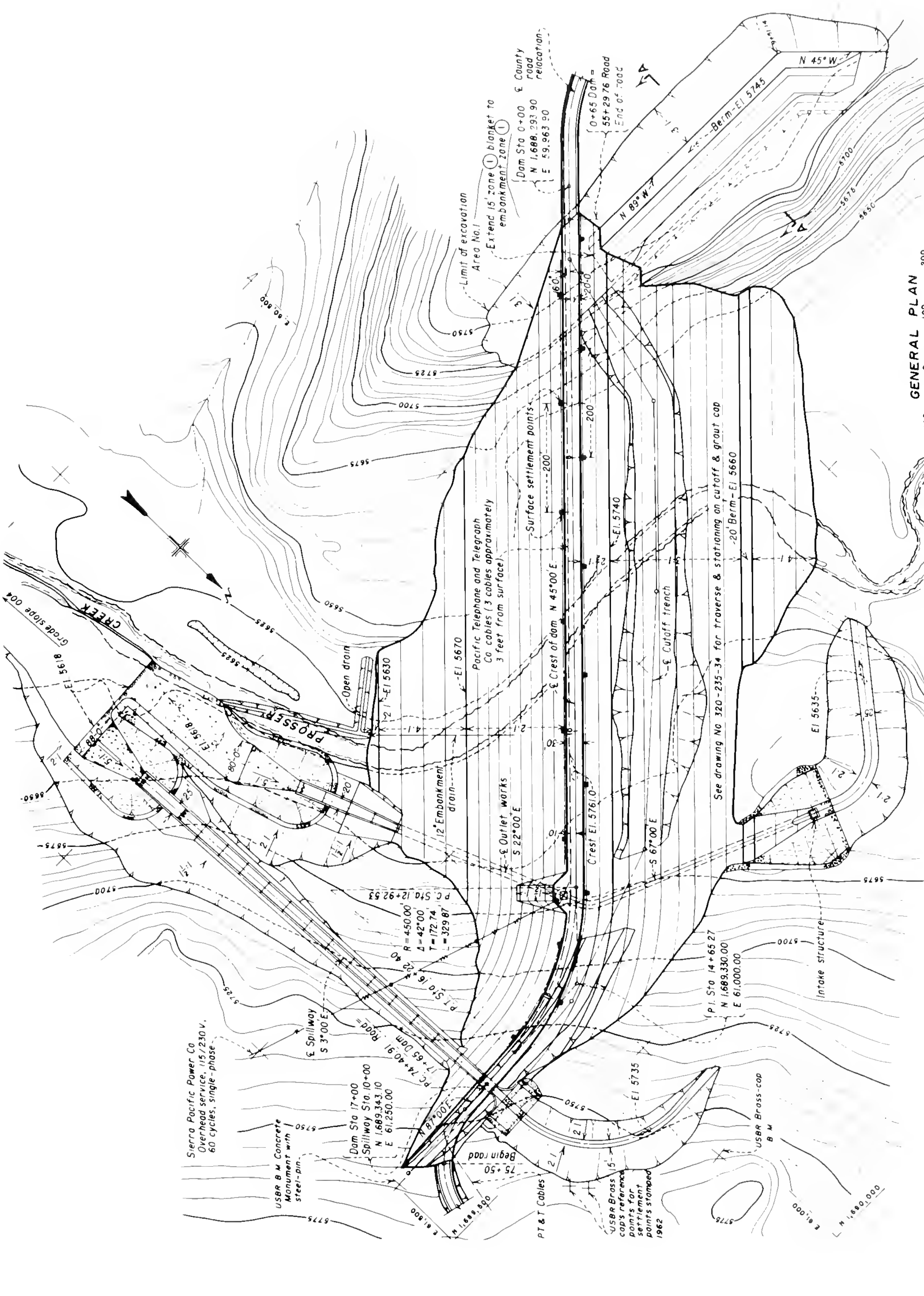
Structural height	35	ft
Hydraulic height	22	ft
Crest length	1,622	ft
Crest elevation	3866.0	ft
Volume	208,000	yd^3
Diversion capacity—Pyramid Lake Fishway	50	ft^3/s
Spillway capacity, El. 3864.87	19,300	ft^3/s

Pyramid Lake Fishway

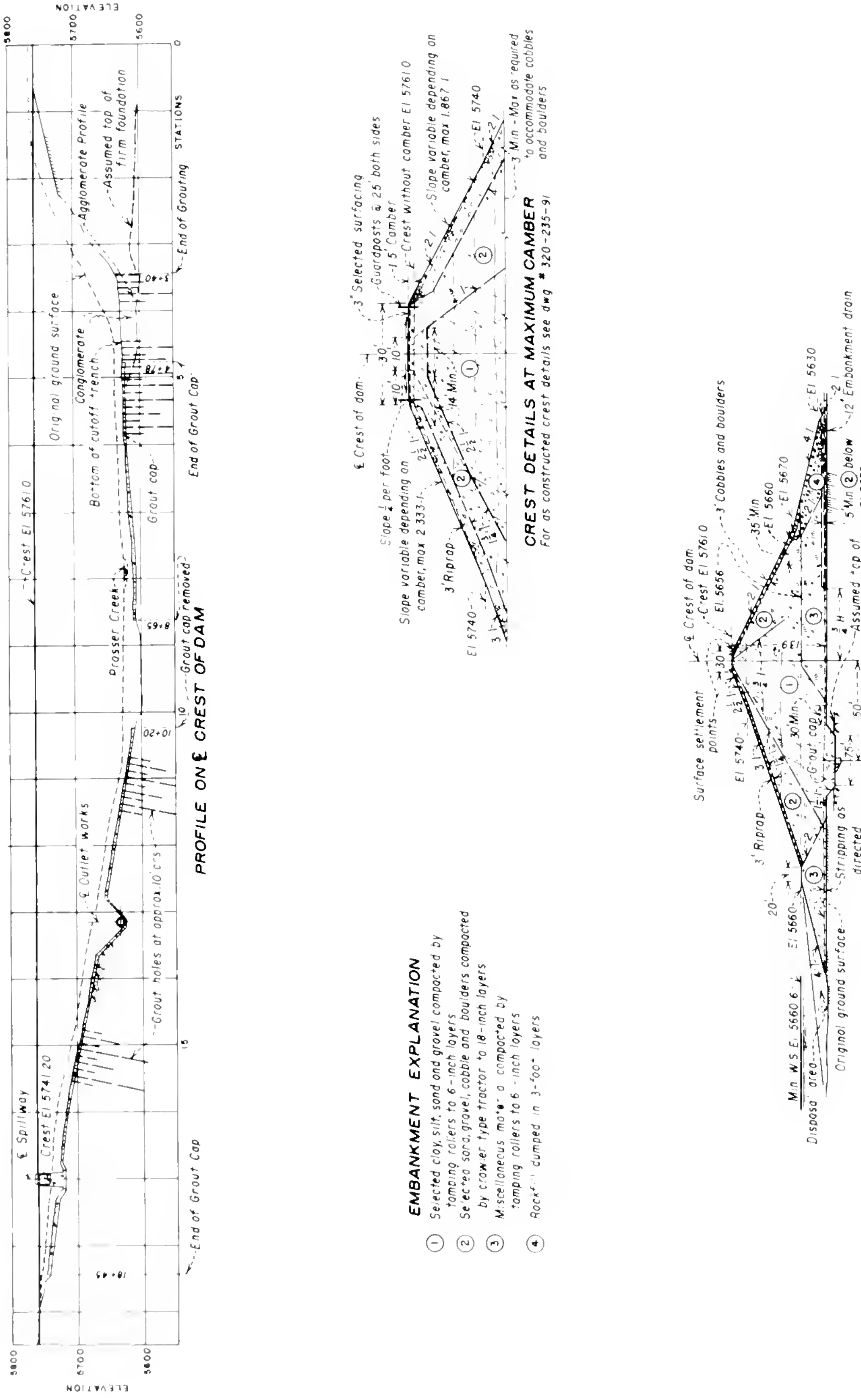
Location: From Marble Bluff Dam to Pyramid Lake.
Year completed: 1975

Length	3	mi
Capacity	50	ft^3/s
Section:		
Bottom width	6	ft
Side slopes	1.75:1	
Water depth	4	ft
Lining thickness	1.5	ft

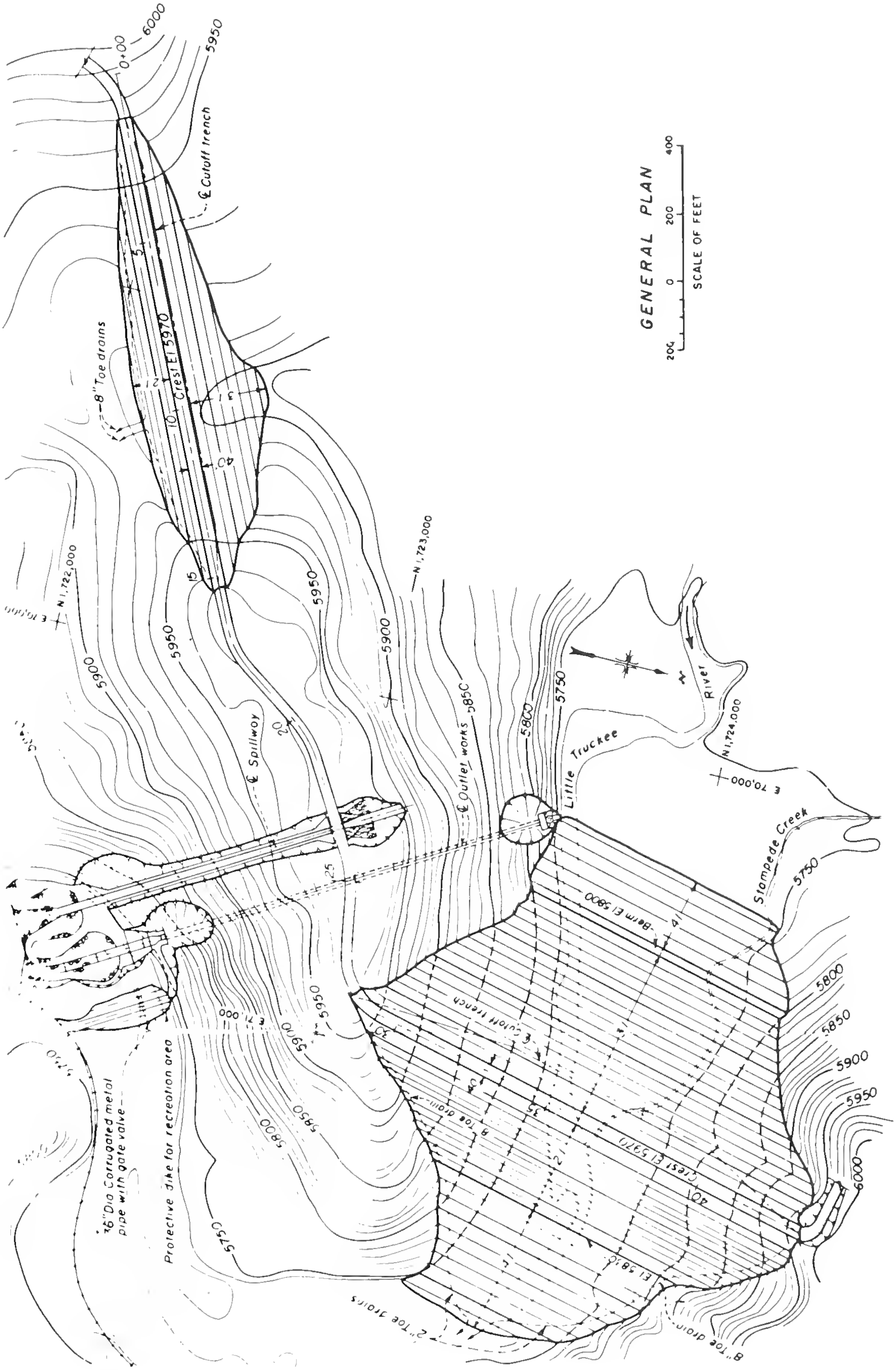
Fish handling facilities are located at Marble Bluff Dam.



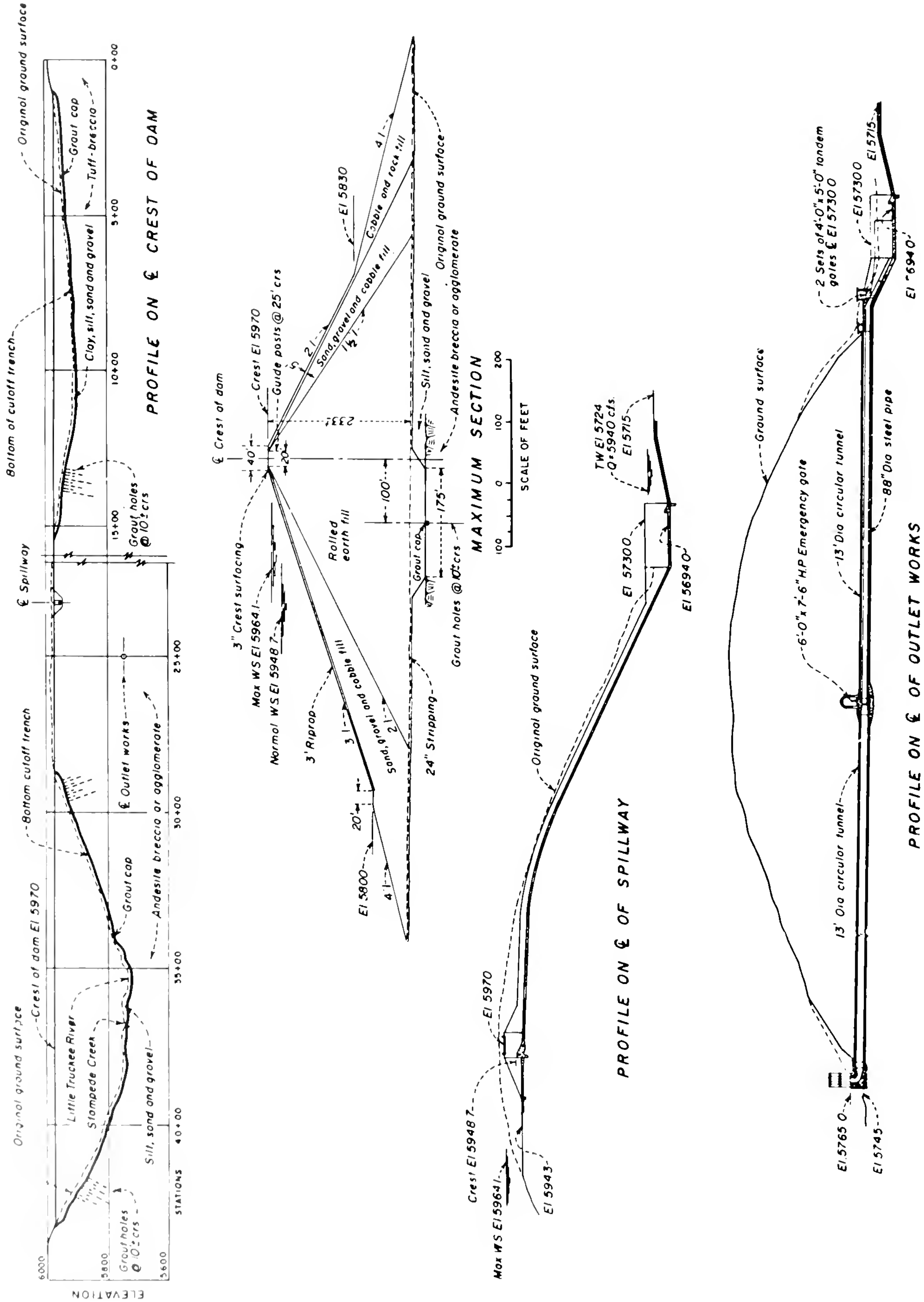
Prosser Creek Dam, Plan



Prosser Creek Dam, Sections



Stampede Dam, Plan

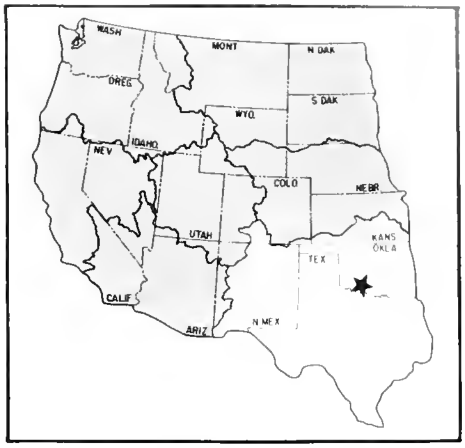


Stampede Dam, Sections

W. C. Austin Project

Oklahoma: Greer, Jackson, and Kiowa Counties

Southwest Region
Water and Power Resources Service



The W. C. Austin (formerly Altus) Project is in southwestern Oklahoma. The project is designed to provide water for irrigation of approximately 48,000 acres of privately owned land in southwestern Oklahoma, flood control on the North Fork of the Red River, an augmented municipal water supply for the city of Altus, fish and wildlife conservation benefits, and recreation facilities. Project features include Altus Dam, the Main, Altus, West, and Ozark Canals, a 218-mile lateral distribution system, and 26 miles of drains.

PLAN

The primary storage unit is Lake Altus, a reservoir formed by a dam across the North Fork of the Red River about 18 miles north of Altus, and by several earth dikes at low places in the reservoir rim. The Main Canal transports water from Lake Altus to the northern boundary of the project's irrigable land. The North Fork of the Red River is crossed about midway along the length of the Main Canal by means of a concrete siphon. The terminus of the Main Canal at the northern boundary of the project lands forms a bifurcation from which a 270-mile-long system of canals and laterals, including the Main Canal, distributes the water. The city of Altus receives a municipal and industrial water supply from the project.

Altus Dam

Altus Dam is a concrete gravity, partially curved structure faced with granite masonry except on the downstream face of the overflow section. The dam is 110 feet above foundation and 1,112 feet long. It contains 70,200 cubic yards of concrete and masonry. Incorporated within the dam section are both controlled and uncontrolled overflow-type spillways and an outlet works which delivers water into the project canal system. The 58,000-cubic-foot-per-second spillway is regulated by nine radial gates. Lake Altus has a total capacity of 154,145 acre-feet, of which 1,663 acre-feet are dead storage, 19,596 acre-feet are flood control storage, and 132,886 acre-feet are conservation storage. The last 10,000 acre-feet of conservation storage is reserved for municipal water for Altus. Appurtenant reservoir structures are Lugert, East, North, and South Dikes, located at low places on the reservoir rim. Lugert Dike, the largest, is 4,245 feet long and has a maximum height of 45 feet.

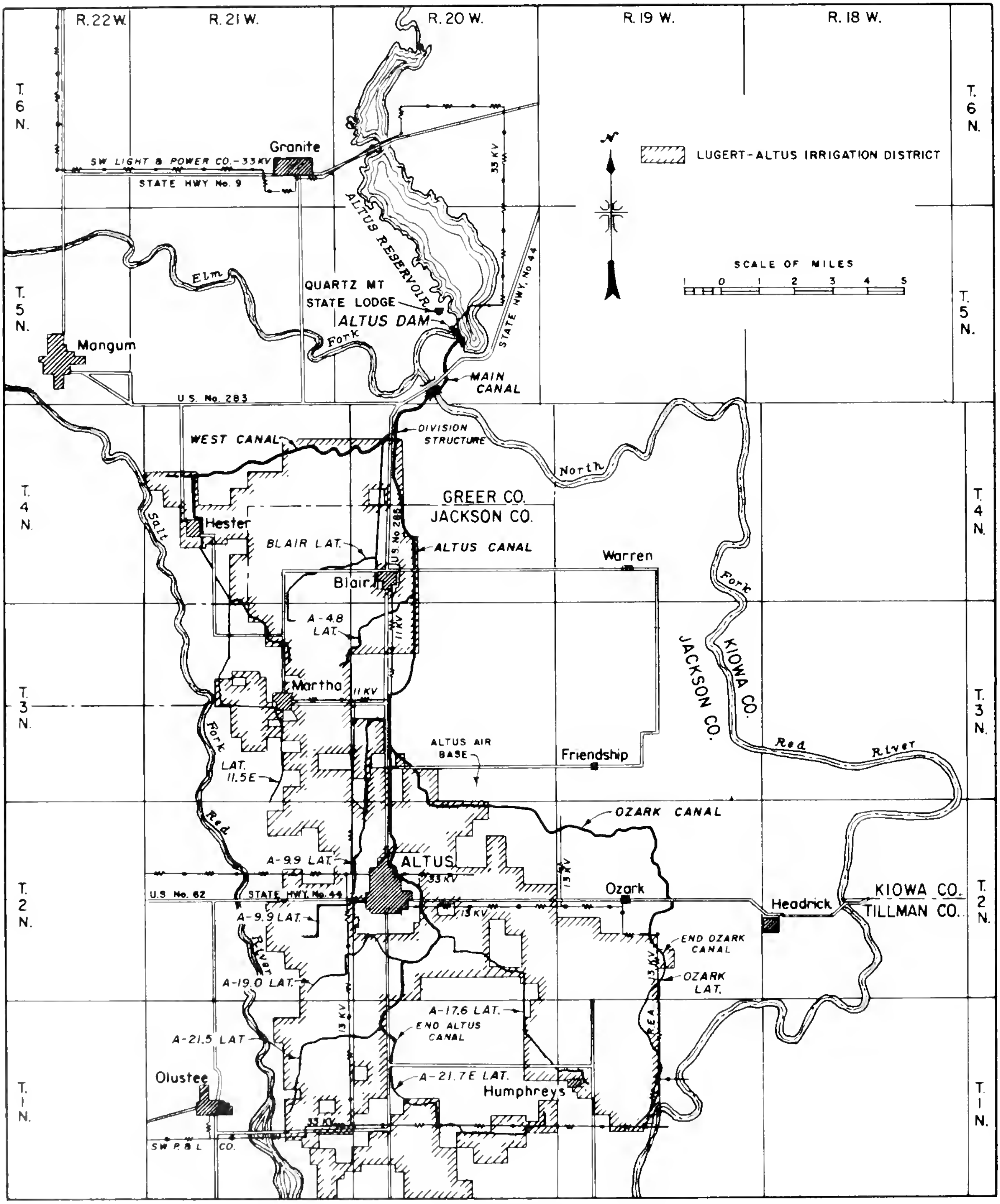
Canal and Lateral System

Water stored in Lake Altus is delivered into the 1,000-cubic-foot-per-second-capacity Main Canal, which transports the water 4.2 miles to the northern boundary of the project's irrigable lands. This canal crosses the North Fork of the Red River by means of a 10-foot 3-inch-diameter siphon, 1,920 feet long. Approximately 270 miles of canals and laterals, including the Main Canal, are required to serve project lands. The terminus of the Main Canal forms a bifurcation for diverting into the 21.7-mile Altus and the 11.1-mile West Canals, which serve the main delivery system. The 14.8-mile Ozark Canal branches off from Altus Canal.

DEVELOPMENT

Early History

Greer County was formed in 1886 by an act of the Texas legislature. At that time, the State of Texas contended that the North Fork of the Red River was the boundary between Oklahoma and Texas. The U.S. Supreme Court decreed in 1896 that Greer County belonged to Oklahoma. The present counties of Jackson, Greer, and Harmon were formed later from the original Greer County. The area was largely homesteaded prior to 1890. Most of the project lands were dry-farmed for many years prior to the construction of Altus Dam. Crop yields were good in wet years and poor in dry years. Irrigation of small tracts by private interests after 1927 demonstrated the value of irrigation.



W. C. Austin Project

Investigations

Engineering investigations to determine the feasibility of developing an irrigation project in the area began in 1902, and continued periodically until 1937. During 1937, renewed interest in irrigation by local civic leaders and the State of Oklahoma resulted in further investigations by several Federal agencies. The efforts of these agencies were coordinated and the remaining investigations and construction preliminaries were conducted by the Bureau of Reclamation. A project planning report issued in December 1937 recorded the results of the investigations.

Authorization

Construction of the W. C. Austin Project was authorized by the Rivers and Harbors Act of June 28, 1938 (52 Stat. 1215, 1219), and specifically by the President on February 13, 1941.

Construction

Construction began on April 21, 1941, but was interrupted by World War II. Work resumed on May 12, 1944, when the War Production Board lifted restrictions. The first section of canal lying within the project lands was completed on April 30, 1946. First water deliveries to project lands were made on June 19, 1946. Construction of the distribution system was completed in 1949. Main drainage features were completed during 1953. Several additional miles of drains have been constructed by the Lugert-Altus Irrigation District.

Operating Agency

The Lugert-Altus Irrigation District is responsible for the operation and maintenance of the project.

BENEFITS

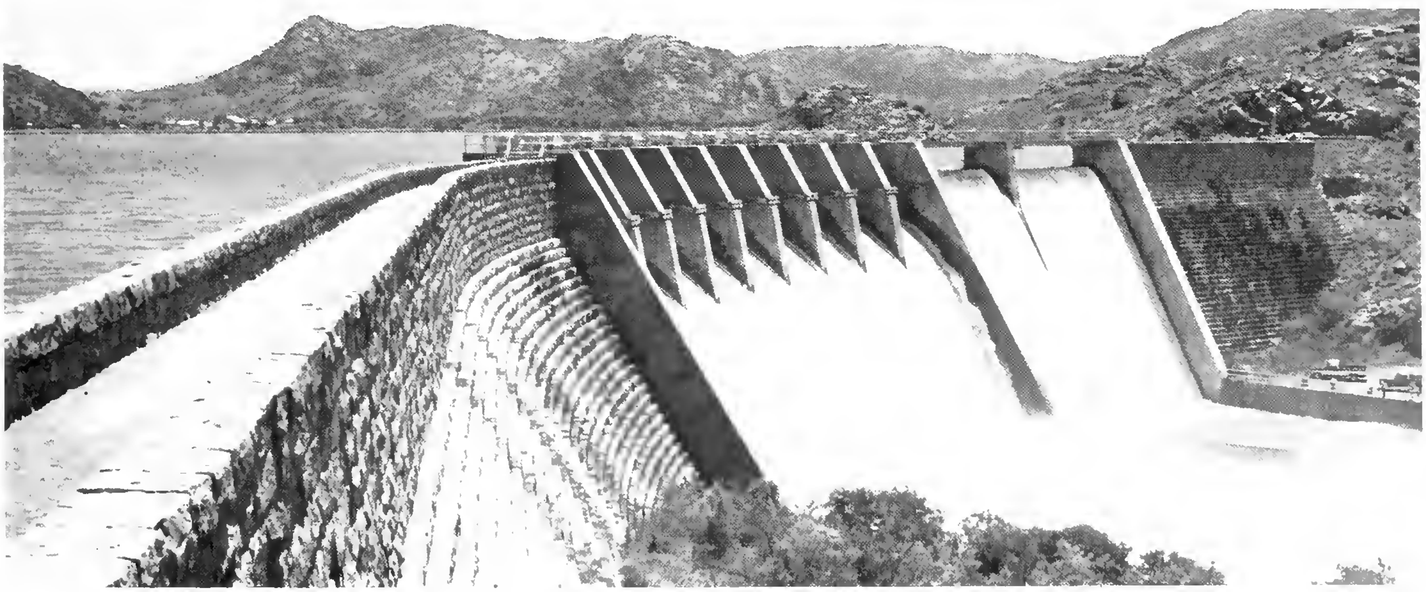
Irrigation

The mean annual rainfall in the project area, although sufficient to grow fairly good crops, often is so poorly distributed that droughts are frequent. Irrigation supplements the inadequate rainfall, stabilizes the economy of the area, and permits a more diversified agriculture. Cotton is a major crop under irrigation, as it was under dry farming in the project area. Wheat, another major dry land crop, is being replaced by alfalfa, grain sorghums, potatoes, onions, and other specialty crops.

Recreation and Fish and Wildlife

Lake Altus, in the scenic Quartz Mountains, offers year-round recreation. The south portion of the area adjacent to the reservoir is managed for recreation purposes by the Oklahoma Tourism and Recreation Department. The north portion of the reservoir area is managed for wildlife benefits by the Oklahoma Department of Wildlife Conservation. This includes a total water surface area of over 6,500 acres, and a land area of over 4,000 acres.

The Quartz Mountain State Park is located at the west edge of the reservoir. Public recreation facilities of all types are available, including an 18-hole golf course, lodging, cafe, indoor and outdoor swimming pools, grocery store, service dock, Fish-o-Rama, organized group camps, recreation-vehicle pads, tent spaces, two swimming beaches, boat launching ramps, trailer spaces, campgrounds, picnic areas with shelters and tables, drinking water, restrooms, hiking trails, and access roads with parking. Visitation exceeds 750,000 visitor days annually. Fishing and hunting are popular, as well as picnicking, sightseeing, and many water sport activities.



Altus Dam

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	47,123	acres
Number of irrigated farms	182	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	39,313	4,743,556
1969	41,265	4,654,234
1970	40,766	5,498,639
1971	23,764	2,996,593
1972	37,582	5,502,669
1973	42,507	13,873,846
1974	43,122	6,357,917
1975	44,093	8,648,790
1976	44,482	10,904,710
1977	43,948	10,816,917

Facilities in Operation

Storage dams	1	
Canals	52	mi
Laterals	218	mi
Drains	26	mi

Climatic Conditions

Annual precipitation	25.4	in
Temperature:		
Maximum	120	°F
Minimum	−11	°F
Mean	63	°F
Growing season	225	days
Elevation of irrigable area	1270-1500.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	302
Municipal water service	30,000
Other water service[1]	678
Total	30,980

[1]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

NORTH FORK, RED RIVER

Drainage area above Altus Dam	2,515	mi²
Annual discharge at Granite and Carter, Okla.:[2]		
Maximum (1942)	256,718	acre-ft
Minimum (1940)	4,572	acre-ft
Average at Carter	86,220	acre-ft
Average at Granite	128,868	acre-ft
Average annual diversion, 1948-76[3]	48,050	acre-ft

[2]At Granite 1904, 07, 1938-44. At Carter 1944-62, 1964-75.
[3]Includes diversions to the city of Altus.

Storage Facilities

ALTUS DAM

Type: Concrete gravity, masonry faced
Location: On North Fork, Red River, about 18 mi northeast of Altus, Okla.
Construction period: 1941-45
Reservoir, Lake Altus:

Average annual inflow, 1944-62, 1964-75	86,200	acre-ft
Total capacity to El. 1562	154,145	acre-ft
Active capacity, El. 1517.5-1562[4]	152,482	acre-ft
Surface area	7,420	acres
Dimensions:		
Structural height	110	ft
Hydraulic height	82	ft
Top width	10	ft
Maximum base width	71	ft
Crest length	1,112	ft
Crest elevation	1564.0	ft
Total volume	70,200	yd³
Spillway: Overflow crest near center of dam with uncontrolled section and section controlled by nine 21- by 15-ft radial gates.		
Controlled crest length	229	ft
Uncontrolled crest length	114.5	ft
Controlled crest elevation	1547.0	ft
Uncontrolled crest elevation	1559.0	ft
Elevation top of gates	1562.0	ft
Capacity at El. 1564	58,000	ft³/s
Outlet works:		
River: Two steel pipes through base of dam controlled by two 4-ft-square slide gates.		
Capacity at El. 1559[5]	1,000	ft³/s
Diversion: Three steel pipes through base of dam, each controlled by one 5-ft-square slide gate.		
Capacity at El. 1559	3,500	ft³/s
Foundation: Competent fine-grained granite.		
Special treatment: Foundation and abutments grouted.		
Mass concrete: Crushed granite from nearby railroad relocation supplemented by durable limestone from Chico, Tex., for aggregate; modified portland cement with up to 29 percent pumicite added for interior concrete; natural temperature control.		
Volume	50,524	yd³
Average net water/cement ratio (by weight)	0.60-0.90	
Cement content:		
Exterior concrete	1.04	bbl/yd³
Interior concrete	0.68	bbl/yd³
Contraction joints: Four transverse joints in nonoverflow section, pressure grouted after initial cooling of concrete.		

[4]Includes 19,596 acre-ft of flood-control storage capacity.
[5]Abandoned. Pipes welded shut.

Carriage Facilities

MAIN CANAL

Location: From Altus Reservoir southwest to division point for West and Altus Canals, about 13 mi north of Altus, Okla.

Length	4.2	mi
Diversion capacity	1,000	ft³/s

Typical maximum section in earth:

Bottom width	22	ft
Slide slopes	2:1	
Water depth	9.92	ft

Typical maximum section, bench flume:

Width	16	ft
Water depth	9.5	ft

Cross section: Rectangular
Material: Concrete

River Crossing (Main Canal)

Location: On North Fork, Red River, about 2 mi south of Altus Reservoir.
Description: Monolithic concrete siphon

Length	1,920	ft
Diameter	10.25	ft
Capacity	1,000	ft³/s

Cross section: Circular

West Canal

Location: From end of Main Canal west about 6 mi, then south.

Length	11.1	mi
Diversion capacity	290	ft³/s

Typical maximum section in earth:

Bottom width	14	ft
Side slopes	1.5:1	
Water depth	5.34	ft

Altus Canal

Location: From end of Main Canal south to a point about 3 mi south of Altus, Okla.

Length	21.7	mi
Diversion capacity	710	ft³/s

Typical maximum section in earth:

Bottom width	20	ft
Side slopes	1.5:1	
Water depth	8.73	ft

Ozark Canal

Location: From Altus Canal about 3.5 mi north of Altus, Okla., generally southeast.

Length	14.8	mi
Diversion capacity	180	ft³/s

Typical maximum section in earth:

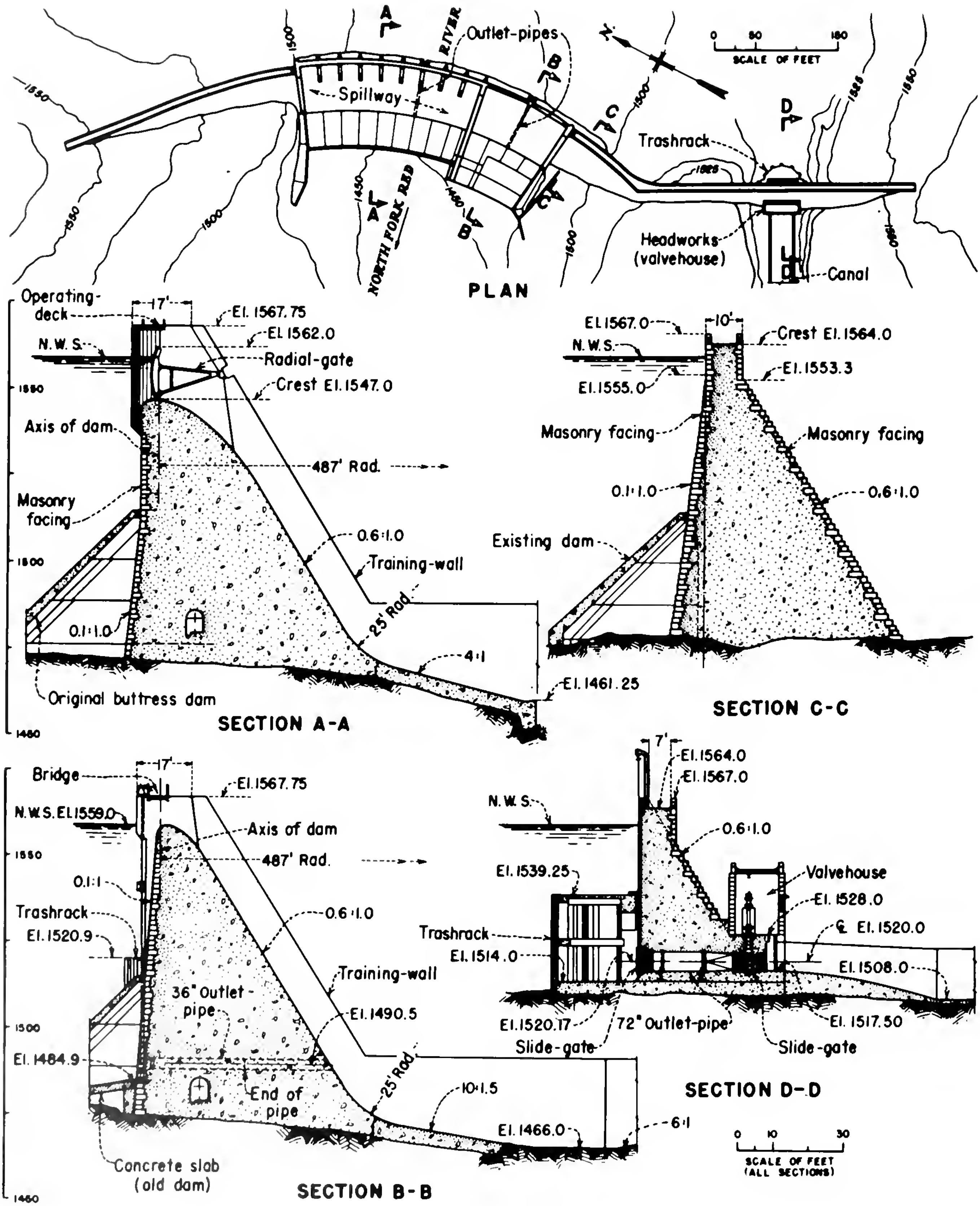
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	4	ft

City Pipeline[a]

Location: From a point on Altus Canal about 3 mi north of Altus, Okla.
Description: Circular concrete pressure pipe

Length	3.2	mi
Diameter	30 and 24	in
Capacity	25	ft³/s

[a]The City Pipeline lateral was abandoned downstream of the valve structure by the city of Altus in 1976.

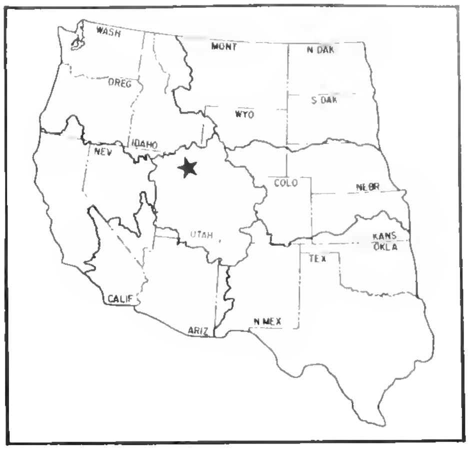


Altus Dam, Plan and Sections

Weber Basin Project

Utah: Davis, Morgan, Summit, and Weber Counties

Upper Colorado Region
Water and Power Resources Service



The Weber Basin Project conserves and utilizes, for multiple purposes, streamflows in the natural drainage basin of the Weber River, including the basin of the Ogden River, its principal tributary. Other areas encompassed are those lying between the west slope of the Wasatch Mountains and the east shore of Great Salt Lake.

Water resources of the area were extensively developed before initiation of the Weber Basin Project. Prior Federal reclamation developments include the Weber River Project with Echo Reservoir on Weber River, and the Ogden River Project with Pineview Reservoir and conveyance facilities on the Ogden River. The Weber River and Provo River Projects diverted water from the high reaches of Weber River for multiple uses on Provo River. Numerous private developments antedate the Federal projects. The Weber Basin Project supplements all of these earlier undertakings and its operations are integrated with them in approaching full development of the area's water resources. In full operation, the Weber Basin Project provides an average of 164,480 acre-feet of water annually for irrigation and 50,000 acre-feet for municipal and industrial use in a heavily populated and industrialized area.

PLAN

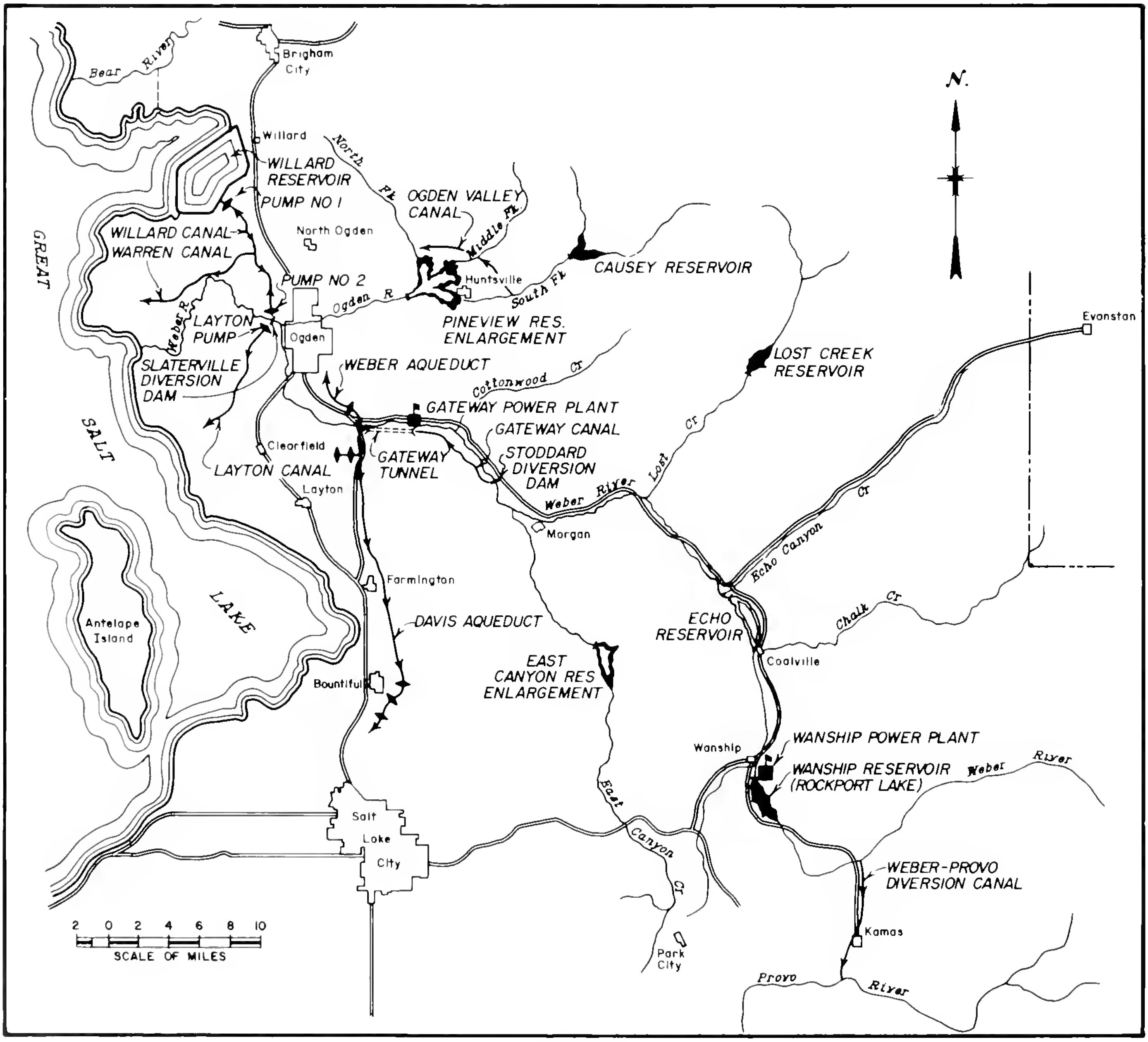
Streamflow for project purposes is regulated by four new project reservoirs and two enlarged reservoirs, and the correlated operation of project reservoirs and the existing Echo Reservoir. Three of the six project reservoirs, Rockport Lake (formerly Wanship Reservoir), Lost Creek, and East Canyon (enlarged), as well as Echo Reservoir, regulate the flow of Weber River before it emerges from its mountain watershed into the east shore area. Two project reservoirs, Causey and Pineview (enlarged), regulate the Ogden River flow before it emerges from the mountains to join Weber River. Arthur V. Watkins Reservoir (formerly Willard), is the lowest reservoir of the system. It receives water from Weber River, diverted at the Slaterville Diversion Dam below the mouth of Ogden River and conveyed through the Willard Canal. Water is returned from Arthur V. Watkins Reservoir to Weber River as needed over the same route, facilitated by two pumping plants.

Weber River System

The three project reservoirs on the Weber River and its tributary creeks are operated to supply water for irrigation, municipal, and industrial purposes in the east shore area and for power production at the Wanship Powerplant. In addition, the reservoirs provide water for irrigation, domestic, and miscellaneous uses to lands in mountain valleys along the Weber River, Lost Creek, and East Canyon Creek, as well as for flood control and maintenance of streamflows to support game fish.

The highest lands to be irrigated in the Weber River Valley are near the town of Oakley above Rockport Lake. These lands receive water exchanged from Rockport Lake and delivered through existing canals and ditches, some of which have been enlarged and extended as a project undertaking. Other mountain valley lands receive project water above Rockport Lake, Lost Creek,

Wanship Dam and Rockport Lake



Weber Basin Project

and East Canyon Reservoirs. Delivery is made through the Weber River, Lost Creek, East Canyon Creek, the Gateway Canal, and existing canals and ditches. Lands above the reservoirs receive water from wells which is exchanged for water released from the reservoirs.

Stoddard Diversion Dam, on the Weber River about 4 miles downstream from Morgan, Utah, diverts water into the Gateway Canal which extends 8.5 miles westward on the south side of Weber Canyon. Gateway Canal has an initial capacity of 700 cubic feet per second. About 8.5 miles from the canal head of the inlet to the Gateway Tunnel, the portion of the diverted water that is surplus or is required for prior downstream rights is turned into the penstock of the Gateway Powerplant and returned through the plant to the Weber River. The remaining water is conveyed through the 3.3-mile-long Gateway Tunnel to the west face of the Wasatch Mountains, where bifurcation works divert it to the Weber Aqueduct to the north and the Davis Aqueduct to the south.

Weber Aqueduct is 4.2 miles long with a capacity of 80 cubic feet per second, conveying irrigation water to land on the Uintah Bench and municipal and industrial water to Ogden and adjacent communities. Part of the irrigation water is pumped to lands above the aqueduct. The remainder is delivered by an existing high-pressure distribution system. At the terminal of the aqueduct, water is delivered to a water treatment plant from which it is distributed to the city of Ogden and surrounding communities.

Davis Aqueduct extends to the south along the foot of the Wasatch Mountains about 22 miles to North Salt Lake City and has an initial capacity of 355 cubic feet per second. It carries irrigation water to lands below the aqueduct. It also conveys water for municipal and industrial use by communities in Davis County. Six pump stations and discharge lines lift water to land above the aqueduct.

Ogden River System

Causey Reservoir, on the South Fork of Ogden River, provides supplemental irrigation water for mountain valley lands near Huntsville and Eden. Irrigation water released from the reservoir is diverted from the South Fork of Ogden River by the Ogden Valley Diversion Dam and conveyed through the Ogden Valley Canal to lands in the Huntsville-Eden area.

The enlarged capacity in Pineview Reservoir increases the irrigation supply for lands north and south of Ogden River in the area of the Ogden River Project. It also provides irrigation water for diversion from the lower Weber River at the Slaterville Diversion Dam and makes additional water available for municipal and industrial use in the Ogden area.

Causey Dam and Reservoir

Water available to the Weber Basin Project at the Slaterville Diversion Dam consists of both the natural flows of Weber and Ogden Rivers not required for prior rights, and of storage releases from the upstream reservoirs. The natural flows are surplus high flows not regulated by upstream reservoirs, winter flows released through upstream powerplants, return flows, and other river inflows below upstream reservoirs. Water is diverted at the Slaterville Diversion Dam into Willard Canal or the Layton Canal intake channel. Water diverted into Willard Canal during the nonirrigation season is conveyed 8 miles to the Arthur V. Watkins Reservoir, where it is stored. When upstream supplies are insufficient to supply water demands below the Slaterville Diversion Dam, water is pumped from the reservoir at Willard Pumping Plant No. 1. By reverse flow through Willard Canal, it is either returned to the Slaterville Diversion Dam through Willard Pumping Plant No. 2 or released at turnouts in the canal. Willard Canal has a capacity of 1,050 cubic feet per second for gravity flow from the dam to the Plain City Canal turnout, and 950 cubic feet per second from the turnout to the reservoir. In the reverse direction, the capacity for pumped flows is 500 cubic feet per second from the reservoir to the turnouts and 300 cubic feet per second from the turnouts to Slaterville Diversion Dam.

Water diverted through the Layton intake channel is delivered to Hooper Canal and the project's Layton Pumping Plant. Water is pumped from the intake channel into Layton Canal or Wilson Canal. Layton Canal, a project feature, extends 9 miles in a generally southerly direction. Under an emergency loan project, the Weber Basin Water Conservancy District constructed a 60-inch pipeline that conveys water pumped from an equalizing reservoir near Layton Canal into the Davis-Weber Canal, thus allowing the district to exchange water from Arthur

V. Watkins Reservoir during periods of drought. Water exchanged is held in upstream reservoirs or diverted through the Gateway Canal and Tunnel.

Nine deep wells provide emergency standby service, supplemental water in times of drought, and peaking supply for high industrial and municipal demands.

Arthur V. Watkins Dam, and Willard Canal and Pumping Plant

Flows that cannot be controlled by the mountain reservoirs, as well as winter releases through the powerplants, are diverted from Weber River at the Slaterville Diversion Dam west of Ogden and carried 8 miles north in the Willard Canal to Arthur V. Watkins Reservoir. The earth-lined canal has an initial capacity of 1,050 cubic feet per second. About 5 miles from the canal heading, a turnout diverts water into the Plain City Canal, a privately owned irrigation system.

Twelve miles northwest of Ogden on the shore of the Great Salt Lake, Arthur V. Watkins Dam is an offstream structure with a structural height of 36 feet. It is 14.5 miles long in a rough rectangle, contains about 17 million cubic yards of material, and encloses a reservoir of 215,100-acre-foot capacity. Its siphon spillway has a capacity of 2,000 cubic feet per second. The 300-cubic-foot-per-second capacity outlet works functions only as a reservoir drain.

During the irrigation season, water can be pumped by Willard Pumping Plants No. 1 and No. 2 back through the Willard Canal from Arthur V. Watkins Reservoir to Slaterville Diversion Dam and on into the Layton Pumping Plant intake channel for irrigation of lands lying along the shores of Great Salt Lake.

Slaterville Diversion Dam and Willard Canal

Slaterville Diversion Dam

Slaterville Diversion Dam is on the Weber River about 2 miles west of Ogden. It is a reinforced concrete structure with a river regulating section controlled by six 25-foot-wide radial gates. It diverts water into Willard Canal, Slaterville Canal, and the Layton Pumping Plant intake channel.

Layton Canal, Pumping Plant, and Laterals

The Layton Canal conveys Weber River water southward about 9 miles from the Slaterville Diversion Dam. The canal has an initial headgate capacity of 180 cubic feet per second. The Layton Pumping Plant, located at the foot of a bench to the south of Slaterville Diversion Dam, pumps project water into Layton Canal. With four units and an installed horsepower capacity of 1,050, it lifts water an average height of 25 feet at the rate of 250 cubic feet per second.

Pineview Dam and Reservoir Enlargement

Pineview Dam, on the Ogden River about 7 miles east of Ogden, was constructed by the Bureau of Reclamation as part of the Ogden River Project in 1937. The original structure, 103 feet high, created a 44,000-acre-foot reservoir. Under the Weber Basin Project, the dam was enlarged to a height of 137 feet, increasing the reservoir capacity to 110,150 acre-feet. The 10,000-cubic-foot-per-second-capacity spillway is controlled by two radial gates. The maximum discharge capacity of the outlet works is 2,300 cubic feet per second. The increased storage capacity in Pineview Reservoir provides supplemental irrigation and municipal water within the Ogden River Project area and, together with Arthur V. Watkins Reservoir storage, provides water to irrigate new land in the Willard and Layton Canal areas, and to replace natural flows of Weber River that are diverted at Stoddard Diversion Dam into Gateway Canal.

Causey Dam and Reservoir

Causey Dam is on the South Fork of the Ogden River about 11 miles upstream from Pineview Dam. A zoned earthfill structure, it has a height of 218 feet and a crest length of 845 feet. Causey Reservoir has a total capacity of 7,870 acre-feet with a surface area of 136 acres.

Weber Aqueduct

Weber Aqueduct, extending about 4 miles northward from the outlet of Gateway Tunnel, has a capacity of 80 cubic feet pér second. It carries an average of 9,900 acre-feet of irrigation water annually to the Uintah Bench and about 19,000 acre-feet of municipal and industrial water annually to Ogden and adjacent cities. A complete pressure pipe lateral system distributes project water to the Uintah Bench lands.

Davis Aqueduct

Davis Aqueduct, extending 21.6 miles southward from the outlet of Gateway Tunnel, has an initial capacity of 355 cubic feet per second. It conveys an average of 51,000 acre-feet annually for irrigation of foothill lands between Weber Canyon and North Salt Lake, and approximately 21,000 acre-feet annually for municipal and industrial use in 15 communities. Several lateral systems, mostly pressure pipe, serve approximately 16,000 acres in the Davis Aqueduct service area.

Stoddard Diversion Dam

The Stoddard Diversion Dam is a concrete gate structure on the Weber River 4 miles northwest of Morgan. It has a river regulating section 110 feet wide, controlled by four 25-foot-wide radial gates. This structure diverts up to 700 cubic feet per second of water supplied from the upper Weber River storage and natural flow into Gateway Canal.

Gateway Canal System

Gateway Canal extends from Stoddard Diversion Dam westward about 8.5 miles on the south side of the Weber Canyon. Its initial capacity is 700 cubic feet per second. At the end of the canal, a portion of the water may be diverted through the Gateway Powerplant to the Weber River. The remaining water is conveyed through the 3.25-mile Gateway Tunnel to the west face of the Wasatch Mountains, where the water is divided between the Weber and Davis Aqueducts.

Stoddard Diversion Dam

East Canyon Dam and Reservoir Enlargement

East Canyon Dam is a concrete thin-arch structure, 10 miles southeast of Morgan on East Canyon Creek. The new dam, with a height of 260 feet, a top thickness of 7 feet, crest length of 436 feet, and a volume of 35,716 cubic yards, replaces an old concrete arch dam and increases the reservoir capacity from 29,000 to 51,200 acre-feet, covering a surface area of 684 acres. The uncontrolled spillway is on the left end of the dam and has a 1,000-cubic-foot-per-second capacity; the outlet through the dam has a capacity of 100 cubic feet per second.

Lost Creek Dam and Reservoir

Lost Creek Dam is on Lost Creek, 12 miles upstream from its confluence with Weber River. It impounds a reservoir with a total capacity of 22,510 acre-feet covering a surface area of 365 acres. A zoned earthfill structure 248 feet high with a crest length of 1,078 feet, the dam has a volume of 1,831,820 cubic yards. The uncontrolled spillway on the right abutment has a concrete-lined chute with a capacity of 2,455 cubic feet per second. The outlet works, with a capacity of 805 cubic feet per second, consists of an intake structure at the right abutment, a concrete-lined tunnel, a gate chamber for two 2.25-foot-square high-pressure gates, a concrete tunnel, and stilling basin.

Lost Creek Dam

Wanship Powerplant

Wanship Dam and Rockport Lake

Located 1.5 miles south of Wanship on the Weber River, the Wanship Dam impounds Rockport Lake. The lake has 62,120 acre-feet total capacity, and a surface area of 1,077 acres. The dam, a zoned earthfill structure, is 175 feet high, has a crest length of 2,015 feet, and contains 3,183,000 cubic yards of material. The spillway is an uncontrolled open concrete chute with a capacity of 10,800 cubic feet per second. The outlet works tunnel provides for releases to the powerplant or to the river. The outlet works has a capacity of 1,000 cubic feet per second.

Powerplants

The Gateway Powerplant is at the lower end of Gateway Canal, 10 miles southeast of Ogden. The plant is driven by water returning to the river from Gateway Canal. Its two units develop 4,275 kilowatts under a head of 147 feet.

Wanship Powerplant is at Wanship Dam 1.5 miles south of Wanship. With one unit, it develops 1,425 kilowatts of energy under a maximum head of 152 feet.

The two plants provide power for the operation of project works including pumping of irrigation, drainage, and municipal water. Energy produced in the nonirrigation season, as well as surplus energy produced during the irrigation season, is available to preferential customers.

Drainage System

A system of 34.5 miles of drains has been constructed to improve and reclaim project land.

DEVELOPMENT

Early History

The early history of the Weber Basin Project is very similar to the history of the Ogden and Weber River Projects. Weber River water was first used by new settlers for irrigation about 1848. The development was reasonably rapid, and by 1896 more than 100 canal companies had begun to divert water from the river or its tributaries and had established rights to all of the normal summer flow. Storage of spring floodflows was undertaken to overcome shortages during the late irrigation season or drought periods. The 3,850-acre-foot East Canyon Reservoir, constructed by private interests on a tributary of Weber River in 1896, was one of the first storage developments. It was enlarged to a capacity of 29,000 acre-feet in 1916. Numerous small reservoirs, ranging up to 1,900-acre-foot capacity, also were constructed by irrigation companies.

Investigations

Two Bureau of Reclamation reservoirs were constructed on the Weber River system before authorization of the Weber Basin Project. The 74,000-acre-foot Echo Reservoir on Weber River was completed in 1931 as the principal feature of the Weber River Project. The 44,000-acre-foot Pineview Reservoir on the Ogden River was completed in 1936 as a part of the Ogden River Project. Additional canals and conduits were built under the Ogden River Project. Some water from Weber River watershed is diverted to the Provo River Project through the Weber-Provo Diversion Canal, constructed as a part of the Weber River Project and enlarged by the Provo River Project.

Planning for the Weber Basin Project started in 1942, was discontinued during the war years, and was resumed in 1946 when it became apparent that the marked population growth in the project area during World War II was permanent. Newcomers, attracted mainly by war installations, remained after the war ended, creating an acute demand for municipal water and accentuating the need for additional irrigation supplies. A status report on investigations was made in January 1948. A project report issued July 1949 led to congressional authorization of the project in 1949. The first appropriation of construction funds was made July 9, 1952. The definite plan report was prepared in 1952. This initial report was revised in 1955 and 1959.

Authorization

Construction of the Weber Basin Project was authorized by the Congress on August 29, 1949 (63 Stat. 677).

Construction

First contracts for construction of project features were awarded in 1956. All were completed in 1969.

Operating Agency

Operation and maintenance of the project was turned over to the Weber Basin Water Conservancy District on October 1, 1968.

BENEFITS

Irrigation

The new land developed by the project is practically all in private ownership. Development of this acreage will permit the formation of new farms and the expansion of many existing units. Principal crops are fruits, vegetables, sugarbeets, potatoes, alfalfa, and cereals.

Municipal and Industrial Water

Benefits to communities and cities are extensive throughout the project area.

Flood Control

Flood control is a major contribution of the thorough development of the resources of the Weber and Ogden Rivers.

Recreation and Fish and Wildlife

Minimum storage pools for game fish are maintained at Rockport Lake, East Canyon, Lost Creek, Causey, and Pineview Reservoirs. Recreation is administered by the Forest Service at Pineview and Causey Reservoirs. The Utah Division of Parks and Recreation administers Arthur V. Watkins, East Canyon, Lost Creek, and Rockport Reservoirs. Facilities for picnicking, camping, swimming, boating, water skiing, fishing, and hunting, as well as sanitation facilities, are available for the increasing number of visitors. Substantial improvements of recreation facilities have been completed. Recreational use is increasing correspondingly, with a total of 1,364,838 visitor days reported for the reservoir areas during 1977.

PROJECT DATA

Land Areas (1977)

Irrigable areas:		
Available for service	32,819	acres
Not for service	57,682	acres
Total	90,501	acres
Number of farms tracts served	1,153	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	18,056	2,153,723
1969	18,303	1,827,545
1970	19,331	1,948,671
1971	19,298	2,202,739
1972	18,819	1,836,087
1973	18,819	4,279,169
1974	18,849	5,484,007
1975	18,838	4,817,775
1976	18,829	5,454,798
1977	18,809	6,260,897

Facilities in Operation

Storage dams	7	
Diversion dams	3	
Canals	121.8	mi
Tunnels	3.3	mi
Laterals	143.3	mi
Drains	34.5	mi
Pumping plants	11	
Wells	9	

Climatic Conditions

Annual precipitation	18	in
Temperature:		
Maximum	105	°F
Minimum	−23	°F
Mean	50	°F
Growing season	87-160	days
Elevation of irrigable area	4215-5200.0	ft

ENGINEERING DATA

Water Supply

Weber River

Drainage area at Wanship Dam	339	mi²
Annual discharge:		
Maximum (1952)	279,500	acre-ft
Minimum (1977)	53,300	acre-ft
Average	137,300	acre-ft

Ogden River

Drainage area at Pineview Dam	298	mi²
Annual discharge:		
Maximum (1936)	263,500	acre-ft
Minimum (1934)	25,800	acre-ft
Average	161,000	acre-ft

Storage Facilities

Arthur V. Watkins (Willard) Dam

Type: Zoned earthfill
Location: Approximately 11 mi northwest of Ogden, Utah.
Construction period: 1958-64
Reservoir, Arthur V. Watkins:

Total capacity to El. 4226.85	215,100	acre-ft
Active capacity	198,200	acre-ft
Surface area	1,950	acres
Total allowable storage (1977)[1]	185,000	acre-ft
Dimensions:		
Structural height	36	ft
Top width	25	ft
Base width	470	ft
Crest length	76,665	ft
Volume	17,060,000	yd³
Spillway: Siphon		
Capacity	2,000	ft³/s
Outlet: Concrete intake structure, gate chamber with 7-ft-square slide gates and reservoir level control sills, a free-flow discharge conduit, and stilling basin.		
Capacity	300	ft³/s

[1]Storage capacity is limited due to settlement in the west dike of the reservoir.

Pineview Dam

Type: Zoned earthfill
Location: On Ogden River 7 mi east of Ogden, Utah.
Construction period: 1934-37. Enlarged under the Weber Basin Project: 1955-57
Date of closure (first storage): November 1936
Reservoir, Pineview (enlarged):

Total capacity to El. 4902	110,000	acre-ft
Active capacity	110,000	acre-ft
Surface area	2,874	acres
Dimensions (enlarged dam):		
Structural height	137	ft
Top width	30	ft
Maximum base width	480	ft
Crest length	600	ft
Crest elevation	4908.0	ft
Volume	418,000	yd³
Spillway: Concrete-lined open channel in right abutment, controlled by two 12- by 22-ft radial gates.		
Elevation top of gates	4900.0	ft
Crest elevation	4878.0	ft
Capacity at El. 4902	10,000	ft³/s
Outlet works: Concrete-lined tunnel through right abutment, branching into a 5- and a 6-ft-diameter steel pipe, controlled by one 4- by 5-ft and one 5- by 6-ft gate, respectively, discharges into spillway stilling basin. The 5-ft pipe branches into a 3.5-ft steel pipe, controlled by a butterfly valve, leading to city of Ogden filtration plant. The 6-ft pipe has a 6-ft branch, without a gate, that leads into the 75-in Ogden Canyon Conduit, which branches into the Ogden-Brigham Canal, the South Ogden Highline Canal, and to Utah Power and Light Co.'s Pioneer Powerplant at the mouth of Ogden Canyon.		
Capacity, all outlets at El. 1902	2,300	ft³/s
City of Ogden water supply: 3-ft-diameter steel conduit beneath invert of outlet tunnel provides direct connection from city's artesian well collecting system in reservoir area to city supply line.		

Causey Dam

Type: Zoned earthfill
Location: On the South Fork of the Ogden River about 18 mi east of Ogden, Utah.
Construction period: 1962-66
Reservoir, Causey:

Total capacity to El. 5698.1	7,870	acre-ft
Active capacity	6,870	acre-ft
Surface area	136	acres
Dimensions:		
Structural height	218	ft
Hydraulic height	180	ft
Top width	30	ft
Maximum base width	1,200	ft

Crest length	815	ft
Crest elevation	5704.0	ft
Total volume	1,110,000	yd³
Spillway: Approach channel, concrete inlet structure, concrete chute, concrete stilling basin, two concrete bridges, and outlet channel.		
Capacity at El. 5698.1	7,570	ft³/s
Outlet works: Concrete-lined diversion tunnel, concrete intake structure with a concrete-lined shaft, concrete-lined tunnel with gate chamber for one 4-ft-square high-pressure gate, 52-inch-diameter outlet pipe, concrete control structure, concrete stilling basin, and outlet channel.		
Capacity at El. 5698.1	8,900	ft³/s

WANSHIP DAM

Type: Zoned earthfill
Location: On the Weber River, 1.5 mi south of Wanship, Utah.
Construction period: 1951-57
Reservoir, Rockport Lake:

Total capacity to El. 6037	62,120	acre-ft
Active capacity	60,860	acre-ft
Surface area	1,007	acres
Dimensions:		
Structural height	175	ft
Hydraulic height	156	ft
Top width	35	ft
Maximum base width	890	ft
Crest length	2,015	ft
Crest elevation	6055.0	ft
Total volume	3,183,000	yd³
Spillway: Uncontrolled concrete crest and concrete-lined chute at right abutment.		
Crest length	75	ft
Crest elevation	6037.0	ft
Capacity at El. 6049	10,800	ft³/s
Outlet works: Concrete-lined tunnel through right abutment.		
River: 85-in-diameter steel pipe in outlet tunnel, controlled by two 3.5-ft-square slide gates.		
Canal: 24- and 16-in-diameter branches from outlet pipe for West Wanship Ditch and East Wanship Canal, respectively.		
Power: 72-in-diameter branch from outlet pipe for power installation.		
Capacity at El. 6049	1,000	ft³/s

LOST CREEK DAM

Type: Zoned earthfill
Location: On Lost Creek, 12 mi northwest of Devils Slide, Utah.
Construction period: 1963-66
Reservoir, Lost Creek:

Total capacity to El. 6015.9	22,510	acre-ft
Active capacity	20,010	acre-ft
Surface area	365	acres
Dimensions:		
Structural height	248	ft
Hydraulic height	190	ft
Top width	30	ft
Maximum base width	1,000	ft
Crest length	1,078	ft
Crest elevation	6022.0	ft
Total volume	1,831,820	yd³
Spillway: Approach channel, concrete crest structure, concrete bridge, concrete chute, and concrete stilling basin.		
Capacity at El. 6015.9	2,455	ft³/s
Outlet works: Concrete intake structure, concrete-lined tunnel, access shaft and gate chamber for two 2.25-foot-square high-pressure gates, concrete shaft house, concrete stilling basin, and outlet channel.		
Capacity at El. 6015.9	805	ft³/s

EAST CANYON DAM

Type: Concrete thin arch
Location: On East Canyon Creek, 10 mi southeast of Morgan, Utah.
Construction period: 1964-66
Reservoir, East Canyon:

Total capacity to El. 5715	51,200	acre-ft
Active capacity	48,110	acre-ft
Surface area	681	acres
Dimensions:		
Structural height	260	ft
Hydraulic height	195	ft
Top width	7	ft
Maximum base width	20	ft
Crest length	436	ft
Crest elevation	5715.0	ft
Total volume	35,716	yd³
Spillway: Uncontrolled overflow spillway on the left (south) abutment.		
Capacity at El. 5715	1,000	ft³/s
Outlet works: A 2.75-ft-square outlet, a trashrack, and gatehouse.		
Capacity at El. 5715	100	ft³/s

Diversion Facilities

SLATERVILLE DIVERSION DAM

Type: Concrete gate structure, embankment wing
Location: On the Weber River, 2 mi west of Ogden, Utah.
Year completed: 1957
Dimensions:

Hydraulic height	8	ft
Crest length	162	ft
Crest elevation	1253.0	ft
Volume	2,000	yd³
River regulating structure: Six 25- by 7.5-ft radial gates.		
Capacity	6,600	ft³/s
Willard Canal headworks: Three 14- by 7.5-ft radial gates.		
Diversion capacity	1,150	ft³/s
Slaterville Canal headworks: One 3-ft-square slide gate.		
Diversion capacity	35	ft³/s
Layton Pump intake channel headworks: Direct diversion from river regulating structure without gates.		
Diversion capacity	1,570	ft³/s

STODDARD DIVERSION DAM

Type: Concrete gate structure
Location: On the Weber River, about 4 mi northwest of Morgan, Utah.
Year completed: 1956
Dimensions:

Hydraulic height	8	ft
Crest length	110	ft
Crest elevation	4965.0	ft
Volume	2,000	yd³
River regulating structure: Four 25- by 7.5-ft radial gates.		
Capacity	2,000	ft³/s
Gateway Canal headworks: Two 10- by 10.5-ft radial gates.		
Diversion capacity	700	ft³/s

OGDEN VALLEY DIVERSION DAM

Type: Gated spillway
Location: On South Fork of the Ogden River, about 7 mi upstream from Pineview Dam.
Year completed: 1964
Dimensions:
Hydraulic height .... 6 ft
Crest length .... 150 ft
Crest elevation (operating deck) .... 5090.83 ft
Volume (concrete) .... 168 yd³
Sluiceway: One 8- by 5-ft radial gate.
Headworks - Left: One 36- by 24-in gate.
Right: Two 48- by 36-in gates.
Diversion capacity:
Left .... 20 ft³/s
Right .... 80 ft³/s

Carriage Facilities

WILLARD CANAL

Location: From Arthur V. Watkins Dam southerly to Slaterville Diversion Dam.
Construction period: 1961-64
Length .... 10.7 mi
Initial capacity .... 1,050 ft³/s
Typical maximum section, earth lined:
Bottom width .... 30 ft
Side slopes 2:1
Water depth .... 9 ft

LAYTON CANAL

Location: From the Weber River at the Layton Pumping Plant near Slaterville Diversion Dam southward about 18 mi.
Construction period: 1963-64
Length .... 9 mi
Diversion capacity .... 180 ft³/s
Typical maximum section, earth lined:
Bottom width .... 10 ft
Side slopes 2:1
Water depth .... 1.83 ft

WEBER AQUEDUCT

Location: Generally northwest from outlet of Gateway Tunnel to south outskirts of Ogden, Utah.
Construction period: 1955-56
Description: Precast concrete pipe.
Length .... 4.2 mi
Diameter .... 18 and 42 in
Capacity .... 80 to 65 ft³/s

DAVIS AQUEDUCT

Location: From end of Gateway Tunnel to 21.6 mi south to North Salt Lake, Utah.
Construction period: 1954-57
Description: Precast concrete pipe.
Length .... 21.6 mi
Diameter .... 84 and 21 in
Capacity .... 355 to 30 ft³/s

GATEWAY CANAL

Location: From Stoddard Diversion Dam 8.5 mi westward to a point about 13 mi southeast of Ogden, Utah.
Construction period: 1954-56
Length .... 8.5 mi
Diversion capacity .... 700 ft³/s
Typical maximum section, concrete lined:
Bottom width .... 10 ft
Side slopes 1.5:1
Water depth .... 6.9 ft
Lining thickness .... 4 in

GATEWAY TUNNEL

Location: From end of Gateway Canal 3.25 mi west to a point about 7 mi south of Ogden, Utah.
Construction period: 1953-54
Length .... 3.25 mi
Capacity .... 435 ft³/s
Cross section: Horseshoe
Diameter .... 9.3 ft
Lining: Concrete
Thickness .... 5 to 8.5 in

OGDEN VALLEY CANAL

Location: From Ogden Valley Diversion Dam on the South Fork of the Ogden River about 7 mi upstream from Pineview Dam in a northwesterly direction to the North Fork of the Ogden River.
Construction period: 1962-64
Length .... 9.3 mi
Diversion capacity .... 80 ft³/s
Typical maximum section, earth lined:
Bottom width .... 10 ft
Side slopes 2:1
Water depth .... 2.5 ft

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
South Davis	4	14	225-580	1,025
East Bountiful	4	13	225-475	775
East Layton	2	4	175	150
East Sand Ridge	2	8	107	160
Val Verda	2	5	253	225
West Sand Ridge	2	13	155	325
Weber Aqueduct	4	17	225-365	750
Willard No. 1	3	500	46	3,000
Willard No. 2	3	300	17	800
Layton No. 1	4	277.5	28	1,050
Layton No. 2	6	150	343	7,500

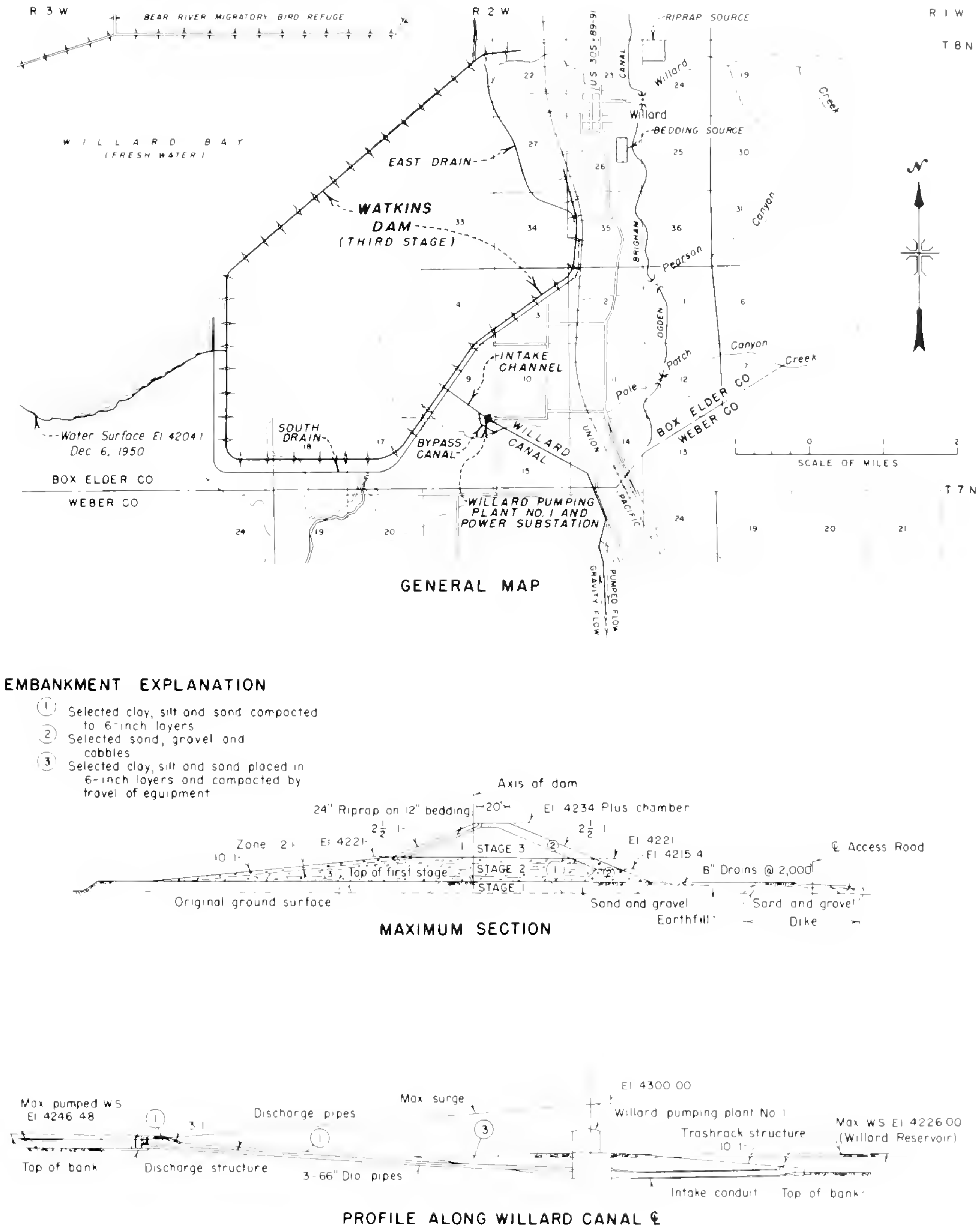
Power Facilities

GATEWAY POWERPLANT

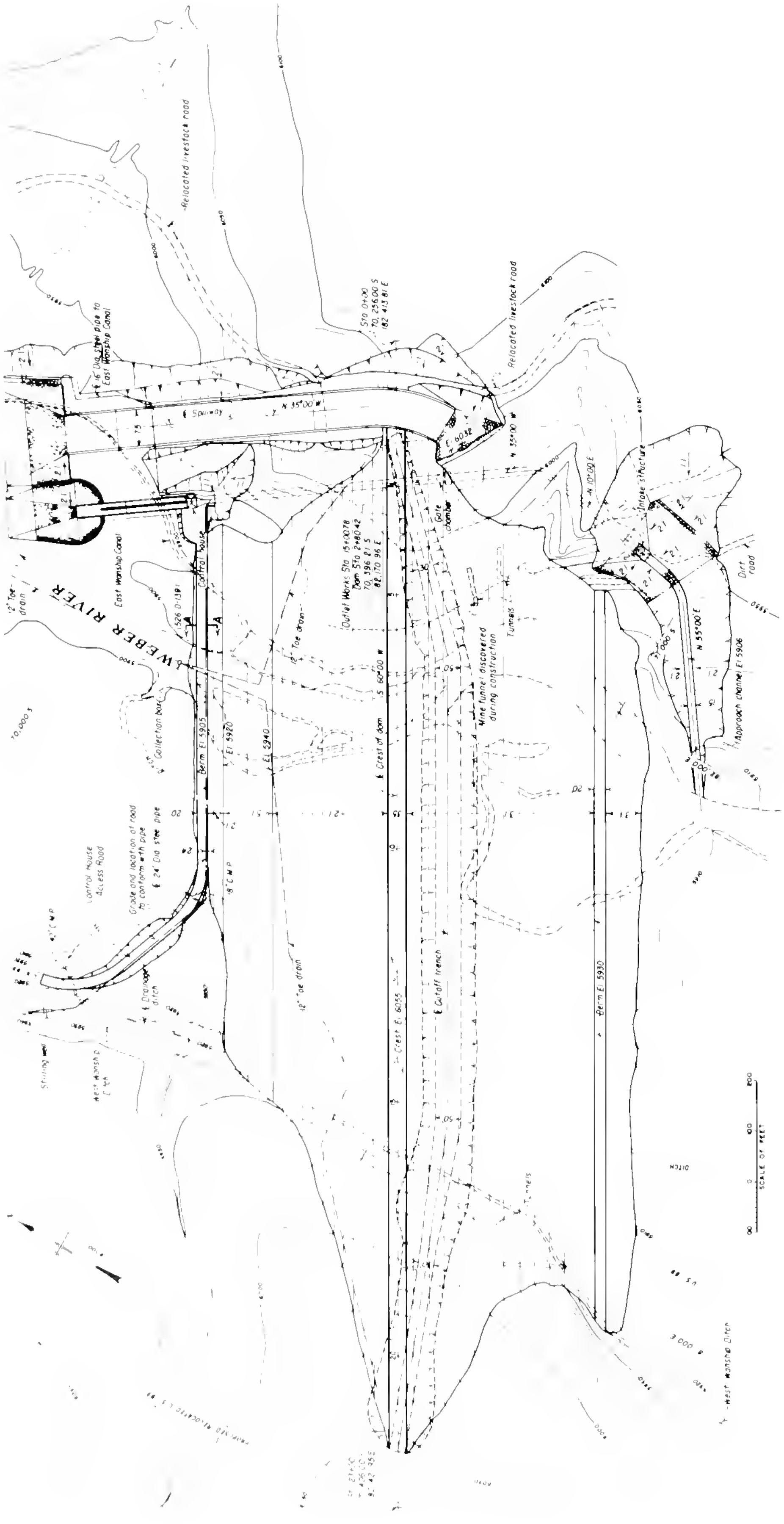
Location: 10 mi southeast of Ogden.
Year of initial operation: 1958
Nameplate capacity .... 4,275 kW
Number and capacity of generators .... (2) 2,137.5 kW
Maximum head .... 147 ft

WANSHIP POWERPLANT

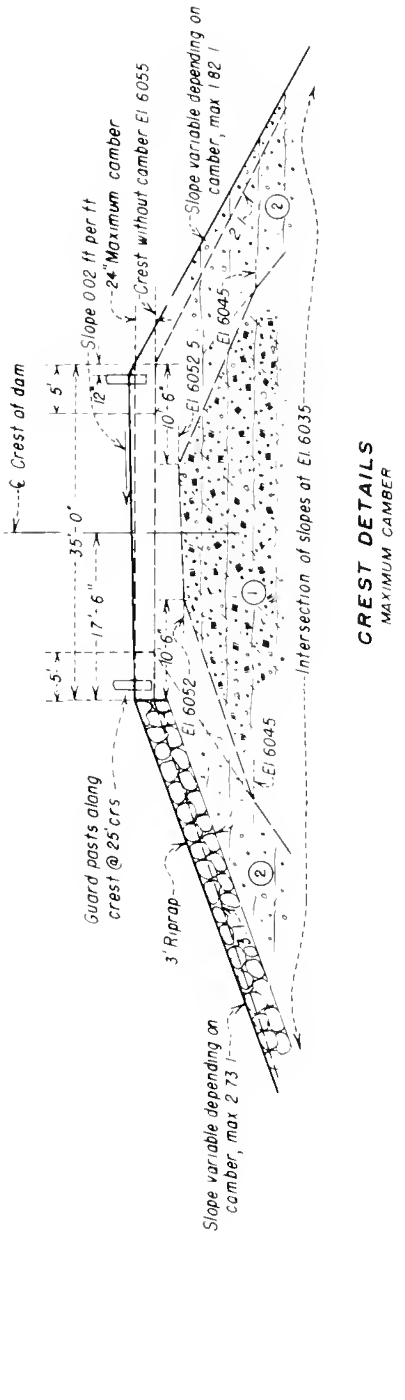
Location: Wanship Dam
Year of initial operation: 1958
Nameplate capacity .... 1,425 kW
Number of generators 1
Maximum head .... 152 ft

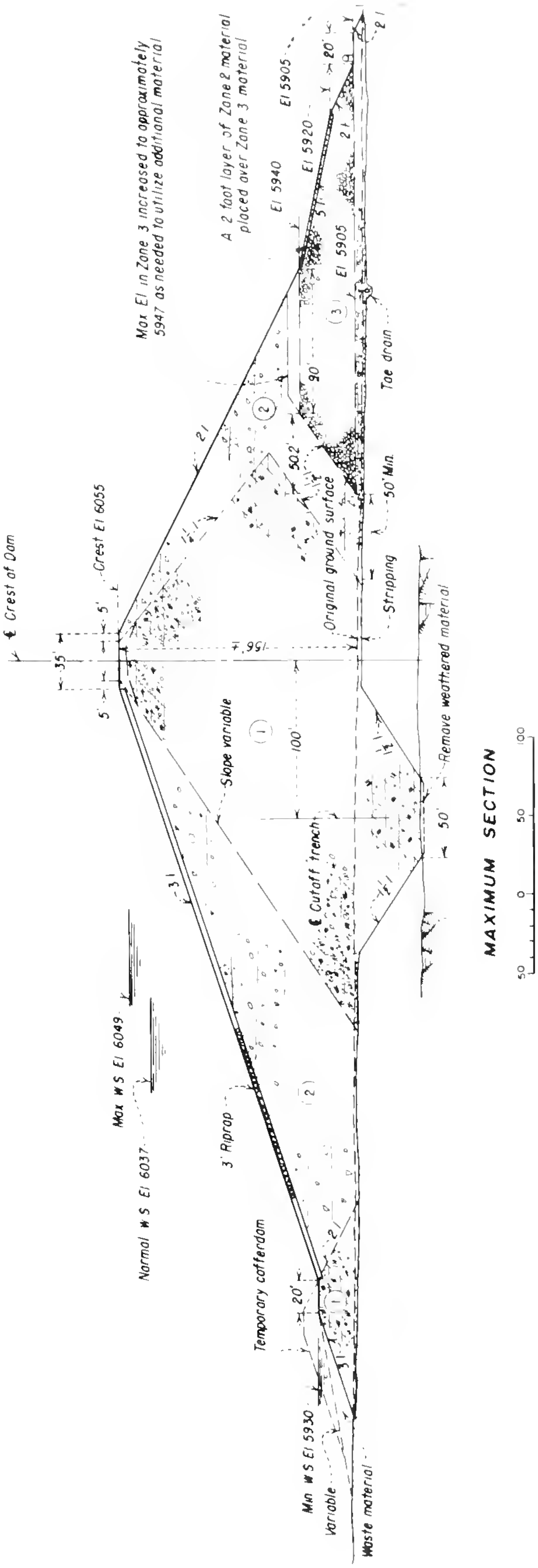


Arthur V. Watkins (Willard) Dam, Plan and Sections

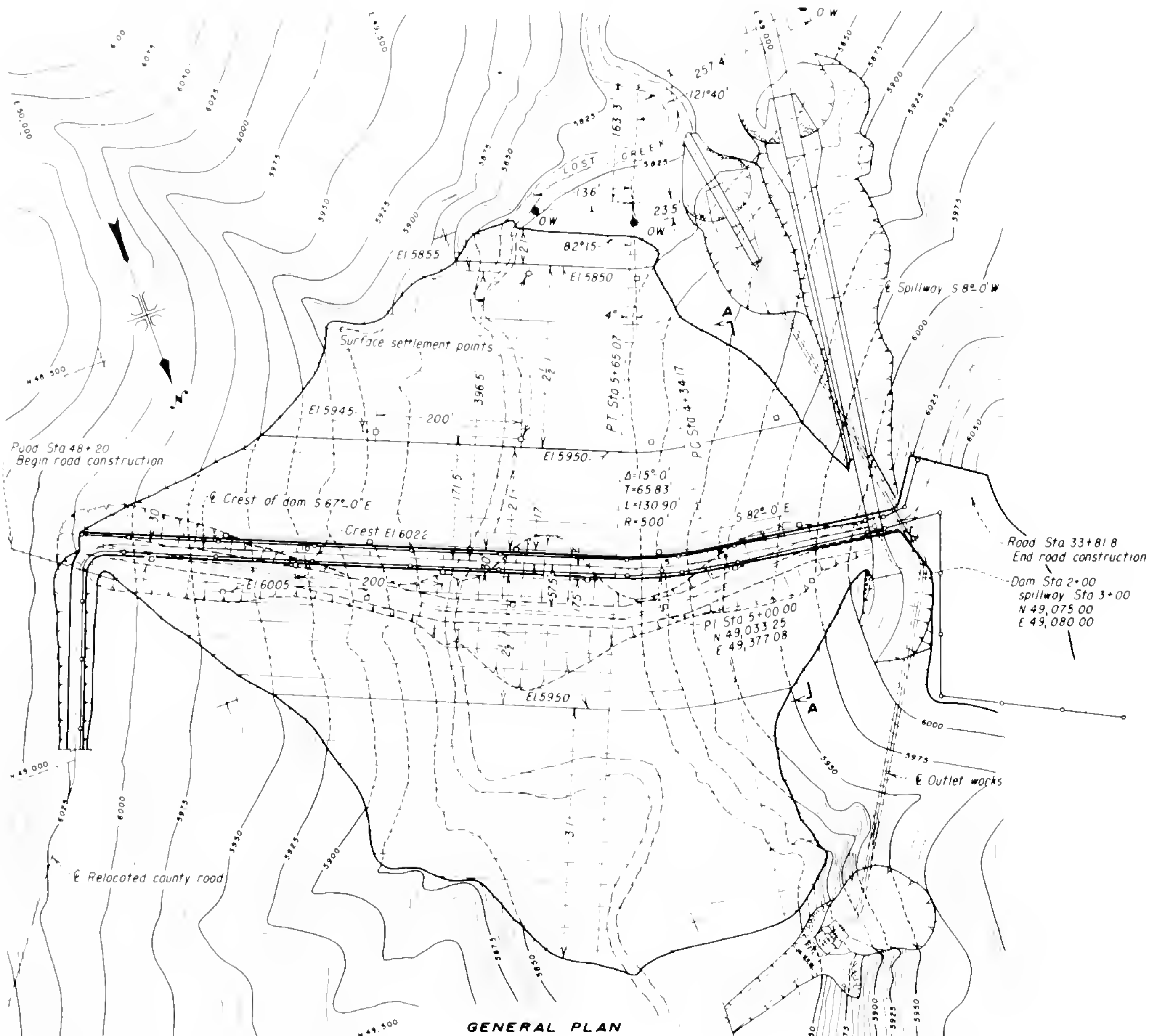


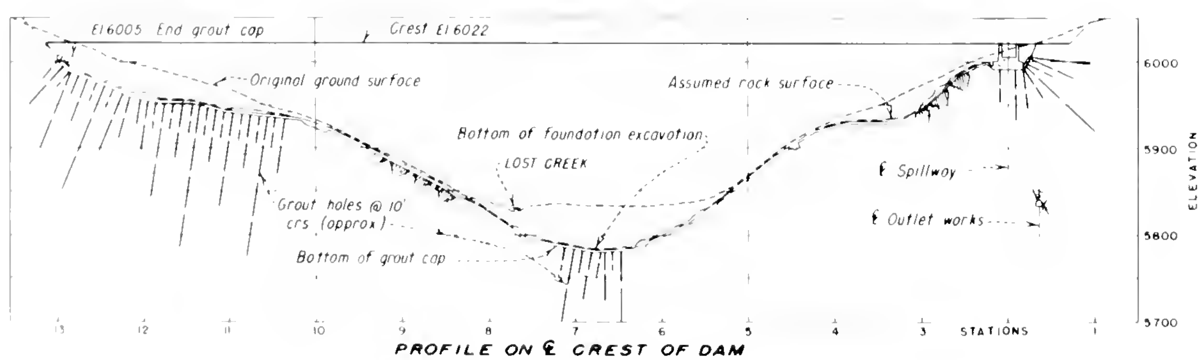
Wanship Dam, General Plan



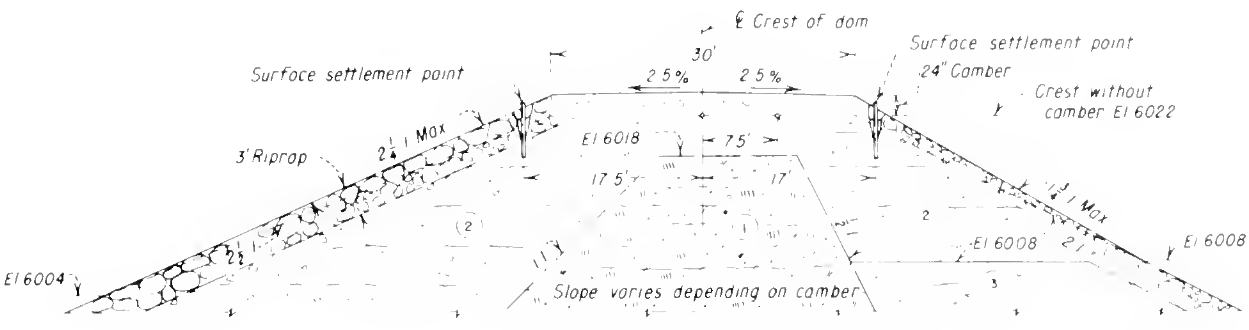


Wanship Dam, Sections

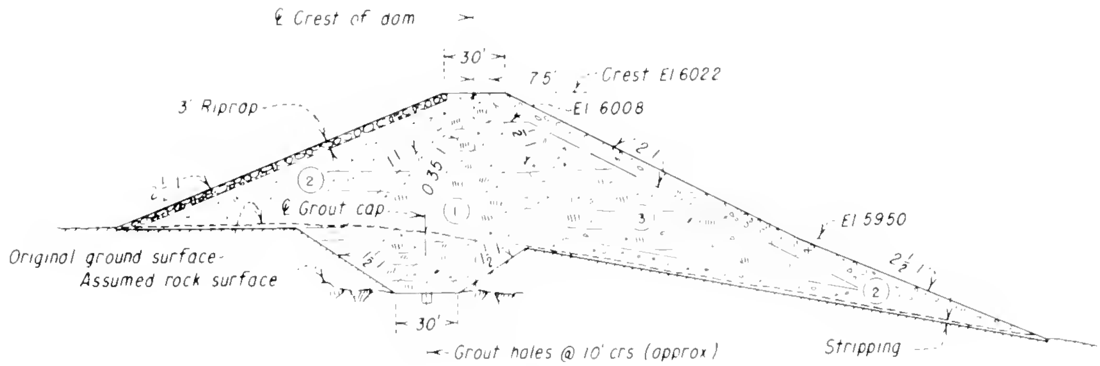




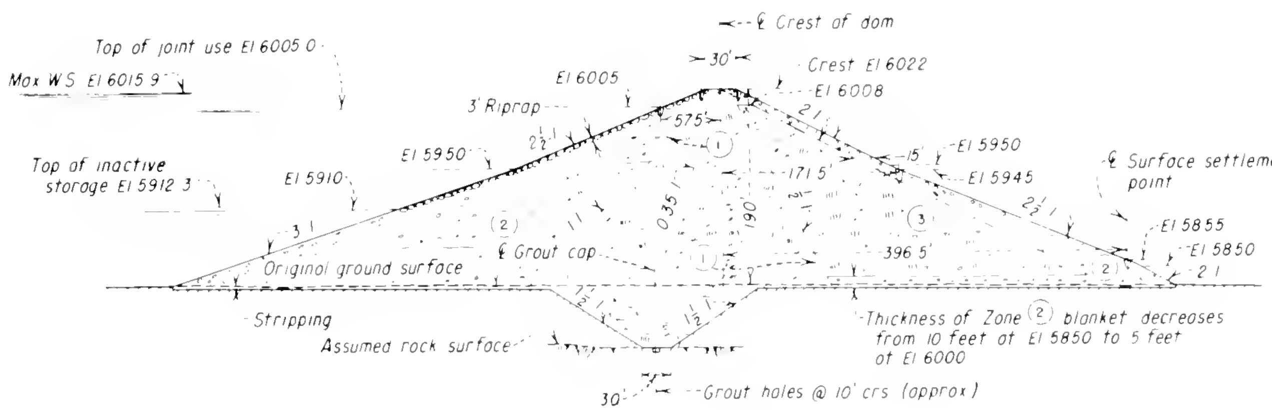
Lost Creek Dam, Plan and Profile



CREST DETAILS AT MAXIMUM CAMBER

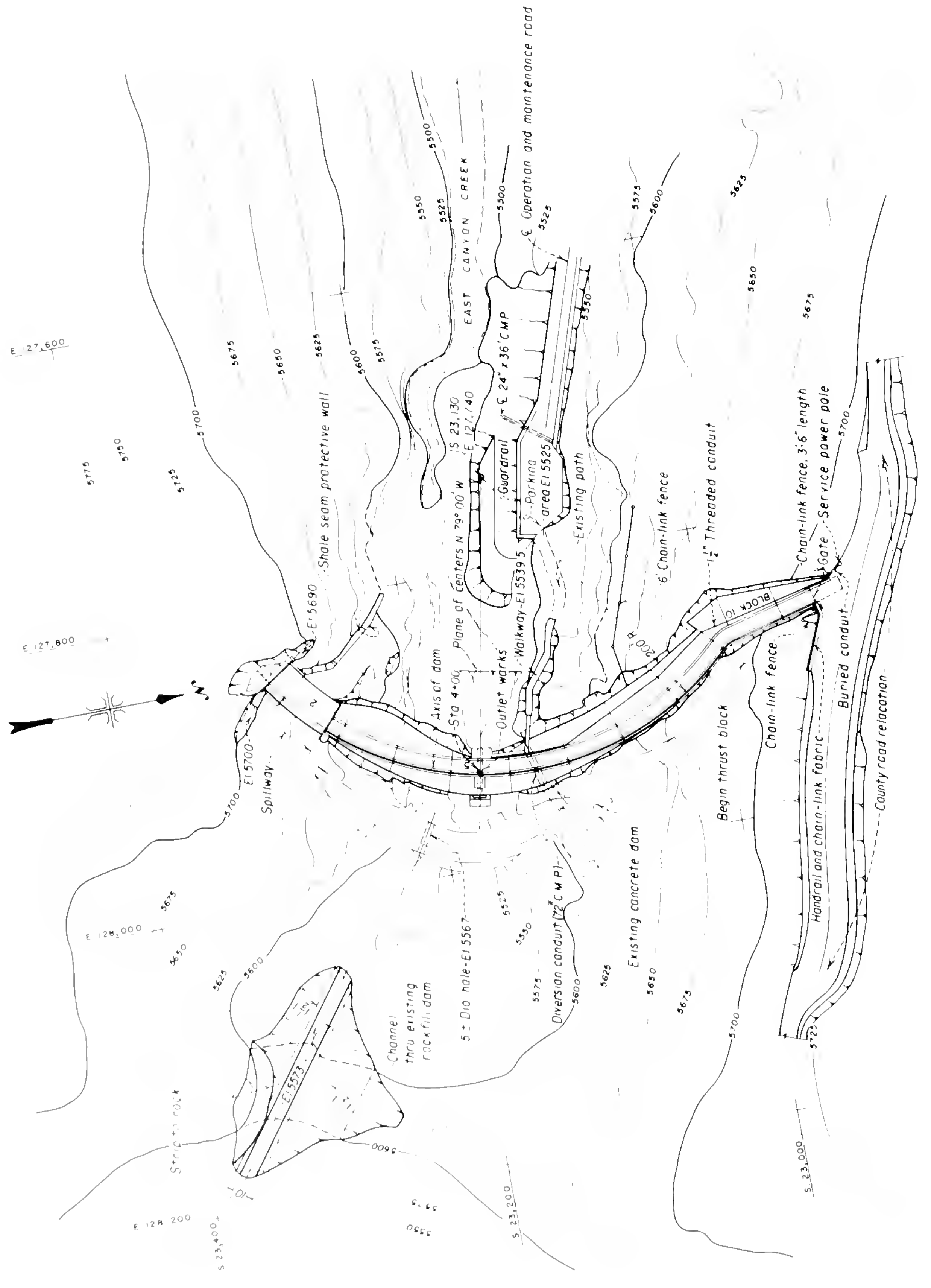


SECTION A-A

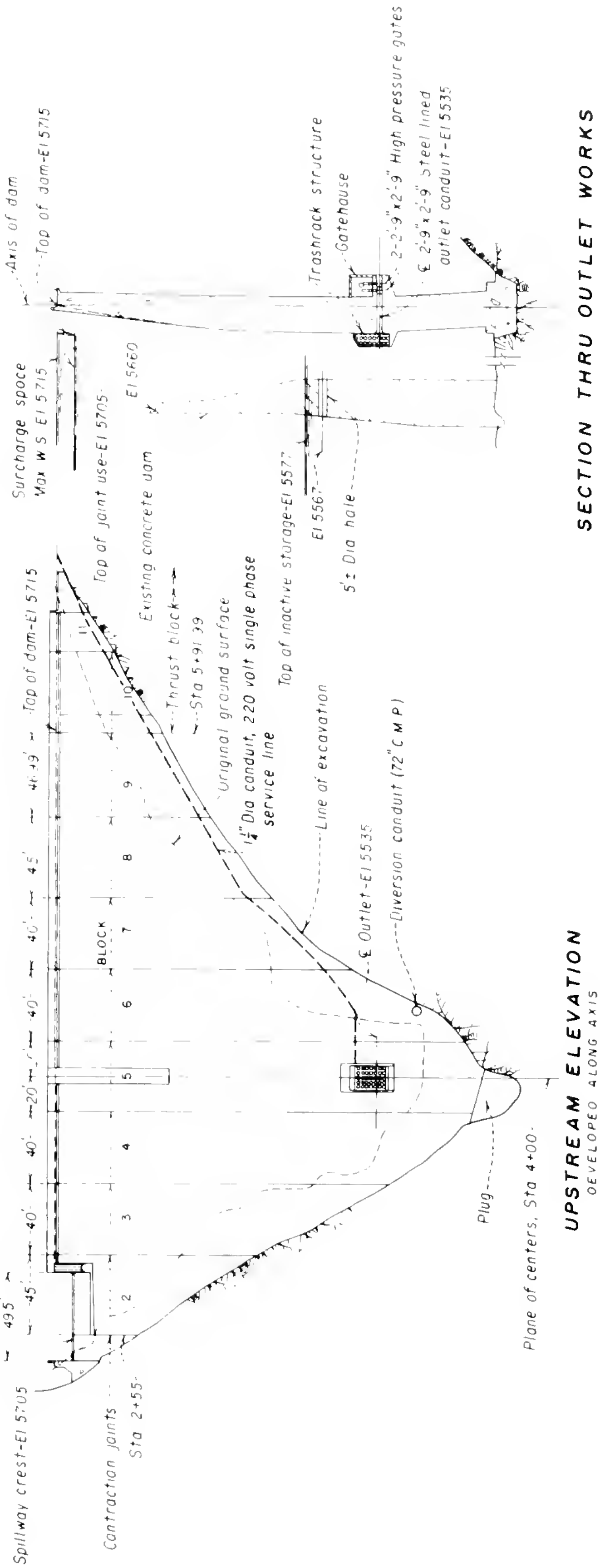


MAXIMUM SECTION

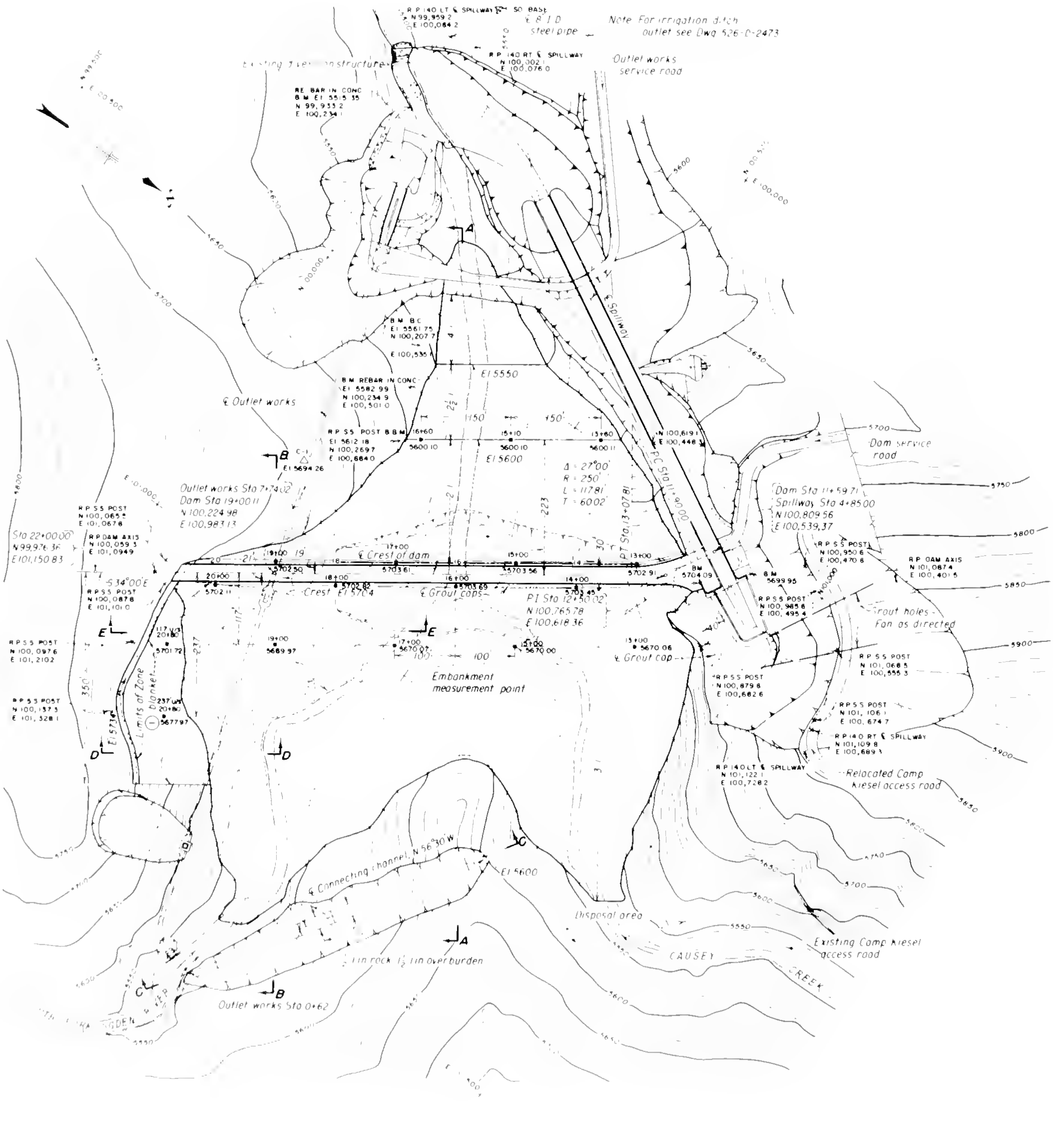
Lost Creek Dam, Sections



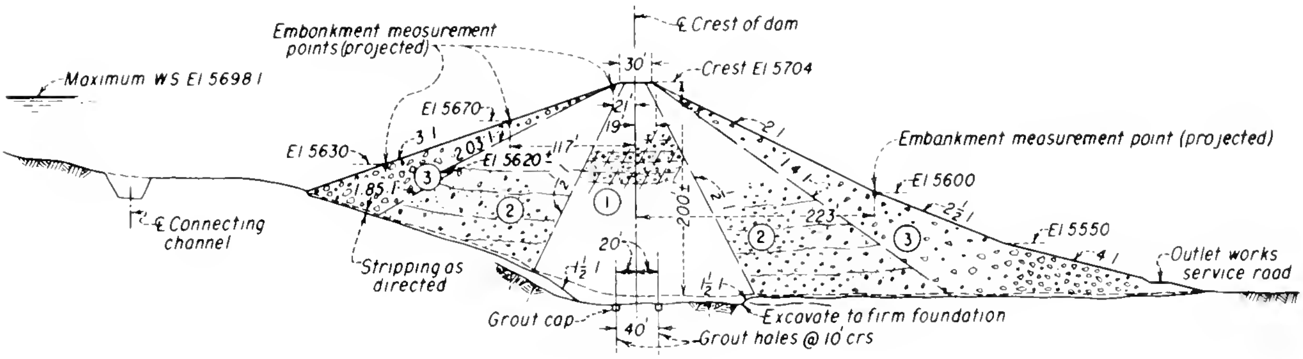
East Canyon Dam. Plan



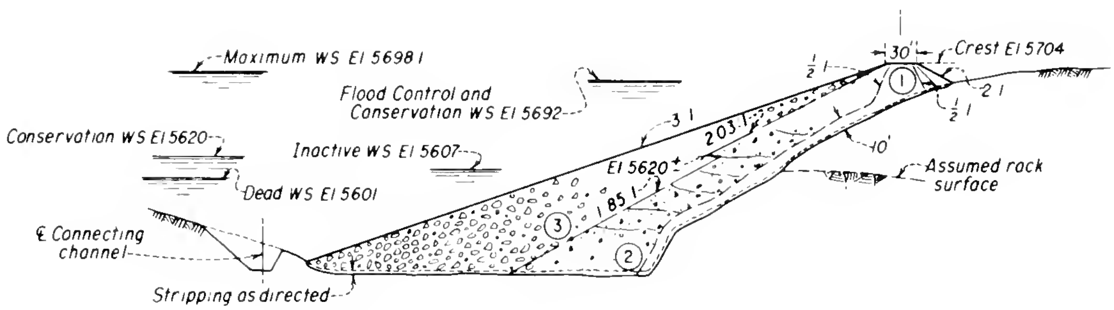
East Canyon Dam, Profile and Section



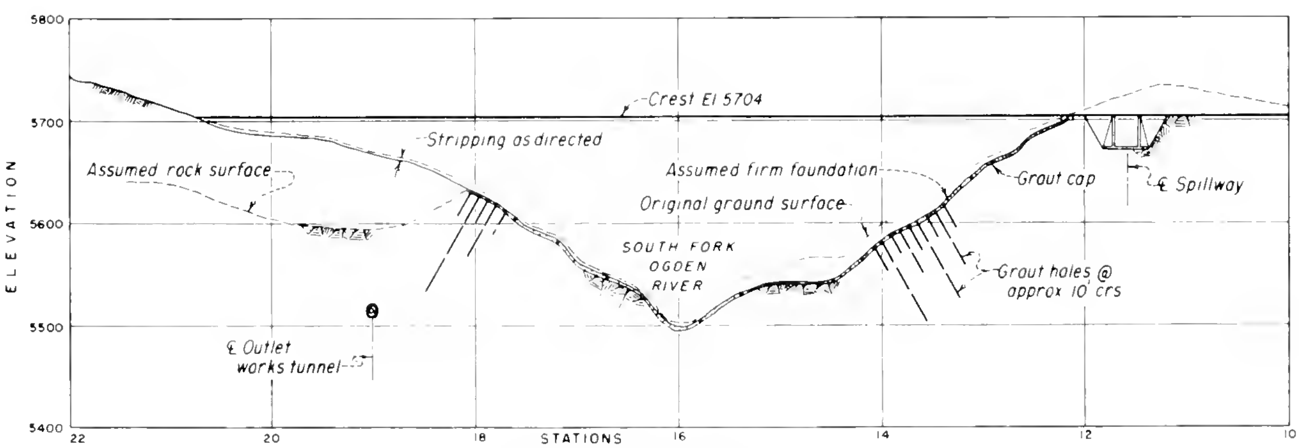
Causey Dam, Plan



SECTION A-A

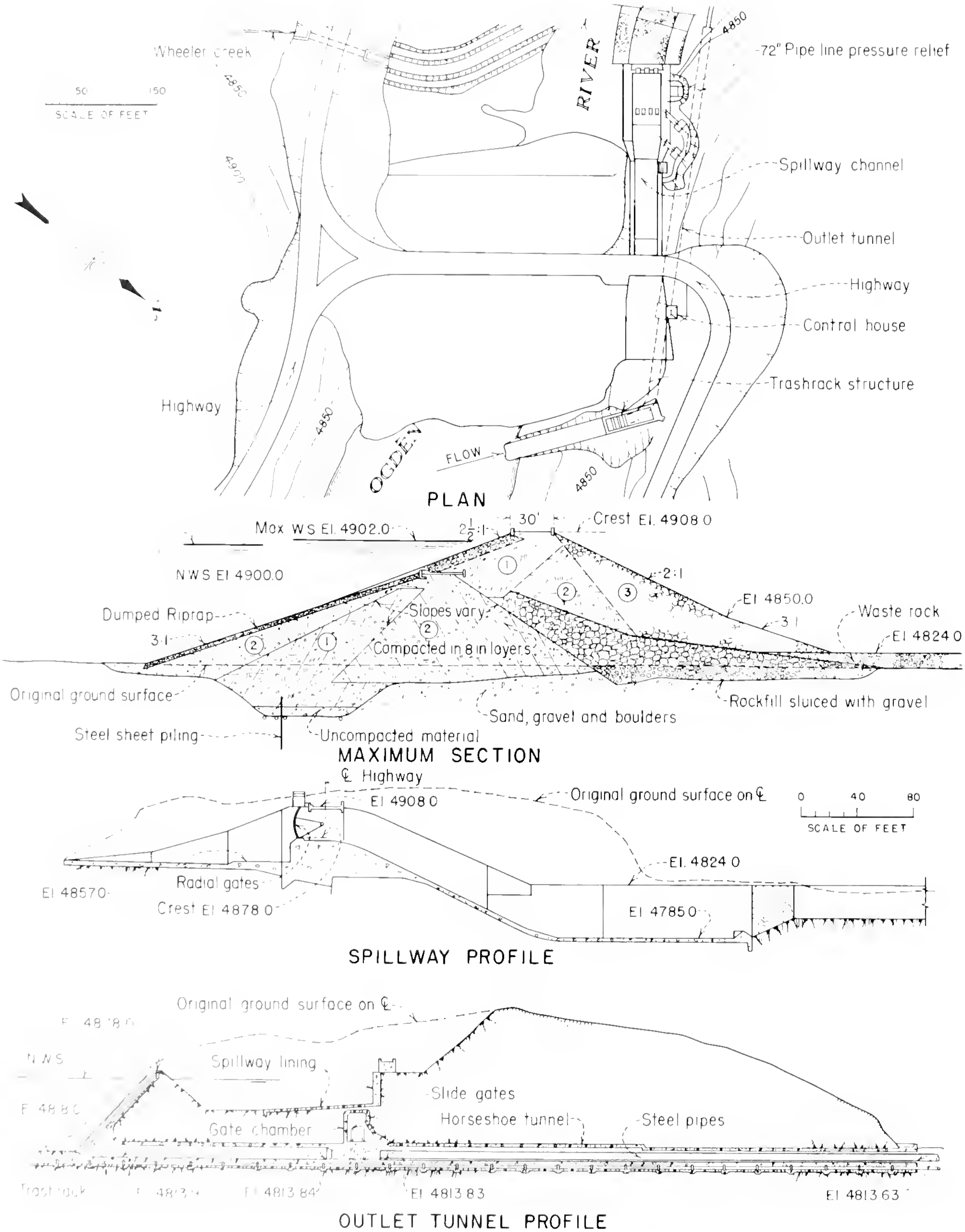


SECTION B-B



PROFILE ON ℄ CREST OF DAM

Causey Dam, Profile and Sections

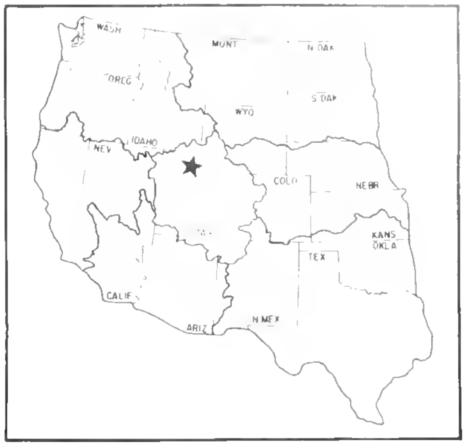


Pineview Dam (enlarged), Plan and Sections

Weber River Project

Utah: Davis, Morgan, Summit, Wasatch, and Weber Counties

Upper Colorado Region
Water and Power Resources Service



The Weber River Project, formerly designated as the Salt Lake Basin Project, first division, is in the vicinity of Ogden, Utah. It was developed primarily to supply supplemental irrigation water to about 109,000 acres of land east of the Great Salt Lake, lying between the lake and the Wasatch Mountains. Its principal engineering feature is Echo Dam and Reservoir, 42 miles southeast of Ogden, on Weber River. A secondary feature is the construction of the original Weber-Provo Diversion Canal. This canal was enlarged as part of the Provo River Project. The project distribution system is privately owned, operated, and maintained by approximately 50 organizations and individuals.

PLAN

Water is stored in Echo Reservoir, and released as needed by the irrigators. Delivery to the land is made through privately owned distribution systems that divert water from Weber River.

Echo Dam and Reservoir

Echo Dam is a zoned earthfill structure, 1 mile upstream from the town of Echo and about 6 miles north of Coalville. It has a structural height of 158 feet and contains 1,540,000 cubic yards of materials. The spillway has a capacity of 15,000 cubic feet per second. The outlet conduit is a concrete-lined horseshoe tunnel to the gatehouse, from which two steel pipes pass through a tunnel to the valvehouse. The outlet works has a capacity of 2,100 cubic feet per second.

DEVELOPMENT

Early History

Irrigation of lands from the Weber River was started about 1850. The late summer natural flow was sufficient for full water supply for about 3,000 acres, but before many years had passed a larger area was developed for which there was only a partial supply.

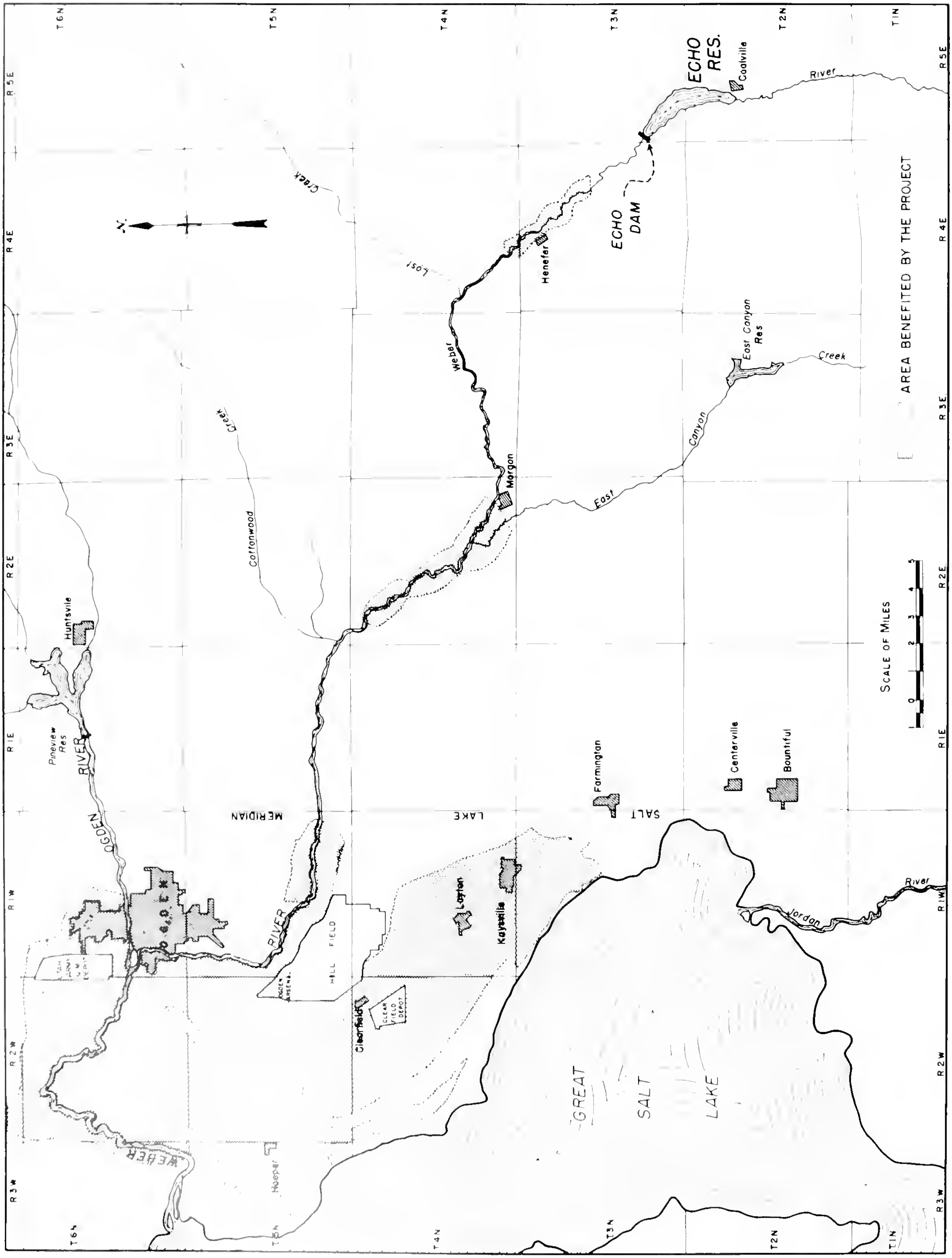
Investigations

The Reclamation Service made a reconnaissance of this area in 1904 and 1905, which resulted in the Geological Survey establishing stream-gaging stations in 1905. Early in 1922, the Reclamation Service, in cooperation with the Utah State Water Storage Commission, started investigations for a storage reservoir. Final selection of a site for the dam and reservoir was made in 1924. Congressional approval and an appropriation for construction of Echo Dam was received in 1924, and after 2 years of detailed investigation, design, and legal work, the project was approved for construction.

Authorization

The President approved the project on January 8, 1927, under the terms of section 4 of the act of June 25, 1910, and subsection B, section 4, of the act of December 5, 1924 (43 Stat. 701).

Echo Dam and Reservoir



Weber River Project

Construction

Construction of Echo Dam commenced on November 26, 1927, and was completed in December 1931. It was necessary to relocate portions of the Union Pacific Railroad branch lines and the Lincoln Highway. The original Weber-Provo Diversion Canal also was constructed during this time.

Operating Agency

The project is operated and maintained by the Weber River Water Users Association. By agreement, the association also operates and maintains the Weber-Provo Diversion Dam and Canal.

BENEFITS

Irrigation

Project soils are deep, fertile, and generally well-drained; they are particularly adapted to production of barley, wheat, corn, alfalfa, potatoes, fruits, vegetables, and sugar beets. An abundance of fruits and vegetables, including tomatoes, peas, beans, cabbage, cherries, peaches, and apricots, are raised, primarily for canning purposes. Carload lots of fruits and vegetables are shipped to outside markets.

Recreation

Recreation facilities at Echo Reservoir are administered by the Weber River Water Users Association and consist primarily of camping, swimming, boating, and water skiing. There were 47,729 visitor days generated by the facilities during 1977.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental irrigation service	108,975	acres
Number of irrigated farms	3,425	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	87,805	9,648,599
1969	87,676	9,818,014
1970	86,990	10,364,859
1971	87,375	10,241,944
1972	86,900	9,564,546
1973	86,600	15,508,171
1974	87,400	18,068,145
1975	87,412	15,557,213
1976	87,493	17,129,555
1977	85,793	13,836,074

Facilities in Operation

Storage dams	1	

Climatic Conditions

Annual precipitation	17.6	in
Temperature:		
Maximum	105	°F
Minimum	−23	°F
Mean	50	°F
Growing season	150	days
Elevation of irrigable area	4300-5400.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	17,860
Urban, suburban, and industrial service	7,500
Total	25,360

ENGINEERING DATA

Water Supply

WEBER RIVER
(See Weber Basin Project for streamflow data.)

Average annual diversion for storage	52,000	acre-ft

Storage Facilities

ECHO DAM

Type: Zoned earthfill
Location: On the Weber River, about 6 mi north of Coalville, Utah.
Construction period: 1927-31
Date of closure (first storage): 1930
Reservoir, Echo:

Active capacity to El. 5543	73,900	acre-ft
Surface area	1,470	acres
Dimensions:		
Structural height	158	ft
Hydraulic height	113	ft
Top width	25	ft
Maximum base width	844	ft
Crest length	1,887	ft
Crest elevation	5570.0	ft
Total volume	1,540,000	yd^3

Spillway: Concrete-lined chute at left abutment, controlled by four 18- by 17-ft radial gates.

Elevation top of gates	5560.0	ft
Crest elevation	5543.0	ft
Capacity at El. 5560	15,000	ft^3/s

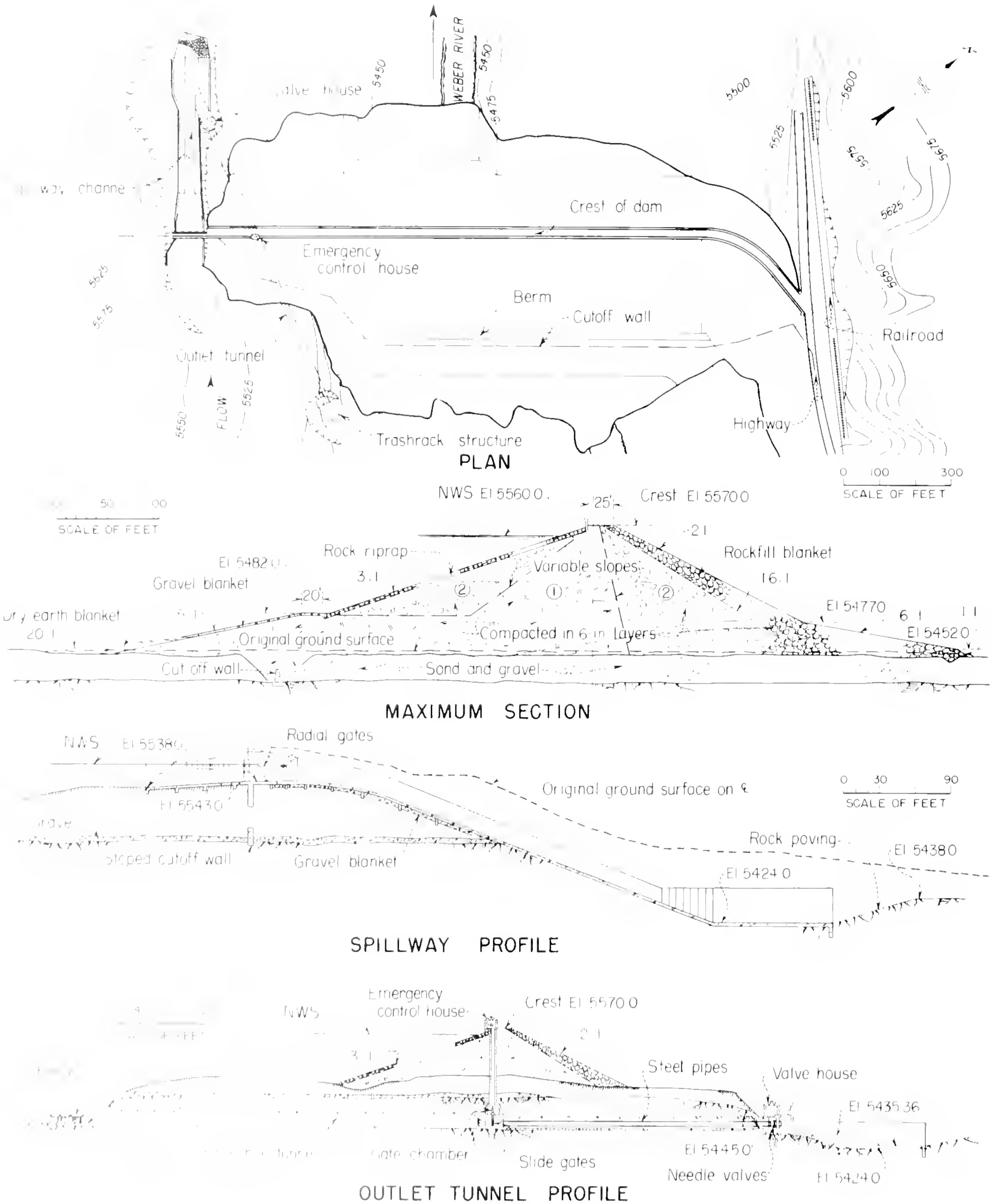
Outlet works: Concrete-lined tunnel through left abutment, controlled by two 60-in needle valves.

Capacity at El. 5560	2,100	ft^3/s

Carriage Facilities

WEBER-PROVO DIVERSION CANAL

Location: From the Weber River about 5 mi north of Kamas, Utah, generally south to the Provo River.
Construction period: Originally constructed in 1931 as part of the Weber River Project. Enlarged in 1947 under the Provo River Project. See the section on the Provo River Project for data.

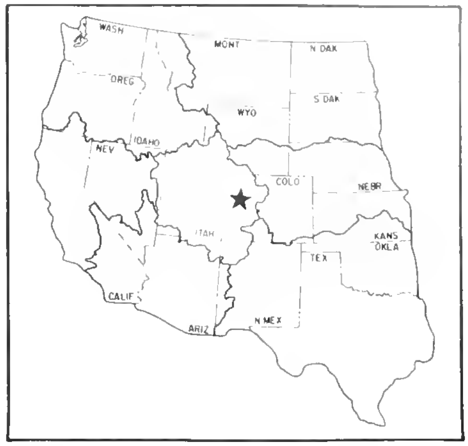


Echo Dam, Plan and Sections

West Divide Project
(Proposed)

Colorado: Mesa and Garfield Counties

Upper Colorado Region
Water and Power Resources Service



The West Divide Project is to be located in west-central Colorado south of the Colorado River between the towns of Grand Valley and New Castle in Garfield county.

PLAN
(Preliminary)

The West Divide Project would provide water for irrigation and municipal uses. It also would provide for fish and wildlife enhancement and new recreation opportunities.

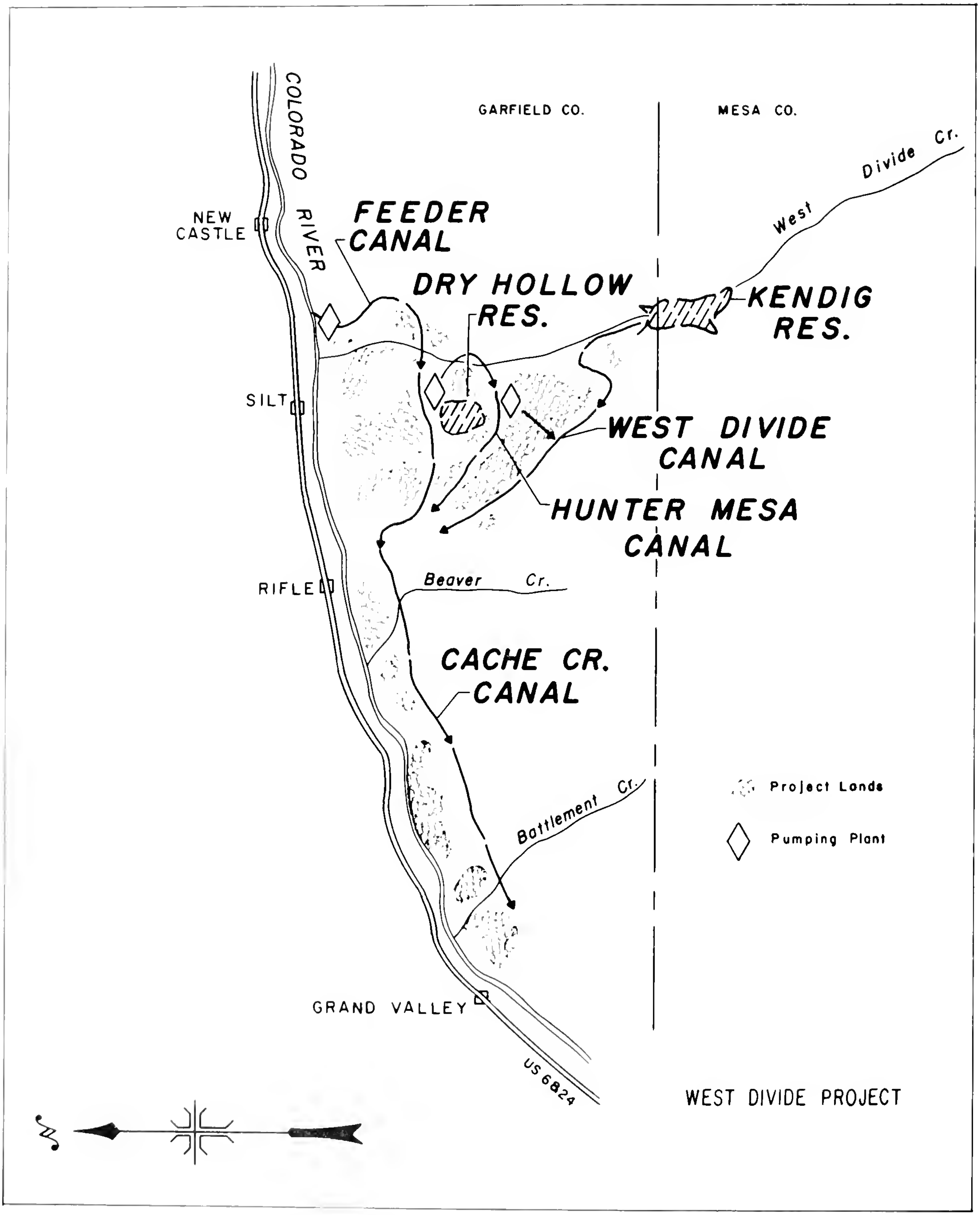
An average of about 66,800 acre-feet of water would be supplied each year for the irrigation of 25,550 acres of land. This would consist of 32,500 acre-feet for about 10,580 acres of presently unirrigated but arable land, and 33,000 acre-feet for 14,970 acres of land presently irrigated but with an inadequate water supply. About 5,580 acres of the total service lands lie in the East Battlement area, a system of high bench lands along the south side of the Colorado River between Grand Valley and Rifle, and the remaining 19,970 acres are located in the Divide Creek-Hunter Mesa area consisting of an open valley south of the town of Silt sloping generally north toward the Colorado River and an adjacent mesa to the west.

An annual average of 5,800 acre-feet of water would be developed for municipal and industrial use within the project area. The town of Rifle would receive 4,000 acre-feet. The Grand Valley area, which includes the town of Grand Valley and the proposed new community of Arco, would receive 1,100 acre-feet. These communities anticipate rapid population increases because of the possible development of a full-scale oil shale industry in the mountains north of the project area. About 200 acre-feet of water would be available for rural domestic systems.

Flat-water fisheries and recreation facilities would be provided at project reservoirs.

The project water supply would be developed by storing the flows of West Divide Creek and by pumping from the Colorado River. West Divide Creek water would be stored in Kendig Reservoir for irrigation of the higher lands west of West Divide Creek and for municipal and industrial use. Colorado River water would be pumped into the Dry Hollow Feeder Canal by the Divide Creek Pumping Plant, and released from the feeder canal for irrigation of adjacent lands. At the terminus of the feeder canal, part of the water would flow directly into the Cache Creek Canal for irrigation of lower bench lands in the Divide Creek-Hunter Mesa area and the entire East Battlement area. Also at the terminus of the feeder canal, water would be pumped by Dry Hollow Pumping Plant No. 1 to Dry Hollow Reservoir where it would be stored for municipal and industrial use and irrigation. Water from Dry Hollow Reservoir would be pumped during the irrigation season to the Hunter Mesa Canal for irrigation of lands above the Cache Creek Canal that could not be served adequately by the West Divide Canal. Releases from Dry Hollow Reservoir also would be made to Cache Creek Canal at peak demand times when the feeder canal flow was inadequate. Some water from the Hunter Mesa Canal would be pumped by the West Divide Pumping Plant to the West Divide Canal in late season

Site of proposed West Divide Project



West Divide Project

when supplies from Kendig Reservoir would be inadequate to meet the demand. Late season diversions from the Colorado River would be replaced by releases from Green Mountain Reservoir.

Two areas would be designated for sprinkler irrigation. One of these consists of Hunter Mesa and the lands along the west side of Mamm Creek lying below the West Divide Canal. The other sprinkler area would be on the southwest of Rifle, from Taugenbaugh Mesa to the lands at the mouth of Cache Creek which would be served by the Cache Creek Canal. In both of these areas, gravity pressure would be provided because of the elevation of the canal above the irrigable lands.

Where necessary, laterals would be constructed by the project to distribute irrigation water from the canals. As far as possible, however, existing ditches would be used. Drains would be provided as needed.

Municipal water would be available directly from Kendig Reservoir and from Beaver and Battlement Creeks by exchanging releases from Dry Hollow Reservoir for existing irrigation supplies from those streams. Facilities for the reregulation, distribution, and treatment of the municipal supply would be the responsibility of the water users.

DEVELOPMENT

Early History

Settlement of the lands south of the Colorado River and along the Crystal and Roaring Fork Rivers in Garfield and Pitkin Counties began about 1880. Irrigated agriculture was established on low lying lands adjacent to the streams to provide supplemental livestock feed. It soon became evident that there was insufficient water in the tributary streams to satisfy the demand. As early as 1905, the farmers of the area started looking for ways to augment the water supply, especially in late season after the spring snowmelt.

The Bureau of Reclamation investigated several alternative plans of development during the 1930's. In 1966, a feasibility report was published which presented a water development plan for the area using the Crystal River of the Roaring Fork drainage as the principal water supply. This plan called for a 105,000-acre-foot reservoir on Crystal River, about 35 miles south of the city of Glenwood Springs, with one smaller auxiliary reservoir in the West Divide drainage and another in the Four Mile Creek drainage. Approximately 90 miles of conveyance system would have been constructed. About 116,000 acre-feet of water would have been available each year for the irrigation of nearly 61,000 acres of land, and 77,500 acre-feet would have been made available to meet municipal and industrial demands.

Following project authorization in 1968, strong opposition developed among environmental groups and residents of the Crystal and Roaring Fork Valleys to any impoundment on, or reduction of flows of the Crystal River. At the same time, a major oil shale industry failed to materialize so the large quantity of municipal and industrial water provided by the plan was not needed. These factors resulted in a reduction in the scope of the plan and development of the current project.

Investigations

Studies were initiated in 1959 and a feasibility report was published in March 1966. During advance planning studies, the original plan of development described in the 1966 report has undergone considerable modification resulting from environmental and other concerns. Planning studies have covered many different methods of conveying water to the project service area.

Authorization

The West Divide Project was authorized for construction by the Colorado River Basin Project Act of September 30, 1968 (82 Stat 885), as a participating project of the Colorado River Storage Project, act of April 11, 1956 (Public Law 84-485).

Operating Agency

The West Divide Water Conservancy District will serve as the contractual and sponsoring agency for the project.

BENEFITS

Irrigation

About 65,500 acre-feet of water developed for irrigation will be available for 25,550 acres.

Municipal and Industrial Water

A supply of 5,900 acre-feet will be provided each year for municipal use.

Recreation and Fish and Wildlife

Facilities would be provided at both reservoirs for recreational use and fish and wildlife protection.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Supplemental service	14,970	acres
Full service	10,580	acres
Total	25,550	acres

Climatic Conditions

Annual precipitation	13	in
Temperature:		
Maximum	99	°F
Minimum	−26	°F
Mean	48	°F
Growing season	120	days
Elevation of irrigable area	5200-6800.0	ft

ENGINEERING DATA

Water Supply

Average annual	71,400	acre-ft
Colorado River stream depletion (annually)	40,000	acre-ft

Storage Facilities

KENDIG DAM

Type: Rolled earth
Location: On West Divide Creek, 16 mi south of Silt, Colo.

Height above streambed	190	ft
Crest width	30	ft
Crest length	630	ft
Reservoir, Kendig:		
Total capacity	18,060	acre-ft
Active capacity	15,630	acre-ft
Dead and inactive capacity	760	acre-ft
Full surface area	270	acres
Top of inactive pool surface area	54	acres
Full reservoir length	2.6	mi

DRY HOLLOW DAM

Type: Rolled earth
Location: On Dry Hollow Creek, 5 mi south of Silt, Colo.

Height above streambed	168	ft
Crest width	30	ft
Crest length	1,980	ft
Reservoir, Dry Hollow:		
Total capacity	23,000	acre-ft
Active capacity	18,800	acre-ft
Dead and inactive capacity	4,200	acre-ft
Full surface area	494	acres
Top of inactive surface area	147	acres
Full reservoir length	2.6	mi

Carriage Facilities

WEST DIVIDE CANAL

Length	21	mi
Initial Capacity	105	ft³/s

HUNTER MESA CANAL

Length	17	mi
Initial capacity	135	ft³/s

CACHE CREEK CANAL

Length	32	mi
Initial capacity	245	ft³/s

DRY HOLLOW FEEDER CANAL

Length	14	mi
Initial capacity	140	ft³/s

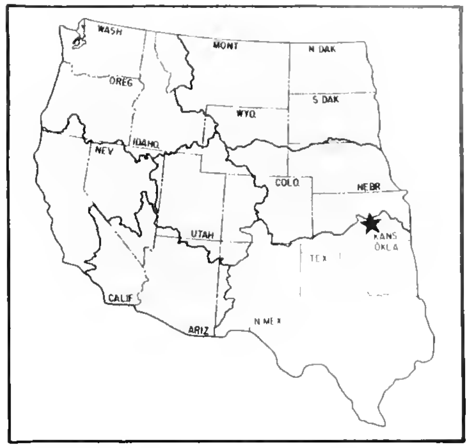
PUMPING PLANTS

Capacity:		
Divide Creek	140	ft³/s
Dry Hollow No. 1	120	ft³/s
Dry Hollow No. 2	140	ft³/s
West Divide	25	ft³/s

Wichita Project
Cheney Division

Kansas: Kingman, Reno, and Sedgwick Counties

Southwest Region
Water and Power Resources Service



The Cheney Division of the Wichita Project consists of the Cheney Dam and Reservoir on the North Fork of the Ninnescah River. This division of the project provides a supplemental water supply to the city of Wichita, flood control for protection of downstream areas, and recreation and fish and wildlife benefits. Because of the flood control features of the division, approximately 3,700 acres of land downstream from the dam can be irrigated, although no stored water is to be provided for irrigation purposes.

PLAN

Municipal water supply storage is used to supplement the present supply pumped from wells. On an equal-use basis — well water and reservoir water — the supply is estimated to be adequate until the year 2010. A pumping plant and pipeline was constructed and is operated by the city of Wichita to convey water from Cheney Dam to the water treatment plant in the city.

No direct flow from the reservoir will be used as an irrigation supply, although the alleviation of flood threat will permit irrigation of about 3,700 acres of suitable land in scattered tracts below the dam. Diversion of water for irrigation will be individual or group developments.

Cheney Dam and Reservoir

Cheney Dam is on the North Fork of the Ninnescah River about 6 miles north of Cheney and 24 miles west of Wichita, Kans. The site is at the common intersection of the boundaries of Kingman, Reno, and Sedgwick Counties, with portions of the dam lying in all three. The upstream slope of the dam is protected by soil cement and the downstream slope is protected by a 12-foot horizontal layer of topsoil and grass. The crest of the dam provides a roadway 30 feet wide. The spillway is an uncontrolled morning-glory inlet leading into a 9.5-foot circular conduit and stilling basin. The river outlet works consists of an intake structure, an 11-foot-diameter conduit to the gate chamber containing two 6- by 7.5-foot high-pressure regulating gates and two 6- by 7.5-foot high-pressure emergency gates. Downstream of the river outlet works gate chamber is a 15-foot-diameter flat bottom conduit and stilling basin. The municipal outlet works consists of a vertical intake structure with four 6-foot-square motor operated slide gates for selective withdrawal of water from elevations 1379.0, 1389.0, 1399.0, and 1409.0, a foot bridge, and a 6- by 8-foot emergency gate leading into an 8-foot-diameter circular conduit to the axis of the dam, at which point flows are carried by an 8-foot-diameter steel pipe in a 12.5-foot-diameter conduit. The city of Wichita constructed and operates a 93-cubic-foot-per-second pumping plant at the dam which conveys municipal water through a 5-foot-diameter pipeline to the water treatment plant in the city.

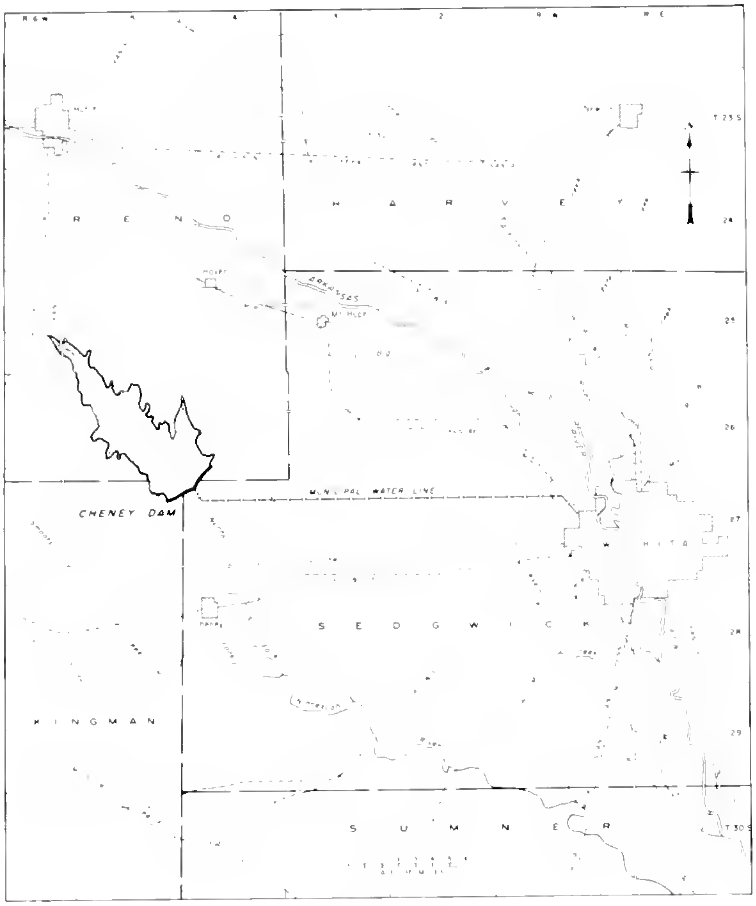
Development of Cheney Reservoir required the relocation of several miles of electrical transmission lines, telephone lines, and petroleum pipelines, as well as county road relocations and modifications which were accomplished through relocation contracts with the owners.

DEVELOPMENT

Investigations

Studies of the Ninnescah River Basin were undertaken by the Bureau of Reclamation as part of an overall investigation of the Arkansas River Basin and were continued by the Arkansas-White-Red Basin Interagency Committee, which was established in 1950. A water-use and control plan resulted from these investigations. The plan included optimum use of available surface waters to provide a regulated water supply for the city of Wichita, and irrigation, flood control, fish and wildlife, and recreation benefits. Construction of multiple-purpose reservoirs at the Cheney and Murdock sites on the North and South Forks, respectively, of the Ninnescah River was an integral part of the plan. The Murdock site has been renamed the Norwich site.

The city of Wichita developed a series of municipal water supply wells northwest of the city, but further develop-



Wichita Project

ment was hampered because of cost and distance. A closer source of suitable surface water to supplement the pumped well supply was sought. The quality of water and the municipal and industrial pollution ruled out development of the water of the Arkansas River, and conveyance distances made development of stream sources other than the Ninnescah prohibitive in cost. The general plan was accepted by the city and the Cheney site was chosen for the first stage of construction. A report by the Bureau of Reclamation in 1957 formed the basis for authorization of the project.

Although dry-farming methods of agriculture were customary in the vicinity prior to 1953, an increase in irrigated farming has developed. Construction of Cheney Reservoir minimizes the risk of flood damage and will allow irrigation of certain bottom lands downstream totaling about 3,700 acres. These lands, if developed for irrigation, will not receive reservoir water or contribute to repayment of construction costs.

Authorization

Public Law 86-787 authorized the Cheney Division on September 14, 1960, by act of Congress, (74 Stat. 1026).

Construction

Construction of Cheney Dam began in 1962, and was completed in 1965.

BENEFITS

Municipal and Industrial Water

The project provides storage and delivery of a supplemental municipal and industrial water supply to the city of Wichita, Kans. Cheney Dam and Reservoir provide storage and regulation of available surface waters of the North Fork of Ninnescah River. A pumping plant located at the dam and a 5-foot-diameter pipeline were constructed by the city of Wichita for conveying the regulated flows from Cheney Dam to the water treatment facilities.

Storage began at Cheney Dam with closure of the river outlet works gates on November 5, 1964. Delivery of municipal and industrial water to the city of Wichita began in the summer of 1965. Operation and maintenance of Government constructed project facilities by the city of Wichita began October 1, 1965. The conservation storage in Cheney Reservoir gradually increased until it was filled in October 1968.

Flood Control

The project works provide flood control benefits in protection of downstream areas. Flood control operations at Cheney Dam involve cooperation between the Corps of Engineers, the city of Wichita, and the Bureau of Reclamation. No significant flood control releases were made from Cheney Reservoir until after the conservation storage had been filled in October 1968. Releases have since been made for the protection of downstream areas.

Recreation and Fish and Wildlife

The construction of Cheney Dam and Reservoir has provided this otherwise arid region of Kansas with a variety of recreational uses and fish and wildlife benefits. Located near Wichita in south-central Kansas, Cheney State Park at Cheney Reservoir provides most species of sport fish common to Kansas. White bass and walleye are the favorites of anglers, and there is good fishing for crappie, channel catfish, striped bass, and largemouth bass. There are excellent camping, boating, swimming and picnicking facilities, and trailer park facilities with electric, water, and sewer hookups.

The Kansas State Park and Resources Authority administers the recreation areas at Cheney Reservoir, including some 1,900 acres of land and over 5,400 acres of water. The Kansas Forestry, Fish and Game Commission administers over 5,200 acres of land and 4,100 acres of water for conservation and management of migratory birds and other wildlife. Visitation at Cheney Reservoir exceeded 839,000 visitor days in 1976.

Cheney Dam and Reservoir

PROJECT DATA

Climatic Conditions

Annual precipitation	32	in
Temperature:		
Maximum	110	°F
Minimum	−20	°F
Mean	56	°F
Growing season	195	days

ENGINEERING DATA

Water Supply

NINNESCAH RIVER

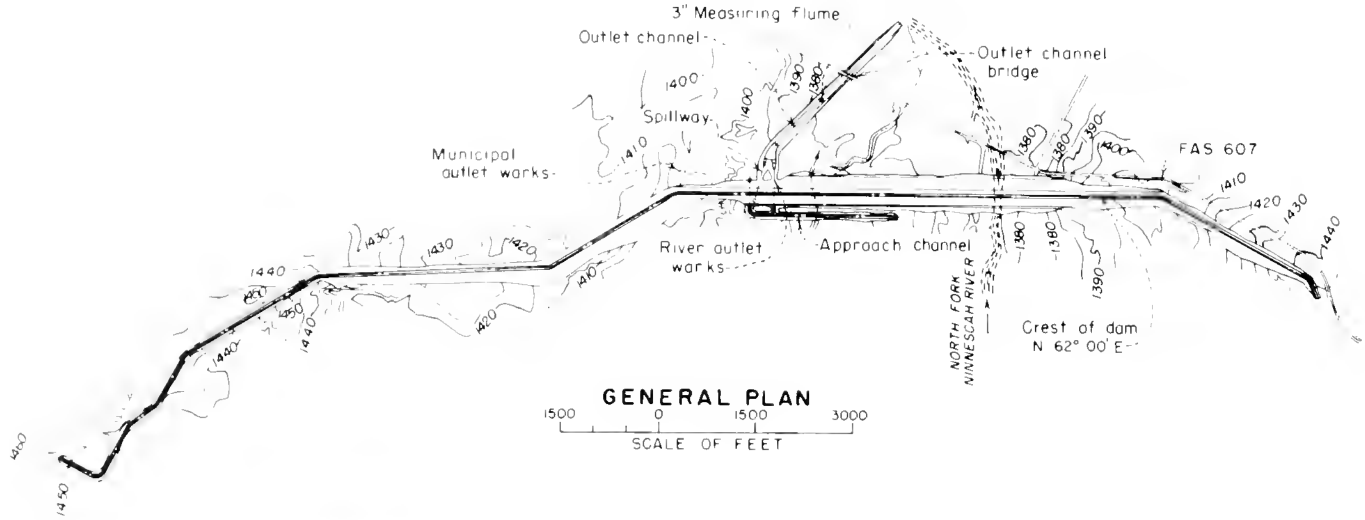
Drainage area at Cheney damsite	535	mi²
Annual discharge:		
Average	123,800	acre-ft

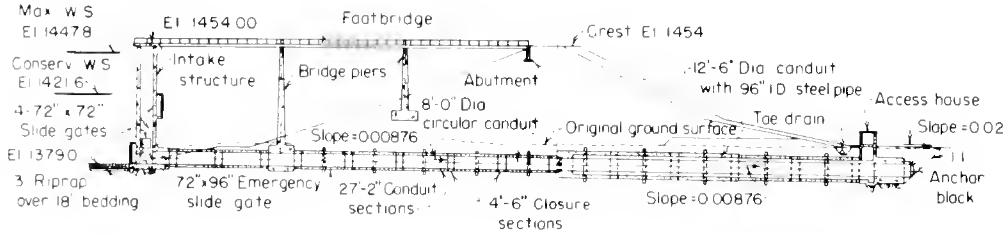
Storage Facilities

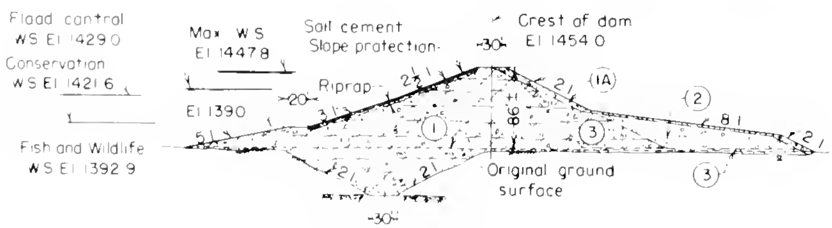
CHENEY DAM

Type: Rolled earthfill
Location: North Fork of Ninnescah River, about 24 mi west of Wichita, Kans.
Construction period: 1962-65
Reservoir, Cheney:

Dead capacity—Streambed to El. 1378.5	980	acre-ft
Fish and wildlife capacity—El. 1378.5 to 1392.9	14,310	acre-ft
Active conservation capacity—El. 1392.9 to 1421.6	151,780	acre-ft
Exclusive flood control capacity—El. 1421.6 to 1429	80,860	acre-ft
Surcharge capacity—El. 1429 to 1447.8	318,350	acre-ft
Total capacity to El. 1429	247,930	acre-ft
Surface area at El. 1429	12,417	acres
Dimensions:		
Height above streambed	86	ft
Top width	30	ft
Maximum base width	650	ft
Crest length	24,458	ft
Crest elevation	1454.0	ft
Volume	7,341,000	yd³
Spillway: Morning-glory with ungated crest having a diameter of 22.25 ft at El. 1429. Conduit is 9.5-ft-diameter into chute stilling basin and outlet channel.		
Capacity at El. 1447.8	3,000	ft³/s
Outlet works: River outlet works: 11-ft-diameter conduit controlled by two 6- by 7.5-ft high-pressure regulating gates and two 6- by 7.5-ft high-pressure emergency gates, into chute, stilling basin, and outlet channel.		
Capacity at El. 1447.8	4,580	ft³/s
Municipal outlet works:		
Intake structure with four 72-in-square slide gates, one 72- by 96-in emergency gate, 8 ft conduit to axis of dam, 96-in-diameter steel pipe in 12.5-ft-diameter conduit to toe of dam. Connects to pumping plant constructed by city of Wichita (93-ft³/s capacity).		







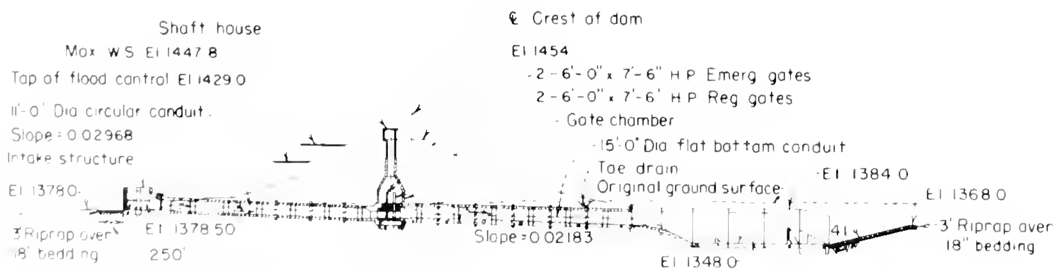
EMBANKMENT EXPLANATION

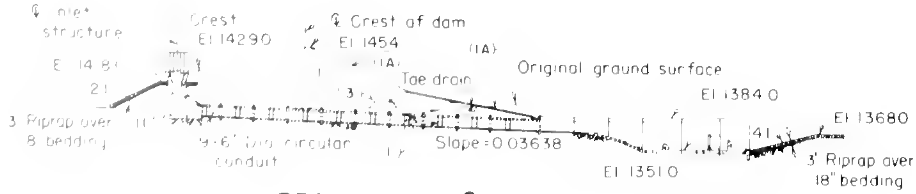
(1) Selected clay, silt, and sand compacted by tamping rollers to 6-inch layers

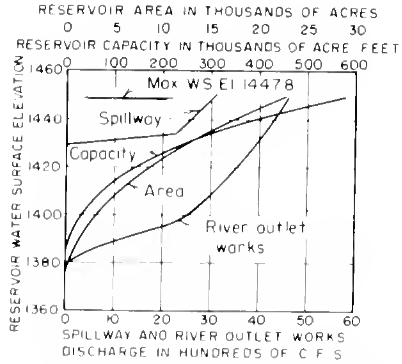
(1A) Selected topsoil compacted by tamping rollers to 6-inch layers

(2) Selected miscellaneous material compacted by equipment travel to 12-inch layers

(3) Selected sand compacted to 12-inch layers to 75% relative density







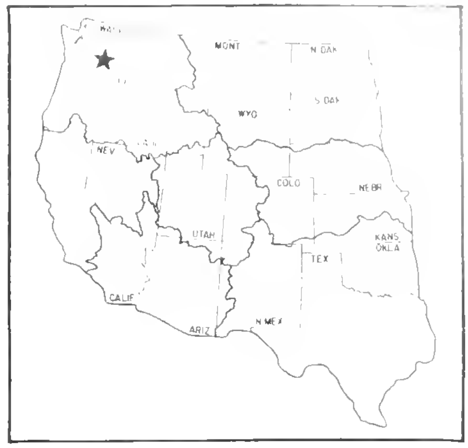
AREA-CAPACITY-DISCHARGE CURVES

Cheney Dam, Plan and Sections

Yakima Project

Washington: Benton, Franklin, Yakima, and Kittitas Counties

Pacific Northwest Region
Water and Power Resources Service



PLAN

The Yakima Project provides irrigation water for a comparatively narrow strip of fertile land that extends for 175 miles on both sides of the Yakima River in south-central Washington. The irrigable lands presently being served total approximately 464,000 acres.

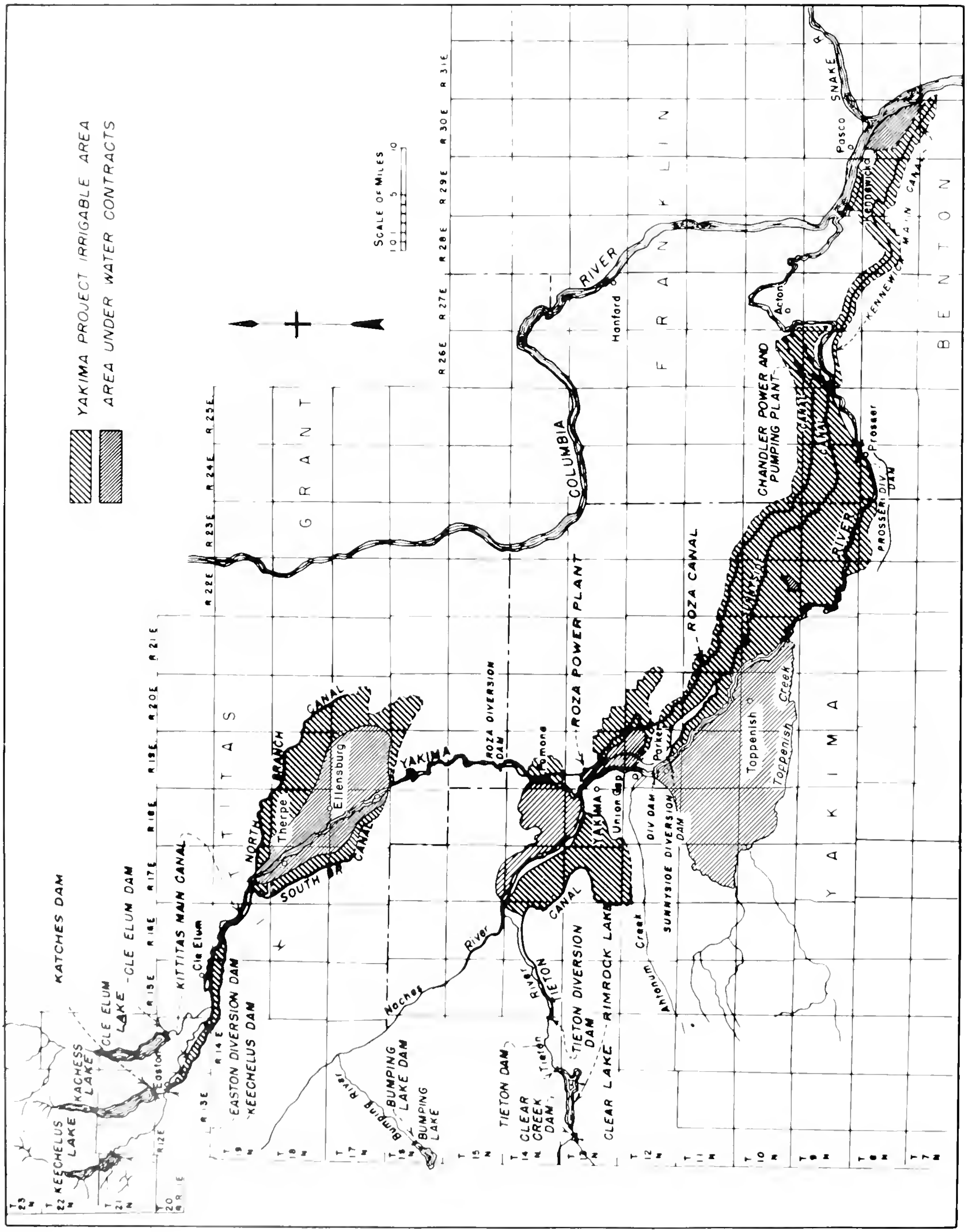
There are seven divisions in the project: Storage, Kittitas, Tieton, Sunnyside, Roza, Kennewick, and Wapato. The Wapato Division is operated by the Bureau of Indian Affairs, but receives most of its water supply from the Yakima Project for irrigation of 136,000 acres of land. Over 45,000 acres not included in the seven divisions are irrigated by private interests under water supply contracts with the Bureau of Reclamation. Storage dams and reservoirs on the project are Bumping Lake, Clear Creek, Tieton, Cle Elum, Kachess, and Keechelus. Other project features are 5 diversion dams, 416 miles of canals, 1,698 miles of laterals, 30 pumping plants, 144 miles of drains, 2 powerplants, and 73 circuit miles of transmission lines.

Irrigation water for the 59,582 acres of land in the Kittitas Division is diverted from the Yakima River into the Main Canal by the Easton Diversion Dam near Easton, Wash. The Main Canal carries the water along the south side of the river to a point near Thorp, where it divides into the North and South Branches. The North Branch Canal crosses the Yakima River through a siphon to irrigate land lying on the north side of the river, while the South Branch Canal continues generally southeast from the point of division to irrigate lands lying on the south side of the river.

The Tieton Division includes 27,271 acres of land lying west of the city of Yakima between the Naches River and Ahtanum Creek. Irrigation water for the lands in this division is diverted from the Tieton River by the Tieton Diversion Dam, about 8 miles downstream from Rimrock Lake. The diversions flow through Tieton Main

Bumping Lake Dam and Bumping Lake

Kachess Dam and Lake



Yakima Project

Canal and, after supplying the distribution system of the Tieton Division, drain into Ahtanum Creek about 14 miles west of Union Gap.

The Sunnyside Division consists of 103,600 acres of land lying mostly north of the Yakima River, and extends from the Sunnyside Diversion Dam, on the Yakima River near Parker, to the vicinity of Benton City. Water is diverted from the Yakima River by the Sunnyside Diversion Dam and flows generally southeast through the Sunnyside Canal, which supplies the distribution system of the division. Four irrigation districts in the Sunnyside Division pump water to their lands by hydraulic turbine pumps at drops on the Sunnyside Canal.

The Roza Division, a unit containing 72,511 acres of land north of the Yakima River, extends from the vicinity of Pomona to a point north of Benton City. The distribution system is supplied by the Roza Canal, which originates at the Roza Diversion Dam on the Yakima River about 10 miles north of Yakima. The Roza Powerplant is adjacent to the Roza Canal, 3 miles from Yakima.

The Kennewick Division is a combined irrigation and power development. It includes the 12,000-kilowatt Chandler Powerplant and 19,171 acres of irrigable land, of which 4,637 acres are in the Kennewick Highlands and have been irrigated for many years. All of the lands receive a full water supply.

The Kennewick Division Extension is an additional area for development that consists of approximately 6,300 acres. The definite plan for construction is in the process of preparation. Facilities being planned probably will include a 167-cubic-foot-per-second hydraulic pump at the existing Chandler Power and Pumping Plant, additional capacity in the first 6.7 miles of the Kennewick Main Canal, a 5,800-foot-long siphon, six small relift pumping plants, some 22 miles of canals, and required laterals and drains.

The Storage Division has supervision over the entire Yakima River water supply, both natural riverflow and the stored water in six reservoirs. The reservoirs have a total active capacity of 1,070,700 acre-feet.

Bumping Lake Dam and Bumping Lake

Bumping Lake Dam is an earthfill structure on the Bumping River about 29 miles northwest of Naches. The dam, completed in 1910, is 61 feet high and contains 253,000 cubic yards of material. In 1973, the road crossing the spillway was replaced and a new concrete T-beam bridge was installed to replace a wood-truss bridge. Situated at the lower end of a natural lake, the dam formed a reservoir with an active capacity of 33,700 acre-feet.

Kachess Dam and Kachess Lake

Kachess Dam is an earthfill structure located on the Kachess River about 2 miles northwest of Easton. This dam, 115 feet high with a volume of 200,000 cubic yards, also was built at the lower end of a natural lake, and created a reservoir with a capacity of 239,000 acre-feet.

Keechelus Dam and Keechelus Lake

Keechelus Dam was constructed at the lower end of a natural lake and is on the Yakima River 10 miles north-

Keechelus Dam and Lake

Clear Creek Dam and Clear Lake

west of Easton. This earthfill structure, completed in 1917, is 128 feet high and contains 684,000 cubic yards of material. Keechelus Lake has 157,800 acre-feet of active storage. Total rehabilitation of the outlet works and control tower was started in 1976. The two original cylinder gates were replaced by a single 8.5-foot-square hydraulically operated slide gate, and a new concrete chute and stilling basin that is 156 feet long, 18 feet wide, and up to 28 feet deep were constructed. The concrete outlet conduit was lined with reinforced concrete, and a 22-inch-diameter pipe was installed in the outlet conduit to bypass minimum flows for fishery and stream enhancement when the outlet gates are closed.

Clear Creek Dam and Clear Lake

Clear Creek Dam, a concrete thin-arch structure on the North Fork of the Tieton River about 27 miles southwest of Naches, creates a reservoir with a capacity of 5,300 acre-feet. The dam is 83 feet high and contains 5,800 cubic yards of concrete. Originally constructed in 1914, the dam was raised 21 feet in 1918 to its present height. Rehabilitation work in 1964 consisted primarily of placing new concrete in the arch section between elevation 2991.0 and the crest, repairing cracks and poorly consolidated concrete with neoprene and epoxies, and installing protective wire-mesh fences from the abutments to upstream areas.

Tieton Dam and Rimrock Lake

On the Tieton River about 40 miles northwest of Yakima, Tieton Dam is an earthfill structure with a concrete core wall that extends from the crest to about 100 feet below the riverbed. The dam is 319 feet high and contains 2,049,000 cubic yards of material. The reservoir capacity is 198,000 acre-feet.

Cle Elum Dam and Lake

Cle Elum Dam, on the Cle Elum River 8 miles northwest of Cle Elum, is an earthfill dam that forms a reservoir with an active capacity of 436,900 acre-feet. The dam is 165 feet high and, including the dikes, contains 1,411,000 cubic yards of material.

Diversion Dams

Roza Diversion Dam, 10 miles north of Yakima, diverts water from the Yakima River. The dam is a concrete weir, movable crest structure, 486 feet long at the crest, 67 feet high, and contains 21,700 cubic yards of concrete. Easton Diversion Dam, on the Yakima River near Easton, is a concrete gravity ogee weir, movable crest structure. This dam is 66 feet high and contains 5,800 cubic yards of concrete. Sunnyside Diversion Dam, on the Yakima River near Parker, is an 8-foot-high concrete weir with an embankment wing. Tieton Diversion Dam, on the Tieton River about 16 miles southwest of Naches, is a 5-foot-high concrete weir, flanked by an embankment wing. Prosser Diversion Dam, on the Yakima River near Prosser, is a 9-foot-high concrete weir. Two fishways are provided to facilitate movement of fish over the dam.

Powerplants and Transmission Lines

The Chandler Powerplant develops 12,000 kilowatts, which are delivered to the Bonneville Power Administra-

Tieton Dam and Rimrock Lake

Cle Elum Dam and Lake

tion. More than 70 miles of transmission lines deliver power to pumping plants in the Roza Division. The Roza Powerplant develops 11,250 kilowatts.

Canal and Drainage Systems

There are 416 miles of main canals on the project and 1,702 miles of laterals to deliver water to the project lands. The canals vary in capacity from 347 cubic feet per second in Tieton Canal to 2,200 cubic feet per second in Roza Canal. Approximately 144 miles of drains make up the drainage system.

Pumping Plants

The project has 30 pumping plants varying in capacity from 500 cubic feet per second at Chandler to 1.56 cubic feet per second at Hillcrest. A 167-cubic-foot-per-second hydraulic unit may be installed in the Chandler plant.

Under a rehabilitation and betterment agreement, the Bureau of Reclamation installed a pumping plant and intake canal for the Cascade Irrigation District during 1974-75. The plant has eight units with a total capacity of 160 cubic feet per second and a dynamic head of 108 feet. The 0.89-mile-long intake canal diverts Yakima River water to the pumping plant that delivers the water through a 300-foot-long discharge line to the portal of Tunnel No. 7 on the Cascade Irrigation District Canal.

DEVELOPMENT

Early History

The first settlers came to the Yakima Valley in about 1860. They were cattlemen attracted by the abundance of bunch grass and wild game, and the fertile bottom lands. The first irrigation ditch of record was constructed in 1864. The ditch conveyed water from Ahtanum Creek for irrigation of a small garden above the Catholic mission.

Hops were first raised in 1872, and alfalfa was successfully grown in 1881. Private canal companies were formed along the river, and successfully irrigated a large area. Construction of the Northern Pacific Railway into the valley in 1886 gave greater impetus to irrigation development.

Investigations

As a result of a petition dated January 28, 1903, from citizens of Yakima County to the Secretary of the Interior presenting the very favorable opportunities for construction and development, investigations were initiated which led to the beginning of construction by the Reclamation Service. The Sunnyside and Tieton Units were approved for construction in 1905. Early in 1906, investigation of storage sites was initiated, including Bumping Lake, McAllister Meadows (Tieton Reservoir), and Cle Elum, Kachess, and Keechelus Lakes.

Easton Diversion Dam

Studies on a proposed Bumping Lake Enlargement dating back to the mid-1960's were issued in a March 1976 report prepared by the Bureau of Reclamation and the Fish and Wildlife Service. These studies centered on a proposal to construct a new dam on Bumping River about 4,500 feet downstream from the existing Bumping Lake Dam that would impound 458,000 acre-feet of water. Benefits from the proposed additional storage would include fish resource enhancement, supplemental irrigation, flood control, and recreation.

In February 1977, a study was released that included Cle Elum and Tieton Dams as potential sites for powerplant installations. These sites are under further investigation.

Authorization

The Tieton and Sunnyside Divisions of the Yakima Project were authorized by the Secretary of the Interior on December 12, 1905. The report, approved by the President on January 5, 1911, included Benton, Kittitas, and Wapato Divisions. Roza Division was approved by the President on November 6, 1935. Kennewick Division was authorized for construction by the Congress on June 12, 1948, under Public Law 629, 80th Congress (62 Stat. 382). The Kennewick Division Extension was authorized on August 25, 1969, Public Law 91-66 (83 Stat. 106). Cascade Irrigation District rehabilitation and betterment work was authorized by Public Works Appropriation Act dated October 7, 1970, Public Law 91-439.

Roza Canal

Construction

Construction of the Tieton and Sunnyside Units began in 1906. The first water for irrigation of project lands was available for the 1907 season, and on October 17, 1907, the Sunnyside Diversion Dam was completed. Development of the project progressed with the construction of Tieton Diversion Dam in 1908, Bumping Lake Dam in 1910, Kachess Dam in 1912, Clear Creek Dam in 1914, Keechelus Dam in 1917, Tieton (storage) Dam in 1925, Easton Dam in 1929, Prosser Powerplant in 1932, Cle Elum Dam in 1933, Roza Diversion Dam in 1939, and Chandler Powerplant in 1956. Distribution systems were built concurrently with the storage and diversion facilities. Prosser Powerplant was retired in 1955, and Roza Powerplant was completed in 1958. Construction of Kennewick Division facilities began in January 1953, and were completed in January 1958. Cascade Irrigation District rehabilitation and betterment work began February 1974 and was completed in May 1975.

Operating Agencies

The Kittitas Division is operated by the Kittitas Reclamation District, the Roza Division by the Roza Irrigation District, the Kennewick 'Division by the Kennewick Irrigation District, and the Tieton Division by the Yakima-Tieton Irrigation District. The major features of the Sunnyside Division distribution system are operated by the Sunnyside Valley Irrigation District and the Board of Control. The Storage Division is operated by the Bureau of Reclamation. Pumping plants and laterals serving the smaller districts are operated and maintained by those districts. Laterals of 10 cubic feet per second or less usually are maintained by the water users. The Wapato Division is operated by the Bureau of Indian Affairs.

BENEFITS

Irrigation

The record of crop production on the Yakima Project is outstanding. Nearly one-half million acres of sage-covered lands have been transformed into one of the richest agricultural areas in the Nation. Yakima County ranks first among all counties of the United States in the production of apples, mint, and hops. Principal crops are fruit, vegetables, forage, hops, and mint.

Hydroelectric Power

The project has an installed generating capacity of 23,250 kilowatts. Much of the power produced is used for pumping irrigation water; the surplus is marketed by the Bonneville Power Administration.

Recreation and Fish and Wildlife

Bumping, Rimrock, and Clear Lakes are in Snoqualmie National Forest. The rugged mountain terrain, surrounded by coniferous forests, creates magnificent scenic settings. Cabins, camping, boating, and fishing are available at Bumping Lake. Much of the shoreland at Clear Lake is reserved for group camp use. Rimrock Lake is used intensively by fishermen and other recreationists. There are private cabins and several campgrounds. Good fishing is available in the reservoir for rainbow and other trout, and in the stream below the dam for rainbow trout and whitefish.

Cle Elum, Kachess, and Keechelus Reservoirs are in the Wenatchee National Forest. Cabins, camping, swimming, boating, picnicking, and fishing, primarily for trout and freshwater ling, are available at all three reservoirs. Since construction of the dams, fishing has improved greatly in the streams below the dams.

Sunnyside, Prosser, Roza, and Easton Dams on the Yakima River have recreation associated with their impoundments. Sunnyside is limited to sightseeing and fishing. Prosser and Roza diversions both provide excellent fisheries and Rosa also has boat launching facilities.

The Easton Diversion Dam area is much larger than the other three as it has 112 acres of land and 240 acres of water surface. There is a State park that provides facilities for camping, swimming, and boat launching and mooring. Recreational use is heavy; the reservoir also has a good fishery.

Tieton Dam

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	282,097	acres
Supplemental irrigation service	181,831	acres
Temporary irrigation service	153	acres
Total	464,081	acres
Number of irrigated farms	13,247	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	385,961	105,225,477
1969	383,132	107,422,488
1970	377,858	119,143,928
1971	378,268	114,369,162
1972	373,955	143,436,753
1973	380,742	221,024,138
1974	395,184	262,115,033
1975	398,165	233,172,151
1976	391,150	241,664,031
1977	358,127	271,369,387

Facilities in Operation

Storage dams	6	
Diversion dams	5	
Canals	416	mi
Laterals	1,698	mi
Pumping plants	30	
Drains	144	mi
Powerplants	2	
Transmission lines	73.4	mi
Substations	11	

Climatic Conditions

Annual precipitation	7.5	in
Temperature:		
Maximum	110	°F
Minimum	−17	°F
Mean	50	°F
Growing season	177	days
Elevation of irrigable area	400-2200.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	46,477
Other water service[1]	108,949
Total	155,426

[1]Urban and suburban, residential, commercial, and industrial lands.

Power Generation

Fiscal year	Chandler Powerplant, kWh	Roza Powerplant, kWh
1968	50,531,000	76,125,000
1969	57,071,000	59,982,000
1970	69,679,000	64,126,000
1971	66,674,000	69,004,000
1972	66,220,000	89,206,000
1973	41,703,000	75,203,000
1974	57,614,000	76,313,000
1975	71,279,000	82,852,000
1976	[2]81,116,000	[2]110,509,000
1977	37,094,000	53,815,000

[2]15-month period. Transitional quarter July-Sept. 1976 included. Fiscal year changed from July-June to October-Sept.

ENGINEERING DATA

Water Supply

Yakima River

Drainage area above Keechelus Dam	55	mi^2
Annual discharge at Keechelus Dam:		
Maximum (1972)	372,200	acre-ft
Minimum (1977)	160,500	acre-ft
Average	256,800	acre-ft

Kachess River

Drainage area at gaging station 0.25 mi below dam	64	mi^2
Annual discharge:		
Maximum (1972)	332,000	acre-ft
Minimum (1977)	120,800	acre-ft
Average	218,900	acre-ft

Cle Elum River

Drainage area at gaging station 1,000 ft below dam	203	mi^2
Annual discharge:		
Maximum (1972)	1,036,900	acre-ft
Minimum (1977)	393,700	acre-ft
Average	698,900	acre-ft

Bumping River

Drainage area at gaging station 0.25 mi below dam	69	mi^2
Annual discharge:		
Maximum (1972)	315,400	acre-ft
Minimum (1977)	104,000	acre-ft
Average	214,100	acre-ft

Tieton River

Drainage area at gaging station 1,200 ft below dam	187	mi^2
Annual discharge:		
Maximum (1972)	569,100	acre-ft
Minimum (1977)	193,500	acre-ft
Average	387,500	acre-ft

Yakima River

Drainage area above gage	3,660	mi^2
Annual discharge:		
Maximum (1972)	5,449,700	acre-ft
Minimum (1977)	1,505,200	acre-ft
Average	3,748,900	acre-ft
Average annual diversion by project (1963-77)	2,162,560	acre-ft

Storage Facilities

Keechelus Dam

Type: Zoned earthfill
Location: On Yakima River, 10 mi northwest of Easton, Wash.
Construction period: 1913-17
Outlet works reconstructed: 1976-78
Date of closure (first storage): August 19, 1911
Reservoir, Keechelus Lake:

Total capacity to El. 2517	157,800	acre-ft
Active capacity, El. 2425-2517	157,800	acre-ft
Surface area	2,562	acres
Dimensions:		
Structural height	128	ft
Hydraulic height	68	ft
Top width	20	ft
Maximum base width	370	ft
Crest length	6,550	ft
Crest elevation	2525.0	ft
Total volume	684,000	yd^3
Spillway: Uncontrolled concrete weir, concrete lined, and natural ravine channel at left abutment of dam.		
Crest length	302	ft
Crest elevation	2517.0	ft
Capacity at El. 2521	10,000	ft^3/s
Outlet works: Concrete conduit through base of dam controlled by an 8.5-ft-square hydraulically operated slide gate.		
Capacity at El. 2519.5	3,000	ft^3/s

Kachess Dam

Type: Zoned earthfill
Location: On Kachess River, 2 mi northwest of Easton, Wash.
Construction period: 1910-12
New spillway constructed in 1936.
Date of closure (first storage): June 30, 1911
Reservoir, Kachess Lake:

Active capacity, El. 2262	239,000	acre-ft
Surface area	4,535	acres
Dimensions:		
Structural height	115	ft
Hydraulic height	59	ft
Top width	20	ft
Maximum base width	335	ft
Crest length	1,400	ft
Crest elevation	2268.0	ft
Total volume	200,000	yd^3
Spillway: Concrete-lined open channel in right abutment, controlled by one 50- by 8-ft radial gate.		
Elevation, top of gate	2262.0	ft
Crest elevation	2254.0	ft
Capacity at El. 2262	4,000	ft^3/s
Outlet works: Open channel and conduit to base of dam and concrete conduit through base of dam, controlled by three 4- by 10-ft slide gates.		
Capacity at El. 2255	5,000	ft^3/s

Cle Elum Dam

Type: Zoned earthfill
Location: On Cle Elum River, 8 mi northwest of Cle Elum, Wash.
Construction period: 1931-33
Spillway and parapet wall: 1936
Date of closure (first storage): February 26, 1932
Reservoir, Cle Elum Lake:

Active capacity, El. 2110-2240	436,900	acre-ft
Surface area	4,812	acres
Dimensions:		
Structural height	165	ft
Hydraulic height	124	ft
Top width	35	ft
Maximum base width	1,700	ft
Crest length (including dikes)	1,801	ft
Crest elevation	2250.0	ft
Total volume	1,411,000	yd^3
Spillway: Concrete-lined open channel in right abutment, controlled by five 37- by 17-ft radial gates.		
Elevation, top of gates	2240.0	ft
Crest elevation	2223.0	ft
Capacity at El. 2240	40,000	ft^3/s
Outlet works: Concrete-lined tunnel through right abutment, controlled by two 18- by 6.5-ft cylinder gates.		
Capacity at El. 2212	5,000	ft^3/s

BUMPING LAKE DAM

Type: Earthfill, puddled core diaphragm
Location: On Bumping River, 29 mi northwest of Naches, Wash.
Construction period: 1909-10
Date of closure (first storage): November 3, 1910
Reservoir, Bumping Lake:

Total capacity to El. 3426	33,700	acre-ft
Active capacity, El. 3389-3426	33,700	acre-ft
Surface area	1,303	acres
Dimensions:		
Structural height	61	ft
Hydraulic height	38	ft
Top width	20	ft
Maximum base width	275	ft
Crest length	2,925	ft
Crest elevation	3435.0	ft
Total volume	253,000	yd³
Spillway: Open, uncontrolled concrete weir with concrete and wooden chute at north end of dam.		
Crest length	235	ft
Crest elevation	3420.0	ft
Capacity at El. 3429	3,400	ft³/s
Outlet works: Concrete conduit through base of dam, controlled by two 5-ft-square service gates and two 5-ft-square emergency gates.		
Capacity at El. 3426	1,500	ft³/s

CLEAR CREEK DAM

Type: Concrete thin-arch
Two small earth embankments close saddles about 155 and 325 ft southeast of the dam.
Location: On North Fork of Tieton River, 27 mi southwest of Naches, Wash.
Construction period: 1914
Dam raised 21 ft and spillway and earth dikes constructed in 1918. Rehabilitated in 1964.
Date of closure (first storage): 1914
Reservoir, Clear Lake:

Active capacity to El. 3013	5,300	acre-ft
Surface area	260	acres
Dimensions:		
Structural height	83	ft
Hydraulic height	60	ft
Top width	3	ft
Maximum base width	10	ft
Crest length	404	ft
Crest elevation[3]	3015.0	ft
Total volume (concrete)	5,800	yd³
Spillway: Dam overflow and concrete weir in open rock cut channel about 600 ft northwest of dam.		
Weir crest length	120	ft
Weir crest elevation (with 2-ft flashboards)	3015.0	ft
Weir capacity at El. 3015 (without flashboards)	1,000	ft³/s
Dam overflow capacity at El. 3017	4,000	ft³/s
Outlet works: Two cast-iron pipes through base of dam near left abutment, controlled by two 36-in-diameter slide gates.		
Capacity to El. 3015	500	ft³/s

TIETON DAM

Type: Earthfill with concrete core wall diaphragm
Location: On Tieton River, about 40 mi northwest of Yakima, Wash.
Construction period: 1917-25
Date of closure (first storage): April 27, 1925
Reservoir, Rimrock Lake:

Active capacity to El. 2926	198,000	acre-ft
Surface area	2,526	acres
Dimensions:		
Structural height	319	ft
Hydraulic height	198	ft
Top width	40	ft
Maximum base width	1,100	ft
Crest length	920	ft
Crest elevation	2935.0	ft
Total volume	2,049,000	yd³
Spillway: Concrete-lined open channel in left abutment with concrete side channel weir, controlled by six 65- by 8-ft drum gates.		
Elevation, top of gates	2926.0	ft
Crest elevation	2918.0	ft
Capacity at El. 2928.2	45,700	ft³/s
Outlet works: Tunnel through left abutment joined by inclined auxiliary inlet shaft near center, controlled by two 60-in and one 24-in needle valves.		
Capacity at El. 2926	3,000	ft³/s

[3]To equate elevations with sea-level data, subtract 24.6 ft from all elevations shown.

Diversion Facilities

TIETON DIVERSION DAM

Type: Concrete weir with embankment wing
Location: On Tieton River about 16 mi southwest of Naches, Wash.
Year completed: 1908
Dimensions:

Structural height	5	ft
Hydraulic height	3	ft
Weir crest length	110	ft
Total crest length	510	ft
Crest elevation	2301.6	ft
Volume	1,400	yd³
Headworks: Concrete structure, three 4- by 5-ft cast iron slide gates.		
Diversion capacity	320	ft³/s

EASTON DIVERSION DAM

Type: Concrete gravity ogee weir, movable crest
Location: On Yakima River, near Easton, Wash.
Year completed: 1929
Dimensions:

Structural height	66	ft
Hydraulic height	43	ft
Weir crest length	64	ft
Total crest length	248	ft
Weir crest elevation (gate raised)	2180.3	ft
Volume	5,800	yd³
Spillway: Ogee weir, one automatically controlled 14.5- by 64-ft drum gate.		
Headworks: Concrete structure at right abutment, two motor-operated 12- by 11-ft radial gates.		
Diversion capacity	1,200	ft³/s
Fish facilities: Concrete fish ladder on left abutment, twenty 10- by 6-ft bays.		

PROSSER DIVERSION DAM

Type: Concrete weir
Location: On Yakima River near Prosser, Wash.

Year completed: 1904
Privately constructed, modified by Reclamation in 1932-33 and 1956.
Dimensions:

Structural height	9 ft
Hydraulic height	7 ft
Weir crest length	661 ft
Crest elevation	633.5 ft
Volume	2,500 yd³

Headworks: Concrete structure with three 16- by 7.75-ft top-seal radial gates.

Diversion capacity	1,500 ft³/s

Fish facilities: Two vertical concrete fish ladders, 1 ladder with 14 pools for right bank, 1 ladder with 12 pools for left bank. One 36- by 48-in slide gate to control auxiliary flow for right bank fish ladder.

Sunnyside Diversion Dam

Type: Concrete ogee weir with embankment wing
Location: On Yakima River near Parker, Wash.
Year completed: 1907
Dimensions:

Structural height	8 ft
Hydraulic height	6 ft
Weir crest length	500 ft
Crest elevation	898.5 ft
Volume	1,800 yd³

Headworks: Concrete structure with six 6-ft-square cast iron gates.

Diversion capacity	1,320 ft³/s

Fish facilities: Three stairstep ladders, one on each bank and one near center of dam.

Roza Diversion Dam

Type: Concrete weir, movable crest
Location: On Yakima River about 10 mi north of Yakima, Wash.
Year completed: 1939
Dimensions:

Structural height	67 ft
Hydraulic height	34 ft
Weir crest length	241 ft
Total crest length	486 ft
Weir crest elevation	1205.0 ft
Volume	21,700 yd³

Spillway gates: Two 14- by 110-ft motor-operated roller gates, float controlled.
Headworks: Concrete structure in right abutment with trashrack at inlet end protecting revolving fish screens in transition section. Radial gate structure at outlet end controls discharges into canal. Six 20-ft-long, 13.08-ft-diameter fish screens, motor operated. One 28- by 15-ft radial gate, motor operated, manually controlled. Two hand-operated sluice gates, one 16-in and one 14-in, on fish bypass.

Diversion capacity	2,200 ft³/s

Fish facilities: Main concrete fish ladder with 28 pools in left abutment; auxiliary ladder with 4 pools in right pier. One 12- by 7-ft fixed-wheel gate on fish ladder, and one 30-in sluice gate on diffuser beneath main fish ladder.

Carriage Facilities

Kittitas Main Canal

Location: From Easton Diversion Dam generally southeast along south side of Yakima River to about 13 mi northwest of Ellensburg, Wash.
Construction period: 1926-29

Length	25 mi
Diversion capacity	1,320 ft³/s
Typical maximum section in earth:	
Bottom width	30 ft
Side slopes	1.5:1
Water depth	11.35 ft
Typical maximum section, lined:	
Bottom width	12 ft
Side slopes	1.5:1

North Branch Canal (Kittitas)

Location: From end of Kittitas Main Canal generally east-southeast along northern edge of Kittitas Division irrigated area.
Construction period: 1926-31

Length	34 mi
Diversion capacity	925 ft³/s
Typical maximum section in earth:	
Bottom width	30 ft
Side slopes	1.5:1
Water depth	8.2 ft
Typical maximum section, lined:	
Bottom width	10 ft
Side slopes	1.25:1
Water depth	7.85 ft

Yakima River Pressure Tunnel

Location: On North Branch Canal in the Kittitas Division.
Construction period: 1929-31

Length	3,640 ft
Capacity	925 ft³/s
Cross-section: Circular	
Diameter	9.25 ft

Lining: Concrete and steel

South Branch Canal

Location: From end of Kittitas Main Canal generally south-southeast along southern edge of Kittitas Division irrigated area.
Construction period: 1926-29

Length	14 mi
Diversion capacity	220 ft³/s
Typical maximum section in earth:	
Bottom width	12 ft
Side slopes	1.5:1
Water depth	3.95 ft
Typical maximum section, lined:	
Bottom width	5 ft
Side slopes	1.25:1
Water depth	3.8 ft

Cascade Intake Canal

Location: On east side of Yakima River, 3 mi northwest of Ellensburg, Wash.
Construction period: 1974-75

Length	0.89 mi
Capacity	150 ft³/s
Typical maximum section in earth:	
Bottom width	10 ft
Side slopes	2:1
Water depth	5 ft

Tieton Canal

Location: From Tieton Diversion Dam generally east along south side of Tieton River to vicinity of Tieton, Wash.

Construction period: 1907-09

Length	10 mi
Diversion capacity	347 ft³/s

NACHES BRANCH CANAL

Location: From end of Tieton Canal generally southeast along Naches River to vicinity of Yakima, Wash.
Construction period: 1909-10

Length	12.5 mi
Diversion capacity	92 ft³/s

WIDE HOLLOW BRANCH CANAL

Location: From end of Tieton Canal generally south to vicinity of Harwood, Wash.
Construction period: 1911

Length	29.7 mi
Diversion capacity	191 ft³/s
Typical maximum section in earth:	
Bottom width	12 ft
Water depth	9 ft

ROZA CANAL

Location: From Roza Diversion Dam generally southeast along north side of Yakima River Valley to vicinity of Benton City, Wash.

Length	90 mi
Diversion capacity	2,200 ft³/s
Typical maximum section in earth:	
Bottom width	55 ft
Side slopes	1.5:1
Water depth	12 ft
Typical maximum section, lined:	
Bottom width	14 ft
Side slopes	1.25:1
Water depth	11.26 ft

TUNNELS NO. 1 AND 3

Location: On Roza Canal near Roza Diversion Dam and Yakima, Wash.
Construction period: 1936-37

Length:	
Tunnel No. 1	8,231 ft
Tunnel No. 3	9,588 ft
Capacity (each tunnel)	2,200 ft³/s
Cross-section: Horseshoe	
Vertical height	17 ft
Lining: Concrete	

SUNNYSIDE CANAL

Location: From Sunnyside Diversion Dam generally southeast to vicinity of Benton City, Wash.
Construction period: 1892-1912

Length	60 mi
Diversion capacity	1,295 ft³/s
Typical maximum section in earth:	
Bottom width	40 ft
Side slopes	1.5:1
Water depth	8 ft
Typical maximum section, lined:	
Bottom width	10 ft
Side slopes	1.5:1
Water depth	4 ft

OUTLOOK CANAL

Location: From and parallel to Sunnyside Canal in the vicinity of Sunnyside, Wash.
Construction period: 1915

Length	10 mi
Diversion capacity	42 ft³/s
Typical maximum section, lined:	
Bottom width	3 ft
Side slopes	1:1
Water depth	2.5 ft

SNIPES MOUNTAIN CANAL

Location: South from Sunnyside Canal near Sunnyside, Wash.
Construction period: 1912

Length	12.5 mi
Diversion capacity	195 ft³/s
Typical maximum section in earth:	
Bottom width	14 ft
Side slopes	1:1
Water depth	4 ft
Typical maximum section, lined:	
Bottom width	10 ft
Side slopes	1:1
Water depth	3 ft

GRANDVIEW CANAL

Location: From and parallel to Sunnyside Canal in the vicinity of Grandview, Wash.
Construction period: 1916

Length	8 mi
Diversion capacity	36 ft³/s
Typical maximum section, lined:	
Bottom width	2.5 ft
Side slopes	1:1
Water depth	2 ft

PROSSER IRRIGATION DISTRICT CANAL

Location: From and parallel to Sunnyside Canal across Yakima River from Prosser, Wash.
Construction period: 1917

Length	9 mi
Diversion capacity	20 ft³/s
Typical maximum section, lined:	
Bottom width	2 ft
Side slopes	1:1
Water depth	2 ft

MABTON CANAL

Location: On south side of Yakima River across from Grandview, Wash. (Water supply through siphon from Sunnyside Canal).
Construction period: 1910

Length	13.5 mi
Diversion capacity	125 ft³/s
Typical maximum section in earth:	
Bottom width	7 ft
Side slopes	1:1
Water depth	4 ft

PROSSER CANAL

Location: On south side of Yakima River near Prosser, Wash. (Water supply through siphon from Sunnyside Canal).
Construction period: 1912

Length	10 mi
Diversion capacity	33 ft³/s
Typical maximum section in earth:	
Bottom width	3.5 ft
Side slopes	1:1

Water depth	3	ft
Typical maximum section, lined:		
Bottom width	3.5	ft
Side slopes	1:1	
Water depth	3	ft

CHANDLER POWER CANAL

Location: From Prosser Diversion Dam generally northeast along Yakima River to Chandler Power and Pumping Plant.
Construction period: 1953-54

Length	10.6	mi
Diversion capacity	1,500	ft³/s
Typical maximum section in earth:		
Bottom width	50	ft
Side slopes	1.5:1	
Water depth	9.9	ft
Typical maximum section, lined:		
Bottom width	12	ft
Side slopes	1.5:1	
Water depth	10.9	ft

KENNEWICK MAIN CANAL

Location: From Chandler Power and Pumping Plant generally southeast to vicinity of Hover, Wash.
Construction period: 1954-56

Length	44	mi
Diversion capacity	500	ft³/s
Typical maximum section in earth:		
Bottom width	14	ft
Side slopes	2:1	
Water depth	7.6	ft
Earth lining thickness	18	in
Typical maximum section, concrete lined:		
Bottom width	7	ft
Side slopes	1.5:1	
Water depth	6.5	ft

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horse-power
Kennewick Division:				
Chandler[4]	2	500	108	5,200
Amon	1	20	225	700
Sunnyside Division:				
Snipes Mountain	2	80	63	850
Outlook	2	48	--	800
Grandview	3	38	35-78	365
West Grandview	1	4	64	--
Prosser	1	40	106	190
Spring Creek	1	22	77	160
Hillcrest	1	1.56	--	35
Kittitas Division: Wippel	1	65	136.5	1,500
Roza Division:				
Mile 7.2—Area No. 1	4	39	106-218	1,000
Mile 16.8—Area No. 2	5	50.6	106-233	1,600
Mile 22.5—Area No. 3	5	46.9	155-237	1,600
Mile 24.0—Area No. 4	2	11	164	400
Mile 27.0—Area No. 5	1	5.5	115	100
Mile 29.6—Area No. 6	1	5.5	151	125
Mile 37.8—Area No. 7	3	21.6	157	600
Mile 42.8—Area No. 8	3	32.1	141	750
Mile 48.5—Area No. 9	3	30.6	185	900
Mile 52.4—Area No. 9A	3	33	166	900
Mile 56.1—Area No. 10	2	13.5	139	300
Mile 61.8—Area No. 12	2	11.8	150	300
Mile 67.3—Area No. 13	2	18	111	800
Roza Division (contd):				
Mile 71.0—Area No. 14	3	33	241	1,200
Mile 78.8—Area No. 15	6	77.1	148-275	2,550
Mile 81.5—Severyns	1	3	70	40
Mile 88.3—Area No. 16	5	46	139-271	1,500
Mile 92.7—Area No. 17	2	12.2	235	500
Terrace Heights	2	6	94	80
Cascade[5]	8	160	108	2,400

[4]Chandler Power and Pumping Plant has two 6,000-kW generating units and two 167-ft³/s hydraulic pumping units in operation. A third hydraulic pumping unit may be installed to serve the Kennewick Division Extension.
[5]Installed for the Cascade Irrigation District in 1974-75.

Power Facilities

CHANDLER POWERPLANT

Location: Adjacent to Yakima River about 10 mi northeast of Prosser, Wash.
Year of initial operation: 1956
Year last generator placed in operation: 1956

Name plate capacity	12,000	kW
Number and capacity of generators ...... (2)	6,000	kW
Maximum head	122	ft

ROZA POWERPLANT

Location: On Roza Main Canal about 3 mi northeast of Yakima, Wash.
Year of initial operation: 1958

Nameplate capacity	11,250	kW
Number of generators	1	
Maximum head	162	ft

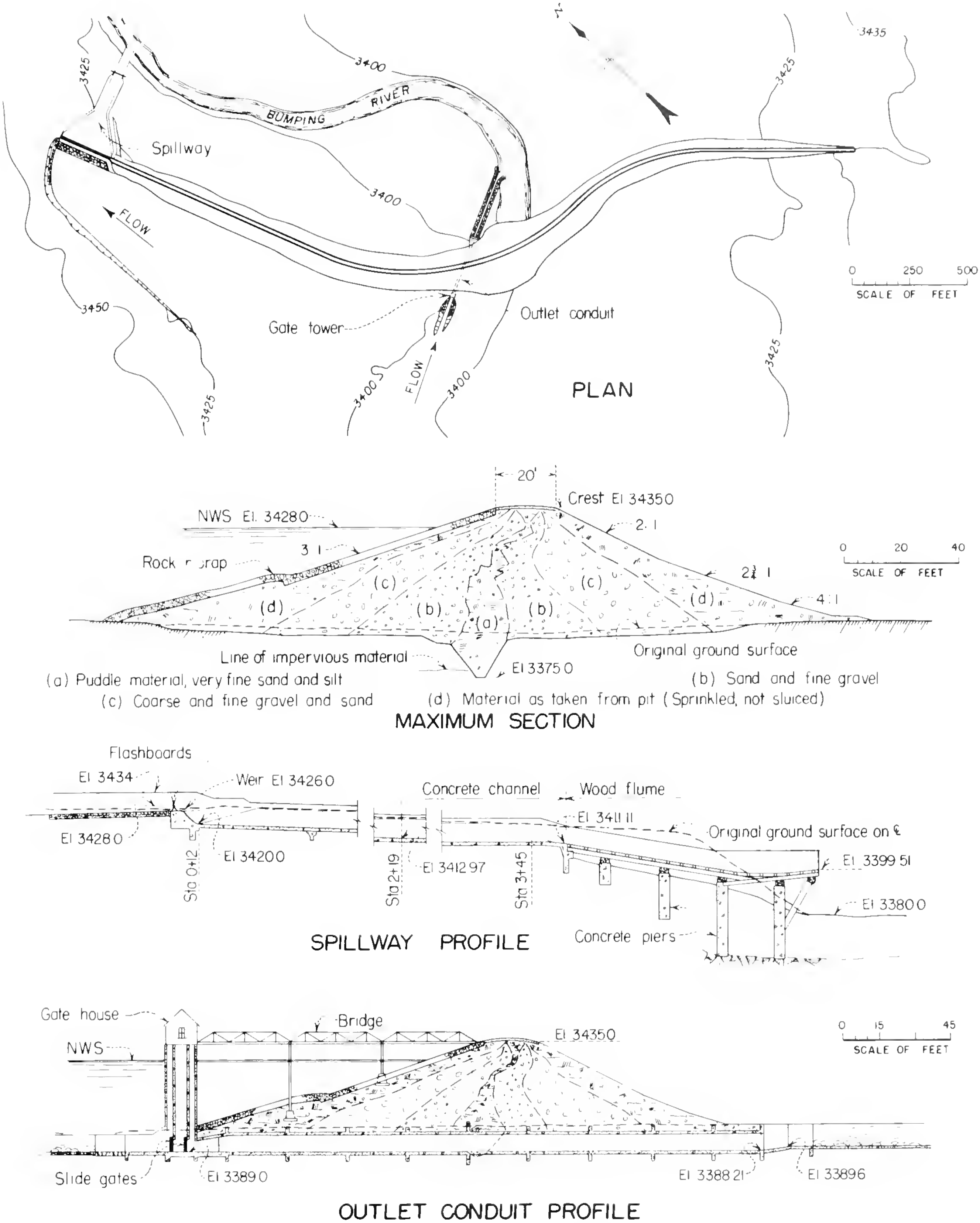
SUBSTATIONS

Number in operation	11	
Total capacity of transformers	40,000	kVA

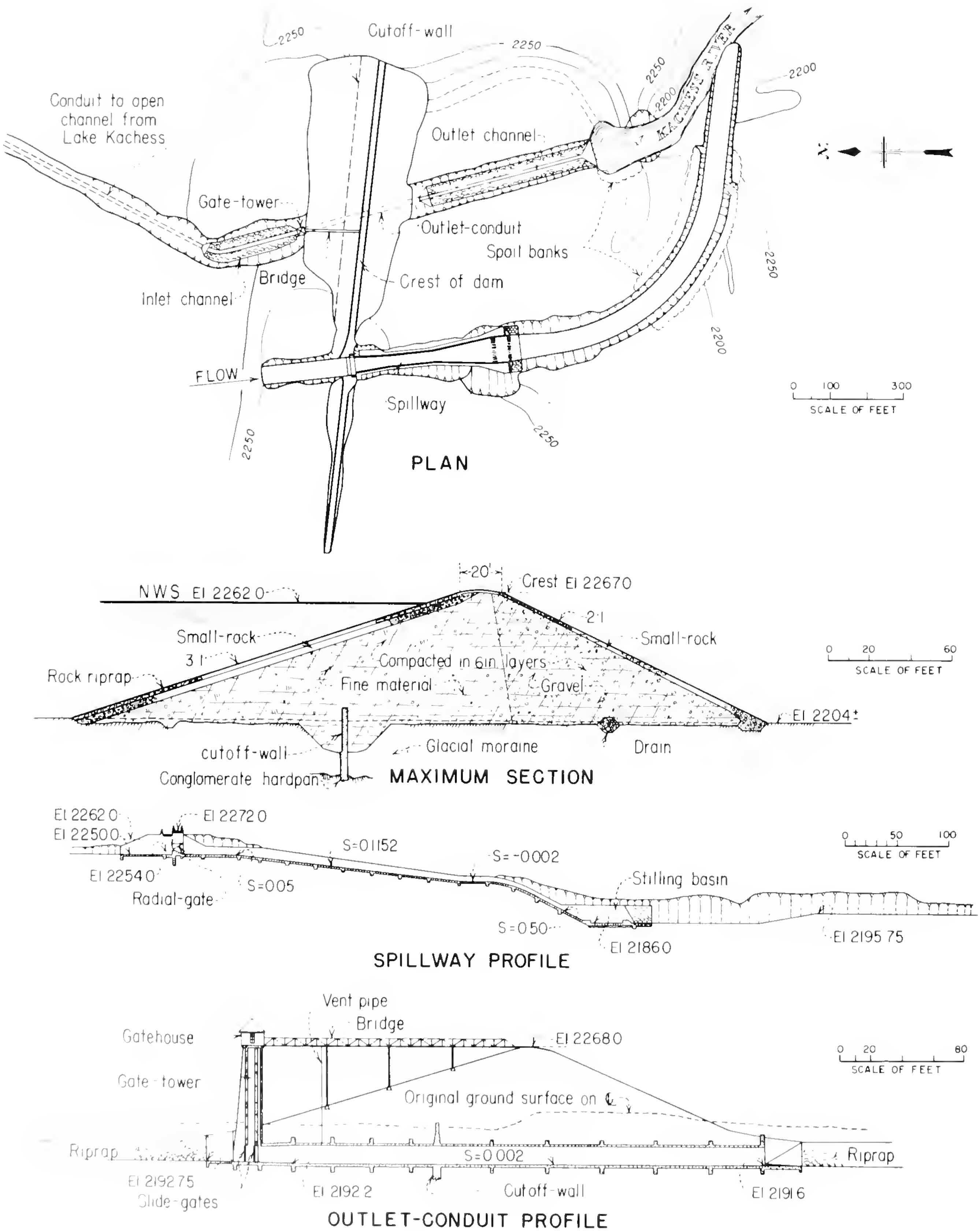
TRANSMISSION LINES

Total number of lines	5
Total circuit miles	73.40

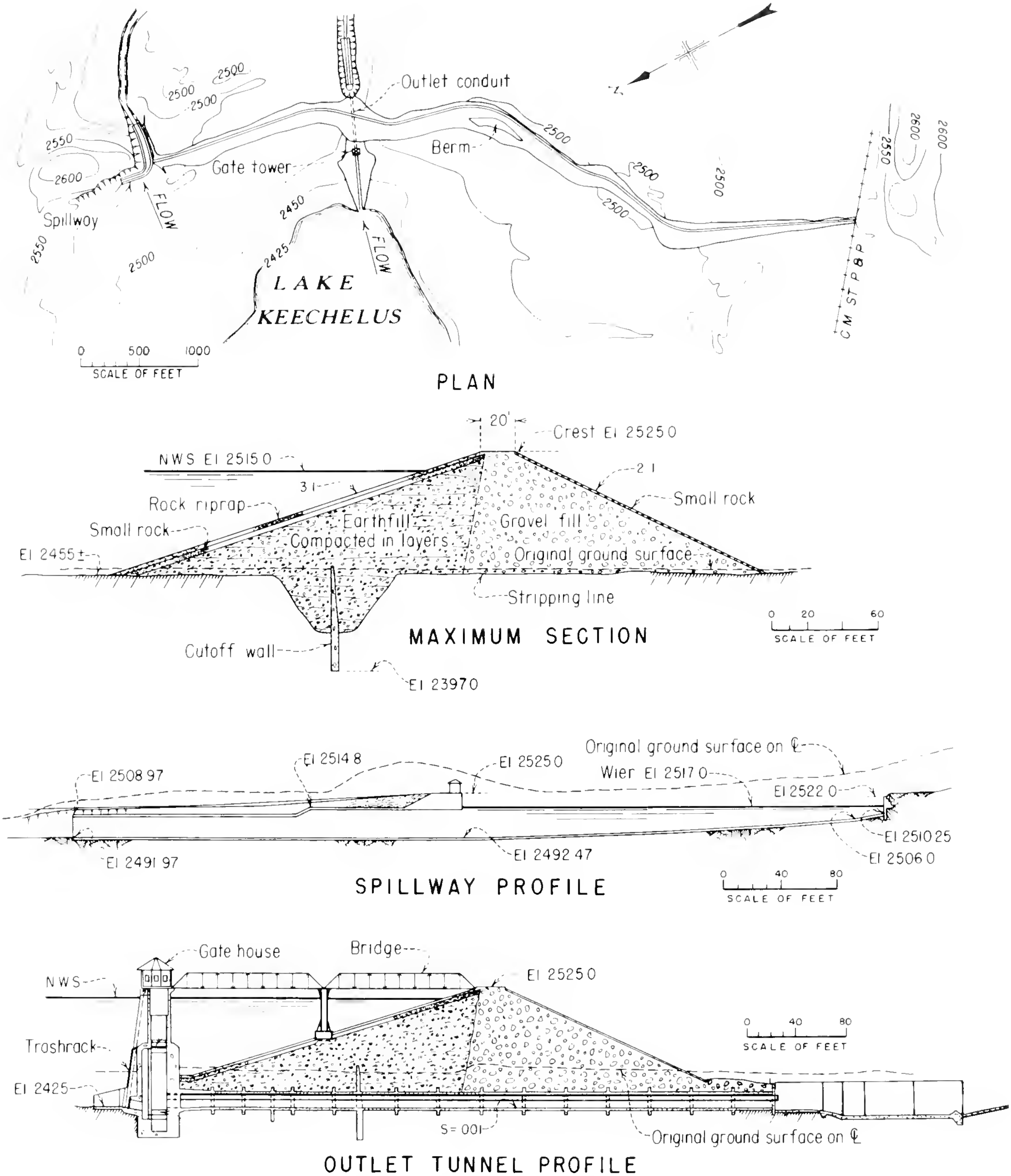
Designation	Capacity kV	Capacity kW	Circuit miles	Year placed in service
East Selah—Pumping Plant No. 17	34.5	7,500	64.06	1950 & 1971
Puget Sound Power & Light, U.S. Highway No. 10—Lake Kachess	13.2	---	0.60	1954
East Selah—Roza Dam	12.5	---	6.20	1950 & 1960
Pacific Power & Light—Wasteway No. 2	12.5	1,500	0.30	1940
Roza Pumping Plant No. 15—Severyn's Pumping Plant	2.4	30	2.24	1950



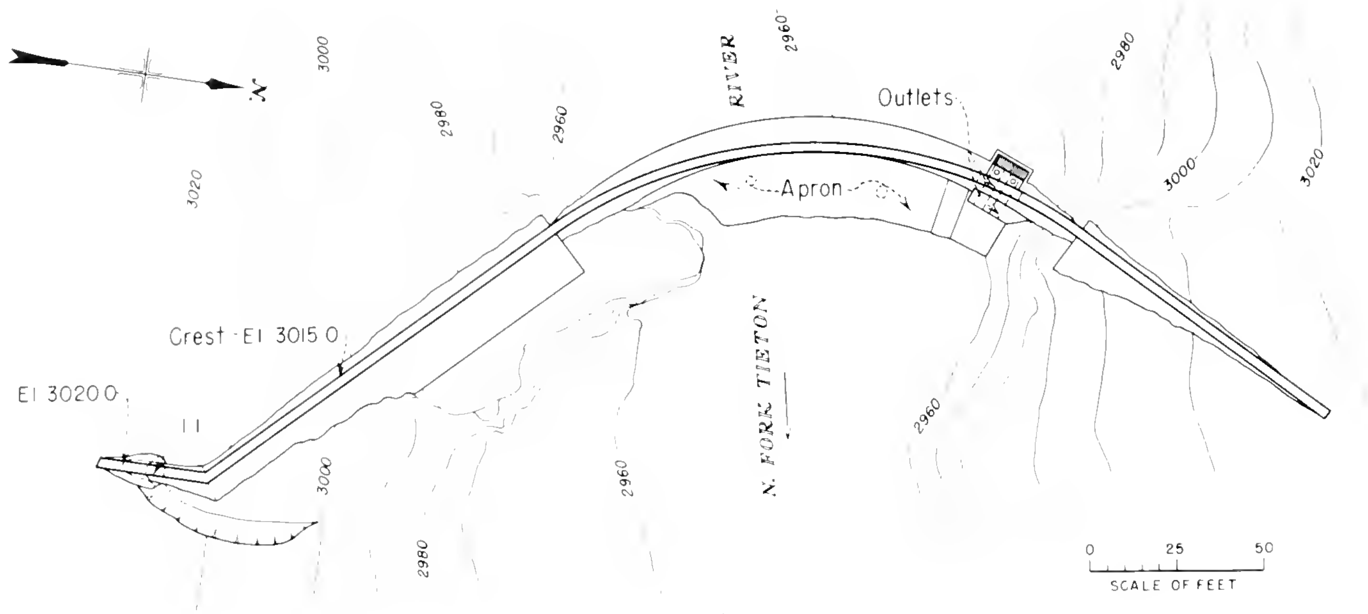
Bumping Lake Dam, Plan and Sections



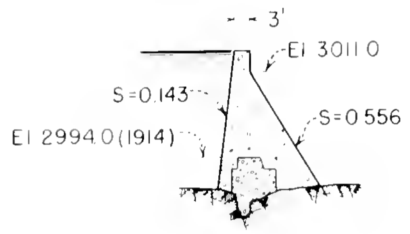
Kachess Dam, Plan and Sections



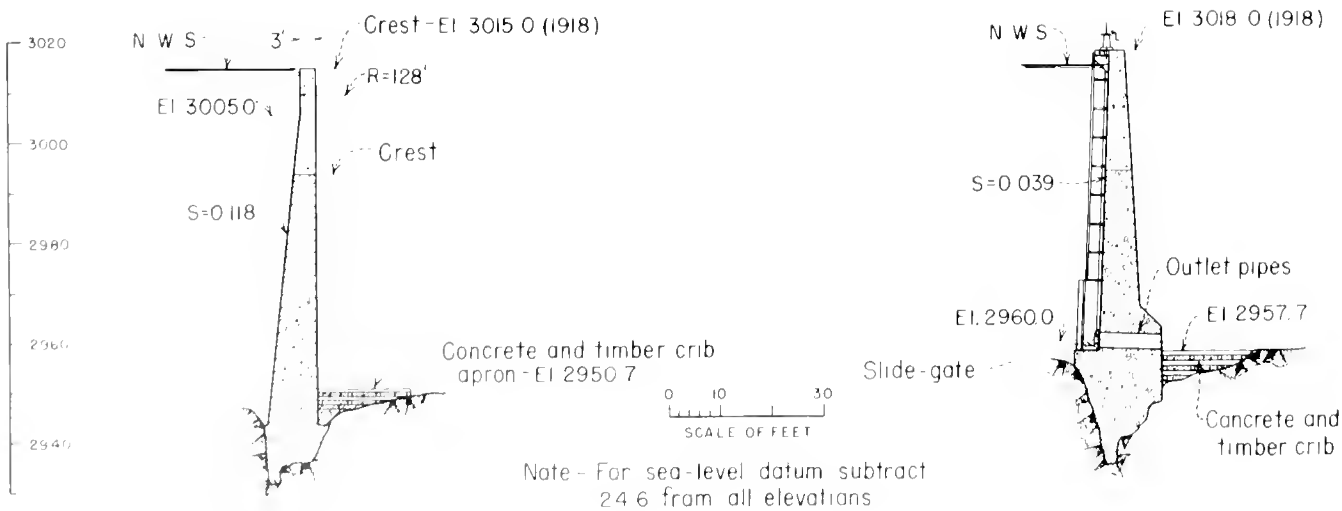
Keechelus Dam, Plan and Sections



PLAN



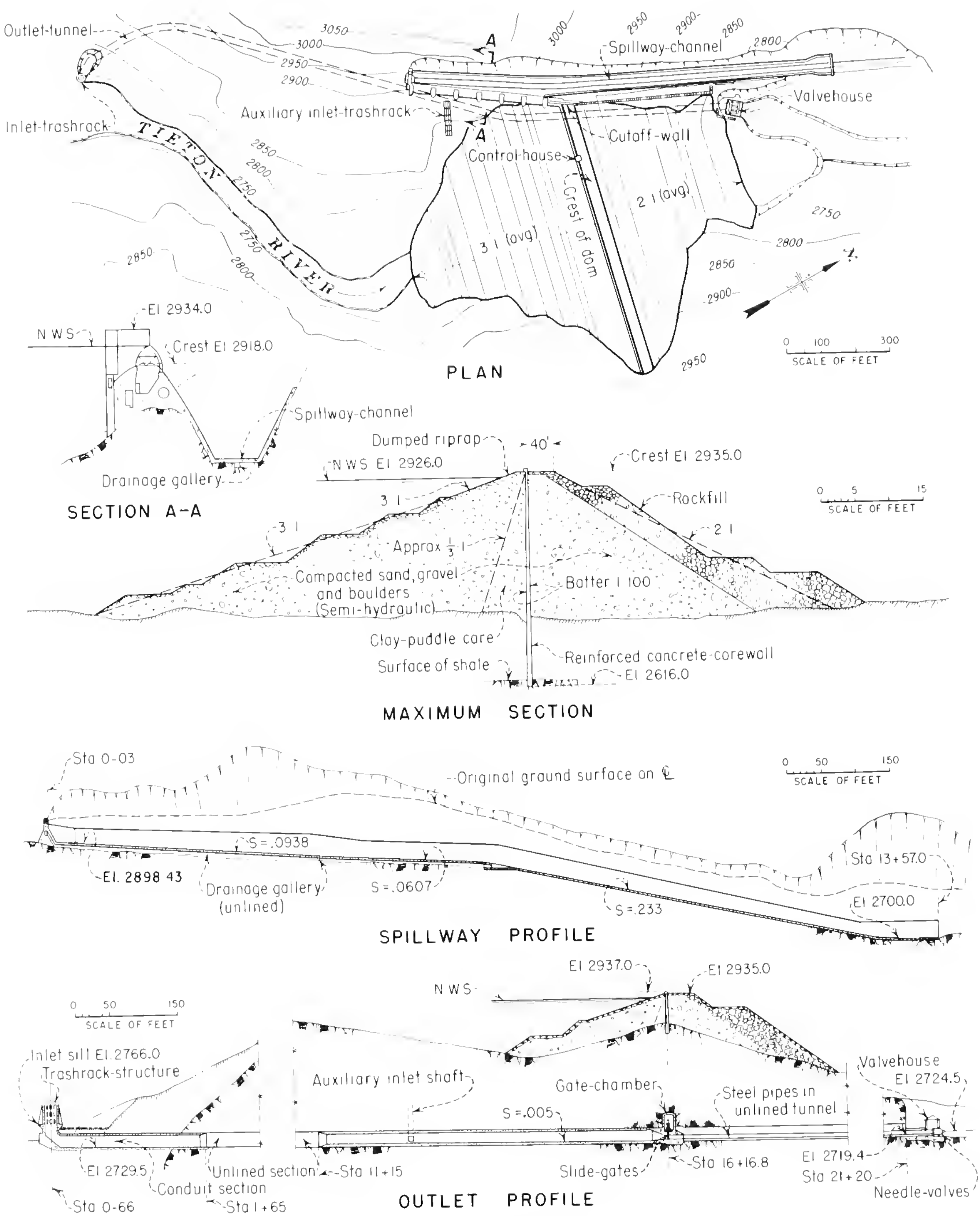
GRAVITY SECTION



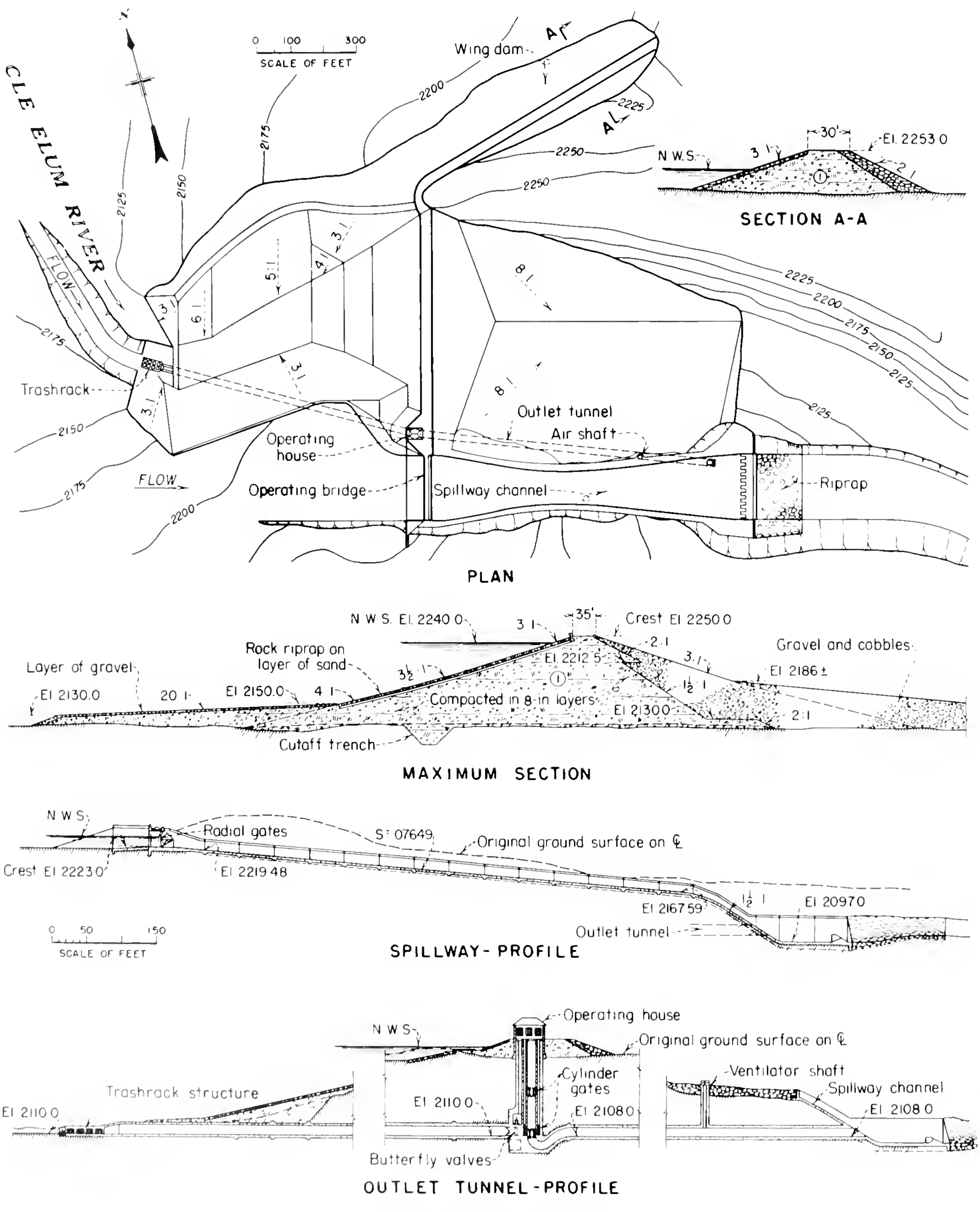
ARCH SECTION

OUTLET SECTION

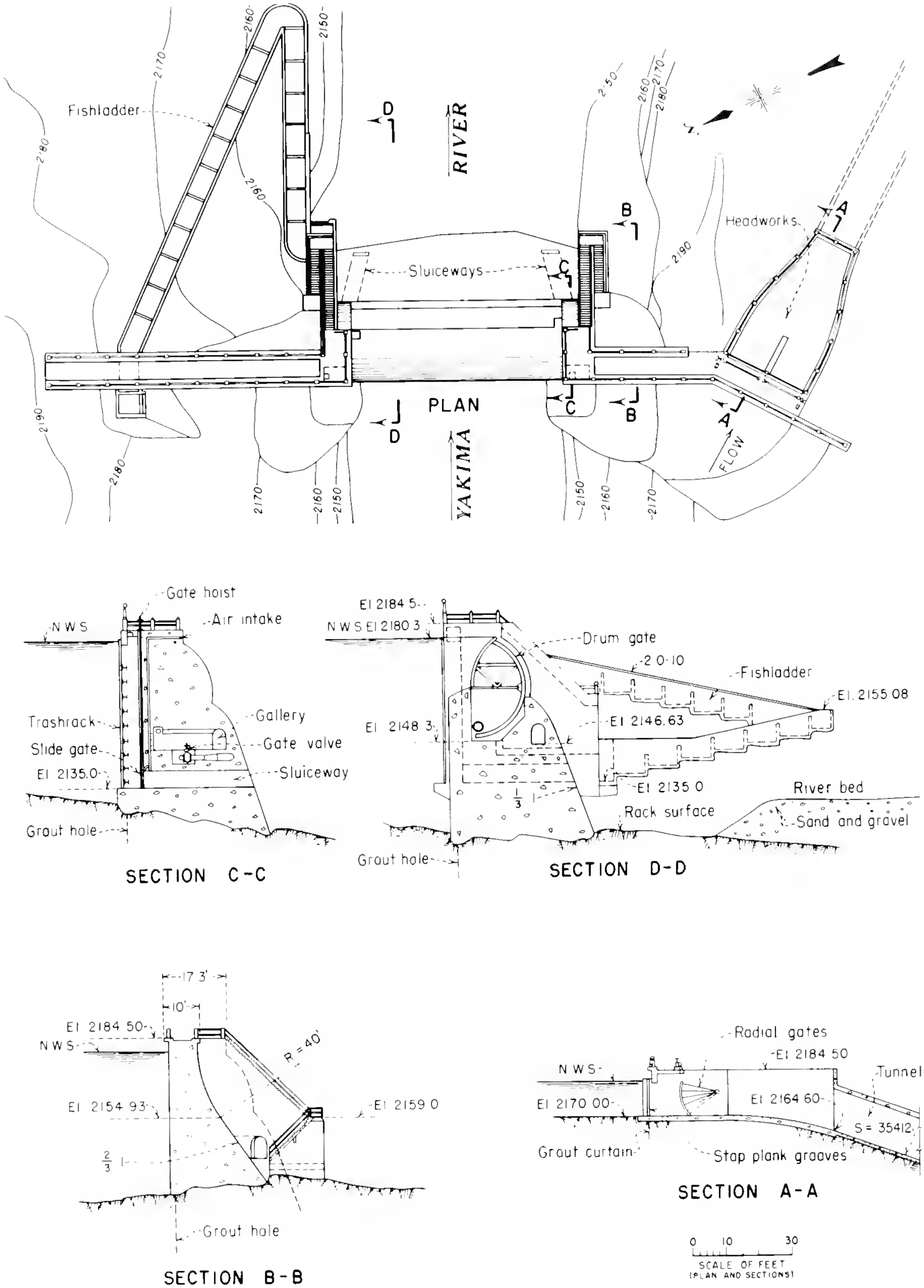
Clear Creek Dam, Plan and Sections



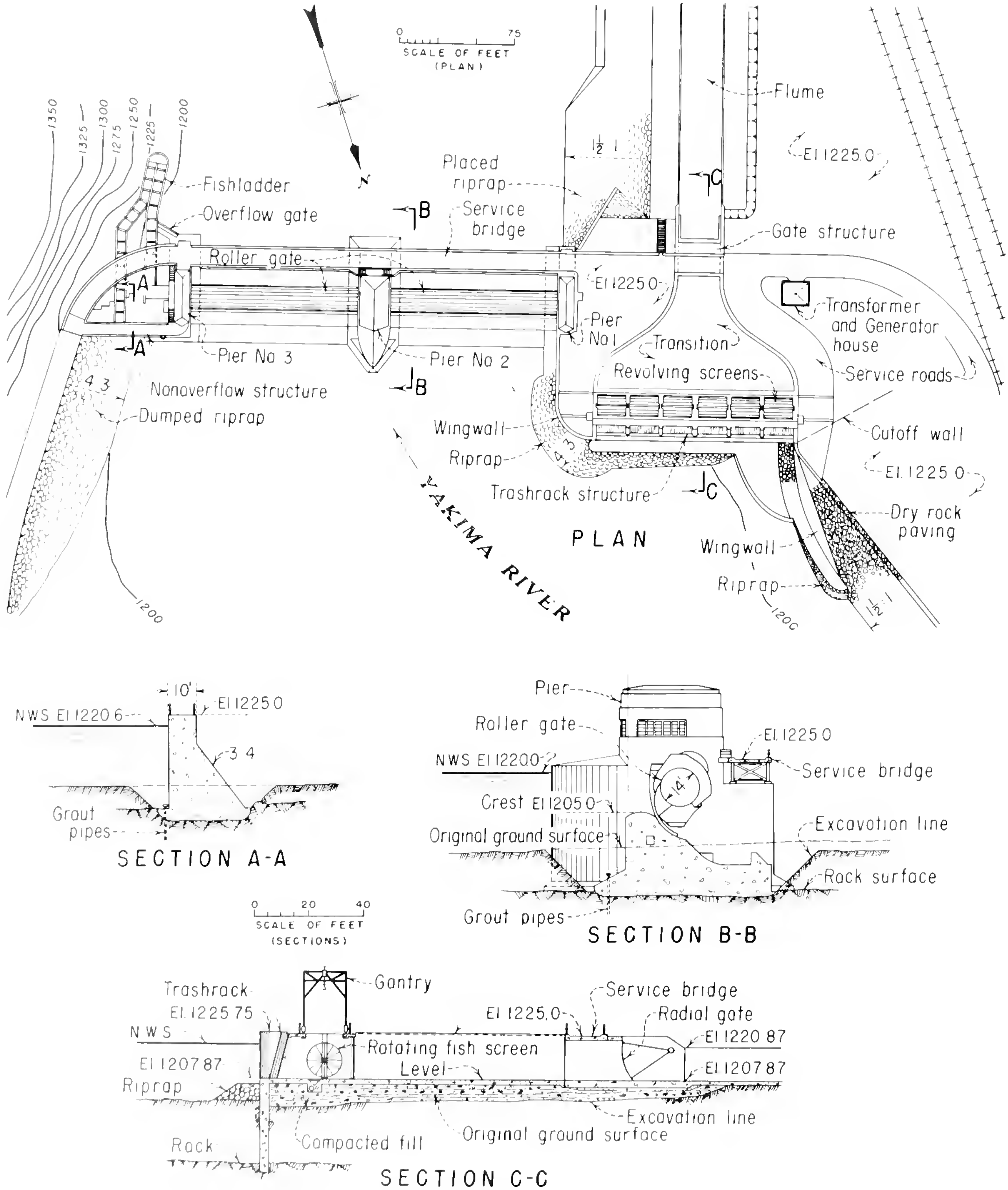
Tieton Dam, Plan and Sections



Cle Elum Dam, Plan and Sections



Easton Diversion Dam, Plan and Sections

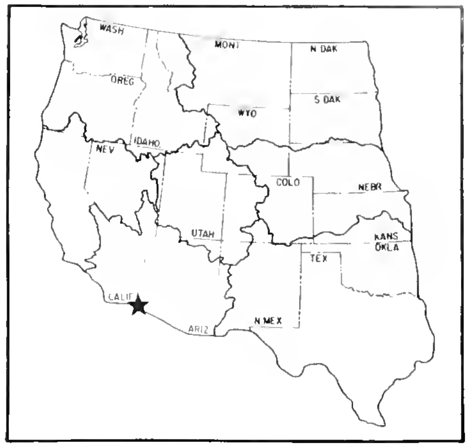


Roza Diversion Dam, Plan and Sections

Yuma Project

Arizona: Yuma County
California: Imperial County

Lower Colorado Region
Water and Power Resources Service



The Yuma Project provided water in 1977 to irrigate 68,091 acres in the vicinity of the towns of Yuma, Somerton, and Gadsden in Arizona, and Bard and Winterhaven in California. The project is divided into the Reservation Division, which consists of 14,676 acres in California, and the Valley Division, which consists of 53,415 acres in Arizona. The Reservation Division is further subdivided into the 7,120-acre Bard Unit and the 7,556-acre Indian Unit. The original features of the project include Laguna Dam on the Colorado River, the Boundary Pumping Plant, one powerplant, and a system of canals, laterals, and drains. Laguna Dam has not been used as a diversion structure since 1948.

PLAN

Water for the project is diverted from the All-American Canal to the forebay of the Siphon Drop Powerplant on the Yuma Main Canal, then is distributed over the Valley Division and a portion of the Reservation Division. Some Reservation Division lands are served directly from turnouts on the All-American Canal above Siphon Drop. The Yuma Main Canal crosses underneath the Colorado River near Yuma in an inverted siphon to supply the West Main, Central, and East Main Canals of the Valley Division, which flow south and irrigate land to the Mexican border. The Siphon Drop Powerplant on the California side was operated from July 15, 1926, until December 1972, when the plant was shut down. The hydroelectric power generated at the plant was interconnected with the Parker-Davis power system for distribution and sale.

Laguna Dam

Laguna Dam, an original feature of the project, is located on the Colorado River 13 miles northeast of Yuma, Ariz., and about 5 miles downstream from Imperial Dam. The original purpose of this dam was to divert Colorado River water to the project area. Since 1948, irrigation water for the project has been diverted at Imperial Dam. Laguna Dam now serves as a regulating structure for sluicing flows and for downstream toe protection for Imperial Dam. It has a structural height of 43 feet and contains 486,800 cubic yards of material.

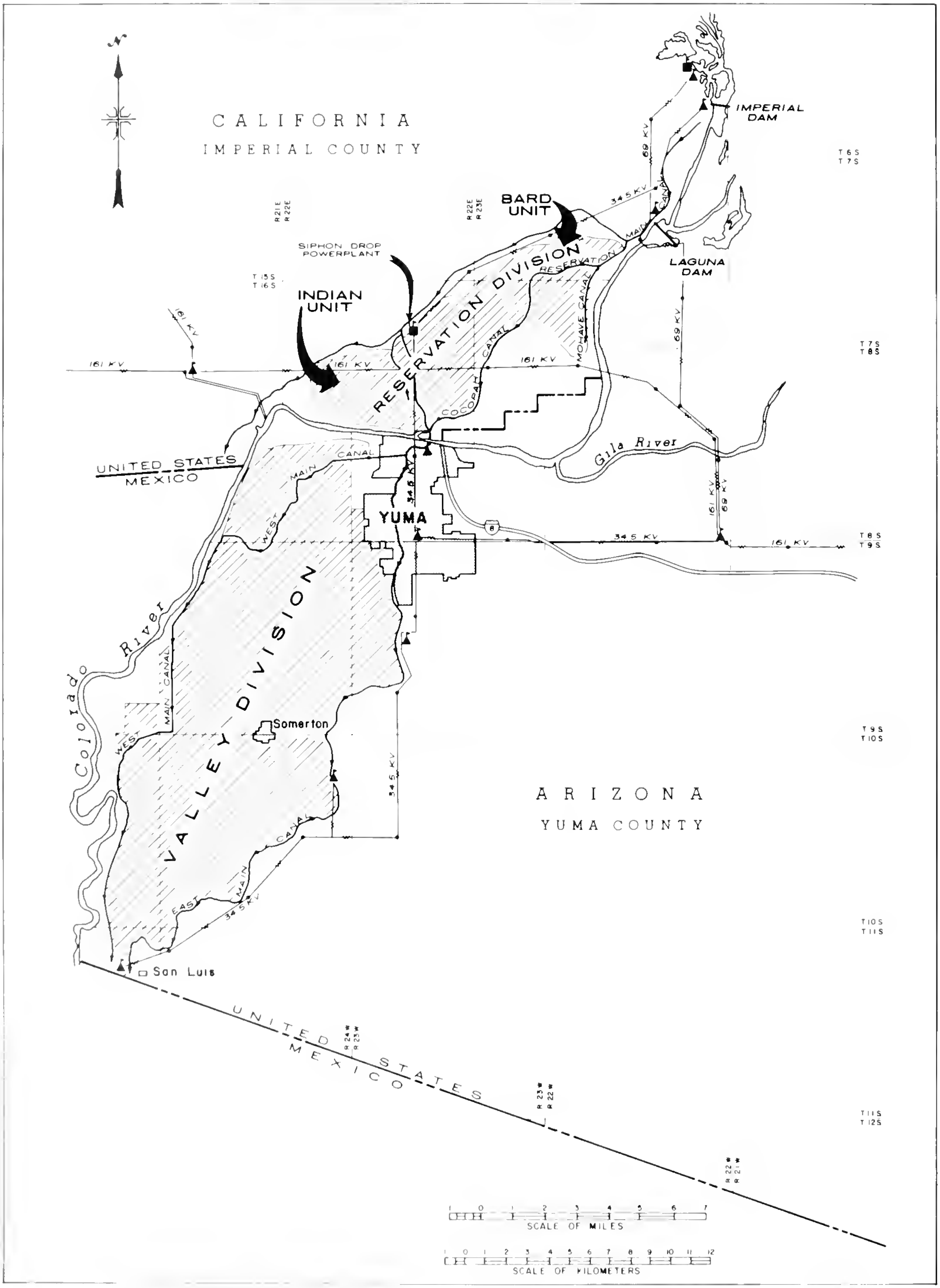
Drainage System

A system of open drains, supplemented by wells in problem areas, removes excess water from irrigated land in the Yuma Project area. There are approximately 29 miles of open drains in the Reservation Division that discharge into the Colorado River at two locations. Nearly one-half the Reservation Division drainage system has been installed to intercept seepage from the All-American Canal.

In the Valley Division, the main drain runs through the central part of the area, terminating at the Boundary Pumping Plant adjacent to the Mexican border. The main drain and its several branches total approximately 56 miles in length. There are 16 drainage wells along the east side of the valley that intercept underground flows from Yuma Mesa and divert seepage from cultivated lands. Eleven of these wells are operated and maintained by the Yuma County Water Users' Association; the remaining five wells are operated by the Bureau of Reclamation. Most of the water pumped from the drainage wells is discharged into the open drain system. A small quantity of drainage water from wells and isolated open drains is pumped into irrigation canals.

The original Boundary Pumping Plant began operating in 1919. In 1953, a more modern outdoor plant was put into operation. This plant has an installed capacity of 245 cubic feet per second using four vertical turbine, electric motor units. The lift is about 12 feet. A portion of the equipment in the original plant has been maintained as a standby plant, including a diesel engine unit which has a capacity of approximately 120 cubic feet per second.

The drainage water pumped by the Boundary Pumping Plant is discharged into a canal that flows into Mexico. This water, along with water from other sources, sustains a significant agricultural economy along the east side of the Colorado River in Mexico.



Yuma Project

Powerplant and Transmission Lines

The powerplant is located at Siphon Drop on the Yuma Main Canal 3.5 miles upstream of the Colorado River siphon. The plant is no longer in operation. Studies are being made on the possibility of rehabilitating and modernizing the powerplant. The average head under which it operated was 15 feet. It had two units and a total capacity of 1,600 kilowatts. About 27 miles of transmission lines were used to deliver the power produced.[1]

Distribution System

Originally, the Yuma Main Canal extended from the California side of Laguna Dam 10.5 miles to Siphon Drop Powerplant, then southerly 3.5 miles to and under the Colorado River to the Valley Division. In 1941, a turnout was completed in the All-American Canal at Siphon Drop Powerplant to supply part of the Reservation Division and all of the Valley Division with water diverted at Imperial Dam. In addition to the Siphon Drop Powerplant turnout, the Reservation Main, Titsink, Yaqui, and Pontiac turnouts were constructed in the All-American Canal to serve the remainder of the Reservation Division. On June 23, 1948, the outlet works at Laguna Dam were sealed and the reach of the Yuma Main Canal from Laguna Dam to Siphon Drop Powerplant was abandoned. The Yuma Main Canal extension from the All-American Canal Siphon Drop turnout to the Colorado River Siphon is 3.5 miles long, with a capacity of 2,000 cubic feet per second. In addition to the main canals, there are approximately 218 miles of laterals to deliver the water to individual farms. The drainage system includes 127 miles of drains.

DEVELOPMENT

Early History

In the 1890's and early 1900's, three private ditch companies were organized for the purpose of developing and irrigating the bottom lands of Yuma Valley. The Yuma County Water Users' Association was founded in 1903, and contracted with the United States for the construction of Laguna Dam, the Yuma Main Canal in California, an invert siphon under the Colorado River, and a distribution system.

Following the authorization of the Yuma Project in 1904, the United States purchased the properties of the original ditch companies. The first Colorado River water was delivered through the siphon to the Arizona side of the river on June 29, 1912.

[1]Operation and maintenance of the transmission facilities were transferred to the Parker-Davis Project on January 1, 1952. The operation of the Parker-Davis transmission system has been under the jurisdiction of the Department of Energy since October 1, 1977.

The Fort Yuma Indian Reservation in California was established by executive order of January 9, 1884. The lands in the Indian Unit of the project are a part of the reservation lands and are owned by Indian allottees. The land that is irrigated is leased to various operations and is administered by the Bureau of Indian Affairs. The Bard Unit of the division is private land.

Work began on the distribution system of the Reservation Division in 1908 and the deeded land was opened to settlers in 1910. The Bard Irrigation District was organized in 1927 to represent owners of the patented land in the Bard Unit.

Investigations

On August 31, 1903, the President ordered that the abandoned Fort Yuma Military Reservation in Arizona be reserved and set apart for use by the newly established Reclamation Service. The report by the Reclamation Service engineers indicated the value of constructing a large irrigation project, which prompted the project authorization.

Authorization

The project was authorized by the Secretary of the Interior on May 10, 1904, in accordance with section 4 of the Reclamation Act of June 17, 1902 (32 Stat. 388).

Construction

Construction work on Laguna Diversion Dam began in July 1905. The Government obtained the pumping plant of the Colorado Valley Pumping & Irrigation Company and the distribution system of the Yuma Valley Land & Water Company in 1907. The pumping plant and the distribution system were repaired and improved. A new heading with a capacity of 100 cubic feet per second was built for the distribution system early in 1908, and a scoop wheel with a capacity of 80 cubic feet per second was installed at the heading to provide for irrigation at times of low water. The Government purchased the Ives' heading pumps and ditches and the Rollings' ditch in 1908. The Laguna Diversion Dam was completed in 1909 to furnish the diversion for the Yuma Main Canal. In 1941, a turnout was provided at Siphon Drop on the All-American Canal to supply part of the Yuma Project with water diverted by Imperial Dam, and on June 23, 1948, the turnouts on the California side of the Laguna Diversion Dam were sealed. The principal canals were constructed in 1907-09.

Operating Agencies

The Bureau of Reclamation has operated and maintained the distribution and drainage facilities of the Reservation

Division since they were constructed. The Yuma County Water Users' Association assumed the operating responsibility from the Bureau of Reclamation for the Valley Division irrigation facilities on July 1, 1951, and for the Yuma Main Canal, the Siphon Drop Powerplant, and the 34.5-kV transmission line from Siphon Drop Powerplant in California to the Boundary Pumping Plant in Arizona on January 1, 1963.

BENEFITS

Irrigation

Fertile bottom lands ranging from 90 to about 140 feet in elevation make up both divisions of the project. Flax, alfalfa, cotton, vegetables, cereal grains, and citrus (grown on the Reservation Division) are the most profitable crops. Winter and early spring vegetables have become predominantly important.

PROJECT DATA

Land Areas (1977)

Irrigable area:		
Full irrigation service	68,091	acres
Number of irrigated farms	372	

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	55,395	24,133,131
1969	56,521	21,533,483
1970	56,364	20,137,289
1971	56,680	31,727,224
1972	56,280	28,776,853
1973	56,834	37,530,114
1974	55,054	43,721,567
1975	56,084	31,524,017
1976	58,110	51,059,413
1977	[2]57,837	45,646,809

[2]Arizona 45,681; California 12,156.

Facilities in Operation

Diversion dams	1	
Canals	53	mi
Laterals	218	mi
Pumping plants	1	
Drainage wells with pumps	16	
Drainage sump pumps	2	
Substations	2	

Climatic Conditions

Annual precipitation	3.5	in
Temperature:		
Maximum	120	°F
Minimum	22	°F
Mean	74	°F
Growing season	365	days
Elevation of irrigable area	90-140.0	ft

Settlement

Number of persons served with project water (1977):	
Farm irrigation service	9,735
Other water service[3]	16,490
Municipal and industrial	34,000
Total	60,225

[3]Urban and suburban, residential, commercial, and industrial lands.

ENGINEERING DATA

Water Supply

COLORADO RIVER

(See Boulder Canyon Project for drainage area and discharge figures.)		
Average annual diversion, total project, 1966-76[4]	1,060	ft³/s
Reservation Division	123	ft³/s
Valley Division	937	ft³/s

[4]Period of record 1955-76.

Diversion Facilities

LAGUNA DIVERSION DAM[5]

Type: Rockfill weir, concrete surfaced
Location: On the Colorado River, 13 mi northeast of Yuma, Ariz.
Construction period: 1905. Modified in 1923-24.

Dimensions:		
Structural height	43	ft
Hydraulic height	10	ft
Weir crest length	4,780	ft
Crest elevation	151.0	ft
Volume	486,800	yd³

Headworks: The California and Arizona headworks structures, located in the abutments, are similar in size, each consisting of concrete-lined desilting basin and sluiceway channel; broad-crested concrete weir structure (canal inlet) with flashboards and operating bridge, and concrete sluiceway gate structure.

[5]Diversion outlets closed June 23, 1948.

Carriage Facilities, Valley Division

YUMA MAIN CANAL

Location: From All-American Canal at Siphon Drop Powerplant, south to California Wasteway.
Construction period: 1907-09

Length	3.5	mi
Diversion capacity	2,000	ft³/s
Typical maximum section in earth:		
Bottom width	50	ft
Side slopes	1.25:1	
Water depth	9	ft

WEST MAIN CANAL

Location: From Yuma Main Canal at Yuma, Ariz., generally south along Colorado River to Mexican border.
Construction period: 1907-09

Length	21.4	mi
Diversion capacity	500	ft³/s

Typical maximum section in earth:

Bottom width	20 ft
Side slopes	1.25:1
Water depth	5.6 ft

Typical maximum section, lined:

Bottom width	5 ft
Side slopes	1.25:1
Water depth	3.3 ft
Lining thickness	1.5 in
Length	0.9 mi

CENTRAL CANAL

Location: From a point on Yuma Main Canal near Yuma, Ariz., generally southwest.

Construction period: 1907-09

Length	12.35 mi
Diversion capacity	200 ft³/s

Typical maximum section in earth:

Bottom width	20 ft
Side slopes	1.25:1
Water depth	4.7 ft

EAST MAIN CANAL

Location: From Colorado River Siphon south and southwest to the Mexican border.

Construction period: 1907-09

Length	24 mi
Diversion capacity	450 ft³/s

Typical maximum section in earth:

Bottom width	25 ft
Side slopes	1.25:1
Water depth	5 ft

Carriage Facilities, Reservation Division

RESERVATION MAIN CANAL

Location: From All-American Canal at Reservation Main turnout, southwest to Cocopah Lateral No. 4.

Construction period: 1907-09

Length	3.25 mi
Diversion capacity	220 ft³/s

MOHAVE CANAL

Location: From Reservation Main Canal to the Vomical Lateral near the southwestern boundary of the Bard Unit.

Construction period: 1908-10

Length	2.79 mi
Diversion capacity	40 ft³/s

COCOPAH CANAL

Location: From Cocopah Lateral No. 4 to Cocopah Wasteway.

Construction period: 1908-10

Length	6.19 mi
Diversion capacity	80 ft³/s

WALAPAI CANAL

Location: From Siphon Drop Powerplant to the Ottowa Lateral north of Winterhaven.

Construction period: 1908-10

Length	1.93 mi
Diversion capacity	48 ft³/s

PUMPING PLANTS

Designation	Number of units	Total capacity, ft³/s	Total dynamic head, ft	Total horsepower
Boundary (current)	2	133.6	12	575
Boundary (original)[6]	1	66.8	12	287
Boundary (original)[6]	1	44.6	8	120
Gardenhire Drain	2	9	7	25
Drainage Well	16	65	30-50	30-150

[6]Used for standby.

Power Facilities

SIPHON DROP POWERPLANT

Location: On Yuma Main Canal, about 5 mi north of Yuma, Ariz.

Year of initial operation: 1926

Year last generator placed in operation: 1926

Last year of operation: 1972

Nameplate capacity	1,600 kW
Number and capacity of generators (2)	800 kW
Maximum head	15.3 ft

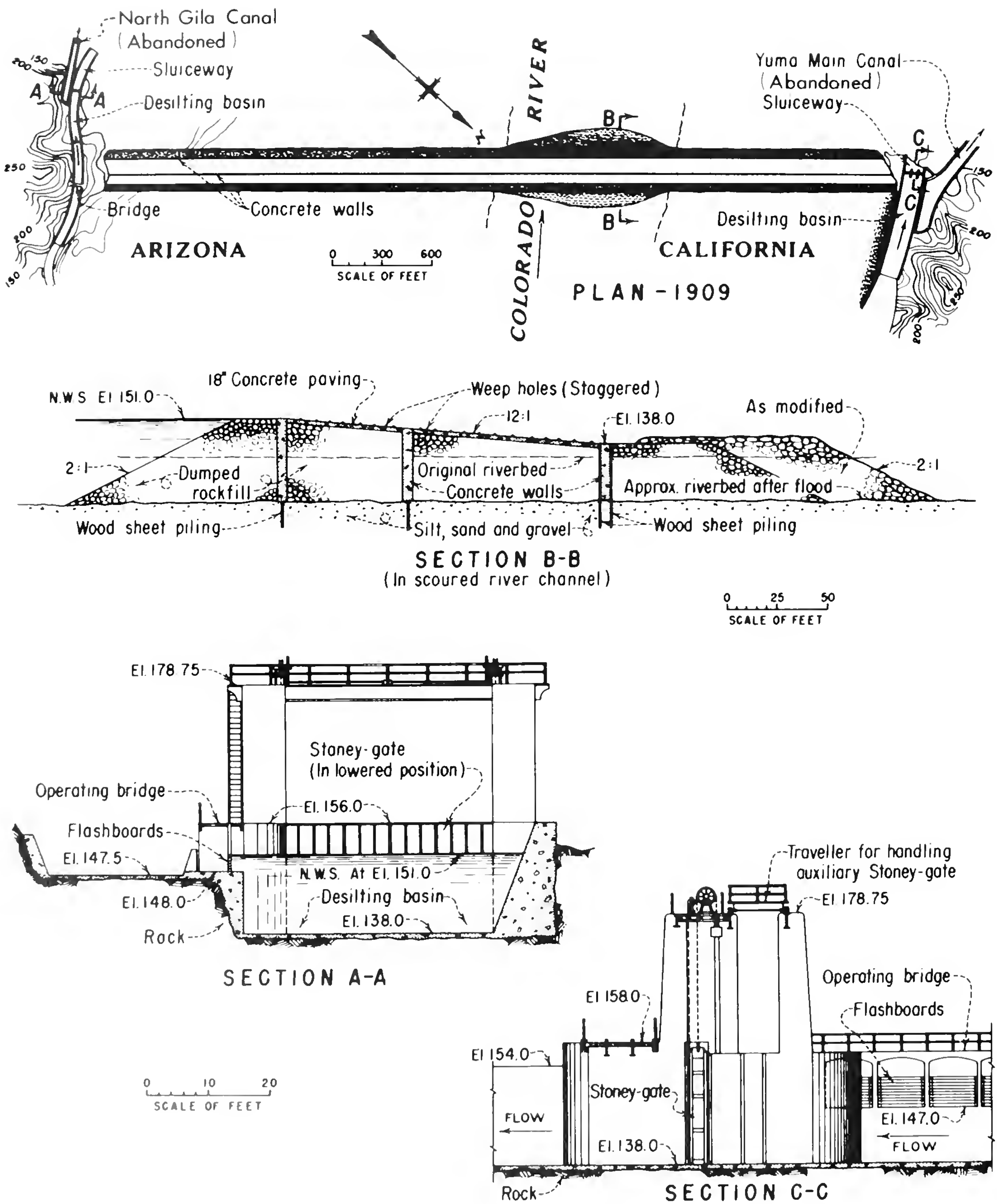
SUBSTATIONS

Number in operation	2
Total capacity of transformers	2,050 kVA

Transmission lines:[7]

Total number of lines	2
Total circuit	27 mi
Transmission capacity	34.5 kV

[7]Transferred to the Parker-Davis Project in 1952.

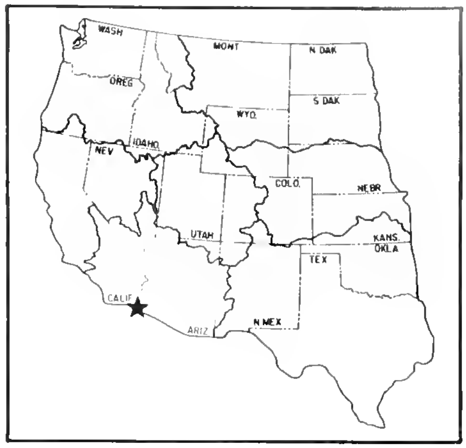


Laguna Diversion Dam

Yuma Auxiliary Project

Arizona: Yuma County

Lower Colorado Region
Water and Power Resources Service



The Yuma Auxiliary Project (also referred to as Unit "B"), located about 5 miles south of the city of Yuma, Ariz., distributes water to irrigate 3,406 acres of land on the Yuma Mesa lying between the Gila Project on the east, and the Valley Division of the Yuma Project on the west. Works constructed exclusively for the project include the Unit "B" Main Canal and the irrigation distribution system. Water for the project is diverted from the Colorado River at Imperial Dam and delivered through facilities of the Gila Project.

PLAN

The Yuma Auxiliary Project, from the time water first was available in 1922 until July 6, 1953, received its water supply through the Yuma Project's East Main Canal and the B Lift Pumping Plant. It was necessary to lift water 72 feet for irrigating lands on the mesa. The act of June 13, 1949, provided for delivery of water to the project through facilities of the Gila Project.

Distribution System

The concrete-lined Unit "B" Main Canal is 3.6 miles long and has an initial capacity of 100 cubic feet per second. This canal is connected to the A-8.9 lateral of the Gila Project's distribution system on the Mesa Unit. The Yuma Auxiliary Project's distribution system includes 5.6 miles of concrete-lined open laterals and approximately 12.5 miles of underground concrete pipe.

DEVELOPMENT

Early History

Original plans for irrigating agricultural lands in the Yuma Project included 45,000 acres on the adjacent Yuma Mesa, to be known as the Yuma Auxiliary Project, which would receive water by a pump lift of 72 feet from the East Main Canal in the Valley Division of the Yuma Project. The Secretary of the Interior on June 8, 1920, authorized construction to proceed on Unit B of the project. Legislation passed in 1949 reduced the project's boundaries to the present area of 3,305 acres.

On December 22, 1952, the Unit "B" Irrigation and Drainage District contracted with the United States for delivery of irrigation water through the Gila Project works, and all works of the project were transferred to the district for operation and maintenance on January 1, 1960.

Investigations

The first detailed investigations resulted in tentative plans for construction of four units, designated as Units A, B, C, and D, with a total acreage of 45,000. Part 1 of Unit B, containing 6,396 acres, was subdivided into 5-, 10-, and 20-acre farm units.

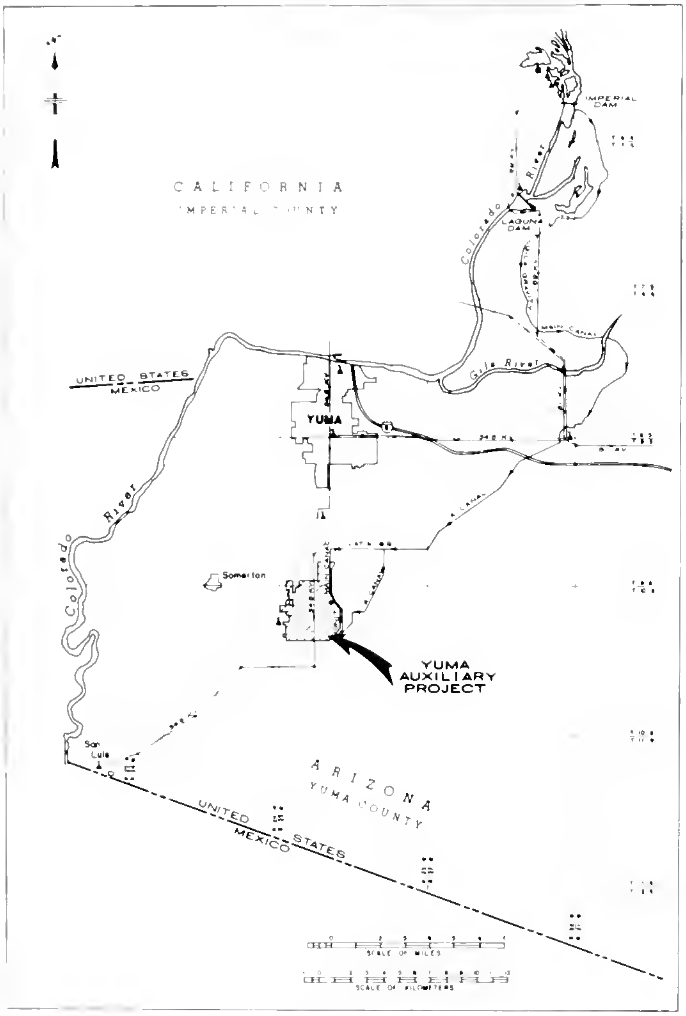
Authorization

The project was authorized by the act of January 25, 1917 (39 Stat. 868), as amended, and the joint resolution of February 21, 1925 (435 Stat. 9632). The act of June 13, 1949 (63 Stat. 172), reduced the area of the Yuma Auxiliary Project to 3,305 acres and authorized the furnishing of water to the project through the works of the Gila Project to serve 3,406 acres, which includes 101 acres of Warren Act lands.

Construction

Construction of the project commenced on September 27, 1920, with excavation of the Unit "B" Main Canal. The B Lift Pumping Plant was completed and regular operation began on May 1, 1922.

The district initiated the rehabilitation and betterment of the project works on October 1, 1962. The work consisted of concrete lining of 3.25 miles of the Unit "B" Main Canal; reconstructing, relocating, and modifiying the existing distribution system; and building two ditchrider houses, a storage yard, and an equipment shed with incorporated offices. The work was completed November 15, 1965.



Yuma Auxiliary Project

Operating Agency

Unit "B" Irrigation and Drainage District operates and maintains the water distribution facilities of the Yuma Auxiliary Project.

BENEFITS

Irrigation

The lands on this highly productive project are devoted almost entirely to the production of grapefruit, oranges, lemons, and other citrus fruits.

PROJECT DATA

Land Areas (1977)

Irrigable area:

Full irrigation service[1]	3,406	acres
Number of irrigated farms	126	

[1]Includes 101 acres of Warren Act lands adjacent to the project.

Area Irrigated and Crop Value

Year	Area irrigated, acres	Crop value, dollars
1968	3,221	2,836,625
1969	3,301	1,751,475
1970	3,196	1,416,460
1971	3,196	2,101,846
1972	3,196	2,562,287
1973	3,196	2,785,789
1974	3,196	2,704,254
1975	3,196	2,758,303
1976	3,301	1,315,140
1977	3,301	2,365,175

Facilities in Operation

Canals	3.6	mi
Laterals	18.1	mi

Climatic Conditions

Annual precipitation	3.5	in
Temperature:		
Maximum	120	°F
Minimum	22	°F
Mean	74	°F
Growing season	365	days
Elevation of irrigable area	170-190.0	ft

Settlement

Number of persons served with project water (1977):

Farm irrigation service[2]	184

[2]The Yuma Auxiliary Project is a specialized cropping area located between the Gila Project and the Yuma Project, with many small farm units without living quarters. Resident population therefore is small.

ENGINEERING DATA

Water Supply

COLORADO RIVER

Source: Water for the project is furnished through Gila Project carriage system. (See Boulder Canyon Project, All-American Canal System for streamflow data.)

Average annual diversion	32,800	acre-ft

Carriage Facilities

UNIT "B" MAIN CANAL

Location: South from end of Gila Project A-8.9 lateral, about 5 mi south of Yuma, Ariz.
Construction period: Rehabilitated and extended by Reclamation in 1955-56.

Length	3.6	mi
Diversion capacity	100	ft³/s
Typical maximum section, concrete lined:		
Bottom width	5	ft
Side slopes	1.5:1	
Water depth	4.5	ft
Lining thickness	2	in

GLOSSARY

Dam Terminology

Structural Height.—Distance between the lowest point in the excavated foundation (excluding narrow fault zones) and the top of dam.

- The structural height of an embankment (earth or rockfill) dam is the vertical distance between the top of the embankment and the lowest point in the excavated foundation area, including the main cutoff trench, if any, but excluding small trenches or narrow backfilled areas. The top elevation does not include the camber, crown, or roadway surfacing.

- The structural height of a concrete dam is the vertical distance between the top of the dam and lowest point of the excavated foundation area, excluding narrow fault zones.

Hydraulic Height.—Height to which the water rises behind the dam, and is the difference between the lowest point in the original streambed at the axis or the centerline crest of the dam and the maximum controllable water surface.

Volume of Dam.—The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. The volume includes all mass concrete appurtenances not separated from the dam by construction or contraction joints. Where a powerplant is located at the downstream toe of a concrete dam, the limit of concrete in the dam should be taken as the downstream face projected to the general excavated foundation surface.

Length of Dam.—The distance, measured along the axis or centerline crest of the dam at the top level of the main body of the dam or of the roadway surface on the crest, from abutment contact to abutment contact exclusive of an abutment spillway; provided that, if the spillway lies wholly within the dam and not in any area especially excavated for the spillway, the length includes the spillway.

Top of Dam.—The elevation of the uppermost surface of a dam, usually a road or walkway, excluding any parapet wall, railing, curb, etc.

Crest of Dam.—On embankment dams, the crest of the dam is the top of the embankment, not including camber, crown, or roadway surfacing.

Crest Length.—See *Length of Dam.*

Left or Right Designation.—The designation of left or right is made with the observer looking downstream.

Thickness or Width of Dam.—The thickness or width of a dam as measured horizontally between the upstream and downstream faces and normal to the axis or centerline crest of the dam.

Base Thickness (Base Width).—The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis or centerline crest of the dam, but excluding projections for outlets, etc. In general, the term thickness is used for gravity or arch dams, and width is used for other dams.

Top Thickness (Top Width).—The thickness or width of a dam at the level of the top of dam (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Mass Concrete.—Any large volume of concrete cast-in-place, generally as a monolithic structure. Dimensions of the structure are of such magnitude that measures must be taken to cope with the generation of heat and the resulting volume changes and cracking.

Axis of Dam (Concrete).—A vertical reference surface coincident with the upstream face at the top of the dam.

Cutoff Trench.—An excavation in the foundation of an embankment (earth or rockfill) dam, usually located upstream of the dam axis or centerline crest which extends to bedrock or to an impervious stratum. The excavation is backfilled with impervious material to reduce percolation under the dam.

Cutoff Wall.—A wall of impervious material (e.g., concrete, asphaltic concrete, timber, steel sheet piling, or impervious grout curtain) located in the foundation beneath the dam and which forms a water barrier and reduces seepage under a dam or spillway.

Top of Dead Capacity.—The lowest elevation in the reservoir from which water can be drawn by gravity.

Streambed at the Dam Axis.—The elevation of the lowest point in the streambed at the axis or centerline crest of the dam prior to construction.

Dam Types

Concrete:

Arch Dam.—A concrete or masonry dam which is curved upstream in plan so as to transmit part of the water load to the abutments.

Thin Arch.—An arch dam with a base thickness to structural height ratio of 0.2 or less (previously listed as 0.3 or less).*

Medium-thick Arch.—An arch dam with a base thickness to structural height ratio between 0.2 and 0.3 (previously listed as between 0.3 and 0.5).*

Thick Arch.—An arch dam with a base thickness to structural height ratio of 0.3 or greater (previously listed as 0.5 or greater).*

Double Curvature Arch Dam.—An arch dam which is curved in plan and elevation, with undercutting of the heel and a downstream overhang near the crest of downstream cantilever.

Buttress Dam.—A dam consisting of a watertight upstream part supported at intervals on the downstream side by a series of buttresses (walls normal to the axis of the dam).

Multiple Arch Dam.—A buttress dam, the upstream part of which comprises a series of arches.

Flat Slab or Slab and Buttress.—A buttress dam with buttresses which support the flat slab of reinforced concrete which forms the upstream face.

Massive Head Buttress.—A buttress dam in which the buttress is greatly enlarged on the upstream side to span the gap between buttresses.

Gravity Dam.—A dam constructed of concrete and/or masonry which relies on its mass for stability.

Arch-Gravity Dam.—An arch dam which is only slightly thinner than a gravity dam.

Curved Gravity Dam.—A gravity dam which is curved in plan.

Embankment:

Embankment.—Fill material, usually earth or rock, placed with sloping sides and with a length greater than its height.

Embankment Dam.—Any dam constructed of excavated natural materials.

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*The criteria in parentheses was used in the 1961 edition of Reclamation Project Data.

Earth Dam or Earthfill Dam.—An embankment type dam in which more than 50 percent of the total volume is formed of compacted fine-grained material.

Homogeneous Earthfill Dam.—An embankment type dam constructed of only one type of material.

Modified Homogeneous Earthfill Dam.—A homogeneous earthfill dam that uses pervious material specially placed in the embankment to control seepage.

Hydraulic Fill Dam.—An embankment type dam constructed of materials which are conveyed and/or placed by suspension in flowing water.

Rockfill Dam.—An embankment type dam in which more than 50 percent of the total volume comprises compacted or dumped cobbles, boulders, rock fragments, or quarried rock.

Rolled Fill Dam.—An embankment type dam of earth or rock in which the material is placed in layers and compacted by the use of rollers or rolling equipment.

Zoned Earthfill (or Zoned Embankment).—An embankment type dam composed of zones of selected materials where the permeablility of the material increases to the upstream or downstream face from the relatively impermeable core material.

Diaphragm-Type Earthfill.—An embankment type dam which is constructed mostly of pervious material and having a diaphragm of impermeable material which forms a water barrier. The diaphragm which forms the water barrier may consist of earth, portland cement concrete, bitumenous concrete, or other material, and may occupy a position within the embankment or on the upstream face.

Dike.—A low embankment, usually constructed to close up low areas of the reservoir rim and thus limit the extent of the reservoir.

Reservoir

General.—Dam design and reservoir operation use reservoir capacity and water surface elevation data. To ensure uniformity in the establishment, use, and publication of these data, the following standard definitions of water surface elevations and reservoir capacities shall be used. Reservoir capacity as used here is exclusive of bank storage capacity.

Surcharge Capacity.—The reservoir capacity provided for use in passing the inflow design flood through the reservoir. It is the reservoir capacity between the maximum water surface elevation and the highest of the following elevations (1) top of exclusive flood control capacity, (2) top of joint use capacity, or (3) top of active conservation capacity.

Total Capacity.—The reservoir capacity below the highest of the elevations representing (1) the top of exclusive flood control capacity, (2) the top of joint use capacity, or (3) the top of active conservation capacity. Total capacity is used to express the total quantity of water which can be impounded and is exclusive of surcharge capacity.

Live Capacity.—That part of the total reservoir capacity which can be withdrawn by gravity. This capacity is equal to the total capacity less the dead capacity.

Active Capacity.—The reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements. It extends from the highest of (1) the top of exclusive flood control capacity, (2) the top of joint use capacity, or (3) the top of active conservation capacity, to the top of inactive capacity. It is also the total capacity less the sum of the inactive and dead capacities.

Exclusive Flood Control Capacity.—The reservoir capacity assigned to the sole purpose of regulating flood inflows to reduce possible damage downstream. In some instances, the top of exclusive flood control capacity is above the maximum controllable water surface elevation.

Joint Use Capacity.—The reservoir capacity assigned to flood control purposes during certain periods of the year and to conservation purposes during other periods of the year.

Active Conservation Capacity.—The reservoir capacity assigned to regulate reservoir inflow for irrigation, power, municipal and industrial use, fish and wildlife, navigation, recreation, water quality, and other purposes. It does *not* include exclusive flood control or joint use capacity. It extends from the top of the active conservation capacity to the top of the inactive capacity.

Inactive Capacity.—The reservoir capacity exclusive of and above the dead storage from which the stored water is normally not available because of operating agreements or physical restrictions. Under abnormal conditions, such as a shortage of water or a requirement for structural repairs, water may be evacuated from this space.

Dead Capacity.—The reservoir capacity from which stored water cannot be evacuated by gravity.

Maximum Water Surface.—The highest acceptable water surface elevation with all factors affecting the safety of the structure considered. It is the highest water surface elevation resulting from a computed routing of the inflow design flood through the reservoir under established operating criteria. This surface elevation is also the top of the surcharge capacity.

Maximum Controllable Water Surface.—The highest reservoir water surface elevation at which gravity flows from the reservoir can be completely shut off.

Normal Water Surface.—The elevation at the top of the active conservation capacity. The maximum elevation to which the reservoir may rise under normal operating conditions exclusive of flood control storage. (The term is no longer used by the Service but is offered because of its prior usage).

Top of Exclusive Flood Control Capacity.—The reservoir water surface elevation at the top of the reservoir capacity allocated to exclusive use for regulation of flood inflows to reduce damage downstream.

Top of Joint Use Capacity.—The reservoir water surface elevation at the top of the reservoir capacity allocated to joint use, i.e., flood control and conservation purposes.

Top of Active Conservation Capacity.—The reservoir water surface elevation at the top of the capacity allocated to the storage of water for conservation puposes only.

Top of Inactive Capacity.—The reservoir water surface elevation below which the reservoir will not be evacuated under normal conditions.

Appurtenant Works

Outlet Works.—A combination of structures and equipment required for the safe operation and control of water released from the reservoir to serve various purposes, i.e., regulate stream flow and quality; release floodwater; and provide irrigation, municipal, and/or industrial water. Included in the outlet works are the intake structure, conduit, control house-gates, regulating gate or valve, gate chamber, and stilling basin.

Spillway (Service).—A structure located on or adjacent to a storage or detention dam over or through which surplus or floodwaters which cannot be contained in the allotted storage space are passed, and at diversion dams to bypass flows exceeding those which are turned into the diversion system. Included as part of the spillway would be the intake and/or control structure, discharge channel, terminal structure, and entrance and outlet channels.

Auxiliary Spillway.—A spillway, usually located in a saddle or depression in the reservoir rim which leads to a natural or excavated waterway, located away from the dam which permits the planned release of excess floodflow beyond the capacity of the service spillway. A control structure is seldom furnished. The crest is set at the maximum water surface elevation for a 100-year flood or some other specific frequency flood. The auxiliary spillway thus has only infrequent use.

Emergency Spillway.—A spillway which provides for additional safety should emergencies not contemplated by normal design assumptions be encountered, i.e., inoperable outlet works, spillway gates, or spillway structure problems. The crest is usually set at maximum water surface.

Diversion Capacity.—The flow which can be passed through the canal headworks at a dam under normal head.

Irrigation

Arable Land.—Land which when farmed in adequate size units for the prevailing climatic and economic setting and provided with the essential onfarm improvements of removing vegetation, leveling, soil reclamation, drainage, and irrigation related facilities will generate sufficient income under irrigation to pay all farm production expenses; provide a reasonable return to the farm family's labor, management, and capital; and at least pay the operation, maintenance, and replacement costs of associated irrigation and drainage facilities.

Gross Crop Value.—This value is the sum of annual receipts from sale of crops produced. Production of crops, such as pasture and hay which normally are consumed on the farm by livestock, shall be converted to cash market values and included with crop sales.

Irrigable Acreage for Service.—The acreage classified as irrigable for which works have been constructed and water is available. This figure may change from year to year, generally upward, as project works are completed and service is made available to additional acreage. Upon completion of the project, the irrigable acreage for service will equal the irrigable land as presented in the repayment contract or most recent project authorization.

Irrigable Land.—Arable land under a specific plan for which a water supply is or can be made available and which is provided with or planned to be provided with irrigation, drainage, flood protection, and other facilities as necessary for sustained irrigation. The plan to provide irrigation service to the area must be technically feasible from an engineering standpoint and meet the justification requirements of the Water Resources Council's Principles and Standards for Water and Related Land Resources planning as adopted by the Department of the Interior for Reclamation projects. The *irrigable area* comprises that portion of the arable area provided with, or to be provided with, a water supply and necessary drainage facilities under ultimate development of the project or unit under consideration.

Irrigated Acreage.—The irrigable acreage actually irrigated in any one year. It will include irrigated crop land harvested, irrigated pasture, crop land planted but not harvested, and acreage in irrigated rotation used for soil-building crops.

Power

Powerplant Capacity.—The capacity for powerplants is the nameplate rating in kW (kilowatts) and generally includes only the main generating units, except for very large plants such as Grand Coulee and Hoover where the station service units are included in the total rated capacity.

Circuit Mile.—For single circuit electric power transmission lines, circuit miles are equal to geographic miles or pole miles. For double circuit transmission lines, the number of circuit miles is twice the structure, pole, or geographic miles.

Generation.—The energy generated in kWh (kilowatt-hours) represents gross generation. It consists of the total generation minus station use.

Substation Capacity.—The substation capacities are given in kVA (kilovolt amperes). To determine the load in kilowatts, which could be served from the transformers, the kilovolt-ampere rating should be multiplied by the load power factor.

STATISTICAL SUMMARY

Summary Tabulation of Storage Dams and Dikes

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
ARBUCKLE PROJECT ARBUCKLE DAM, OKLAHOMA ROCK CREEK ZONED EARTHFILL	134254 1 (108840 0)	43 3 (142 0)	576 1 (1890 0)	2178967 5 (2850000 0)	1966	(2-3)
ARBUCKLE DIKE NO 1, OKLAHOMA OFFSTREAM ZONED EARTHFILL		7 6 (25 0)	70 4 (231 0)		1966	(2)
ARBUCKLE DIKE NO 2, OKLAHOMA OFFSTREAM ZONED EARTHFILL		4 6 (15 0)	22 9 (75 0)		1966	(2)
BAKER PROJECT MASON DAM, OREGON POWDER RIVER EARTH AND ROCK FILL	117799 3 (95500 0)	52 7 (173 0)	272 8 (895 0)	684879 3 (895794 0)	1968	
BAKER PROJECT THIEF VALLEY DAM, OREGON POWDER RIVER CONCRETE SLAB AND BUTTRESS	21709 6 (17600 0)	22 3 (73 0)	118 9 (390 0)	4816 7 (6300 0)	1932	
BELLE FOURCHE PROJECT BELLE FOURCHE DAM, SOUTH DAKOTA OWL CREEK - - - HOMOGENEOUS EARTHFILL RIP RAP ON CONCRETE SLABS, UPSTREAM FACE	236795 0 (191970 0)	37 2 (122 0)	1908 7 (6262 0)	1363345 6 (1783200 0)	1911	
BITTER ROOT PROJECT COMO DAM, MONTANA ROCK CREEK SEMI-HYDRAULIC EARTHFILL	45516 2 (36900 0)	21 3 (70 0)	777 2 (2550 0)	851708 7 (1114000 0)	1954	(20)
BOISE PROJECT ANDERSON RANCH DAM, IDAHO SOUTH FORK BOISE RIVER ZONED EARTHFILL	608115 5 (493000 0)	139 0 (456 0)	411 5 (1350 0)	7380201 2 (9653000 0)	1950	
BOISE PROJECT ARROWROCK DAM IDAHO BOISE RIVER CONCRETE THICK ARCH	353397 8 (286500 0)	106 7 (350 0)	350 5 (1150 0)	486253 8 (636000 0)	1915	
BOISE PROJECT CASCADE DAM, IDAHO PAYETTE RIVER, NORTH FORK ZONED EARTHFILL	867150 5 (703000 0)	32 6 (107 0)	239 3 (785 0)	301997 3 (395000 0)	1948	
BOISE PROJECT DEADWOOD DAM, IDAHO DEADWOOD RIVER CONCRETE THICK ARCH	199827 0 (162000 0)	50 3 (165 0)	228 3 (749 0)	43120 6 (56400 0)	1931	
BOISE PROJECT DEER FLAT LOWER DAM, IDAHO OFFSTREAM ZONED EARTHFILL	234365 0 (190000 0)	14 0 (46 0)	2194 6 (7200 0)	948042 0 (1240000 0)	1907	(21)
DEER FLAT MIDDLE DAM IDAHO OFFSTREAM ZONED EARTHFILL		4 9 (16 0)	289 6 (950 0)		1911	(21)
DEER FLAT UPPER DAM, IDAHO OFFSTREAM ZONED EARTHFILL		22 6 (74 0)	1219 2 (4000 0)	951864 8 (1245000 0)	1908	(21)
BOSTWICK PARK PROJECT SILVER JACK DAM, COLORADO CIMARRON CREEK ZONED EARTHFILL	16676 9 (13520 0)	52 7 (172 9)	320 0 (1050 0)	977201 9 (1278140 0)	1971	
BOULDER CANYON PROJECT CAHUILLA DIKE, CALIFORNIA OFFSTREAM EARTHFILL	1603 6 (1300 0)	6 7 (22 0)	1913 8 (6279 0)		1970	
BOULDER CANYON PROJECT HOOVER DAM, ARIZONA-NEVADA COLORADO RIVER CONCRETE THICK ARCH	35200389 5 (28537000 0)	221 3 (726 0)	379 2 (1244 0)	3364020 0 (4400000 0)	1936	
BURNT RIVER PROJECT UNITY DAM, OREGON BURNT RIVER ZONED EARTHFILL	31824 3 (25800 0)	25 0 (82 0)	211 5 (694 0)	194195 7 (254000 0)	1938	

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
CACHUMA PROJECT BRADBURY DAM CALIFORNIA SANTA YNEZ RIVER ZONED EARTHFILL	252867 5 (205000 0)	85 0 (279 0)	1021 1 (3350 0)	5118662 3 (6695000 0)	1953	
CACHUMA PROJECT CARPINTERIA DAM, CALIFORNIA CARPINTERIA CREEK EARTHFILL, CONCRETE LINED		9 4 (31 0)	411 5 (1350 0)	31346 6 (41000 0)	1954	
CACHUMA PROJECT GLEN ANNE DAM, CALIFORNIA WEST FORK GLEN ANNE CANYON CREEK-ZONED EARTHFILL,ASPHALTIC CNCRT UPSTREAM SLOPE	616 8 (500 0)	41 1 (135 0)	73 2 (240 0)	250772 4 (328000 0)	1953	
CACHUMA PROJECT LAURO DAM CALIFORNIA DIABLO CREEK ZONED EARTHFILL	791 9 (642 0)	41 8 (137 0)	164 6 (540 0)	358574 0 (469000 0)	1952	
CACHUMA PROJECT ORTEGA DAM CALIFORNIA OFFSTREAM EARTHFILL, CONCRETE LINED		39 9 (131 0)	131 1 (430 0)	111624 3 (146000 0)	1954	
CANADAIAN RIVER PROJECT SANFORD DAM, TEXAS CANADAIN RIVER ZONED EARTHFILL	1736237 6 (1407570 0)	69 5 (228 0)	1944 6 (6380 0)	11703731 4 (15308000 0)	1965	
CARLSBAD PROJECT AVALON DAM NEW MEXICO PECOS RIVER ZONED EARTHFILL	6142 8 (4980 0)	17 7 (58 0)	312 4 (1025 0)	154439 1 (202000 0)	1907	(5)
CARLSBAD PROJECT MCMILLAN DAM, NEW MEXICO PECOS RIVER ZONED EARTHFILL	41445 6 (33600 0)	17 4 (57 0)	630 6 (2069 0)	178904 7 (234000 0)	1908	(20)
CARLSBAD PROJECT SUMNER DAM NEW MEXICO PECOS RIVER ZONED EARTHFILL	136486 8 (110650 0)	50 0 (164 0)	940 0 (3084 0)	1720237 5 (2250000 0)	1937	
CENTRAL ARIZONA PROJECT HAVASU INTAKE CHANNEL DIKE, ARIZONA BILL WILLIAMS ARM OF LAKE HAVASU EARTHFILL		18 3 (60 0)	792 5 (2600 0)	573412 5 (750000 0)	1979	(27)
CENTRAL UTAH PROJECT CURRANT CREEK DAM UTAH CURRANT CREEK ZONED EARTHFILL EMBANKMENT	19328 9 (15670 0)	53 9 (177 0)	487 7 (1600 0)	1758465 0 (2300000 0)		(7)
CENTRAL UTAH PROJECT NORTH BOTTLE HOLLOW DAM, UTAH OFFSTREAM ZONED EARTHFILL	13695 6 (11103 0)	22 6 (74 1)	152 4 (500 0)	229771 0 (300531 0)	1970	(2-3)
SOUTH BOTTLE HOLLOW DAM UTAH OFFSTREAM ZONED EARTHFILL		26 1 (85 6)	207 3 (680 0)		1970	(2)
BOTTLE HOLLOW DIKE, UTAH OFFSTREAM ZONED EARTHFILL		2 9 (9 4)	262 1 (860 0)		1970	(2)
CENTRAL UTAH PROJECT REDFLEET DAM, UTAH BIG BRUSH CREEK ZONED EARTHFILL	32071 0 (26000 0)	44 2 (145 0)	518 2 (1700 0)	1691184 6 (2212000 0)		(7)
CENTRAL UTAH PROJECT SOLDIER CREEK DAM UTAH STRAWBERRY RIVER ZONED EARTHFILL	1364867 8 (1106500 0)	81 1 (266 0)	393 2 (1290 0)	2558948 9 (3347000 0)	1974	
CENTRAL UTAH PROJECT STARVATION DAM UTAH STRAWBERRY RIVER ZONED EARTHFILL	206376 9 (167310 0)	61 3 (201 0)	829 1 (2720 0)	3746295 0 (4900000 0)	1970	
CENTRAL UTAH PROJECT STEINAKER DAM UTAH OFFSTREAM ZONED EARTHFILL	47086 4 (38173 0)	49 4 (162 2)	602 6 (1977 0)	1446528 6 (1892000 0)	1961	
CENTRAL VALLEY PROJECT AUBURN DAM CALIFORNIA AMERICAN RIVER CONCRETE ARCH	2869121 0 (2326000 0)	208 8 (685 0)	1264 9 (4150 0)	4816665 0 (6300000 0)		(7)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
CENTRAL VALLEY PROJECT CONTRA LOMA DAM, CALIFORNIA OFFSTREAM ZONED EARTHFILL	2584 2 (2095 0)	32 6 (107 0)	320 0 (1050 0)	490076 6 (641000 0)	1967	(2-3-4)
CONTRA LOMA DIKE NO 2, CALIFORNIA OFFSTREAM EARTHFILL		7 6 (25 0)	112 8 (370 0)		1967	(2)
CONTRA LOMA DIKE NO 3, CALIFORNIA OFFSTREAM EARTHFILL		5 2 (17 0)	91 4 (300 0)		1967	(2)
CENTRAL VALLEY PROJECT DIAMOND NATIONAL DIKE, CALIFORNIA SACRAMENTO RIVER EARTHFILL		6 1 (20 0)	518 2 (1700 0)	39756 6 (52000 0)	1964	
CENTRAL VALLEY PROJECT DUTCH SLOUGH DAM, CALIFORNIA OFFSTREAM EARTHFILL		4 6 (15 0)	118 9 (390 0)		1939	(33)
CENTRAL VALLEY PROJECT FRIANT DAM, CALIFORNIA SAN JOAQUIN RIVER CONCRETE GRAVITY	642036 8 (520500 0)	97 2 (319 0)	1063 1 (3488 0)	1632314 3 (2135000 0)	1942	(5)
FRIANT DIKE, CALIFORNIA OFFSTREAM EARTHFILL		5 5 (18 0)	7 6 (25 0)		1940	
CENTRAL VALLEY PROJECT KESWICK DAM, CALIFORNIA SACRAMENTO RIVER CONCRETE GRAVITY, EMBANKMENT WINGS	29322 8 (23772 0)	47 9 (157 0)	318 8 (1046 0)	150616 4 (197000 0)	1950	(4)
CENTRAL VALLEY PROJECT LEWISTON DAM, CALIFORNIA TRINITY RIVER ZONED EARTHFILL	18083 1 (14660 0)	27 7 (91 0)	227 1 (745 0)	202605 8 (265000 0)	1963	(5)
CENTRAL VALLEY PROJECT LITTLE PANOCHE DETENTION DAM, CALIFORNIA LITTLE PANOCHE CREEK ZONED EARTHFILL	6882 9 (5580 0)	46 0 (151 0)	438 9 (1440 0)	886878 0 (1160000 0)	1966	
CENTRAL VALLEY PROJECT LOS BANOS DETENTION DAM, CALIFORNIA LOS BANOS CREEK ZONED EARTHFILL	42679 1 (34600 0)	50 9 (167 0)	417 6 (1370 0)	1613200 5 (2110000 0)	1965	
CENTRAL VALLEY PROJECT MARTINEZ DAM, CALIFORNIA OFFSTREAM MODIFIED HOMOGENEOUS EARTHFILL	330 6 (268 0)	18 9 (62.0)	365 8 (1200 0)	149087 3 (195000 0)	1947	
CENTRAL VALLEY PROJECT NIMBUS DAM, CALIFORNIA AMERICAN RIVER CONCRETE GRAVITY	10854 8 (8800 0)	26 5 (87 0)	333 1 (1093 0)	92587 0 (121100 0)	1955	(4)
CENTRAL VALLEY PROJECT O'NEILL DAM, CALIFORNIA SAN LUIS CREEK ZONED EARTHFILL	69606 4 (56430 0)	26 5 (87 0)	4358 6 (14300 0)	2201904 0 (2880000 0)	1967	(2)
O'NEILL DIKE, CALIFORNIA OFFSTREAM ZONED EARTHFILL		4 9 (16 0)	341 4 (1120 0)	23701 0 (31000 0)	1967	(2)
CENTRAL VALLEY PROJECT SAN LUIS DAM, CALIFORNIA SAN LUIS CREEK ZONED EARTHFILL	2517018 4 (2040550 0)	116 4 (382 0)	5669 3 (18600 0)	59382598 5 (77670000 0)	1967	(2)
SAN LUIS DIKE, CALIFORNIA OFFSTREAM ZONED EARTHFILL		7 0 (23 0)	70 7 (232 0)	8410 0 (11000 0)	1967	(2)
CENTRAL VALLEY PROJECT SAN LUIS FOREBAY DAM, CALIFORNIA OFFSTREAM ZONED EARTHFILL	70926 2 (57500 0)	21 3 (70 0)	4114 8 (13500 0)	2293650 0 (3000000 0)	1967	
CENTRAL VALLEY PROJECT SHASTA DAM, CALIFORNIA SACRAMENTO RIVER CONCRETE CURVED GRAVITY, EMBANKMENT WING	5615003 0 (4552090 0)	183 5 (602 0)	1054 6 (3460 0)	6445156 5 (8430000 0)	1945	
CENTRAL VALLEY PROJECT SLY PARK DAM, CALIFORNIA SLY PARK CREEK ZONED EARTHFILL	50573 5 (41000 0)	57 9 (190 0)	231 6 (760 0)	863941 5 (1130000 0)	1955	(2-3)
SLY PARK SADDLE DAM, CALIFORNIA OFFSTREAM ZONED EARTHFILL		39 6 (130 0)	192 0 (630 0)		1955	(2)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT DIVISION OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
CENTRAL VALLEY PROJECT SPRING CREEK DEBRIS DAM CALIFORNIA SPRING CREEK EARTHFILL	7245 6 (5874 0)	59 7 (196 0)	338 3 (1110 0)	1445977 4 (1891279 0)	1963	
CENTRAL VALLEY PROJECT SUGAR PINE DAM, CALIFORNIA NORTH SHIRTTAIL CANYON EARTH AND ROCKFILL	8634 5 (7000 0)	57 9 (190 0)	182 9 (600 0)	529068 6 (692000 0)		(7)
CENTRAL VALLEY PROJECT SWIFTS CORRAL DAM, CALIFORNIA SWIFTS CORRAL CREEK	6352 5 (5150 0)	20 7 (68 0)	914 4 (3000 0)	527539 5 (690000 0)		(7)
CENTRAL VALLEY PROJECT TRINITY DAM, CALIFORNIA TRINITY RIVER ZONED EARTHFILL	3019176 3 (2447650 0)	163 8 (537 5)	746 8 (2450 0)	22477770 0 (29400000 0)	1962	
CENTRAL VALLEY PROJECT WHISKEYTOWN DAM, CALIFORNIA CLEAR CREEK ZONED EARTHFILL	297391 9 (241096 0)	85 8 (281 5)	1219 2 (4000 0)	3467234 3 (4535000 0)	1963	
CHIEF JOSEPH DAM PROJECT SPECTACLE LAKE DIKE, WASHINGTON OFFSTREAM HOMOGENEOUS EARTHFILL	16528 9 (13400 0)	7 3 (24 0)	338 3 (1110 0)	32111 1 (42000 0)	1969	
COLLBRAN PROJECT ATKINSON DAM, COLORADO ATKINSON CREEK EARTHFILL	2467 0 (2000 0)	10 7 (35 0)	228 6 (750 0)		1965	(20)
COLLBRAN PROJECT BIG MEADOWS DAM, COLORADO COTTONWOOD CREEK EARTHFILL		6 1 (20 0)	135 6 (445 0)		1899	
COLLBRAN PROJECT BONHAM DAM, COLORADO BIG CREEK EARTHFILL	1504 9 (1220 0)	12 2 (40 0)	414 5 (1360 0)	11540 1 (15094 0)	1962	(20)
COLLBRAN PROJECT COTTONWOOD DAM NO 1, COLORADO COTTONWOOD CREEK EARTHFILL	3700 5 (3000 0)	5 8 (19 0)	125 0 (410 0)		1962	(20)
COLLBRAN PROJECT COTTONWOOD DAM NO 2, COLORADO COTTONWOOD CREEK EARTHFILL		6 1 (20 0)	41 1 (135 0)		1966	(20)
COLLBRAN PROJECT COTTONWOOD DAM NO 4 COLORADO COTTONWOOD CREEK EARTHFILL	1233 5 (1000 0)	3 7 (12 0)	73 2 (240 0)		1974	
COLLBRAN PROJECT DECAMP DAM, COLORADO COTTONWOOD CREEK EARTHFILL		4 6 (15 0)	243 8 (800 0)		1962	(20)
COLLBRAN PROJECT FORTY ACRE DAM COLORADO BIG CREEK EARTHFILL		4 3 (14 0)	61 0 (200 0)		1970	(20)
COLLBRAN PROJECT KITSON DAM COLORADO COTTONWOOD CREEK EARTHFILL		5 2 (17 0)	155 4 (510 0)		1974	
COLLBRAN PROJECT LAMBERT DAM, COLORADO EAST FORK BIG CREEK EARTHFILL		4 6 (15 0)	365 8 (1200 0)		1965	(20)
COLLBRAN PROJECT LITTLE MEADOWS DAM COLORADO COTTONWOOD CREEK EARTHFILL		4 3 (14 0)	44 2 (145 0)		1968	(20)
COLLBRAN PROJECT NEVERSWEAT DAM COLORADO COTTONWOOD CREEK EARTHFILL		4 9 (16 0)	48 8 (160 0)		1969	(20)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
COLLBRAN PROJECT SILVER LAKE DAM, COLORADO BIG CREEK EARTHFILL		5 8 (19 0)	70 1 (230 0)		1966	(20)
COLLBRAN PROJECT VEGA DAM, COLORADO PLATEAU CREEK ZONED, ROLLED EARTH AND ROCKFILL	41692 3 (33800 0)	49 4 (162 0)	640 1 (2100 0)	750654 3 (981825 0)	1959	
COLORADO-BIG THOMPSON PROJECT CARTER LAKE DAM NO 1, COLORADO OFFSTREAM ZONED EARTH FILL	138435 7 (112230 0)	65 2 (214 0)	376 4 (1235 0)	1947308 9 (2547000 0)	1952	(8)
CARTER LAKE DAM NO 2, COLORADO OFFSTREAM ZONED EARTHFILL		22 9 (75 0)	350 5 (1150 0)	246185 1 (322000 0)	1952	(8)
CARTER LAKE DAM NO 3, COLORADO OFFSTREAM ZONED EARTHFILL		16 8 (55 0)	434 3 (1425 0)	161971 4 (211852 0)	1952	(8)
COLORADO-BIG THOMPSON PROJECT FLATIRON DAM, COLORADO CHIMNEY HOLLOW CREEK ZONED EARTHFILL	937 0 (759 6)	26 2 (86 0)	525 8 (1725 0)	291675 8 (381500 0)	1953	
COLORADO-BIG THOMPSON PROJECT GRANBY DAM, COLORADO COLORADO RIVER ZONED EARTHFILL	665791 5 (539758 0)	90 8 (298 0)	262 4 (861 0)	2273771 7 (2974000 0)	1950	(2)
GRANBY DIKES NO 1, 2, AND 4, COLORADO OFFSTREAM ZONED EARTHFILL		29 9 (98 0)	1350 3 (4430 0)	760727 3 (995000 0)	1950	(2-11)
GRANBY DIKE NO 3, COLORADO OFFSTREAM ZONED EARTHFILL		18 3 (60 0)	607 8 (1994 0)	568825 2 (744000 0)	1950	(2)
COLORADO-BIG THOMPSON PROJECT GREEN MOUNTAIN DAM, COLORADO BLUE RIVER ZONED EARTHFILL	190754 6 (154645 0)	94 2 (309 0)	350 5 (1150 0)	3333438 0 (4360000 0)	1943	
COLORADO-BIG THOMPSON PROJECT HORSETOOTH DAM, COLORADO OFFSTREAM ZONED EARTHFILL	187492 0 (152000 0)	47 2 (155.0)	560 8 (1840 0)	1430473 1 (1871000 0)	1949	(9-10)
DIXON CANYON DAM, COLORADO OFFSTREAM ZONED EARTHFILL		73 2 (240 0)	385 6 (1265 0)	2263832 6 (2961000 0)	1949	(9)
SANTANKA DIKE, COLORADO OFFSTREAM ZONED EARTHFILL		9 1 (30 0)	106 1 (348 0)		1949	(9)
SOLDIER CANYON DAM, COLORADO OFFSTREAM ZONED EARTHFILL		68 9 (226 0)	438 3 (1438 0)	2455734 6 (3212000 0)	1949	(9)
SPRING CANYON DAM, COLORADO OFFSTREAM ZONED EARTHFILL		67 1 (220 0)	341 4 (1120 0)	1601732 3 (2095000 0)	1949	(9)
COLORADO-BIG THOMPSON PROJECT MARYS LAKE DIKE NO 1, COLORADO OFFSTREAM HOMOGENEOUS EARTHFILL	1143 5 (927 0)	8 8 (29 0)	249 9 (820 0)	68809 5 (90000 0)	1949	(12)
MARYS LAKE DIKE NO 2, COLORADO OFFSTREAM HOMOGENEOUS EARTHFILL		10 7 (35 0)	289 6 (950 0)		1949	(12)
COLORADO-BIG THOMPSON PROJECT OLYMPUS DAM, COLORADO BIG THOMPSON RIVER ZONED EARTHFILL, CONCRETE OVERFLOW SECT	3784 4 (3068 0)	21 3 (70 0)	594 7 (1951 0)	238233 8 (311600 0)	1949	
COLORADO-BIG THOMPSON PROJECT RATTLESNAKE DAM, COLORADO RATTLESNAKE CREEK ZONED EARTHFILL	2690 3 (2181 0)	39 6 (130 0)	335 3 (1100 0)	330362 1 (432100 0)	1952	
COLORADO-BIG THOMPSON PROJECT SHADOW MOUNTAIN DAM, COLORADO COLORADO RIVER ZONED EARTHFILL	22658 2 (18369 0)	19 2 (63 0)	937 9 (3077 0)	127679 9 (167000 0)	1946	(13)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION OR UNIT FEATURE STATE STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
COLORADO-BIG THOMPSON PROJECT WILLOW CREEK DAM COLORADO WILLOW CREEK ZONED EARTHFILL	12992 5 (10533 0)	38 7 (127 0)	335 3 (1100 0)	299703 6 (392000 0)	1953	
COLORADO RIVER PROJECT, TEXAS MARSHALL FORD DAM, TEXAS COLORADO RIVER CONCRETE GRAVITY/EMBANKMENT WINGS	2410180 1 (1953936 0)	84 7 (278 0)	1552 3 (5093 0)	2591060 0 (3389000 0)	1942	
COLORADO RIVER FRONT WORK-LEVEE SYSTEM SENATOR WASH DAM, CALIFORNIA SENATOR WASH ZONED EARTHFILL	17066 7 (13836 0)	28 5 (93 6)	713 B (2342 0)	1740863 5 (227697B 0)	1966	(3-4-14)
SQUAW LAKE DAM, CALIFORNIA OFFSTREAM ZONED EARTHFILL		29 0 (95 3)	1156 7 (3795 0)		1966	(14)
NORTH DIKE, CALIFORNIA OFFSTREAM ZONED EARTHFILL		20 5 (67 2)	186 8 (613 0)		1966	(14)
COLORADO RIVER STORAGE PROJECT 8LUE MESA DAM, COLORADO GUNNISON RIVER ZONEO EARTHFILL	1160353 5 (940700 0)	118 9 (390 0)	239 3 (785 0)	2354814 0 (3080000 0)	1966	
COLORADO RIVER STORAGE PROJECT CRYSTAL DAM, COLORADO GUNNISON RIVER DOU8LE CURVATURE CONCRETE THIN ARCH	31094 1 (25208 0)	98 5 (323 0)	193 5 (635 0)	112159 5 (146700 0)	1978	
COLORADO RIVER STORAGE PROJECT FLAMING GORGE DAM, UTAH GREEN RIVER CONCRETE MEDIUM THICK ARCH	4673608 2 (3788900 0)	153 0 (502 0)	359 7 (1180 0)	754610 9 (987000 0)	1964	
COLORADO RIVER STORAGE PROJECT GLEN CANYON DAM, ARIZONA COLORADO RIVER CONCRETE THICK ARCH	33304500 0 (27000000 0)	216 4 (710 0)	475 5 (1560 0)	3747059 6 (4901000 0)	1964	
COLORADO RIVER STORAGE PROJECT MORROW POINT OAM, COLORADO GUNNISON RIVER CONCRETE THIN ARCH	144523 0 (117165 0)	143 0 (469 0)	226 2 (742 0)	279198 4 (365180 0)	1968	
COLORADO RIVER STORAGE PROJECT NAVAJO DAM, NEW MEXICO SAN JUAN RIVER ZONED EARTHFILL	2107558 1 (1708600 0)	122 5 (402 0)	1111 9 (3648 0)	20521181 8 (26840863 0)	1963	
COLUMBIA BASIN PROJECT DRY FALLS DAM WASHINGTON OFFSTREAM ZONEO EARTHFULL	1572712 5 (1275000 0)	37 5 (123 0)	2987 0 (9800 0)	1267623 9 (1658000 0)	1949	(4-15)
NORTH DAM, WASHINGTTON OFFSTREAM ZONED EARTHFILL		44 2 (145 0)	442 0 (1450 0)	1126182 2 (1473000 0)	1951	(4-15)
COLUMBIA BASIN PROJECT GRAND COULEE DAM, WASHINGTON COLUM8IA RIVER CONCRETE GRAVITY	11794727 0 (9562000 0)	167 6 (550 0)	1271 9 (4173 0)	B092761 8 (10585000 0)	1942	(19)
COLUM8IA 8ASIN PROJECT NORTH SCOOTENEY DIKE WASHINGTON OFFSTREAM EARTHFILL	18810 9 (15250 0)	10 7 (35 0)	1097 3 (3600 0)	57341 3 (75000 0)	1952	(31)
SOUTH SCOOTENEY DIKE WASHINGTON OFFSTREAM EARTHFILL		2 1 (7 0)	85 3 (280 0)	1123888 5 (1470000 0)	1952	(31)
COLUMBIA BASIN PROJECT PINTO DAM, WASHINGTON OFFSTREAM ZONEO EARTHFILL	79190 7 (64200 0)	39 6 (130 0)	579 1 (1900 0)	1117772 1 (1462000 0)	1948	
COLUMBIA 8ASIN PROJECT O'SULLIVAN DAM, WASHINGTON LOWER CRAB CREEK ZONED EARTHFILL	631182 0 (511700 0)	61 0 (200 0)	5791 2 (19000 0)	6692106 2 (8753000 0)	1949	
COLUMBIA BASIN PROJECT SODA LAKE DIKE WASHINGTON OFFSTREAM ZONED EARTHFILL	12520 0 (10150 0)	18 0 (59 0)	512 1 (1680 0)	165525 1 (216500 0)	1952	
CRESCENT LAKE DAM PROJECT CRESCENT LAKE DAM OREGON CRESCENT CREEK ZONED EARTHFILL	113112 0 (91700 0)	12 2 (40 0)	137 2 (450 0)	14526 5 (19000 0)	1956	(16-20)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
CROOKED RIVER PROJECT ARTHUR R BOWMAN DAM, OREGON CROOKED RIVER ZONED EARTHFILL	190575 8 (154500 0)	74 7 (245 0)	243 8 (800 0)	1088719 2 (1424000 0)	1961	
CROOKED RIVER PROJECT OCHOCO DAM, OREGON OCHOCO CREEK ZONED EARTHFILL	59208 0 (48000 0)	38 1 (125 0)	411 5 (1350 0)	573412 5 (750000 0)	1950	(20)
DESCHUTES PROJECT CRANE PRAIRIE DAM, OREGON DESCHUTES RIVER ZONED EARTHFILL	68212 6 (55300 0)	11 0 (36 0)	86 9 (285 0)	22936 5 (30000 0)	1940	
DESCHUTES PROJECT HAYSTACK DAM OREGON OFFSTREAM ZONED EARTHFILL	6969 3 (5650 0)	32 0 (105 0)	365 8 (1200 0)	409034 3 (535000 0)	1957	
DESCHUTES PROJECT WICKIUP DAM, OREGON DESCHUTES RIVER ZONED EARTHFILL	246700 0 (200000 0)	30 5 (100 0)	4224 5 (13860 0)	1415946 6 (1852000 0)	1940	(2-3)
WICKIUP DIKE, OREGON OFFSTREAM ZONED EARTHFILL			1042 4 (3420 0)		1940	(2)
EDEN PROJECT BIG SANDY DAM, WYOMING BIG SANDY CREEK ZONED EARTHFILL	48970 0 (39700 0)	25 9 (85 0)	716 3 (2350 0)	642222 0 (840000 0)	1952	(2)
BIG SANDY DIKE, WYOMING OFFSTREAM ZONED EARTHFILL		5 5 (18 0)	2529 8 (8300 0)	81806 9 (107000 0)	1952	(2)
EDEN PROJECT EDEN DAM, WYOMING OFFSTREAM EARTHFILL	9868 0 (8000 0)	7 6 (25 0)	1066 8 (3500 0)	70338 6 (92000 0)	1910	
EMERY COUNTY PROJECT HUNTINGTON NORTH DAM, UTAH OFFSTREAM ZONED EARTHFILL	6685 6 (5420 0)	22 6 (74 0)	883 0 (2897 0)	739475 8 (967204 0)	1946	(22)
EAST DIKE, UTAH OFFSTREAM ZONED EARTHFILL		9 4 (31 0)	361 2 (1185 0)		1966	(22)
WEST DIKE, UTAH OFFSTREAM ZONED EARTHFILL		7 3 (24 0)	584 9 (1919 0)		1966	(22)
EMERY COUNTY PROJECT JOES VALLEY DAM, UTAH SEELY CREEK ZONED EARTHFILL	77044 4 (62460 0)	58 5 (192 0)	228 6 (750 0)	986269 5 (1290000 0)	1966	
FLORIDA PROJECT LEMON DAM, COLORADO FLORIDA RIVER ZONED EARTHFILL	49520 1 (40146 0)	86 6 (284 0)	414 5 (1360 0)	2325761 1 (3042000 0)	1963	
FRUITGROWERS DAM PROJECT FRUITGROWERS DAM, COLORADO ALFALFA RUN HOMOGENEOUS EARTHFILL	5600 1 (4540 0)	16 8 (55 0)	463 3 (1520 0)	103978 8 (136000 0)	1938	
FRYINGPAN-ARKANSAS PROJECT PUEBLO DAM, COLORADO ARKANSAS RIVER ZONED EARTHFILL EMBANKMENT	441195 8 (357678 0)	64 9 (213 0)	2584 7 (8480 0)	9556875 0 (12500000 0)	1975	
CONCRETE MASSIVE HEAD BUTTRESS OVERFLOW SPILLWAY SECTION		76 2 (250 0)	533 4 (1750 0)	382275 0 (500000 0)		
FRYINGPAN-ARKANSAS PROJECT RUEDI DAM, COLORADO FRYINGPAN RIVER EARTHFILL	126273 4 (102370 0)	98 1 (321 7)	317 6 (1042 0)	2863384 2 (3745189 0)	1968	
FRYINGPAN-ARKANSAS PROJECT SUGAR LOAF DAM, COLORADO LAKE FORK OF ARKANSAS RIVER EARTHFILL	159664 2 (129440 0)	49 6 (162 8)	615 7 (2020 0)	1401967 6 (1833716 0)	1968	(2-3)
SUGAR LOAF DIKE, COLORADO OFFSTREAM EARTHFILL		3 7 (12 0)	137 2 (450 0)		1968	(2)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION OR UNIT FEATURE STATE STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
HUMBOLDT PROJECT RYE PATCH DAM NEVADA HUMBOLDT RIVER HOMOGENEOUS EARTHFILL	234365 0 (190000 0)	22 9 (75 0)	278 6 (914 0)	272179 8 (356000 0)	1976	(16-20)
HUNGRY HORSE PROJECT HUNGRY HORSE DAM, MONTANA SOUTH FORK FLATHEAD RIVER CONCRETE THICK ARCH	4277778 0 (3468000 0)	171 9 (564 0)	644 7 (2115 0)	2359554 2 (3086200 0)	1953	
HUNTLEY PROJECT ANITA DAM, MONTANA OFFSTREAM MODIFIED HOMOGENEOUS EARTHFILL	493 4 (400 0)	12 8 (42 0)	320 0 (1050 0)	109330 7 (143000 0)	1937	
HYRUM PROJECT HYRUM DAM, UTAH LITTLE BEAR RIVER HOMOGENEOUS EARTHFILL	23189 8 (18800 0)	35 4 (116 0)	164 6 (540 0)	328756 5 (430000 0)	1935	(5)
HYRUM DIKE, UTAH OFFSTREAM EARTHFILL		4 6 (15 0)	274 3 (900 0)		1935	
KENDRICK PROJECT ALCOVA DAM, WYOMING NORTH PLATTE RIVER ZONED EARTHFILL	227327 9 (184295 0)	80 8 (265 0)	232 6 (763 0)	1250039 3 (1635000 0)	1938	(5)
KENDRICK PROJECT SEMINOE DAM, WYOMING NORTH PLATTE RIVER CONCRETE MEDIUM THICK ARCH	1254813 6 (1017279 0)	89 9 (295 0)	161 5 (530 0)	160555 5 (210000 0)	1939	
KLAMATH PROJECT CLEAR LAKE DAM, CALIFORNIA LOST RIVER EARTH AND ROCK FILL	649783 1 (526780 0)	12 8 (42 0)	256 0 (840 0)	48472 5 (63400 0)	1910	(2-3)
CLEAR LAKE DIKE, CALIFORNIA OFFSTREAM EARTHFILL		4 3 (14 0)	509 0 (1670 0)		1910	(2)
KLAMATH PROJECT GERBER DAM, OREGON MILLER CREEK CONCRETE MEDIUM THICK ARCH	116319 1 (94300 0)	25 8 (84 5)	147 8 (485 0)	9098 1 (11900 0)	1925	(16)
LITTLE WOOD RIVER LITTLE WOOD RIVER DAM, IDAHO LITTLE WOOD RIVER ZONED EARTHFILL	37005 0 (30000 0)	39 3 (129 0)	944 9 (3100 0)	733203 5 (959000 0)	1960	(20)
LYMAN PROJECT MEEKS CABIN DAM, WYOMING BLACKS FORK EARTH AND ROCK FILL	40051 7 (32470 0)	56 2 (184 5)	963 8 (3162 0)	2742817 0 (3587492 0)	1971	
LYMAN PROJECT STATELINE DAM WYOMING EAST FORK OF SMITH'S FORK EARTHFILL	17269 0 (14000 0)	39 0 (128 0)	883 9 (2900 0)	707208 8 (925000 0)		(7)
MANCOS PROJECT JACKSON GULCH DAM, COLORADO OFFSTREAM ZONED EARTHFILL	12310 3 (9980 0)	54 9 (180 0)	579 1 (1900 0)	1307380 5 (1710000 0)	1949	
MANN CREEK PROJECT MANN CREEK DAM IDAHO MANN CREEK EARTHFILL	16035 5 (13000 0)	45 1 (148 0)	358 4 (1176 0)	857510 1 (1121588 0)	1967	
MIDDLE RIO GRANDE PROJECT EL VADO DAM NEW MEXICO RIO CHAMA RIVER RANDOM FILL EARTH, STEEL FACED	241766 0 (196000 0)	53 3 (175 0)	404 2 (1326 0)	464846 4 (608000 0)	1955	(20)
MILK RIVER PROJECT FRESNO DAM MONTANA MILK RIVER HOMOGENEOUS EARTHFILL	159198 0 (129062 0)	33 5 (110 0)	630 9 (2070 0)	1609377 8 (2105000 0)	1939	
MILK RIVER PROJECT LAKE SHERBURNE DAM MONTANA SWIFTCURRENT CREEK HOMOGENEOUS EARTHFILL	83389 5 (67604 0)	28 7 (94 0)	331 0 (1086 0)	174317 4 (228000 0)	1921	
MILK RIVER PROJECT NELSON DIKES(5) MONTANA OFFSTREAM HOMOGENEOUS EARTHFILL	97720 3 (79222 0)	8 2 (27 0)	3017 5 (9900 0)	178140 2 (233000 0)	1915	(11)
MINIDOKA PROJECT GRASSY LAKE DAM WYOMING GRASSY CREEK ZONED EARTHFILL	19119 3 (15500 0)	36 0 (118 0)	356 6 (1170 0)	412092 5 (539000 0)	1939	

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
MINIDOKA PROJECT ISLAND PARK DAM, IDAHO HENRYS FORK RIVER ZONED EARTHFILL	157888 0 (128000 0)	27 5 (90 3)	2879 8 (9448 0)	431206 2 (564000 0)	1938	
MINIDOKA PROJECT JACKSON LAKE DAM, WYOMING SNAKE RIVER CONCRETE GRAVITY, EMBANKMENT WINGS	1044774 5 (847000 0)	20 0 (65 5)	1500 0 (4920 0)	375929 2 (491700 0)	1911	(16)
MINIDOKA PROJECT MINIDOKA DAM, IDAHO SNAKE RIVER - ZONED EARTHFILL, CONCRETE GRAVITY SPILLWAY AND GATE SECTION	259035 0 (210000 0)	26 2 (86 0)	1364 0 (4475 0)	196718 7 (257300 0)	1909	(5)
MIRAGE FLATS PROJECT BOX BUTTE DAM, NEBRASKA NIOBRARA RIVER ZONED EARTHFILL	38312 5 (31060 0)	26 5 (87 0)	1678 8 (5508 0)	1087190 1 (1422000 0)	1946	
MOON LAKE PROJECT MIDVIEW DAM, UTAH OFFSTREAM ZONED EARTHFILL	7135 8 (5785.0)	16 5 (54 0)	202 1 (663 0)	106272 5 (139000 0)	1937	(2-16)
MIDVIEW DIKE, UTAH OFFSTREAM ZONED EARTHFILL		6 4 (21 0)	784 9 (2575 0)	65751 3 (86000 0)	1937	(2)
MOON LAKE PROJECT MOON LAKE DAM, UTAH WEST FORK OF LAKE FORK, DUCHESNE RIV ZONED EARTHFILL	61058 3 (49500 0)	30 8 (101 0)	337 7 (1108 0)	392214 2 (513000 0)	1938	
MOUNTAIN PARK PROJECT MOUNTAIN PARK DAM, OKLAHOMA OTTER CREEK CONCRETE THIN ARCH	145337 1 (117825 0)	34 4 (113 0)	163 1 (535 0)	13570 8 (17750 0)	1975	
EAST DIKE OKLAHOMA OFFSTREAM ROLLED EARTHFILL		10 4 (34 0)	3240 0 (10630 0)	339383 7 (443900 0)	1975	
WEST DIKE, OKLAHOMA OFFSTREAM ROLLED EARTHFILL		7 6 (25 0)	4032 5 (13230 0)	260405 7 (340600 0)	1975	
NAVAJO INDIAN IRRIGATION PROJECT CUTTER DAM, NEW MEXICO OFFSTREAM ZONED EARTHFILL	2220 3 (1800 0)	48 2 (158 0)	289 6 (950 0)	552005 1 (722000 0)	1972	(4-17)
NEWLANDS PROJECT LAHONTAN DAM, NEVADA CARSON RIVER ZONED EARTHFILL	391364 9 (317280 0)	49 4 (162 0)	1645 9 (5400 0)	560 4 (733 0)	1915	
NEWLANDS PROJECT LAKE TAHOE DAM, CALIFORNIA TRUCKEE RIVER CONCRETE SLAB AND BUTTRESS	902922 0 (732000 0)	5 5 (18 2)	33 2 (109 0)		1913	(5-16-23)
NEWTON PROJECT NEWTON DAM, UTAH CLARKSTON CREEK ZONED EARTHFILL	6932 3 (5620 0)	30 8 (101 0)	1018 0 (3340 0)	313465 5 (410000 0)	1946	
NORMAN PROJECT NORMAN DAM, OKLAHOMA HOG CREEK AND LITTLE RIVER ZONED EARTHFILL	242012 7 (196200 0)	43 9 (144 0)	2213 8 (7263 0)	2378820 9 (3111400 0)	1965	
NORTH PLATTE PROJECT GUERNSEY DAM, WYOMING NORTH PLATTE RIVER DIAPHRAGM-TYPE EARTHFILL	55788 7 (45228 0)	41 1 (135 0)	170 7 (560 0)	448026 3 (586000 0)	1927	
NORTH PLATTE PROJECT LOWER LAKE ALICE DAM, NEBRASKA OFFSTREAM HOMOGENEOUS EARTHFILL	135870 0 (110150 0)	7 3 (24 0)	777 2 (2550 0)	90981 4 (119000 0)	1912	(24)
UPPER LAKE ALICE DAM, NEBRASKA OFFSTREAM HOMOGENEOUS EARTHFILL		11 3 (37 0)	944 9 (3100 0)	184256 6 (241000 0)	1913	(24)
NORTH PLATTE PROJECT MINATARE DAM, NEBRASKA OFFSTREAM ZONED EARTHFILL, CONCRETE FACED	76711 4 (62190 0)	34 7 (114 0)	1146 0 (3760 0)	532126 8 (696000 0)	1915	
NORTH PLATTE PROJECT PATHFINDER DAM, WYOMING NORTH PLATTE RIVER MASONRY ARCH	1253097 8 (1015888 0)	65 2 (214 0)	131 7 (432 0)	50460 3 (66000 0)	1909	(2)
PATHFINDER DIKE, WYOMING NORTH PLATTE RIVER HOMOGENEOUS EARTHFILL		11 6 (38 0)	502 9 (1650 0)	116211 6 (152000 0)	1909	(2)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT DIVISION OR UNIT FEATURE STATE STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
NUECES RIVER PROJECT CHOKE CANYON DAM TEXAS FRIO RIVER ZONED EARTHFILL	880719 0 (714000 0)	35 1 (115 0)	5647 0 (18527 0)	4659932 3 (6095000 0)		(7)
OGDEN RIVER PROJECT PINEVIEW DAM, UTAH OGDEN RIVER ZONED EARTHFILL	135685 0 (110000 0)	41 8 (137 0)	182 9 (600 0)	319581 9 (418000 0)	1937	
OKANOGAN PROJECT CONCONULLY DAM WASHINGTON SALMON CREEK HYDRAULIC EARTHFILL	16035 5 (13000 0)	21 9 (72 0)	327 7 (1075 0)	275238 0 (360000 0)	1969	(20)
OKANOGAN PROJECT SALMON LAKE DAM WASHINGTON OFFSTREAM ZONED EARTHFILL	19366 0 (15700 0)	16 5 (54 0)	381 0 (1250 0)	149087 3 (195000 0)	1921	(16)
ORLAND PROJECT EAST PARK DAM, CALIFORNIA LITTLE STONY CREEK CONCRETE THICK ARCH	62785 2 (50900 0)	42 1 (138 0)	81 1 (266 0)	12037 8 (15745 0)	1910	(2)
COLEMAN DIKE, CALIFORNIA OFFSTREAM EARTHFILL		4 9 (16 0)	42 4 (139 0)		1910	(2)
GORDON DIKE, CALIFORNIA OFFSTREAM EARTHFILL		3 7 (12 0)	69 2 (227 0)		1910	(2)
ORLAND PROJECT STONY GORGE DAM CALIFORNIA STONY CREEK CONCRETE SLAB AND BUTTRESS	62143 7 (50380 0)	42 4 (139 0)	264 6 (868 0)	32952 1 (43100 0)	1928	(16)
OWYHEE PROJECT OWYHEE DAM, OREGON OWYHEE RIVER CONCRETE THICK ARCH	1381520 0 (1120000 0)	127 1 (417 0)	253 9 (833 0)	410945 6 (537500 0)	1932	(5)
PALISADES PROJECT PALISADES DAM, IDAHO SOUTH FORK SNAKE RIVER ZONED EARTHFILL	1728133 5 (1401000 0)	82 3 (270 0)	640 1 (2100 0)	10375708 1 (13571000 0)	1957	
PALMETTO BEND PROJECT PALMETTO BEND DAM, TEXAS NAVIDID AND LAVACA RIVERS EARTHFILL	209695 0 (170000 0)	19 8 (65 0)	12713 8 (41712 0)	4281480 0 (5600000 0)		(7)
PAONIA PROJECT PAONIA DAM COLORADO MUDDY CREEK ZONED EARTHFILL	25841 8 (20950 0)	60 7 (199 0)	234 7 (770 0)	995444 1 (1302000 0)	1962	
PARKER-DAVIS PROJECT DAVIS DAM, ARIZONA-NEVADA COLORADO RIVER ZONED EARTHFILL AND CONCRETE SPILLWAY	2242873 1 (1818300 0)	61 0 (200 0)	487 7 (1600 0)	2784491 1 (3642000 0)	1950	
PARKER-DAVIS PROJECT PARKER DAM ARIZONA-CALIFORNIA COLORADO RIVER CONCRETE THICK ARCH	764029 9 (619400 0)	97 5 (320 0)	260 9 (856 0)	290529 0 (380000 0)	1938	(5)
PICK-SLOAN MISSOURI BASIN PROGRAM BIGHORN BASIN DIVISION-OWL CREEK UNIT ANCHOR DAM, WYOMING SOUTH FORK OWL CREEK CONCRETE MEDIUM THICK ARCH	21406 2 (17354 0)	63 4 (208 0)	194 2 (637 0)	50460 3 (66000 0)	1960	
PICK-SLOAN MISSOURI BASIN PROGRAM BOSTWICK DIVISION-COUTLAND UNIT LOVEWELL DAM, KANSAS WHITE ROCK CREEK ZONED EARTHFILL	113667 0 (92150 0)	28 3 (93 0)	2590 8 (8500 0)	2293650 0 (3000000 0)	1957	
PICK-SLOAN MISSOURI BASIN PROGRAM BOYSEN DIVISION-BOYSEN UNIT BOYSEN DAM, WYOMING WIND RIVER ZONED EARTHFILL	1174824 9 (952432 0)	67 1 (220 0)	348 4 (1143 0)	1167467 9 (1527000 0)	1952	
PICK-SLOAN MISSOURI BASIN PROGRAM CHEYENNE DIV -ANGOSTURA UNIT ANGOSTURA DAM, SOUTH DAKOTA CHEYENNE RIVER CONCRETE GRAVITY, EMBANKMENT WING	171161 7 (138761 0)	58 8 (193 0)	618 7 (2030 0)	648827 7 (848640 0)	1949	
PICK-SLOAN MISSOURI BASIN PROGRAM CHEYENNE DIVISION-KEYHOLE UNIT KEYHOLE DAM, WYOMING BELLE FOURCHE RIVER ZONED EARTHFILL	419460 3 (340057 0)	51 2 (168 0)	1042 4 (3420 0)	1020674 3 (1335000 0)	1952	
PICK-SLOAN MISSOURI BASIN PROGRAM CHEYENNE DIVISION-RAPID VALLEY UNIT PACTOLA DAM, SOUTH DAKOTA RAPID CREEK ZONED EARTHFILL	122116 5 (99000 0)	70 1 (230 0)	382 5 (1255 0)	3230223 8 (4225000 0)	1956	

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM FRENCHMAN-CAMBRIDGE DIV - CAMBRIDGE UNIT MEDICINE CREEK DAM, NEBRASKA MEDICINE CREEK ZONED EARTHFILL	110167 6 (89313 0)	50 3 (165 0)	1726 7 (5665 0)	2087221 5 (2730000 0)	1949	
PICK-SLOAN MISSOURI BASIN PROGRAM FRENCHMAN-CAMBRIDGE DIV - FRENCHMAN UNIT ENDERS DAM, NEBRASKA FRENCHMAN CREEK HOMOGENEOUS EARTHFILL	91895 7 (74500 0)	40 8 (134 0)	793 4 (2603 0)	1490872 5 (1950000 0)	1951	
PICK-SLOAN MISSOURI BASIN PROGRAM FRENCHMAN-CAMBRIDGE DIV - MEEKER-DRIFTWOOD UNIT TRENTON DAM, NEBRASKA REPUBLICAN RIVER ZONED EARTHFILL	313247 3 (253950 0)	43 9 (144 0)	2621 3 (8600 0)	6215791 5 (8130000 0)	1953	
PICK-SLOAN MISSOURI BASIN PROGRAM FRENCHMAN-CAMBRIDGE DIV - RED WILLOW UNIT RED WILLOW DAM, NEBRASKA RED WILLOW CREEK ZONED EARTHFILL	106854 4 (86627 0)	38 4 (126 0)	962 9 (3159 0)	2269949 0 (2969000 0)	1962	
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIV - GARRISON DIVERSION UNIT JAMESTOWN DAM, NORTH DAKOTA JAMES RIVER ZONED EARTHFILL	272576 4 (220978 0)	33 5 (110 0)	432 2 (1418 0)	736261 7 (963000 0)	1954	
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIV - GARRISON DIVERSION UNIT WINTERING DAM NORTH DAKOTA OFFSTREAM EARTHFILL		12 2 (40 0)	1578 9 (5180 0)	570354 3 (746000 0)	1976	(17)
PICK-SLOAN MISSOURI BASIN PROGRAM GRAND DIVISION-SHADEHILL UNIT SHADEHILL DAM SOUTH DAKOTA GRAND RIVER MODIFIED HOMOGENEOUS EARTHFILL	440359 5 (357000 0)	44 2 (145 0)	3914 5 (12843 0)	2675925 0 (3500000 0)	1951	(2-3)
SHADEHILL DIKE NO 1, SOUTH DAKOTA OFFSTREAM EARTHFILL		25 3 (83 0)	334 1 (1096 0)		1951	(2)
SHADEHILL DIKE NO 2, SOUTH DAKOTA OFFSTREAM EARTHFILL		5 5 (18 0)	80 5 (264 0)		1951	(2)
PICK-SLOAN MISSOURI BASIN PROGRAM HEART DIVISION - DICKINSON UNIT DICKINSON DAM, NORTH DAKOTA HEART RIVER HOMOGENEOUS EARTHFILL	8234 8 (6676 0)	18 9 (62 0)	693 4 (2275 0)	247714 2 (324000 0)	1950	
PICK-SLOAN MISSOURI BASIN PROGRAM HEART DIVISION - HEART BUTTE UNIT HEART BUTTE DAM, NORTH DAKOTA HEART RIVER HOMOGENEOUS EARTHFILL	275867 3 (223646 0)	43 3 (142 0)	563 9 (1850 0)	871587 0 (1140000 0)	1949	(2-3)
HEART BUTTE DIKE, NORTH DAKOTA OFFSTREAM HOMOGENEOUS EARTHFILL		3 7 (12 0)	879 0 (2884 0)		1949	(2)
PICK-SLOAN MISSOURI BASIN PROGRAM HELENA GREAT FALLS DIV - CANYON FERRY CANYON FERRY DAM, MONTANA MISSOURI RIVER CONCRETE GRAVITY	2529785 2 (2050900 0)	68 6 (225 0)	304 8 (1000 0)	316523 7 (414000 0)	1954	
PICK-SLOAN MISSOURI BASIN PROGRAM HELENA-GREAT FALLS DIV - HELENA VALLEY UNIT HELENA VALLEY DAM, MONTANA OFFSTREAM ZONED EARTHFILL	12891 3 (10451 0)	27 7 (91 0)	807 7 (2650 0)	232423 2 (304000 0)	1958	
PICK-SLOAN MISSOURI BASIN PROGRAM KANASKA DIVISION - ALMENA UNIT NORTON DAM, KANSAS PRAIRIE DOG CREEK ZONED EARTHFILL	166199 3 (134738 0)	39 8 (130 5)	1966 0 (6450 0)	2859417 0 (3740000 0)	1964	
PICK-SLOAN MISSOURI BASIN PROGRAM LOWER BIG HORN DIVISION YELLOWTAIL UNIT YELLOWTAIL DAM, MONTANA BIGHORN RIVER CONCRETE MEDIUM THICK ARCH	1696062 5 (1375000 0)	160 0 (525 0)	451 1 (1480 0)	1181737 4 (1545664 0)	1966	
PICK-SLOAN MISSOURI BASIN PROGRAM LOWER BIG HORN DIVISION YELLOWTAIL AFTERBAY DAM, MONTANA BIGHORN RIVER CONCRETE GRAVITY, EEBANKMENT WINES	3885 5 (3150 0)	21 9 (72 0)	414 5 (1V60 0)	140677 2 (184000 0)	1966	(4)
PICK-SLOAN MISSOURI BASIN PROGRAM MARIAS DIVISION - LOWER MARIAS UNIT TIBER DAM- MONTANA MARIAS RIVER ZONED EARTHFILL	1649189 5 (1337000 0)	+62 8 (206 0)	1379 5 (4526 0)	8780856 7 (11485000 0)	1956	(2-3)
TIBER DIKE, MONTANA MARIAS RIVER EARTH		17 2 (56 3)	5074 9 (16650 0)		1956	(2)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION OR UNIT FEATURE, STATE STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM MIDDLE LOUP DIV -FARWELL UNIT SHERMAN DAM NEBRASKA OAK CREEK HOMOGENEOUS EARTHFILL	85210 2 (69080 0)	40 8 (134 0)	1356 4 (4450 0)	1446528 6 (1892000 0)	1962	
PICK-SLOAN MISSOURI BASIN PROGRAM OREGON TRAILS DIVISION - GLENDO UNIT GLENDO DAM, WYOMING NORTH PLATTE RIVER ZONED EARTHFILL	973727 4 (789402 0)	57 9 (190 0)	638 9 (2096 0)	2045935 8 (2676000 0)	1958	(2)
GLENDO DIKE NO 1, WYOMING OFFSTREAM EARTHFILL		10 7 (35 0)	304 8 (1000 0)	185785 7 (243000 0)	1958	(2-6)
GLENDO DIKE NO 2 OFFSTREAM EARTHFILL		15 2 (50 0)	18 0 (59 0)		1958	(2-6)
GLENDO DIKE NO 4, WYOMING OFFSTREAM EARTHFILL		22 9 (75 0)	259 1 (850 0)		1958	(2-6)
PICK-SLOAN MISSOURI BASIN PROGRAM OREGON TRAILS DIV - GLENDO UNIT GRAY REEF DAM, WYOMING NORTH PLATTE RIVER ZONED EARTHFILL	2225 2 (1804 0)	11 0 (36 0)	198 1 (650 0)	30582 0 (40000 0)	1961	(4)
PICK-SLOAN MISSOURI BASIN PROGRAM OREGON TRAILS DIV - KORTES UNIT KORTES DAM WYOMING NORTH PLATTE RIVER CONCRETE GRAVITY	5877 6 (4765 0)	74 4 (244 0)	134 1 (440 0)	112388 9 (147000 0)	1951	
PICK-SLOAN MISSOURI BASIN PROGRAM SANDHILLS DIVISION-AINSWORTH UNIT MERRITT DAM, NEBRASKA SNAKE RIVER ZONED EARTHFILL	91878 5 (74486 0)	38 4 (126 0)	982 1 (3222 0)	1183523 4 (1548000 0)	1964	
PICK-SLOAN MISSOURI BASIN PROGRAM SMOKY HILLS DIVISION - CEDAR BLUFF UNIT CEDAR BLUFF DAM, KANSAS SMOKY HILL RIVER ZONED EARTHFILL	464967 8 (376950 0)	61 6 (202 0)	3828 3 (12560 0)	6491029 5 (8490000 0)	1951	(2)
CAWKER CITY PROTECTIVE DIKE, KANSAS OFFSTREAM ZONED EARTHFILL		14 6 (48 0)	4559 8 (14960 0)	1501576 2 (1964000 0)	1969	(2)
DOWNS PROTECTIVE DIKE,KANSAS OFFSTREAM ZONED EARTHFILL		27 4 (90 0)	6035 0 (19800 0)	1827274 5 (2390000 0)	1963	(2)
PICK-SLOAN MISSOURI BASIN PROGRAM SOLOMON DIV - GLEN ELDER UNIT GLEN ELDER DAM, KANSAS SOLOMON RIVER ZONED EARTHFILL	1188816 5 (963775 0)	43 3 (142 0)	4655 8 (15275 0)	7665194 8 (10025760 0)	1969	(2-3)
GLEN ELDER DIKE KANSAS OFFSTREAM ZONED EARTHFILL		3 0 (10 0)	556 3 (1825 0)		1969	(2)
PICK-SLOAN MISSOURI BASIN PROGRAM SOLOMON DIVISION - KIRWIN UNIT KIRWIN DAM KANSAS NORTH FORK SOLOMON RIVER ZONED EARTHFILL	387997 4 (314550 0)	51 5 (169 0)	3854 5 (12646 0)	7291513 4 (9537000 0)	1955	
PICK-SLOAN MISSOURI BASIN PROGRAM SOLOMON DIVISION - WEBSTER UNIT WEBSTER DAM, KANSAS SOUTH FORK SOLOMON RIVER ZONED EARTHFILL	321943 5 (261000 0)	46 9 (154 0)	3267 5 (10720 0)	6227259 8 (8145000 0)	1956	
PICK-SLOAN MISSOURI BASIN PROGRAM THREE FORKS DIVISION - EAST BENCH UNIT CLARK CANYON DAM MONTANA BEAVERHEAD RIVER ZONED EARTHFILL	317197 0 (257152 0)	45 0 (147 5)	899 2 (2950 0)	1506163 5 (1970000 0)	1964	
PICK-SLOAN MISSOURI BASIN PROGRAM UPPER REPUBLICAN DIVISION - ARMEL UNIT BONNY DAM, COLORADO SOUTH FORK REPUBLICAN RIVER MODIFIED HOMOGENEOUS EARTHFILL	209892 4 (170160 0)	48 2 (158 0)	2804 2 (9200 0)	6768561 2 (8853000 0)	1951	
PICK-SLOAN MISSOURI BASIN PROGRAM WIND DIVISION - RIVERTON UNIT BULL LAKE DAM, WYOMING BULL LAKE CREEK MODIFIED HOMOGENEOUS EARTHFILL	188058 2 (152459 0)	24 4 (80 0)	1053 4 (3456 0)	626931 0 (820000 0)	1938	(16)
PICK-SLOAN MISSOURI BASIN PROGRAM WIND DIVISION - RIVERTON UNIT LAKE CAMEAHWAIT DIKE WYOMING OFFSTREAM HOMOGENEOUS EARTHFILL	13568 5 (11000 0)	3 4 (11 0)	140 2 (460 0)			
PICK-SLOAN MISSOURI BASIN PROGRAM WIND DIVISION - RIVERTON UNIT PILOT BUTTE DAM NO 1, WYOMING OFFSTREAM ZONED EARTHFILL	45639 5 (37000 0)	12 8 (42 0)	396 2 (1300 0)	152145 5 (199000 0)	1926	(3-25)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM WIND DIVISION - RIVERTON UNIT (CONT) PILOT BUTTE DAM NO 2, WYOMING OFFSTREAM ZONED EARTHFILL		7 6 (25 0)	365 8 (1200 0)		1926	(25)
PILOT BUTTE DAM NO 3, WYOMING OFFSTREAM ZONED EARTHFILL		2 7 (9 0)	1036 3 (3400 0)		1926	(25)
PINE RIVER PROJECT VALLECITO DAM, COLORADO LOS PINOS RIVER ZONED EARTHFILL	159985 0 (129700 0)	49 4 (162 0)	1222 2 (4010 0)	2857887 9 (3738000 0)	1941	
PROVO RIVER PROJECT DEER CREEK DAM, UTAH PROVO RIVER ZONED EARTHFILL	188195 1 (152570 0)	71 6 (235 0)	397 5 (1304 0)	2148385 5 (2810000 0)	1941	
RAPID VALLEY PROJECT DEERFIELD DAM, SOUTH DAKOTA CASTLE CREEK ZONED EARTHFILL	19388 2 (15718 0)	40 5 (133 0)	251 5 (825 0)	464081 9 (607000 0)	1946	
RIO GRANDE PROJECT CABALLO DAM, NEW MEXICO RIO GRANDE RIVER ZONED EARTHFILL	424324 0 (344000 0)	33 5 (110 0)	1389 3 (4558 0)	951100 2 (1244000 0)	1938	(5)
RIO GRANDE PROJECT ELEPHANT BUTTE DAM, NEW MEXICO RIO GRANDE RIVER CONCRETE GRAVITY	2601973 3 (2109423 0)	91 7 (301 0)	354 2 (1162 0)	481284 2 (629500 0)	1916	(2)
ELEPHANT BUTTE DIKE, NEW MEXICO RIO GRANDE RIVER EARTH AND ROCK FILL, CONCRETE FACED		15 2 (50 0)	609 6 (2000 0)	1368544 5 (1790000 0)	1916	(2)
RIO GRANDE PROJECT LUCERO DETENTION DIKE, NEW MEXICO LUCERO ARROYO EARTHFILL	585 9 (475 0)	5 8 (19 0)	1476 8 (4845 0)	77984 1 (102000 0)	1951	
RIO GRANDE PROJECT PERCHA ARROYO DIKE, NEW MEXICO PERCHA ARROYO EARTHFILL, ROCK FACED		8 8 (29 0)	758 6 (2489 0)	147558 2 (193000 0)	1939	
RIO GRANDE PROJECT PICACHO NORTH DAM, NEW MEXICO NORTH BRANCH PICACHO ARROYO EARTHFILL		12 8 (42 0)	490 7 (1610 0)	113690 9 (148703 0)	1954	
RIO GRANDE PROJECT PICACHO SOUTH DAM, NEW MEXICO SOUTH BRANCH PICACHO ARROYO EARTHFILL		8 8 (29 0)	490.7 (1624 0)	66454 7 (86920 0)	1954	
ROGUE RIVER BASIN PROJECT AGATE DAM, OREGON DRY CREEK ZONED EARTHFILL	5896 1 (4780 0)	26 2 (86 0)	1158 2 (3800 0)	321875 6 (421000 0)	1966	
ROGUE RIVER BASIN PROJECT EMIGRANT DAM, OREGON EMIGRANT CREEK ZONED EARTHFILL	49956 8 (40500 0)	62 2 (204 0)	228 6 (750 0)	1194991 7 (1563000 0)	1960	(2-3-20)
COAXIAL CABLE DIKE, OREGON OFFSTREAM ZONED EARTH AND ROCKFILL		5 8 (19 0)	204 2 (670 0)		1960	(2)
HIGHWAY SADDLE DIKE, OREGON OFFSTREAM ZONED EARTH AND ROCKFILL		21 3 (70 0)	390 1 (1280 0)		1960	(2)
SPILLWAY DIKE, OREGON OFFSTREAM ZONED EARTH-ROCKFILL, CONCRETE SPILLWAY		3 4 (11 0)	115 8 (380 0)		1960	(2)
ROGUE RIVER BASIN PROJECT FISH LAKE DAM, OREGON FISH LAKE OUTLET EARTH AND ROCKFILL	9744 7 (7900 0)	14 9 (49 0)	292 6 (960 0)	97862.4 (128000 0)	1956	(20)
ROGUE RIVER BASIN PROJECT FOURMILE LAKE DAM, OREGON FOURMILE LAKE OUTLET ROCKFILL W/ CONCRETE FACING	19242 6 (15600 0)	7 6 (25 0)	201 2 (660.0)	1529 1 (2000 0)	1956	(20)
ROGUE RIVER BASIN PROJECT HOWARD PRAIRIE DAM, OREGON BEAVER CREEK ZONED EARTHFILL	76600 4 (62100 0)	30 5 (100 0)	317 0 (1040 0)	318052 8 (416000 0)	1958	
ROGUE RIVER BASIN PROJECT HYATT PRAIRIE DAM, OREGON KEENE CREEK EARTH AND ROCKFILL	19982 7 (16200 0)	16 2 (53 0)	236 2 (775 0)	55812 2 (73000 0)	1961	(20)

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION OR UNIT FEATURE, STATE STREAM TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
ROGUE RIVER BASIN PROJECT KEENE CREEK DAM OREGON KEENE CREEK ZONED EARTHFILL	419 4 (340 0)	23 8 (78 0)	170 1 (558 0)	130738 1 (171000 0)	1959	(4)
SALT RIVER PROJECT BARTLETT DAM, ARIZONA VERDE RIVER CONCRETE MULTIPLE ARCH	220167 4 (178490 0)	87 5 (287 0)	243 8 (800 0)	139148 1 (182000 0)	1939	
SALT RIVER PROJECT HORSE MESA DAM ARIZONA SALT RIVER CONCRETE THIN ARCH	302377 7 (245138 0)	94 5 (310 0)	201 2 (660 0)	123857 1 (162000 0)	1927	(20)
SALT RIVER PROJECT MORMON FLAT DAM ARIZONA SALT RIVER CONCRETE THIN ARCH	71360 4 (57852 0)	69 8 (229 0)	115 8 (380 0)	45796 5 (59900 0)	1938	(20)
SALT RIVER PROJECT STEWART MOUNTAIN DAM ARIZONA SALT RIVER CONCRETE THIN ARCH	86055 1 (69765 0)	63 1 (207 0)	384 0 (1260 0)	92128 3 (120500 0)	1936	(20)
SALT RIVER PROJECT THEODORE ROOSEVELT DAM ARIZONA SALT RIVER CYCLOPEAN MASONRY THICK ARCH	1704178 9 (1381580 0)	86 6 (284 0)	220 4 (723 0)	272026 9 (355800 0)	1911	
SAN ANGELO PROJECT TWIN BUTTES DAM, TEXAS MIDDLE AND SOUTH CONCHO RIVERS SPRING CREEK - ZONED EARTHFILL	790155 4 (640580 0)	40 8 (134 0)	12941 8 (42460 0)	16393481 1 (21442000 0)	1963	
SAN JUAN CHAMA PROJECT HERON DAM, NEW MEXICO WILLOW CREEK EARTH AND ROCK FILL	495028 2 (401320 0)	83 8 (275 0)	371 9 (1220 0)	2317443 6 (3031121 0)	1971	(2-3)
HERON DIKE NEW MEXICO OFFSTREAM EARTH AND ROCKFILL		28 7 (94 0)	733 0 (2405 0)		1971	(2)
SAN JUAN CHAMA PROJECT NAMBE FALLS DAM, NEW MEXICO RIO NAMBE RIVER CONCRETE THIN ARCH	2467 0 (2000 0)	45 7 (150 0)	97 5 (320 0)	24 5 (32 0)	1976	
ZONED EARTHFILL EMBANKMENTS		33 2 (109 0)	205 1 (673 0)	152298 4 (199200 0)		
SAN LUIS VALLEY PROJECT PLATORO DAM COLORADO CONEJOS RIVER ZONED EARTHFILL	73479 6 (59570 0)	50 3 (165 0)	449 6 (1475 0)	695740 5 (910000 0)	1951	
SANTA MARIA PROJECT TWITCHELL DAM CALIFORNIA CUYAMA RIVER ZONED EARTHFILL	296179 4 (240113 0)	73 5 (241 0)	549 9 (1804 0)	4459620 2 (5833000 0)	1958	
SCOFIELD PROJECT SCOFIELD DAM, UTAH PRICE RIVER ZONED EARTHFILL	90785 6 (73600 0)	38 1 (125 0)	175 3 (575 0)	155968 2 (204000 0)	1946	
SEEDSKADEE PROJECT FONTENELLE DAM WYOMING GREEN RIVER ZONED EARTHFILL	426001 6 (345360 0)	42 4 (139 1)	1652 3 (5421 0)	4025076 7 (5264635 0)	1964	
SHOSHONE PROJECT BUFFALO BILL DAM WYOMING SHOSHONE RIVER CONCRETE THICK ARCH	522971 9 (423974 0)	99 1 (325 0)	61 0 (200 0)	63381 2 (82900 0)	1910	
SHOSHONE PROJECT DEAVER DAM WYOMING OFFSTREAM HOMOGENEOUS EARTHFILL	840 0 (681 0)	4 6 (15 0)	396 2 (1300 0)	22936 5 (30000 0)	1918	
SILT PROJECT RIFLE GAP DAM COLORADO RIFLE CREEK ZONED EARTHFILL	16778 1 (13602 0)	47 9 (157 0)	442 0 (1450 0)	1351724 4 (1768000 0)	1967	
SMITH FORK PROJECT CRAWFORD DAM COLORADO IRON CREEK ZONED EARTHFILL	17750 1 (14390 0)	49 4 (162 0)	176 8 (580 0)	764550 0 (1000000 0)	1962	
SOLANO PROJECT MONTICELLO DAM CALIFORNIA PUTAH CREEK CONCRETE MEDIUM THICK ARCH	1976409 9 (1602278 0)	92 7 (304 0)	311 8 (1023 0)	249243 3 (326000 0)	1957	

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
SOLANO PROJECT TERMINAL DAM, CALIFORNIA OFFSTREAM COMPACTED EARTHFILL	146.8 (119.0)	7.3 (24.0)	265.2 (870.0)	44343.9 (58000.0)	1959	
SOUTH DIKE, CALIFORNIA OFFSTREAM COMPACTED EARTHFILL		7.3 (24.0)	152.4 (500.0)		1959	
STRAWBERRY VALLEY PROJECT STRAWBERRY DAM, UTAH STRAWBERRY RIVER HOMOGENEOUS EARTHFILL	349080.5 (283000.0)	21.9 (72.0)	149.4 (490.0)	90216.9 (118000.0)	1913	(26)
INDIAN CREEK DIKE, UTAH STRAWBERRY RIVER HOMOGENEOUS EARTHFILL		11.3 (37.0)	399.6 (1311.0)	87158.7 (114000.0)	1913	(26)
SUN RIVER PROJECT GIBSON DAM NORTH FORK SUN RIVER CONCRETE THICK ARCH	122189.3 (99059.0)	60.7 (199.0)	292.6 (960.0)	128062.1 (167500.0)	1929	
SUN RIVER PROJECT PISHKUN DIKES (8), MONTANA OFFSTREAM ZONED EARTHFILL	57567.4 (46670.0)	15.2 (50.0)	2758.4 (9050.0)	458.0 (599.0)	1931	(11)
SUN RIVER PROJECT WILLOW CREEK DAM, MONTANA WILLOW CREEK MODIFIED HOMOGENEOUS EARTHFILL	39842.1 (32300.0)	28.3 (93.0)	198.1 (650.0)	279825.3 (366000.0)	1911	(2-3)
WILLOW CREEK DIKE NO. 2, MONTANA OFFSTREAM EARTHFILL		1.5 (5.0)	18.3 (60.0)		1941	(2)
WILLOW CREEK DIKE NO. 3, MONTANA OFFSTREAM EARTHFILL		1.2 (4.0)	18.3 (60.0)		1941	(2)
WILLOW CREEK DIKE NO. 4, MONTANA OFFSTREAM EARTHFILL		1.8 (6.0)	30.5 (100.0)		1941	(2)
WILLOW CREEK DIKE, NO. 5, MONTANA OFFSTREAM EARTHFILL		7.6 (25.0)	347.5 (1140.0)		1941	(2)
TRUCKEE STORAGE PROJECT BOCA DAM, CALIFORNIA LITTLE TRUCKEE RIVER ZONED EARTHFILL	50709.2 (41110.0)	35.4 (116.0)	496.5 (1629.0)	697269.6 (912000.0)	1939	
TUALATIN PROJECT SCOGGINS DAM, OREGON SCOGGINS CREEK - ZONED EARTHFILL AND SANDSTONE FRAGMENT FILL	73899.0 (59910.0)	46.0 (151.0)	823.0 (2700.0)	3058200.0 (4000000.0)	1975	
UMATILLA PROJECT COLD SPRINGS DAM, OREGON OFFSTREAM ZONED EARTHFILL	55098.0 (44668.0)	35.1 (115.0)	1051.6 (3450.0)	606288.2 (793000.0)	1908	(16)
UMATILLA PROJECT MCKAY DAM, OREGON MCKAY CREEK - HOMOGENEOUS EARTHFILL CONCRETE FACED	91032.3 (73800.0)	50.3 (165.0)	823.0 (2700.0)	1807396.2 (2364000.0)	1927	(16)
UNCOMPAHGRE PROJECT TAYLOR PARK DAM, COLORADO TAYLOR RIVER ZONED EARTHFILL	130997.7 (106200.0)	62.8 (206.0)	205.7 (675.0)	852473.3 (1115000.0)	1937	(16)
VALE PROJECT AGENCY VALLEY DAM, OREGON NORTH FORK MALHEUR RIVER ZONED EARTHFILL	73886.7 (59900.0)	33.5 (110.0)	563.9 (1850.0)	493899.3 (646000.0)	1935	
VALE PROJECT BULLY CREEK DAM, OREGON BULLY CREEK ZONED EARTHFILL	38978.6 (31600.0)	36.9 (121.0)	935.7 (3070.0)	777707.9 (1017210.0)	1963	
VENTURA RIVER PROJECT CASITAS DAM, CALIFORNIA COYOTE CREEK ZONED EARTHFILL	313311.5 (254002.0)	101.8 (334.0)	609.6 (2000.0)	6987987.0 (9140000.0)	1959	(2)
CASITAS SADDLE DIKE OFFSTREAM EARTH AND ROCK FILL		13.1 (43.0)	498.3 (1635.0)	129973.5 (170000.0)	1959	(2)

Summary Tabulation of Storage Dams and Dikes - Continued

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VERMEJO PROJECT DAM NO 2 NEW MEXICO OFFSTREAM HOMOGENEOUS EARTHFILL	2541 0 (2060 0)	3 7 (12 0)	3270 5 (10730 0)	157497 3 (206000 0)	1954	
VERMEJO PROJECT DAM NO 13 NEW MEXICO OFFSTREAM HOMOGENEOUS EARTHFILL	5896 1 (4780 0)	9 8 (32 0)	2439 3 (8003 0)	189608 4 (248000 0)	1954	
VERMEJO PROJECT STUBLEFIELD DAM NEW MEXICO OFFSTREAM MODIFIED HOMOGENEOUS EARTHFILL	19935 8 (16162 0)	14 3 (47 0)	3084 3 (10119 0)	632282 9 (827000 0)	1954	(2-3)
STUBBLEFIELD DIKE, NEW MEXICO OFFSTREAM EARTHFILL		2 7 (9 0)	1663 0 (5456 0)		1954	(2)
W C AUSTIN PROJECT ALTUS DAM, OKLAHOMA NORTH FORK RED RIVER MASONRY FACED CONCRETE GRAVITY	190144 0 (154150 0)	33 5 (110 0)	338 9 (1112 0)	53671 4 (70200 0)	1945	(2-5)
EAST DIKE OKLAHOMA OFFSTREAM EARTHFILL		10 4 (34 0)	3113 5 (10215 0)		1945	(2)
LUGERT DIKE, OKLAHOMA OFFSTREAM EARTHFILL		18 0 (59 0)	1283 2 (4210 0)		1945	(2)
NORTH DIKE OKLAHOMA OFFSTREAM EARTHFILL		14 3 (47 0)	283 5 (930 0)		1945	(2)
SOUTH DIKE OKLAHOMA OFFSTREAM EARTHFILL		11 9 (39 0)	99 1 (325 0)		1945	(2)
WAPINITIA PROJECT WASCO DAM, OREGON CLEAR CREEK ZONED EARTHFILL	16158 9 (13100 0)	18 0 (59 0)	126 5 (415 0)	43028 9 (56280 0)	1959	
WASHITA BASIN PROJECT FORT COBB DAM, OKLAHOMA POND (COBB) CREEK HOMOGENEOUS EARTHFILL	177303 3 (143740 0)	37 2 (122 0)	3017 5 (9900 0)	2691216 0 (3520000 0)	1959	
WASHITA BASIN PROJECT FOSS DAM OKLAHOMA WASHITA RIVER ZONED EARTHFILL	539039 5 (437000 0)	43 3 (142 0)	5526 0 (18130 0)	8056063 4 (10537000 0)	1961	
WASHOE PROJECT PROSSER CREEK DAM, CALIFORNIA PROSSER CREEK ZONED EARTHFILL	36807 6 (29840 0)	49 7 (163 0)	557 8 (1830 0)	1378876 6 (1803514 0)	1963	
WASHOE PROJECT STAMPEDE DAM CALIFORNIA LITTLE TRUCKEE RIVER ZONED EARTHFILL	279387 8 (226500 0)	72 8 (239 0)	460 6 (1511 0)	34534723 5 (45170000 0)	1970	(2)
STAMPEDE DIKE CALIFORNIA OFFSTREAM ZONED EARTHFILL		25 9 (85 0)	441 7 (1449 0)	296645 4 (388000 0)	1970	(2)
WEBER BASIN PROJECT ARTHUR V WATKINS DAM UTAH OFFSTREAM ZONED EARTHFILL	265325 9 (215100 0)	11 0 (36 0)	23367 5 (76665 0)	13043223 0 (17060000 0)	1964	
WEBER BASIN PROJECT CAUSEY DAM UTAH SOUTH FORK OGDEN RIVER ZONED EARTHFILL	9707 6 (7870 0)	66 3 (217 5)	257 6 (845 0)	1078015 5 (1410000 0)	1966	
WEBER BASIN PROJECT EAST CANYON DAM UTAH EAST CANYON CREEK CONCRETE THIN ARCH	63155 2 (51200 0)	79 2 (259 8)	132 9 (436 0)	27306 7 (35716 0)	1966	
WEBER BASIN PROJECT LOST CREEK DAM UTAH LOST CREEK ZONED EARTHFILL	27766 1 (22510 0)	75 6 (248 0)	328 6 (1078 0)	1400518 0 (1831820 0)	1966	
WEBER BASIN PROJECT WANSHIP DAM UTAH WEBER RIVER ZONED EARTHFILL	76625 0 (62120 0)	53 3 (175 0)	614 2 (2015 0)	2433562 7 (3183000 0)	1957	

Summary Tabulation of Storage Dams and Dikes - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM, TYPE OF STRUCTURE	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	STRUCTURAL HEIGHT METERS (FEET)	CREST LENGTH METERS (FEET)	VOLUME CUBIC METERS (CUBIC YARDS)	CALENDAR YEAR COMPLETED	FOOTNOTES
WEBER RIVER PROJECT ECHO DAM, UTAH WEBER RIVER ZONED EARTHFILL	91205 0 (73940 0)	48 2 (158 0)	575 2 (1887 0)	1177407 0 (1540000 0)	1931	(16)
WICHITA PROJECT CHENEY DAM, KANSAS NORTH FORK NINNESCAH RIVER ROLLED EARTHFILL	305821 7 (247930 0)	38 5 (126 2)	7454 8 (24458 0)	5612561 6 (7341000 0)	1965	
YAKIMA PROJECT BUMPING LAKE DAM, WASHINGTON BUMPING RIVER EARTHFILL, PUDDLED CORE DIAPHRAGM	415689 5 (337000 0)	18 6 (61 0)	891 5 (2925 0)	193431 2 (253000 0)	1910	(16)
YAKIMA PROJECT CLEAR CREEK DAM, WASHINGTON NORTH FORK TIETON RIVER CONCRETE THIN ARCH	6537 6 (5300 0)	25 3 (83 0)	123 1 (404 0)	4434 4 (5800 0)	1964	(20)
YAKIMA PROJECT CLE ELUM DAM, WASHINGTON CLE ELUM RIVER ZONED EARTHFILL	87578 5 (71000 0)	50 3 (165 0)	548 9 (1801 0)	1078780 1 (1411000 0)	1933	(16)
YAKIMA PROJECT KACHESS DAM, WASHINGTON KACHESS RIVER ZONED EARTHFILL	294806 5 (239000 0)	35 1 (115 0)	426 7 (1400 0)	152910 0 (200000 0)	1936	(16)
YAKIMA PROJECT KEECHSLUS DAM, WASHINGTON YAKIMA RIVER ZONED EARTHFILL	194893 0 (158000 0)	39 0 (128 0)	1996 4 (6550 0)	522952 2 (684000 0)	1917	(16)
YAKIMA PROJECT TIETON DAM, WASHINGTON TIETON RIVER - EARTH, CONCRETE CORE WALL DIAPHRAGM	244233 0 (198000 0)	97 2 (319 0)	280 4 (920 0)	1566563 0 (2049000 0)	1925	(18)

DEFINITIONS

TOTAL CAPACITY	TOTAL RESERVOIR STORAGE TO HIGHEST CONTROLLED WATER SURFACE ELEVATION EXCEPT WHERE INDICATED BY FOOTNOTE (16)
STRUCTURAL HEIGHT	DISTANCE BETWEEN LOWEST POINT OF FOUNDATION EXCAVATION AND CREST OF DAM
CREST LENGTH	EXTENT OF BARRIER IN DAM AN INTEGRAL FEATURES CONSTRUCTED BETWEEN NATURAL ABUTMENTS
VOLUME	SPACE OCCUPIED BY ALL MATERIAL IN DAM AND ITS APPURTENANT FEATURES
YEAR COMPLETED	DATE ORIGINAL CONSTRUCTION COMPLETED, EXCEPT AS INDICATED BY FOOTNOTE (20)

CONVERSION TO ENGLISH SYSTEM

CUBIC METERS TIMES 0 00081071 EQUALS ACRE-FEET
METERS TIMES 3 28084 EQUALS FEET
CUBIC METERS TIMES 1 30796 EQUALS CUBIC YARDS

FOOTNOTES

(1) THE SERVICE HAS RESPONSIBILITY FOR THE REVIEW AND MAINTENANCE OF FIVE DAMS BY SPECIAL AGREEMENT
(2) DAM AND DIKE(S) FORM ONE RESERVOIR
(3) VOLUME OF DAM AND DIKES
(4) REREGULATING RESERVOIR
(5) STORAGE AND DIVERSION STRUCTURE
(6) VOLUME OF ALL DIKES
(7) UNDER CONSTRUCTION
(8) CARTER LAKE DAMS NO 1, 2, AND 3, FORM ONE RESERVOIR
(9) DIXON CANYON, HORSETOOTH, SOLDIER CANYON, AND SPRING CANYON DAMS PLUS SATANKA DIKE FORM ONE RESERVOIR
(10) VOLUME INCLUDES HORSETOOTH DAM AND SATANKA DIKE
(11) MAXIMUM STRUCTURAL HEIGHT OF THE LARGEST DIKE
(12) MARYS LAKE DIKES NO 1 AND 2 FORM ONE RESERVOIR VOLUME OF BOTH DIKES INCLUDED WITH DIKE NO 1
(13) TOTAL CAPACITY INCLUDES SHADOW MOUNTAIN RESERVOIR AND GRAND LAKE
(14) SENATOR WASH DAM, SQUAW LAKE AND NORTH DIKES, FORM ONE RESERVOIR
(15) DRY FALLS AND NORTH DAMS FORM ONE RESERVOIR
(16) CAPACITY IS ACTIVE STORAGE - DEAD STORAGE NOT EVALUATED
(17) NOT YET IN OPERATION
(18) HEIGHT IS FROM CORE WALL FOUNDATION
(19) CREST LENGTH INCLUDES THE FOREBAY DAM (COMPLETED 1978) THE FOREBAY CHANNEL IS PART OF FRANKLIN D ROOSEVELT LAKE
(20) YEAR COMPLETED INDICATES WATER AND POWER RESOURCES SERVICE REHABILITATION WORK
(21) LOWER, MIDDLE, AND UPPER DEER FLAT DAMS FORM ONE RESERVOIR
(22) HUNTINGTON NORTH DAM, EAST AND WEST DIKES FORM ONE RESERVOIR
(24) LOWER AND UPPER LAKE ALICE DAMS FORM ONE RESERVOIR
(25) PILOT BUTTE DAMS NO 1, 2, AND 3 FORM ONE RESERVOIR
(26) STRAWBERRY DAM AND INDIAN CREEK DIKE FORM ONE RESERVOIR
(27) HAVASU INTAKE CHANNEL WILL SERVE AS THE INTAKE CHANNEL TO HAVASU PUMPING PLANT
(28) CREST LENGTH AND VOLUME ARE FOR ENLARGEMENT ONLY
(29) CREST LENGTH INCLUDES DAM AND SPILLWAY
(31) NORTH SCOOTNEY AND SOUTH SCOOTNEY DIKES FORM ONE RESERVOIR
(32) EMBANKMENT CONTAINS AUDUBON LAKE FROM WHICH WATER IS DIVERTED TO THE GARRISON UNIT
(33) CONTRA COSTA CANAL CONTROL STRUCTURE

Summary Tabulation of Storage Reservoirs

PROJECT DIVISION OR UNIT RESERVOIR NAME STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
ARBUCKLE PROJECT LAKE OF THE ARBUCKLES (ARBUCKLE) OKLAHOMA ROCK CREEK	FC M&I-F&W	122128 8 (99010 0)	134254 1 (108840 0)	1265 5 (3127 0)	1966	
BAKER PROJECT PHILLIPS LAKE (MASON) OREGON POWDER RIVER	I-FC-F&W	111631 8 (90500 0)	117799 3 (95500 0)	904 5 (2235 0)	1968	
BAKER PROJECT THIEF VALLEY RESERVOIR OREGON POWDER RIVER	I	21462 9 (17400 0)	21709 6 (17600 0)	299 5 (740 0)	1932	
BELLE FOURCHE PROJECT BELLE FOURCHE RESERVOIR SOUTH DAKOTA OWL CREEK	I	228407 2 (185170 0)	236795 0 (191970 0)	3253 7 (8040 0)	1911	
BITTER ROOT PROJECT LAKE COMO MONTANA ROCK CREEK	I	43295 9 (35100 0)	45516 2 (36900 0)	396 6 (980 0)	1954	(6)
BOISE PROJECT ANDERSON RANCH RESERVOIR IDAHO SOUTH FORK BOISE RIVER	I-P-FC	521770 5 (423000 0)	608115 5 (493000 0)	1918 2 (4740 0)	1950	
BOISE PROJECT ARROWROCK RESERVOIR IDAHO BOISE RIVER	I-FC	353397 8 (286500 0)	353397 8 (286500 0)	1254 5 (3100 0)	1915	
BOISE PROJECT CASCADE RESERVOIR IDAHO NORTH FORK PAYETTE RIVER	I-P-FC	805475 5 (653000 0)	867150 5 (703000 0)	11452 7 (28300 0)	1948	
BOISE PROJECT DEADWOOD RESERVOIR IDAHO DEADWOOD RIVER	I-P-FC	199827 0 (162000 0)	199827 0 (162000 0)	1214 1 (3000 0)	1931	
BOISE PROJECT LAKE LOWELL (UPPER LOWER AND MIDDLE DEER FLAT) IDAHO OFFSTREAM	I-FC	208461 5 (169000 0)	234365 0 (190000 0)	3982 1 (9840 0)	1908	
BOSTWICK PARK PROJECT SILVER JACK RESERVOIR COLORADO CIMARRON CREEK	I-F&W	15813 5 (12820 0)	16676 9 (13520 0)	118 6 (293 0)	1971	
BOULDER CANYON PROJECT LAKE CAHUILLA CALIFORNIA OFFSTREAM	I	1233 5 (1000 0)	1233 5 (1000 0)	40 5 (100 0)	1970	
BOULDER CANYON PROJECT LAKE MEAD (HOOVER) ARIZONA-NEVADA COLORADO RIVER	I-P-FC- RR-N-M&I	21404925 5 (17353000 0)	35200389 5 (28537000 0)	65843 1 (162700 0)	1936	
BURNT RIVER PROJECT UNITY RESERVOIR OREGON BURNT RIVER	I	31084 2 (25200 0)	31824 3 (25800 0)	374 7 (926 0)	1938	
CACHUMA PROJECT CARPINTERIA RESERVOIR CALIFORNIA OFFSTREAM	I M&I				1954	
CACHUMA PROJECT GLEN ANNE RESERVOIR CALIFORNIA WEST FORK GLEN ANNE CANYON CREEK	I-M&I	579 7 (470 0)	616 8 (500 0)	6 5 (16 0)	1953	
CACHUMA PROJECT LAKE CACHUMA (BRADBURY) CALIFORNIA SANTA YNEZ RIVER	I M&I	212778 8 (172500 0)	252867 5 (205000 0)	1250 5 (3090 0)	1953	
CACHUMA PROJECT LAURO RESERVOIR CALIFORNIA DIABLO CREEK	I-M&I	767 2 (622 0)	791 9 (642 0)	8 9 (22 0)	1952	
CACHUMA PROJECT ORTEGA RESERVOIR CALIFORNIA OFFSTREAM	I-M&I				1954	
CANADIAN RIVER PROJECT LAKE MEREDITH (SANFORD) TEXAS CANADIAN RIVER	FC M&I-F&W	1638495 1 (1328330 0)	1736237 6 (1407570 0)	6677 4 (16500 0)	1965	
CARLSBAD PROJECT AVALON RESERVOIR NEW MEXICO PECOS RIVER	I	6142 8 (4980 0)	6142 8 (4980 0)	388 5 (960 0)	1907	
CARLSBAD PROJECT LAKE McMILLAN NEW MEXICO PECOS RIVER	I	34291 3 (27800 0)	41445 6 (33600 0)	2047 7 (5060 0)	1908	(6)
CARLSBAD PROJECT LAKE SUMNER NEW MEXICO PECOS RIVER	I FC	134007 4 (108640 0)	136486 8 (110650 0)	1845 4 (4560 0)	1937	
CENTRAL UTAH PROJECT BOTTLE HOLLOW RESERVOIR UTAH OFFSTREAM	F&W	13693 1 (11101 0)	13695 6 (11103 0)	169 2 (418 0)	1970	
CENTRAL UTAH PROJECT CURRANT CREEK RESERVOIR UTAH CURRANT CREEK	I-F&W P M&I	1381 5 (1120 0)	19328 9 (15670 0)	115 7 (286 0)		(3)

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION, OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
CENTRAL UTAH PROJECT - JENSEN UNIT REDFLEET RESERVOIR, UTAH BIG BRUSH CREEK	I-F&W-M&I	29604 0 (24000 0)	32071 0 (26000 0)	202 3 (500 0)		(3)
CENTRAL UTAH PROJECT STEINAKER RESERVOIR, UTAH OFFSTREAM	I-M&I	41054 6 (33283 0)	47086 4 (38173 0)	331 8 (820 0)	1961	
CENTRAL UTAH PROJECT STARVATION RESERVOIR, UTAH STRAWBERRY RIVER	I-M&I	187899 1 (152330 0)	206376 9 (167310 0)	1339 5 (3310 0)	1970	
CENTRAL UTAH PROJECT STRAWBERRY RESERVOIR(SOLDIER CREEK),UTAH STRAWBERRY RIVER	I-M&I-FC	1173502 6 (951360 0)	1364867 8 (1106500 0)	6946 1 (17164 0)	1974	
CENTRAL VALLEY PROJECT AUBURN RESERVOIR, CALIFORNIA AMERICAN RIVER	I-FC-M&I	2425061 0 (1966000 0)	2869121 0 (2326000 0)	4031 9 (9963 0)		(3)
CENTRAL VALLEY PROJECT CLAIR ENGLE LAKE (TRINITY), CALIFORNIA TRINITY RIVER	I-P	2633534 8 (2135010 0)	3019176 3 (2447650 0)	6691 5 (16535 0)	1962	
CENTRAL VALLEY PROJECT CONTRA LOMA RESERVOIR, CALIFORNIA OFFSTREAM		2193 2 (1778 0)	2584 2 (2095 0)	32 8 (81 0)	1967	(2)
CENTRAL VALLEY PROJECT JENKINSON LAKE (SLY PARK), CALIFORNIA SLY PARK CREEK	I-M&I	50080 1 (40600 0)	50573 5 (41000 0)	263 0 (650 0)	1955	
CENTRAL VALLEY PROJECT KESWICK RESERVOIR, CALIFORNIA SACRAMENTO RIVER		9219 2 (7474 0)	29322 8 (23772 0)	259 0 (640 0)	1950	(2)
CENTRAL VALLEY PROJECT LAKE NATOMA (NIMBUS), CALIFORNIA AMERICAN RIVER		3453 8 (2800 0)	10854 8 (8800 0)	218 5 (540 0)	1955	(2)
CENTRAL VALLEY PROJECT LEWISTON LAKE, CALIFORNIA TRINITY RIVER	P	3564 8 (2890 0)	18083 1 (14660 0)	303 5 (750 0)	1963	
CENTRAL VALLEY PROJECT LITTLE PANOCHE RESERVOIR, CALIFORNIA LITTLE PANOCHE CREEK	FC	6500 5 (5270 0)	6882 9 (5580 0)	76 1 (188 0)	1966	
CENTRAL VALLEY PROJECT LOS BANOS RESERVOIR, CALIFORNIA LOS BANOS CREEK	FC	32441 1 (26300 0)	42679 1 (34600 0)	190 2 (470 0)	1965	
CENTRAL VALLEY PROJECT MARTINEZ RESERVOIR, CALIFORNIA OFFSTREAM	I-M&I	320 7 (260 0)	330 6 (268 0)	5 7 (14 0)	1947	
CENTRAL VALLEY PROJECT MILLERTON LAKE (FRIANT), CALIFORNIA SAN JOAQUIN RIVER	I-FC	535092 3 (433800 0)	642036 8 (520500 0)	1983 0 (4900 0)	1942	
CENTRAL VALLEY PROJECT O NEILL RESERVOIR, CALIFORNIA SAN LUIS CREEK	I-P	25644 5 (20790 0)	69606 4 (56430 0)	910 6 (2250 0)	1967	
CENTRAL VALLEY PROJECT SAN LUIS RESERVOIR, CALIFORNIA SAN LUIS CREEK	I-P	2419288 2 (1961320 0)	2517018 4 (2040550 0)	5261 0 (13000 0)	1967	
CENTRAL VALLEY PROJECT SAN LUIS FOREBAY RESERVOIR, CALIFORNIA SAN LUIS CREEK		24670 0 (20000 0)	70926 2 (57500 0)	725 2 (1792 0)	1967	
CENTRAL VALLEY PROJECT SHASTA LAKE, CALIFORNIA SACRAMENTO RIVER	I-P-FC- RR-N-M&I	4890778 2 (3964960 0)	5615003 0 (4552090 0)	12036 7 (29743 0)	1945	
CENTRAL VALLEY PROJECT SPRING CREEK RESERVOIR, CALIFORNIA SPRING CREEK	F&W-S	6968 0 (5649 0)	7245 6 (5874 0)	35 2 (87 0)	1963	
CENTRAL VALLEY PROJECT SUGAR PINE RESERVOIR, CALIFORNIA NORTH SHIRTTAIL CANYON	I-M&I	7401 0 (6000 0)	8634 5 (7000 0)	121 4 (300 0)		(3)
CENTRAL VALLEY PROJECT SWIFTS CORRAL RESERVOIR, CALIFORNIA STONE CORRAL CREEK		1048 5 (850 0)	6352 5 (5150 0)	121 4 (300 0)		(3)
CENTRAL VALLEY PROJECT WHISKEYTOWN LAKE, CALIFORNIA CLEAR CREEK	I-P	263418 9 (213554 0)	297391 9 (241096 0)	1303 1 (3220 0)	1963	
CHIEF JOSEPH DAM PROJECT SPECTACLE LAKE, WASHINGTON OFFSTREAM	I	7709 4 (6250 0)	16528 9 (13400 0)	160 3 (396 0)	1969	
COLLBRAN PROJECT ATKINSON RESERVOIR, COLORADO BIG CREEK	I-P	2467 0 (2000 0)	2467 0 (2000 0)	40 5 (100 0)	1965	(6)

Summary Tabulation of Storage Reservoirs - Continued

PROJECT DIVISION OR UNIT RESERVOIR NAME STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
COLLBRAN PROJECT BIG MEADOWS RESERVOIR, COLORADO COTTONWOOD CREEK	I-P				1899	
COLLBRAN PROJECT BONHAM RESERVOIR, COLORADO BIG CREEK	I-P	1381 5 (1120 0)	1504 9 (1220 0)	35 6 (88 0)	1962	(6)
COLLBRAN PROJECT COTTONWOOD RESERVOIR NO 1, COLORADO COTTONWOOD CREEK	I-P	2467 0 (2000 0)	3700 5 (3000 0)	40 5 (100 0)	1962	(6)
COLLBRAN PROJECT COTTONWOOD RESERVOIR NO 2, COLORADO COTTONWOOD CREEK	I-P				1966	(6)
COLLBRAN PROJECT COTTONWOOD RESERVOIR NO 4, COLORADO COTTONWOOD CREEK	I-P		1233 5 (1000 0)		1974	
COLLBRAN PROJECT DECAMP RESERVOIR, COLORADO COTTONWOOD CREEK	I-P				1962	(6)
COLLBRAN PROJECT FORTY ACRE LAKE, COLORADO BIG CREEK	I-P				1970	(6)
COLLBRAN PROJECT KITSON RESERVOIR, COLORADO COTTONWOOD CREEK	I-P				1974	
COLLBRAN PROJECT LAMBERT RESERVOIR, COLORADO EAST FORK BIG CREEK	I-P				1965	(6)
COLLBRAN PROJECT LITTLE MEADOWS RESERVOIR, COLORADO COTTONWOOD CREEK	I-P				1968	(6)
COLLBRAN PROJECT NEVERSWEAT RESERVOIR, COLORADO COTTONWOOD CREEK	I-P				1969	(6)
COLLBRAN PROJECT SILVER LAKE, COLORADO BIG CREEK	I-P				1966	(6)
COLLBRAN PROJECT VEGA RESERVOIR, COLORADO PLATEAU CREEK	I-F&W	40680 8 (32980 0)	41692 3 (33800 0)	404 7 (1000 0)	1959	
COLORADO-BIG THOMPSON PROJECT CARTER LAKE (DAMS NO 1,2,AND 3),COLORADO OFFSTREAM	I-P-M&I	124610 6 (101022 0)	138435 7 (112230 0)	463 0 (1144 0)	1962	
COLORADO-BIG THOMPSON PROJECT FLATIRON RESERVOIR, COLORADO CHIMNEY HOLLOW CREEK	I-P	537 8 (436 0)	937 5 (760 0)	19 0 (47 0)	1953	
COLORADO-BIG THOMPSON PROJECT GREEN MOUNTAIN RESERVOIR, COLORADO BLUE RIVER	I-P	139199 2 (112849 0)	190754 6 (154645 0)	862 0 (2130 0)	1943	
COLORADO-BIG THOMPSON PROJECT HORSETOOTH RESERVOIR, COLORADO OFFSTREAM	I-M&I	162205 3 (131500 0)	187492 0 (152000 0)	768 9 (1900 0)	1949	
COLORADO-BIG THOMPSON PROJECT LAKE ESTES (OLYMPUS), COLORADO BIG THOMPSON RIVER	I-P	3279 9 (2659 0)	3784 4 (3068 0)	74 9 (185 0)	1949	
COLORADO-BIG THOMPSON PROJECT LAKE GRANBY, COLORADO COLORADO RIVER	I-P	574278 1 (465568 0)	665791 5 (539758 0)	2938 0 (7260 0)	1950	
COLORADO-BIG THOMPSON PROJECT MARYS LAKE (DIKES NO 1 AND 2), COLORADO OFFSTREAM	P	674 7 (547 0)	1143 5 (927 0)	17 0 (42 0)	1949	
COLORADO-BIG THOMPSON PROJECT PINEWOOD LAKE (RATTLESNAKE), COLORADO RATTLESNAKE CREEK	P	1934 1 (1568 0)	2690 3 (2181 0)	39 3 (97 0)	1952	
COLORADO-BIG THOMPSON PROJECT SHADOW MOUNTAIN AND GRAND LAKES, (SHADOW MOUNTAIN) COLO -COLORADO RIVER	I-P	2268 4 (1839 0)	22658 2 (18369 0)	749 5 (1852 0)	1946	
COLORADO-BIG THOMPSON PROJECT WILLOW CREEK RESERVOIR, COLORADO WILLOW CREEK	I-P	5237 4 (4246 0)	12992 5 (10533 0)	122 6 (303 0)	1953	
COLORADO RIVER FRONT WORK AND LEVEE SYS SENATOR WASH RESERVOIR, CALIFORNIA SENATOR WASH		15121 5 (12259 0)	17066 7 (13836 0)	190 2 (470 0)	1966	(2)
COLORADO RIVER PROJECT (TEXAS) MARSHALL FORD RESERVOIR, TEXAS COLORADO RIVER	I-P- FC-RR-N	2265939 5 (1837000 0)	2410180 1 (1953936 0)	13050 8 (32249 0)	1942	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION, OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
COLORADO RIVER STORAGE PROJECT BLUE MESA RESERVOIR, COLORADO GUNNISON RIVER	I-P-FC	923188 4 (748430 0)	1160353 5 (940700 0)	3715 1 (9180 0)	1966	
COLORADO RIVER STORAGE PROJECT CRYSTAL RESERVOIR, COLORADO GUNNISON RIVER	P	15940 5 (12923 0)	31094 1 (25208 0)	113 3 (280 0)	1978	
COLORADO RIVER STORAGE PROJECT FLAMING GORGE RESERVOIR,UTAH-WYOMING GREEN RIVER	I-P	4336616 0 (3515700 0)	4673608 2 (3788900 0)	17005 1 (42020 0)	1964	
COLORADO RIVER STORAGE PROJECT LAKE POWELL (GLEN CANYON), ARIZONA-UTAH COLORADO RIVER	P-RR	25750546 0 (20876000 0)	33304500 0 (27000000 0)	65312 9 (161390 0)	1964	
COLORADO RIVER STORAGE PROJECT MORROW POINT RESERVOIR, COLORADO GUNNISON RIVER	P	51918 0 (42090 0)	144523 0 (117165 0)	330 6 (817 0)	1968	
COLORADO RIVER STORAGE PROJECT NAVAJO RESERVOIR,NEW MEXICO-COLORADO SAN JUAN RIVER	I-FC-RR	1277906 0 (1036000 0)	2107558 1 (1708600 0)	6317 2 (15610 0)	1963	
COLUMBIA BASIN PROJECT BANKS LAKE (NORTH AND DRY FALLS) WASHINGTON - OFFSTREAM	I	881952 5 (715000 0)	1572712 5 (1275000 0)	10926 6 (27000 0)	1951	(2)
COLUMBIA BASIN PROJECT BILLY CLAPP LAKE (PINTO), WASHINGTON OFFSTREAM	I-FC	26150 2 (21200 0)	79190 7 (64200 0)	408 7 (1010 0)	1948	
COLUMBIA BASIN PROJECT FRANKLIN D ROOSEVELT LAKE (GRAND COULEE), WASHINGTON - COLUMBIA RIVER	I-P-FC- RR-N	6453672 0 (5232000 0)	11794727 0 (9562000 0)	32618 0 (80600 0)	1942	
COLUMBIA BASIN PROJECT POTHOLES RESERVOIR (O'SULLIVAN) WASHINGTON - LOWER CRAB CREEK	I-FC	409768 7 (332200 0)	631182 0 (511700 0)	11250 4 (27800 0)	1949	
COLUMBIA BASIN PROJECT SCOOTENEY RESERVOIR, WASHINGTON OFFSTREAM	I	8326 1 (6750 0)	18810 9 (15250 0)	37433 8 (92500 0)	1952	
COLUMBIA BASIN PROJECT SODA LAKE, WASHINGTON OFFSTREAM			12520 0 (10150 0)	74 5 (184 0)	1952	
CRESCENT LAKE DAM PROJECT CRESCENT LAKE, OREGON CRESCENT CREEK	I	107191 2 (86900 0)	113112 0 (91700 0)	1622 0 (4008 0)	1956	(4-6)
CROOKED RIVER PROJECT OCHOCO RESERVOIR, OREGON OCHOCO CREEK	I	57357 8 (46500 0)	59208 0 (48000 0)	445 2 (1100 0)	1950	(6)
CROOKED RIVER PROJECT PRINEVILLE RESERVOIR (ARTHUR R BOWMAN), OREGON, CROOKED RIVER	I-FC	188478 8 (152800 0)	190575 8 (154500 0)	1218 1 (3010 0)	1961	
DESCHUTES PROJECT CRANE PRAIRIE RESERVOIR DESCHUTES RIVER	I	68212 6 (55300 0)	68212 6 (55300 0)	1999 2 (4940 0)	1940	
DESCHUTES PROJECT HAYSTACK EQUALIZING RESERVOIR, OREGON OFFSTREAM	I	6950 8 (5635 0)	6969 3 (5650 0)	94 3 (233 0)	1957	
DESCHUTES PROJECT WICKIUP RESERVOIR, OREGON DESCHUTES RIVER	I	246700 0 (200000 0)	246700 0 (200000 0)	4532 5 (11200 0)	1940	
EDEN PROJECT BIG SANDY RESERVOIR, WYOMING BIG SANDY CREEK	I	47243 1 (38300 0)	48970 0 (39700 0)	1015 8 (2510 0)	1952	
EDEN PROJECT EDEN RESERVOIR, WYOMING OFFSTREAM	I	8634 5 (7000 0)	9868 0 (8000 0)	364 2 (900 0)	1910	
EMERY COUNTY PROJECT HUNTINGTON NORTH RESERVOIR, UTAH OFFSTREAM	I-M&I	4786 0 (3880 0)	6685 6 (5420 0)	97 9 (242 0)	1966	
EMERY COUNTY PROJECT JOES VALLEY RESERVOIR, UTAH SEELY CREEK	I-M&I	67743 8 (54920 0)	77044 4 (62460 0)	473 5 (1170 0)	1966	
FLORIDA PROJECT LEMON RESERVOIR,COLORADO FLORIDA RIVER	I	48143 5 (39030 0)	49520 1 (40146 0)	251 7 (622 0)	1963	
FRUITGROWERS DAM PROJECT FRUITGROWERS RESERVOIR, COLORADO ALFALFA RUN	I	5501 4 (4460 0)	5600 1 (4540 0)	192 6 (476 0)	1938	
FRYINGPAN-ARKANSAS PROJECT PUEBLO RESERVOIR, COLORADO ARKANSAS RIVER	FC-M&I	403752 9 (327323 0)	441195 8 (357678 0)	2292 2 (5664 0)	1975	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
FRYINGPAN-ARKANSAS PROJECT RUEDI RESERVOIR, COLORADO FRYINGPAN RIVER	I-M&I-F&W	124928 9 (101280 0)	126273 4 (102370 0)	403 5 (997 0)	1968	
FRYINGPAN-ARKANSAS PROJECT TURQUOISE LAKE (SUGAR LOAF), COLORADO LAKE FORK OF ARKANSAS RIVER	I-M&I-F&W	148624 4 (120490 0)	159664 2 (129440 0)	723 6 (1788 0)	1968	
HUMBOLDT PROJECT RYE PATCH RESERVOIR, NEVADA HUMBOLDT RIVER	I	234365 0 (190000 0)	234365 0 (190000 0)	4378 7 (10820 0)	1935	(4-6)
HUNGRY HORSE PROJECT HUNGRY HORSE RESERVOIR, MONTANA SOUTH FORK FLATHEAD RIVER	I-P-FC-N	3678297 0 (2982000 0)	4277778 0 (3468000 0)	9631 6 (23800 0)	1953	
HUNTLEY PROJECT ANITA RESERVOIR, MONTANA OFFSTREAM	I	493 4 (400 0)	493 4 (400.0)	16 2 (40 0)	1937	
HYRUM PROJECT HYRUM RESERVOIR, UTAH LITTLE BEAR RIVER	I	18872 6 (15300 0)	23189 8 (18800 0)	192 2 (475 0)	1935	
KENDRICK PROJECT ALCOVA RESERVOIR, WYOMING NORTH PLATTE RIVER	I-P	37752 5 (30606 0)	227327 9 (184295 0)	1011 7 (2500 0)	1938	
KENDRICK PROJECT SEMINOE RESERVOIR, WYOMING NORTH PLATTE RIVER	I-P	1215747 5 (985608 0)	1254813 6 (1017279 0)	8211 6 (20291 0)	1939	
KLAMATH PROJECT CLEAR LAKE RESERVOIR, CALIFORNIA LOST RIVER	I-FC	633192 6 (513330 0)	649783 1 (526780 0)	10441 0 (25800 0)	1910	
KLAMATH PROJECT GERBER RESERVOIR, OREGON MILLER CREEK	I	116319 1 (94300 0)	116319 1 (94300 0)	1550 0 (3830 0)	1925	(4)
LITTLE WOOD RIVER PROJECT LITTLE WOOD RIVER RESERVOIR, IDAHO LITTLE WOOD RIVER	I-FC	37005 0 (30000 0)	37005 0 (30000 0)	231 5 (572 0)	1960	(6)
LYMAN PROJECT MEEKS CABIN RESERVOIR, WYOMING BLACKS FORK	I-F&W	36363 6 (29480 0)	40051 7 (32470 0)	191 4 (473 0)	1971	
LYMAN PROJECT STATELINE RESERVOIR, WYOMING EAST FORK SMITH'S FORK	M&I	14802 0 (12000 0)	17269 0 (14000 0)	117 4 (290 0)		(3)
MANCOS PROJECT JACKSON GULCH RESERVOIR, COLORADO OFFSTREAM	I	12274 6 (9951 0)	12310 3 (9980 0)	87 8 (217 0)	1949	
MANN CREEK PROJECT MANN CREEK RESERVOIR, IDAHO MANN CREEK	I-FC-F&W	13691 9 (11100 0)	16035 5 (13000 0)	114 5 (283 0)	1967	
MIDDLE RIO GRANDE PROJECT EL VADO RESERVOIR NEW MEXICO RIO CHAMA RIVER	I	241075 2 (195440 0)	241766 0 (196500 0)	1367 9 (3380 0)	1955	(6)
MILK RIVER PROJECT FRESNO RESERVOIR, MONTANA MILK RIVER	I-M&I	156901 2 (127200 0)	159198 0 (129062 0)	2331 0 (5760 0)	1939	
MILK RIVER PROJECT LAKE SHERBURNE, MONTANA SWIFTCURRENT CREEK	I	79289 4 (64280 0)	83389 5 (67604 0)	647 9 (1601 0)	1921	
MILK RIVER PROJECT NELSON RESERVOIR (5 DIKES) MONTANA OFFSTREAM	I	82119 0 (66574 0)	97720 3 (79222 0)	1748 3 (4320 0)	1915	
MINIDOKA PROJECT GRASSEY LAKE, WYOMING GRASSEY CREEK	I-FC	18749 2 (15200 0)	19119 3 (15500 0)	125 5 (310 0)	1939	
MINIDOKA PROJECT ISLAND PARK RESERVOIR, IDAHO HENRYS FORK RIVER	I-FC	157271 3 (127500 0)	157888 0 (128000 0)	3154 2 (7794 0)	1938	
MINIDOKA PROJECT JACKSON LAKE, WYOMING SNAKE RIVER	I-FC	1044774 5 (847000 0)	1044774 5 (847000 0)	10335 8 (25540 0)	1911	(4)
MINIDOKA PROJECT LAKE WOLCOTT (MINIDOKA), IDAHO SNAKE RIVER	I-P-FC	117429 2 (95200 0)	259035 0 (210000 0)	4795 6 (11850 0)	1909	
MIRAGE FLATS PROJECT BOX BUTTE RESERVOIR, NEBRASKA NIOBRARA RIVER	I	37523 1 (30420 0)	38312 5 (31060 0)	647 5 (1600 0)	1946	
MOON LAKE PROJECT MIDVIEW RESERVOIR UTAH OFFSTREAM	I	7135 8 (5785 0)	7135 8 (5785 0)	163 9 (405 0)	1937	(4)

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION, OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
MOON LAKE PROJECT MOON LAKE, UTAH WEST FORK OF LAKE FORK DUCHENSE RIVER	I	44159 3 (35800 0)	61058 3 (49500 0)	312 8 (773 0)	1938	
MOUNTAIN PARK PROJECT TOM STEED RESERVOIR (MOUNTAIN PARK), OKLA WEST OTTER CREEK	M&I-FC-F&W	134791 9 (109276 0)	145337 1 (117825 0)	2590 8 (6402 0)	1975	
NAVAJO INDIAN IRRIGATION PROJECT CUTTER RESERVOIR, NEW MEXICO OFFSTREAM	I	996 7 (808 0)	2220 3 (1800 0)	25 1 (62 0)	1972	(2-5)
NEWLANDS PROJECT LAHONTAN RESERVOIR, NEVADA CARSON RIVER	I-P	364067 5 (295150 0)	391364 9 (317280 0)	4538 6 (11215 0)	1915	
NEWLANDS PROJECT LAKE TAHOE, CALIFORNIA-NEVADA TRUCKEE RIVER	I-P	902922 0 (732000 0)	902922 0 (732000 0)	48562 8 (120000 0)	1913	(4)
NEWTON PROJECT NEWTON RESERVOIR, UTAH CLARKSON CREEK	I	6660 9 (5400 0)	6932 3 (5620 0)	120 2 (297 0)	1946	
NORMAN PROJECT LAKE THUNDERBIRD (NORMAN), OKLAHOMA HOG CREEK AND LITTLE RIVER	FC-M&I-F&W	225113 8 (182500 0)	242012 7 (196200 0)	2456 5 (6070 0)	1965	
NORTH PLATTE PROJECT GUERNSEY RESERVOIR, WYOMING NORTH PLATTE RIVER	I-P	55788 7 (45228 0)	55788 7 (45228 0)	963 2 (2380.0)	1927	
NORTH PLATTE PROJECT LAKE ALICE, NEBRASKA OFFSTREAM	I	13587 0 (11015 0)	13587 0 (11015 0)	315 7 (780 0)	1913	
NORTH PLATTE PROJECT LAKE MINATARE, NEBRASKA OFFSTREAM	I	74587 3 (60468 0)	76711 4 (62190 0)	873 3 (2158 0)	1915	
NORTH PLATTE PROJECT PATHFINDER RESERVOIR, WYOMING NORTH PLATTE RIVER	I-P	1214588 0 (984668 0)	1253097 8 (1015888 0)	8903 2 (22000 0)	1909	
NUECES RIVER PROJECT CHOKE CANYON RESERVOIR, TEXAS FRIO RIVER	I-M&I-F&W	859749 5 (697000 0)	880719 0 (714000 0)	10602 9 (26200 0)		(3)
OGDEN RIVER PROJECT PINEVIEW RESERVOIR, UTAH OGDEN RIVER	I-M&I	135685 0 (110000 0)	135685 0 (110000 0)	1163 1 (2874 0)	1937	
OKANOGAN PROJECT CONCONULLY RESERVOIR, WASHINGTON SALMON CREEK	I	16035 5 (13000 0)	16035 5 (13000 0)	182 1 (450 0)	1969	
OKANOGAN PROJECT CONCONULLY LAKE (SALMON LAKE), WASH OFFSTREAM	I	12951 8 (10500 0)	19366 0 (15700 0)	125 5 (310 0)	1921	(4)
ORLAND ROJECT EAST PARK RESERVOIR, CALIFORNIA LITTLE STONY CREEK	I	62415 1 (50600 0)	62785 2 (50900 0)	736 5 (1820 0)	1910	
ORLAND PROJECT STONY GORGE RESERVOIR, CALIFORNIA STONY CREEK	I	62106 7 (50350 0)	62143 7 (50380 0)	518 0 (1280 0)	1928	(4)
OWYHEE PROJECT LAKE OWYHEE, OREGON OWYHEE RIVER	I-FC	881952 5 (715000 0)	1383987 0 (1122000 0)	5625 2 (13900 0)	1932	
PALISADES PROJECT PALISADES RESERVOIR IDAHO-WYOMING SOUTH FORK SNAKE RIVER	I-P-FC	1480200 0 (1200000 0)	1728133 5 (1401000 0)	6535 7 (16150 0)	1957	
PALMETTO BENO PROJECT PALMETTO BENO RESERVOIR, TEXAS NAVIDAD AND LAVACA RIVERS	M&I	209695 0 (170000 0)	251634 0 (204000 0)	445 2 (1100 0)		(3)
PAONIA PROJECT PAONIA RESERVOIR, COLORADO MUDDY CREEK	I-FC-F&W	22388 0 (18150 0)	25841 8 (20950 0)	135 2 (334 0)	1962	
PARKER DAVIS PROJECT LAKE HAVASU (PARKER), ARIZONA-CALIFORNIA COLORADO RIVER	P-FC-M&I	222030 0 (180000 0)	764029 9 (619400 0)	8251 6 (20390 0)	1938	
PARKER-DAVIS PROJECT LAKE MOHAVE (DAVIS), ARIZONA-NEVADA COLORADO RIVER	I-P-RR	1964102 1 (1592300 0)	2242873 1 (1818300 0)	11412 3 (28200 0)	1950	
PICK-SLOAN MISSOURI BASIN PROGRAM						
BIG HORN BASIN DIVISION-OWL CREEK UNIT ANCHOR RESERVOIR, WYOMING SOUTH FORK OWL CREEK	I-FC-F&W	21222 4 (17205 0)	21406 2 (17354 0)	176 8 (437 0)	1960	
BOSTWICK DIVISION-COURTLAND UNIT LOVEWELL RESERVOIR, KANSAS WHITE ROCK CREEK	I-FC	92993 6 (75390 0)	113667 0 (92150 0)	2033 6 (5025 0)	1957	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM (CONTINUED)						
BOYSEN DIVISION-BOYSEN UNIT BOYSEN RESERVOIR, WYOMING WIND RIVER	I-P-FC	863813 9 (700295 0)	1174824 9 (952432 0)	7915 7 (19560 0)	1952	
CHEYENNE DIVISION-ANGOSTURA UNIT ANGOSTURA RESERVOIR, SOUTH DAKOTA CHEYENNE RIVER	I-FC-F&W	106278 4 (86160 0)	171161 7 (138761 0)	1914 9 (4706.0)	1949	
CHEYENNE DIVISION- KEYHOLE UNIT KEYHOLE RESERVOIR, WYOMING BELLE FOURCHE RIVER	I-FC-F&W	407769 2 (330579 0)	419460 3 (340057 0)	3801 7 (9394 0)	1952	
CHEYENNE DIVISION-RAPID VALLEY UNIT PACTOLA RESERVOIR, SOUTH DAKOTA RAPID CREEK	I-FC- M&I-F&W	120883 0 (98000 0)	122116 5 (99000 0)	498 6 (1232 0)	1956	
FRENCHMAN-CAMBRIDGE DIV - CAMBRUDGE UNIT, HARRY STRUNK LAKE (MEDICINE CREEK) NEBRASKA - MEDICINE CREEK	I-FC	98390 1 (79765 0)	110167 6 (89313 0)	1400 2 (3460 0)	1949	
FRENCHMAN-CAMBRIDGE DIV - FRENCHMAN UNIT, ENDERS RESERVOIR, NEBRASKA FRENCHMAN CREEK	I-FC	79684 1 (64600 0)	91895 7 (74500 0)	973 3 (2405 0)	1951	
FRENCHMAN-CAMBRIDGE DIV - MEEKER DRIFTWOOD UNIT, SWANSON LAKE (TRENTON) NEBRASKA REPUBLICAN RIVER	I-FC	294115 7 (238440 0)	313247 3 (253950 0)	3229 4 (7980 0)	1953	
FRENCHMAN-CAMBRIDGE DIV -RED WILLOW UNIT, HUGH BUTLER LAKE (RED WILLOW) NEBRASKA, RED WILLOW CREEK	I-FC	93968 0 (76180 0)	106854 4 (86627 0)	1084 6 (2680 0)	1962	
GARRISON DIV - GARRISON DIVERSION UNIT JAMESTOWN RESERVOIR, NORTH DAKOTA JAMES RIVER	I-FC- M&I-F&W	271562 4 (220156 0)	272576 4 (220978 0)	1034 4 (2556 0)	1954	
GARRISON DIV - GARRISON DIVERSION UNIT LONE TREE RESERVOIR (WINTERING), NORTH DAKOTA CHEYENNE RIVER	I-FC	345380 0 (280000 0)	658689 0 (534000 0)	22217 5 (54900 0)	1976	(5)
GRAND DIVISION - SHADEHILL UNIT SHADEHILL RESERVOIR, SOUTH DAKOTA GRAND RIVER	I-FC-F&W	368816 5 (299000 0)	440976 3 (357500 0)	4006 4 (9900 0)	1951	
HEART DIVISION - DICKINSON UNIT EDWARD ARTHUR PATTERSON LAKE (DICKINSON) NORTH DAKOTA, HEART RIVER	I-FC- M&I-F&W	6711 5 (5441 0)	8234 8 (6676 0)	331 4 (819 0)	1950	
HEART DIVISION - HEART BUTTE UNIT LAKE TSCHIOA (HEART BUTTE) NORTH DAKOTA, HEART RIVER	I-FC-F&W	267535 0 (216891 0)	275867 3 (223646 0)	1374 7 (3397 0)	1949	
HELENA-GREAT FALLS DIV - CANYON FERRY UNIT, CANYON FERRY LAKE, MONTANA, MISSOURI RIVER	I-FC-P- M&I-F&W	1993783 8 (1616363 0)	2529785 2 (2050900 0)	13935 5 (34435 0)	1954	
HELENA-GREAT FALLS DIV -HELENA VALLEY UNIT, HELENA VALLEY RESERVOIR, MONTANA, OFFSTREAM	I-M&I-F&W	7273 9 (5897 0)	12891 3 (10451 0)	214 9 (531 0)	1958	
KANASKA DIVISION - ALMENA UNIT NORTON RESERVOIR, KANSAS PRAIRIE DOG CREEK	I-FC-M&I	159681 5 (129454 0)	166199 3 (134738 0)	2151 3 (5316 0)	1964	
LOWER BIGHORN DIV - YELLOWTAIL UNIT BIGHORN LAKE (YELLOWTAIL), MONTANA BIGHORN RIVER	I-FC- FC-F&W	1076440 9 (872672 0)	1696062.5 (1375000 0)	7001 1 (17300 0)	1966	
LOWER BIGHORN DIV - YELLOWTAIL UNIT YELLOWTAIL AFTERBAY RESERVOIR, MONTANA, BIGHORN RIVER	P	3700 5 (3000 0)	3700 5 (3000 0)	80 9 (200 0)	1966	(2)
MARIAS DIVISION - LOWER MARIAS UNIT LAKE ELWELL (TIBER), MONTANA MARIAS RIVER	I-F&W		706795 5 (573000 0)	7154 1 (17678 0)	1956	
MIDDLE LOUP DIVISION-FARWELL UNIT SHERMAN RESERVOIR, NEBRASKA OAK CREEK	I	72258 4 (58580 0)	85210 2 (69080 0)	1160 7 (2868 0)	1962	
OREGON TRAILS DIVISION - GLENDO UNIT GLENDO RESERVOIR, WYOMING NORTH PLATTE RIVER	I-P-FC	895834 3 (726254 0)	973727 4 (789402 0)	5004 0 (12365 0)	1958	
OREGON TRAILS DIV - GLENDO UNIT GRAY REEF RESERVOIR WYOMING NORTH PLATTE RIVER		2156 2 (1748 0)	2225 2 (1804 0)	73 7 (182 0)	1961	(2)
OREGON TRAILS DIV - KORTES UNIT KORTES RESERVOIR, WYOMING NORTH PLATTE RIVER	P	3753 5 (3043 0)	5877 6 (4765 0)	33 6 (83 0)	1951	
SANDHILLS DIVISION-AINSWORTH UNIT MERRITT RESERVOIR NEBRASKA SNAKE RIVER	I	83490 7 (67686 0)	91878 5 (74486 0)	1303 9 (3222 0)	1964	
SMOKY HILL DIV - CEDAR BLUFF UNIT CEDAR BLUFF RESERVOIR KANSAS SMOKY HILL RIVER	I-FC- M&I-F&W	421400 6 (341630 0)	464967 8 (376950 0)	4366 6 (10790 0)	1951	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION, OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM (CONTINUED)						
SOLOMON DIVISION - GLEN ELDER UNIT WACONDA LAKE (GLEN ELDER), KANSAS SOLOMON RIVER	I-FC-M&I	1143582 8 (927104 0)	1188816 5 (963775 0)	5099 9 (12602 0)	1969	
SOLOMON DIVISION - KIRWIN UNIT KIRWIN RESERVOIR, KANSAS NORTH FORK SOLOMON RIVER	I-FC	375927 6 (304765 0)	387997 4 (314550 0)	4305 9 (10640 0)	1955	
SOLOMON DIVISION - WEBSTER UNIT WEBSTER RESERVOIR, KANSAS SOUTH NFORK SOLOMON RIVER	I-FC	315159 3 (255500 0)	321326.8 (260500 0)	3431 8 (8480 0)	1956	
THREE FORKS DIV - EAST BENCH UNIT CLARK CANYON RESERVOIR, MONTANA BEAVERHEAD RIVER	I-FC-F&W	315335 6 (255643 0)	317197 0 (257152 0)	2388 9 (5903 0)	1964	
UPPER REPUBLICAN DIV - ARMEL UNIT BONNY RESERVOIR, COLORADO SOUTH FORK REPUBLICAN RIVER	I-FC	207260 1 (168026 0)	209892 4 (170160 0)	2038 0 (5036 0)	1951	
WIND DIVISION - RIVERTON UNIT BULL LAKE, WYOMING BULL LAKE CREEK	I-P	187167 6 (151737 0)	188058 2 (152459 0)	1277 6 (3157 0)	1938	(4)
WIND DIVISION - RIVERTON UNIT LAKE CAMEHWAIT, WYOMING OFFSTREAM	I-F&W	13568 5 (11000 0)	13568 5 (11000 0)			
WIND DIVISION - RIVERTON UNIT PILOT BUTTE RESERVOIR (DAMS 1, 2, AND 3) WYOMING, - OFFSTREAM	I	38916 9 (31550 0)	45639 5 (37000 0)	364 2 (900 0)	1926	
PINE RIVER PROJECT VALLECITO RESERVOIR, COLORADO LOS PINOS RIVER	I	154680 9 (125400.0)	159985 0 (129700 0)	1100 8 (2720 0)	1941	
PROVO RIVER PROJECT DEER CREEK RESERVOIR, UTAH PROVO RIVER	I-P-FC-M&I	143209 4 (116100 0)	188195 1 (152570 0)	1085 8 (2683 0)	1941	
RAPID VALLEY PROJECT DEERFIELD RESERVOIR, SOUTH DAKOTA CASTLE CREEK	I-M&I	18691 2 (15153 0)	19388 2 (15718 0)	167 5 (414 0)	1946	
RIO GRANDE PROJECT CABALLO RESERVOIR, NEW MEXICO RIO GRANDE RIVER	I-P-FC	424324 0 (344000 0)	424324 0 (344000 0)	4653 9 (11500 0)	1938	
RIO GRANDE PROJECT ELEPHANT BUTTE RESERVOIR, NEW MEXICO RIO GRANDE RIVER	I-P	2601973 3 (2109423 0)	2601973 3 (2109423 0)	14779 7 (36521 0)	1916	
ROGUE RIVER BASIN PROJECT AGATE RESERVOIR, OREGON DRY CREEK	I-F&W	5760 4 (4670 0)	5896 1 (4780 0)	87 4 (216 0)	1966	
ROGUE RIVER BASIN PROJECT EMIGRANT LAKE, OREGON EMIGRANT CREEK	I-FC-F&W	48106 5 (39000 0)	49956 8 (40500 0)	326 2 (806 0)	1960	(6)
ROGUE RIVER BASIN PROJECT FISH LAKE, OREGON FISH LAKE OUTLET	I	9665 7 (7836 0)	9744 7 (7900 0)	167 9 (415 0)	1956	(6)
ROGUE RIVER BASIN PROJECT FOURMILE LAKE, OREGON FOURMILE LAKE OUTLET	I	19242 6 (15600 0)	19242 6 (15600 0)	388 5 (960 0)	1956	(6)
ROGUE RIVER BASIN PROJECT HOWARD PRAIRIE LAKE, OREGON BEAVER CREEK	I-P-FC	74750 1 (60600 0)	76600 4 (62100 0)	805 3 (1990 0)	1958	
ROGUE RIVER BASIN PROJECT HYATT PRAIRIE RESERVOIR, OREGON KEENE CREEK	I-P-FC	19982 7 (16200 0)	19982 7 (16200 0)	356 1 (880 0)	1961	(6)
ROGUE RIVER BASIN PROJECT KEENE CREEK RESERVOIR, OREGON KEENE CREEK	I-P-FC	320 7 (260 0)	419 4 (340 0)	5 9 (14 5)	1959	(2)
SALT RIVER PROJECT APACHE LAKE (HORSE MESA), ARIZONA SALT RIVER	I-P	302266 7 (245048 0)	302377 7 (245138 0)	1076 5 (2660 0)	1937	(6)
SALT RIVER PROJECT BARTLETT RESERVOIR, ARIZONA VERDE RIVER	I	220167 4 (178490 0)	220167 4 (178490 0)	1123 0 (2775 0)	1939	
SALT RIVER PROJECT CANYON LAKE (MORMON FLAT), ARIZONA SALT RIVER	I-P	71360 4 (57852 0)	71360 4 (57852 0)	384 5 (950 0)	1938	(6)
SALT RIVER PROJECT SAGUARO LAKE (STEWART MOUNTAIN), ARIZONA SALT RIVER,	I-P	86055 1 (69765 0)	86055 1 (69765 0)	509 9 (1260 0)	1936	(6)
SALT RIVER PROJECT THEODORE ROOSEVELT LAKE, ARIZONA SALT RIVER	I-P	1704178 9 (1381580 0)	1704178 9 (1381580 0)	7001 1 (17300 0)	1911	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT DIVISION OR UNIT RESERVOIR NAME STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
SAN ANGELO PROJECT TWIN BUTTES RESERVOIR, TEXAS MIDDLE AND SOUTH CONCHO RIVERS, SPRING CREEK	I-FC- M&I-F&W	779831 0 (632210 0)	790155 4 (640580 0)	9513 5 (23508 0)	1963	
SAN JUAN CHAMA PROJECT HERON RESERVOIR NEW MEXICO WILLOW CREEK	I-F&W-M&I	493375 3 (399980 0)	495028 2 (401320 0)	2389 7 (5905 0)	1971	
SAN JUAN CHAMA PROJECT NAMBE FALLS RESERVOIR, NEW MEXICO RIO NAMBE RIVER	I-FC-F&W	1973 6 (1600 0)	2467 0 (2000 0)	22 7 (56 0)	1976	
SAN LUIS VALLEY PROJECT PLATORO RESERVOIR, COLORADO CONEJOS RIVER	I-FC	66004 6 (53510 0)	73479 6 (59570 0)	383 6 (948 0)	1951	
SANTA MARIA PROJECT TWITCHELL RESERVOIR, CALIFORNIA CUYAMA RIVER	I-FC	296179 4 (240113 0)	296179 4 (240113 0)	1485 2 (3670 0)	1958	
SCOFIELD PROJECT SCOFIELD RESERVOIR, UTAH PRICE RIVER	I-M&I	81164 3 (65800 0)	90785 6 (73600 0)	1137 2 (2810 0)	1946	
SEEDSKADEE PROJECT FONTENELLE RESERVOIR, WYOMING GREEN RIVER	I-P- M&I-F&W	185641 8 (150500 0)	426001 6 (345360 0)	3261 0 (8058 0)	1964	
SHOSHONE PROJECT BUFFALO BILL RESERVOIR, WYOMING SHOSHONE RIVER	I-P-M&I	340164 8 (275772 0)	522971 9 (423974 0)	2719 5 (6720 0)	1910	
SHOSHONE PROJECT DEAVER RESERVOIR, WYOMING OFFSTREAM	I	840 0 (681 0)	840 0 (681 0)	32 4 (80 0)	1918	
SILT PROJECT RIFLE GAP RESERVOIR, COLORADO RIFLE CREEK	I-F&W	15009 2 (12168 0)	16778 1 (13602 0)	145 3 (359 0)	1967	
SMITH FORK PROJECT CRAWFORD RESERVOIR, COLORADO IRON CREEK	I-F&W	17343 0 (14060 0)	17750 1 (14390 0)	164 3 (406 0)	1962	
SOLANO PROJECT LAKE BERRYESSA (MONTICELLO), CALIFORNIA PUTAH CREEK	I-FC-M&I	1963655 5 (1591938 0)	1976409 9 (1602278 0)	8377 1 (20700 0)	1957	
SOLANO PROJECT TERMINAL RESERVOIR, CALIFORNIA OFFSTREAM	I-M&I	146 8 (119 0)	146 8 (119 0)		1959	
STRAWBERRY VALLEY PROJECT STRAWBERRY RESERVOIR (STRAWBERRY AND INDIAN CREEK DIKE), UTAH, STRAWBERRY RV	I-P	333045 0 (270000 0)	349080 5 (283000 0)	3399 4 (8400 0)	1913	
SUN RIVER PROJECT GIBSON RESERVOIR, MONTANA NORTH FORK SUN RIVER	I	122175 7 (99048 0)	122189 3 (99059 0)	524 5 (1296 0)	1929	
SUN RIVER PROJECT PISHKUN RESERVOIR (8 DIKES), MONTANA OFFSTREAM	I	37523 1 (30420 0)	57567 4 (46670 0)	627 3 (1550 0)	1931	
SUN RIVER PROJECT WILLOW CREEK RESERVOIR MONTANA WILLOW CREEK	I	39755 7 (32230 0)	39842 1 (32300 0)	594 9 (1470 0)	1911	
TRUCKEE STORAGE PROJECT BOCA RESERVOIR, CALIFORNIA LITTLE TRUCKEE RIVER	I-P	50413 1 (40870 0)	50709 2 (41110 0)	395 4 (977 0)	1939	
TUALATIN PROJECT HENRY HAGG LAKE (SCOGGINS), OREGON SCOGGINS CREEK	I-M&I	66115 6 (53600 0)	73899 0 (59910 0)	458 1 (1132 0)	1975	
UMATILLA PROJECT COLD SPRINGS RESERVOIR, OREGON OFFSTREAM	I	55012 9 (44599 0)	55098 0 (44668 0)	619 2 (1530 0)	1908	
UMATILLA PROJECT MCKAY RESERVOIR OREGON MCKAY CREEK	I	91032 3 (73800 0)	91032 3 (73800 0)	485 6 (1200 0)	1927	(4)
UNCOMPAHGRE PROJECT TAYLOR PARK RESERVOIR COLORADO TAYLOR RIVER	I	130997 7 (106200 0)	130997 7 (106200 0)	825 6 (2040 0)	1937	(4)
VALE PROJECT BEULAH RESERVOIR (AGENCY VALLEY), OREGON NORTH FORK MALHEUR RIVER	I-FC	73886 7 (59900 0)	73886 7 (59900 0)	768 9 (1900 0)	1935	
VALE PROJECT BULLY CREEK RESERVOIR OREGON BULLY CREEK	I-FC-F&W	37005 0 (30000 0)	38978 6 (31600 0)	398 6 (985 0)	1963	
VENTURA RIVER PROJECT LAKE CASITAS CALIFORNIA COYOTE CREEK	I M&I	309405 0 (250835 0)	313311 5 (254002 0)	1100 8 (2720 0)	1959	

Summary Tabulation of Storage Reservoirs - Continued

PROJECT, DIVISION, OR UNIT RESERVOIR NAME, STATE STREAM	PURPOSE	ACTIVE CAPACITY THOUSAND CUBIC M (ACRE FEET)	TOTAL CAPACITY THOUSAND CUBIC M (ACRE FEET)	SURFACE AREA HECTARES (ACRES)	CALENDAR YEAR COMPLETED	FOOTNOTES
VERMEJO PROJECT RESERVOIR NO 2 (DAM 2), NEW MEXICO OFFSTREAM	I-FC-F&W	2541 0 (2060 0)	2541 0 (2060 0)	170 0 (420 0)	1954	
VERMEJO PROJECT RESERVOIR NO 13 (DAM 13), NEW MEXICO OFFSTREAM	I-FC-F&W	6107 1 (4951 0)	6107 1 (4951 0)	136 0 (336 0)	1954	
VERMEJO PROJECT STUBBLEFIELD RESERVOIR, NEW MEXICO OFFSTREAM	I-FC-F&W	19827 3 (16074 0)	19935 8 (16162 0)	465 4 (1150 0)	1954	
W C AUSTIN PROJECT ALTUS RESERVOIR, OKLAHOMA NORTH FORK RED RIVER	I-FC-M&I	188096 4 (152490 0)	190144 0 (154150 0)	2900 8 (7168 0)	1945	
WAPINITIA PROJECT CLEAR LAKE (WASCO), OREGON CLEAR CREEK	I	14678 7 (11900 0)	16158 9 (13100 0)	225 4 (557 0)	1959	
WASHITA BASIN PROJECT FORT COBB RESERVOIR, OKLAHOMA POND (COBB) CREEK	I-FC- M&I-F&W	175250 7 (142076 0)	177303 3 (143740 0)	2410 3 (5956 0)	1959	
WASHITA BASIN PROJECT FOSS RESERVOIR, OKLAHOMA WASHITA RIVER	I-FC- M&I-F&W	523620 8 (424500 0)	539039 5 (437000 0)	5318 0 (13141 0)	1961	
WASHOE PROJECT PROSSER CREEK RESERVOIR, CALIFORNIA PROSSER CREEK	FC-F&W	35327 4 (28640 0)	36807 6 (29840 0)	297 0 (734 0)	1963	
WASHOE PROJECT STAMPEDE RESERVOIR, CALIFORNIA LITTLE TRUCKEE RIVER	FC-F&W-M&I	273220 3 (221500 0)	279387 8 (226500 0)	1396 2 (3450 0)	1970	
WEBER BASIN PROJECT CAUSEY RESERVOIR, UTAH SOUTH FORK OGDEN RIVER	I-FC	8474 1 (6870 0)	9707 6 (7870 0)	55 0 (136 0)	1966	
WEBER BASIN PROJECT EAST CANYON RESERVOIR, UTAH EAST CANYON CREEK	I-F&W -M&I	59343 7 (48110 0)	63155 2 (51200 0)	276 8 (684 0)	1966	
WEBER BASIN PROJECT LOST CREEK RESERVOIR, UTAH LOST CREEK	I-FC	24682 3 (20010 0)	27766 1 (22510 0)	147 7 (365 0)	1966	
WEBER BASIN PROJECT ROCKPORT LAKE (WANSHIP), UTAH WEBER RIVER	I-P- FC	75070 8 (60860 0)	76625 0 (62120 0)	435 9 (1077 0)	1957	
WEBER BASIN PROJECT WILLIARD RESERVOIR (ARTHUR V WATKINS), UTAH, OFFSTREAM	I	244479 7 (198200 0)	265325 9 (215100 0)	4026 7 (9950 0)	1964	
WEBER RIVER PROJECT ECHO RESERVOIR, UTAH WEBER RIVER	I	91205 0 (73940 0)	91205 0 (73940 0)	588 8 (1455 0)	1931	(4)
WICHITA PROJECT CHENEY RESERVOIR, KANSAS NORTH FORK NINNESCAH RIVER	FC-M&I-F&W	286961 4 (232640 0)	305821 7 (247930 0)	5026 2 (12420 0)	1965	
YAKIMA PROJECT BUMPING LAKE, WASHINGTON BUMPING RIVER	I	41569 0 (33700 0)	41569 0 (33700 0)	527 3 (1303 0)	1910	(4)
YAKIMA PROJECT CLEAR LAKE (CLEAR CREEK), WASHINGTON NORTH FORK TIETON RIVER	I	6537 6 (5300 0)	6537 6 (5300 0)	105 2 (260 0)	1914	
YAKIMA PROJECT CLE ELUM LAKE, WASHINGTON CLE ELUM RIVER	I	539039 5 (437000 0)	875785 0 (710000 0)	1947 4 (4812 0)	1933	(4)
YAKIMA PROJECT KACHESS LAKE, WASHINGTON KACHESS RIVER	I	294806 5 (239000 0)	294806 5 (239000 0)	1835 3 (4535 0)	1912	(4)
YAKIMA PROJECT KEECHELUS LAKE, WASHINGTON YAKIMA RIVER	I	194893 0 (158000 0)	194893 0 (158000 0)	1036 8 (2562 0)	1917	(4)
YAKIMA PROJECT RIMROCK LAKE (TIETON), WASHINGTON TIETON RIVER	I	244233 0 (198000 0)	244233 0 (198000 0)	1021 8 (2525 0)	1925	

DEFINITIONS

PURPOSE	FC - FLOOD CONTROL, P - POWER, I - IRRIGATION, M&I - MUNICIPAL OR INDUSTRIAL, N - NAVIGATION, RR - RIVER REGULATION, F&W - FISH AND WILDLIFE, S - SEDIMENT
CAPACITY, ACTIVE -	STORAGE AVAILABLE FOR PROJECT PURPOSES, USUALLY THE STORAGE ABOVE THE LOWEST POINT OF RELEASE
TOTAL -	STORAGE AT HIGHEST CONTROLLED WATER SURFACE
SURFACE AREA	WATER SURFACE AT TOTAL CAPACITY
YEAR COMPLETED	DATE ORIGINAL CONSTRUCTION COMPLETED EXCEPT AS INDICATED IN FOOTNOTE (6)

FOOTNOTES

(1) THE WATER AND POWER RESOURCES SERVICE HAS RESPONSIBILITY FOR THE PROPER CARE AND MANAGEMENT OF FIVE RESERVOIRS BY SPECIAL AGREEMENT
(2) REREGULATING RESERVOIR
(3) UNDER CONSTRUCTION
(4) DEAD STORAGE NOT EVALUATED
(5) NOT YET IN OPERATION
(6) DATE INDICATES WATER AND POWER RESOURCES SERVICE REHABILITATION WORK

Summary Tabulation of Diversion Dams

PROJECT DIVISION OR UNIT FEATURE STATE STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
ARNOLD PROJECT ARNOLD DIVERSION DAM OREGON DESCHUTES RIVER ROCKFILL CONCRETE WEIR	3 4 (120 0)	9 (3 0)	68 6 (225 0)	8 (1 0)	1951	
BALMORHEA PROJECT MADERA DIVERSION DAM TEXAS MADERA RIVER CONCRETE WEIR EMBANKMENT WINGS	21 2 (750 0)	4 0 (13 0)	289 6 (950 0)		1947	
BELLE FOURCHE PROJECT BELLE FOURCHE DIVERSION DAM SOUTH DAKOTA BELLE FOURCHE RIVER - CONCRETE OGEE WEIR EMBANKMENT WINGS	36 8 (1300 0)	5 5 (18 0)	769 0 (2523 0)	27 5 (36 0)	1907	
BITTER ROOT PROJECT ROCK CREEK DIVERSION DAM MONTANA ROCK CREEK - TIMBER SHEET PILING CONCRETE WEIR CAP	9 3 (330 0)	3 2 (10 5)	24 4 (80 0)	5 (6)	1950	
BOISE PROJECT BLACK CANYON DIVERSION DAM IDAHO PAYETTE RIVER - CONCRETE GRAVITY OGEE-GATED SPILLWAY	38 5 (1360 0)	33 8 (111 0)	316 7 (1039 0)	62 1 (81 2)	1924	(1)
BOISE PROJECT BOISE RIVER DIVERSION DAM IDAHO BOISE RIVER - CONCRETE AND MASONRY WEIR REMOVABLE CREST	79 7 (2815 0)	11 9 (39 0)	152 4 (500 0)	19 9 (26 0)	1908	
BOULDER CANYON PROJECT IMPERIAL DIVERSION DAM ARIZONA-CALIF COLORADO RIVER - CONCRETE SLAB AND BUTTRESS OGEE WEIR	491 4 (17355 0)	7 0 (23 0)	1059 2 (3475 0)	150 6 (197 0)	1938	
CARLSBAD PROJECT BLACK RIVER DIVERSION DAM NEW MEXICO BLACK RIVER CONCRETE WEIR MOVABLE CREST	2 3 (80 0)				1906	
CENTRAL UTAH PROJECT FORT THORNBURGH DIVERSION DAM UTAH ASHLEY CREEK - ROCKFILL OVERFLOW EMBANKMENT WINGS	20 1 (710 0)	2 7 (9 0)	476 7 (1564 0)	5 4 (7 0)	1961	
CENTRAL UTAH PROJECT KNIGHT DIVERSION DAM UTAH DUCHESNE RIVER CONCRETE OGEE WEIR EMBANKMENT WINGS	8 5 (300 0)	8 8 (29 0)	654 4 (2147 0)	37 5 (49 0)	1968	
CENTRAL UTAH PROJECT WATER HOLLOW CREEK DIVERSION DAM UTAH WATER HOLLOW CREEK - UNCONTROLLED OVERFLOW CONCRETE WEIR EMBANKMENT WINGS	6 (20 0)	3 0 (10 0)	64 0 (210 0)	9 2 (12 0)	1971	(2)
CENTRAL VALLEY PROJECT CAMP CREEK DIVERSION DAM CALIFORNIA CAMP CREEK CONCRETE OGEE WEIR	14 2 (500 0)	3 4 (11 0)	36 3 (119 0)	1 5 (2 0)	1953	
CENTRAL VALLEY PROJECT JOHN A FRANCHI DIVERSION DAM CALIF FRESNO RIVER EARTH SHEET PILING		4 6 (15 0)	80 2 (263 0)	9 9 (13 0)	1964	(13)
CENTRAL VALLEY PROJECT RED BLUFF DIVERSION DAM CALIFORNIA SACRAMENTO RIVER - CONCRETE OGEE-GATED WEIR EMBANKMENT WINGS	85 8 (3030 0)	6 2 (20 5)	1824 2 (5985 0)	153 9 (201 3)	1964	
CHIEF JOSEPH DAM PROJECT TOATS COULEE CREEK DIVERSION DAM WASHINGTON TOATS COULEE CREEK CONCRETE OGEE WEIR	2 0 (70 0)	1 5 (5 0)	12 2 (40 0)	1 5 (2 0)	1970	
COLLBRAN PROJECT EAST FORK DIVERSION DAM COLORADO EAST FORK BIG CREEK CONCRETE WEIR EMBANKMENT WINGS	8 (30 0)	2 4 (8 0)	36 6 (120 0)	8 (1 0)	1962	
COLLBRAN PROJECT LEON CREEK DIVERSION DAM COLORADO LEON CREEK CONCRETE OGEE WEIR	9 9 (350 0)	3 0 (10 0)	70 1 (230 0)	1 5 (2 0)	1960	
COLLBRAN PROJECT PARK CREEK DIVERSION DISTRICT COLORADO PARK CREEK CONCRETE OGEE WEIR	4 2 (150 0)	2 4 (8 0)	42 7 (140 0)	8 (1 0)	1960	
COLORADO-BIG THOMPSON PROJECT BIG THOMPSON DIVERSION DAM COLORADO BIG THOMPSON RIVER CONCRETE DROP INLET	17 0 (600 0)	2 4 (8 0)	27 4 (90 0)	8 (1 0)	1950	
COLORADO-BIG THOMPSON PROJECT EAST PORTAL DIVERSION DAM COLORADO WIND RIVER ROCK CONCRETE CORE WALL	15 6 (550 0)	3 0 (10 0)	74 7 (245 0)		1947	

Summary Tabulation of Diversion Dams - Continued

PROJECT, OIVISION, OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSANO CUBIC YD)	CALENOAR YEAR COMPLETEO	FOOTNOTES
COLORADO-BIG THOMPSON PROJECT LITTLE HELL CREEK OIVERSION DAM COLORADO, LITTLE HELL CREEK EARTH ANO ROCK FILL	15 6 (550 0)	10 1 (33 0)	67 1 (220 0)	7 6 (10 0)	1952	
COLORADO-BIG THOMPSON PROJECT NORTH POUROE DIVERSION DAM, COLORADO CACHE LA POURDE RIVER CONCRETE OGEE WEIR	7 1 (250 0)	1 8 (6 0)	61 0 (200 0)	8 (1 0)	1952	
COLORADO-BIG THOMPSON PROJECT POLE HILL AFTERBAY DIVERSION DAM, COLORADO, LITTLE HELL CREEK EARTH AND ROCK FILL	15 6 (550 0)	6 4 (21 0)	67 1 (220 0)	4 6 (6 0)	1953	
COLORADO BIG THOMPSON PROJECT SOUTH PLATTE SUPPLY CANAL OIV DAM, COLORADO, BOULDER CREEK - CONCRETE WEIR, STOPLOGGEO CREST	6 5 (230 0)	1 5 (5 0)	10 4 (34 0)		1956	(3)
COLORADO-BIG THOMPSON PROJECT WILLOW CREEK FOREBAY DIVERSION DAM, COLORADO, OFFSTREAM EARTH AND ROCK FILL	11 3 (400 0)	3 4 (11 0)	176 8 (580 0)	11 5 (15 0)	1953	
CRDOKEO RIVER PROJECT LYTLE CREEK DIVERSION PROJECT, OREGON LYTLE CREEK - ROCKFILL WITH TIMBER CUTOFF, EMBANKMENT WINGS	2 0 (72 0)	1 2 (4 0)	61 0 (200 0)		1962	
EDEN PROJECT LITTLE SANOY DIVERSION DAM, WYOMING LITTLE SANDY CREEK - CONCRETE GATE STRUCTURE, EMBANKMENT WINGS	4 2 (150 0)	2 7 (9 0)	68 6 (225 0)		1959	
EMERY COUNTY PROJECT SWASEY DIVERSION DAM, UTAH COTTONWOOD CREEK - CONCRETE OGEE WEIR, EMBANKMENT WINGS	4 7 (165 0)	3 4 (11 0)	22 9 (75 0)	6 9 (9 0)	1965	
FLORIOA PROJECT FLORIOA FARMERS DIVERSION DAM, COLORADO FLORIOA RIVER - CONCRETE OVERFLOW WEIR, EMBANKMENT WINGS	5 2 (185 0)	4 3 (14 0)	192 0 (630 0)		1963	
FORT SUMNER PROJECT FORT SUMNER DIVERSION DAM, NEW MEXICO PECOS RIVER CONCRETE OGEE WEIR	2 8 (100 0)	3 4 (11 0)	280 6 (920 6)	20 6 (27 0)	1951	
FRENCHTOWN PROJECT FRENCHTOWN DIVERSION DAM, MONTANA CLARK FORK RIVER - EARTH AND ROCKFILL, NONOVERFLOW	4 9 (172 0)	4 0 (13 0)	149 0 (489 0)	9 2 (12 0)	1936	
FRUITGROWERS DAM PROJECT DRY CREEK DIVERSION DAM, COLORADO DRY CREEK CONCRETE OGEE WEIR	2 8 (100 0)	1 5 (5 0)	11 0 (36 0)		1940	(6)
FRYINGPAN-ARKANSAS PROJECT CARTER CREEK DIVERSION DAM, COLORADO CARTER CREEK - GATED STRUCTURE LEADING TO A VERTICAL SHAFT	2 8 (100 0)	2 4 (8 0)	15 2 (50 0)			(15)
FRYINGPAN-ARKANSAS PROJECT CHAPMAN DIVERSION DAM, COLORADO CHAPMAN GULCH - CONCRETE OGEE WEIR EMBANKMENT WING	8 5 (300 0)	4 0 (13 0)	45 7 (150 0)	8 (1 0)	1971	
FRYINGPAN-ARKANSAS PROJECT FRYINGPAN OIVERSION DAM, COLORADO FRYINGPAN RIVER AND MORTEN CREEK CONCRETE OGEE WEIR, EMBANKMENT WING	11 3 (400 0)	4 3 (14 0)	115 8 (380 0)	3 8 (5 0)	1971	
FRYINGPAN-ARKANSAS PROJECT HALFMOON CREEK DIVERSION OAM, COLORADO HALFMOON CREEK - CONCRETE OGEE WEIR WITH EMBANKMENT WING	4 2 (150 0)	5 2 (17 0)	21 3 (70 0)			(15)
FRYINGPAN-ARKANSAS PROJECT HUNTER CREEK DIVERSION OAM, COLORARO HUNTER CREEK - GATED STRUCTURE LEADING TO A VERTICAL SHAFT	4 0 (140 0)	3 0 (10 0)	61 0 (200 0)			(15)
FRYINGPAN-ARKANSAS PROJECT IVANHOE OIVERSION OAM, COLORADO IVANHOE CREEK CONCRETE OGEE SECTION	4 2 (150 0)	3 0 (10 0)	12 2 (40 0)	2 (2)		
FRYINGPAN-ARKANSAS PROJECT LILY PAD OIVERSION DAM, COLORADO LILY PAD LAKE - CONCRETE VERTICAL SHAFT, EMBANKMENT INTERCEPTOR	6 (20 0)	2 7 (9 0)	39 6 (130 0)	8 (1 0)	1973	
FRYINGPAN-ARKANSAS PROJECT MIDOLE CUNNINGHAM CREEK DIVERSION DAM, COLORADO, MIDOLE CUNNINGHAM CREEK - GATED STRUCTURE LDNG TO A VERTICAL SHAFT	1 4 (50 0)	3 0 (10 0)	12 2 (40 0)			(15)

Summary Tabulation of Diversion Dams - Continued

PROJECT DIVISION OR UNIT FEATURE STATE, STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
FRYINGPAN-ARKANSAS PROJECT MIDWAY CREEK DIVERSION DAM COLORADO MIDWAY CREEK - GATED STRUCTURE LEADING TO A VERTICAL SHAFT	2 4 (85 0)	3 7 (12 0)	33 5 (110 0)			(15)
FRYINGPAN-ARKANSAS PROJECT MORMON CREEK DIVERSION DAM, COLORADO MORMON CREEK - GATED STRUCTURE LEADING TO A VERTICAL SHAFT	1 7 (60 0)	3 0 (10 0)	12 2 (40 0)			(15)
FRYINGPAN ARKANSAS PROJECT NO NAME CK DIVERSION DAM, COLORADO NO NAME CREEK - GATED STRUCTURE LEADING TO A VERTICAL SHAFT	2 7 (95 0)	4 0 (13 0)	21 3 (70 0)			(15)
FRYINGPAN ARKANSAS PROJECT NORTH CUNNINGHAM CK DIV DAM, COLORADO NORTH CUNNINGHAM CREEK - CONCRETE DROP INLET WITH EMBANKMENT DIKE	8 (30 0)	3 7 (12 0)	13 7 (45 0)			(15)
FRYINGPAN-ARKANSAS PROJECT NORTH FORK DIVERSION DAM COLORADO NORTH FORK FRYINGPAN RIVER - CONCRETE DROP INLET WITH EMBANKMENT DIKE	8 (30 0)	4 0 (13 0)	19 8 (65 0)			(15)
FRYINGPAN-ARKANSAS PROJECT SAWYER DIVERSION DAM COLORADO SAWYER CREEK CONCRETE DROP INLET WITH DIKE	8 (30 0)	1 8 (6 0)	15 2 (50 0)	8 (1 0)	1973	
FRYINGPAN-ARKANSAS PROJECT SO CUNNINGHAM CK DIV DAM COLORADO SOUTH CUNNINGHAM CREEK - CONCRETE DROP INLET WITH EMBANKMENT DIKE	6 (20 0)	3 7 (12 0)	15 2 (50 0)			(15)
FRYINGPAN-ARKANSAS PROJECT SOUTH FORK DIVERSION DAM, COLORADO SOUTH FORK FRYINGPAN RIVER - CONCRETE OGEE WEIR, EMBANKMENT WING	6 1 (215 0)	4 0 (13 0)	61 0 (200 0)	8 (1 0)	1971	
GRAND VALLEY PROJECT GRAND VALLEY DIVERSION DAM, COLORADO COLORADO RIVER CONCRETE OGEE-GATED WEIR	47 4 (1675 0)	4 3 (14 0)	166 4 (546 0)	19 9 (26 0)	1916	
GRANTS PASS PROJECT SAVAGE RAPIDS DIVERSION DAM, OREGON ROGUE RIVER - CONCRETE GRAVITY AND MULTIPLE ARCH WEIR STOPLOGGED CREST	5 9 (207 0)	9 1 (30 0)	139 0 (456 0)	4 6 (6 0)	1955	(14)
HAMMOND PROJECT HAMMOND DIVERSION DAM, NEW MEXICO SAN JUAN RIVER - ROCKFILL OVERFLOW EMBANKMENT WINGS	2 6 (90 0)	3 7 (12 0)	417 6 (1370 0)	19 1 (25 0)	1962	
HUMBOLDT PROJECT UPPER SLAVIN DIVERSION DAM NEVADA HUMBOLDT RIVER SLAB AND BUTTRESS	8 (30 0)	2 4 (8 0)	26 8 (88 0)		1958	(6)
HUNTLEY PROJECT YELLOWSTONE RIVER DIVERSION DAM MONTANA YELLOWSTONE RIVER CONCRETE WEIR	17 0 (600 0)	2 4 (8 0)	99 1 (325 0)	1 5 (2 0)	1957	
KLAMATH PROJECT ANDERSON-ROSE DIVERSION DAM OREGON LOST RIVER - REINFORCED CONCRETE SLAB AND BUTTRESS	22 7 (800 0)	3 7 (12 0)	98 8 (324 0)	8 (1 0)	1921	
KLAMATH PROJECT LOST RIVER DIVERSION DAM OREGON LOST RIVER - CONCRETE MULTIPLE-ARCH WEIR EMBANKMENT WINGS	85 0 (3000 0)	7 9 (26 0)	205 7 (675 0)	15 3 (20 0)	1912	
KLAMATH PROJECT MALONE DIVERSION DAM OREGON LOST RIVER - CONCRETE GATE STRUCTURE EMBANKMENT WINGS	6 2 (220 0)	5 5 (18 0)	157 0 (515 0)	19 1 (25 0)	1923	
KLAMATH PROJECT MILLER DIVERSION DAM OREGON MILLER CREEK - CONCRETE WEIR REMOVABLE CREST EMBANKMENT WING	5 4 (190 0)	1 5 (5 0)	88 4 (290 0)	1 5 (2 0)	1924	
LEWISTON ORCHARDS PROJECT SWEETWATER DIVERSION DAM IDAHO SWEETWATER CREEK - ROCKFILL WEIR CONCRETE CREST WALL	2 2 (77 0)	2 4 (8 0)	24 4 (80 0)	6 1 (8 0)	1948	
LEWISTON ORCHARDS PROJECT WEBB CREEK DIVERSION DAM, IDAHO WEBB CREEK - ROCKFILL WEIR CONCRETE CREST WALL	6 (20 0)	3 0 (10 0)	22 9 (75 0)	8 (1 0)	1948	
LOWER YELLOWSTONE PROJECT LOWER YELLOWSTONE DIVERSION DAM MONTANA YELLOWSTONE RIVER - ROCKFILL TIMBER- CRIB WEIR EMBANKMENT WING	31 1 (1100 0)	1 2 (4 0)	21 3 (70 0)	17 6 (23 0)	1910	

Summary Tabulation of Diversion Dams - Continued

PROJECT DIVISION OR UNIT FEATURE. STATE. STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
MIDDLE RIO GRANDE PROJECT ANGOSTURA DIVERSION DAM, NEW MEXICO RIO GRANDE RIVER CONCRETE WEIR	18 4 (650 0)	1 5 (5 0)	243 8 (800 0)	1 5 (2 0)	1958	
MIDDLE RIO GRANDE PROJECT ISLETA DIVERSION DAM, NEW MEXICO RIO GRANDE RIVER CONCRETE GATE STRUCTURE	30 3 (1070 0)	1 5 (5 0)	205 4 (674 0)	3 1 (4 0)	1955	
MIDDLE RIO GRANDE PROJECT SAN ACACIA DIVERSION DAM NEW MEXICO RIO GRANDE RIVER CONCRETE GATE STRUCTURE	8 0 (283 0)	2 4 (8 0)	213 4 (700 0)	2 3 (3 0)	1958	
MILK RIVER PROJECT DODSON DIVERSION DAM, MONTANA MILK RIVER - TIMBER-CRIB, CONCRETE WEIR CAP, MOVABLE CREST, EMBANKMENT WING	19 8 (700 0)	7 0 (23 0)	2485 3 (8154 0)	66 5 (87 0)	1910	
MILK RIVER PROJECT PARADISE DIVERSION DAM, MONTANA MILK RIVER - CONCRETE OGEE OVERFLOW WEIR, EMBANKMENT	5 7 (200 0)	4 3 (14 0)	173 7 (570 0)	3 8 (5 0)	1966	
MILK RIVER PROJECT ST MARY DIVERSION DAM, MONTANA ST MARY RIVER CONCRETE WEIR	24 1 (850 0)	1 8 (6 0)	60 4 (198 0)	8 (1 0)	1915	
MILK RIVER PROJECT SWIFT CURRENT DIVERSION DAM, MONTANA SWIFT CURRENT CREEK - EARTH AND ROCK, TIMBER-CRIB CORE, NONOVERFLOW		4 0 (13 0)	1463 0 (4800 0)	74 9 (98 0)	1915	
MILK RIVER PROJECT VANDALIA DIVERSION DAM, MONTANA MILK RIVER - REINFORCED CONCRETE SLAB AND BUTTRESS WEIR MOVABLE CREST, EMBANKM	8 5 (300 0)	8 2 (27 0)	716 3 (2350 0)	11 5 (15 0)	1917	
MINIDOKA PROJECT CASCADE CREEK DIVERSION DAM, WYOMING CASCADE CREEK ROCKFILLED LOG-CRIB WEIR	6 2 (220 0)	1 8 (6 0)	66 1 (217 0)	2 3 (3 0)	1937	
MINIDOKA PROJECT CROSS CUT DIVERSION DAM, IDAHO HENRYS FORK RIVER - CONCRETE OGEE WEIR	16 7 (591 0)	3 0 (10 0)	139 3 (457 0)	5 4 (7 0)	1938	
MIRAGE FLATS PROJECT DUNLAP DIVERSION DAM NEBRASKA NIOBRARA RIVER - CONCRETE WEIR EMBANKMENT WING	6 2 (220 0)	1 8 (6 0)	175 9 (577 0)	4 6 (6 0)	1945	
MOON LAKE PROJECT DUCHESNE FEEDER CANAL DIV DAM, UTAH DUCHENSE RIVER - CONCRETE WEIR EMBANKMENT WINGS	5 7 (200 0)	1 8 (6 0)	67 1 (220 0)	3 1 (4 0)	1939	(3)
MOUNTAIN PARK PROJECT BRETCH DIVERSION DAM, OKLAHOMA ELK RIVER CONCRETE WEIR EARTH EMBANKMENT	28 3 (1000 0)	10 7 (35 0)	1576 4 (5172 0)	18 3 (24 0)	1978	
NEWLANDS PROJECT CARSON RIVER DIVERSION DAM, NEVADA CARSON RIVER CONCRETE GATE STRUCTURE	55 2 (1950 0)	4 3 (14 0)	73 5 (241 0)	2 3 (3 0)	1905	
NEWLANDS PROJECT DERBY DIVERSION DAM, NEVADA TRUCKEE RIVER - CONCRETE GATE STRUCTURE, EMBANKMENT WING	42 5 (1500 0)	4 6 (15 0)	405 7 (1331 0)	28 3 (37 0)	1905	
NORTH PLATTE PROJECT DRY SPOTTED TAIL DIVERSION DAM NEBRASKA DRY SPOTTED TAIL CREEK STEEL SHEET PILE AND EARTH		4 0 (13 0)	77 7 (255 0)	8 (1 0)	1954	
NORTH PLATTE PROJECT HORSE CREEK DIVERSION DAM WYOMING HORSE CREEK CONCRETE WEIR, EMBANKMENT WING	12 2 (430 0)	1 8 (6 0)	219 5 (720 0)	3 8 (5 0)	1923	
NORTH PLATTE PROJECT TUB SPRINGS CREEK DIVERSION DAM, NEBRASKA TUB SPRINGS CREEK STEEL SHEEL PILE AND EARTH		2 7 (9 0)	62 5 (205 0)	2 3 (3 0)	1954	
NORTH PLATTE PROJECT WHALEN DIVERSION DAM WYOMING NORTH PLATTE RIVER - CONCRETE OGEE WEIR, EMBANKMENT WINGS	104 8 (3700 0)	3 4 (11 0)	749 8 (2460 0)	62 7 (82 0)	1909	
OKANOGAN PROJECT SALMON CREEK DIVERSION DAM, WASHINGTON SALMON CREEK - CONCRETE OGEE WEIR EMBANKMENT WINGS	2 8 (100 0)	1 5 (5 0)	42 7 (140 0)	8 (1 0)	1906	

Summary Tabulation of Diversion Dams - Continued

PROJECT DIVISION OR UNIT FEATURE STATE STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
ORLAND PROJECT NORTHSIDE DIVERSION DAM CALIFORNIA STONY CREEK - CONCRETE WEIR REMOVABLE CREST	3 5 (125 0)	0 9 (3 0)	114 3 (375 0)	8 (1 0)	1913	
ORLAND PROJECT RAINBOW DIVERSION DAM CALIFORNIA STONY CREEK CONCRETE ARCH WEIR	5 7 (200 0)	8 8 (29 0)	82 6 (271 0)	1 5 (2 0)	1914	
PALO VERDE DIVERSION PROJECT PALO VERDE DIVERSION DAM ARIZ -CALIF COLORADO RIVER - CONCRETE OGEE-GATED WEIR EMBANKMENT WINGS	51 0 (1800 0)	14 0 (46 0)	396 2 (1300 0)	120 0 (157 0)	1957	
PAONIA PROJECT FIRE MOUNTAIN DIVERSION DAM COLORADO NORTH FORK GUNNISON RIVER TIMBER SHEET PILING ROCKFILL	5 1 (180 0)	3 4 (11 0)	57 0 (187 0)	1 5 (2 0)	1950	
PICK-SLOAN MISSOURI BASIN PROGRAM						
BOSTWICK DIV -COURTLAND &SUPERIOR COURTLAND UNITS SUPERIOR-COURTLAND DIVERSION DAM NEBRASKA REPUBLICAN RIVER CONCRETE OGEE WEIR EMBANK WINGS	25 2 (890 0)	2 4 (8 0)	1219 2 (4000 0)	136 9 (179 0)	1950	
FRENCHMAN-CAMBRIDGE DIV CAMBRIDGE UNIT CAMBRIDGE DIVERSION DAM NEBRASKA REPUBLICAN RIVER - CONCRETE OGEE WEIR EMBANKMENT WINGS	9 2 (325 0)	6 (2 0)	310 9 (1020 0)	14 5 (19 0)	1949	
FRENCHMAN-CAMBRIDGE DIV RED WILLOW UNIT BARTLEY DIVERSION DAM NEBRASKA REPUBLICAN RIVER - CONCRETE OGEE WEIR EMBANKMENT WINGS	3 7 (130 0)	9 (3 0)	944 9 (3100 0)	45 9 (60 0)	1954	
FRENCHMAN-CAMBRIDGE DIV - FRENCHMAN UNIT CULBERTSON DIV DAM NEBRASKA FRENCHMAN CREEK - CONCRETE GATE STRUCTURE EMBANKMENTS	11 3 (400 0)	2 1 (7 0)	9 1 (30 0)		1959	(3)
FRENCHMAN CAMBRIDGE DIV RED WILLOW UNIT RED WILLOW CREEK DIV DAM NEBRASK RED WILLOW CREEK - BAFFLED APRON WEIR EMBANKMENT WINGS	2 5 (90 0)	3 4 (11 0)	333 8 (1095 0)	26 8 (35 0)	1963	
JAMES DIVISION - OAHE UNIT JAMES DIVERSION DAM SOUTH DAKOTA JAMES RIVER - CONCRETE OVERFLOW WEIR EMBANKMENT WINGS	14 2 (500 0)	6 1 (20 0)	85 3 (280 0)	1 1 (1 5)	1964	(7)
KANASKA DIVISION - ALMENA UNIT ALMENA DIVERSION DAM KANSAS PRAIRIE DOG CREEK - CONCRETE WEIR EMBANKMENT WINGS	2 8 (100 0)	5 8 (19 0)	140 2 (460 0)	17 6 (23 0)	1967	
MIDDLE LOUP DIVISION - FARWELL UNIT ARCADIA DIVERSION DAM NEBRASKA MIDDLE LOUP RIVER - CONCRETE GATE STRUCTURE EMBANKMENT WINGS	24 1 (850 0)	2 4 (8 0)	2426 2 (7960 0)	10 7 (14 0)	1962	(8)
MIDDLE LOUP DIVISION - SARGENT UNIT MILBURN DIVERSION DAM NEBRASKA MIDDLE LOUP RIVER - CONCRETE OGEE GATED WEIR EMBANKMENT WINGS	7 4 (260 0)	4 0 (13 0)	1182 6 (3880 0)	53 5 (70 0)	1956	(8)
SOLOMON DIVISION - WEBSTER UNIT WOODSTON DIVERSION DAM KANSAS SOUTH FORK SOLOMON RIVER - CONCRETE OGEE WEIR EMBANKMENT WINGS	4 5 (160 0)	4 3 (14 0)	716 6 (2351 0)	55 0 (72 0)	1959	
THREE FORKS DIVISION EAST BENCH UNIT BARRETTS DIVERSION DAM MONTANA BEAVERHEAD RIVER CONCRETE GATE STRUCTURE EMBANKMENT WINGS	18 5 (652 0)	3 0 (10 0)	524 3 (1720 0)	9 9 (13 0)	1963	
WIND DIVISION RIVERTON UNIT WIND RIVER DIVERSION DAM WYOMING WIND RIVER CONCRETE OGEE WEIR EMBANKMENT WINGS	62 3 (2200 0)	5 8 (19 0)	751 0 (2464 0)	94 8 (124 0)	1923	
PROVO RIVER PROJECT DUCHESNE DIVERSION DAM UTAH NORTH FORK DUCHESNE RIVER - ROCKFILL WEIR CONCRETE CORE WALL	17 0 (600 0)	5 2 (17 0)	146 3 (480 0)	7 6 (10 0)	1952	
PROVO RIVER PROJECT MURDOCK DIVERSION DAM UTAH PROVO RIVER CONCRETE OGEE WEIR EMBANKMENT WINGS	15 6 (550 0)	5 8 (19 0)	112 8 (370 0)	6 9 (9 0)	1950	
PROVO RIVER PROJECT WEBER PROVO DIVERSION DAM UTAH WEBER RIVER - CONCRETE OGEE WEIR EMBANKMENT WINGS	28 3 (1000 0)	5 8 (19 0)	547 1 (1795 0)	11 5 (15 0)	1930	
RIO GRANDE PROJECT LEASBURG DIVERSION DAM NEW MEXICO RIO GRANDE RIVER CONCRETE OGEE WEIR EMBANKMENT WINGS	17 7 (625 0)	2 1 (7 0)	873 3 (2865 0)	17 6 (23 0)	1907	

Summary Tabulation of Diversion Dams - Continued

PROJECT, DIVISION, OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
RIO GRANDE PROJECT MESILLA DIVERSION DAM, NEW MEXICO RIO GRANDE RIVER - CONCRETE WEIR RADIAL GATE STRUCTURE	26 9 (950 0)	3 0 (10 0)	92 4 (303 0)	2 3 (3 0)	1916	(3)
RIO GRANDE PROJECT PERCHA DIVERSION DAM, NEW MEXICO RIO GRANDE RIVER - CONCRETE OGEE WEIR, EMBANKMENT WINGS	9 9 (350 0)	2 4 (8 0)	829 1 (2720 0)	32 9 (43 0)	1918	
RIO GRANDE PROJECT RIVERSIDE DIVERSION DAM, TEXAS RIO GRANDE RIVER - CONCRETE WEIR RADIAL GATE STRUCTURE	25 5 (900 0)	2 4 (8 0)	81 4 (267 0)	2 3 (3 0)	1928	(3)
ROGUE RIVER BASIN PROJECT ANTELOPE CREEK DIVERSION DAM, OREGON ANTELOPE CREEK STREAM DROP INLET	1 4 (50 0)	2 1 (7 0)	31 7 (104 0)	8 (1 0)	1966	
ROGUE RIVER BASIN PROJECT ASHLAND LATERIAL DIVERSION DAM, OREGON EMIGRANT CREEK - CONCRETE OGEE WEIR, EARTH DIKE	1 4 (48 0)	1 5 (5 0)	22 6 (74 0)	2 3 (3 0)	1959	(3)
ROGUE RIVER BASIN PROJECT BEAVER DAM CREEK DIVERSION DAM, OREGON BEAVER DAM CREEK ROCKFILL, CONCRETE CORE WALL	1 8 (65 0)	1 2 (4 0)	51 2 (168 0)	8 (1 0)	1960	
ROGUE RIVER BASIN PROJECT CONDE CREEK DIVERSION DAM, OREGON CONDE CREEK CONCRETE AND ROCKFILL WEIR	7 (25 0)	1 2 (4 0)	33 2 (109 0)	8 (1 0)	1958	
ROGUE RIVER BASIN PROJECT DALEY CREEK DIVERSION DAM, OREGON DALEY CREEK ROCKFILL, TIMBER CORE WALL	7 (25 0)	1 2 (4 0)	34 1 (112 0)	8 (1 0)	1960	
ROGUE RIVER BASIN PROJECT DEAD INDIAN DIVERSION DAM, OREGON DEAD INDIAN CREEK CONCRETE AND ROCKFILL WEIR	2 4 (86 0)	1 2 (4 0)	39 9 (131 0)	1 5 (2 0)	1958	
ROGUE RIVER BASIN PROJECT DRY CREEK DIVERSION DAM, OREGON DRY CREEK CONCRETE WEIR, STOPLOGGED CREST	1 4 (50 0)	2 7 (9 0)	10 1 (33 0)		1967	
ROGUE RIVER BASIN PROJECT LITTLE BEAVER CREEK DIVERSION DAM,OREGON LITTLE BEAVER CREEK CONCRETE CORE WALL, ROCKFILL	7 (24 0)	2 7 (9 0)	24 4 (80 0)	8 (1 0)	1959	
ROGUE RIVER BASIN PROJECT OAK STREET DIVERSION DAM, OREGON BEAR CREEK CONCRETE WEIR, STOPLOGGED CREST	2 1 (75 0)	1 5 (5 0)	40 5 (133 0)	2 3 (3 0)	1961	
ROGUE RIVER BASIN PROJECT PHOENIX CANAL DIVERSION DAM, OREGON BEAR CREEK CONCRETE WEIR, STOPLOGGED CREST	2 9 (102 0)	1 5 (5.0)	54 9 (180 0)	1 5 (2 0)	1960	
ROGUE RIVER BASIN PROJECT SODA CREEK DIVERSION DAM, OREGON SODA CREEK EARTHFILL	3 (11.0)	4 0 (13 0)	131 1 (430 0)	7 6 (10 0)	1959	(9)
ROGUE RIVER BASIN PROJECT SOUTH FORK LITTLE BUTTE CREEK DIV DAM, OREGON, SOUTH FORK LITTLE BUTTE CREEK ROCKFILL, TIMBER CORE WALL	1 8 (65 0)	1 2 (4 0)	121 9 (400 0)	3 8 (5 0)	1960	
SAN JUAN-CHAMA PROJECT BLANCO DIVERSION DAM, COLORADO BLANCO RIVER - CONCRETE OGEE WEIR, EMBANKMENT WINGS	14 7 (520 0)	5 5 (17 9)	61 0 (200 0)	17 6 (23 0)	1969	
SAN JUAN- CHAMA PROJECT LITTLE OSO DIVERSION DAM, COLORADO LITTLE NAVAJO RIVER CONCRETE OGEE WEIR	4 2 (150 0)	4 4 (14 3)	89 9 (295 0)	5 4 (7 0)	1970	
SAN JUAN-CHAMA PROJECT OSO DIVERSION DAM, COLORADO NAVAJO RIVER - CONCRETE OGEE WEIR, EMBANKMENT WING	18 4 (650 0)	7 0 (23 0)	240 8 (790 0)	24 5 (32 0)	1970	
SALT RIVER PROJECT GRANITE REEF DIVERSION DAM, ARIZONA SALT RIVER - CONCRETE OGEE WEIR, EMBANKMENT WINGS	101 9 (3600 0)	5 5 (18 0)	343 8 (1128 0)	26 8 (35 0)	1908	
SHOSHONE PROJECT CORBETT DIVERSION DAM, WYOMING SHOSHONE RIVER - CONCRETE-SLAB AND BUTTRESS WEIR, EMBANKMENT WINGS	28 3 (1000 0)	3 7 (12 0)	285 9 (938 0)	7 6 (10 0)	1908	

Summary Tabulation of Diversion Dams - Continued

PROJECT DIVISION OR UNIT FEATURE STATE STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
SHOSHONE PROJECT WILLWOOD DIVERSION DAM WYOMING SHOSHONE RIVER - CONCRETE GRAVITY OGEE WEIR, EMBANKMENT WINGS	9 1 (320 0)	12 5 (41 0)	145 1 (476 0)	16 8 (22 0)	1924	
SMITH FORK PROJECT SMITH FORK DIVERSION DAM, COLORADO SMITH FORK CREEK - CONCRETE OGEE WEIR, EMBANKMENT WINGS	2 3 (80 0)	3 0 (10 0)	240 8 (790 0)	4 6 (6 0)	1962	
SOLANO PROJECT PUTAH DIVERSION DAM, CALIFORNIA PUTAH CREEK - CONCRETE OGEE-GATED WEIR, EMBANKMENT WING	27 1 (956 0)	3 0 (10 0)	277 4 (910 0)	19 3 (25 3)	1959	
STRAWBERRY VALLEY PROJECT INDIAN CREEK CROSSING DIV DAM UTAH INDIAN CREEK EARTH	21 2 (750 0)	1 5 (5 0)	411 5 (1350 0)	11 5 (15 0)	1913	
STRAWBERRY VALLEY PROJECT SPANISH FORK DIVERSION DAM UTAH SPANISH FORK CONCRETE OGEE WEIR	14 2 (500 0)	4 0 (13 0)	22 6 (74 0)	8 (1 0)	1908	
SUN RIVER PROJECT FORT SHAW DIVERSION DAM MONTANA SUN RIVER ROCK OVERFLOW	6 4 (225 0)	2 7 (9 0)	121 9 (400 0)	2 3 (3 0)	1908	
SUN RIVER PROJECT SUN RIVER DIVERSION DAM, MONTANA NORTH FORK SUN RIVER CONCRETE WEIR ARCH	39 6 (1400 0)	34 7 (114 0)	79 6 (261 0)	5 4 (7 0)	1915	
UMATILLA PROJECT FEED CANAL DIVERSION DAM, OREGON UMATILLA RIVER - CONCRETE, ROCK AND TIMBER WEIR EMBANKMENT WINGS	9 9 (350 0)	1 2 (4 0)	640 1 (2100 0)	10 7 (14 0)	1907	
UMATILLA PROJECT MAXWELL DIVERSION DAM, OREGON UMATILLA RIVER - CONCRETE AND TIMBER-CRIB WEIR, EMBANKMENT WINGS	4 0 (140 0)	1 2 (4 0)	121 9 (400 0)	8 (1 0)	1912	
UMATILLA PROJECT THREE MILE FALLS DIVERSION DAM, OREGON UMATILLA RIVER CONCRETE MULTIPLE ARCH WEIR	10 6 (375 0)	7 0 (23 0)	278 9 (915 0)	3 8 (5 0)	1914	
UNCOMPAHGRE PROJECT EAST CANAL DIVERSION DAM, COLORADO UNCOMPAHGRE RIVER - CONCRETE WEIR EMBANKMENT WINGS	9 3 (330 0)	2 4 (8 0)	232 9 (764 0)	8 (1 0)	1940	
UNCOMPAHGRE PROJECT GARNET DIVERSION DAM COLORADO UNCOMPAHGRE RIVER - ROCKFILL WEIR CONCRETE SURFACED	2 1 (75 0)	1 2 (4 0)	22 9 (75 0)	8 (1 0)	1914	(3)
UNCOMPAHGRE PROJECT GUNNISON DIVERSION DAM, COLORADO GUNNISON RIVER - TIMBER-CRIB WEIR, CONCRETE WINGS REMOVABLE CREST	28 3 (1000 0)	3 0 (10 0)	74 4 (244 0)	2 3 (3 0)	1912	
UNCOMPAHGRE PROJECT IRONSTONE DIVERSION DAM COLORADO UNCOMPAHGRE RIVER - CONCRETE GATE STRUCTURE	9 9 (350 0)	4 0 (13 0)	36 6 (120 0)	8 (1 0)	1962	
UNCOMPAHGRE PROJECT LOUTZENHIZER DIVERSION DAM COLORADO UNCOMPAHGRE RIVER - BROADCRESTED CONCRETE WEIR CONCRETE APRON	8 2 (290 0)	2 7 (9 0)	34 7 (114 0)		1970	(3-6)
UNCOMPAHGRE PROJECT MONTROSE AND DELTA DIV DAM COLORADO UNCOMPAHGRE RIVER GATED SPILLWAY	15 6 (550 0)	2 4 (8 0)	57 9 (190 0)	4 6 (6 0)	1963	
UNCOMPAHGRE PROJECT SELIG DIVERSION DAM COLORADO UNCOMPAHGRE RIVER - PILE AND TIMBER WEIR CONCRETE APRON REMOVABLE CREST	9 1 (320 0)	3 0 (10 0)	29 3 (96 0)	8 (1 0)	1914	
VALE PROJECT BULLY CREEK DIVERSION DAM OREGON BULLY CREEK ROCKFILL WITH TIMBER CUTOFF	8 (27 0)	1 2 (4 0)	64 9 (213 0)	3 1 (4 0)	1964	
VALE PRJECT HARPER DIVERSION DAM OREGON MALHEUR RIVER - CONCRETE GATE STRUCTURE EMBANKMENT WINGS	18 7 (662 0)	3 7 (12 0)	278 6 (914 0)	6 9 (9 0)	1929	
VERMEJO PROJECT VERMEJO DIVERSION DAM NEW MEXICO VERMEJO RIVER - CONCRETE SLAB AND BUTTRESS WEIR EMBANKMENT WINGS	17 0 (600 0)	1 5 (5 0)	311 2 (1021 0)	3 1 (4 0)	1955	

Summary Tabulation of Diversion Dams - Continued

PROJECT, DIVISION OR UNIT FEATURE, STATE, STREAM TYPE OF STRUCTURE	DIVERSION CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	HYDRAULIC HEIGHT METERS (FT)	CREST LENGTH METERS (FT)	VOLUME THOUSAND CUBIC M (THOUSAND CUBIC YD)	CALENDAR YEAR COMPLETED	FOOTNOTES
VENTURA RIVER PROJECT ROBLES DIVERSION DAM, CALIFORNIA VENTURA RIVER - ROCKFILL WEIR, TIMBER CUTOFF WALL	14 2 (500 0)	4 0 (13 0)	161 5 (530 0)	8 4 (11 0)	1958	(3-10)
WASHOE PROJECT MARBLE BLUFF DIVERSION DAM NEVADA TRUCKEE RIVER ZONED EARTHFILL	1 4 (50 0)	6 7 (22 0)	494 4 (1622 0)	159 0 (208 0)	1975	(12)
WEBER BASIN PROJECT OGDEN VALLEY DIVERSION DAM, UTAH SOUTH FORK OGDEN RIVER GATED SPILLWAY	2 8 (100 0)	1 8 (6 0)	45 7 (150 0)		1964	
WEBER BASIN PROJECT SLATERVILLE DIVERSION DAM, UTAH WEBER RIVER - CONCRETE GATE STRUCTURE, EMBANKMENT WINGS	44 5 (1570 0)	2 4 (8 0)	49 4 (162 0)	1 5 (2 0)	1957	
WEBER BASIN PROJECT STODDARD DIVERSION DAM, UTAH WEBER RIVER CONCRETE GATE STRUCTURE	19 8 (700 0)	2 4 (8 0)	33 5 (110 0)	1 5 (2 0)	1956	
YAKIMA PROJECT EASTON DIVERSION DAM, WASHINGTON YAKIMA RIVER - CONCRETE GRAVITY OGEE WEIR, MOVABLE CREST	34 0 (1200 0)	13 1 (43 0)	75 6 (248 0)	4 6 (6 0)	1929	(1)
YAKIMA PROJECT PROSSER DIVERSION DAM, WASHINGTON YAKIMA RIVER CONCRETE WEIR	42 5 (1500 0)	2 1 (7 0)	201 5 (661 0)	2 3 (3 0)	1933	(3)
YAKIMA PROJECT ROZA DIVERSION DAM, WASHINGTON YAKIMA RIVER CONCRETE WEIR, MOVABLE CREST	62 3 (2200 0)	10 4 (34 0)	148 1 (486 0)	16 8 (22 0)	1939	
YAKIMA PROJECT SUNNYSIDE DIVERSION DAM, WASHINGTON YAKIMA RIVER - CONCRETE OGEE WEIR, EMBANKMENT WINGS	37 4 (1320 0)	1 8 (6 0)	152 4 (500 0)	1 5 (2 0)	1907	(3)
YAKIMA PROJECT TIETON DIVERSION DAM, WASHINGTON TIETON RIVER - CONCRETE WEIR, EMBANKMENT WINGS	9 1 (320 0)	9 (3 0)	155 4 (510 0)	8 (1 0)	1908	
YUMA PROJECT LAGUNA DIVERSION DAM, ARIZONA-CALIFORNIA COLORADO RIVER - ROCKFILL WEIR CONCRETE SURFACED	56 6 (2000 0)	3 0 (10 0)	1456 9 (4780 0)	372 3 (487 0)	1909	(3-4)

DEFINITIONS

DIVERSION CAPACITY	AMOUNT DIVERTED AT CANAL HEADWORKS
HYDRAULIC HEIGHT	DISTANCE BETWEEN ORIGINAL STREAMBED AND HIGHEST CONTROLLED WATER SURFACE
CREST LENGTH	EXTENT OF BARRIER IN DAM AND INTEGRAL FEATURES CONSTRUCTED BETWEEN NATURAL ABUTMENTS, EXCEPT AS INDICATED IN FOOTNOTE (3)
VOLUME	SPACE OCCUPIED BY ALL MATERIAL IN DAM AND ITS APPURTENANT FEATURES
YEAR COMPLETED	DATE ORIGINAL CONSTRUCTION COMPLETED EXCEPT AS INDICATED IN FOOTNOTE (5)

CONVERSION TO ENGLISH SYSTEM

CUBIC METERS PER SECOND TIMES 35 31 EQUALS CUBIC FEET PER SECOND
METERS TIMES 3 2808 EQUALS FEET
CUBIC METERS TIMES 1 3079 EQUALS CUBIC YARDS

FOOTNOTES

(1) DIVERSION AND STORAGE STRUCTURE
(2) NOT YET IN OPERATION
(3) CREST LENGTH OF WEIR ONLY
(4) DIVERSION OUTLETS CLOSED IN JUNE 1948 NOW SERVES AS PROTECTION FOR IMPERIAL DAM
(5) DATE INDICATES WATER AND POWER RESOURCES SERVICE REHABILITATION WORK
(6) VOLUME LESS THAN 1000 CUBIC METERS
(7) SUPPLEMENTAL STORAGE OF MUNICIPAL WATER SUPPLY FOR CITY OF HURON, SOUTH DAKOTA
(8) CREST LENGTH AND VOLUME INCLUDES DESILTING WORKS
(9) DIVERSION CAPACITY LESS THAN 1 CUBIC METER PER SECOND
(10) VOLUME OF WEIR ONLY
(11) THIS DAM REPLACES PREVIOUSLY EXISTING SERVICE STRUCTURE OF SAME NAME
(12) EMBANKMENT VOLUME ONLY
(13) CONSTRUCTED UNDER PUBLIC LAW 84-575
(14) INCLUDES 3 CMS (107 CFS) PUMPING CAPACITY
(15) UNDER CONNSTRUCTION

Summary Tabulation of Carriage Facilities (Canals)

PROJECT, DIVISION, OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
BALMORHEA PROJECT INLET FEEDER CANAL	4.5 (2.8)	2.8 (100.0)	1.2 (4.0)	.6 (2.0)	1-1/4:1	1946-1947	
BALMORHEA PROJECT PHANTOM LAKE CANAL	6.8 (4.2)	.7 (25.0)	.9 (3.0)	.7 (2.4)	1-1/4:1	1946-1947	
BELLE FOURCHE PROJECT INLET CANAL	10.1 (6.3)	46.3 (1635.0)	12.2 (40.0)	3.0 (10.0)	1:1	1905-1906	
BELLE FOURCHE PROJECT NORTH CANAL	69.2 (43.0)	17.0 (600.0)				1908-1916	
BELLE FOURCHE PROJECT SOUTH CANAL	71.6 (44.5)	9.2 (325.0)				1906-1910	
BITTER ROOT PROJECT BITTER ROOT IRR. DISTRICT CANAL	107.8 (67.0)	9.3 (330.0)	6.7 (22.0)	1.6 (5.3)	1-1/2:1	1907-1910	
BOISE PROJECT "A" LINE CANAL	53.1 (33.0)	6.4 (226.0)	3.7 (12.0)	1.6 (5.4)	1-1/2:1	1938-1940	
BOISE PROJECT "C" LINE EAST CANAL	33.8 (21.0)	13.3 (469.0)	4.9 (16.0)	2.3 (7.5)	1-1/2:1	1946-1948	
BOISE PROJECT "C" LINE WEST CANAL	38.6 (24.0)	1.7 (60.0)	2.1 (7.0)	.9 (3.0)	1-1/2:1	1946-1947	
BOISE PROJECT "D" LINE CANAL	62.8 (39.0)	7.2 (254.0)	3.7 (12.0)	1.6 (5.4)	1-1/2:1	1938-1940	
BOISE PROJECT BLACK CANYON CANAL	46.7 (29.0)	36.8 (1300.0)				1936-1940	
BOISE PROJECT DEER FLAT HIGH LINE CANAL	35.4 (22.0)	3.7 (130.0)	6.1 (20.0)	1.1 (3.5)	1-1/2:1	1909-1910	
BOISE PROJECT DEER FLAT LOW LINE CANAL	59.1 (36.7)	34.0 (1200.0)	13.7 (45.0)	1.8 (6.0)	1-1/2:1	1907-1908	
BOISE PROJECT GOLDEN GATE CANAL	30.3 (18.8)	14.2 (500.0)	12.2 (40.0)	1.0 (3.4)	1-1/2:1	1908-1909	
BOISE PROJECT MORA CANAL	90.0 (55.9)	36.8 (1300.0)	16.8 (55.0)	1.4 (4.5)	1-1/2:1	1909-1911	
BOISE PROJECT MAIN SOUTH SIDE (NEW YORK) CANAL	64.4 (40.0)	79.3 (2800.0)	21.3 (70.0)	2.4 (8.0)	1-1/2:1	1906-1908	
BOISE PROJECT NOTUS CANAL	40.2 (25.0)	3.4 (120.0)	4.9 (16.0)	.9 (3.0)	1-1/2:1	1919-1920	
BOULDER CANYON PROJECT - ALL-AMERICAN CANAL SYSTEM - ALL-AMERICAN CANAL	128.7 (80.0)	429.1 (15155.0)	48.8 (160.0)	6.3 (20.6)	1-3/4:1	1934-1940	
BOULDER CANYON PROJECT - ALL-AMERICAN CANAL SYSTEM - COACHELLA CANAL	199.6 (124.0)	70.8 (2500.0)	18.3 (60.0)	3.1 (10.3)	2:1	1938-1948	
BOULDER CANYON PROJECT - ALL AMERICAN CANAL SYSTEM - COACHELLA CANAL RELOCATION	77.9 (48.4)	43.9 (1550.0)	4.9 (16.0)	3.2 (10.4)	1-1/2:1	1979	(7)
BUFFALO RAPIDS PROJECT FALLON MAIN CANAL	4.8 (3.0)	2.0 (72.0)	1.8 (6.0)	1.1 (3.7)	1-1/2:1	1946-1948	
BUFFALO RAPIDS PROJECT FALLON RELIFT CANAL	5.6 (3.5)	1.0 (34.0)	1.2 (4.0)	.8 (2.7)	1-1/2:1	1946-1948	
BUFFALO RAPIDS PROJECT GLENDIVE CANAL	54.9 (34.1)	9.3 (330.0)	4.0 (13.0)	2.1 (7.0)	1-1/2:1	1937-1941	
BUFFALO RAPIDS PROJECT SHIRLEY MAIN CANAL	21.4 (13.3)	3.0 (105.0)	2.4 (8.0)	1.2 (4.0)	1-1/2:1	1940-1943	
BUFFALO RAPIDS PROJECT TERRY MAIN CANAL	12.4 (7.7)	1.7 (60.0)	1.5 (5.0)	1.1 (3.5)	1-1/2:1	1940-1944	
BUFORD-TRENTON PROJECT MAIN CANAL	18.5 (11.5)	7.1 (250.0)	3.7 (12.0)	1.8 (5.9)	1-1/2:1	1940-1942	
CARLSBAD PROJECT BLACK RIVER CANAL	16.4 (10.2)	2.3 (80.0)	2.4 (8.0)	.6 (2.0)	1-1/4:1	1906	(3)
CARLSBAD PROJECT EAST CANAL	10.1 (6.3)	1.0 (35.0)	.9 (3.0)	.7 (2.2)	1-1/4:1	1906	(3)
CARLSBAD PROJECT MAIN CANAL	39.6 (24.6)	12.7 (450.0)	13.7 (45.0)	1.4 (4.5)	1-1/2:1	1906-1907	(3)
CENTRAL ARIZONA PROJECT - GRANITE REEF AQUEDUCT (REACHES 5A, 9, 10, 11)	91.1 (56.6)	85.0 (3000.0)	7.3 (24.0)	5.0 (16.4)	1-1/2:1	1974-1978	(2)
CENTRAL UTAH PROJECT BOTTLE HOLLOW INLET CHANNEL	.5 (.3)	1.4 (50.0)	1.8 (6.0)	.8 (2.6)	2:1	1969-1970	
CENTRAL UTAH PROJECT STARVATION FEEDER CONDUIT OUTLET CHANNEL	.3 (.2)	8.5 (300.0)	4.3 (14.0)	1.6 (5.1)	3:1	1967-1968	
CENTRAL UTAH PROJECT STEINAKER FEEDER CANAL	4.5 (2.8)	11.3 (400.0)	4.9 (16.0)	1.9 (6.1)	2:1	1960-1961	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION, OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
CENTRAL UTAH PROJECT STEINAKER SERVICE CANAL	18 7 (11 6)	7 2 (255 0)	5 5 (18 0)	1 4 (4 6)	2 1	1961-1962	
CENTRAL UTAH PROJECT - STRAWBERRY AQUEDUCT - OUTLET CHANNEL NO 2	1 6 (1 0)	17 6 (620 0)	5 5 (18 0)	2 7 (8 8)	1-1 2 1	1968-1971	
CENTRAL VALLEY PROJECT CLAYTON CANAL	7 7 (4 8)	1 1 (38 0)	1 2 (4 0)	7 (2 2)	1-1 4 1	1947-1948	
CENTRAL VALLEY PROJECT COALINGA CANAL	18 7 (11 6)	31 1 (1100 0)	3 7 (12 0)	3 4 (11 3)	1-1 2 1	1968-1973	
CENTRAL VALLEY PROJECT CONTRA COSTA CANAL	76 8 (47 7)	9 9 (350 0)	7 3 (24 0)	2 0 (6 5)	3 1	1937-1948	
CENTRAL VALLEY PROJECT CORNING CANAL	33 8 (21 0)	14 2 (500 0)	6 7 (22 0)	2 2 (7 2)	2 1	1954-1959	
CENTRAL VALLEY PROJECT CORNING CANAL PUMPING PLANT INTAKE CHANNEL	8 (5)	14 2 (500 0)	9 1 (30 0)	1 7 (5 5)	3 1	1959-1960	
CENTRAL VALLEY PROJECT DELTA CROSS CHANNEL	1 9 (1 2)	99 1 (3500 0)	64 0 (210 0)	7 9 (26 0)	3 1	1950-1951	
CENTRAL VALLEY PROJECT DELTA-MENDOTA CANAL	186 2 (115 7)	130 3 (4600 0)	30 5 (100 0)	4 4 (14 3)	3 1	1946-1951	
CENTRAL VALLEY PROJECT FOLSOM SOUTH CANAL	43 0 (26 7)	99 1 (3500 0)	10 4 (34 0)	5 4 (17 8)	1-1/2 1	1970-1973	
CENTRAL VALLEY PROJECT FRIANT KERN CANAL	243 3 (151 2)	113 3 (4000 0)	11 0 (36 0)	4 7 (15 5)	1-1 4 1	1945-1951	
CENTRAL VALLEY PROJECT MADERA CANAL	57 8 (35 9)	28 3 (1000 0)	6 1 (20 0)	2 8 (9 2)	1-1 2 1	1940-1945	
CENTRAL VALLEY PROJECT O'NEILL FOREBAY INLET CHANNEL	8 (5)	118 9 (4200 0)	24 4 (80 0)		1-1/2 1	1965-1966	
CENTRAL VALLEY PROJECT PACHECO INLET CHANNEL	2 4 (1 5)	19 0 (670 0)	6 1 (20 0)		4 1	1965-1968	
CENTRAL VALLEY PROJECT PLEASANT INTAKE CHANNEL	2 6 (1 6)	32 3 (1140 0)	3 7 (12 0)	3 6 (11 8)	1-1/2 1	1968-1969	
CENTRAL VALLEY PROJECT SAN LUIS CANAL	163 0 (101 3)	371 0 (13100 0)	33 5 (110 0)	10 0 (32 8)	2 1	1963-1968	
CENTRAL VALLEY PROJECT TEHAMA-COLUSA CANAL	132 8 (82 5)	71 6 (2530 0)	7 3 (24 0)	4 8 (15 8)	1-1 2 1	1965-1978	(1)
CENTRAL VALLEY PROJECT TEHAMA-COLUSA CANAL	47 5 (29 5)	59 5 (2100 0)	4 3 (14 0)	4 8 (15 8)	1-1 2 1	1979	(7)
CENTRAL VALLEY PROJECT YGNACIO CANAL	8 4 (5 2)	8 (30 0)	1 5 (5 0)	6 (1 9)	1-1 2 1	1947-1948	
CHIEF JOSEPH DAM PROJECT - OROVILLE TONASKET UNIT - MAIN CANAL	5 3 (3 3)	5 7 (200 0)	3 0 (10 0)	1 3 (4 4)	1-1 2 1	1965-1968	(3)
CHIEF JOSEPH DAM PROJECT - OROVILLE TONASKET UNIT - MAIN CANAL EXTENSION	8 (5)	5 7 (200 0)	3 0 (10 0)	1 3 (4 4)	1-1 2 1	1965-1966	
CHIEF JOSEPH DAM PROJECT - WHITESTONE COULEE UNIT - NORTH BRANCH CANAL	4 8 (3 0)	2 (8 0)	9 (3 0)	5 (1 7)	1-1 2 1	1973-1976	(4)
CHIEF JOSEPH DAM PROJECT - WHITESTONE COULEE UNIT - SPECTACLE LAKE CANAL	7 7 (4 8)	9 (32 0)	1 2 (4 0)	6 (1 9)	1-1 2 1	1973-1976	(4)
CHIEF JOSEPH DAM PROJECT - WHITESTONE COULEE UNIT - WHITESTONE FLATS CANAL	3 7 (2 3)	4 (15 0)	9 (3 0)	4 (1 2)	1-1 2 1	1973-1976	(4)
COLLBRAN PROJECT EAST FORK FEEDER CANAL	2 1 (1 3)	1 0 (35 0)	1 2 (4 0)	7 (2 4)	1-1 2 1	1961-1962	
COLLBRAN PROJECT LEON-PARK FEEDER CANAL	4 5 (2 8)	9 9 (350 0)	3 7 (12 0)	1 8 (5 8)	1-1 2 1	1960-1961	
COLLBRAN PROJECT SOUTHSIDE CANAL	52 8 (32 8)	6 8 (240 0)	4 9 (16 0)	1 3 (4 4)	1-1 2 1	1959-1960	
COLORADO-BIG THOMPSON PROJECT BOULDER CREEK SUPPLY CANAL	25 3 (15 7)	5 7 (200 0)	3 7 (12 0)	1 4 (4 6)	1-1 2 1	1953-1955	
COLORADO-BIG THOMPSON PROJECT CHARLES HANSEN CANAL	8 2 (5 1)	42 5 (1500 0)	9 8 (32 0)	3 3 (10 8)	1-1 2 1	1950-1952	
COLORADO-BIG THOMPSON PROJECT - CHARLES HANSEN FEEDER CANAL - FLATIRON SECTION	6 1 (3 8)	26 3 (930 0)	4 0 (13 0)	2 7 (8 8)	1-1 4 1	1949-1953	
COLORADO-BIG THOMPSON PROJECT - CHARLES HANSEN FEEDER CANAL - HORSETOOTH SECTION	15 1 (9 4)	15 6 (550 0)	2 1 (7 0)	2 5 (8 2)	1-1 4 1	1949-1953	
COLORADO-BIG THOMPSON PROJECT DIXON FEEDER CANAL	4 8 (3 0)	2 (8 0)	9 (3 0)	3 (1 0)	1-1 2 1	1950	
COLORADO-BIG THOMPSON PROJECT ELLIOTT CREEK FEEDER CANAL	1 8 (1 1)	2 5 (90 0)	1 2 (4 0)	6 (2 0)	2 1	1943	
COLORADO-BIG THOMPSON PROJECT FLATIRON CANAL	5 (3)	27 2 (960 0)	6 1 (20 0)	5 7 (18 8)	1-1 2 1	1951-1953	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT DIVISION OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
COLORADO-BIG THOMPSON PROJECT GRANBY PUMP CANAL	2 9 (1 8)	31 1 (1100 0)	6 1 (20 0)	3 2 (10 5)	2 1	1949-1950	
COLORADO-BIG THOMPSON PROJECT NORTH POUDRE SUPPLY CANAL	20 1 (12 5)	7 1 (250 0)	4 3 (14 0)	1 7 (5 6)	1/2 1	1951-1953	
COLORADO-BIG THOMPSON PROJECT POLE HILL CANAL	8 (5)	15 6 (550 0)	2 1 (7 0)	2 3 (7 4)	1-1/4 1	1952	
COLORADO-BIG THOMPSON PROJECT ST VRAIN SUPPLY CANAL	15 8 (9 8)	17 7 (625 0)	2 1 (7 0)	1 8 (6 0)	1-1/4 1	1952-1954	
COLORADO-BIG THOMPSON PROJECT SOUTH PLATTE SUPPLY CANAL	51 8 (32 2)	6 5 (230 0)	6 1 (20 0)	1 0 (3 2)	2 1	1954-1956	
COLORADO-BIG THOMPSON PROJECT WILLOW CREEK FEEDER CANAL	5 5 (3 4)	11 3 (400 0)	4 3 (14 0)	2 1 (6 9)	1-1/2 1	1951-1953	
COLORADO-BIG THOMPSON PROJECT WINDSOR EXTENSION CANAL	8 (5)	7 1 (250 0)	2 1 (7 0)	1 7 (5 6)	1-1/4 1	1952	
COLUMBIA BASIN PROJECT EAST LOW CANAL	132 6 (82 4)	127 4 (4500 0)	20 7 (68 0)	4 7 (15 5)	1-1/2 1	1946-1954	
COLUMBIA BASIN PROJECT ELTOPIA BRANCH CANAL	40 7 (25 3)	15 7 (555 0)	6 1 (20 0)	2 0 (6 6)	1-1/2 1	1953-1954	
COLUMBIA BASIN PROJECT FEEDER CANAL	2 3 (1 4)	453 1 (16000 0)	15 2 (50 0)	7 6 (25 0)	1-1/2 1	1946-1951	
COLUMBIA BASIN PROJECT MAIN CANAL	20 8 (12 9)	373 8 (13200 0)	15 2 (50 0)	6 3 (20 7)	1-1/2 1	1946-1951	
COLUMBIA BASIN PROJECT POTHOLES EAST CANAL	100 4 (62 4)	110 4 (3900 0)	14 6 (48 0)	4 8 (15 9)	1-1/2 1	1949-1953	
COLUMBIA BASIN PROJECT ROYAL BRANCH CANAL	13 7 (8 5)	25 5 (900 0)	11 3 (37 0)	2 2 (7 2)	1-1/2 1	1956-1957	
COLUMBIA BASIN PROJECT WAHLUKE BRANCH CANAL	66 3 (41 2)	43 0 (1520 0)	3 7 (12 0)	3 2 (10 4)	1-1/2 1	1957-1967	
COLUMBIA BASIN PROJECT WEST CANAL	132 3 (82 2)	144 4 (5100 0)	11 6 (38 0)	5 0 (16 4)	1-1/2 1	1946-1955	
CROOKED RIVER PROJECT DISTRIBUTION CANAL	25 4 (15 8)	2 9 (102 0)	2 7 (9 0)	1 1 (3 6)	1-1/2 1	1960-1961	
CROOKED RIVER PROJECT DIVERSION CANAL	13 4 (8 3)	4 5 (160 0)	3 7 (12 0)	1 2 (4 1)	1-1/2 1	1960-1961	
DESCHUTES PROJECT HAYSTACK FEEDER CANAL	8 (5)	19 9 (703 0)	9 8 (32 0)	2 0 (6 4)	1-1/2 1	1956-1957	
DESCHUTES PROJECT NORTH UNIT MAIN CANAL	104 6 (65 0)	28 3 (1000 0)	18 3 (60 0)	1 7 (5 6)	1-1/2 1	1938-1948	
EDEN PROJECT EDEN CANAL	17 4 (10 8)	13 5 (475 0)	5 5 (18 0)	1 6 (5 2)	2 1	1952-1955	
EDEN PROJECT LITTLE SANDY CANAL	6 4 (4 0)	4 2 (150 0)				1957	
EDEN PROJECT MEANS CANAL	9 7 (6 0)	18 0 (635 0)	8 5 (28 0)	2 1 (6 9)	1-1/2 1	1952	
EMERY COUNTY PROJECT COTTONWOOD CREEK-HUNTINGTON CANAL	26 9 (16 7)	4 7 (165 0)	3 7 (12 0)	1 2 (4 0)	2 1	1963-1965	
EMERY COUNTY PROJECT HUNTINGTON NORTH RESERVOIR FEEDER CANAL	5 (3)	2 8 (100 0)	2 4 (8 0)	1 0 (3 4)	2 1	1965-1966	
EMERY COUNTY PROJECT HUNTINGTON NORTH SERVICE CANAL	5 6 (3 5)	1 0 (35 0)	1 8 (6 0)	6 (2 1)	2 1	1965-1966	
FLORIDA PROJECT FLORIDA CANAL	3 2 (2 0)	4 2 (150 0)	3 0 (10 0)	1 2 (3 8)	2 1	1962-1963	(3)
FLORIDA PROJECT FLORIDA CANAL ENLARGEMENT	2 9 (1 8)	4 2 (150 0)	3 0 (10 0)	1 2 (3 8)	2 1	1962-1963	
FLORIDA PROJECT FLORIDA FARMERS DITCH	6 3 (3 9)	5 2 (185 0)	3 7 (12 0)	1 2 (4 0)	2 1	1962-1963	
FORT SUMNER PROJECT HIGH LINE CANAL	13 5 (8 4)	6 (20 0)	1 2 (4 0)	6 (1 9)	1-1 2 1	1950-1951	
FORT SUMNER PROJECT MAIN CANAL	26 4 (16 4)	2 8 (100 0)	1 8 (6 0)	1 3 (4 4)	1-1 4 1	1950-1951	
FRENCHTOWN PROJECT MAIN CANAL	27 4 (17 0)	4 9 (172 0)	3 7 (12 0)	1 3 (4 4)	1-1/2 1	1935-1936	
FRUITGROWERS DAM PROJECT DRY CREEK DIVERSION DITCH	4 8 (3 0)	2 8 (100 0)	2 4 (8 0)	7 (2 4)	1-1 2 1	1940	
FRUITLAND MESA PROJECT GOULD CANAL (REHABILITATION)	2 6 (1 6)	2 7 (96 0)	3 0 (10 0)	9 (3 1)	2 1	1972	(7)

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION, OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
GILA PROJECT "A" CANAL	21 9 (13 6)	17 6 (620 0)	2 4 (8 0)	3 1 (10 1)	1-1/2 1	1941-1942	
GILA PROJECT "B" CANAL	15 0 (9 3)	7 9 (280 0)	2 4 (8 0)	1 9 (6 3)	1-1/2 1	1941-1942	
GILA PROJECT DOME CANAL	20 9 (13 0)	6 2 (220 0)	2 1 (7 0)	1 5 (5 0)	1-1/4 1	1953-1954	
GILA PROJECT GILA GRAVITY MAIN CANAL	32 2 (20 0)	62 3 (2200 0)	6 7 (22 0)	4 1 (13 5)	2 1	1936-1939	
GILA PROJECT MOHAWK CANAL	75 3 (46 8)	25 5 (900 0)	3 7 (12 0)	3 4 (11 3)	1-1/4 1	1950-1953	
GILA PROJECT NORTH GILA CANAL	17 5 (10 9)	7 1 (250 0)	12 8 (42 0)	9 (3 0)	2 1	1909-1912	
GILA PROJECT SOUTH GILA VALLEY CANAL	12 4 (7 7)	3 1 (11 0)	1 5 (5 0)	1 3 (4 2)	1-1/2 1	1963-1965	
GILA PROJECT TEXAS HILL CANAL	15 8 (9 8)	3 5 (125 0)	1 5 (5 0)	1 5 (5 0)	1-1/4 1	1955-1956	
GILA PROJECT WELLTON CANAL	32 0 (19 9)	8 5 (300 0)	2 1 (7 0)	2 0 (6 5)	1-1/4 1	1951-1953	
GILA PROJECT WELLTON MOHAWK CANAL	29 8 (18 5)	36 8 (1300 0)	4 9 (16 0)	3 9 (12 8)	1-1/4 1	1949-1951	
GRAND VALLEY PROJECT GOVERNMENT HIGH LINE CANAL	88 5 (55 0)	47 4 (1675 0)	10 4 (34 0)	3 2 (10 5)	2 1	1912-1917	
GRAND VALLEY PROJECT ORCHARD MESA CANAL NO 1	24 9 (15 5)	2 4 (85 0)	2 4 (8 0)	9 (3 1)	1-1/2 1		
GRAND VALLEY PROJECT ORCHARD MESA CANAL NO 2	25 9 (16 1)	1 8 (65 0)	2 1 (7 0)	9 (2 8)	1-1/2 1		
GRAND VALLEY PROJECT ORCHARD MESA POWER CANAL	5 6 (3 5)	22 7 (800 0)	6 1 (20 0)	3 0 (9 8)	1 1	1922-1924	
HAMMOND PROJECT HAMMOND MAIN CANAL	44 1 (27 4)	2 5 (90 0)	3 0 (10 0)	1 0 (3 2)	1-1/2 1	1960-1962	
HUNTLEY PROJECT HIGH LINE CANAL	19 3 (12 0)	2 8 (100 0)					
HUNTLEY PROJECT MAIN CANAL	51 8 (32 2)	20 7 (730 0)				1906-1908	
HUNTLEY PROJECT RESERVOIR LINE CANAL	16 1 (10 0)	8 (30 0)					
HYRUM PROJECT HYRUM-MENDON CANAL	22 5 (14 0)	2 5 (89 0)	1 2 (4 0)	9 (3 0)	1-1/2 1	1934-1935	
HYRUM PROJECT HYRUM FEEDER CANAL	2 1 (1 3)	3 (9 0)	1 2 (4 0)	3 (1 1)	1-1/2 1	1934-1935	
HYRUM PROJECT WELLSVILLE CANAL	8 7 (5 4)	4 (15 0)	1 2 (4 0)	5 (1 5)	1-1/2 1	1934-1935	
KENDRICK PROJECT CASPER CANAL	94 3 (58 6)	34 0 (1200 0)	10 4 (34 0)	3 0 (9 8)	1-1/2 1	1934-1939	
KLAMATH PROJECT "A" CANAL	14 0 (8 7)	32 6 (1150 0)	13 4 (44 0)	3 4 (11 0)	1/2 1	1906-1907	
KLAMATH PROJECT "B" CANAL	6 6 (4 1)	8 2 (290 0)	4 9 (16 0)	1 8 (6 0)	1/2 1	1906-1912	
KLAMATH PROJECT "C" CANAL	21 7 (13 5)	9 3 (330 0)	9 8 (32 0)	2 7 (9 0)	2 1	1907-1908	
KLAMATH PROJECT "C-G" CANAL	1 4 (9)	11 3 (400 0)	7 6 (25 0)		2 1	1921	(6)
KLAMATH PROJECT "D" CANAL	29 9 (18 6)	8 5 (300 0)	6 7 (22 0)	1 6 (5 3)	2 1	1913-1914	(3)
KLAMATH PROJECT "E" CANAL	16 9 (10 5)	1 0 (35 0)	1 8 (6 0)	7 (2 2)	1-1/2 1	1912	
KLAMATH PROJECT "F" CANAL	18 7 (11 6)	2 5 (90 0)	3 0 (10 0)	1 4 (4 7)	1-1/2 1	1912	
KLAMATH PROJECT "G" CANAL	13 7 (8 5)	11 3 (400 0)	6 7 (22 0)	2 0 (6 5)	2 1	1913-1915	(3)
KLAMATH PROJECT "J" CANAL	37 7 (23 4)	22 7 (800 0)	7 9 (26 0)	2 9 (9 5)	1-1/2 1	1921	
KLAMATH PROJECT "M" CANAL	10 5 (6 5)	2 8 (100 0)	1 2 (4 0)	1 3 (4 2)	1-1/2 1	1947-1948	
KLAMATH PROJECT "N" CANAL	42 6 (26 5)	8 5 (300 0)	9 8 (32 0)		2 1	1935-1966	(6)

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT DIVISION OR UNIT / NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
KLAMATH PROJECT "P" CANAL	2 9 (1 8)	5 7 (200 0)	4 9 (16 0)	1 9 (6 3)	1-1 2 1	1941-1942	
KLAMATH PROJECT "P-1" CANAL	14 5 (9 0)	7 1 (250 0)	4 9 (16 0)	1 9 (6 3)	1-1 2 1	1941-1942	
KLAMATH PROJECT "Q" CANAL	6 3 (3 9)	3 7 (130 0)	3 0 (10 0)	1 6 (5 1)	2 1	1960	
KLAMATH PROJECT "R" CANAL	5 1 (3 2)	2 2 (76 0)	2 4 (8 0)	1 3 (4 2)	2 1	1960	
KLAMATH PROJECT LOST RIVER DIVERSION CHANNEL	12 6 (7 8)	85 0 (3000 0)	18 3 (60 0)		2 1	1911-1912	(6)
KLAMATH PROJECT NORTH CANAL	23 2 (14 4)	5 4 (190 0)				1924-1925	
KLAMATH PROJECT WEST CANAL	19 5 (12 1)	5 4 (190 0)				1924-1925	
LEWISTON ORCHARDS PROJECT SWEETWATER CANAL	14 5 (9 0)	1 4 (50 0)	2 4 (8 0)	1 0 (3 2)	1-1 2 1	1948	(3)
LEWISTON ORCHARDS PROJECT WEBB CREEK CANAL	4 0 (2 5)	6 (20 0)	1 8 (6 0)	6 (1 9)	1-1 2 1	1947-1948	(3)
LOWER RIO GRANDE REHABILITATION PROJECT LA FERIA DIVISION - MAIN CANAL	28 3 (17 6)	1 6 (56 0)	1 5 (5 0)	1 4 (4 6)	1-1 2 1	1962-1963	(3)
LOWER RIO GRANDE REHABILITATION PROJECT MERCEDES DIVISION - MAIN CANAL	21 7 (13 5)	20 7 (730 0)	17 7 (58 0)	3 0 (10 0)	1-1 2 1	1963-1964	(3)
LOWER YELLOWSTONE PROJECT MAIN CANAL	115 2 (71 6)	34 0 (1200 0)	9 1 (30 0)	3 0 (9 8)	1-1 2 1	1905-1909	
MANCOS PROJECT INLET CANAL	4 2 (2 6)	7 3 (258 0)	3 7 (12 0)	1 4 (4 5)	1-1 2 1	1944-1949	
MANCOS PROJECT OUTLET CANAL	3 5 (2 2)	5 9 (207 0)	3 7 (12 0)	1 2 (4 0)	1-1 2 1	1943-1950	
MICHAUD FLATS PROJECT MAIN EAST CANAL	16 1 (10 0)	2 5 (88 0)	3 0 (10 0)	1 0 (3 3)	2 1	1957-1958	
MICHAUD FLATS PROJECT MAIN CANAL WEST	15 3 (9 5)	1 1 (38 0)	2 1 (7 0)	1 2 (3 9)	1-1 2 1	1956-1958	
MIDDLE RIO GRANDE PROJECT ALBUQUERQUE MAIN CANAL	5 (3)	11 3 (400 0)				1954-1961	(3)
MIDDLE RIO GRANDE PROJECT ATRISCO FEEDER CANAL	20 8 (12 9)	7 1 (250 0)				1954-1961	(3)
MIDDLE RIO GRANDE PROJECT SAN JUAN FEEDER CANAL	8 2 (5 1)	4 0 (140 0)				1954-1961	(3)
MILK RIVER PROJECT BOWDOIN CANAL	29 0 (18 0)	5 0 (175 0)	3 0 (10 0)	8 (2 5)	2 1	1915-1917	
MILK RIVER PROJECT DODSON NORTH CANAL	45 1 (28 0)	5 7 (200 0)	3 8 (12 4)	1 5 (5 0)	2 1	1912-1914	
MILK RIVER PROJECT DODSON PUMP CANAL	12 1 (7 5)	8 (30 0)	1 5 (5 0)	9 (2 8)	1 1	1946	
MILK RIVER PROJECT DODSON SOUTH CANAL	69 2 (43 0)	14 2 (500 0)	12 8 (42 0)	1 5 (4 8)	2 1	1914-1915	
MILK RIVER PROJECT NELSON NORTH CANAL	1 6 (1 0)	7 1 (250 0)	12 2 (40 0)	1 6 (5 2)	2 1	1915	
MILK RIVER PROJECT NELSON SOUTH CANAL	43 5 (27 0)	14 2 (500 0)	5 5 (18 0)	1 0 (3 2)	1-1 2 1	1915-1917	
MILK RIVER PROJECT ST MARY CANAL	47 2 (29 3)	24 1 (850 0)	7 9 (26 0)	2 7 (9 0)	2 1	1907-1915	
MILK RIVER PROJECT VANDALIA SOUTH CANAL	74 7 (46 4)	8 5 (300 0)	1 5 (5 0)	1 5 (5 0)	1-1 2 1	1913-1915	
MINIDOKA PROJECT CROSS CUT CANAL	10 6 (6 6)	16 7 (591 0)	7 9 (26 0)	1 7 (5 7)	1-1 2 1	1936-1938	
MINIDOKA PROJECT DIVERSION CANAL	1 1 (7)	6 (20 0)	3 0 (10 0)	1 5 (5 0)	1-1 2 1	1937	
MINIDOKA PROJECT MILNER-GOODING CANAL	112 7 (70 0)	76 5 (2700 0)	15 2 (50 0)	3 8 (12 6)	1-1 2 1	1928-1932	
MINIDOKA PROJECT NORTH SIDE CANAL	12 9 (8 0)	48 1 (1700 0)				1905-1907	
MINIDOKA PROJECT SOUTH SIDE CANAL	20 9 (13 0)	37 5 (1325 0)	17 4 (57 0)	2 3 (7 5)	1-1 4 1	1905-1907	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT DIVISION, OR UNIT / NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
MINIDOKA PROJECT UNIT "A" MAIN CANAL	7 1 (4 4)	6 8 (240 0)	4 3 (14 0)	1 4 (4 5)	2 1	1954-1955	
MIRAGE FLATS PROJECT MIRAGE FLATS CANAL	21 2 (13 2)	6 2 (220 0)	4 9 (16 0)	1 3 (4 2)	1-1 2 1	1941-1946	
MISSOULA VALLEY PROJECT BIG FLAT CANAL	15 0 (9 3)	7 (25 0)	1 5 (5 0)	7 (2 2)	1-1 2 1	1945-1949	
MOON LAKE PROJECT DUCHESNE FEEDER CANAL	24 1 (15 0)	5 7 (200 0)	4 3 (14 0)	1 0 (3 4)	1-1 2 1	1934-1935	
MOON LAKE PROJECT YELLOWSTONE FEEDER CANAL	36 2 (22 5)	2 5 (88 0)	2 1 (7 0)	9 (3 0)	1-1 2 1	1938-1940	
MOUNTAIN PARK PROJECT BRETCH DIVERSION CANAL	15 9 (9 9)	28 3 (1000 0)	3 0 (10 0)	2 9 (9 6)	1-1 2 1	1975	
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	19 5 (12 1)	51 0 (1800 0)	7 0 (23 0)	3 7 (12 0)	1-1 2 1	1965-1975	(2)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	2 4 (1 5)	51 0 (1800 0)	6 1 (20 0)	4 5 (14 9)	1-1 4 1	1965-1968	(2-5)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	3 4 (2 1)	46 0 (1625 0)	6 4 (21 0)	3 5 (11 6)	1-1 2 1	1972-1975	(1-2)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	5 6 (3 5)	46 0 (1625 0)	6 4 (21 0)	3 5 (11 6)	1-1 2 1	1974-1976	(2)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	10 0 (6 2)	42 5 (1500 0)	6 1 (20 0)	3 4 (11 3)	1-1 2 1	1974-1976	(2)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	15 6 (9 7)	51 0 (1800 0)	7 0 (23 0)	3 6 (11 8)	1-1 2 1	1970	(7)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	5 6 (3 5)	46 0 (1625 0)	6 4 (21 0)	3 5 (11 6)	1-1 2 1	1974	(7)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	10 0 (6 2)	42 5 (1500 0)	6 1 (20 0)	3 4 (11 3)	1-1 2 1	1974	(7)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	3 7 (2 3)	38 4 (1355 0)	5 5 (18 0)	3 4 (11 2)	1-1 2 1	1975	(7)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL	5 (3)	36 4 (1285 0)	5 5 (18 0)	3 3 (10 9)	1-1 2 1	1975	(7)
NAVAJO INDIAN IRRIGATION PROJECT GRAVITY MAIN CANAL	1 8 (1 1)	36 4 (1285 0)	5 5 (18 0)	3 3 (10 9)	1-1 2 1	1975	(7)
NAVAJO INDIAN IRRIGATION PROJECT GRAVITY MAIN CANAL	10 8 (6 7)	19 0 (670 0)	3 7 (12 0)	2 7 (8 9)	1-1 2 1	1975	(7)
NAVAJO INDIAN IRRIGATION PROJECT GRAVITY MAIN CANAL	1 4 (9)	17 3 (610 0)	3 0 (10 0)	2 7 (9 0)	1-1 2 1	1975	(7)
NAVAJO INDIAN IRRIGATION PROJECT GRAVITY MAIN CANAL	7 6 (4 7)	7 8 (275 0)	2 1 (7 0)	1 8 (6 0)	1-1/2 1	1975	(7)
NEWLANDS PROJECT "T" CANAL	14 5 (9 0)	11 3 (400 0)	3 0 (10 0)	1 8 (6 0)	2 1	1904-1905	
NEWLANDS PROJECT TRUCKEE CANAL	36 2 (22 5)	42 5 (1500 0)	6 1 (20 0)	4 0 (13 0)	1 2 1	1903-1905	
NEWLANDS PROJECT "V" CANAL	43 5 (27 0)	42 5 (1500 0)	6 7 (22 0)	3 7 (12 0)	2 1	1904-1905	
NEWTON PROJECT EAST CANAL	3 2 (2 0)	3 (9 0)	9 (3 0)	3 (1 0)	1-1/2 1	1946-1947	
NEWTON PROJECT HIGHLINE CANAL	6 4 (4 0)	5 (18 0)	9 (3 0)	3 (1 0)	1-1/2 1	1946-1947	
NEWTON PROJECT MAIN CANAL	1 0 (6)	7 (25 0)	1 2 (4 0)	5 (1 8)	1-1/2 1	1946-1947	
NORTH PLATTE PROJECT FORT LARAMIE CANAL	206 8 (128 5)	42 5 (1500 0)	13 7 (45 0)	2 7 (9 0)	2 1	1915-1924	
NORTH PLATTE PROJECT HIGH LINE CANAL	56 3 (35 0)	4 5 (160 0)	3 7 (12 0)	1 4 (4 5)	2 1	1910-1913	
NORTH PLATTE PROJECT INTERSTATE CANAL	152 2 (94 6)	62 3 (2200 0)	13 4 (44 0)	3 0 (10 0)	1-1 2 1	1905-1915	
NORTH PLATTE PROJECT LOW LINE CANAL	68 9 (42 8)	9 7 (343 0)	4 9 (16 0)	1 8 (6 0)	2 1	1913-1914	
NORTH PLATTE PROJECT NORTHPORT CANAL	43 5 (27 0)	7 1 (250 0)	6 1 (20 0)	1 6 (5 2)	2 1	1919-1923	
NORTH PLATTE PROJECT RESERVOIR SUPPLY CANAL	7 4 (4 6)	13 9 (492 0)	6 7 (22 0)	1 8 (6 0)	2 1	1910-1913	
OGDEN RIVER PROJECT OGDEN-BRIGHAM CANAL	38 9 (24 2)	3 4 (120 0)	1 2 (4 0)	9 (3 1)	1-1/4 1	1935-1937	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION, OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
OGDEN RIVER PROJECT SOUTH OGDEN HIGHLINE CANAL	8 4 (5 2)	1 0 (35 0)	6 (1 9)	6 (2 0)	1-1/4 1	1936-1937	
OKANOGAN PROJECT HIGH LINE CANAL	19 3 (12 0)		3 0 (10 0)	8 (2 5)	1-1/2 1	1911-1917	
OKANOGAN PROJECT LOW LINE CANAL	9 7 (6 0)		9 (3 0)	5 (1 5)	1-1/2 1	1911-1917	
OKANOGAN PROJECT MAIN CANAL	3 2 (2 0)	2 8 (100 0)	3 0 (10 0)	9 (3 0)	1-1/2 1	1911-1917	
OKANOGAN PROJECT NORTH FORK SALMON CREEK FEEDER CANAL	3 (2)						
ORLAND PROJECT EAST PARK FEED CANAL	11 3 (7 0)	7 1 (250 0)	1 8 (6 0)	1 8 (6 0)	1 1	1913-1915	
ORLAND PROJECT NORTH CANAL	7 7 (4 8)	3 5 (125 0)	4 3 (14 0)	1 2 (4 1)	1-1/2 1	1913	
ORLAND PROJECT SOUTH CANAL	15 4 (9 6)	7 4 (260 0)	5 5 (18 0)	1 2 (3 8)	1-1/2 1	1912-1916	
OWYHEE PROJECT NORTH CANAL	99 0 (61 5)	33 7 (1190 0)	7 3 (24 0)	3 3 (10 9)	1-1/2 1	1930-1936	
OWYHEE PROJECT SOUTH CANAL	59 5 (37 0)	13 9 (490 0)	4 9 (16 0)	2 2 (7 1)	1-1/2 1	1930-1936	
PAONIA PROJECT FIRE MOUNTAIN CANAL	55 8 (34 7)	5 7 (200 0)	3 0 (10 0)	1 2 (4 0)	1-1/2 1	1949-1953	(3)
PICK-SLOAN MISSOURI BASIN PROGRAM BIGHORN BASIN DIV - HANOVER-BLUFF UNIT BLUFF CANAL	11 7 (7 3)	2 6 (93 0)	3 0 (10 0)	1 0 (3 2)	1-1/2 1	1957	(3)
BIGHORN BASIN DIV - HANOVER-BLUFF UNIT MAIN CANAL NO 1	2 9 (1 8)	4 (15 0)	1 2 (4 0)	5 (1 5)	1-1/2 1	1956-1957	
BIGHORN BASIN DIV - HANOVER-BLUFF UNIT MAIN CANAL NO 2	21 1 (13 1)	2 7 (97 0)	3 0 (10 0)	1 0 (3 4)	1-1/2 1	1956-1957	
BIGHORN BASIN DIV - HANOVER-BLUFF UNIT UPPER HANOVER CANAL	20 9 (13 0)	13 8 (487 0)	4 3 (14 0)	1 8 (5 9)	2 1	1956	(3)
BIGHORN BASIN DIV - OWL CREEK UNIT LUCERNE PUMPING DITCH	1 1 (7)	2 7 (94 0)	2 4 (8 0)	9 (3 0)	1-1/2 1	1956	
BIGHORN BASIN DIV - OWL CREEK UNIT LUCERNE RELIFT CANAL	5 0 (3 1)	1 2 (44 0)	2 1 (7 0)	6 (2 1)	1-1/2 1	1956	
BOSTWICK DIVISION COURTLAND CANAL	89 5 (55 6)	21 3 (751 0)	7 9 (26 0)	2 6 (8 5)	1-1/2 1	1949-1959	
BOSTWICK DIVISION COURTLAND PUMP CANAL 3A	2 4 (1 5)	4 (15 0)	1 2 (4 0)	6 (2 0)	1-1/2 1	1967-1968	
BOSTWICK DIVISION COURTLAND PUMP CANAL 3B	1 3 (8)	3 (9 0)	9 (3 0)	5 (1 5)	1-1/2 1	1967-1968	
BOSTWICK DIVISION COURTLAND WEST CANAL	17 1 (10 6)	5 7 (200 0)	3 7 (12 0)	1 6 (5 2)	2 1	1957-1958	
BOSTWICK DIVISION FRANKLIN CANAL	77 1 (47 9)	6 5 (230 0)	4 3 (14 0)	1 5 (4 8)	1-1/2 1	1952-1956	
BOSTWICK DIVISION FRANKLIN SOUTHSIDE CANAL	7 9 (4 9)	1 2 (42 0)	1 8 (6 0)	8 (2 6)	1-1/2 1	1951-1953	
BOSTWICK DIVISION MILLER CANAL	13 4 (8 3)	5 4 (190 0)	4 9 (16 0)	1 4 (4 6)	2 1	1957-1958	
BOSTWICK DIVISION NAPONEE CANAL	14 5 (9 0)	8 (30 0)	1 8 (6 0)	6 (2 0)	1-1/2 1	1953-1955	
BOSTWICK DIVISION NORTH CANAL	10 1 (6 3)	1 4 (50 0)	2 4 (8 0)	8 (2 6)	1-1/2 1	1954-1955	
BOSTWICK DIVISION PUMP NO 1 CANAL	8 5 (5 3)	1 0 (36 0)	1 8 (6 0)	8 (2 6)	1-1/2 1	1960-1961	
BOSTWICK DIVISION PUMP NO 1 SOUTH CANAL	2 4 (1 5)	4 (15 0)	9 (3 0)	5 (1 7)	1-1/2 1	1910-1961	
BOSTWICK DIVISION PUMP NO 4 CANAL	3 4 (2 1)	7 (24 0)	1 5 (5 0)		1-1/2 1	1960-1961	
BOSTWICK DIVISION PUMP NO 4 WEST CANAL	1 6 (1 0)	4 (15 0)	9 (3 0)	6 (2 0)	1-1/2 1	1960-1961	
BOSTWICK DIVISION RIDGE CANAL	9 7 (6 0)	2 5 (90 0)	3 7 (12 0)	1 0 (3 4)	1-1/2 1	1954-1955	
BOSTWICK DIVISION SUPERIOR CANAL	48 3 (30 0)	3 9 (139 0)	4 0 (13 0)	1 2 (4 0)	1-1/2 1	1949-1951	
BOSTWICK DIVISION WHITE ROCK CANAL (AND EXTENSIONS)	23 8 (14 8)	2 8 (100 0)	3 7 (12 0)	1 2 (4 0)	1-1/2 1	1958-1961	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION, OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM (CONTINUED) CHEYENNE DIVISION - ANGOSTURA UNIT ANGOSTURA MAIN CANAL	47 8 (29 7)	8 2 (290 0)	4 3 (14 0)	1 6 (5 2)	2 1	1951-1953	
FRENCHMAN-CAMBRIDGE DIVISION BARTLEY CANAL	31 2 (19 4)	3 7 (130 0)	4 0 (13 0)	9 (2 8)	1-1/2 1	1953-1954	
FRENCHMAN-CAMBRIDGE DIVISION CAMBRIDGE CANAL	79 2 (49 2)	9 2 (325 0)	4 9 (16 0)	1 6 (5 2)	1-1/2 1	1948-1954	
FRENCHMAN-CAMBRIDGE DIVISION FRENCHMAN UNIT - CULBERTSON CANAL (AND EXTENSIONS)	78 2 (48 6)	11 3 (400 0)	6 1 (20.0)	1 9 (6 2)	2 1	1959-1961	(3)
FRENCHMAN-CAMBRIDGE DIVISION DRIFTWOOD CANAL (AND EXTENSIONS)	49 7 (30 9)	6 4 (225 0)	4 3 (14 0)	1 5 (5 0)	1-1/2 1	1957-1959	
FRENCHMAN-CAMBRIDGE DIVISION MEEKER EXTENSION CANAL	17 1 (10 6)	2 5 (90 0)	3 0 (10 0)	1 0 (3 2)	1-1/2 1	1957-1959	
FRENCHMAN-CAMBRIDGE DIVISION RED WILLOW CANAL	38 8 (24 1)	2 5 (90 0)	3 0 (10 0)	1 2 (3 8)	1-1/2 1	1961-1964	
FRENCHMAN-CAMBRIDGE DIVISION UPPER MEEKER CANAL AND SUB-CANAL	34 6 (21 5)	8 0 (284 0)	4 9 (16 0)	1 5 (5 0)	1-1/2 1	1956-1957	
GARRISON DIV - GARRISON DIVERSION UNIT - MCCLUSKY CANAL	118 4 (73 6)	55 2 (1950 0)	7 6 (25 0)	5 3 (17 3)	2 1	1970	(7)
HELENA-GREAT FALLS DIVISION HELENA VALLEY CANAL	51 0 (31 7)	8 5 (300 0)	4 3 (14 0)	1 7 (5 5)	1-1/2 1	1957-1958	
JAMES DIVISION - OAHE UNIT PIERRE CANAL	58 4 (36 3)	40 8 (1440 0)	13 4 (44 0)	3 4 (11 0)	2 1	1976	(7)
KANASKA DIVISION - ALMENA UNIT ALMENA MAIN CANAL	32 2 (20 0)	2 8 (100 0)	4 3 (14 0)	1 1 (3 6)	1-1/2 1	1965-1967	
KANASKA DIVISION - ALMENA UNIT ALMENA SOUTH CANAL	13 4 (8 3)	1 0 (36 0)	2 1 (7 0)	8 (2 6)	1-1/2 1	1965-1967	
MIDDLE LOUP DIVISION - FARWELL UNIT FARWELL CENTRAL CANAL	29 8 (18 5)	4 8 (170 0)	4 3 (14 0)	1 2 (4 1)	2 1	1961-1963	
MIDDLE LOUP DIVISION - FARWELL UNIT FARWELL MAIN AND LOWER MAIN CANAL	60 3 (37 5)	27 2 (960 0)	9 8 (32 0)	2 7 (9 0)	2 1	1961-1963	
MIDDLE LOUP DIVISION - FARWELL UNIT FARWELL SOUTH AND UPPER SOUTH CANAL	63 9 (39 7)	9 6 (340 0)	6 1 (20 0)	1 8 (5 9)	2 1	1963-1965	
MIDDLE LOUP DIVISION - FARWELL UNIT SHERMAN FEEDER CANAL	30 7 (19 1)	24 1 (850 0)	8 5 (28 0)	2 6 (8 5)	2 1	1960-1962	
MIDDLE LOUP DIVISION - SARGENT UNIT SARGENT CANAL	63 7 (39 6)	7 4 (260 0)	4 6 (15 0)	1 6 (5 1)	2 1	1955-1958	
NORTH DAKOTA PUMPING DIV - FORT CLARK UNIT CANAL "A"	5 8 (3 6)	3 (10 0)	9 (3 0)	5 (1 6)	1-1/2 1	1952-1953	
NORTH DAKOTA PUMPING DIV - FORT CLARK UNIT CANAL "B"	10 3 (6 4)	8 (30 0)	1 2 (4 0)	8 (2 5)	1-1 2 1	1952-1953	
SANDHILLS DIVISION - AINSWORTH UNIT AINSWORTH CANAL	85 1 (52 9)	16 4 (580 0)	2 7 (9 0)	2 2 (7 2)	2 1	1961-1965	
SMOKY HILLS DIV - CEDAR BLUFF UNIT CEDAR BLUFF CANAL	29 1 (18 1)	3 5 (125 0)	3 7 (12 0)	1 2 (4 1)	2 1	1961-1963	
SOLOMON DIVISION - KIRWIN UNIT KIRWIN MAIN CANAL	21 6 (13 4)	5 0 (175 0)	4 3 (14 0)	1 5 (4 8)	1-1/2 1	1956-1957	
SOLOMON DIVISION - KIRWIN UNIT KIRWIN NORTH CANAL	23 0 (14 3)	2 0 (70 0)	2 7 (9 0)	1 2 (4 0)	1-1/2 1	1956-1957	
SOLOMON DIVISION - KIRWIN UNIT KIRWIN SOUTH CANAL	29 6 (18 4)	1 7 (60 0)	3 0 (10 0)	8 (2 7)	1-1 2 1	1957-1958	
SOLOMON DIVISION - WEBSTER UNIT OSBORNE CANAL	52 5 (32 6)	4 6 (161 0)	3 7 (12 0)	1 3 (4 2)	2 1	1961-1963	
THREE FORKS DIV - CROW CREEK PUMP UNIT LOMBARD CANAL	4 8 (3 0)	1 7 (60 0)	2 1 (7 0)	9 (2 8)	1-1/2 1	1953-1954	
THREE FORKS DIV - CROW CREEK PUMP UNIT TOSTON CANAL	12 6 (7 8)	2 8 (100 0)	2 4 (8 0)	1 0 (3 4)	1-1/2 1	1953-1954	
THREE FORKS DIV - EAST BENCH UNIT EAST BENCH CANAL	71 1 (44 2)	12 5 (440 0)	6 1 (20 0)	2 0 (6 6)	2 1	1961-1964	
WIND DIVISION - RIVERTON UNIT PILOT CANAL	61 5 (38 2)	28 3 (1000 0)	9 1 (30 0)	3 0 (10 0)	2 1	1926-1947	
WIND DIVISION - RIVERTON UNIT WYOMING CANAL	100 4 (62 4)	62 3 (2200 0)	19 8 (65 0)	3 0 (10 0)	1-1/2 1	1920-1851	
YELLOWSTONE DIVISION - SAVAGE UNIT MAIN CANAL	12 6 (7 8)	1 2 (44 0)	1 5 (5 0)	9 (2 8)	1-1/2 1	1949	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT DIVISION OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM (CONTINUED)							
PROVO RIVER PROJECT PROVO RESERVOIR CANAL	37 0 (23 0)	15 6 (550 0)	4 3 (14 0)	1 3 (4 3)	1-1/4 1	1940-1950	(3)
PROVO RIVER PROJECT WEBER-PROVO DIVERSION CANAL	14 5 (9 0)	28 3 (1000 0)	7 3 (24 0)	2 2 (7 3)	1-3/4 1	1929-1930	
RATHDRUM PRAIRIE PROJECT MAIN CANAL	14 5 (9 0)	1 7 (60 0)	2 1 (7 0)	1 0 (3 2)	2 1	1945-1946	
RIO GRANDE PROJECT - POST FALLS UNIT EAST SIDE CANAL	21 7 (13 5)	8 5 (300 0)	7 3 (24 0)	1 0 (3 2)	1-1/2 1	1918-1919	
RIO GRANDE PROJECT - POST FALLS UNIT FRANKLIN CANAL	45 7 (28 4)	9 2 (325 0)	7 3 (24 0)	1 5 (5 0)	1/2 1	1914-1915	(3)
RIO GRANDE PROJECT - POST FALLS UNIT LEASBURG CANAL	22 0 (13 7)	17 7 (625 0)	10 4 (34 0)	1 2 (4 0)	1 1	1906-1908	
RIO GRANDE PROJECT - POST FALLS UNIT RINCON VALLEY MAIN CANAL	45 2 (28 1)	9 9 (350 0)	6 7 (22 0)	1 3 (4 2)	2 1	1916-1919	
RIO GRANDE PROJECT - POST FALLS UNIT RIVERSIDE CANAL	27 7 (17 2)	25 5 (900 0)	25 6 (84 0)	1 2 (4 0)	1-1/2 1	1927-1940	
RIO GRANDE PROJECT - POST FALLS UNIT TORNILLO CANAL	19 3 (12 0)	9 2 (325 0)	7 9 (26 0)	1 6 (5 4)	1-1/2 1	1923-1924	
RIO GRANDE PROJECT - POST FALLS UNIT WEST SIDE CANAL	37 8 (23 5)	18 4 (650 0)	15 8 (52 0)	9 (3 0)	1-1/2 1	1914-1915	
ROGUE RIVER BASIN PROJECT AGATE FEEDER CANAL	2 4 (1 5)	1 4 (50 0)	2 1 (7 0)	9 (2 9)	1-1/2 1	1965-1966	
ROGUE RIVER BASIN PROJECT ASHLAND CANAL	27 2 (16 9)	1 4 (48 0)	1 8 (6 0)	9 (2 8)	1-1/2 1	1957	(3)
ROGUE RIVER BASIN PROJECT DALEY CREEK COLLECTION CANAL	47 2 (29 3)	7 (25 0)	1 2 (4 0)	6 (2 0)	1-1/2 1	1958-1960	
ROGUE RIVER BASIN PROJECT DEAD INDIAN COLLECTION CANAL	1 0 (6)	2 4 (86 0)	1 8 (6 0)	9 (2 9)	1-1/2 1	1958	
ROGUE RIVER BASIN PROJECT EAST CANAL	40 2 (25 0)	3 7 (132 0)				1957-1961	(3)
ROGUE RIVER BASIN PROJECT GRIZZLY CREEK CHANNEL IMPROVEMENT	2 7 (1 7)	3 7 (130 0)	3 0 (10 0)	1 2 (4 1)	1-1/2 1	1958-1959	
ROGUE RIVER BASIN PROJECT HOPKINS CANAL	45 9 (28 5)	1 4 (50 0)	2 1 (7 0)	9 (2 9)	1-1/2 1	1956-1960	(3)
ROGUE RIVER BASIN PROJECT HOWARD PRAIRIE DELIVERY CANAL	30 1 (18 7)	1 7 (60 0)	1 8 (6 0)	9 (3 0)	1-1/2 1	1956-1959	
ROGUE RIVER BASIN PROJECT MAIN CANAL	27 4 (17 0)	5 0 (175 0)				1956-1959	(3)
ROGUE RIVER BASIN PROJECT MEDFORD CANAL	40 2 (25 0)	3 5 (125 0)				1956-1961	(3)
ROGUE RIVER BASIN PROJECT MIDDLE CANAL	31 2 (19 4)	1 8 (65 0)	3 0 (10 0)	9 (3 1)	1-1/2 1	1959-1961	(3)
ROGUE RIVER BASIN PROJECT PHOENIX CANAL	29 1 (18 1)	2 9 (102 0)				1957-1961	(3)
ROGUE RIVER BASIN PROJECT SOUTH FORK COLLECTION CANAL	20 4 (12 7)	1 8 (65 0)	1 8 (6 0)	1 0 (3 4)	1-1/2 1	1958-1959	
ROGUE RIVER BASIN PROJECT WEST CANAL	37 3 (23 2)	1 1 (39 0)	1 5 (5 0)	6 (2 1)	1-1/2 1	1957	(3)
SALT RIVER PROJECT ARIZONA CANAL	61 6 (38 3)	56 6 (2000 0)	15 2 (50 0)	2 1 (6 8)	3/4 1	1911-1912	(3)
SALT RIVER PROJECT CONSOLIDATED CANAL	29 6 (18 4)	37 5 (1325 0)	18 3 (60 0)	2 4 (8 0)	3/4 1	1925-1927	(3)
SALT RIVER PROJECT CROSS-CUT CANAL	5 6 (3 5)	11 3 (400 0)	4 9 (16 0)	1 8 (6 0)	1 1	1912-1913	
SALT RIVER PROJECT EASTERN CANAL	23 3 (14 5)	9 2 (325 0)	9 4 (31 0)	1 3 (4 2)	3/4 1	1925-1927	(3)
SALT RIVER PROJECT GRAND CANAL	35 9 (22 3)	25 5 (900 0)	8 5 (28 0)	1 5 (5 0)	3/4 1	1907-1913	(3)
SALT RIVER PROJECT SOUTH CANAL	16 3 (10 1)	46 7 (1650 0)	19 2 (63 0)	2 4 (8 0)	3/4 1		(8)
SALT RIVER PROJECT TEMPE CANAL	15 4 (9 6)	14 2 (500 0)	10 4 (34 0)	1 2 (4 0)	3/4 1	1926-1927	(3)
SALT RIVER PROJECT WESTERN CANAL	23 2 (14 4)	15 6 (550 0)	10 7 (35 0)	1 2 (4 0)	3/4 1	1911-1913	
SAN ANGELO PROJECT MAIN CANAL	25 6 (23 2)	4 7 (165 0)	1 5 (5 0)	1 5 (2 0)	1-1/2 1	1961-1963	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
SANPETE PROJECT BECK S FEEDER CANAL	1 0 (6)	2 7 (94 0)	1 8 (6 0)	9 (2 8)	1-1/2 1	1934-1935	
SANPETE PROJECT BROUGH S FORK FEEDER CANAL	6 (4)	9 (32 0)	1 2 (4 0)	4 (1 4)	1-1/2 1	1935-1939	
SANPETE PROJECT CEDAR CREEK FEEDER CANAL	2 1 (1 3)	1 9 (66 0)	1 8 (6 0)	5 (1 7)	1-1/2 1	1935-1939	
SANPETE PROJECT SOUTH FEEDER CANAL	4 7 (2 9)	1 7 (60 0)	1 5 (5 0)	7 (2 4)	1-1/2 1	1934-1935	
SHOSHONE PROJECT DEAVER CANAL	38 6 (24 0)	5 5 (194 0)	6 1 (20 0)	1 1 (3 6)	1-1/2 1	1916-1917	
SHOSHONE PROJECT FRANNIE CANAL	70 8 (44 0)	14 2 (500 0)	110 0 (36 0)	1 4 (4 5)	2 1	1917-1920	
SHOSHONE PROJECT GARLAND CANAL	29 8 (18 5)	28 3 (1000 0)	12 2 (40 0)	2 0 (6 5)	2 1	1906-1908	
SHOSHONE PROJECT HEART MOUNTAIN CANAL	42 2 (26 2)	25 9 (915 0)	9 8 (32 0)	2 6 (8 4)	1-1/2 1	1937-1947	
SHOSHONE PROJECT WILLWOOD CANAL	44 3 (27 5)	9 1 (320 0)	3 0 (10 0)	1 5 (5 0)	1-1 2 1	1924-1927	
SILT PROJECT DAVIE DITCH CANAL	7 9 (4 9)	5 (18 0)	1 5 (5 0)	4 (1 4)	2 1	1965-1966	
SILT PROJECT GRASS VALLEY CANAL	1 6 (1 0)	1 7 (60 0)	2 4 (8 0)	1 1 (3 5)	2 1	1965-1966	(3)
SILT PROJECT SILT PUMP CANAL	12 2 (7 6)	9 (32 0)	1 8 (6 0)	5 (1 8)	2 1	1965-1966	
SMITH FORK PROJECT ASPEN CANAL	9 3 (5 8)	3 5 (125 0)	3 0 (10 0)	1 2 (4 0)	1-1/2 1	1961-1962	
SMITH FORK PROJECT CLIPPER CANAL	8 (5)	1 7 (60 0)	2 1 (7 0)	8 (2 5)	2 1	1961-1962	
SMITH FORK PROJECT SMITH FORK FEEDER CANAL	3 9 (2 4)	2 3 (80 0)	2 4 (8 0)	9 (3 0)	2 1	1961-1962	
SOLANO PROJECT PUTAH SOUTH CANAL	52 0 (32 3)	27 1 (956 0)	3 7 (12 0)	3 1 (10 3)	1-1/2 1	1956-1959	
STRAWBERRY VALLEY PROJECT CURRANT CREEK FEEDER CANAL	7 6 (4 7)	3 1 (110 0)	2 4 (8 0)	9 (3 0)	1-1/2 1	1934-1936	
STRAWBERRY VALLEY PROJECT HIGH LINE CANAL	28 2 (17 5)	8 5 (300 0)	6 1 (20 0)	1 2 (4 1)	1-1 2 1	1915-1918	
STRAWBERRY VALLEY PROJECT INDIAN CREEK FEEDER CANAL	3 2 (2 0)	21 2 (750 0)	6 7 (22 0)	2 0 (6 5)	1-1 2 1	1911-1912	
STRAWBERRY VALLEY PROJECT STRAWBERRY POWER CANAL	5 3 (3 3)	14 2 (500 0)	5 8 (19 0)	1 9 (6 2)	1-1 2 1	1907-1908	
STRAWBERRY VALLEY PROJECT TRAIL HOLLOW CANAL	6 4 (4 0)	3 5 (125 0)	3 7 (12 0)	1 0 (3 3)	1-1 2 1	1911-1912	
SUN RIVER PROJECT BIG COULEE CANAL	11 7 (7 3)	1 1 (40 0)	2 4 (8 0)	8 (2 6)	1-1 2 1	1921	
SUN RIVER PROJECT FORT SHAW CANAL	19 5 (12 1)	6 4 (225 0)	3 7 (12 0)	1 2 (4 0)	1-1/2 1	1907-1908	
SUN RIVER PROJECT GREENFIELDS MAIN CANAL	44 1 (27 4)	34 0 (1200 0)	11 6 (38 0)	2 2 (7 3)	1-1/2 1		
SUN RIVER PROJECT GREENFIELDS SOUTH CANAL	23 5 (14 6)	12 0 (425 0)	7 3 (24 0)	1 2 (4 0)	1-1 3 1		
SUN RIVER PROJECT, MILL COULEE CANAL	17 2 (10 7)	5 7 (200 0)	6 1 (20 0)	9 (3 0)	1-1/2 1		
SUN RIVER PROJECT PISHKUN SUPPLY CANAL	19 5 (12 1)	39 6 (1400 0)	8 2 (27 0)	3 7 (12 0)	1-1/2 1		
SUN RIVER PROJECT SPRING VALLEY CANAL	22 9 (14 2)	34 0 (1200 0)	12 2 (40 0)	2 4 (8 0)	1-1 2 1	1931-1932	
SUN RIVER PROJECT SUN RIVER SLOPE CANAL	40 2 (25 0)	45 3 (1600 0)	11 0 (36 0)	3 8 (12 6)	1-1 2 1	1917-1919	
SUN RIVER PROJECT WILLOW CREEK FEEDER CANAL	11 7 (7 3)	14 2 (500 0)	4 3 (14 0)	1 4 (4 5)	1-1 2 1	0-1938	
TUCUMCARI PROJECT CONCHAS CANAL	126 0 (78 3)	19 8 (700 0)	7 3 (24 0)	2 7 (8 7)	1-1 2 1	1939-1948	
TUCUMCARI PROJECT HUDSON CANAL	41 8 (26 0)	10 9 (384 0)	4 9 (16 0)	2 1 (7 0)	1-1 2 1	1945-1950	
UMATILLA PROJECT A CANAL	16 1 (10 0)						(8)

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT DIVISION OR UNIT NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
UMATILLA PROJECT FEED CANAL	40 2 (25 0)	9 9 (350 0)	7 0 (23 0)	1 7 (5 5)	1-1/2 1	1906-1907	(3)
UMATILLA PROJECT MAXWELL CANAL	16 1 (10 0)	4 0 (140 0)				1917	(3)
UMATILLA PROJECT WEST EXTENTION MAIN CANAL	43 5 (27 0)	10 6 (375 0)	1 5 (5 0)	2 0 (6 5)	1-1 2 1	1913-1916	
UNCOMPAHGRE PROJECT EAST CANAL	17 1 (10 6)	4 7 (165 0)	7 3 (24 0)	5 (1 5)	1-1 2 1	1911	(3)
UNCOMPAHGRE PROJECT GARNET CANAL	17 2 (10 7)	2 1 (75 0)	5 5 (18 0)	5 (1 5)	1-1 2 1	1914	(3)
UNCOMPAHGRE PROJECT LOUTZENHIZER CANAL	23 3 (14 5)	3 4 (120 0)	4 9 (16 0)	8 (2 5)	1 1	1908	(3)
UNCOMPAHGRE PROJECT MONTROSE AND DELTA CANAL	64 4 (40 0)	15 9 (563 0)	7 9 (26 0)	1 2 (4 0)	1 1	1908-1912	(3)
UNCOMPAHGRE PROJECT SELIG CANAL	32 2 (20 0)	9 1 (320 0)	7 9 (26 0)	5 (1 5)	1-1 2 1	1914	(3)
UNCOMPAHGRE PROJECT SOUTH CANAL	18 3 (11 4)	28 6 (1010 0)	7 6 (25 0)	1 4 (4 5)	1 1	1904-1909	
UNCOMPAHGRE PROJECT WEST CANAL	34 1 (21 2)	4 9 (172 0)	6 1 (20 0)	8 (2 5)	1 1	1912	
VALE PROJECT BULLY CREEK FEEDER CANAL	4 0 (2 5)	8 5 (300 0)	4 9 (16 0)	1 7 (5 5)		1962-1963	
VALE PROJECT LITTLE VALLEY CANAL	12 9 (8 0)	9 (33 0)	1 2 (4 0)	7 (2 3)	1-1 2 1	1929-1930	
VALE PROJECT VALE MAIN CANAL	119 1 (74 0)	18 7 (662 0)	6 7 (22 0)	2 3 (7 6)	1-1/2 1	1927-1935	
VENTURA RIVER PROJECT ROBLES-CASITAS CANAL	7 2 (4 5)	14 2 (500 0)	2 1 (7 0)	1 7 (5 6)	1-1 2 1	1957-1958	
VERMEJO PROJECT EAGLE TRAIL CANAL	24 9 (15 5)	8 5 (300 0)	5 5 (18 0)	1 3 (4 3)	1-1 2 1	1954-1955	(3)
VERMEJO PROJECT VERMEJO CANAL	15 3 (9 5)	17 0 (600 0)	9 1 (30 0)	1 7 (5 7)	1-1 2 1	1954-1955	(3)
W C AUSTIN PROJECT ALTUS CANAL	34 9 (21 7)	20 1 (710 0)	6 1 (20 0)	2 7 (8 7)	1-1/2 1	1946-1948	
W C AUSTIN PROJECT MAIN CANAL	6 8 (4 2)	28 3 (1000 0)	6 7 (22 0)	3 0 (9 9)	2 1	1944-1945	
W C AUSTIN PROJECT OZARK CANAL	23 8 (14 8)	5 1 (180 0)	3 7 (12 0)	1 2 (4 0)	1-1/2 1	1946-1947	
W C AUSTIN PROJECT WEST CANAL	17 9 (11 1)	8 2 (290 0)	4 3 (14 0)	1 6 (5 3)	1-1/2 1	1945-1947	
WEBER BASIN PROJECT GATEWAY CANAL	13 7 (8 5)	19 8 (700 0)	3 0 (10 0)	2 1 (6 9)	1-1 2 1	1954-1956	
WEBER BASIN PROJECT LAYTON CANAL	14 5 (9 0)	5 1 (180 0)	3 0 (10 0)	1 5 (4 8)	2 1	1963-1965	
WEBER BASIN PROJECT OGDEN VALLEY CANAL	15 0 (9 3)	2 3 (80 0)	3 0 (10 0)	8 (2 5)	2 1	1962-1964	
WEBER BASIN PROJECT WILLARD CANAL	17 2 (10 7)	29 7 (1050 0)	3 0 (10 0)	2 7 (9 0)	2 1	1961-1964	
WEBER RIVER PROJECT - WEBER-PROVO DIVERSION CANAL (SEE PROVO RIVER PROJECT)							
YAKIMA PROJECT - KENNEWICK DIVISION CHANDLER POWER CANAL	17 1 (10 6)	42 5 (1500 0)	15 2 (50 0)	3 0 (9 9)	1-1 2 1	1953-1954	
YAKIMA PROJECT - KENNEWICK DIVISION KENNEWICK MAIN CANAL	70 8 (44 0)	14 2 (500 0)	4 3 (14 0)	2 3 (7 6)	2 1	1954-1956	
YAKIMA PROJECT - KITTITAS DIVISION KITTITAS MAIN CANAL	40 1 (24 9)	37 4 (1320 0)	9 1 (30 0)	3 5 (11 4)	1-1 2 1	1926-1929	
YAKIMA PROJECT - KITTITAS DIVISION NORTH BRANCH CANAL	55 2 (34 3)	26 2 (925 0)	9 1 (30 0)	2 5 (8 2)	1-1 2 1	1926-1931	
YAKIMA PROJECT - KITTITAS DIVISION SOUTH BRANCH CANAL	21 4 (13 3)	6 2 (220 0)	3 7 (12 0)	1 2 (4 0)	1-1 2 1	1926-1929	
YAKIMA PROJECT - KITTITAS DIVISION CASCADE CANAL	1 6 (1 0)	4 2 (150 0)	3 0 (10 0)	1 5 (5 0)	2 1	1976	
YAKIMA PROJECT - ROZA DIVISION ROZA CANAL	145 5 (90 4)	62 3 (2200 0)	16 8 (55 0)	3 7 (12 0)	1-1 2 1		
YAKIMA PROJECT - SUNNYSIDE DIVISION BENTON CANAL	19 5 (11 5)	1 8 (63 0)	1 8 (6 0)	9 (2 8)	1-1 2 1	1915	

Summary Tabulation of Carriage Facilities (Canals) - Continued

PROJECT, DIVISION, OR UNIT / NAME OF CANAL	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	INITIAL REACH BOTTOM WIDTH METERS (FEET)	INITIAL REACH WATER DEPTH METERS (FEET)	INITIAL REACH SIDE SLOPES	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
YAKIMA PROJECT - SUNNYSIDE DIVISION GRANDVIEW CANAL	12 9 (8 0)	1 0 (36 0)	8 (2 5)	6 (2 0)	1 1	1916	
YAKIMA PROJECT - SUNNYSIDE DIVISION MABTON CANAL	21 7 (13 5)	3 5 (125 0)	2 1 (7 0)	1 2 (4 0)	1 1	1910	
YAKIMA PROJECT - SUNNYSIDE DIVISION OUTLOOK CANAL	16 6 (10 3)	1 2 (42 0)	9 (3 0)	8 (2 5)	1 1	1915	
YAKIMA PROJECT - SUNNYSIDE DIVISION PROSSER CANAL	16 1 (10 0)	9 (33 0)	1 1 (3 5)	9 (3 0)	1 1	1912	
YAKIMA PROJECT - SUNNYSIDE DIVISION PROSSER IRRIGATION DISTRICT CANAL	14 8 (9 2)	6 (20 0)	6 (2 0)	6 (2 0)	1 1	1917	
YAKIMA PROJECT - SUNNYSIDE DIVISION SNIPES MOUNTAIN CANAL	20 1 (12 5)	5 5 (195 0)	4 3 (14 0)	1 2 (4 0)	1 1	1912	
YAKIMA PROJECT - SUNNYSIDE DIVISION SUNNYSIDE CANAL	96 6 (60 0)	36 7 (1295 0)	12 2 (40 0)	2 4 (8 0)	1-1 2 1	1912	(3)
YAKIMA PROJECT - TIETON DIVISION NACHES BRANCH CANAL	20 1 (12 5)	2 6 (92 0)				1909-1910	
YAKIMA PROJECT - TIETON DIVISION TIETON CANAL	15 9 (9 9)	9 8 (347 0)	4 9 (16 0)	1 5 (5 0)	1-1 2 1	1907-1909	
YAKIMA PROJECT - TIETON DIVISION WIDE HOLLOW BRANCH CANAL	47 8 (29 7)	5 4 (191 0)	3 7 (12 0)	2 7 (9 0)		1911	
YUMA PROJECT CENTRAL CANAL	20 1 (12 5)	4 5 (160 0)	5 0 (16 4)	1 1 (3 5)	2 1	1907-1909	
YUMA PROJECT EAST MAIN CANAL	38 9 (24 2)	24 9 (880 0)	20 1 (66 0)	1 5 (5 0)	2 1	1907-1909	
YUMA PROJECT WEST MAIN CANAL	39 3 (24 4)	14 7 (520 0)	12 2 (40 0)	1 5 (5 0)	2 1	1907-1909	
YUMA PROJECT YUMA MAIN CANAL	7 6 (4 7)	56 6 (2000 0)	15 2 (50 0)	2 7 (9 0)	2 1	1907-1909	
YUMA AUXILIARY PROJECT B MAIN CANAL	5 8 (3 6)	2 8 (100 0)	1 5 (5 0)	1 4 (4 5)	1-1 4 1	1955-1956	(3)

DEFINITION

CANAL AN ARTIFICIAL OPEN CHANNEL CONSTRUCTED TO CONVEY WATER FOR IRRIGATION POWER OR NAVIGATIONAL PURPOSES

CONVERSION TO ENGLISH SYSTEM

KILOMETERS TIMES 0 62139 EQUALS MILES
CUBIC METERS PER SECOND TIMES 35 315 EQUALS CUBIC FEET PER SECOND
METERS TIMES 3 28084 EQUALS FEET

FOOTNOTES

(1) ADDITIONAL CONSTRUCTION UNDERWAY
(2) NOT YET IN OPERATION
(3) DATE OF SUPPLEMENTAL CONSTRUCTION OR REHABILITATION BY WATER AND POWER RESOURCES SERVICE PROJECT DATA
(4) TO REPLACE EXISTING STRUCTURES
(5) INCLUDES 1 4 METERS (9 MILES) FOR CUTTER RESERVOIR SINCE INTEGRAL PART OF CONVEYANCE SYSTEM
(6) DEPTH VARIES
(7) UNDER CONSTRUCTION
(8) YEAR OF SUPPLEMENTAL CONSTRUCTION OR REHABILITATION UNKOWN

Summary Tabulation of Carriage Facilities (Pipelines)

PROJECT, DIVISION, OR UNIT NAME OF FEATURE	TYPE	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	DIAMETER MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
ARBUCKLE PROJECT WYNNEWOOD AQUEDUCT(DAVIS & REFINERY BRS)	PRECAST CONCRETE	28 9 (17 9)	0 (10)	610- 305 (24- 12)	1965-1967	(1-2)
BOULDER CANYON PROJECT WATERLINE TO BOULDER CITY	STEEL COAL-TAR ENAMEL LINED	11 3 (7 0)	0 (4)	305- 203 (12- 8)	1931	(2)
BOULDER CANYON PROJECT - SUPPLEMENTAL WATERLINE TO BOULDER CITY	STEEL COAL-TAR ENAMEL LINED	12 0 (7 4)	0 (4)	356- 305 (14- 12)	1949	(1-2)
CACHUMA PROJECT SOUTH COAST CONDUIT	REINFORCED CONCRETE	39 2 (24 3)	2 (70)	1219- 686 (48- 27)	1950-1953	
CANADIAN RIVER PROJECT MAIN AQUEDUCT	PRETENSIONED, NONCYLINDER PRE- STRESSED REINFORCED CONCRETE	519 4 (322 7)	5 (183)	2438- 381 (96- 15)	1963-1967	(1)
CENTRAL ARIZONA PROJECT AGUA FRIA RIVER SIPHON	PRECAST CONCRETE PRESSURE PIPE	3 1 (1 9)	85 (3000)	6401 (252)	1975-1978	(3)
CENTRAL ARIZONA PROJECT CENTENNIAL WASH SIPHON	PRECAST CONCRETE PIPE	1 8 (1 1)	85 (3000)	6401 (252)	1979	(3)
CENTRAL ARIZONA PROJECT HASSAYAMPA RIVER SIPHON	PRECAST CONCRETE PIPE	1 2 (7)	85 (3000)	6401 (252)	1979	(3)
CENTRAL ARIZONA PROJECT JACKRABBIT WASH SIPHON	PRECAST CONCRETE PIPE	5 (3)	85 (3000)	6401 (252)	1979	(3)
CENTRAL ARIZONA PROJECT NEW RIVER SIPHON	PRECAST CONCRETE PRESSURE PIPE	1 8 (1 1)	85 (3000)	6401 (252)	1975-1978	(3)
CENTRAL ARIZONA PROJECT SALT RIVER SIPHON	PRECAST CONCRETE PRESSURE PIPE	2 6 (1 6)	85 (3000)	6401 (252)	1975-1978	(3)
CENTRAL UTAH PROJECT JORDAN AQUEDUCT - SCHEDULES 1 AND 2	STEEL AND CONCRETE	24 0 (14 9)	8 (270)	1981 (78)	1971-1973	(5)
CENTRAL UTAH PROJECT LAYOUT CREEK FEEDER PIPELINE	ASBESTOS-CEMENT PRESSURE PIPE	1 3 (8)	1 (20)	457- 381 (18- 15)	1970-1975	(2)
CENTRAL UTAH PROJECT LAYOUT CREEK SIPHON	PRECAST CONCRETE PRESSURE PIPE	2 (1)	18 (620)	3353 (132)	1970-1974	(4)
CENTRAL UTAH PROJECT STARVATION FEEDER CONDUIT PIPELINE	PRECAST CONCRETE PIPE	1 2 (7)	8 (300)	2134 (84)	1967-1968	
CENTRAL UTAH PROJECT - STRAWBERRY AQUEDUCT - CURRANT CREEK PIPELINE	PRECAST CONCRETE PRESSURE PIPE	1 3 (8)	18 (620)	3353 (132)	1974	(6)
CENTRAL UTAH PROJECT - TYZACK AQUEDUCT - AQUEDUCT DISCHARGE LINE	STEEL, ENCASED PIPE	4 (2)	1 (46)	991 (39)	1977	(4-6)
CENTRAL UTAH PROJECT WATER HOLLOW CREEK SIPHON	PRECAST CONCRETE PRESSURE PIPE	2 (1)	18 (620)	3353 (132)	1970-1974	(4)
CENTRAL UTAH PROJECT WATER HOLLOW FEEDER PIPELINE	ASBESTOS-CEMENT PRESSURE PIPE	2 (1)	1 (20)	533 (21)	1970-1972	(3)
CENTRAL VALLEY PROJECT CAMINO CONDUIT	PRECAST CONCRETE AND WELDED PLATE STEEL	11 6 (7 2)	4 (125)	1219- 914 (48- 36)	1953-1955	
CENTRAL VALLEY PROJECT CLEAR CREEK SOUTH MAIN AQUEDUCT	STEEL AND CONCRETE	13 7 (8 5)	2 (73)	1143-1067 (45- 42)	1963-1967	
CENTRAL VALLEY PROJECT COW CREEK MAIN AQUEDUCT	PRETENSIONED REINFORCED CONCRETE	12 6 (7 8)	3 (92)	1372 (54)	1965-1966	
CENTRAL VALLEY PROJECT DELTA-CONTRA COSTA SHORTCUT PIPELINE	PRETENSIONED CONCRETE, MORTER CO ATED & LINED STEEL PIPE	8 4 (5 2)	3 (90)	1524-1067 (60- 42)	1971-1972	
CENTRAL VALLEY PROJECT TRACY PUMPING PLANT DISCHARGE LINES (3)	STEEL AND CONCRETE	4 4 (2 7)	130 (4602)	4572 (180)	1948-1950	
CENTRAL VALLEY PROJECT KINGS RIVER SIPHON	MONOLITHIC CONCRETE	1 0 (6)	130 (4600)	7391 (291)	1946-1949	
CENTRAL VALLEY PROJECT - DOS AMIGOS PUMPING PLANT DISCHARGE LINES (6)	MONOLITHIC CONCRETE CYLINDER	2 0 (1 2)	374 (13200)	5486 (216)	1963-1966	(4)
CENTRAL VALLEY PROJECT PANOCHE CREEK SIPHON	MONOLITHIC CONCRETE	7 (4)	334 (11800)	8534 (336)	1964-1966	(4)
CENTRAL VALLEY PROJECT - PLEASANT VALLEY PUMPING PLANT DISCHARGE LINE	CYLINDER PRESTRESSED	2 0 (1 2)	32 (1140)	3962 (156)	1968-1970	
CENTRAL VALLEY PROJECT - SPRING CREEK POWER CONDUIT ROCK CREEK SIPHON	MONOLITHIC CONCRETE	1 0 (6)	108 (3800)	5182 (204)	1963	

Summary Tabulation of Carriage Facilities (Pipelines) - Continued

PROJECT, DIVISION OR UNIT NAME OF FEATURE	TYPE	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	DIAMETER MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
CHIEF JOSEPH DAM PROJECT - MANSON UNIT LAKE CHELAN PUMPING PLANT DISCHARGE LINE	STEEL PIPE	1 3 (8)	2 (85)	1219 (48)	1971-1976	
CHIEF JOSEPH DAM PROJECT - MANSON UNIT PUMPING PLANT A DISCHARGE LINE	REINFORCED PLASTIC MORTAR PRESSURE PIPE	7 (4)	3 (95)	1143 (45)	1972-1976	
CHIEF JOSEPH DAM PROJECT - MANSON UNIT PUMPING PLANT B DISCHARGE LINE	REINFORCED PLASTIC MORTAR PRESSURE PIPE	2 (1)	1 (47)	838 (33)	1972-1976	
CHIEF JOSEPH DAM PROJECT - MANSON UNIT PUMPING PLANT C DISCHARGE LINE		2 (1)	1 (28)	457 (18)	1973	
CHIEF JOSEPH DAM PROJECT - WHITESTONE COULEE UNIT - SINLAHKIN CREEK SIPHON	PRETENSIONED CONCRETE AND ASBESTOS CEMENT	9 7 (6 0)	2 (70)	1143- 457 (45- 18)	1967-1970	
COLLBRAN PROJECT BONHAM PIPELINE	PRETENSIONED REINFORCED CONCRETE	8 7 (5 4)	1 (50)	813 (32)	1959-1962	
COLLBRAN PROJECT COTTONWOOD PIPELINE	PRETENSIONED REINFORCED CONCRETE	6 8 (4 2)	1 (50)	914 (36)	1959-1962	
COLORADO-BIG THOMPSON PROJECT CARTER LAKE PRESSURE CONDUIT	STEEL LINED CONCRETE, MANIFOLD SECTION	4 (2)	16 (550)	2438 (96)	1950-1952	(4)
COLORADO-BIG THOMPSON PROJECT PROSPECT MOUNTAIN CONDUIT	REINFORCED CONCRETE, CIRCULAR PIPE	1 0 (6)	37 (1300)	3810 (150)	1947-1949	
COLORADO RIVER FRONT WORK & LEVEE SYSTEM - YUMA MESA CONDUIT	REINFORCED CONCRETE AND ASBESTOS CEMENT	31 4 (19 5)	4 (125)	1676- 533 (66- 21)	1967-1970	
COLUMBIA BASIN PROJECT EAST LOW CANAL - BLACK ROCK	MONOLITHIC CONCRETE PIPE	5 (3)	127 (4500)	5893 (232)	1951	(4)
COLUMBIA BASIN PROJECT EAST LOW CANAL - BROCKEN ROCK NO 1	MONOLITHIC CONCRETE PIPE	4 (2)	127 (4500)	5893 (232)	1949	(4)
COLUMBIA BASIN PROJECT EAST LOW CANAL - BROKEN ROCK NO 2	MONOLITHIC CONCRETE PIPE	5 (3)	127 (4500)	5893 (232)	1951	(4)
COLUMBIA BASIN PROJECT EAST LOW CANAL - CRAB CREEK NO 1	MONOLITHIC CONCRETE PIPE	1 0 (6)	127 (4500)	5893 (232)	1949	(4)
COLUMBIA BASIN PROJECT EAST LOW CANAL - CRAB CREEK NO 2	MONOLITHIC CONCRETE PIPE	5 (3)	127 (4500)	5893 (232)	1949	(4)
COLUMBIA BASIN PROJECT EAST LOW CANAL - ROCKY COULEE	MONOLITHIC CONCRETE PIPE	1 2 (7)	127 (4500)	5893 (232)	1951	
COLUMBIA BASIN PROJECT EAST LOW CANAL - WEBER BRANCH	MONOLITHIC CONCRETE PIPE	1 0 (6)	48 (1700)	4470 (176)	1954	
COLUMBIA BASIN PROJECT EAST LOW CANAL - WEBER COULEE	MONOLITHIC CONCRETE PIPE	2 0 (1 2)	48 (1700)	4470 (176)	1954	
COLUMBIA BASIN PROJECT FEEDER CANAL PIPELINE	MONOLITHIC CONCRETE PIPE	7 (4)	453 (16000)	7620 (300)	1951	
COLUMBIA BASIN PROJECT - IRRIGATION DIV ESQUATZEL PUMPING PLANT DISCHARGE LINE	CONCRETE PRESSURE PIPE	1 3 (8)	1 (50)	914 (36)	1974-1976	
COLUMBIA BASIN PROJECT MAIN CANAL - BACON SIPHON, FIRST UNIT	MONOLITHIC CONCRETE PIPE	4 (2)	187 (6600)	7087 (279)	1946-1950	(4)
COLUMBIA BASIN PROJECT MAIN CANAL - BACON SIPHON, SECOND UNIT	MONOLITHIC CONCRETE PIPE	4 (2)	341 (12050)	8534 (336)	1976	(4-6)
COLUMBIA BASIN PROJECT WAHLUKE BRANCH CANAL - WAHLUKE SIPHON	MONOLITHIC CONCRETE AND PLATE STEEL PIPE	4 9 (3 0)	57 (2000)	4674 (184)	1956-1959	
COLUMBIA BASIN PROJECT WEST CANAL - DRY COULEE SIPHON NO 1	MONOLITHIC CONCRETE PIPE	1 5 (9)	144 (5100)	7620 (300)	1949	
COLUMBIA BASIN PROJECT WEST CANAL - DRY COULEE SIPHON NO 2	MONOLITHIC CONCRETE PIPE	4 (2)	144 (5100)	7620 (300)	1949	(4)
COLUMBIA BASIN PROJECT WEST CANAL - SOAP LAKE SIPHON	MONOLITHIC CONCRETE, PARTIALLY STEEL LINED	4 1 (2 5)	144 (5100)	7620 (300)	1948-1951	
FRYINGPAN-ARKANSAS PROJECT CHAPMAN FEEDER CONDUIT	CONCRETE RECTANGULAR SECTION	1 (1)	8 (300)	3353-2540 (132- 100)	1970-1973	
FRYINGPAN-ARKANSAS PROJECT CUNNINGHAM CONDUIT	PRECAST CONCRETE PRESSURE PIPE	1 3 (8)	6 (220)	1524 (60)	1976	(6)
FRYINGPAN-ARKANSAS PROJECT FRYINGPAN CONDUIT	CONCRETE PRESSURE PIPE	9 (5)	10 (360)	2134 (84)	1970-1974	
FRYINGPAN-ARKANSAS PROJECT FRYINGPAN FEEDER CONDUIT	CONCRETE RECTANGULAR SECTION	1 (1)	11 (400)	3962-2819 (156- 111)	1970-1973	(4)
FRYINGPAN-ARKANSAS PROJECT IVANHOE CREEK CROSSING & FEEDER CONDUIT	CONCRETE PIPE	2 (1)	10 (360)	2134 (84)	1975-1976	(4)

Summary Tabulation of Carriage Facilities (Pipelines) - Continued

PROJECT, DIVISION, OR UNIT NAME OF FEATURE	TYPE	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	DIAMETER MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTE
FRYINGPAN-ARKANSAS PROJECT MORMON CONDUIT	PRECAST CONCRETE PRESSURE PIPE	5 (3)	4 (130)	1143 (45)	1976	(6)
FRYINGPAN-ARKANSAS PROJECT MT ELBERT CONDUIT	PRECAST CONCRETE PRESSURE PIPE	17 3 (10.7)	10 (370)	2286 (90)	1977	(6)
FRYINGPAN-ARKANSAS PROJECT - MT ELBERT PUMPED-STORAGE POWERPLANT (PENSTOCK)	STEEL PIPE	1 0 (6)	96 (3400)	4572 (180)	1972	(6)
FRYINGPAN-ARKANSAS PROJECT SAWYER CREEK CONDUIT	CONCRETE PRESSURE PIPE	1.0 (6)	1 (30)	686 (27)	1970-1973	
FRYINGPAN-ARKANSAS PROJECT SOUTH CUNNINGHAM CONDUIT	PRECAST CONCRETE PRESSURE PIPE	7 (4)	1 (20)	457- 610 (18- 24)		(6)
FRYINGPAN-ARKANSAS PROJECT SOUTH FORK FEEDER CONDUIT	CONCRETE RECTANGULAR SECTION	2 (1)	6 (215)	2743-2286 (108- 90)	1970-1973	(4)
MICHAUD FLATS PROJECT - AMERICAN FALLS PUMPING PLANT DISCHARGE LINE	STEEL AND PRECAST CONCRETE	1 7 (1.0)	4 (126)	1524 (60)	1956	
MOUNTAIN PARK PROJECT FREDERICK AQUEDUCT	CONCRETE PIPE	19 5 (12.1)	0 (8)	610 (24)	1976-1978	(1-2)
MOUNTAIN PARK PROJECT ALTUS AQUEDUCT	PRECAST CONCRETE PIPE	33 2 (20 6)	1 (24)	914- 991 (36- 39)	1974-1978	(1-2)
MOUNTAIN PARK PROJECT SNYDER AQUEDUCT	PRECAST CONCRETE PIPE	8 9 (5 5)	0 (10)	406- 686 (16- 27)	1974-1978	(1-2)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL - LARGO SIPHON	MONOLITHIC CONCRETE PARTIALLY STEEL LINED PIPE	2 5 (1 5)	51 (1800)	5334 (210)	1967-1969	(3)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL - ARMENTA SIPHON	PRESTRESSED CONCRETE PIPE	1 2 (7)	51 (1800)	5334 (210)	1972-1975	(3)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL-EAST GALLEGOS SIPHON CONDUIT	PRESTRESSED CONCRETE PIPE	1 7 (1 0)	38 (1355)	4801 (189)	1975	(6)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL - KUTZ SIPHON	PRESTRESSED CONCRETE PIPE	1 8 (1 1)	51 (1800)	5334 (210)	1972-1975	(3)
NAVAJO INDIAN IRRIGATION PROJECT MAIN CANAL - WEST KUTZ SIPHON	PRESTRESSED CONCRETE PIPE	1 2 (7)	46 (1625)	5334 (210)	1972-1975	(3)
NORMAN PROJECT MIDWEST PIPELINE	PRECAST CONCRETE PIPE	35 6 (22 1)	1 (28)	914 (36)	1963-1965	(1)
NORMAN PROJECT NORMAN PIPELINE	PRECAST CONCRETE PIPE	13 6 (8 4)	1 (22)	838 (33)	1963-1965	(1)
OGDEN RIVER PROJECT OGDEN RIVER CONDUIT	WOOD STAVE	7.6 (4 7)	8 (280)	1905 (75)	1935-1936	
OGDEN RIVER PROJECT SOUTH OGDEN PIPELINE	REINFORCED CONCRETE PIPE	2 9 (1 8)	1 (35)	838 (33)	1975	
OWYHEE PROJECT DEAD OX PUMPING PLANT DISCHARGE LINE	REINFORCED CONCRETE AND PLATE STEEL	1 (1)	5 (176)	864-1372 (34- 54)	1936	
OWYHEE PROJECT DUNAWAY PUMPING PLANT DISCHARGE LINE	REINFORCED CONCRETE AND PLATE STEEL	2 1 (1 3)	4 (130)	1524 (60)	1957-1958	
OWYHEE PROJECT GEM PUMPING PLANT DISCHARGE LINE	REINFORCED CONCRETE AND PLATE STEEL	7 (4)	9 (334)	1067-1524 (42- 60)	1938-1941	
OWYHEE PROJECT NORTH CANAL - MALHEUR RIVER SIPHON	PLATE STEEL PIPE	7 0 (4 3)	9 (325)	2007 (79)	1935	
OWYHEE PROJECT - NORTH CANAL - OWYHEE DITCH PUMPING PLANT DISCHARGE LINE	MONOLITHIC CONCRETE PIPE	2 (1)	6 (222)	2134 (84)	1938-1939	
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIV - GARRISON DIVERSION UNIT MINOT PIPELINE (MILOT EXTENSION)	REINFORCED PLASTIC MORTAR PRESSURE PIPE	6 3 (3 9)	1 (19)	1219 (48)	1972-1975	(1)
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIV - GARRISON DIVERSION UNIT SUNDRE PIPELINE (MINOT EXTENSION)	REINFORCED PLASTIC MORTAR PRESSURE PIPE	5 4 (3 3)	1 (19)	762- 686 (30- 27)	1972-1974	(1)
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIV - GARRISON DIVERSION UNIT SNAKE CREEK PUMPING PLANT DISCHARGE LINES (6)	STEEL PIPE	1 (1)	58 (2055)	3353 (132)	1968-1976	(3-4)
	MONOLITHIC CONCRETE, STEEL LINED PIPE	3 (2)	58 (2055)	3353 (132)	1968-1976	(3-4)
PROVO RIVER PROJECT SALT LAKE AQUEDUCT	CONCRETE PIPE	60 2 (37 4)	4 (150)	1753 (69)	1939-1951	

Summary Tabulation of Carriage Facilities (Pipelines) - Continued

PROJECT, DIVISION, OR UNIT NAME OF FEATURE	TYPE	LENGTH KILO-METERS (MILES)	INITIAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	DIAMETER MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTE
RATHDRUM PRAIRIE PROJECT POST FALLS 'B' DISCHARGE LINE	STEEL PIPE	1 0 (6)	2 (60)	1067 (42)	1974	
SAN DIEGO PROJECT SAN DIEGO AQUEDUCT	REINFORCED CONCRETE AND PLATE STEEL	107 6 (66 8)	5 (165)	2438-1219 (96- 48)	1945-1954	
SOLANO PROJECT - PUTAH SOUTH CANAL GREEN VALLEY CONDUIT	PRECAST CONCRETE PIPE	3 9 (2 4)	0 (14)	686- 305 (27-, 12)	1958-1959	(2)
SOLANO PROJECT - PUTAH SOUTH CANAL PUTAH SOUTH PIPELINE	PRECAST REINFORCED CONCRETE PIPE	1 7 (1 0)	5 (180)	1829 (72)	1958-1959	
SOUTHERN NEVADA WATER PROJECT BOULDER CITY LATERAL	CONCRETE PRESSURE PIPE	12 3 (7 6)	1 (30)	914- 686 (36- 27)	1968-1969	(1)
SOUTHERN NEVADA WATER PROJECT HENDERSON LATERAL	CONCRETE PRESSURE PIPE	12 3 (7 6)	1 (28)	914 (36)	1970-1971	(1)
SOUTHERN NEVADA WATER PROJECT LAS VEGAS VALLEY LATERAL	STEEL AND CONCRETE PRESSURE PIPE	11 2 (6 9)	8 (289)	2438-2286 (96- 90)	1970-1971	(1)
SOUTHERN NEVADA WATER PROJECT MAIN AQUEDUCT	MONOLITHIC CONCRETE AND CONCRETE PRESSURE PIPE	4 7 (2 9)	17 (585)	3048-2438 (120- 96)	1968-1971	(1)
SOUTHERN NEVADA WATER PROJECT NORTH LAS VEGAS LATERAL	STEEL AND CONCRETE PRESSURE PIPE	16 3 (10 1)	3 (101)	1829- 610 (72- 24)	1970-1971	(1)
SOUTHERN NEVADA WATER PROJECT SAHARA LATERAL	CONCRETE PRESSURE PIPE	5 (3)	0 (15)	610 (24)	1970-1971	(1-2-4)
SOUTHERN NEVADA WATER PROJECT WHITNEY LATERAL	STEEL AND CONCRETE PRESSURE PIPE	5 5 (3 4)	5 (160)	1676-1372 (66- 54)	1970-1971	(1)
TUALATIN PROJECT SPRING HILL PUMPING PLANT DISCHARGE LINE	STEEL PIPE	5 (3)	4 (137)	1524 (60)	1975	(4-6)
VENTURA RIVER PROJECT MAIN PIPELINE SYSTEM		54 6 (33 9)	0 (0)	1372- 305 (54- 12)	1957-1959	
VENTURA RIVER PROJECT ROBLES-CASITAS DIVERSION	REINFORCED CONCRETE PIPE	1 5 (9)	14 (500)	1981 (78)	1957-1959	
WASHITA BASIN PROJECT FORT COBB AQUEDUCT	PRECAST CONCRETE PIPE	33 7 (20 9)	0 (16)	838- 381 (33- 15)	1959-1960	(1-2)
WASHITA BASIN PROJECT FOSS AQUEDUCT	PRECAST CONCRETE PIPE	81 8 (50 8)	1 (20)	1067- 152 (42- 6)	1960-1962	(1)
WEBER BASIN PROJECT DAVIS AQUEDUCT	PRECAST CONCRETE PIPE	34 8 (21 6)	10 (355)	2134- 533 (84- 21)	1954-1957	
WEBER BASIN PROJECT WEBER AQUEDUCT	PRECAST CONCRETE PIPE	6 8 (4 2)	2 (80)	1219-1067 (48- 42)	1955-1956	

DEFINITIONS

PIPELINE USED PRIMARILY FOR THE CARRIAGE OF WATER RATHER THAN FOR THE DISTRIBUTION OF WATER

CONVERSION TO ENGLISH SYSTEM

KILOMETERS TIMES 0 62139 EQUALS MILES
CUBIC METERS PER SECOND TIMES 35 314 EQUALS CUBIC FEET PER SECOND
MILLIMETERS TIMES 0 03937 EQUALS INCHES

FOOTNOTES

(1) MUNICIPAL AND/OR INDUSTRIAL WATER SUPPLY
(2) LESS THAN 1 CUBIC METER PER SECOND
(3) NOT YET IN OPERATION
(4) LESS THAN 1 KILOMETER
(5) SCHEDULE 3 (8 7 METERS, 5 4 MILES) DEFFERED
(6) UNDER CONSTRUCTION

Summary Tabulation of Carriage Facilities (Tunnels)

PROJECT, DIVISION OR UNIT NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
BOISE PROJECT TUNNEL NO 1 BLACK CANYON CANAL	251 (825)	30 (1090)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 2, BLACK CANYON CANAL	144 (475)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 2A, BLACK CANYON CANAL	128 (422)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1938	
BOISE PROJECT TUNNEL NO 3 BLACK CANYON CANAL	419 (1375)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 4, BLACK CANYON CANAL	387 (1270)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 5, BLACK CANYON CANAL	195 (640)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 6, BLACK CANYON CANAL	265 (870)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 7, BLACK CANYON CANAL	496 (1630)	29 (1044)	4 27 H (14 00)	177-304 (7- 12)	1936-1937	
BOISE PROJECT TUNNEL NO 8, BLACK CANYON CANAL	966 (3170)	9 (349)	2 59 H (8 50)	101-203 (4- 8)	1936-1937	
CACHUMA PROJECT SHEFFIELD TUNNEL, SOUTH COAST CONDUIT	1819 (5968)	0 (22)	1 83 H (6 00)	76-177 (3- 7)	1951-1953	
CACHUMA PROJECT TECOLOTE TUNNEL, SOUTH COAST CONDUIT	10228 (33557)	2 (100)	2 13 H (7 00)	101-203 (4- 8)	1950-1956	
CENTRAL ARIZONA PROJECT BUCKSKIN MOUNTAIN TUNNEL	10945 (35910)	84 (3000)	6 71 C (22 00)	152 (6)	1975	(12)
CENTRAL UTAH PROJECT CURRANT TUNNEL, STRAWBERRY AQUEDUCT	2735 (8976)	17 (620)	3 15 C (10 33)	191-203 (7 5-8)	1970-1975	(2)
CENTRAL UTAH PROJECT - JORDAN AQUEDUCT SYSTEM, ALPINE AQUEDUCT, SECTION I	536 (1760)	12 (450)	2 29 C (7 50)	355-431 (14- 17)	1979	(12)
CENTRAL UTAH PROJECT LAYOUT TUNNEL, STRAWBERRY AQUEDUCT	5149 (16896)	17 (620)	3 15 C (10 33)	191-203 (7 5-8)	1970-1975	
CENTRAL UTAH PROJECT - STARVATION TUNNEL, STARVATION FEEDER CONDUIT	1629 (5345)	8 (300)	2 23 C (7 33)	177-203 (7- 8)	1967-1968	
CENTRAL UTAH PROJECT STILLWATER TUNNEL, STRAWBERRY AQUEDUCT	12922 (42398)	8 (285)	2 21 AND 2 51 C (7 25 AND 8 25)	126-406 (5- 16)	1977	(12)
CENTRAL UTAH PROJECT VAT TUNNEL, STRAWBERRY AQUEDUCT	11814 (38760)	13 (475)	2 51 C (8 25)	355-431 (14- 17)	1975	(12)
CENTRAL UTAH PROJECT WATER HOLLOW TUNNEL, STRAWBERRY AQUEDUCT	6574 (21571)	17 (620)	3 15 C (10 33)	203-355 (7 5-14)	1968-1971	
CENTRAL VALLEY PROJECT - CLEAR CREEK TUNNEL, CREAR CREEK POWER CONDUIT	17272 (56668)	90 (3200)	5 33 C (17 50)	228-939 (9- 37)	1957-1962	
CENTRAL VALLEY PROJECT JUDGE FRANCIS CARR POWERPLANT BYPASS	82 (270)	45 (1600)	1 83 C (6 00)	228 (9)	1969-1970	
CENTRAL VALLEY PROJECT SAN FELIPE DIVISION PACHECO TUNNEL	2923 (9592)	18 (670)	3 96 C (13 00)	203-457 (8- 18)	1964-1968	(2)
CENTRAL VALLEY PROJECT SAN FELIPE DIVISION - PACHECO TUNNEL	8528 (27980)	13 (480)	2 90 C (9 50)	304 (12)	1979	(4-12))
CENTRAL VALLEY PROJECT SLY PARK UNIT, CAMINO TUNNEL	697 (2289)	3 (125)	2 13 H (7 00)	89-177 (3 5-7)	1954-1955	
CENTRAL VALLEY PROJECT SLY PARK UNIT, CAMP CREEK TUNNEL	867 (2845)	14 (500)	2 13 H (7 00)	89-177 (3 5-7)	1953	
CENTRAL VALLEY PROJECT TAILRACE TUNNEL, SPRING CREEK POWERPLANT	172 (567)	101 (3600)	6 40 H (21 00)		1960-1962	
CENTRAL VALLEY PROJECT TUNNEL NO 1, CONTRA COSTA CANAL	414 (1360)	9 (320)	2 82 H (9 25)	126-177 (5- 7)	1938-1939	
CENTRAL VALLEY PROJECT TUNNEL NO 1 SPRING CREEK POWER CONDUIT	2516 (8257)	107 (3800)	5 64 C (18 50)	228-939 (9- 37)	1960-1963	
CENTRAL VALLEY PROJECT TUNNEL NO 2 SPRING CREEK POWER CONDUIT	1356 (4450)	107 (3800)	5 64 C (18 50)	228-939 (9- 37)	1960-1963	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT DIVISION OR UNIT NAME OF TUNNEL CANAL OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
COLLBRAN PROJECT SOUTHSIDE TUNNEL SOUTHSIDE CANAL	727 (2388)	6 (240)	1 91 H (6 25)	89-177 (3 5-7)	1958-1960	
COLORADO-BIG THOMPSON PROJECT ALVA B ADAMS TUNNEL	20973 (68810)	15 (550)	2 97 C (9 75)	177-304 (7- 12)	1940-1946	
COLORADO-BIG THOMPSON PROJECT BALD MOUNTAIN PRESSURE TUNNEL	2039 (6690)	27 (960)	3 20 C (10 50)	152-279 (6- 11)	1951-1952	
COLORADO-BIG THOMPSON PROJECT BALD MOUNTAIN PRESSURE TUNNEL	2039 (6690)	27 (960)	3 20 C (10 50)	152-279 (6- 11)	1951-1952	
COLORADO-BIG THOMPSON PROJECT CARTER LAKE TUNNEL	1765 (5792)	15 (550)	2 44 C (8 00)	140-241 (5 5-9 5)	1950-1952	
COLORADO-BIG THOMPSON PROJECT OLYMPUS TUNNEL	2906 (9537)	15 (550)	2 97 H (9 75)	126-253 (5- 10)	1949-1951	
COLORADO-BIG THOMPSON PROJECT POLE HILL TUNNEL	8707 (28567)	15 (550)	2 97 H (9 75)	126-253 (5- 10)	1949-1952	
COLORADO-BIG THOMPSON PROJECT PROSPECT MOUNTAIN PRESSURE TUNNEL	1711 (5615)	36 (1300)	3 81 C (12 50)	152-304 (6- 12)	1946-1948	
COLORADO-BIG THOMPSON PROJECT RAMS HORN TUNNEL	2110 (6924)	15 (550)	3 05 H (10 00)	126-253 (5- 10)	1944-1947	
COLORADO-BIG THOMPSON PROJECT RATTLESNAKE TUNNEL	2669 (8757)	15 (550)	2 97 H (9 75)	126-253 (5- 10)	1950-1952	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 1 HORSETOOTH SUPPLY CONDUIT	1561 (5123)	10 (375)	2 51 H (8 25)		1949-1950	(3)
COLORADO-BIG THOMPSON PROJECT - DRY RIDGE TUNNEL CHARLES HANSEN FDR CANAL	185 (608)	26 (930)	3 20 H (10 50)	126-253 (5- 10)	1951-1952	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 2 CHARLES HANSEN FDR CANAL	877 (2878)	15 (550)	3 20 H (10 50)	126-253 (5- 10)	1947-1948	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 3 CHARLES HANSEN FDR CANAL	553 (1815)	15 (550)	3 20 H (10 50)	126-253 (5- 10)	1947-1948	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 4 CHARLES HANSEN FDR CANAL	413 (1355)	15 (550)	3 20 H (10 50)	126-253 (5- 10)	1947-1948	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 5 CHARLES HANSEN FDR CANAL	2853 (9363)	15 (550)	3 20 H (10 50)	126-253 (5- 10)	1947-1949	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 1 NORTH POUDRE SUPPLY CANAL	1392 (4570)	7 (250)	2 44 H (8 00)	101-203 (4- 8)	1951-1952	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 2 NORTH POUDRE SUPPLY CANAL	1423 (4670)	7 (250)	2 44 H (8 00)	101-203 (4- 8)	1951-1952	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 3 NORTH POUDRE SUPPLY CANAL	383 (1257)	7 (250)	2 44 H (8 00)	101-203 (4- 8)	1951-1952	
COLORADO-BIG THOMPSON PROJECT TUNNEL NO 4 NORTH POUDRE SUPPLY CANAL	1066 (3500)	7 (250)	2 44 H (8 00)	101-203 (4- 8)	1951-1952	
COLORADO-BIG THOMPSON PROJECT LYONS TUNNEL ST VRAIN SUPPLY CANAL	365 (1200)	16 (575)	2 59 H (8 50)	101-203 (4- 8)	1953	
COLORADO-BIG THOMPSON PROJECT - RABBIT MOUNTAIN TUNNEL ST VRAIN SUPPLY CANAL	958 (3145)	16 (575)	2 59 H (8 50)	101-203 (4- 8)	1952-1953	
COLUMBIA BASIN PROJECT BACON TUNNEL MAIN CANAL	3059 (10037)	205 (7250)	7 09 H (23 25)	253-457 (10- 18)	1946-1950	
COLUMBIA BASIN PROJECT BACON TUNNEL SECOND UNIT	3032 (9950)	341 (12050)	8 69 C (28 50)	558 (22)	1976	(9-12)
DO				787 (31)		(10)
COLUMBIA BASIN PROJECT FRENCHMAN HILLS TUNNEL WEST CANAL	2828 (9280)	43 (1540)	4 27 H (14 00)	177-355 (7- 14)	1951-1953	
DESCHUTES PROJECT TUNNEL NO 1 MAIN CANAL	1049 (3443)	28 (1000)	3 43 H (11 25)	152-228 (6- 9)	1944-1945	
DESCHUTES PROJECT TUNNEL NO 2 MAIN CANAL	1024 (3361)	28 (1000)	3 43 H (11 25)	152-228 (6- 9)	1944-1945	
FRYINGPAN-ARKANSAS PROJECT - CARTER TUNNEL SOUTH SIDE COLLECTION SYSTEM	863 (2832)	3 (130)	2 46 H (8 08)	253 (10)	1976-1978	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT, DIVISION, OR UNIT / NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
FRYINGPAN-ARKANSAS PROJECT - CHAPMAN TUNNEL, SOUTH SIDE COLLECTION SYSTEM	4450 (14600)	8 (300)	2 13 H (7 00)	89 (3 5)	1965-1971	
FRYINGPAN-ARKANSAS PROJECT CHARLES H BOUSTEAD TUNNEL	8686 (28500)	26 (945)	3 20 H (10 50)	140 (5 5)	1965-1971	
FRYINGPAN-ARKANSAS PROJECT - CUNNINGHAM TUNNEL, NORTH SIDE COLLECTION SYSTEM	4596 (15082)	7 (270)	2 29 H (7 50)	253 (10)	1974-1976	(4)
DO			2 67 H (8 75)			(5)
FRYINGPAN-ARKANSAS PROJECT - HUNTER TUNNEL, SOUTH SIDE COLLECTION SYSTEM	7330 (24049)	7 (270)	2 59 H (8 50)		1970-1973	(2)
FRYINGPAN-ARKANSAS PROJECT - HUNTER TUNNEL (COMPLETION), SOUTH SIDE SYSTEM	4899 (16074)	7 (270)	2 51 H (8 25)		1975-1978	(11)
FRYINGPAN-ARKANSAS PROJECT - HUNTER TUNNEL EXTENSION NO 1, SOUTH SIDE SYS	1871 (6139)	4 (175)	2 31 H (7 58)	253-457 (10- 18)	1975-1979	(4)
DO			2.49 H (8 17)			(5)
FRYINGPAN-ARKANSAS PROJECT - HUNTER TUNNEL EXTENSION NO 2, SOUTH SIDE SYS	2997 (9835)	2 (90)	2 31 H (7 58)	253 (10)	1975-1979	(4)
DO			2 49 H (8 17)			(5)
FRYINGPAN-ARKANSAS PROJECT - MORMON TUNNEL, SOUTH SIDE COLLECTION SYSTEM	2247 (7374)	5 (190)	2 51 H (8 25)	253 (10)	1976-1979	
FRYINGPAN-ARKANSAS PROJECT - NAST TUNNEL, NORTH SIDE COLLECTION SYSTEM	4828 (15840)	10 (360)	2 34 C (7 67)	152 (6)	1970-1974	(4)
DO			2 84 C (9 33)			(5)
FRYINGPAN-ARKANSAS PROJECT - SOUTH FORK TUNNEL, SOUTH SIDE COLLECTION SYSTEM	4953 (16250)	12 (450)	2 44 H (8 00)	101 (4)	1965-1971	
GILA PROJECT - SOUTHERN PACIFIC RAILROAD TUNNEL, WELLTON-MOHAWK CANAL	68 (224)	33 (1200)	4 65 H (15 25)	253-406 (10- 16)	1950	
GILA PROJECT TUNNEL NO 1, GRAVITY MAIN CANAL	530 (1740)	58 (2058)	6 10 H (20 00)	253-406 (10- 16)	1936-1938	
GILA PROJECT TUNNEL NO 2, GRAVITY MAIN CANAL	1257 (4125)	57 (2031)	6 10 H (20 00)	253-406 (10- 16)	1937-1938	
GRAND VALLEY PROJECT TUNNEL NO 1, GOVERNMENT HIGH LINE CANAL	1134 (3723)	40 (1425)	5 33 4 27 H (17 50 BY14 00)	101 (4)	1912-1914	
GRAND VALLEY PROJECT TUNNEL NO 2, GOVERNMENT HIGH LINE CANAL	504 (1655)	40 (1425)	4 88 4 27 H (16 00 BY14 00)	101 (4)	1913-1914	
GRAND VALLEY PROJECT TUNNEL NO 3, GOVERNMENT HIGH LINE CANAL	2222 (7293)	18 (670)	3 51 3 35 H (11 50 BY11 00)	101 (4)	1913-1914	
HUNTLEY PROJECT TUNNEL NO 1, MAIN CANAL	218 (716)	11 (399)	2 80 2 74 R (9 17 BY 9 00)	203 (8)	1906-1907	
HUNTLEY PROJECT TUNNEL NO 2, MAIN CANAL	471 (1548)	11 (399)	2 80 2 74 R (9 17 BY 9 00)	203 (8)	1906-1909	
HUNTLEY PROJECT TUNNEL NO 3, MAIN CANAL	118 (390)	11 (399)	2 80 2 74 R (9 17 BY 9 00)	203 (8)	1906-1907	
KENDRICK PROJECT TUNNEL NO 1, CASPER CANAL	874 (2870)	33 (1200)	4 27 H (14 00)	177-304 (7- 12)	1934-1935	
KENDRICK PROJECT TUNNEL NO 2, CASPER CANAL	1347 (4420)	33 (1200)	4 27 H (14 00)	177-304 (7- 12)	1934-1935	
KENDRICK PROJECT TUNNEL NO 3, CASPER CANAL	365 (1200)	29 (1054)	4 27 H (14 00)	177-304 (7- 12)	1937-1938	
KENDRICK PROJECT TUNNEL NO 4 CASPER CANAL	609 (2000)	29 (1054)	4 27 H (14 00)	177-304 (7- 12)	1937-1938	
KENDRICK PROJECT TUNNEL NO 5, CASPER CANAL	579 (1900)	28 (1023)	4 19 H (13 75)	177-304 (7- 12)	1937	
KENDRICK PROJECT TUNNEL NO 6, CASPER CANAL	1644 (5394)	27 (964)	4 19 H (13 75)	177-304 (7- 12)	1936-1937	
KLAMATH PROJECT A CANAL TUNNEL, 'A CANAL	1005 (3300)	32 (1150)	4 11 3 35 R (13 50 BY11 00)		1907	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT, DIVISION, OR UNIT / NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
KLAMATH PROJECT - TULE LAKE TUNNEL PUMPING PLANT 'O' DISCHARGE CONDUIT	2011 (6600)	7 (250)	1 75 H (5 75)	76-177 (3- 7)	1940-1941	
NAVAJO INDIAN IRRIGATION PROJECT STATE HIGHWAY 44 CROSSING TUNNEL	171 (564)	46 (1625)	5 49 H (18 00)	228-609 (9- 24)	1972-1975	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 1, MAIN CANAL	3072 (10079)	50 (1800)	5 49 C (18 00)	228 (9)	1964-1967	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 2, MAIN CANAL	7839 (25720)	50 (1800)	5 33 H (17 50)	228-394 (9-15 5)	1965-1968	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 3 MAIN CANAL	4705 (15438)	50 (1800)	5 49 C (18 00)	305 (12)	1970-1974	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 3A, MAIN CANAL	1009 (3312)	50 (1800)	5 49 C (18 00)	305 (12)	1970-1974	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 4 MAIN CANAL	1523 (4999)	50 (1800)	5 33 C (17 50)	228-482 (9- 19)	1973-1975	(2)
NAVAJO INDIAN IRRIGATION PROJECT TUNNEL NO 5	2301 (7550)	17 (610)	3 20 C (10 50)	203-406 (8- 16)	1975	(12)
NEWLANDS PROJECT TUNNEL NO 1 TRUCKEE CANAL	275 (905)	42 (1500)	4 67 H (15 33)		1903-1906	
NEWLANDS PROJECT TUNNEL NO 2 TRUCKEE CANAL	94 (309)	42 (1500)	4 67 H (15 33)	203 (8)	1903-1906	
NEWLANDS PROJECT TUNNEL NO 3, TRUCKEE CANAL	463 (1521)	42 (1500)	4 67 H (15 33)		1903-1906	
NORTH PLATTE PROJECT TUNNEL NO 1 FORT LARAMIE CANAL	822 (2697)	40 (1420)	4 27 H (14 00)	152-305 (6- 12)	1916-1917	
NORTH PLATTE PROJECT TUNNEL NO 2 FORT LARAMIE CANAL	653 (2144)	40 (1420)	4 27 H (14 00)	152-305 (6- 12)	1916-1918	
NORTH PLATTE PROJECT TUNNEL NO 3, FORT LARAMIE CANAL	1981 (6501)	17 (622)	3 12 H (10 25)	152-253 (6- 10)	1923-1924	
OGDEN RIVER PROJECT OGDEN-BRIGHAM TUNNEL	1275 (4186)	3 (110)	1 98 H (6 50)	76-152 (3- 6)	1935-1936	
OWYHEE PROJECT APPROACH TUNNEL NORTH CANAL	134 (440)	31 (1100)	3 73 H (12 25)	152-304 (6- 12)	1932	
OWYHEE PROJECT KINGMAN LATERAL TUNNEL NORTH CANAL	106 (350)	3 (120)	1 45 H (4 75)	101-203 (4- 8)	1934-1935	
OWYHEE PROJECT TUNNEL NO 1, NORTH CANAL	5706 (18723)	52 (1840)	5 05 H (16 58)	203-406 (8- 16)	1930-1932	
OWYHEE PROJECT TUNNEL NO 3, NORTH CANAL	412 (1354)	33 (1190)	4 27 H (14 00)	177-355 (7- 14)	1932	
OWYHEE PROJECT TUNNEL NO 4 NORTH CANAL	606 (1990)	27 (963)	3 58 H (11 75)	152-304 (6- 12)	1934	
OWYHEE PROJECT TUNNEL NO 5 NORTH CANAL	6689 (21948)	18 (650)	2 82 H (9 25)	152-253 (6- 10)	1930-1933	
OWYHEE PROJECT TUNNEL NO 6 NORTH CANAL	316 (1040)	13 (490)	2 51 H (8 25)	101-152 (4- 6)	1935	
OWYHEE PROJECT TUNNEL NO 7 NORTH CANAL	1318 (4325)	9 (330)	2 13 H (7 00)	89-152 (3 5-6)	1935	
PICK-SLOAN MISSOURI BASIN PROGRAM GARRISON DIVERSION UNIT MCKLUSKY TUNNEL	146 (480)	55 (1950)	4 57 C (15 00)	152 (6)	1974	(12)
PICK-SLOAN MISSOURI BASIN PROGRAM HELENA-GREAT FALLS DIVISION - HELENA VALLEY TUNNEL, HELENA VALLEY CANAL	4262 (13985)	8 (300)	2 13 H (7 00)	89-177 (3 5-7)	1957-1958	
PICK-SLOAN MISSOURI BASIN PROGRAM MIDDLE LOUP DIVISION SHERMAN TUNNEL, SHERMAN CANAL	625 (2053)	24 (850)	3 51 H (11 50)	267 (10 5)	1960-1962	
PICK-SLOAN MISSOURI BASIN PROGRAM OREGON TRAILS DIVISION GLENDO POWERPLANT PRESSURE TUNNEL	639 (2099)	368 (13000)	6 40 C (21 00)	406-507 (16- 20)	1955-1956	
PICK-SLOAN MISSOURI BASIN PROGRAM OREGON TRAILS DIVISION - TUNNELS NO 1 & 2, FREMONT CANYON POWER CONDUIT	4797 (15741)	65 (2320)	5 49 H (18 00)	228-406 (9- 16)	1957-1960	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT DIVISION, OR UNIT / NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
PICK-SLOAN MISSOURI BASIN PROGRAM THREE FORKS DIVISION CROW CREEK PUMP UNIT, TOSTON TUNNEL	623 (2044)	2 (100)	1 98 H (6 50)	101-203 (4- 8)	1952-1953	
PICK-SLOAN MISSOURI BASIN PROGRAM WIND DIVISION RIVERTON UNIT, WYOMING CANAL	863 (2832)	16 (567)	2 29 (7 50)	101-203 (4- 8)	1948-1949	
PRESTON BENCH PROJECT STATION CREEK TUNNEL, MINK CREEK CANAL	342 (1125)	7 (254)	1 98 H (6 50)	101-203 (4- 8)	1948-1949	
PROVO RIVER PROJECT DUCHESNE TUNNEL	9647 (31652)	16 (600)	2 82 H (9 25)	126-203 (5- 8)	1940-1952	
PROVO RIVER PROJECT ALPINE-DRAPER TUNNEL, SALT LAKE AQUEDUCT	4583 (15037)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1939-1941	
PROVO RIVER PROJECT OLMSTED TUNNEL, SALT LAKE AQUEDUCT	1101 (3614)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1939	
PROVO RIVER PROJECT TUNNEL NO 1, SALT LAKE AQUEDUCT	191 (994)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1948-1949	
PROVO RIVER PROJECT TUNNEL NO 2, SALT LAKE AQUEDUCT	149 (490)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1948-1949	
PROVO RIVER PROJECT TUNNEL NO 3 SALT LAKE AQUEDUCT	777 (2550)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1949	
PROVO RIVER PROJECT TUNNEL NO 4, SALT LAKE AQUEDUCT	126 (415)	4 (150)	1 98 H (6 50)	76-177 (3- 7)	1949	
ROGUE RIVER BASIN PROJECT - CASCADE DIVIDE TUNNEL,GREEN SPRINGS PWR CONDUIT	640 (2100)	3 (133)	1 83 C (6 00)	101-191 (4-7 5)	1957-1959	
ROGUE RIVER BASIN PROJECT - DEADWOOD TUNNEL, SOUTH FORK COLLECTION SYSTEM	1082 (3553)	3 (130)	1 83 H (6 00)	89-177 (3 5-7)	1956-1958	
ROGUE RIVER BASIN PROJ - GREEN SPRINGS TUNNEL, GREEN SPRINGS POWER CONDUIT	1473 (4833)	3 (133)	1 83 C (6 00)	101-191 (4-7 5)	1958-1959	
SAN DIEGO PROJECT FIRE HILL TUNNEL, SAN DIEGO AQUEDUCT	1630 (5350)	5 (165)	1 83 H (6 00)	76-177 (3- 7)	1946-1947	
SAN DIEGO PROJECT LILAC TUNNEL, SAN DIEGO AQUEDUCT	152 (500)	5 (165)	1 83 H (6 00)	761-177 (30- 7)	1947	
SAN DIEGO PROJECT OAT HILLS TUNNEL, SAN DIEGO AQUEDUCT	1094 (3592)	5 (165)	1 83 H (6 00)	76-177 (3- 7)	1946-1947	
SAN DIEGO PROJECT POWAY TUNNEL, SAN DIEGO AQUEDUCT	969 (3180)	5 (165)	1 83 H (6 00)	76-177 (3- 7)	1946-1947	
SAN DIEGO PROJECT RED MOUNTAIN TUNNEL, SAN DIEGO AQUEDUCT	930 (3053)	5 (165)	1 83 H (6 00)	76-177 (3- 7)		
SAN DIEGO PROJECT RAINBOW TUNNEL, SAN DIEGO AQUEDUCT	1430 (4694)	5 (165)	1 83 H (6 00)	76-177 (3- 7)	1946-1947	
SAN DIEGO PROJECT SAN VICENTE TUNNEL, SAN DIEGO AQUEDUCT	748 (2455)	5 (165)	1 83 H (6 00)	76-177 (3- 7)	1945-1947	
SAN JUAN-CHAMA PROJECT AZOTEA TUNNEL	20693 (67892)	26 (950)	3 33 C (10 92)	203-304 (8- 12)	1964-1970	
SAN JUAN-CHAMA PROJECT BLANCO TUNNEL	13910 (45636)	15 (520)	2 62 C (8 58)	165 (6 5)	1965-1969	
SAN JUAN-CHAMA PROJECT OSO TUNNEL	8125 (26660)	16 (550)	2 62 C (8 58)	165 (6 5)	1966-1970	
SANPETE PROJECT EPHRAIM TUNNEL	2168 (7113)	2 (95)	1 68 H (5 50)	76-152 (3- 6)	1935-1939	(6)
SANPETE PROJECT SPRING CITY TUNNEL	1495 (4907)	2 (95)	1 68 H (5 50)	76-152 (3- 6)	1937-1939	
SHOSHONE PROJECT CORBETT TUNNEL	5290 (17357)	28 (1000)	3 51 H (11 50)	228 (9)	1905-1907	
SHOSHONE PROJECT - SHOSHONE CANYON CONDUIT, HEART MOUNTAIN CANAL	4227 (13870)	34 (1201)	3 66 H (12 00)	152-267 (6-10 5)	1936-1938	(7)
SHOSHONE PROJECT TUNNEL NO 1 HEART MOUNTAIN CANAL	272 (895)	25 (914)	3 35 H (11 00)	152-253 (6- 10)	1936-1938	
SHOSHONE PROJECT TUNNEL NO 2, HEART MOUNTAIN CANAL	259 (850)	15 (554)	2 59 H (8 50)	114-216 (4 5-8 5)	1938-1939	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT, DIVISION, OR UNIT / NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
SHOSHONE PROJECT FRANNIE TUNNEL, FRANNIE CANAL	405 (1330)	8 (300)	R	152 (6)	1912-1916	
SHOSHONE PROJECT DEAVER TUNNEL, D-23 LATERAL	91 (300)	2 (100)	H		1912-1916	
SOUTHERN NEVADA WATER PROJECT INTAKE TUNNEL, PUMPING PLANT NO 1	426 (1400)	16 (585)	3 96 H (13 00)		1968-1971	(8)
SOUTHERN NEVADA WATER PROJECT RIVER MOUNTAIN TUNNEL	6125 (20096)	14 (500)	3 05 C (10 00)	191 (7 5)	1968-1970	
STRAWBERRY VALLEY PROJECT HIGHLINE CANAL TUNNEL	70 (230)	8 (300)	2 44 R 2 44 (8 00 BY 8 00)	304 (12)	1915	
STRAOBERRY VALLEY PROJECT STRAWBERRY TUNNEL	5832 (19135)	15 (545)	2 59 2 13 R (8 50 BY 7 00)	203 (8)	1906-1912	
STRAWBERRY VALLEY PROJECT TUNNEL NO 1, POWER CANAL	243 (800)	14 (500)	2 82 2 44 R (9 25 BY 8 00)	304 (12)	1907-1908	
STRAWBERRY VALLEY PROJECT TUNNEL NO 2, POWER CANAL	219 (721)	14 (500)	2 82 2 44 R (9 25 BY 8 00)	304 (12)	1907-1908	
SUN RIVER PROJECT TUNNEL NO 1, PISHKUN SUPPLY CANAL	190 (625)	39 (1400)	3 51 H (11 50)	152-228 (6- 9)	1948-1949	
SUN RIVER PROJECT TUNNEL NO 3, PISHKUN SUPPLY CANAL	688 (2258)	39 (1400)	3 25 H (10 67)	228 (9)	1914	
TUCUMCARI PROJECT TUNNEL NO 1, CONCHAS CANAL	762 (2500)	19 (700)	3 51 H (11 50)	126-253 (5- 10)	1940-1941	
TUCUMCARI PROJECT TUNNEL NO 2, CONCHAS CANAL	2407 (7900)	19 (700)	3 51 H (11 50)	126-253 (5- 10)	1940-1941	
TUCUMCARI PROJECT TUNNEL NO 3, CONCHAS CANAL	2926 (9600)	19 (700)	3 51 H (11 50)	126-253 (5- 10)	1941-1942	
TUCUMCARI PROJECT TUNNEL NO 4, CONCHAS CANAL	2160 (7087)	19 (700)	3 51 H (11 50)	126-253 (5- 10)	1944-1945	
TUCUMCARI PROJECT TUNNEL NO 5, CONCHAS CANAL	930 (3053)	16 (580)	3 51 H (11 50)	126-253 (5- 10)	1945	
UNCOMPAHGRE PROJECT GUNNISON TUNNEL	9321 (30582)	36 (1300)	3 20 3 66 R (10 50 BY12 00)		1905-1912	
UNCOMPAHGRE PROJECT TUNNELS NO 1, 2, 3, 4, 5, SOUTH CANAL	811 (2663)	35 (1248)	2 97 3 20 R (9 75 BY10 50)	152 (6)	1905	
VALE PROJECT TUNNEL NO 1, MAIN CANAL	655 (2150)	18 (662)	3 20 H (10 50)	152-253 (6- 10)	1928-1929	
VALE PROJECT TUNNEL NO 2, MAIN CANAL	1526 (5007)	18 (662)	3 20 H (10 50)	152-253 (6- 10)	1928-1930	
VALE PROJECT TUNNEL NO 3, MAIN CANAL	399 (1312)	18 (662)	3 20 H (10 50)	152-253 (6- 10)	1928-1929	
VALE PROJECT TUNNEL NO 4, MAIN CANAL	152 (500)	15 (546)	3 05 H (10 00)	152-253 (6- 10)	1929-1930	
VALE PROJECT TUNNEL NO 5, MAIN CANAL	87 (286)	15 (546)	3 05 H (10 00)	152-253 (6- 10)	1929-1930	
WEBER BASIN PROJECT GATEWAY TUNNEL	5243 (17203)	12 (435)	2 84 H (9 33)	126-216 (5-8 5)	1953-1954	
YAKIMA PROJECT - KITTITAS DIVISION MILWAUKEE TUNNEL, MAIN CANAL	55 (179)	37 (1320)	3 73 H (12 25)	203-304 (8- 12)	1928-1929	
YAKIMA PROJECT - KITTITAS DIVISION NORTHERN PACIFIC TUNNEL, MAIN CANAL	93 (305)	37 (1320)	3 73 H (12 25)	203-304 (8- 12)	1928-1929	
YAKIMA PROJECT - KITTITAS DIVISION ROCKY POINT TUNNEL, MAIN CANAL	294 (965)	26 (925)	3 63 H (11 92)	152-304 (6- 12)	1927-1928	
YAKIMA PROJECT - KITTITAS DIVISION YAKIMA RIVER TUNNEL, MAIN CANAL	1109 (3640)	26 (925)	2 82 C (9 25)	228-761 (9- 30)	1929-1931	
YAKIMA PROJECT - KITTITAS DIVISION TUNNEL NO 1, NORTH BRANCH CANAL	513 (1686)	26 (925)	3 57 H (11 71)	152-304 (6- 12)	1928	
YAKIMA PROJECT - KITTITAS DIVISION TUNNEL NO 2, NORTH BRANCH CANAL	312 (1025)	26 (925)	3 57 H (11 71)	152-304 (6- 12)	1928-1929	
YAKIMA PROJECT - KITTITAS DIVISION TUNNEL NO 3, NORTH BRANCH CANAL	693 (2276)	26 (925)	3 57 H (11 71)	152-304 (6- 12)	1928-1929	

Summary Tabulation of Carriage Facilities (Tunnels) - Continued

PROJECT. DIVISION, OR UNIT NAME OF TUNNEL, CANAL, OR FEATURE	LENGTH METERS (FEET)	CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	CROSS SECTION (1) METERS (FEET)	CONCRETE LINING THICKNESS MILLI-METERS (INCHES)	CONSTRUCTION PERIOD CALENDAR YEAR	FOOTNOTES
YAKIMA PROJECT - KITTITAS DIVISION TUNNEL NO 4, NORTH BRANCH CANAL	146 (482)	22 (77S)	3 40 H (11 17)	1S2-304 (6- 12)	1930	
YAKIMA PROJECT - KITTITAS OIVISION TUNNEL NO S, NORTH BRANCH CANAL	10S7 (3470)	7 (280)	2 05 H (6 71)	152-228 (6- 9)	1930-1931	
YAKIMA PROJECT - KITTITAS OIVISION TUNNEL NO 1, SOUTH BRANCH CANAL	609 (2000)	6 (220)	1 91 H (6 2S)	1S2-2S3 (6- 10)	1927-1928	
YAKIMA PROJECT - KITTITAS DIVISION TUNNEL NO 2, SOUTH BRANCH CANAL	423 (1390)	3 (135)	1 52 H (S 00)	126-203 (S- 8)	1928-1929	
YAKIMA PROJECT - ROZA DIVISION TUNNEL NO 1, YAKIMA RIDGE	2S08 (8231)	62 (2200)	5 18 H (17 00)	203-406 (8- 16)	1936-1938	
YAKIMA PROJECT - ROZA OIVISION TUNNEL NO 3, YAKIMA RIDGE	2922 (9S88)	62 (2200)	S 18 H (17 00)	203-406 (8- 16)	1936-1938	
YAKIMA PROJECT - ROZA OIVISION TUNNEL NO S, YAKIMA RIDGE	121S (3988)	3S (12S0)	4 19 H (13 7S)	177-304 (7- 12)	1938-1939	
YAKIMA PROJECT - ROZA OIVISION TUNNEL NO 7, YAKIMA RIDGE	230 (755)	32 (11S0)	4 04 H (13 2S)	1S2-304 (6- 12)	1939	
YAKIMA PROJECT - ROZA DIVISION TUNNEL NO 8, YAKIMA RIDGE	449 (147S)	31 (1100)	4 04 H (13 25)	1S2-304 (6- 12)	1939	
YAKIMA PROJECT - TIETON DIVISION TIETON CANAL TUNNELS (1S)	3341 (10963)	9 (347)	1 86 C (6 10)	101 (4)	1907-1909	

CONVERSION TO ENGLISH SYSTEM

METERS TIMES 3 28084 EQUALS FEEET
CUBIC METERS PER SECONO TIMES 3S.314 EQUALS CUBIC FEET PER SECOND
MILLIMETERS TIMES 0 03937 EQUALS INCHES

FOOTNOTES

(1) H = HORSESHOE, C = CIRCULAR, R = RECTANGULAR, ARCHEO ROOF
(2) NOT YET IN OPERATION
(3) 81 METERS (265 FEET) LINEO
(4) 130 METERS (427 FEET LINEO
(S) CONCRETE
(6) SHOTCRETE
(7) 4169 METERS (13678 FEET) LINEO
(8) LENGTH INCLUDES PUMP CHAMBER
(9) UNSUPPORTED
(10) SUPPORTEO
(11) UNLINED
(12) UNDER CONSTRUCTION

Summary Tabulation of Major Pumping Plants

PROJECT, DIVISION, OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
BAKER PROJECT LILLEY PUMPING PLANT	4	1.9 (67.5)	30.8 (101.0)	1090.1 (1075.0)	
BOISE PROJECT 'C' LINE PUMPING PLANT	5	17.0 (600.0)	28.0 (92.0)	7351.5 (7250.0)	
BOISE PROJECT BLACK CANYON PUMPING PLANT	2	7.6 (270.0)	8.2 (27.0)	1267.5 (1250.0)	
BOULDER CANYON PROJECT PUMPING PLANT NO. 1A	3	.2 (7.0)	304.8 (1000.0)	1216.8 (1200.0)	
BOULDER CANYON PROJECT PUMPING PLANT NO. 2A	3	.2 (7.0)	335.3 (1100.0)	1216.8 (1200.0)	
BUFFALO RAPIDS PROJECT FIRST DIVISION GLENDIVE PUMPING PLANT	3	9.3 (330.0)	31.4 (103.0)	4563.0 (4500.0)	
CANADIAN RIVER PROJECT MAIN AQUEDUCT PUMPING PLANT NO. 1	5	5.4 (189.0)	90.2 (296.0)	8872.5 (8750.0)	
CANADIAN RIVER PROJECT MAIN AQUEDUCT PUMPING PLANT NO. 2	4	4.7 (165.0)	49.5 (228.0)	5070.0 (5000.0)	(1)
CANADIAN RIVER PROJECT MAIN AQUEDUCT PUMPING PLANT NO. 3	4	4.7 (165.0)	69.5 (228.0)	5070.0 (5000.0)	(1)
CANADIAN RIVER PROJECT MAIN AQUEDUCT PUMPING PLANT NO. 4	4	4.7 (165.0)	69.5 (228.0)	5070.0 (5000.0)	(1)
CENTRAL VALLEY PROJECT TRINITY RIVER DIVISION COW CREEK UNIT WINTU PUMPING PLANT	4	2.8 (100.0)	89.9 (295.0)	4056.0 (4000.0)	
DELTA DIVISION CONTRA COSTA CANAL PUMPING PLANT NO. 1	6	11.6 (410.0)	7.6-8.5 (25.0-28.0)	1571.7 (1550.0)	
DELTA DIVISION CONTRA COSTA CANAL PUMPING PLANT NO. 2	6	11.6 (410.0)	7.6-7.9 (25.0-26.0)	1571.7 (1550.0)	
DELTA DIVISION CONTRA COSTA CANAL PUMPING PLANT NO. 3	6	11.6 (410.0)	10.4-10.7 (34.0-35.0)	1926.6 (1900.0)	
DELTA DIVISION CONTRA COSTA CANAL PUMPING PLANT NO. 4	6	11.2 (394.0)	15.5-16.2 (51.0-53.0)	3042.0 (3000.0)	
DELTA DIVISION CONTRA COSTA CANAL TRACY PUMPING PLANT	6	130.3 (4602.0)	60.0 (197.0)	136890.0 (135000.0)	
FRIANT-KERN CANAL DISTRIBUTION SYSTEM DELANO EARLIMART IRRIGATION DISTRICT PUMPING PLANT NO. D-3	11	3.9 (136.4)	9.4-14.9 (31.0-49.0)	1105.3 (1090.0)	
FRIANT-KERN CANAL DISTRIBUTION SYSTEM LINDSAY-STRATHMORE IRRIGATION DISTRICT TRAUGER PUMPING PLANT	9	4.0 (143.0)	32.6-57.0 (107.0-187.0)	3954.6 (3900.0)	
SACRAMENTO RIVER DIVISION COLUSA COUNTY WATER DISTRICT PUMPING PLANT NO. 2A	7	2.4 (84.0)	33.8 (111.0)	1521.0 (1500.0)	
SACRAMENTO RIVER DIVISION COLUSA COUNTY WATER DISTRICT PUMPING PLANT NO. 2A1	6	2.4 (83.0)	33.8 (111.0)	1470.3 (1450.0)	

Summary Tabulation of Major Pumping Plants - Continued

PROJECT, DIVISION OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
CENTRAL VALLEY PROJECT (CONTINUED) SACRAMENTO RIVER DIVISION COLUSA COUNTY WATER DISTRICT PUMPING PLANT NO 2B	6	2 4 (83 0)	30 8 (101 0)	1521 0 (1500 0)	
SACRAMENTO RIVER DIVISION COLUSA COUNTY WATER DISTRICT PUMPING PLANT NO 2C	6	2 4 (85 0)	31 4 (103 0)	1039 4 (1025 0)	
SACRAMENTO RIVER OIVISION COLUSA COUNTY WATER DISTRICT CORNING CANAL PUMPING PLANT	6	13 5 (477 0)	18 0-21 6 (59 0-71 0)	4106 7 (4050 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT DOS AMIGOS PUMPING PLANT	6	373 8 (13200 0)	32 6-38 1 (107 0-125 0)	243360 0 (240000 0)	
WEST SAN JOAQUIN OIV - SAN LUIS UNIT O NEILL PUMPING PLANT	6	118 9 (4200 0)	13 4-17 1 (44 0-56 0)	36504 0 (36000 0)	(2)
WEST SAN JOAQUIN OIV - SAN LUIS UNIT PLEASANT VALLEY PUMPING PLANT	9	33 6 (1185 0)	60 0 (197 0)	35743 5 (35250 0)	
WEST SAN JOAQUIN OIV - SAN LUIS UNIT SAN LUIS PUMPING-GENERATING PLANT	8	311 5 (11000 0)	88 4 (290 0)	511056 0 (504000 0)	(3)
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 3	4	2 9 (103 0)	49 4 (162 0)	2737 8 (2700 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 5	5	2 0 (71 0)	80 5 (264 0)	3042 0 (3000 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 6	5	2 0 (71 0)	54 9 (180 0)	2180 1 (2150 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER OISTRICT PUMPING PLANT NO 7	6	1 6 (56 0)	77 1 (253 0)	2433 6 (2400 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 8	5	1 2 (43 0)	59 7 (196 0)	1470 3 (1450 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 9	5	9 (31 0)	75 0 (246 0)	1216 8 (1200 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT SAN LUIS WATER DISTRICT PUMPING PLANT NO 10	5	1 1 (40.0)	63 4 (208 0)	1115 4 (1100 0)	
WEST SAN JOAQUIN OIV - SAN LUIS UNIT WESTLANDS WATER OISTRICT DSTRBTN SYSTEM LATERAL 1R, PUMPING PLANT NO 1RA	8	4 3 (152 0)	55 8 (183 0)	4309 5 (4250 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANOS WATER DISTRICT DSTRBTN SYSTEM LATERAL 1R, PUMPING PLANT NO 1R-4 0B	6	2 7 (96 0)	38 7 (127 0)	1926 6 (1900 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT OSTRBTN SYSTEM LATERAL 1R, PUMP PLT NO 1R-4 0-1 0	4	1 0 (34 0)	69 5 (228 0)	1216 8 (1200 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT OSTRBTN SYSTEM LATERAL 2R, PUMPING PLANT NO 2R-A	6	2 5 (89 0)	28 7 (94 0)	1267 5 (1250 0)	
WEST SAN JOAQUIN OIV - SAN LUIS UNIT WESTLANOS WATER DISTRICT DSTRBTN SYSTEM LATERAL 2R, PUMPING PLANT NO 2R-B	6	1 9 (66 0)	40 2 (132 0)	1318 2 (1300 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 4R, PUMPING PLANT NO 4R	6	1 4 (51 0)	48 2 (158 0)	1267 5 (1250 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER OISTRICT OSTRBTN SYSTEM LATERAL 6, PUMPING PLANT NO 6-1	8	3 2 (113 0)	43 0 (141 0)	2180 1 (2150 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 7R, PUMPING PLANT NO 7R-A	5	2 1 (73 0)	43 6 (143 0)	1571 7 (1550 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 7R, PUMPING PLANT NO 7R-B	5	1 7 (61 0)	44 8 (147 0)	1419 6 (1400 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER OISTRICT DSTRBTN SYSTEM LATERAL 7R PUMPING PLANT NO 7R-C	5	1 2 (44 0)	58 5 (192 0)	1318 2 (1300 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 13R, PUMPING PLANT NO 13R-A	6	2 4 (86 0)	26 5 (87 0)	1216 8 (1200 0)	

Summary Tabulation of Major Pumping Plants - Continued

PROJECT, DIVISION, OR UNIT / PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
CENTRAL VALLEY PROJECT (CONTINUED) WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 13R, PUMPING PLANT NO 13R-8	6	2 1 (73 0)	45 7 (150 0)	1622 4 (1600 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 15R, PUMPING PLANT NO 15R	5	1 1 (39 0)	78 6 (258 0)	1622 4 (1600 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 19R, PUMPING PLANT NO 19R	4	8 (29 5)	78 9 (259 0)	1368 9 (1350 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 21R, PUMPING PLANT NO 21R	6	1 6 (56 0)	35 1 (115 0)	1039 4 (1025 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 22R, PUMPING PLANT NO 22R	6	1 9 (67 0)	38 1 (125 0)	1318 2 (1300 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 27R, PUMPING PLANT NO 27R	5	1 3 (46 0)	78 9 (259 0)	1977 3 (1950 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 28R, PUMPING PLANT NO 28R-A	6	2 7 (96 0)	47 9 (157 0)	2433 6 (2400 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 28R, PUMPING PLANT NO28B	5	1 2 (43 0)	50 0 (164 0)	1115 4 (1100 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 28R, PUMP PLT NO 28R8-1 OW	4	7 (23 0)	84 4 (277 0)	1419 6 (1400 0)	
WEST SAN JOAQUIN DIV - SAN LUIS UNIT WESTLANDS WATER DISTRICT DSTRBTN SYSTEM LATERAL 29R PUMPING PLANT NO 29RA	5	1 3 (45 0)	57 9 (190 0)	1318 2 (1300 0)	
CHIEF JOSEPH DAM PROJECT CHELAN DIVISION - MANSON UNIT LAKE CHELAN PUMPING PLANT	8	3 0 (107 0)	81 4 (267 0)	4309 5 (4250 0)	
CHIEF JOSEPH DAM PROJECT CHELAN DIVISION - MANSON UNIT PUMPING PLANT A	9	2 7 (95 0)	84 4 (277 0)	3853 2 (3800 0)	
CHIEF JOSEPH DAM PROJECT CHELAN DIVISION - MANSON UNIT PUMPING PLANT B	7	1 3 (47 0)	58 8 (193 0)	1470 3 (1450 0)	
CHIEF JOSEPH DAM PROJECT CHELAN DIVISION - MANSON UNIT PUMPING PLANT C	7	8 (30 0)	82 3 (270 0)	1318 2 (1300 0)	
CHIEF JOSEPH DAM PROJECT - FOSTER CREEK DIVISION - BREWSTER FLAT UNIT RIVER PUMPING PLANT, VERTICAL TURBINE	4	1 3 (46 0)	57 9 (190 0)	1216 8 (1200 0)	
CHIEF JOSEPH DAM PROJECT - FOSTER CREEK DIVISION - BREWSTER FLAT UNIT BOOST PUMP PLT, HORIZ CENTRAFUGE	4	1 3 (46 0)	106 7 (350 0)	1433 6 (2400 0)	
CHIEF JOSEPH DAM PROJECT - GREATER WENATCHEE DIVISION - BRAYS LANDING UNIT LATERAL SYSTEM PUMPING PLANT A	5	9 (31 0)	96 6 (317 0)	1521 0 (1500 0)	
CHIEF JOSEPH DAM PROJECT - GREATER WENATCHEE DIVISION - BRAYS LANDING UNIT LATERAL SYSTEM PUMPING PLANT NO 1	5	9 (31 0)	73 5 (241 0)	1115 4 (1100 0)	
CHIEF JOSEPH DAM PROJECT - GREATER WENATCHEE DIVISION - EAST UNIT BOOSTER PUMPING PLANT	4	2 2 (76 0)	198 7 (652 0)	7605 0 (7500 0)	
CHIEF JOSEPH DAM PROJECT - GREATER WENATCHEE DIVISION - HOWARD FLAT UNIT RIVER BOOSTER PUMPING PLANT	3	5 (17 0)	149 4 (490 0)	1216 8 (1200 0)	(4)
CHIEF JOSEPH DAM PROJECT - OKANOGAN-SIMILKAMEEN DIV - OROVILLE-TONASKET UNIT MIDWAY PUMPING PLANT	3	1 6 (56 0)	33 5 (110 0)	1064 7 (1050 0)	(10)
COLORADO-BIG THOMPSON PROJECT FLATIRON POWER AND PUMPING PLANT	1	10 5 (370 0)	73 2 (240 0)	13182 0 (13000 0)	(5)
COLORADO-BIG THOMPSON PROJECT GRANBY PUMPING PLANT	3	17 0 (600 0)	56 7 (186 0)	18252 0 (18000 0)	
COLORADO-BIG THOMPSON PROJECT WILLOW CREEK PUMPING PLANT	2	11 3 (400 0)	53 3 (175 0)	10140 0 (10000 0)	
COLORADO RIVER FRONT WORK AND LEVEE SYSTEM SENATOR WASH PUMPING-GENERATING PLANT	6	28 0 (990 0)	22 6 (74 0)	10647 0 (10500 0)	(6)

Summary Tabulation of Major Pumping Plants - Continued

PROJECT DIVISION OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
COLUMBIA BASIN PROJECT GRAND COULEE PUMPING-GENERATING PLANT	8	357 9 (12640 0)	89 0-94 5 (292 0-310 0)	532350 0 (525000 0)	(7)
COLUMBIA BASIN PROJECT BLOCK NO 11 LOWER SCOOTENEY PUMPING PLANT	3	2 2 (76 0)	45 4 (149 0)	1521 0 (1500 0)	
COLUMBIA BASIN PROJECT BLOCK NO 14 MESA PUMPING PLANT	4	4 5 (160 0)	25 0 (82 0)	1825 2 (1800 0)	
COLUMBIA BASIN PROJECT BLOCK NO 15 RINGOLD PUMPING PLANT	4	6 6 (232 0)	10 7-11 6 (35 0-38 0)	1247 2 (1230 0)	
COLUMBIA BASIN PROJECT BLOCK NO 17 SAGEMOOR PUMPING PLANT	4	2 5 (88 0)	27 7 (91 0)	1216 8 (1200 0)	
COLUMBIA BASIN PROJECT BLOCK NO 20 WHITE BLUFFS PUMPING PLANT NO 1	4	5 0 (178 0)	25 9 (85 0)	2028 0 (2000 0)	
COLUMBIA BASIN PROJECT BLOCK NO 21 RADAR PUMPING PLANT	5	7 2 (256 0)	36 0-84 4 (118 0-277 0)	8213 4 (8100 0)	
COLUMBIA BASIN PROJECT BLOCK NO 23 AND 201 WHITE BLUFFS PUMPING PLANT NO 2	6	6 3 (222 0)	19 2-32 3 (63 0-106 0)	2281 5 (2250 0)	
COLUMBIA BASIN PROJECT BLOCK NO 44 WARDEN PUMPING PLANT	3	3 8 (135 0)	16 8 (55 0)	1064 7 (1050 0)	
COLUMBIA BASIN PROJECT BLOCK NO 49 LOWER SADDLE GAP PUMPING PLANT	4	3 2 (112 0)	28 7 (94 0)	1622 4 (1600 0)	
COLUMBIA BASIN PROJECT BLOCK NO 49 UPPER SADDLE GAP PUMPING PLANT	4	2 5 (90 0)	4 6-34 4 (15 0-113 0)	1384 1 (1365 0)	
COLUMBIA BASIN PROJECT BLOCK NO 70 AND 701 LAKE LENORE PUMPING PLANT NO 2	5	1 1 (40 0)	60 0 (197 0)	1216 8 (1200 0)	
COLUMBIA BASIN PROJECT BLOCK NO 70 AND 701 M-9 PUMPING PLANT	3	1 3 (47 0)	25 9-70 1 (85 0-230 0)	1115 4 (1100 0)	
COLUMBIA BASIN PROJECT BLOCK NO 73 QUINCY PUMPING PLANT	9	11 9 (421 0)	18 0-79 2 (59 0-260 0)	10158 3 (10018 0)	
COLUMBIA BASIN PROJECT BLOCK NO 74 BABCOCK PUMPING PLANT	10	8 3 (292 0)	67 4 (221 0)	6286 8 (6200 0)	
COLUMBIA BASIN PROJECT BLOCK NO 77 EVERGREEN PUMPING PLANT	8	7 2 (253 0)	25 3-67 7 (83 0-222 0)	6895 2 (6800 0)	
COLUMBIA BASIN PROJECT BLOCK NO 79 FRENCHMAN SPRINGS PUMPING PLANT	8	5 6 (197 0)	80 5 (264 0)	4765 8 (4700 0)	
COLUMBIA BASIN PROJECT BLOCK NO 80 AND 81 FRENCHMAN HILLS PUMPING PLANT	9	12 2 (432 0)	51 8-95 7 (170 0-314 0)	13689 0 (13500 0)	
COLUMBIA BASIN PROJECT BLOCK NO 83 SAND HOLLOW PUMPING PLANT	4	5 0 (178 0)	19 8 (65 0)	1622 4 (1600 0)	
CROOKED RIVER PROJECT BARNES BUTTE PUMPING PLANT	5	4 2 (147 0)	25 0 (82 0)	1825 2 (1800 0)	
CROOKED RIVER PROJECT OCHOCO RELIFT PUMPING PLANT	4	2 3 (81 0)	30 2 (99 0)	1318 2 (1300 0)	
FRYINGPAN ARKANSAS PROJECT MT ELBERT PUMPED-STORAGE POWERPLANT	1	74 2 (2620 0)	142 6 (468 0)	172380 0 (170000 0)	(9-13)
GILA PROJECT WELLTON-MOHAWK DIVISION WELLTON-MOHAWK PUMPING PLANT NO 1	9	36 8 (1300 0)	10 7 (35 0)	7605 0 (7500 0)	
GILA PROJECT WELLTON-MOHAWK DIVISION WELLTON-MOHAWK PUMPING PLANT NO 2	8	34 0 (1200 0)	27 4 (90 0)	17491 5 (17250 0)	
GILA PROJECT WELLTON-MOHAWK DIVISION WELLTON MOHAWK PUMPING PLANT NO 3	7	25 5 (900 0)	18 3 (60 0)	8872 5 (8750 0)	
GILA PROJECT YUMA-MESA DIVISION GRAVITY MAIN CANAL- PUMP PLT NO 1	4	27 4 (968 0)	15 2-16 5 (50 0-54 0)	7199 4 (7100 0)	

Summary Tabulation of Major Pumping Plants - Continued

PROJECT, DIVISION, OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
GRAND VALLEY PROJECT ORCHARD MESA PUMPING PLANT	4	4.0 (140.0)	12.5-39.6 (41.0-130.0)	1521.0 (1500.0)	
KLAMATH PROJECT PUMPING DIVISION BOOSTER PUMPING PLANT	7	1.7 (60.0)	38.1 (125.0)	1135.7 (1120.0)	
KLAMATH PROJECT PUMPING DIVISION MAIN PUMPING PLANT	7	2.1 (75.0)	99.7 (327.0)	3447.6 (3400.0)	
KLAMATH PROJECT TULE LAKE DIVISION, PART 3 PUMPING PLANT D	5	11.0 (388.0)	23.8 (78.0)	3701.1 (3650.0)	
LOWER RIO GRANDE REHABILITATION PROJECT LA FERIA DIVISION RIVER PUMPING PLANT	5	9.5 (335.0)	6.4 (21.0)	1977.3 (1950.0)	
LOWER RIO GRANDE REHABILITATION PROJECT MERCEDES DIVISION WESLACO RELIFT PUMPING PLANT NO. 4	6	9.5 (336.0)	5.5 (18.0)	1014.0 (1000.0)	
LOWER RIO GRANDE REHABILITATION PROJECT MERCEDES DIVISION RIVER PUMPING PLANT	3	21.2 (750.0)	6.7 (22.0)	2737.8 (2700.0)	
MICHAUD FLATS PROJECT AMERICAN FALLS PUMPING PLANT	4	3.6 (126.0)	59.4 (195.0)	3751.8 (3700.0)	
MINIDOKA PROJECT NORTH SIDE PUMPING DIVISION UNIT A PUMPING PLANT	5	6.8 (240.0)	51.2 (168.0)	6084.0 (6000.0)	
MINIDOKA PROJECT SOUTH SIDE PUMPING DIVISION LIFT PUMPING PLANT NO. 1	6	28.6 (1011.0)	9.4 (31.0)	4096.6 (4040.0)	
MINIDOKA PROJECT SOUTH SIDE PUMPING DIVISION LIFT PUMPING PLANT NO 2	6	25.2 (891.0)	10.4 (34.0)	3640.3 (3590.0)	
MINIDOKA PROJECT SOUTH SIDE PUMPING DIVISION LIFT PUMPING PLANT NO. 3	3	12.8 (453.0)	9.4 (31.0)	2372.8 (2340.0)	
NORMAN PROJECT RESERVOIR PUMPING PLANT	8	1.4 (49.8)	69.5-97.5 (228.0-320.0)	2230.8 (2200.0)	
OWYHEE PROJECT DEAD OX FLAT DIVISION DEAD OX PUMPING PLANT	5	5.0 (176.0)	15.2-33.8 (50.0-111.0)	2712.5 (2675.0)	
OWYHEE PROJECT DEAD OX FLAT DIVISION - GEM DISTRICT GEM PUMPING PLANT	9	9 5 (334 0)	23 2-54.9 (76.0-180.0)	7716.5 (7610.0)	
OWYHEE PROJECT MITCHELL BUTTE DIVISION ONTARIO-NYSSA PUMPING PLANT	4	3 7 (130.0)	36.6 (120.0)	2281.5 (2250.0)	
OWYHEE PROJECT MITCHELL BUTTE DIVISION OWYHEE DITCH PUMPING PLANT	3	6.3 (222.0)	15.2 (50.0)	1521.0 (1500.0)	
PICK-SLOAN MISSOURI BASIN PROGRAM					
BIGHORN BASIN DIVISION HANOVER-BLUFF UNIT HANOVER PUMPING PLANT NO. 2	4	2.8 (100.0)	13.1-33.2 (43.0-109.0)	1338.5 (1320.0)	
BIGHORN BASIN DIVISION OWL CREEK UNIT LUCERNE PUMPING PLANT NO. 1	4	2.4 (84.0)	20.4-41.5 (67.0-136.0)	1318 2 (1300.0)	
GARRISON DIVISION GARRISON DIVERSION UNIT SNAKE CREEK PUMPING PLANT	3	58 2 (2055.0)	23 2 (76 0)	24336.0 (24000.0)	(12)
HELENA-GREAT FALLS DIVISION HELENA VALLEY UNIT HELENA VALLEY PUMPING PLANT	2	8 5 (300 0)	44.2 (145 0)	10140.0 (10000 0)	(8)
JAMES DIVISION OAHE UNIT OAHE PUMPING PLANT	4	34 0 (1200 0)	57.0 (187 0)	29101 8 (28700 0)	(11-13)
THREE FORKS DIVISION CROW CREEK PUMP UNIT CROW CREEK PUMPING PLANT	3	2 8 (100.0)	54.9 (180 0)	2737 8 (2700.0)	
PROVO RIVER PROJECT JORDAN NARROWS PUMPING PLANT	1	1 8 (65 0)	31 4 (103 0)	1064.7 (1050 0)	
RATHDRUM PRAIRIE PROJECT PRAIRIE DIV. - EAST GREEN ACRES UNIT PUMPING STATION NO. 1	6	1 0 (34.0)	128.0 (420.0)	2058 4 (2030 0)	

Summary Tabulation of Major Pumping Plants - Continued

PROJECT DIVISION OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
RATHDRUM PRAIRIE PROJECT PRAIRIE DIV - EAST GREEN ACRES UNIT PUMPING STATION NO 2	5	9 (33 0)	131 1 (430 0)	2129 4 (2100 0)	
RATHDRUM PRAIRIE PROJECT PRAIRIE DIV - EAST GREEN ACRES UNIT PUMPING STATION NO 3	3	6 (21 0)	128 0 (420 0)	1318 2 (1300 0)	
RATHDRUM PRAIRIE PROJECT PRAIRIE DIV - POST FALLS UNIT POST FALLS PUMPING PLANT	2	1 7 (60 0)	45 7 (150 0)	1368.9 (1350 0)	
SALT RIVER PROJECT HIGHLINE BOOSTER PUMPING PLANT	8	3 5 (125 0)	12 8 (42 0)	1521 0 (1500 0)	
SILT PROJECT SILT PUMPING PLANT	4	1 0 (36 0)	68 6 (225 0)	1292 9 (1275 0)	
SOUTHERN NEVADA WATER PROJECT 1 PUMPING PLANT NO 1	10	8 8 (311 0)	68 0 (223 0)	10140 0 (10000 0)	
2 PUMPING PLANT NO 1A MAIN AQUEDUCT	6	8 5 (300 0)	108 2 (355 0)	15210 0 (15000 0)	(1)
BOULDER CITY LATERAL	2	4 (15 0)	135 6 (445 0)	1216 8 (1200 0)	(1-4)
3 PUMPING PLANT NO 2A	6	8 5 (300 0)	108 2 (355 0)	15210 0 (15000 0)	(1)
4 PUMPING PLANT NO 3	3	8 (28 0)	70 1 (230 0)	1064 7 (1050 0)	(1)
5 PUMPING PLANT NO 4	2	4 (15 0)	135 6 (445 0)	1216 8 (1200 0)	(1-4)
6 PUMPING PLANT NO 5	2	4 (15 0)	135 6 (445 0)	1216 8 (1200 0)	(1-4)
7 PUMPING PLANT NO 6	3	2 5 (90 0)	55 5 (182 0)	2433 6 (2400 0)	(1)
THE DALLES PROJECT MILL CREEK PUMPING PLANT	5	1 5 (54 0)	69 5 (228 0)	1825 2 (1800 0)	
THE DALLES PROJECT LATERAL DISTRIBUTION SYSTEM PUMPING PLANT A	5	1 4 (51 0)	127 7 (419 0)	2535 0 (2500 0)	
THE DALLES PROJECT LATERAL DISTRIBUTION SYSTEM PUMPING PLANT F	5	1 2 (43 0)	93 6 (307 0)	2180 1 (2150 0)	
TUALATIN PROJECT SPRING HILL PUMPING PLANT	13	6 8 (241 0)	113 4 (372 0)	9227 4 (9100 0)	
VENTURA RIVER PROJECT RINCON PUMPING PLANT	2	2 (6 0)	274 3 (900 0)	1054 6 (1040 0)	(4)
VENTURA RIVER PROJECT VENTURA AVENUE PUMPING PLANT NO 1	4	1 4 (50 0)	130 8 (429 0)	3244 8 (3200 0)	
VENTURA RIVER PROJECT VENTURA AVENUE PUMPING PLANT NO 2	3	1 4 (48 0)	67 1 (220 0)	1825 2 (1800 0)	
WEBER BASIN PROJECT LAYTON PUMPING PLANT	4	7 9 (278 0)	8 5 (28 0)	1064 7 (1050 0)	
WEBER BASIN PROJECT SOUTH DAVIS PUMPING PLANT	4	4 (14 0)	68 6-176 8 (225 0-580 0)	1039 4 (1025 0)	(4)
WEBER BASIN PROJECT WILLARD PUMPING PLANT NO 1	3	14 2 (500 0)	14 0 (46 0)	3042 0 (3000 0)	
YAKIMA PROJECT CASCADE IRRIGATION DISTRICT CASCADE PUMPING PLANT	8	4 5 (160 0)	32 9 (108 0)	2433 6 (2400 0)	
YAKIMA PROJECT KENNEWICK DIVISION CHANDLER PUMPING PLANT	2	14 2 (500 0)	32 9 (108 0)	5272 8 (5200 0)	
YAKIMA PROJECT KITTITAS DIVISION WIPPEL PUMPING PLANT	4	1 8 (65 0)	41 8 (137 0)	1521 0 (1500 0)	

Summary Tabulation of Major Pumping Plants - Continued

PROJECT, DIVISION, OR UNIT PUMPING PLANT NAME	NUMBER OF UNITS	TOTAL CAPACITY CUBIC M PER SEC (CUBIC FT PER SEC)	RATED TOTAL HEAD METERS (FEET)	TOTAL METRIC HORSE-POWER (HORSE-POWER)	FOOTNOTES
YAKIMA PROJECT ROZA DIVISION MILE 7 2 PUMPING PLANT - AREA NO 1	4	1 1 (39 0)	32 3-66 4 (106 0-218 0)	1014 0 (1000 0)	
YAKIMA PROJECT ROZA DIVISION MILE 16 8 PUMPING PLANT - AREA NO 2	5	1 6 (57 0)	32 3-71 0 (106 0-233 0)	1622 4 (1600 0)	
YAKIMA PROJECT ROZA DIVISION MILE 22 5 PUMPING PLANT - AREA NO 3	5	1 3 (47 0)	47 2-72 2 (155 0-237 0)	1622 4 (1600 0)	
YAKIMA PROJECT ROZA DIVISION MILE 71 0 PUMPING PLANT - AREA NO 14	3	9 (33 0)	73 5 (241 0)	1216 8 (1200 0)	
YAKIMA PROJECT ROZA DIVISION MILE 78 8 PUMPING PLANT - AREA NO 15		2 2 (77 0)	45 1-83 8 (148 0-275 0)	2585 7 (2550 0)	
YAKIMA PROJECT ROZA DIVISION MILE 88 3 PUMPING PLANT - AREA NO 16	5	1 3 (46 0)	42 4-82 6 (139 0-271 0)	1521 0 (1500 0)	

CONVERSION TO THE ENGLISH SYSTEM

CUBIC METERS PER SECOND TIMES 35 314 EQUALS CUBIC FEET PER SECOND
METERS TIMES 3 28084 EQUALS FEET
METRIC HORSEPOWER TIMES 0 98622 EQUALS HORSEPOWER

FOOTNOTES

(1) PLUS ONE STANDBY UNIT
(2) THE SIX UNITS CAN FUNCTION IN REVERSE TO PRODUCE A TOTAL OF 25200 KW
(3) THE EIGHT UNIT CAN FUNCTION IN REVERSE TO PRODUCE A TOTAL OF 424000 KW
(4) TOTAL CAPACITY LESS THAN ONE CUBIC METER PER SECOND
(5) THE UNIT CAN FUNCTION IN REVERSE AS AN 8500 KW GENERATING UNIT
(6) THE SIX UNITS CAN FUNCTION IN REVERSE TO PRODUCE A TOTAL OF 7200 KW
(7) P/G7 AND P/G8 UNITS INSTALLED IN GRAND COULEE PUMPING-GENERATING PLANT CAN FUNCTION IN REVERSE TO PRODUCE A TOTAL OF 100000 KW
(8) DIRECT CONNECTED HYDRAULIC TURBINE
(9) THE UNIT WILL FUNCTION IN REVERSE TO PRODUCE A TOTAL OF 100000 KW
(10) FORMERLY ELLISFORDE PUMPING PLANT, NAME CHANGED IN 1974
(11) INITIAL PHASE INSTALLATION ULTIMATE CAPACITY OF THE PUMPING PLANT IS 90 6 CUBIC METERS PER SECOND (3200 CUBIC FEET PER SECOND)
(12) NOT YET IN OPERATION
(13) UNDER CONSTRUCTION

Summary Tabulation of Powerplants

Project	Name	Number of units	Capacity of units (kilowatts)	Existing plant capacity (kilowatts)	Ultimate authorized plant capacity (kilowatts)	Date of first generation
Amistad	Amistad[2]	-	-	-	80,000	[1]
Boise	Anderson Ranch	2	13,500	27,000	27,000	1950
	Black Canyon	2	4,000	8,000	8,000	1925
	Boise River Diversion	3	500	1,500	1,500	1912
Boulder Canyon	Hoover	14	82,500			
		1	95,000			
		1	50,000	1,344,800	1,344,800	1936
		1	40,000			
		2	2,400			
Central Arizona	Navajo	-	-	-	546,750[3]	1974
Central Utah	Syar	-	-	-	10,500	[1]
	Sixth Water	-	-	-	90,000	[1]
	Dyne	-	-	-	33,000	[1]
Central Valley	Judge Francis Carr	2	70,722	141,444	141,444	1963
	Folsom	3	66,240	198,720	198,720	1955
	Keswick	3	25,000	75,000	75,000	1949
	Nimbus	2	6,750	13,500	13,500	1955
	O'Neil	6	4,200	25,200	25,200	1967
	San Luis[4]	8	53,000	424,000	424,000	1968
	Shasta	3	95,000			
		2	83,662	456,324	479,000	1944
		2	2,000			
	Spring Creek	2	75,000	150,000	150,000	1964
	Trinity	2	52,778			
		1	350	105,906	105,906	1964
	Auburn	-	-	-	300,000	[1]
	New Melones[5]	2	150,000	300,000	300,000	1979
	Marysville[6]	-	-	-	375,000	[1]
Collbran	Lower Molina	1	4,860	4,860	4,860	1962
	Upper Molina	1	8,640	8,640	8,640	1962
Colorado-Big Thompson	Big Thompson	1	4,500	4,500	4,500	1959
	Estes	3	15,000	45,000	45,000	1950
	Flatiron	2	31,500	63,000	63,000	1954
	Flatiron-3[7]	1	8,500	8,500	8,500	1954
	Green Mountain	2	10,800	21,600	21,600	1943
	Marys Lake	1	8,100	8,100	8,100	1951
	Pole Hill	1	33,250	33,250	33,250	1954
Colorado River Front Work and Levee System	Senator Wash[8]	-	-	-	-	1966
Colorado River Storage	Blue Mesa	2	30,000	60,000	60,000	1967
	Crystal	1	28,000	28,000	28,000	1978
	Flaming Gorge	3	36,000	108,000	108,000	1963
	Glen Canyon	8	118,750	950,000	950,000	1964
	Morrow Point	2	60,000	120,000	120,000	1970

[1] Indefinite
[2] Being constructed for the International Boundary and Water Commission. Power to be marketed by the Western Area Power Administration.
[3] The Service's share of entitlement in the 2,250,000-kW Navajo Steamplant under terms of the Navajo Participating Agreement to be used for pumping in the Central Arizona Project.
[4] San Luis Pumping-Generating plant jointly owned by U.S. and the State of California. Capacity normally available to the Service is 202,000 kW.
[5] Constructed by the Corps of Engineers, but to be operated by the Service as an integral part of the Central Valley Project. Power to be marketed by the Western Area Power Administration.
[6] To be constructed by the Corps of Engineers and operated by the Service as a part of the Central Valley Project.
[7] Pump-generating unit
[8] No longer considered a generating plant as of July 20, 1977.

Summary Tabulation of Powerplants—Continued

Project	Name	Number of units	Capacity of units (kilowatts)	Existing plant capacity (kilowatts)	Ultimate authorized plant capacity (kilowatts)	Date of first generation
Columbia Basin	Grand Coulee	17	125,000			
		1	108,000			
		3	600,000	4,763,000	6,180,000	1941
		1	700,000			
		3	10,000			
	Grand Coulee Pump/Generating	2	50,000	100,000	300,000	1973
Crooked River	Cove[9]	1	1,500	1,500	1,500	1946
Eklutna	Eklutna[10]	2	15,000	30,000	30,000	1955
	Old Eklutna	2	1,000	2,000	2,000	[11]
Falcon	Falcon[12]	3	10,500	31,500	42,000	1954
Fryingpan-Arkansas	Mt. Elbert[7]	2	100,000	200,000	200,000	[1]
	Otero	1	11,000	11,000	11,000	[1]
Grand Valley	Grand Valley[13]	2	1,500	3,000	3,000	1933
Hungry Horse	Hungry Horse	4	71,250	285,000	285,000	1952
Kendrick	Alcova	2	18,000	36,000	36,000	1955
	Seminoe	2	10,800			
		1	15,000	36,600	45,000	1939
Minidoka	Minidoka	5	1,200			
		1	2,400	13,400	13,400	1909
		1	5,000			
	American Falls[14]	-	-	-	-	-
Newlands	Lahontan[15]	2	500			
	(hydro)	1	920	1,920	1,920	1911
	Lahontan (diesel)[16]	2	1,000	2,000	2,000	1949
	"V" Canal (hydro)[16]	2	400	800	1,600	1955
North Platte	Lingle[17]	2	300			
		2	400	1,400	1,400	1919
	Guernsey	2	2,400	4,800	4,800	1927
Palisades	Palisades	2	28,500			
		2	30,875	118,750	118,750	1957
Parker-Davis	Davis	5	48,000	240,000	240,000	1951
	Parker	4	30,000	120,000	120,000	1942
Pick-Sloan Missouri Basin Program	Angostura[18]	1	1,200	1,200	1,200	1951
	Big Bend[19]	8	58,500	468,000	468,000	1964
	Boysen	2	7,500	15,000	15,000	1952
	Canyon Ferry	2	16,667			
		1	16,666	50,000	50,000	1953
	Fort Peck[19]	1	15,000			
		2	35,000	165,000	165,000	1943
		2	40,000			

[9] Transferred to Pacific Power and Light Co. on April 19, 1946. Subsequently retired on October 31, 1963.
[10] Transferred to the Alaska Power Administration on June 16, 1967.
[11] Privately constructed, acquired by the Service in 1955, and since transferred to the Alaska Power Administration.
[12] Falcon Powerplant built and operated by the International Boundary and Water Commission. Power marketed by the Service until October 1977.
[13] Transferred to Grand Valley Water User's Assn. in May 1932. Operated by Public Service Company of Colorado under a lease contract with the water user's association
[14] Subsequently authorized for non-Federal development by P.L. 93-206 dated December 28, 1973.
[15] Presently leased and operated by the Sierra Pacific Power Company.
[16] Constructed and operated by Truckee-Carson Irrigation District
[17] Operation discontinued in April 1956, and site sold in 1961
[18] Operation discontinued in July 1960, and partially dismantled and sold as surplus in FY 1972.
[19] Constructed by the Corps of Engineers and the Power marketed by the Service until October 1977. Power currently marketed by the Western Area Power Administration

Summary Tabulation of Powerplants—Continued

Project	Name	Number of units	Capacity of units (kilowatts)	Existing plant capacity (kilowatts)	Ultimate authorized plant capacity (kilowatts)	Date of first generation
Pick-Sloan Missouri Basin Program—Continued	Fort Randall[19]	8	40,000	320,000	320,000	1954
	Fremont Canyon	2	24,000	48,000	48,000	1960
	Garrison[19]	5	80,000	400,000	400,000	1956
	Gavins Point[19]	2	33,345			
		1	33,310	100,000	100,000	1956
	Glendo	2	12,000	24,000	24,000	1958
	Kortes	3	12,000	36,000	36,000	1950
	Oahe[19]	7	85,000	595,000	595,000	1962
	Prairie Creek[20]	-	-	-	16,800	[1]
	Yellowtail	4	62,500	250,000	250,000	1966
Provo River	Deer Creek	2	2,475	4,950	4,950	1958
Rio Grande	Elephant Butte	3	8,100	24,300	24,300	1940
Riverton	Pilot Butte[21]	2	800	1,600	1,600	1925
Rogue River	Green Springs	1	16,000	16,000	16,000	1960
Salt River	Arizona Falls[22]	2	530	1,060	1,060	1913
	Cross-Cut[22]	1	3,000	3,000	3,000	1914
	Cross-Cut (steam)[23]	4	7,500	30,000	30,000	1948
	Cross-Cut (diesel)[23]	2	4,200	8,400	8,400	1938
	South Consolidated[22]	2	1,000	2,000	2,000	1912
	Horse Mesa[24]	3	10,000	30,000	30,000	1927
	Mormon Flat[24]	1	7,000	7,000	7,000	1926
	Stewart Mountain[24]	1	10,400	10,400	10,400	1930
	Theodore Roosevelt[22]	5	1,080			
		1	4,000	19,290	19,290	1909
		1	9,890			
	Kyrene (steam)[23]	1	30,000			
		1	60,000	90,000	90,000	1952
	Agua Fria (steam)[23]	2	100,000	200,000	200,000	1958
Seedskadee	Fontenelle	1	10,000	10,000	10,000	1968
Shoshone	Heart Mountain	1	5,000	5,000	5,000	1948
	Shoshone	1	800			
		1	1,212	6,012	6,012	1922
		1	4,000			
Strawberry Valley	Upper Spanish Fork[25]	2	450	900	900	1908
	Lower Spanish Fork[26]	1	250	250	250	1937
	Payson[26]	1	400	400	400	1911
Washoe	Watashemeau	-	-	-	8,000	[1]
	Stampede	-	-	-	3,000	[1]
Weber Basin	Gateway[27]	2	2,250	4,500	4,500	1958
	Wanship[27]	1	1,425	1,425	1,425	1958
Yakima	Chandler	2	6,000	12,000	12,000	1956
	Roza	1	11,250	11,250	11,250	1958
	Rocky Ford[28]	1	187	187	187	1917
	Prosser[29]	1	2,400	2,400	2,400	1932
Yuma	Siphon Drop	2	800	1,600	1,600	1926[30]

[20] Authorized as a feature of the Nebraska mid-State Division on November 14, 1967.
[21] Taken out of service in June 1973.
[22] Constructed with funds supplied by Water User's association
[23] Constructed and operated by Salt River Project Agricultural Improvement and Power District.
[24] Constructed by Salt River Valley Water User's Association, operated by Salt River Project Agricultural Improvement and Power District
[25] Constructed by the Service, operated by the Strawberry Water User's Association.
[26] Constructed and operated by the Strawberry Water User's Association
[27] Transferred to Weber Basin Water Conservancy District on October 1, 1968.
[28] Transferred to Grandview Irrigation District in July 1917, subsequently retired in 1953
[29] Discontinued operation in May 1955, and dismantled in 1957.
[30] Transferred to Yuma Co. Water User's Association on January 1, 1963.

Summary Tabulation of Transmission Lines

Project	500 kV	230 & 287.5 kV	138 kV	115 kV	44, 57, & 69 kV	33 & 34.5 kV	23 & 24.9 kV	13.8 kV & below	Total
Boise					19.40		12.45		31.85
Boulder Canyon		5.44	1.09		2.88				9.41
Central Valley		1.56		0.87				16.63	19.06
Collbran				4.75					4.75
Colorado-Big Thompson								3.42	3.42
Colorado River Front Work and Levee System					17.70	8.30			26.00
Colorado River Storage								0.27	0.27
Columbia Basin	6.68			0.06					6.74
Hungry Horse		0.48							0.48
Palisades				0.44					0.44
Parker-Davis		70.00							70.00
Pick-Sloan Missouri Basin Program		0.78		15.37	5.36	3.36		7.64	32.51
Provo River					0.40				0.40
Yakima						64.06		9.34	73.40
Yuma						0.70			0.70
Total	6.68	78.26	1.09	21.49	45.74	76.42	12.45	37.30	279.43

Summary Tabulation of Substations

Project	Number in operation	Capacity of transformers (kVA)
Boise	7	53,715
Boulder Canyon	2	1,707,500
Central Valley	20	1,526,292
Collbran	2	16,500
Colorado-Big Thompson	8	387,438
Colorado River Front Work and Levee System	1	9,375
Colorado River Storage	5	1,607,000
Columbia Basin	4	7,190,334
Hungry Horse	1	438,650
Kendrick	2	107,830
Minidoka	2	39,000
North Platte	1	7,500
Palisades	1	152,500
Parker-Davis	2	707,500
Pick-Sloan Missouri Basin Program	16	709,790
Provo River	1	6,250
Rio Grande	1	28,000
Rogue River Basin	1	18,000
Seedskadee	1	13,750
Shoshone	2	20,654
Yakima	11	40,000
Yuma	1	50

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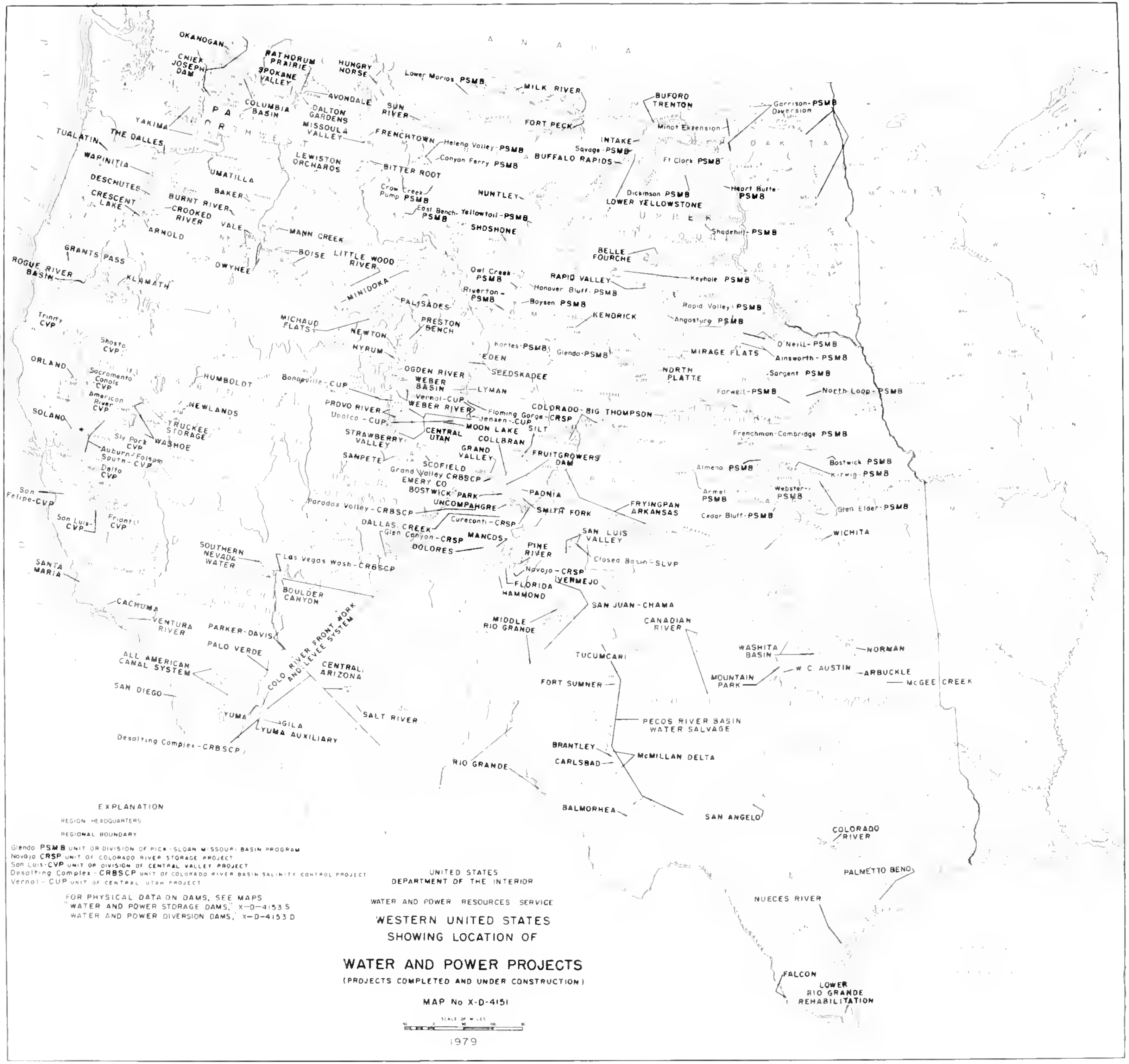
EXPLANATION
REGION HEADQUARTERS
REGIONAL BOUNDARY
Glendo PSMB UNIT OR DIVISION OF PICK-SLOAN MISSOURI BASIN PROGRAM
Navajo CRSP UNIT OF COLORADO RIVER STORAGE PROJECT
San Luis-CVP UNIT OR DIVISION OF CENTRAL VALLEY PROJECT
Desalting Complex-CRBSCP UNIT OF COLORADO RIVER BASIN SALINITY CONTROL PROJECT
Vernal-CUP UNIT OF CENTRAL UTAH PROJECT
FOR PHYSICAL DATA ON DAMS, SEE MAPS
"WATER AND POWER STORAGE DAMS," X-D-4153 S
"WATER AND POWER DIVERSION DAMS," X-D-4153 D
UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
WESTERN UNITED STATES
SHOWING LOCATION OF
WATER AND POWER PROJECTS
(PROJECTS COMPLETED AND UNDER CONSTRUCTION)
MAP No X-D-4151
1979
OKANOGAN
CHIEF JOSEPH DAM
RATHDRUM PRAIRIE
SPOKANE VALLEY
HUNGRY HORSE
Lower Marias PSMB
MILK RIVER
COLUMBIA BASIN
AVONDALE
DALTON GARDENS
SUN RIVER
YAKIMA
MISSOULA VALLEY
FRENCHTOWN
FORT PECK
BUFORD TRENTON
Garrison-PSMB
Garrison Diversion
Minot Extension
INTAKE
Savage-PSMB
BUFFALO RAPIDS
Ft Clark PSMB
TUALATIN
THE DALLES
WAPINITIA
LEWISTON ORCHARDS
Helena Valley PSMB
Canyon Ferry PSMB
BITTER ROOT
UMATILLA
DESCHUTES
BAKER
BURNT RIVER
CRESCENT LAKE
CROOKED RIVER
VALE
ARNOLD
Crow Creek Pump PSMB
East Bench PSMB
Yellowtail-PSMB
HUNTLEY
SHOSHONE
Dickinson PSMB
LOWER YELLOWSTONE
Heart Butte PSMB
Shadehill-PSMB
MANN CREEK
BOISE
LITTLE WOOD RIVER
OWYHEE
GRANTS PASS
ROGUE RIVER BASIN
KLAMATH
BELLE FOURCHE
Owl Creek PSMB
RAPID VALLEY
Keyhole PSMB
Hanover Bluff PSMB
Riverton PSMB
Boysen PSMB
MINIDOKA
PALISADES
KENDRICK
Rapid Valley PSMB
Angostura PSMB
Trinity CVP
Shasta CVP
MICHAUD FLATS
PRESTON BENCH
NEWTON
HYRUM
Kortes PSMB
Glendo PSMB
EDEN
O'Neill-PSMB
MIRAGE FLATS
Ainsworth-PSMB
ORLAND
Sacramento Canals CVP
HUMBOLDT
OGDEN RIVER
SEEDSKADEE
NORTH PLATTE
Sargent PSMB
American River CVP
Bonneville-CUP
WEBER BASIN
LYMAN
Farwell-PSMB
North Loup-PSMB
NEWLANDS
Vernal-CUP
WEBER RIVER
PROVO RIVER
Flaming Gorge-CRSP
Jensen-CUP
COLORADO-BIG THOMPSON
SOLANO
TRUCKEE STORAGE
Upalco-CUP
CENTRAL UTAH
MOON LAKE
SILT
Sly Park CVP
WASHOE
STRAWBERRY VALLEY
COLLBRAN
Frenchman-Cambridge PSMB
Auburn-Folsom South-CVP
GRAND VALLEY
FRUITGROWERS DAM
Delta CVP
SANPETE
SCOFIELD
Grand Valley CRBSCP
EMERY CO
Almena PSMB
Bostwick PSMB
Kirwin PSMB
San Felipe-CVP
BOSTWICK PARK
PAONIA
Webster PSMB
Armel PSMB
Paradox Valley-CRBSCP
UNCOMPAHGRE
SMITH FORK
FRYINGPAN ARKANSAS
Cedar Bluff-PSMB
Glen Elder-PSMB
San Luis CVP
Friant CVP
DALLAS CREEK
Curecanti-CRSP
Glen Canyon-CRSP
MANCOS
SAN LUIS VALLEY
WICHITA
SOUTHERN NEVADA WATER
DOLORES
PINE RIVER
Closed Basin-SLVP
SANTA MARIA
Las Vegas Wash-CRBSCP
Navajo-CRSP
VERMEJO
FLORIDA
HAMMOND
BOULDER CANYON
SAN JUAN-CHAMA
CACHUMA
MIDDLE RIO GRANDE
CANADIAN RIVER
VENTURA RIVER
PARKER-DAVIS
COLO RIVER FRONT WORK AND LEVEE SYSTEM
WASHITA BASIN
NORMAN
PALO VERDE
TUCUMCARI
W C AUSTIN
ARBUCKLE
ALL AMERICAN CANAL SYSTEM
CENTRAL ARIZONA
MOUNTAIN PARK
McGEE CREEK
FORT SUMNER
SAN DIEGO
SALT RIVER
YUMA
GILA
YUMA AUXILIARY
PECOS RIVER BASIN WATER SALVAGE
Desalting Complex-CRBSCP
BRANTLEY
McMILLAN DELTA
CARLSBAD
RIO GRANDE
BALMORHEA
SAN ANGELO
COLORADO RIVER
PALMETTO BEND
NUECES RIVER
FALCON
LOWER RIO GRANDE REHABILITATION