REPORT on the Yellowstone Basin and Adjacent Coal Area LEVEL B STUDY

Volume 6a
Appendix

North Dakota Tributaries

Missouri River Basin Commission
September, 1977

APPENDIX 6A

NORTH DAKOTA STUDY TEAM INVESTIGATIONS OF PROBLEMS, ISSUES AND OPPORTUNITIES IN THE WESTERN DAKOTA TRIBUTARIES PLANNING AREA

YELLOWSTONE BASIN AND ADJACENT COAL AREA LEVEL B STUDY

PREPARED BY: NORTH DAKOTA STUDY TEAM

SEPTEMBER, 1977

TABLE OF CONTENTS

SECTION I

ISSUES AND CONCERNS OF PRIVATE CITIZENS,
SPECIAL INTEREST GROUPS AND LOCAL OR STATE AGENCIES

NATURAL GAS PIPELINE COMPANY OF AMERICA

122 South Michigan Avenue • Chicago, Illinois 60603

C.F. RUPE, JR., Manager
Bismerck, N. D. Office

Reply to:
103-1/2 S. 3rd Street
Suite No. 22
Bismarck, North Dakota 58501
Phone: 701-258-6447

March 24, 1976

Mr. Don Ohnstad, Manager
Missouri Basin Regional Commission
Room 16
601 Bismarck Avenue
Bismarck, ND 58501

Dear Mr. Ohnstad:

Please find attached, information on Natural Gas Pipeline Company's Project in Dunn County, North Dakota, for your Level B Study.

As new information is developed, I will be happy to make it available to you.

Sincerely,

Chuck Rupe

C. F. Rupe, Jr.
Manager, Bismarck Office

CFR/bas

Enclosure

cc: Norm Sidler

YELLOWSTONE LEVEL B STUDY
ACCOUNTS WORK SHEET

by --- NATURAL GAS PIPELINE COMPANY OF AMERICA
122 South Michigan Avenue, Chicago, Illinois 60603

PROJECT NAME

Dunn Center Coal Gasification Project.

PROJECT HIGHLIGHTS

NATURAL GAS PIPELINE COMPANY OF AMERICA, a subsidiary of Peoples Gas Company, Chicago, Illinois, proposes to construct and operate four mine-mouth coal gasification plants, along with supporting surface coal mines, in Dunn County, North Dakota, near Dunn Center. Each plant would be capable of producing 250 million cubic feet of synthetic pipeline gas (SPG) daily. The first plant would be built in the early 1980's; three additional plants would be added at three-to-five year intervals, bringing the total output to one billion cubic feet of synthetic gas per day before the year 2000.

The company secured development rights to coal leases covering approximately 110,250 acres in Dunn County. The general area of interest contains about 2.1 billion tons of lignite, lying at depths up to 200 feet. In October, 1974, the company applied for the nomination of Federal coal reserves, which intersperse the coal leases mentioned above, for competitive bid leasing.

Approximately 17,500 acre feet of water will be required annually for each mine-plant unit. This includes sufficient water for mine use, and land reclamation at each mine-plant site, in addition to process uses.

In mid-April, 1974, Natural filed an application with the North Dakota State Wate Commission for a total of 70,000 acre feet of water annually to sustain operation of the entire project. The water would be diverted from the Little Missouri Arm of Lake Sakakawea.

Natural proposes to transport the gas produced at the facility to markets through the proposed Northern Border Pipeline. When completed, the Northern Border line would deliver both natural gas from the Arctic and synthetic gas from Dunn County to Natural's utility customers in the Upper Midwest.

STATISTICAL INFORMATION

WATER REQUIREMENTS:

Total Annual Water Requirement (4 Plants)	70,000	Acre Feet
Water Consumption/Plant		
Process Uses – (a) Consumed in Reactions	1,912	A.F.
(b) Returned to Atmosphere	12,617	A.F.
(c) Returned to Mine	719	A.F.
(d) Misc. Plant Uses	1,437	A.F.
Sub Total	16,685	A.F.
(e) Entering As Lignite Moisture	(1,714)	A.F.
Net Process Use	14,971	A.F.
Mine Uses – (a) Mine	1,118	A.F.
(b) Reclamation	639	A.F.
Net Mine Use	1,757	A.F.
Total Plant and Mine Use	16,728	A.F.

Anticipated Source of Water . . . . Lake Sakakawea

Method of Transport . . . . Buried Pipeline

THE FEEDSTOCK:

Proven Lignite Reserve	2.1 billion tons
Probable Recovery Factor	90%
Field Average Overburden to Lignite Thickness Ratio	6:1
Lignite Thickness	11 to 24 feet
Heating Value (Moisture Ash Free)	11,881 Btu/pound
As Mined	6,524 Btu/pound

THE GASIFICATION COMPLEX:

Capacity/plant	250 million Cubic feet/day
Maximum Complex Size	4 Plants
Land Requirement	350 Acres/plant
Employment (a) Supervisory and Administrative	40
(b) Engineers and Technicians	40
(c) Operations	240
(d) Maintenance	305
Total Per Plant	625

THE MINES:

Maximum Number of Mines	4
Average Annual Production/Mine	12,900,000 tons
Estimated Acreage Mined Annually	500/Mine
Employment (a) Supervisory and Administrative	50
(b) Technical	15
(c) Production	200
(d) Maintenance	35
Total Mine	300

All values shown were obtained from preliminary investigations based on the use of the LURGI GASIFICATION PROCESS.

CITY OF DICKINSON P. O. BOX 606

DON F. CUSKELLY, CITY ENGINEER PHONE: 225-6765 EX. 68 DICKINSON, NORTH DAKOTA 58601

April 24, 1976

Don Ohnstad
Yellowstone Basin and Adjacent Coal Area
Level B Study
601 East Bismarck Avenue, Room 16
Bismarck, N. D. 58501

Dear Don,

This is a request from the City of Dickinson and its water needs as pertains to your study. The City will need 6000 acre feet of water annually by the year 2020 and the only source would be the Garrison Diversion. Beyond this time the City's need for raw water will grow but it is difficult to estimate. I personally believe that a minimum of 10,000 acre feet of water per year should be set aside for the City of Dickinson.

Sincerely,

Don F. Cuskelly

Don F. Cuskelly
City Engr.

Missouri West Water Systems Cooperative

P. O. BOX 727 • MANDAN, N. D. • 663-7539

James A. Ketterling, Manager

April 28, 1976

Mr. Don Ohnstad
Yellowstone Basin Study
Assistant Study Manager
601 Bismarck Ave. Room 16
Bismarck, ND 58501

Dear Don:

I am enclosing a preliminary outline of several issues which we feel are extremely vital to the interests of citizens in western North Dakota and which, further, should be incorporated in the work of the State Study Team and the ad hoc committees on municipal, rural domestic, livestock, and agri-business water requirements and the committee on ground water supply and impact analysis.

During the meeting at Glen Ullin held on April 20, many of those present indicated a deep concern on the potential effects of development on ground water supplies, water quality, rural and municipal supplies. In addition, expressions were received relating to livestock water, urban water problems, and the need for a comprehensive plan which addresses these concerns. The enclosures are not developed issues, but do express in part the parameter of the problem requiring intensive study. Because of uncertainties surrounding the expectations of citizens submitting issues for consideration in the Yellowstone Study these issues are briefly outlined in anticipation that you and I together with members of the State Water Commission could meet to draft a formal issue paper which is acceptable.

I hope that you will call upon me whenever such a meeting can be scheduled in order that we may complete this work before the next meeting of the State Study Team.

Sincerely yours,

Jim K.

Jim Ketterling, Manager
Missouri West Water Systems Cooperative

ISSUE PAPER: Yellowstone Basin Level B. Study

The Area Problem Defined:

Throughout the West River Area, groundwater is extemely high in sodium bicarbonate, sodium corbonate, sodium sulfate, iron and manganese, and in some localities, high in nitrates. Total dissolved solids often exceed 2,000 ppm, which by Health Department standards classifies this water as very poor or substandard quality. Generally described, rural families in this area are drinking water which is highly saline and alkaline, in some instances totally unfit for human consumption, and in most instances unfit for lawn and garden irrigation. It is not unusual for rural families to haul water for drinking and culinary purposes and for housewives to take family laundry to another city because of the poor water quality.

In an analysis of alternatives for developing and managing the West River Area's water and related land resources, the North Dakota State Water Commission found that, "approximately thirty (30) area cities presently have either water quality or quantity problems... (including) the communities of Beach, Belfield, Bowman, Center, Dickinson, Elgin, Fort Yates, Glen Ullin, Hazen, Hebron, Hettinger, Killdeer, Mott, New England, New Salem, Richardton and Watford City.

Groundwater studies in the area show that .... "most present domestic wells are located in sandstone or lignite (bedrock) aquifers. Water quality is usually considered the most limiting factor in the use of these aquifers. With few exceptions, the water quality is unsuitable for irrigation. The quality is considered only marginal for domestic purposes.

The irony of the problem associated with water quality and water availability for domestic and agri-business use in North Dakota is that while underground supplies do not generally yield good water, the state has an unlimited surface water resource in the Lake Sakakawea impoundment, the flowing Missouri River and the Oahe Reservoir.

A plan for distributing this water to the rural people and communities in need should be studied and analyzed for its practical applications and economic feasibility. In addition, underground aquifer testing and monitoring should be thoroughly explored with particular concern for coal-mining effects in areas presently dependent upon these aquifers for domestic water supplies.

Aquifer study results would indicate water quality and recharge capabilities required to sustain rural water systems demands, and if proven adequate to requirements these aquifers could be included as potential primary or secondary sources of water for a rural water system distribution network in various parts of the state.

Families are concerned about the future effects of major coal development or underground water supplies. With underground aquifers being mined, water tables will be lowered and many shallow wells could conceivably go dry overnight. The possibility of contaminants and pollutants entering underground water supplies looms increasingly more threatening as major coal development occurs in the area. Future and existing needs of families living in the West River Area must be identified, priorities must be established, and a comprehensive domestic water delivery plan should be developed.

Jim Kettering
Missouri West Water Systems
Cooperative

INTERSTATE INTERCHANGE ROUTE 94

HYWY 22

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ERNEST BAILEY, FINANCE, BUILDINGS
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A L BINEK, POLICE, FIRE

CITY AUDITOR
JAMES K GEROU CMC

QUEEN CITY

★ CITY OF DICKINSON

DICKINSON, NORTH DAKOTA 58601

April 29, 1976

Missouri River Basin Commission
ATTENTION. Donald Ohnstad
Manager
601 East Bismarck Avenue
Room 16
Bismarck, ND 58501

Dear Mr. Ohnstad,

I am writing to you in regard to the Yellowstone Basin hearings which you are conducting at the present time to discuss general water needs and uses for the future of our area.

On behalf of the City of Dickinson I would like to be on record stating that sometime in the near future the municipal water needs for the City of Dickinson should be at this time considered in the study when we are projecting the future needs of water from the Yellowstone Basin and the Garrison Reservoir.

I don't feel that at this time we could make any firm committments or requests as to what the future municipal water needs will be for the City of Dickinson, however; I feel that we do want to go on record at this time stating that sometime in the future we will be asking for and hoping that there will be available water for the City of Dickinson for municipal uses.

If there is any other information which you feel you should have or need do not hesitate to let us know.

Thank you.

Sincerely,

Henry Schank

Henry Schank
Mayor, City of Dickinson

HS:pk

MONTANA-DAKOTA UTILITIES CO.

400 NORTH FOURTH STREET - BISMARCK, ND 58501 - TEL. (701)224-3000

May 3, 1976

Mr. Donald Ohnstad
Assistant Study Manager
Yellowstone Basin and Adjacent Coal Area Level B Study
Missouri River Basin Commission
601 East Bismarck Avenue, Room 16
Bismarck, North Dakota 58501

Dear Don:

Attached is a copy of the Informal Study Paper as requested in the meeting of the North Dakota Study Team on April 20, 1976.

Sincerely yours,

R. E. Wood
Public Affairs Representative

REW:ss
Attachment

INFORMAL ISSUE PAPER

The demand for electrical energy continues to grow: nationally, regionally and, as well, here in North Dakota. Although major new sources of energy are being researched (nuclear fusion, solar, wind, etc.) "it seems certain none will become a major factor in meeting energy demands before the year 2000."*

In our North Dakota study area the above mentioned demands for electrical energy leaves but one conclusion: the development of lignite reserves and the use of water resources to meet the growing demand.

MDU's present forecasts indicate a need for additional generating capacity in 1981. This will be supplied by the proposed Coyote I plant in Beulah, North Dakota. The plant will be a mine-mouth operation and will require 11,000 acre feet of water per year, diverted from the Missouri River.

Further forecasts indicate MDU will need additional generating capacity in 1985.

With the lignite coal resources of this region, it is our belief the electric needs will be met on the most economical basis, with lignite-fired steam generating plants.

We firmly believe, with stringent reclamation laws and our commitment to reclaim mined lands, reclamation efforts will be successful in restoring the disturbed land to production as crop or pasture land.

The reservation of water and the use of our coal reserves for future electrical energy generation is essential in the formation of any plan developed as a result of the Yellowstone Basin and Adjacent Coal Area Study.

* Energy, Supply-Demand, Outlook and Study Needs in Montana, Wyoming and North Dakota. Prepared by Study Managers, MRBC Yellowstone Study, August 1975, P. 10.

May 3, 1976

Mr. Don Ohnstad
Assistant Study Manager
Yellowstone Basin Level B Study
601 East Bismarck Avenue, Room 16
Bismarck, ND 58501

Dear Don:

Enclosed are our comments in regard to the water needs of Southwestern North Dakota. We state this as a position and would like to have said information placed in your files.

Sincerely,

Robert A. Stranik

RAS:jh

Enc.

We as Citizens of Southwestern North Dakota and also as members who participated in the County hearings on West River Divirsion, do hereby submit our thoughts and our positions regarding the present and future needs of water use and coal development in Southwestern North Dakota. We recognize that water use also involves industry, irrigation, municipal use, rural water supply, and other uses. Therefore, the comments not only involve water but other developments:

1. We encourage the State Water Commission to take all actions possible to retain control of our Water Resources for the State of North Dakota.

2. Limit Water permits for Coal Development within reason. Actually four or five gasification plants in total by the year 2000.

3. Where practical, require that any allocation of water for coal development be dedicated to the land rather than as the sole water right of the coal developer. Thus it would then be possible to continue the same flow of water through the same transmission facilities without a lot of additional red-tape and the water could be used to aid in land reclamation and to provide increased productivity of reclaimed land.

4. Unitize water transmission lines where feasible to lessen the disturbance of land surface and to allow for multiple use of transmission facilities and water for all beneficial uses. Beneficial uses would include irrigation, municipal use, rural water supply, and other industrial uses besides coal development. We would also recommend that a pipeline be given preference to an open ditch or canal. This would disturb less land and would be better for the area from an enviromental standpoint.

5. Encourage organization of local entities to participate in the governing and control of the water use and as far as possible to have a hand in determining the extent and patterns of industrial and agricultural development.

6. Encourage all sensible research and data gathering on the social problems and how to protect ourselves and our communities from the social changes and tax impact which could accompany extensive Coal Development.

7. Request increased research on Land Reclamation, including the use of irrigation.

8.. We would recommend that coming Legislators enact laws that are more specific and have more definitive enforcement procedures as we learn more about the best practicies on Reclamation of strip mined land to reach the ultimate in agricultural productivity. We feel that reclamation should be the responsibilty of the coal developer. Land to be mined should have a complete soil survey prior to any disturbance. Replacement of the soil could be best done under the supervision of soils specialist to assure that the most beneficial use be made of the available top soil and other surface material. We also recommend that the land be leveled to the best grade for agricultural production which in many cases will be different from the original contour.

9. Compile information to be used to enforce the rights of surface owners and encourage the enactment of State Laws to protect the surface owner who does not own any of the mineral rights, so that he would be property compensated for damages and loss of production.

10. Enact and enforce strict, but realistic air and water pollution standards on <u>all</u> industry.

We submit these thoughts to the Missouri River Basin Commission-Yellowstone Basin and Adjacent Coal Area Level B Study for your uses in evaluating the needs of the West River Area. We have set forth definite recommendations to use in preparing for the problems of future water and coal development.

Sincerely,

Robert A. Stranik

Raymond Schnell

Robert W. Sadowsky

Missouri West Water Systems Cooperative

P. O. BOX 727 • MANDAN. N. D. • 663-7539

James A. Ketterling, Manager

May 6, 1976

Mr. Don Ohnstad
Yellowstone Basin Study
Asst. Study Manager
601 Bismarck Ave. Room 16
Bismarck, ND 58501

Dear Don:

Pursuant to our meeting on Monday of this week at the State Water Commission, I am enclosing brief outlines on a number of additional issues which we feel are deserving of State Study Team evaluation.

Specifically, some of these issues address concerns which although we have no expertise in the field, perhaps could be assigned to other members or agencies for further exploration. I am referring to the soils testing program and the monitoring of underground water supply. Another point of concern, again outside our immediate field of endeavor, is the issue requesting study on net energy ratios which apply to the investment vs. return margins of gain applying to mining of resources.

As we agreed an outline at this time is sufficient to point out areas of interest and concern with the understanding that formal issue papers will be developed following recommendation by the State Study Team.

If I can be of further service please call upon me.

Personal regards,

Jim Ketterling, Manager
Missouri West Water Systems Cooperative

JK/kh
Enclosures

BETTER WATER FOR FARMS AND RURAL HOMES IN WESTERN NORTH DAKOTA

ISSUE #1: Soil Testing Program to Identify Irrigation Potential and Soils Compatability

The concern with irrigation rests not on the argument for increased agriculture productivity but surrounds the question of long-range potential given the nature of soils make-up and the quality of the water which would be applied for irrigation purposes. Although the West River Diversion Study does purport that soils in western North Dakota can be irrigated, it has yet to be ascertained specifically where these soils are located with reference to adequate water supply. The approach used in the past was generalized presumably due to the fact that such a soils testing program is extremely time consuming requiring many manhours of field survey and expense for data collection. If we are to correctly analyze irrigation potential it would seem that a specific soil testing program be initiated throughout the area using a grid of not more than 40 acres. Further soils classifications should be clearly identified and soil profiles established where long-term benefit could reasonably be projected. Cost benefit ratios would be contingent upon water source and means of transmission to irrigable acres. In addition, it must also be recognized that pollution hazards may accompany irrigation in poor terrain. This program might probably be undertaken by the Soil Conservation Service in collaboration with other agencies holding vested interests in this field of exploration.

ISSUE #2: City/Rural Water Quality Program

This issue must be raised in view of the Environmental Protection Agency administered Safe Drinking Water Act which became public law in 1974. Since each community will be affected by this legislation within the next several years, and since each municipal or centralized domestic water delivery system serving a specified minimum of consumers will be subject to regulation on water quality standards, it appears that efforts should be made to more clearly understand provisions of this act as it applies to these instances. Inasmuch as each community water system and rural water systems will be subject to compliance at astronomical costs perhaps adequate planning at this time could alleviate many of the problems these systems might otherwise experience in the future.

ISSUE #3: Monitoring of Underground Water Supplies

As we proceed more closely to the extensive mining of our coal resources, it is imperative that we determine as best we know how the effects this activity will have on the underground aquifer systems in terms of water quality management and in water table levels. Many of the fears associated with mining activities are applicable to the lignite seams which now serve to transmit and purify underground water supplies. Most of the communities in western North Dakota depend solely upon underground water for their total needs; likewise, farmers and ranchers and other rural residents cannot afford the risk such activity might impose upon their dependency on this essential resource. Perhaps the Public Service Commission, the State Water Commission, the USGS, Health Department, and other agencies might wrestle with this concern and provide a means whereby careful controls can be established to guard against the irreversible damage which mining activity could have on underground water sources.

ISSUE #4: A Study of Net Energy Ratios

In the January 13, 1975 issue of Newsweek Magazine, a professor of Environmental Engineering at the University of Florida by the name of Howard T. Odum, describes his theory on Net Energy Ratio which is the total energy produced minus the energy expended to produce it. Using computer models, Odum has calculated that petroleum energy yields 6.5 calories for every one calorie consumed in the production processes. By contrast, strip mined coal yields a ratio of only three to one. In Odum's view the future holds continued economic distress unless man changes the pattern of his energy use. He envisions that the future must provide that the principal economic activity if man is to survive would be labor intensive, land intensive agriculture with a minimum of machines and artificial fertilizers.

The Federal Energy Administration concedes that net energy is an important concept. The Environmental Protection Agency is also seriously reviewing the net energy costs. The State of Oregon is attempting to implement this theory in terms of consumptive energy requirements.

Perhaps it is timely to raise this issue in western North Dakota where we are about to embark on extensive strip mining of coal resources without having fully adjusted our thinking to include the direct cost of severing this resource in addition to the loss of agricultural productivity in strip mined areas. This issue might be properly addressed by some of the agencies which have responsibility in coordinating the interests of energy related industry with the need to preserve the agricultural productivity of western North Dakota.

Jim Ketterling, Manager
Missouri West Water Systems Cooperative

May [illegible], 1976

Donald Ohnstad
Assistant Study Manager
601 East Bismarck Avenue
Room 16
Bismarck, N. Dak. 58501

Dear Mr. Ohnstad:

Would you please rush me a copy of the paper you gave at Glen Ullin with a yellow sheet on front with a map. Title: The Yellowstone River Basin and Adjacent Coal Fields Study Area. It also has the list of names and addresses of State and Federal agencies and ad hoc groups.

Can you also send me, right away, a copy of the paper that was talked about, only a few had a copy of that. I think it had a blue cover, but I do not know the name of it. You mentioned that you would have to make some copies.

Sincerely,

Ruben Hummel

Ruben Hummel

Finding good water and enough water is becoming a bigger problem as time goes on.

To provide water for western North Dakota for municipal, domestic and agricultural use; a study should be made to provide water through a rural water system. This water can be supplied from our lakes, dams and underground aquifers. In order to do this, all underground aquifers need to be found and protected.

A study has to be made on what effects strip mining and core drilling has on our underground water supply and surface water so we do not pollute or contaminate it and also our air. If we do not do this, we may find ourselves with a food supply much shorter than an energy supply.

We need to know what effect is would have on our water supply, in our state, if others around our state would use up all the water so very little would come in from outside.

We need to know what our present and future needs for water are before we give it for more coal developent.

A study needs to be made on what benefits and advantages it would have on a community, state and country if we would have a family farm living on the land for about every section or two; and what can be done about it.

Dear Mr. Ohnstad:

Since I was unable to attend the area meetings I have listed a few of our major concerns. These areas I feel should be included in your study.

If I can help you with any of this study with some of the information that we have accumulated, we will be glad to help you.

Sincerely,

Eugene E. Keller
President Mercer Co. Landowner

1.Social Impact.
If all three plants that are being planned in Mercer County are going to be built there will be tremendous impact. Our elderly will be hurt by higher cost of living and the added impact of social services like cpmpeteing for medical services, roads and streets, and other comunity services.

2. Taxes
Since more roads, police portection, housing, schools, and other services will have to be provided, more tax money must be made available. Tax money from workers will not be available until these people will be in the area for some time.

3. Water.
About three fourth of the farmers and ranchers in this area have wells which are located in the coal beds. Massive mining will certainly affect their water supply. ANG's plant will be located over the Antelope Creek Aquifer. Since they plan on pumping wastes into a deep aquifer how will they prevent leakage so Antelope Aquifer will not be contaminated.

4. Heritage.
Most of the farmers and ranchers in this area are third and forth generations. These people will lose a great deal of their heritage if they are forced to move.

5. Irriagation
It will be impossible to plan or set up irriagation system if the area will be mined. The cost of irriation systems cannot be repaid if the use cant be spread over a period of ten or fifteen years.

6. Wild life.
We have several herds of antelope in the area, a few deer, grouse, many ducks use the sloughs and lakes in the spring and fall. There also are fox, coyotes, and a few pheasant.

7. Reclaimation.
Reclamation has not been proven. There is very little land in Mercer County, yet mining has been in the county for years. Clay is unique it will pact and dry hard. Water will not pentrate clay. The land will never be uaed for cultivation. At best it can possibly be used for grazing. The cost of reclamation per acre may not be feasible if the cost of fertilizer plus years needed to reclaim is figured.

8. Lack of information.
Farming is big business and requires a large investment. A ten year mining plan should be made available to the public by all companies planning to strip mine in the county. This would certainly help thearea people when plans are made.

North Dakota Wildlife Federation

Publishers of FLICKERTALES
North Dakota's Leading Environmental Publication

200 West Main
P. O. Box 1694
Bismarck, North Dakota 58501

Phone 223-8741

May 10, 1976

Mr. Don Ohnstad
Assistant Study Manager
Yellowstone Basin and Adjacent Coal Area Level B Study
Missouri River Basin Commission
601 East Bismarck Avenue, Room 16
Bismarck 58501

Dear Mr. Ohnstad:

Reference is made to your appeal for public input to water and land resource problems of our state. We appreciate the opportunity to comment.

We are particularly concerned with water quality. Some strides have been made in cleaning up point pollution. We are still not convinced that lagoons are the solution to cleaning up domestic sewage; nor are we satisfied with feedlot regulations which apply to only those lots where large numbers of domestic livestock feed. Both contribute to non-point pollution.

If, however, we are to control non-point pollution, more consideration must be given to topsoil erosion which carries the chemicals presently being applied annually to hundreds of thousands of acres of agricultural land in North Dakota. Soil particles which find their way to surface water carry with them many tons of commercial fertilizer, herbicides, insecticides, etc. If project 208 is to be successful, methods must be found to control this pollution.

It appears to us that erosion is the key to the problem. Education may be part of the solution. It is possible that many land operators may not realize how they contribute to non-point pollution. Such an educational promotion should urge land treatment which would minimize erosion. Terracing, contouring, water spreading, cover crop utilization and stripcropping are bur a few tools which might be recommended.

Sincerely,

NORTH DAKOTA WILDLIFE FEDERATION, INC.

H. R. Morgan, Chairman
Water Quality Committee

HRM:b

ISSUE PAPER FOR THE YELLOWSTONE LEVEL B STUDY

Long Term Effects of Lignite Utilization for Energy

The long term effects of lignite utilization are numerous. Impacts will include all areas of the present society, population and environment.

First one must consider the current population trends within the area. The population is presently increasing. Large scale mining requires a tremendous influx of new population. Impacts directly associated with the population increase include: (1) large capital costs for providing public faciliti and services, or inadequate services if the expenditures are not made, (2) significant changes in the present character of the existing communities, and (3) uncertainties about the economic stability of the region when coal resources are exhausted or the energy from coal is replaced by another more economical energy source.

A second, but most important effect, is land reclamation. If the mined agricultural land cannot be reclaimed to 100 percent productivity, it is a loss to North Dakota's number one industry - agriculture. Mining may cause an imbalance in the delicate relationship between soils, plants and animals. Mining may also cause disturbances in ground and surface water supplies.

Another effect we cannot sacrifice would be our crisp, clear air. Tremendous gaps exist in present technology with regard to air quality informatior and control. In 1975, the University of North Dakota performed a study on trace elements in Lignite.[1] In this report the author stated his conclusion

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[1]Baria, D. N., "A Survey of Trace Elements in North Dakota Lignite and Effluent Streams from Combustion and Gasification Facilities." The Engineering Experiment Station, UND, May, 1975.

that "there is very little information available on trace elements in different lignite seams . . . there are no studies on trace element emissions from the Lurgi process . . . there are federal standards for only asbestos, mercury and beryllium in the ambient air and no state standards for pollutants present in the atmosphere . . . there are no state standards for mercury in surface water . . . there are no laws regarding deposition of trace element rich ash in the ground."

In addition to the social, environmental and economic impacts within development areas, there may be other effects from lignite development. Converting lignite to useable energy may delay the need to develop other alternatives to the energy problem. Since lignite is nonrenewable, alternative sources will be required at some point in the future. Development of eastern coal reserves could create jobs and require capitol investments that are needed within those eastern coal areas. The energy would also be produced near areas where it is most needed. Converting lignite coal into electricity and synthetic gas is inefficient. There may be merit in preserving the western lignite for more efficient use at some time in the future.

For those reasons, and probably many others not yet encountered, a full issue paper should be developed on the advisability and timeliness of lignite to useable energy conversion in the Yellowstone Study Area.

Issue Paragraph - Yellowstone Level B Study

Saline Seeps

Saline Seeps have increased in recent years. Estimates of seep - affected soils in North Dakota total nearly 100 thousand acres. Frequently, the most productive land on lower landscape positions is affected. Therefore, all alternatives developed in the Yellowstone Level B Study should consider the effects of saline seeps.

Existing farming practices have been cited as a principal contributor to the increase in saline seeps (Summerfallow, weed control, stubble mulching and wind barriers). To control or reduce saline seeps more information is needed about the soil and geologic conditions conducive to seep formation then, appropriate management practices can be applied to effectively reduce the saline seep problem.

ISSUE PARAGRAPH - YELLOWSTONE LEVEL B STUDY

Mined Land Reclamation

The Strip Mine Reclamation Ad Hoc Committee for the Yellowstone Level B Study will provide a strip mined reclamation analysis. This analysis includes a land use impact report for specific areas and an investigation of reclaimed land for its grazing, cropland, and wildlife habitat capabilities. We encourage further study of any area that the Ad Hoc Committee should find deficient.

Areas we feel are of prime concern include:

1) Proven re-vegetation of mined land on a large-scale basis.

2) Irrigation on mined land - Although water is one of the keys to re-vegetation, a lack of knowledge exists in this area.

3) Reclamation to original production - Will additional fertilizer be required to approach historic yields? What are the long term effects of grazing and cropping patterns.

4) Other areas include: Erosion control from spoil piles, subsidence, and the "optimum" depth of topsoil replacement.

PROGRAM TO PRESERVE NORTH DAKOTA'S EXISTING AGRICULTURAL FRAMEWORK

Issue For The Yellowstone Level B Study

North Dakota presently has fresh air, clean water and, basically, a healthy environment. Not being an industrialized state, North Dakota orientates everything around its number one industry - agriculture - farming is simply "everyone's bread and butter."

Economically speaking, North Dakota is doing well. The recent high agricultural price trends have caused a definite upward shift in the state's economy. North Dakota's per capita income has historically been well below that of the national average. During the last three years, the state has moved onto new horizons, placing its average income at or above the national average. With predictions of world-wide food shortages, the economic future for farming, and the state in general, are excellent.

Current trends in the field of agriculture will continue to expand North Dakota's population and economic base. Irrigation, weather modification and improvements in agriculture technologies will accelerate production. The possibility exists for agriculture to create its own energy source. The production of fuel from grain crops displays merit for study. Utilizing grain in this manner would provide energy while benefitting the existing agricultural economic base. Grain is also a renewable and continuous resource.

Tourism is a fast-developing industry in North Dakota. Our area is endowed with a diversity of scenic landscapes, from the rolling prairies - to the Badlands - to the cool water of Lake Sakakawea.

With North Dakota's current bright economic picture, it is doubtful if North Dakota can gain from industrial diversification. Therefore, a program of study should investigate the optimum preservation of the environment within our agricultural and tourism framework.

ISSUE PARAGRAPH - YELLOWSTONE LEVEL B STUDY

Agricultural Water Rights

The demand on land and water resources in Western North Dakota is rapidly increasing. Programs should be initiated to ensure that the state has control of these resources in the future. Water should be reserved for the highest economic agricultural profile. To achieve this goal requires identification of irrigable lands and making projections for water use for food processing, meat packing and other agricultural related industry.

The identification of irrigable lands will define possible energy related industrial and irrigation conflicts. The construction of energy plant facilities and transmission facilities limit irrigation development. Therefore it is necessary to locate energy facilities in areas that reduce these conflicts.

A study of state water laws may be required. There are questions regarding the establishing of priorities, the legality of water right reservations and whether there is adequate authority in existing law to make these reservations.

First Congregational Church

First Avenue West at Fourth Street
Dickinson, North Dakota 58601

THEODORE K. NACE, PASTOR
Post Office Box 507
Study: (701) 225-8713
Home: (701) 225-5928

May 1, 1976

MEMORANDA: Regarding the YELLOWSTONE RIVER BASIN STUDY

It would be my hope that included with the alternative ~~xxxxxxxxxx~~ plans and values that are being evaluated in this study of the natural resources, and water and land use alternatives, such as:

National Economic Development Objectives

Regional Economic Development Objectives

Quality of Environment Objectives

Maintenance of Existing Values (present multiple use and sustained yield)

that there could ~~xx~~ also be an INTERNATIONAL ECONOMIC NEEDS AND DEVELOPMENT alternative, that would put the resources of the ~~xxxxxxxxxx~~ Yellowstone River Basin in the perspective of the needs of the whole world, that the natural resources and land use alternatives be seen with global awareness.

Theodore Nace

Issue Paragraph - Yellowstone Level B Study

Impacts of Current and Emerging Land Use Patterns on Agriculture

In the past, land has seemed to be an abundant, inexhaustible resource. Only a few years ago, food was thought to be in "surplus" in many parts of the world. However, today's expanding population base and decreasing agricultural land prodution base have created a world wide food shortage rather than a surplus.

Shifts in agricultural land use may have serious consequences. These shifts include urban sprawl, mining and massive transportation systems. These developments not only result in a reduction of food supplies but represent a decline in the region's farm income. Environmental effects are also significant with non-agricultural land use trends resulting in destruction of wildlife habitat, degradation of water quality and reductions in water supplies.

A program is needed to study the land use system of North Dakota. Clearly defined goals and objectives must be developed. Only through an effective land use management system can we hope to minimize inefficient use of one of our limited resources.

CITY OF GLEN ULLIN

Glen Ullin, North Dakota

J. C. BECHTOLD, MAYOR
FRANK H. MORMANN, AUDITOR
MIKE HALPERN, ATTORNEY

CITY COUNCIL
BENNIE SCHMIDT
EMIL OPP
WILFRED DUPPONG
JOE FISCHER
DENNIS HARTMAN
LEONARD RAMBOUSEK

May 12, 1976

Mr. Don Ohnstad
Assistant Study Manager
Yellowstone Basin Study
601 East Bismarck Avenue
Bismarck, North Dakota 58501

Re: Issue Paper

Dear Mr. Ohnstad:

Enclosed you will find what I have designated as an "issue paper". I fully understand that it does not comply with the usual detailed type of paper you may be getting from others. However, please accept it for what it is, that is, a cry for help.

Thank you for providing us with an opportunity to express our views.

Very truly yours,

Mike L. Halpern
City Attorney

MLH:ms
Enclosure

ISSUE PAPER

WATER SUPPLY AND OTHER PROBLEMS

GLEN ULLIN, NORTH DAKOTA

MAY 3, 1976

Prepared by: Mike L. Halpern
City Attorney
Glen Ullin,
North Dakota

SETTING

The City of Glen Ullin is located in Western North Dakota in Morton County, about 50 miles west of the capital city of Bismarck, North Dakota. It is also about 50 miles east of Dickinson, North Dakota. It is located just off of I-94 and ND 49 runs north and south through the City. Glen Ullin serves an area of about 500 square miles, the area running north from the Heart Butte Damn and Heart River (about 18 miles directly south) to its northern boundary for trade of about 12 miles. The trade area from east to west runs from the Eagles Nest turnoff of I-94, 6 miles west of the City to a line about 14 miles east of the City.

Its primary function is to serve as a marketing area for agriculture and ranching interests with a secondary function being a central point for recreation (Heart Butte Damn) and tourists. Its primary source of water presently consists of two (2) wells, together being capable of producing 100 gallons per minute and a third well that when operational, will be capable of producing 120 gallons per minute on its own.

CLIMATE

Glen Ullin and the surrounding area have a semiarid continental climate with four distinct seasons and frequent daily flucuations in the weather. The area is characterized by hot, humid summers, and long, cold, dry winters.

Precipitation in the area averages about 16 inches annually but is erratic, ranging from 6.28 inches in 1936 to 32.40 inches in 1941. About 80 percent of the annual precipitation in the area occurs during the April to September season, and almost 52 percent falls during May, June, and July. The average snowfall over the area is about 31 inches.

Summers are hot with temperatures rising occasionally above 100° F, and the winters are cold with temperatures of 20 to 30 degress below zero not uncommon. The mean annual temperature is 40.6° F, and extreme temperatures have ranged from 114 degrees above zero to 47 degrees below zero.

Prevailing winds blow from the northwest with an average velocity of about 10 miles per hour; the maxium wind velocity recorded in the area is about 70 miles per hour. About 70 percent of possible sunshine occurs during the summer months, and about 50 percent of possible sunshine occurs during the winter.

SETTLEMENT AND POPULATION

Settlement of Glen Ullin began in the 1880's as the Northern Pacific Railroad advanced to the present location of the City. The population of Glen Ullin rose to a high in the 1920's and has reflected a decrease since that time. The 1970 population figure was set at 1,072 and there has been some slight erosion of that figure to an estimated 1,010 in 1976. The population of the total area served is estimated to be about 1,000, meaning that the present service area, including the City, has a population of about 2,000.

Since Glen Ullin is located in the heart of the strippable lignite deposit area, it is believed that there will be problems with growth, if not directly in the Glen Ullin area, as a result of the spilloff of other areas, for example, Beulah, Hazen, Center, and Dunn Center.

EXISTING FACILITIES

As previously indicated, the City is currently supplied with water by two (2) wells. As the City Fathers felt that these were not sufficient, a third well was constructed. At the present time, it is not yet operational. However, if and when it does become operational, it will be capable of pumping in excess of 100 gallons per minute.

However, the problem, as we see it, is not so much the quantity of water (assuming that the third well will be operational), as it is with the quality of the water. Attached hereto are Exhibits "A" and "B" for your information and review. As can be plainly seen, the water supply is NOT really satisfactory.

NEEDS

If the newly built well, for which the City of Glen Ullin will spend about $45,000.00 to have completed, does not work out, for one reason or another, then the City will need to have a greater supply of water. This is particularly true in view of the definite future possibility of growth due to coal development.

Beyond the above, there is a definite immediate need for better water. The water presently ulilized by the City cannot be used for irrigation. That means gardens cannot do well; furthermore, lawns suffer. Additionally, the water is bad for all those having heart conditions and those on salt free diets. Therefore, from a health standpoint, as well as many other reasons, the water of Glen Ullin must be upgraded.

Given the above material, we strongly urge that Glen Ullin be considered a coal impact area for the development of a water treatment plant necessary to make the water in the area the kind that meets all acceptable standards. In addition, if an additional well is necessary, funds should be allocated to this purpose.

OTHER PROBLEMS AND NEEDS

In addition to the needs relating to water, we also have sewer and housing needs, together with school needs.

Specifically, the City of Glen Ullin has really run out of space to develop. What we mean is this: Almost all lots currently developed in Glen Ullin are utilized. By developed, we mean with water and sewer. To make use of the other spaces in the City of Glen Ullin will mean expending large amounts on water and sewer lines as well as road improvements. To do this, we need funds.

Of course, if we make the necessary improvements to meet the future needs of the City due to coal impact, we will increase the burden on the presently overburdened school system. At the present time, the grade school building is not really adequate to handle the load. If there is an increase, it will be impossible to do so. Therefore, funds should be made available for this purpose also.

One final problem and that is one that relates to timing. While being in the middle of a lignite area, we are only presently on the edge of the action. That means we do not really know what is happening. Therefore, we would like to receive information that will help us plan for the future. For example, we would like to know the timetable for the first gasification plant.

PLAN

Ideally, we would like the plan to proceed in the following manner:

1. Plans developed, specifications set out, bids let, and construction completed for a water purification plant to make Glen Ullin's water acceptable. Additionally, the necessary funds should be supplied to make the third well operational. We have no idea as to what the above entails, however, we are sure that this information can be supplied by engineers.

2. Plans developed, specifications set out, bids let and construction completed for the development of a subdivision within the city limits of the City of Glen Ullin. Said development will, of course, require sewer, water, streets and lights. The necessary space is available, however, the funds are not. We believe that one lift station will be necessary and probably another cell will have to be added to the lagoon.

3. Plans developed, specifications set out, bids let and construction completed for a new elementary school. We estimate the cost at about $1,200,000.00.

4. Plans developed, specifications set out, bids let and construction completed for a full recreation area.

BENEFIT AND COST ITEMS

Due to our inexperience, we are unable to compute this data; we do know that the above projects would cost considerable money. However, as to specifics, we need to have engineering skills utilized to determine most, if not all the costs. We realize that there would be limited National and Regional impact, but the local impact would be terrific.

SOCIAL FACTORS

With regard to these factors, we find the following: The items above will have, as far as we can see, no adverse effects. There will be no lives endangered, there will be no damages, there will be great employment opportunities, recreation activities will increase, land use changes will be minimal and flora and fauna will not be greatly disturbed.

SUMMARY

First, we apoligize for submitting a paper that is not expertly done; secondly, we submit that our ideas are not new and are entirely selfish. However, we do honestly contend that were sufficient funds required to do the above plans pumped into the City of Glen Ullin, our town would become one of the most enjoy-able and viable communities in the Nation. It seems to us, that it could be used as a model for small, centralized towns, reflecting an ideal place to live.

Exhibit "A"

No. 74-2934 Product Water Sample

Description of Package and Contents when received:

In two, one pint plastic bottles. Brown.

Instructions Chemical analysis.

Mrs. Coila M. Janaceek; Textiles & Clothing Dep't., N.D.S.U., Fargo, N.D. 58102

Municipal Water Supply, Glen Ullin, N.D.

Analysis:	
Total Solids	2420 ppm
Fixed Solids	2170 ppm
Total Hardness (as $CaCO_3$)	24 ppm or 1.4 gr./gal.
Sodium (Na) calc.	809 ppm
pH	8.3
Elec. Cond. (@ 25° C)	3310 micromhos/cm
Alkalinity (as $CaCO_3$)	
Carbonates	0
Bicarbonates	1080 ppm
Chloride (Cl)	8.0 ppm
Sulfate (SO_4)	832 ppm
Iron (Fe)	1.7 ppm
Nitrate (NO_3)	0
Nitrite (NO_2)	0.53 ppm
Ammonia (NH_3)	positive

Signed FCB Analyst.

Date 8-15-74

NORTH DAKOTA STATE DEPARTMENT OF HEALTH
Division of Laboratories
Bismarck, North Dakota

County Morton

CHEMICAL ANALYSIS OF WATER

Sample Number 75-3654 Date Received 9/22/75 Date Reported 10/1/75

Source Well, 1035ft City Well Section ____ Township ____ Range ____

Submitted By George Opp Address Glen Ullin, North Dakota

Owned By ____ Address ____

ANALYSIS

pH				8.3	
CONDUCTIVITY				2000	Micromhos
TOTAL DISSOLVED SOLIDS	☐ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☑ High ☐ Very High	1983	mg/l
SODIUM (Na)	☐ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☐ High ☑ Very High	620	mg/l
NITRATE (NO3)	☑ Satisfactory	☐ High		8.5	mg/l
IRON (Fe)	☐ Satisfactory	☑ High		1.8	mg/l
TOTAL HARDNESS (as CaCO3)	☑ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☐ High ☐ Very High	14	mg/l
CALCIUM (Ca)				4	mg/l
MAGNESIUM (Mg)				1	mg/l
CHLORIDE (Cl)	☐ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☐ High ☑ Very High	250	mg/l
TOTAL ALKALINITY (as CaCO3)	☐ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☑ High ☐ Very High	935	mg/l
CARBONATE (CO3)				78	mg/l
BICARBONATE (HCO3)				982	mg/l
MANGANESE (Mn)	☑ Satisfactory	☐ High		.08	mg/l
FLUORIDE (F)	☐ Satisfactory	☐ High			mg/l
SULPHATE (SO4)	☑ Low ☐ Fairly Low	☐ Satisfactory ☐ Average	☐ High ☐ Very High	35	mg/l
PHOSPHATE (PO4)					mg/l
TOTAL HARDNESS				.82	Grains/Gallon

Potassium 2 mg/l

This water would be: ☐ Excellent ☐ Good ☐ Satisfactory ☑ Usable, but not desirable ☐ Undesirable
For a: ☑ Private Domestic Suppy ☐ Municipal Supply

This water would be:
- ☐ Excellent for most plants under most conditions
- ☐ Good for irrigation but its effect on the soil, over a period of years, may prove harmful to the more sensitive plants
- ☐ May be injurious for irrigation and its effect on the soil, over a period of years, may prove harmful to all but the most tolerant plant life
- ☑ A water which would be unsatisfactory for irrigation and its effect on the soil would prove harmful to all but the most tolerant of plants.

This water:
- ☑ Would cause staining of laundry and plumbing fixtures due to its high iron or manganese content.
- ☑ May prove harmful to individuals on salt-free diets. Please consult your family doctor.
- ☐ May exert a laxative effect upon persons unaccustomed to its high sulphate content

Statement. This analysis includes chemical content only, and does not determine the bacterial quality of the water

For any further information, write to the State Health Department, Bismarck, N. Dak.

Per. [signature] Chemist

Rural, Domestic and Municipal Water Needs

Most cities and rural areas in the study area have a water quantity and/or quality problem. The ground water is usually extremely high in sodium concentrations and total dissolved solids. The surface waters are highly variable in both quality and quantity.

The Safe Drinking Water Act becomes effective in December, 1976. It requires all drinking water to have a total dissolved solid content of not more than 500 ppm. Only a few cities and farms will be within the limit. Many areas are currently using waters above 2000 ppm.

Coal development can also expand the problems. Population levels will not only add increased pressure to existing marginal supplies but mining will cause disturbances in many of the aquifers presently in use.

Alternatives for the area include: water treatment (desalting, etc.), local diversion and diversion from either Lake Sakakawea, the Missouri River or Lake Oahe.

Buford-Trenton Irrigation Problems

There is an increasing occurrence of high ground-water levels over a major portion of the Buford-Trenton Irrigation District. The problem is caused by high backwater stages of the Missouri River which are influenced by inflow, aggradation, the operating levels of Garrison Reservoir, poor drainage due to sediment deposition across the downstream portion of the main drains and the importation of irrigation waters. Bank erosion along the Missouri and Yellowstone Rivers is also causing loss of land and irrigation works.

A water management study is needed for the area to help arrest the problems. The investigation should include a water budget to determine the quantities of water contributed by precipitation, backup water, aggradation and importation.

Solutions that have been proposed include: bank stabilization, channel improvement, purchase of land, easements, well systems for dewatering, modifying main stem operations, reducing irrigation water applications, diking, and irrigation with ground water rather than imported water.

Beulah Flood Control

The main flood hazard in Beulah stems from two small coulees located northwest and northeast of town. Flooding is usually the result of high intensity local cloud bursts. The northwest and northeast coulees drain approximately 3.3 and 5.4 square miles, respectively, and are normally dry channels. However, excessive rain storms can inundate most of the town.

In 1969, the Corps of Engineers investigated several solutions to these flood problems. The Corps estimated the total direct flood damages at $445,000 based on 45 years of records and 1969 price levels. This indicates an average annual loss of $9,900. Several alternative solutions were studied including zoning, flood-plain evacuation and proofing, channel diversions, channel improvements and reservoirs. However, implementation was not accomplished and local support for some action recently has been increasing.

Dickinson Water Supply

Municipal water for Dickinson should be considered in the Yellowstone Level B Study. Dickinson currently uses more water than what would be supplied during a dry period. Continued rapid growth has placed additional demands on its water supply. Coal development could also increase growth rates.

Bank Stabilization

Serious bank erosion is occuring at many locations throughout the Missouri River reach between Garrison Dam and Oake Oahe. Past bank protection works have been directed at correcting erosion conditions in areas of highest damage potential.

Erosion is still destroying agricultural lands (much that is irrigated or irrigable), reducing the tax base and endangering historical sites. The sediment is being deposited in the headwaters of Lake Oahe. Aggradation is beginning to occur and allowing continued erosion will eventually result in high water tables and jeopardize several million dollars of newly developed property.

Need For Study Of The Water Resources

A detailed evaluation of the water resources within priority areas in western North Dakota is worthy of consideration. The water resources are being developed rapidly. In addition, possible mining and other effects are not completely understood.

Water resource management is a necessity. However, several data gaps must be filled before high level management can be accomplished. The relationships between the surface and ground-water regimes must be further defined. The potential effect of withdrawals must be adequately assessed. Basically, a method should be developed to measure the effect of disturbances within the hydrologic cycle.

Such an approach would result in the efficient achievement of baseline data acquisition. It would culminate in the development of a model that could be used by resource agencies to simulate many schemes of water resource utilization and allow for the assessment of those schemes.

Municipal water supplies in the Yellowstone Basin study area of North Dakota, with the exception of Mandan and Dickinson, are largely obtained from wells. Because of this, this issue paper will address only the problems associated with groundwater. Also, due to the size of the area involved and the variable nature of groundwater, this paper will not attempt to address water supply problems on a site specific basis, but will deal with the general problems associated with the study area as a whole.

The amount, occurrence, and availability of groundwater in a region depends upon climate, topography, character, and structure of the soil and rock, and amount and nature of the vegetative cover. In general, the amount of groundwater is great where rainfall is great, although water falling in one region may move underground to another.

Quality of shallow groundwater is usually related to the quantity; where abundant it is commonly potable, where sparse, it is commonly highly mineralized. The extent of mineralization is in general, proportional to the depth. Deeper bedrock waters being usually more highly mineralized than shallow mantle rock waters. Deep artesian water is usually highly mineralized.

Water supplies for municipalities located in the Yellowstone study area are derived chiefly from shallow aquifers. Shallow aquifers are defined as those aquifers overlying the Pierre Shale; they include glacial-drift and alluvium, sandstone or coal beds in the Fort Union Group, and the Fox Hills-Hell Creek formations.

Glacial-drift and alluvial aquifers are found in the glaciated portion of the Study Area and consist mainly of silt, sand, and gravel deposits formed by glacial valley fill and meltwater channel deposition. These are generally one to five miles in width and in places will yield more than 500 GPM. Water quality is variable with TDS ranging from less than 400 mg/l to more than 2,000 mg/l.

The Fort Union Group, composed of beds of silty clay, clay, sand or lignite, underlies nearly the entire Study Area. Quantity of water from aquifers in this group depends upon the thickness, sorting, and grain size of the sand beds, and the quantity of interstitial clay in the vicinity of each well. In some areas well yields of from 50 to 100 GPM are attainable. Water quality in the Fort Union Group is generally poor. TDS ranges from 1,000 mg/l to 3,000 mg/l and sodium concentrations are high, ranging from 50% to 80% of the anions present.

The Fox Hills-Hell Creek Aquifer, composed of interbedded sand, clay, silt, and lignite, underlies the Fort Union Group in the Study Area. Wells in this aquifer generally yield less than 30 GPM, but in some areas may be as high as 150 GPM. Water quality is similar to that in the Fort Union Group, with high concentrations of TDS and sodium. Also fluoride concentrations are commonly higher than recommended limits.

In general, the municipal water quality problems in the Study Area are related to the high TDS and sodium concentrations. One solution to this problem is physical treatment of the water supply. Unfortunately, conventional water treatment processes such as lime-soda softening and iron removal do not reduce the sodium concentration of water. In order to re-move sodium, some form of demineralization process would have to be used. One of the most promising processes to date is reverse osmosis. In this process, pre-treated water is forced through semi-permeable membrane under pressures of 400 to 600 psi. The membranes reject the sodium and other salts and allow the relatively pure product water to pass through. Approximately 25% of the water entering the unit is lost as reject water with the sodium and other salts.

Costs associated with reverse osmosis treatment are variable and depend upon such factors as quantity of water to be treated, amount of pre-treatment required, and the specific chemistry of the water. To get a feeling of the general cost range, the City of Leeds, North Dakota, (population 675) installed a 100,000 gpd reverse osmosis system in 1973 at a total cost of $175,000. This system has demonstrated that satisfactory water at a reasonable cost can be produced, but it must be realized that reverse osmosis is not foolproof and careful engineering for individual water quality characteristics is essential.

Municipalities in the Study Area will be affected by the Safe Drinking Water Act signed on December 17, 1974. The Act amends the Public Health Service Act and requires the Environmental Protection Agency to establish primary drinking water standards and regulations for bacterial and chemical contaminants for all public water supplies. A public water supply is defined under the Act as a water system that provides piped water for human consumption if it has at least 15 service connections, or regularly serves an average of at least 25 people per day, 60 days out of the year.

National Interim Regulations have been promulgated by EPA and will become effective on June 24, 1977. The primary standards will be revised after a two-year study by the National Academy of Science of the effects of contaminants on Public Health. The primary standards are designed to provide maximum feasible protection of Public Health, utilizing the best treatment methods generally available with cost as a major consideration. These standards have established maximum levels for turbidity and inorganic, organic, and microbiological contaminants. Attached is a list of the sampling frequencies required by the Regulations.

If a municipal water supply cannot comply with the requirements, either a variance or an exemption can be issued. A variance is official permission from the State or EPA to be out of compliance with some regulations, so long as this does not result in unreasonable risk to health. Before issuing a variance, a public hearing must be held and a formal schedule for bringing the system into compliance must be set up. An exemption can be granted to systems that find themselves unable to meet contaminant level or treatment technique requirements "because of compelling reasons, including economic factors." However, once again, no exemption can be granted if it may result in unreasonable risk to health. An exemption must carry a specific time limit and the State must prescribe a formal schedule to correct the situation that brought about the exemption. If the exemption is based on EPA Interim Regulations, a water system must overcome the problem and be in compliance with the law by January 1, 1981.

Sampling Frequency for North Dakota Waters
"Primary Drinking Water Regulations"
Effective Date June 1977

Water System	Nitrate	Turbidity	Inorganic Chemicals	Organic Chemicals	Radioactivity*	Microbiological Contaminants
Community Water Systems						
a. Surface Water		Daily	Analysis to be complete within one year. Repeated at yearly intervals.	Analysis to be completed within one year. Repeated at intervals specified by the State but at least at three year intervals.	Screen for gross alpha activity. Analysis to be completed within two years and repeated at three year intervals.	Sample monthly. May be reduced to one per quarter on systems under 1000 population.
b. Ground Water		Not required.	Analysis to be completed within two years. Repeated at three year intervals.	Analysis to be completed by systems specified by State.	Screen for gross alpha activity. Analysis to be completed within two years and repeated at three year intervals.	Sample monthly. May be reduced to one per quarter on systems under 1000 population.
Non-Community Water Systems	Completed within two years. Repeated at intervals determined by State.	Not required unless surface water is used.	Not required.	Not required.	Not required. * Effective date not established.	One sample in each calendar quarter.

Under the Act, municipalities will be responsible for obtaining the necessary laboratory analysis and maintaining records. The records will consist of bacteriological and chemical analysis, actions taken to correct violations of primary regulations, any sanitary surveys of the system, and variances and exemptions.

Re: Yellowstone Basin and Adjacent Coal Area, Level B Study, 1976

Land Areas Needing Special Concern

The Soil Conservation Service in cooperation with other concerned agencies has developed three categories of land denoting levels of importance to agriculture. These are: (1) Prime farmland; (2) Additional Farmland of Statewide Importance; and (3) Additional Farmland of Local Importance.

Identification and location of these lands denotes the land areas within each county that have the greatest potential for production of feed, fiber, food, and forage under dryland farming as well as under irrigation.

A complete detailed soil survey is needed to identify the three categories of prime, state, and locally important framlands.

Appendix "C" of the 1975 West River Study prepared by the State Water Commission identified approximately one million acres from the general soil map as irrigable and one third of this amount as feasible.

1. A detailed soil survey map is needed to identify and specifically locate the soils best suited for irrigation.

2. Detailed soil surveys are also needed to properly guide planners and decisionmakers directing the future use and management of the potential coal development and impact areas (see attached soil survey status map).

3. A detailed soil survey map is needed to serve as base line data identifying the following:
   (a) Areas of potential high wind erosion hazard. Properly applied conservation practices are needed to help maintain air and water quality.

(b) Identifying the prime, state and locally important farmlands, is important for our state and nation because these soils are most productive for food, feed, fiber and forage production. They are also the soils that can be farmed with the least energy output in relation to production returns. These productive farmlands, in many areas, are also underlain by coal. Identification of high producing farmlands should proceed in order to determine their importance to the state and nation.

LAND APPLICATION OF MUNICIPAL WASTE STABILIZATION POND EFFLUENT

Nearly all of the municipalities in the Yellowstone Study area utilize waste stabilization ponds for the treatment of their domestic wastes. This system, when managed properly, achieves a high degree of treatment and, presently at least, is the only economically feasible treatment alternative available.

The system consists of two or three 8 foot deep ponds, or cells, connected in series. Regulations governing pond design require a maximum liquid level of 5 feet and a storage capacity of 180 days between the 2 and 5 foot levels. Under normal operation, wastewater enters the primary cell and through a combination of sedimentation and bacterial decomposition, the organic material in the wastewater is reduced. When the primary cell is full, the wastewater is transferred to the secondary cell where further reduction occurs. After a laboratory analysis has been made and permission is given by the North Dakota State Health Department, the wastewater from the secondary cell, or cells, is discharged into the receiving watercourse. Discharges usually occur in the spring and again in the late fall in preparation for winter storage.

Land application in the form of sprinkler irrigation is a viable alternative to the discharge of wastewater. Before implementing such a plan, however, many factors must be considered. The composition of the wastewater to be applied to the land must be evaluated with respect to the constituents which may limit irrigation suitability. Some of the limiting constituents include TDS, suspended solids, organic matter, nitrogen, phosphorous, inorganic ions, heavy metals and trace elements, SAR, and bacteriological quality. Also, the soil should be evaluated by a specialist to determine its overall suitability for irrigation. Some of the soil factors to be considered are texture and structure, pH, salinity, nutrient levels, and adsorption and fixation capabilities for various inorganic ions.

In the event that the water quality and soil characteristics are compatible with irrigation, an effective sprinkler system can be designed and installed. Many types of systems are available, but one of the most versatile is the big-gun sprinkler system. Components of this system include a single nozzle gun, a high head centrifugal pump, and connecting pipe. Operating pressures and discharge rates range from 50 to 130 psi and 100 to 1200 GPM respectively. This, coupled with a 120 to 620 foot diameter of coverage range, makes the big-gun system adaptable to nearly all sizes of waste stabilization pond systems.

It should be noted that wastewater volumes are generally not of sufficient magnitude to facilitate large scale irrigation programs. For example, the wastewater produced over a period of 180 days by a city of 1000 people would amount to approximately 40 acre-feet. Therefore, the primary goal of wastewater application is to accomplish disposal and the benefits derived from irrigation are secondary.

ISSUE PAPER

North Dakota Planning Area

Ronald Pense
U.S. Bureau of Mines
JUly 1976

AGENCY OBJECTIVES

Among overall objectives of the Bureau of Mines, the one having the most immediate application to the fifteen-county North Dakota planning area is assurance of a mineral production capability by the private sector to meet projected national demands. The Bureau, therefore, is concerned that water for an appropriate level of mineral development be available in adequate volume, of required quality, and at a reasonable price. In North Dakota this water requirement has particular reference to energy resource production, viz., petroleum, lignite, and, to a much lesser extent, natural gas and uranium. The Bureau also is interested in seeing that sufficient water is available for long-range growth of energy conversion facilities, i.e., thermal powerplants and coal gasification and liquefaction facilities.

POTENTIAL MINERAL DEVELOPMENT IN ABSENCE OF COMPREHENSIVE PLAN

Under existing conditions and in the absence of any comprehensive plan, there is likely to be a significant expansion in coal-related development. Attachment one contains a listing of proposed or planned coal mines, projected coal conversion plants, and projected power generating plants within the fifteen-county planning area. Attachment two contains more detailed data on area coal production by individual mine and year, 1975-85.

PROJECTS, PROGRAMS AND POLICIES CONSIDERED NECESSARY OR DESIRABLE TO MEET AGENCY OBJECTIVES

The Bureau's objectives in the North Dakota planning area are enhanced through its national programs of research and data dissemination to encourage mineral development by the private sector rather than by implementation of specific tangible projects.

MATERIAL UNIQUE TO BUREAU OF MINES AND PERTINENT TO NORTH DAKOTA PLANNING AREA--MINERAL INFORMATION

General

Total value of mineral production in the planning area (counties of Adams, Billings, Bowman, Dunn, Golden Valley, Grant, Hettinger, McKenzie, McLean, Mercer, Morton, Oliver, Sioux, Slope and Stark) was $72 million in 1974, the last year for which complete data are available. This was a record high, 45 percent more than the approximately $50 million of 1973, itself a record and an increase of 21 percent over the previous year. Most of these sharp increases were the result of a rapid rise in the price received for petroleum, mainly because petroleum accounts were by far the largest portion of total mineral output value in the area (66 percent in 1972, 70 percent in 1973, 77 percent in 1974). Based on a known 8-percent increase in petroleum production in 1975 and continuing increases in domestic petroleum prices, the area's total value of mineral production reasonably can be expected to have increased significantly again in 1975. Lignite (19 percent) and natural gas (3 percent) were of secondary importance in value in 1974. Sand and gravel accounted for most of the remaining mineral production. Table 1 shows total value of combined mineral production for the years 1960-74.

TABLE 1. - Total value of mineral production in North Dakota planning area, 1960-74

Year	Value (thousand dollars)
1960	22,144[1]
1961	25,708
1962	28,559
1963	30,763
1964	31,446
1965	33,929
1966	39,775
1967	39,817
1968	39,044
1969	35,100
1970	38,158
1971	42,486
1972	40,950
1973	49,562
1974	71,971

[1]Excludes natural gas and natural gas liquids.

Mineral Fuels

Crude oil production in the planning area rose steadily from 6.7 million barrels in 1960 to 10.7 million barrels in 1966, before beginning a decline to 8.3 million barrels in 1972. Since that time new development work has increased output successively to 8.8 million barrels, 9.1 million barrels, and 9.9 million barrels. Individual oilfields within the area remain small: the largest, Fryburg in Billings County, produced only slightly over one million barrels in 1974.

The value of crude oil production in 1974, the most recent year for which these data are available, was a record $55 million, 60 percent more than in 1973 and more than double the 1972 value.

Based on the most recent complete survey of the North Dakota Geological Survey, remaining technically recoverable reserves in the planning area were approximately 235 million barrels at the beginning of 1973. Since then reserve estimates for Bowman, McKenzie, and Stark Counties, where about 80 percent of the planning area's oil is located, are believed to have increased significantly. Reserve data given above are reserves still recoverable by presently available equipment, current production practices, and the latest technical knowledge.

Output of marketed natural gas in the planning area, most of which is collected in the form of associated gas, rose from 5.9 billion cubic feet in 1961 to 18.1 billion cubic feet in 1968, before beginning an irregular decline to 10.6 billion cubic feet in 1974. The largest producing fields in 1974 were Antelope (2.4 billion cubic feet) and Charlson (1.4 billion cubic feet) in McKenzie County and Fryburg (1.1 billion cubic feet) in Billings County. The 1974 value of all natural gas production was a modest $2.1 million.

Table 2 shows petroleum and natural gas production by quantity and value for 1960-75.

TABLE 2. - Production of petroleum and natural gas in North Dakota planning area, quantity and value, 1960-74

Year	Petroleum		Natural gas	
	(thousand barrels)	(thousand dollars)	(million cubic feet)	(thousand dollars)
1960........	6,686	18,121	NA	NA
1961........	7,132	19,399	5,928	747
1962........	8,108	22,297	6,729	935
1963........	8,457	23,087	8,780	1,678
1964........	8,678	21,521	9,304	2,058
1965........	9,624	24,058	10,292	1,626
1966........	10,638	27,126	17,269	2,797
1967........	10,517	27,345	16,743	2,745
1968........	10 372	27,382	18,121	2,989
1969........	8,822	24,701	14,609	2,367
1970........	8,666	26,435	12,882	2,112
1971........	8,824	28,854	13,946	2,329
1972........	8,281	27,162	11,077	1,861
1973........	8,835	34,469	10,784	2,124
1974........	9,144	55,252	10,619	2,113
1975........	9,391	NA	NA	NA

Lignite output--all of which is surface mined--has increased fairly regularly in the planning area since 1960, reaching in 1974 6.5 million tons valued at $13.8 million. Table 3 shows lignite production by quantity and value for the years 1960-74.

TABLE 3. - Production of lignite in North Dakota planning area, quantity and value, 1960-74

Year	Thousand tons	Value (thousand dollars)
1960................	1,392	3,103
1961................	1,487	3,276
1962................	1,496	3,254
1963................	1,413	2,982
1964................	1,576	3,249
1965................	1,808	3,717
1966................	2,754	5,165
1967................	3,301	6,113
1968................	3,751	6,419
1969................	3,894	6,979
1970................	4,515	8,612
1971................	5,173	9,561
1972................	5,747	11,306
1973................	5,963	12,009
1974................	6,554	13,811

Four mines in Oliver and Mercer Counties accounted for 94 percent of 1974 lignite. Six other mines in Adams, Bowman, Grant, and Stark Counties provided the remainder of production. Somewhat over half (52 percent) of the 1974 output was consumed by mine-mouth generating plants.

Preliminary and unofficial data for 1975 indicate a production increase in the planning area of roughly 17 percent to 7.7 million tons. The principal factor in the surge was the expansion of the Gascoyne mine in Bowman County from 223,000 to approximately 2,000,000 tons to serve a new powerplant in South Dakota.

The lignite reserve base is estimated at nearly 14 billion tons of strippable lignite distributed over all 15 counties of the area. Table 4 shows reserves by county.

TABLE 4. - Lignite reserves in North Dakota planning area by county

County	Million short tons
Adams	163
Billings	1,078
Bowman	785
Dunn	2,000
Golden Valley	278
Grant	115
Hettinger	980
McKenzie	825
McLean	1,009
Mercer	1,986
Morton	342
Oliver	629
Sioux	0
Slope	2,326
Stark	1,275
Total	13,971
Remainder of state	2,032

Uranium

Uranium was produced in the area during the 1962-67 period through the concentration of uraniferous lignite by burning into a processable ash. None has been produced in more recent years, although rapidly rising uranium prices have resulted in intensive new exploration activity.

As of January 1, 1976, uranium reserves were listed by the Energy Research and Development Administration (ERDA) at 240 tons of U_3O_8 at maximum "forward costs" of $8 per pound, 446 tons at $10, 919 tons at $15, and 1,192 tons at $30. Each of these successively higher "forward cost" categories incorporates the estimates of lower cost reserves. ERDA also shows an additional 1,200 tons of U_3O_8 as a probable uranium resource at "forward costs" of up to $30 per pound. "Forward costs" are those operating and capital costs yet to be incurred at the time an estimate is made. It should be noted that the various "forward costs" are independent of the market price at which uranium is sold. Profit and "sunk" costs, such as past expenditures for property acquisition, exploration, and mine development, are not included.

Nonmetallics

Sand and gravel is the most important nonmetallic mineral produced, but still accounted for less than one percent of the total mineral production in the area in 1974. In addition, output, which has dropped considerably since the 1961-68 period when Interstate 94 was being built through the area, reached a virtual 15-year low in 1974 when only 530,000 tons valued at $617,000 was produced.

Clay and stone are the only other nonmetallics currently produced.

Metallics

Small amounts of molybdenum and vanadium were recovered in conjunction with the mining of uraniferous lignite in the middle- and late-1960's, but have not been produced since.

ATTACHMENT # 1

Map Ref. #: ( ) MINE NAME AND LOCATION	OPERATOR	EMPLOYEES Present	EMPLOYEES Max.	MINE TYPE	PROJECTED PRODUCTION MILLION TONS/YR.	POTENTIAL MARKETS	ANALYTICAL INFORMATION	SEAM THICKNESS	DEPTH OR OVERBURDEN THICKNESS	REMARKS
Unnamed Mercer Co., near Beulah (1)	North American Coal Corp. Montana Dakota Utilities Office Bldg. 420 N. 4th, Bismarck, N.D. 58501 Virgil W. Carmichael Vice President 701-223-2794		768 1/	Strip Lignite	1981 12.0	American Natural Gas Service Co., Detroit, Mich				To be mined by Coteau Properties, subsidiary of North American. Water rights applied for. American Natural Gas has acquired plant site. N.A. has long standing order for three 100 yard drag lines Mich-Wis has filed with FPC. North Dakota projects moving ahead because Federal coal is not needed.
Falkirk South of Underwood (2)	North American Coal (see above)		350 1/	strip lignite	1978-79 5.5	United Power Assoc. & Cooperative Power Assoc.				Power plant capacity 965 MW. To be mined by Falkirk Mining Co., subsidiary of North American.
Gascoyne, east of Gascoyne, Bowman Co. (3)	Knife River Coal Mng. Co., 915 N. Kavaney Drive, Bismarck, N.D. 58501 Art S. Kane		142 1/	Strip Lignite	2.3	Bigstone Power Plant				Expansion of existing mine

1/ See Note A, p. 67

31

Map Ref. #: ( ) MINE NAME AND LOCATION	OPERATOR	EMPLOYEES Present	EMPLOYEES Max.	MINE TYPE	PROJECTED PRODUCTION MILLION TONS/YR.	POTENTIAL MARKETS	ANALYTICAL INFORMATION	SEAM THICKNESS	DEPTH OR OVERBURDEN THICKNESS	REMARKS
Center Oliver Co., near Center (4)	Baukol-Noonan, Inc. Lyle Huwe, Supt. Center, N.D. 58523		275 1/	Strip Lignite	1980 4.3	Power Plant				Permits granted. In development stage.
Beart Butte Grant Co. (5)	Peabody Coal Co.		?	Strip Lignite		Mine mouth coal gasification				Permit pending
No Name Dunn Co. Around Dunn Center (6)	Peoples Gas Chicago, Ill. and its subsidiary Natural Gas Pipeline Co. of America Chuck F. Rupe Bismarck, N.D. 701-258-6447	1	300	Strip Lignite	1981 12.9	Mine mouth coal gasification	Moist. 38.56 Ash 6.84 S 0.8 BTU 6,524	11' to 24'	6:1 strip ratio	Selecting mine operator. Need coal mining and water permits to proceed any further. Has filed w/BLM for 44,000 acres of Federal coal lease. Paul Wier Co. drilling property for design information. Has reserve of 2.1 billion tons.

1/ See Note A, p. 67

STATE: NORTH DAKOTA

PROJECTED COAL CONVERSION PLANTS

Map Ref. #: ( ) Project Name and Location	Company/or Project	Product mmcf/day Bbls/day	Type	Completion Date	Water Requirements and Source	Remarks
Mercer Co., near Beulah (1)	Michigan-Wisconsin Gas Pipeline Co. American Natural Gas Co.	250	Coal Gasification	1981 1st unit		Permit granted. 12 million tons coal to be supplied by Coteau Coal Company, subsidiary of North American Coal Co. Est. peak const. personnel: 1,125 1/ Est. oper. personnel: 600 1/
Western N.D. (2)	Tenneco Coal Co. 2705 Montana Ave. Billings, MT 406-248-7816	1500	Coal Gasification	1980 1st unit		Est. peak const. personnel: 6,750 1/ Est. oper personnel: 3,600 1/
Western N.D. (3)	El Paso Natural Gas Co.		Coal Gasification			Holding - withdrew application for water. Has not abandoned project.
Heart Butte Area Stark Co. (4)	Peabody Coal Co.					

1/ See Note C, p. 67

33

STATE: NORTH DAKOTA

PROJECTED COAL CONVERSION PLANTS

Map Ref. #: ( ) Project Name and Location	Company/or Project	Product mmcf/day Bbls/day	Type	Completion Date	Water Requirements and Source	Remarks
Dunn Center Dunn County (5)	Natural Gas Pipeline Co. of America Chuck F. Rupe Bismarck, N. Dak. 701-258-6447	250	Coal Gasification	Late 1981 or early 1982	17,500 ACF/Yr.	Transmission Co. for People's Gas of of Chicago. $3.5 million spent in 1974. Same amount 1975. In detailed planning state. Base line Environmental Studies. Has agreement with Nakota Co. on 100,000 acres in Central Dunn Co. east of Dunn Center. Negotiations with land owners for plant site. Has applied for water (pending since April) 1974 with North Dakota Water Commission) Filed with BLM for 44,000 acres Federal coal lease. Paul Wier Co. drilling property for design information. Fluor Engineers, Calif. doing plant design which will incorporate the Lurgi Process (letter of intent has been signed). One plant will use 12.9 million tons of coal per year. Need water and coal permits to proceed any further. One plant would employ 625 people. Per plant. Est. peak const.: 1,135 1/ Est. oper personnel: 600 1/
Dunn Center Dunn County (5)	(see above)	750	Coal Gasification	One unit each 3 - 5 years	52,500 ACF/Yr.	

1/ See Note C, p. 67

STATE: NORTH DAKOTA

PROJECTED POWER GENERATING PLANTS

Map Ref. #: ( ) Power Plant Name and Location	Company or Project	Fuel MTY For Coal	Capacity	Water Requirements and Source	Completion Date	Remarks
Underwood #1, 2 Underwood, N.D. (1)	Cooperative Power Assn United Power Assn.	Coal (Lignite)	837 MW		#1, 411 MW, 1978 #2, 426 MW, 1979	Coal to be suppled by Falkirk mine. Est. peak const. personnel: 837 1/ Est. oper. personnel: 105 1/
Young #2 Center, N.D. (2)	Minnkota Power Coop, Inc. Box 1318, Grand Forks, N.D. 58201 (701-725-4642)	Coal (Lignite)	408 MW		1977	Addition to existing 234 MW unit. Est. peak const. personnel: 408 1/ Est. oper personnel (2 units): 80 1/
Lignite #3 Lignite, N.D. (3)	Minnkota Power Coop. Inc. (see above)	Coal (Lignite	400 MW		1980	Est. peak const. personnel: 400 1/ Est. oper. personnel: 50 1/
Lelands Olds #2 Stanton, N.D. (4)	Basin Elec. Power Coop. 316 5th St., North Bismarck, N.D. 58501	Coal (Lignite)	438 MW		1975	Addition to existing 212 KW unit. Est. peak const. personnel: 438 1/ Est. oper personnel: 55 1/

1/ See Note B, p. 67

35

STATE: NORTH DAKOTA

PROJECTED POWER GENERATING PLANTS

Map Ref. #: ( ) Power Plant Name and Location	Company or Project	Fuel MTY For Coal	Capacity	Water Requirements and Source	Completion Date	Remarks
JSPD #1, 2 (5)	Basin Elec. Power Coop. (see above)	Coal (Lignite)	800		#1, 400 MW, 1979 #2, 400 MW, 1980	Est. peak const. personnel: 800 1/ Est. oper. personnel: 80 1/
Beulah #1, 2, 3 Mercer Co., N.D. (6)	Otter Tail Power Co. Fergus Falls, Minn. 56537	Coal (Lignite)	1320		#1, 440 MW, 1981 #2, 440 MW, 1985 #3, 440 MW, 1989	Planning stage. Est. peak const. personnel: 1,320 1/ Est. oper personnel: 165 1/
Spiritwood (7)	Otter Tail Power Co. (see above)	Gas Turbine (Diesel)	25		1976	Est. oper personnel: 5 1/

1/ See Note B, p. 67

ATTACHMENT # 2

Coal production, North Dakota planning area, 1975-82 and 1985
(million tons)

Operator	Mine	County	1975	1976	1977	1978	1979	1980	1981	1982	1985
Amax Coal Company	no name	Dunn	0	0	0	0	0	0	0	13.0	13.0
Baukol Noonan, Inc.	Center	Oliver	1.5	1.6	2.8	4.4	4.4	4.4	4.4	4.4	4.4
Consolidation Coal Company	Glenharold	Mercer/ Oliver	2.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Coteau Properties Co. Inc. (North American Coal Co.)	Coteau	Mercer	0	0	0	0	0	0	7.5	7.5	15.0
Falkirk Mining Company	Falkirk	McLean	0	0	0	1.4	3.0	5.5	5.5	5.5	5.5
Husky Industries	Husky	Stark	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Knife River Coal Mining Co.	Gascoyne	Bowman	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Beulah	Mercer/ Oliver	1.3	1.7	1.7	1.7	1.7	1.7	4.2	4.2	4.2
North American Coal Company	Indian Head	Mercer	0.8	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
All planning area			7.7	11.1	12.3	15.3	16.9	19.4	29.4	42.4	49.9
Rest of state			0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total North Dakota			8.4	12.1	13.3	16.3	17.9	20.4	30.4	43.4	50.9

Source: U.S. Bureau of Mines Liaison Office - North Dakota
Date: June 1976

SECTION III

INVESTIGATION OF ISSUES AND CONCERNS

PART A

STUDY TEAM ACTION ON ISSUES AND CONCERNS

The North Dakota State Study Team made up of private citizens, special interest groups and local state and federal agency representatives discussed in detail the issues presented in Section I of this appendix. The study team chairman asked that each person responsible for the issue identified give a brief description of the problem and any possible solutions which should be considered. The study team would then determine how a particular issue is being addressed in the overall study and if necessary seek assistance from a particular state or federal agency to expand on the material provided and focus on the problem. The results of the state study team discussions follow;

1. Mr. Chuck Rupe of Natural Gas Pipeline Company sumbitted an issue paper outlining their energy development proposal in Dunn County. This is a private enterprise development, however, effects on water quantity and quality from coal development will be addressed in the development of alternative plans within the scope of the overall Level B study.

2. A brief paragraph was received from the Dickinson City Engineer, Don Cuskelly, concerning the cities water needs. There was some discussion and disagreement as to the amount of acre feet needed and also some question to the statement Mr. Cuskelly made that the only source would be Garrison Diversion. It was pointed out that Derwood Mercer's sample issue paper provided other possbile methods. The Bureau of Reclamation will be looking at this issue and providing information.

3. Mr. Jim Ketterling explained the items in his first issue paper which dealt with water quality and quantity for rural, domestic and small urban water supplies. Several members of the state study team felt that there has been very little data gathered on potential ground water supplies. The Assistant Study Manager noted that solving this problem was beyond the scope of a Level B study, but the U.S. Geological Survey did have some information from their ongoing and past ground water studies. Also more information will be obtained from the State Water Commission and U.S. Geological Survey on what they have done in the past and what will be done

in the future. The state study team can then make recommendations for additional study needs. It was pointed out that the cost for detailed ground water studies would be millions of dollars.

The USGS informed the group that county groundwater studies have been completed in McLean, Mercer, Oliver, Stark, and Hettinger. Counties in the process of completing a report are Dunn, Morton, Grant and Sioux. Counties now doing field work are Golden Valley, Billings and Slope. McKenzie is the only county within the North Dakota planning area where no work has been done yet. To get these reports the USGS goes through the following steps which takes three to four years;

A. Collect data from the State Water Commission on information filed by drillers.

B. Do a well inventory by talking to the farmers.

C. Drilling Program is layed out.

D. Information is compiled into a Basic Data Report.

E. Completed reports on each separate couty are available at the SWC.

4. The next item, a letter from the mayor of Dickinson, Mr. Henry Schank, was also concerned with future needs of water for the city. This issue had been discussed previously (see item No. 2 above).

5. Mr. Bob Wood of Montana Dakota Utilities briefly presented his issue paper on water requirements for electrical energy growth. Effects on water quantity and quality from coal development will be addressed in the development of alternative plans within the scope of the overall Level B study.

6. Mr. Robert Stranik, Mr. Raymond Schnell and Mr. Robert Sadowsky submitted the following issues;

A. Encouragement for the SWC to take action to retain control of our water resources. This was referred to Ms. Arlene Wilhelm, Commissioner for the State Water Commission.

B. Limit of water permits for coal development (4 or 5 coal gasification plants by 2000). This issue was deferred pending development and analysis of alternative plans.

C. Unitize water transmission lines where feasible and also recommend that a pipeline be given preference to an open ditch or canal. The study team agreed this should be considered by various action agencies, in their development of projects or programs to meet the identified needs.

D. Encourage organization of local entities to participate in control of water uses. The study team agreed this should be covered under our legal and institutional constraints ad hoc group.

E. Increased research on land reclamation - Recommendations can be made by the state study team pending the results of the ad hoc group doing the strip mine reclamation analysis.

F. Compile information to be used to enforce the rights of surface owners. The Bureau of Land Management will be providing information on surface and subsurface ownerships.

G. Enact or enforce air and water pollution standards on all industry. Air quality and water quality analysis will be conducted within the framework of the Level B study.

7. Jim Ketterling also listed the following issues;

A. Identify irrigation potential - we will address this issue using USBR irrigation criteria for NED type projects and ad hoc group projections for food and fiber production. In addition SRD projects will be analyzed.

B. City/rural water quality program - the USGS agreed to provide additional information regarding the problem of groundwater quality within the study area.

C. Monitoring of underground water supplies - This is an ongoing program of the USGS and SWC and the study team agreed it was outside the scope of a level B study.

D. A study of Net Energy Ratios - This was recommended for further research and studies. Mr. Ketterling and Mike Jacobs agreed to approach Mr. Dwight Connors, Governors Office, to ask him to elaborate on this issue.

8. Mr. Ruben Hummel covered several issues, rural water was one which the group covered previously in Mr. Ketterlings paper. The effects of core drilling on ground water was mentioned. Derwood Mercer of the Bureau of Reclamation volunteered to provide additional information on this topic.

9. The President of Mercer County Landowners, Mr. Eugene Keller, submitted several issues, many of which were covered earlier, ie. water quality, irrigation and reclamation.

10. H.R. Morgan, of the North Dakota Wildlife Federation, submitted a paper concerned with domestic sewage, feedlot regulations and top soil erosion. Jeff Hauge of the State Health Dept. agreed to expand on the first two items. The ad hoc group on Land Conservation measures will be addressing the problem of sheet erosion.

11. Ms. Arlene Wilhelm submitted an issue paper concerning the long term effects of lignite utilization for energy. She felt the impacts of lignite development should be considered such as current population trends, land reclamations and air quality. Also she would like to see the possibility of shipping coal outside the region addressed. This item will be adressed in our planning process under the Harza energy study and the population ad hoc groups reports. In addition it was recommended that this issue paper be forwarded to the study management group to ensure that these areas of concern will be addressed.

12. Mr. Richard Lefor outlined his issue paper concerning saline seeps. The ARS has completed a study on this and there are three primary causes of saline seeps - the climate, soil profile and land use. It was recommended that the Soil Conservation Service have the ARS attend our next state study team meeting and make a presentation on exactly what their study results show.

13. An issue paper on mined land reclamation was submitted. There was no particular sponcer for this paper. It was felt that this should be sent to the ad hoc group on strip mine reclamation analysis. After they have completed their work they could make recommendations for further studies of any area they should find deficient.

14. Ms. Arlene Wilhelm explained the next issue paper which suggests fullfilling the desires of the people who would like to maintain an agricultural base. She felt the study should investigate the optimum preservation of the environment within our agriculture and tourism framework.

It was decided by the state study team that this would be looked at in our environmental quality plan alternative which we will be developing in our study.

15. The next issue paper discussed was agricultural water rights. This paper pointed out the following items;

A. The demands of water are increasing rapidly for all uses and because we are an agricultural state we should think about reserving water to develop the highest agriculture profile with items such as water for irrigation, meat packing, food processing, etc.

B. Irrigable lands should be identified because of potential conflicts with energy related industry.

C. A study should be conducted on state and federal laws.

The assistant study manager noted that a purpose of this study is to provide information to resolve the conflicts between agriculture and industrial water needs. It was mentioned that the Bureau of Reclamation has an ongoing study called Total Water Management Study above Gavens Point. This particular study does identify irrigable lands and we will be using the study results in our planning efforts. Also there is an ad hoc group which will be looking at the legal and institutional constraints.

The problem of erosion was discussed briefly. Mr. Ohnstad mentioned that the Corps of Engineers has completed an Umbrella study and have come up with river management schemes which will develop various methods for controling erosion along the main stem Missouri. Gene Krenz of the State Water Commission agreed to provide further information on the erosion problem.

16. A brief paragraph was received from Theodore Nace of Dickinson. He stated that in addition to the NED objectives, RED objectives and quality of environmental objectives we should also be concerned with international economic needs and development. He says that doing this would put the resources of the Yellowstone River Basin in perspective of the needs of the whole world. He points out that our natural resources and land uses should be seen with global awareness.

Several members felt that many things in the study covers the international economic needs and development. For example; agriculture projections consider exports and there is consideration for the world price of oil. After a great deal of discussion it was agreed that through the national economic development objectives the international economic needs and development are considered and kept in focus.

17. Mr. Dale Frink commented on the next issue paper which outlined the impacts of current and emerging land use patterns on agriculture. Mr. Frink pointed out that a program is needed to study the land use system in North Dakota and clearly defined goals and objectives must be developed.

It was noted that we have a land use update committee in the study. Fred Martin who is on this committee informed the group that they are now completing statistics of land use in terms of urban, forest, wetland, irrigated farmland, and open range. However, he felt that this particular issue paper went beyond what the ad hoc group was doing. He felt the paper was stressing changing land uses. The assistant study manager requested that Mr. Martin obtain from the land use ad hoc group the needed information and if the study team decides further studies are needed we can then make the recommendations.

18. A very thorough issue paper was submitted from the city of Glen Ullin concerning the water quality in the city. The state study team felt there was no need to

further discuss this issue since it had been decided earlier that the Geological Survey with assistance from the State Water Commission and the State Health Department will be identifying domestic water requirements and other agencies will be addressing the problem as to how these cities could be supplied.

19. The issue of rural, domestic and municipal water needs was prepared by Dale Frink of the State Water Commission. The state study team agreed that this was discussed previously and would adequately be taken care of during the coarse of the study.

20. The Buford - Trenton irrigation problem was submitted by Dale Frink. He was somewhat unsure as to whether this was in the scope of a Level B study. The area being talked about is outside the 15 county study area and there are also results available from the Corps of Engineers Umbrella study.

The state study team did decide this was outside the scope, but consideration should be given the bank èrosion problem which occurs along the Yellowstone and Missouri Rivers. Gene Krenz of the State Water Commission will check with the Corps of Engineers and report back to the state study team on this problem.

21. The next issue paper outlined Beulah flood control. The SCS is addressing this problem under one of their programs. The assistant study manager requested the Soil Conservation Service to develop this project proposal under the Four-account system.

22. The Dickinson water supply was the next issue which the state study team felt had already been discussed, so they passed on to the next issue.

23. This issue paper covered the serious bank erosion problem along the Missouri River reach between Garrison Dam and the Oahe Reservoir. It was requested that the Corps of Engineers update the state study team on the work they have completed and also ask them to investigate bank erosion along the Yellowstone. Mr. Krenz will contact the Corps requesting this information.

24. A brief paragraph outlining the need for a study of the water resources was submitted. This was developed to determine the effects of mining on underground

water supplies and to point out the need for data collection and a drilling program. The state study team felt the ground water supply and impact analysis ad hoc group would address this issue.

25. An issue paper submitted by Jeff Hauge covering municipal water problems in coal impact areas was discussed. This had been previously covered, but it was felt the Health Department could work along with the USGS to provide information regarding water quality.

PART B

CONCERNS ADDRESSED BY ASSIGNMENT

MUNICIPAL AND RURAL WATER SUPPLIES IN SOUTHWESTERN NORTH DAKOTA

By Orlo A. Crosby

This report addresses issue papers presented at meetings of the North Dakota State Study Team for the Yellowstone Basin and Adjacent Coal Area Level B Study. The issue papers addressed are those dealing with the quality and quantity of water available for municipal and rural use.

The people in the study area, whether urban or rural, are largely dependent upon agriculture for their livelihood. The climate is semiarid and there is sometimes a shortage of water for domestic and livestock use as well as for irrigation. Most of the people are dependent on ground-water sources and the shortage problem is often worsened by poor quality water.

Much of the water is unfit for irrigation of lawns or crops because of salinity and sodium hazards, with resultant damage to soil structure. Some of the water is barely tolerable for drinking or laundry purposes because of salinity, alkalinity, color, or iron content. Some is unfit for human consumption, although it can be used for livestock.

The issue is discussed herein on a broad areal basis and will not relate to the individual problems of particular farmers or ranchers. Each would have a different problem with regard to quantity or quality of water. The discussion does not relate to Mandan, owing to its source of water, which is the Missouri River; Dickinson, which is undergoing a detailed study of its problem; or any other municipality dependent on surface-water supply.

Ground water in the area is obtained from the bedrock of Late Cretaceous age--Fox Hills and Hell Creek Formations; the bedrock of Tertiary age--Ludlow, Cannonball, Tongue River, and Sentinel Butte Formations; and the unconsolidated rocks of Quaternary age--glacial and alluvial deposits. Most of the farmers and ranchers are dependent on bedrock aquifers for their supplies, the glacial and alluvial deposits often being very limited in extent. To better enable the individual to relate to his or her individual problem and because of the methods of study, this report is somewhat divided by county or counties.

The rural population and all municipalities in McLean County, except for Washburn, are dependent on ground-water supplies. McLean County has some fairly extensive aquifers composed of glacial deposits of sand and gravel. Elsewhere, supplies are obtained from sandstone or lignite in the preglacial rocks. Wells range from 10 feet to 1,200 feet and most yield less than 10 gallons per minute (gpm) which is usually sufficient for most domestic and livestock uses.

Wells tapping the Cretaceous aquifers generally will yield 10 to 50 gallons per minute. The water is predominantly a sodium bicarbonate type and is soft.

Wells tapping the Tertiary aquifers will generally yield from 5 to 75 gallons per minute. The water is predominantly a sodium bicarbonate type and is often hard.

Water from the aquifers in the glacial deposits is predominantly a calcium bicarbonate or sodium bicarbonate type and is usually hard. These aquifers have the most potential for development. There is irrigation at present and there will probably be considerable expansion in the near future.

There are scattered farms where the water is very high in total dissolved solids and particularly in sulfate. Generally these are in glacial deposits and can be remedied by drilling deeper wells which will yield water of lower sulfate content but of a higher sodium content, however. At the present time it is believed all municipalities in the county have or can get an adequate supply for present and some future development. The possible exception is Max, where exploratory work may be necessary before any development requiring large supplies.

At the present time, the rural and municipal population of Mercer and Oliver Counties utilizes ground water as the source of supply.

Major aquifers in the Fox Hills, Hell Creek, and Tongue River Formations underlie the two-county area. Flowing wells tapping these aquifers are numerous in the stream valleys. The wells will generally flow from 5 to 50 gallons per minute unless restricted. The water is used mainly for domestic and livestock purposes. The water is a sodium bicarbonate type that is slightly saline (1,000 to 3,000 mg/l). It is not suitable for irrigation.

Much of the water for domestic and livestock supplies is obtained from wells tapping beds of lignite. The yield is generally probably less than 10 gallons per minute but adequate for the intended purpose. The water is highly variable in chemical quality.

There are fairly extensive sand and gravel deposits in the valleys of the various creeks and rivers. These aquifers are the most productive and contain water suitable for irrigation.

The municipalities in Mercer and Oliver Counties generally have adequate supplies for present use and foreseeable development.

The various bedrock aquifers supply most of the water for domestic and livestock purposes in Morton County. The water is generally not suitable for irrigation. Yields are less than 10 gallons per minute. The water is generally of a sodium bicarbonate type and in places is undesirable for domestic use owing to high sulfate content. There are several glacial-drift and alluvial aquifers with irrigation potential. Almont, Flasher, Glen Ullin, Hebron, New Salem, and four housing developments near Mandan rely on ground-water sources. There is probably adequate water available in the vicinity of all communities to satisfy present and some future needs. Almont and New Salem have wells in glacial deposits. Additional supplies can be developed in the Fox Hills aquifer at most locations.

Grant and Sioux Counties rely primarily on the bedrock aquifers for domestic and livestock supplies, but have important aquifers in several valley deposits.

The bedrock wells generally yield less than 10 gallons per minute except for some municipal wells which yield 20 to 50 gallons per minute. The water varies from a sodium bicarbonate type to a sodium bicarbonate chloride type that is generally soft. It is unsuitable for irrigation. The valley aquifers could be a source of water for irrigation.

The towns of Carson, Elgin, New Leipzig, Fort Yates, Selfridge, and Solen use bedrock wells in the various aquifers. Additional supplies can probably be obtained with additional wells in the same or other aquifers. It is possible that some could develop wells in glacial deposits.

Most of the domestic and livestock supplies in Dunn County are from ground water and primarily the bedrock aquifers. Most wells are in the sand and lignite of the Sentinel Butte Formation, though many in the Little Missouri Valley tap deeper formations. The water in the Sentinel Butte is predominantly a sodium bicarbonate type and is hard. That of the lower aquifers is generally a sodium bicarbonate type but soft. The quality is quite variable. Yields to wells can range from less than 1 gallon per minute to more than 100 gallons per minute. There are some aquifers in glacial deposits that could yield water for irrigation.

The municipalities now have adequate supplies and could probably develop further supplies in the deeper aquifers.

Stark, Hettinger, Adams, and Bowman Counties rely almost entirely on the bedrock aquifers for their ground-water supplies. Domestic and livestock wells generally tap the upper aquifers. The water is a sodium bicarbonate type and slightly saline. Some wells are developed in fractured lignite and much of this water is colored due to dissolved or suspended organic carbon. Most of the municipalities have an adequate supply of water for present uses, though often require several wells. Bowman, Hettinger, Reeder, and Scranton have developed wells in the Fox Hills and Hell Creek aquifers. Total dissolved solids are generally high in the municipal supplies.

Not too much is known yet about conditions in Slope, Golden Valley, Billings, and McKenzie Counties. The three former counties are being studied at the present time. The primary source of ground water is the bedrock aquifers, though there is the possibility of some glacial-deposit aquifers in McKenzie County. The Fox Hills and Hell Creek aquifers underlie most of the area and are probably the most important. Also, there is probably some potential for development in the Ludlow, Tongue River, and Sentinel Butte Formations. The water is probably predominantly a sodium bicarbonate type.

In summary, there appears to be adequate supplies of water for domestic and livestock uses in most parts of the study area. Deep wells are necessary in some areas and the attendant costs may be prohibitive. In most of the area the water will not meet the recommended minimums set by health agencies, but this does not prohibit its use or mean it poses a threat to health. Each source must be considered separately for quality purposes.

One solution to poor quality or lack of adequate supply is test drilling. Quite often, this involves deeper drilling--a cost the individual may not want to undertake--or possibly exploratory drilling over an extended area.

Another prospect is importation. There are large-scale plans such as "The West River Study", but these are grandiose schemes which are still confined mainly to natural water courses and municipalities where domestic and livestock needs are least critical.

Impoundment of streams is another possibility and is commonly used for livestock purposes but seldom for domestic purposes. Rural water districts with attendant distribution systems is also a possibility in some areas.

Processes are available for desalinization of water but may not be within the means of an individual. There are also methods for removal of iron, a common problem in some areas.

This report merely addresses the issue and is not intended to present a solution. For further information, consult the various publications of the U.S. Geological Survey and the North Dakota State Water Commission.

PREPARED BY THE UNITED STATES DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION, BILLINGS, MONTANA

DRILLING AND WATER QUALITY

Introduction

Many people in North Dakota are concerned about the declining water quality in local ground water supplies. Some are blaming open holes left by drillers for this problem. There is no definitive information on the supposed decline in water quality or on its cause. However, open drill holes may be one of several reasons why the water quality has deteriorated in certain areas. Other causes would be contamination by feedlots, fertilizers, septic tanks, landfills, and irrigation return flows. Only the contamination potential caused by open drill holes will be discussed in this report.

Drilling

Drilling is a tool to obtain subsurface data for (1) mineral (2) groundwater (3) engineering (4) agricultural, and (5) other types of investigations. This requires boring holes of different sizes and depths into the earth's crust. Some holes are cased with metal or plastic pipe for long term use. Others are drilled for temporary purposes and abandoned.

Thousands of shallow holes have been drilled in North Dakota. Those types which could contribute most to the potential contamination of subsurface aquifers include:

Seismic - Seismic studies require that explosive charges be detonated in drill holes to determine subsurface geologic structure by recording the resulting seismic waves. The explosion generally bridges the hole and prevents the formation of an impervious seal.

Mineral - Many holes completed for oil, gas, coal, uranium, and other types of minerals are left open at depth for future geophysical logging. Natural caving soon closes the hole, preventing logging and the construction of an effective plug.

Groundwater - There are many abandoned water wells on old farmsteads in North Dakota because of farm consolidation since the 1930's. The number of farms in the 15 counties under study has declined from 17,331 in 1930 to 10,151 in 1964, the latest figure available. Casing in many of these abandoned farm wells has been destroyed by oxidation (rust) leaving open conduits to subsurface water systems.

Sealing

Contamination in drill holes occurs when polluted or saline surface or groundwater is allowed to migrate vertically and intermix with unpolluted aquifers. To seal an abandoned well properly, the type of groundwater occurrence must be considered. If under water table conditions, the objective is to prevent the percolation of the surface water through the interior of the well or along the outside of the casing to the water table. If under artesian conditions, the sealing operations must contain the water to the aquifer in which it occurs. This prevents loss of artesian pressure that will result from uncontrolled flow from the aquifer. Removal of liner pipe from wells may be necessary to assure placement of an effective seal.

The basic concept in the proper sealing of an abandoned well is the restoration, as far as possible, of the previously existing geologic conditions. Sealing is usually achieved by grouting with puddled clay, cement, or concrete. When grouting below the water table, the cementing material should be placed from the bottom up to avoid segregation or dilution of the material.

Regulations

The North Dakota State Department of Health publishes a pamphlet, titled "Rules and Regulations for Water Well Construction and Water Pump Installation." These regulations state that abandoned water wells shall be sealed by restoring as far as possible the geologic conditions which existed before the wells were drilled. Whenever feasible, the well should be completely filled with concrete. Drill holes completed for exploration and production of oil, gas, (includes seismic, gravel, or other minerals) are not included in these regulations, but are covered under EPA's "Underground Discharge Regulations." These regulations are based on the "Safe Drinking Water Act" passed by Congress.

Sufficient regulations exist to govern the proper abandonment of drill holes. The problem lies in the fact that a trained force with policing powers is not available to inspect the sealing of each hole. This is especially critical during the present time, due to the numerous drill holes being completed in North Dakota for energy related minerals.

HYDROLOGIC ASPECTS OF SALINE SEEPS IN SOUTHWESTERN NORTH DAKOTA*

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Agricultural Engineer and Soil Scientist

Saline seeps are recent ground water discharges on hillside locations in semiarid regions. Their principal visible characteristics are (1) intermittent or continual surface wetness sometimes accompanied by flow of free water down the slope, (2) reduced plant growth, and (3) quite often the development of a salt crust. Saline seepage on agricultural land has become a major problem for farmers of western North Dakota during the past 10 to 15 years. A 1969 survey of Hettinger County in southwestern North Dakota (Figure 1) revealed that saline seeps and their downslope wet areas occupied about 1.4% of the cropland (slightly less than 1% of the land) in 1968 (10). Hettinger County is in the Rolling Soft Shale Plain land resource area (1), but seeps also occur in the Brown Glaciated Plain, Dark Brown Glaciated Plain, Black Glaciated Plain, Northern Rolling High Plain, Northern Smooth High Plain, Pierre Shale Plain and Badlands, and Rolling Pierre Shale Plain land resource areas. Extrapolation of the Hettinger County data to cropland in the above land resource areas indicates that more than 100,000 acres of cropland in western North Dakota and up to 400,000 acres of cropland in the Dakotas, Wyoming and Montana may have been removed from production by seeps in 1968 (10). Saline seeps also occur in the provinces of Alberta and Saskatchewan, Canada (3, 14).

The premises that seeps are caused by a combination of geologic, climatic, and cultural conditions (10) and that seeps are sustained by local recharge have been widely accepted (6, 7, 10, 13, 15, 20). From a hydrogeologic study in Montana, Bahls and Miller (2) concluded that geologic conditions are favorable for seep development in 228,000 square miles of the northern Great Plains of the United States and Canada. From studies of physical characteristics of soil profiles associated with seeps in southwestern North Dakota, Doering and Sandoval (10, 11) found that seeps occurred where highly permeable layers of lignitic material were truncated at a shallow depth below the surface of a hillside. The soil layers both above and below the lignitic layers were finer textured and apparently had much lower hydraulic conductivities than the lignitic layers. Detailed hydrologic data collected at two sites in southwestern North Dakota showed that seeps are sustained by local recharge; i.e. by precipitation that percolates past the root zone of adjacent, upslope landscape positions, is intercepted by highly permeable lignitic layers, and

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* Contribution from NCR-ARS-USDA, Northern Great Plains Research Center, P. O. Box 459, Mandan, North Dakota 58554.

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is conducted horizontally to the hillside surface (11). A summary of that hydrologic data is presented herein.

Procedure

To describe the ground water flow system, hydraulic head must be measured at selected points in the three-dimensional system because soil water flows from points of higher to points of lower hydraulic head. Hydraulic head in the soil-water system is customarily measured with tensiometers and piezometers. Two sites located about 1/4 mile apart in Hettinger County were selected for flow system analysis. A topographic map of the study area and the locations at which various measurements were made are presented as Figure 2. A less detailed topographic map of the surrounding area is presented as Figure 3, with the locations of 10 seeps shown as hatched areas. Site B has two active seeps — one that has been active for several years at an elevation of about 2460 ft above mean sea level (MSL) and a smaller one that appeared in 1969 about 20 ft higher on the landscape. Site C has a prominent knoll with seep actively along about 1/3 of its perimeter at about 2447 ft above MSL. Principal surface soils of the study area are of the Morton (TYPIC ARGIBOROLL) and Vebar (TYPIC HAPLOBOROLL) series.

During the summer of 1970, batteries of piezometers and/or tensiometers were installed at 36 locations in sites B and C (hexagons in Figure 2) to measure the hydraulic head in the lignitic layers and in the fine-textured materials above and below these layers. Depths for hydraulic-head measurement ranged from 3 to 44 ft below the ground surface and spanned profile elevations from 2438 to 2495 ft above MSL. The tensiometers consisted of 7/8-inch diameter by 2 3/8-inch long ceramic cups bonded to 1/2-inch diameter, schedule 80, PVC pipe. The piezometers were 3/4-inch diameter, schedule 40, PVC pipe.

Piezometers can provide hydraulic-head data only at points that have positive hydraulic heads, i.e. at points where the soil is saturated and under pressure. Tensiometers can measure the hydraulic head in both saturated and unsaturated (drier) soils. Tensiometer units were installed to depths less than 33 ft, and piezometers were used for all deeper depths. A power-driven auger drill with a 4-inch diameter auger was used to log the deep profile at each site and to provide holes into which one or two tensiometers or piezometers were installed.

Concrete plugs were strategically placed in each hole (as shown in Figure 4) to insure that the instrument would respond to natural conditions at the desired depth and not to an artificial flow condition produced by the drilling and backfilling process. Inasmuch as the deeper holes always filled with water as soon as they were drilled, the cement grout was placed at the desired depth through a tremie. Before a tremie spout was placed down the hole, the hole was filled with soil to the proper depth. A plastic sock was placed over the lower end of the spout and secured with rubber bands to prevent water from entering. As soon as the tremie was in place, the proper amount of cement grout was poured in. A sharp upward jerk would pull the plastic sock from the lower end of the tremie, and the grout would flow out into the hole, displacing the water; thus, instead of the grout falling through the water to be washed and sorted, it remained stable at the desired depth.

Mercury manometer systems, similar to those described by Doering and Harms (9), were attached to the tensiometers. Water levels in the piezometers were measured with either a depth popper or a 2-wire, electric sounder.

During September 1971, corrugated, perforated, plastic pipe interceptor drains were installed in the upper seep at site B and in the upper lignitic layer that conducted water to the seep area at site A (Figure 3). The seep area at site A appeared as one wet spot, but it was sustained by at least three lignitic layers separated vertically by several ft. Only the upper layer, or seep, was drained. Outlet structures for each drain were constructed by using 4-inch diameter nonperforated, corrugated, plastic tube to conduct the effluent downhill to a standpipe that was equipped with an orifice meter and a water stage recorder. Trenches for the outlet pipes were constructed with a 12-hp, chain-type, trencher, but a backhoe was required to construct the trench for the interceptors. Both interceptors were installed to a grade of 0.004 in a trench that was cut into the slowly permeable soil beneath the lignitic layer. Sufficient gravel envelop material (3/8-inch washed pea gravel) was used to insure hydraulic contact between the lignitic layer and the interceptor. The interceptor at site A was 850 ft long with 250 ft of 4-inch diameter pipe at the lower end and 600 ft of 3-inch diameter pipe at the upper end. The interceptor at site B was 150 ft long and was 4-inch diameter throughout.

The orifice meters were calibrated in the laboratory before installation. Flow rate was regularly checked in the field to monitor possible changes in orifice characteristics because of corrosion. The orifices were replaced when their characteristics began to change.

Drain effluent samples were collected periodically for chemical analysis. Electrical conductivity, calcium, magnesium, sodium, pH, carbonate, bicarbonate, and chloride were determined using methods described in USDA Handbook No. 60 (19). Ammonia and nitrate concentrations were determined by colorimetric and distillation methods (4, 5, 16). Sulfate concentrations were calculated as the difference between the sums of determined cations and anions.

Results and Discussion

Deep drilling indicated that the lignitic layers varied in thickness and extended somewhat horizontally for considerable distances into the land mass. Sometimes a layer appeared to be a system of lenses and layers separated vertically by thin layers of fine-textured soil. The various lignitic layers of each system are probably interconnected, but the nature of that interconnection was not precisely determined.

During the summers of 1970 and 1971, hydraulic-head data were collected at all 36 stations in sites B and C (Figure 2); and during the summers of 1972 and 1973, at station K-4 of site C and all stations of site B. Station K-4 was monitored the last two seasons to provide base-line data regarding the effects of agronomic practices and annual precipitation on a flow system undisturbed by installation of drains. Annual average hydraulic heads at deeper depths fluctuated about 2 ft during the four seasons.

The hydraulic-head distribution along the 4-line at site C (Figure 2) is presented in Figure 5. Seep discharge was occurring just beyond station G-4 (see also Figure 2). Similar hydraulic-head distributions could be presented for other cross-sections throughout sites B and C and for other dates. The principal conclusion drawn from these data is that hydraulic head decreases with depth, so water is flowing downward in the soil system. Such data provide proof that seep recharge is local; i.e. these seeps are sustained by precipitation that percolates past the root zone of adjacent lands that occupy higher landscape positions.

The authors previously showed that deep percolation rates as small as 0.5 inch/year would be sufficient to sustain the observed seeps (10). Hydraulic conductivities of these fine-textured soils have not been determined, but drainage studies conducted on fine-textured soils in the Red River Valley of the North indicated that such low hydraulic conductivities are reasonable (8).

Even though these data show that soil water moves downward in the overlying, fine-textured soils (Figure 5), different segments of the landscape have different infiltration capacities, permeabilities, slopes, etc. Thus, different landscape positions have different capacities for seep recharge. For example, swales are generally the most level portions of the landscape. Swales have increased potential for infiltration because they have less slope and because they may receive runoff from adjacent lands. Station 0-4 is in a relatively flat area (Figure 2), and the hydraulic head is maximum in the lignitic layer at this station.

The hydraulic-head distribution along the 15-line about 40 days after the drain was installed in the upper seep at site B is presented as Figure 6. Downward percolation of water is evident. Flow in the upper lignitic layer toward the drain and in the lower lignitic layer toward the lower seep area is also evident. During those 40 days, average hydraulic head in the drained layer was reduced by about 2 ft. Simultaneously, average hydraulic head in the lower lignitic layer increased by about 0.3 ft, so the drain had not affected the lower layer.

During construction of the trench for the drain at site B, the lignitic layer was intercepted about midafternoon, but installation was not completed until the next day. Initial outflow rate was not measured, but it was estimated to be greater than 60 gallons/minute (gpm). Outflow rate the next day was 27 gpm. By day 28, flow rate had diminished to 2 gpm; and by day 112 (January 7, 1972) it had diminished to 0.8 gpm. The drain flowed all winter and has flowed continually since.

Construction of the drain at site A required 4 days. The initial flow-rate measurement of 27 gpm represented discharge from only part of the lignitic layer. By the time construction was completed (day 4), flow rate had diminished to 12 gpm. By day 64, flow rate had diminished to 1.7 gpm; and by day 116 (January 7, 1972), the outlet had frozen. Additional winter protection was installed during 1972, and the drain continued to flow until late summer of 1974. Outflow occurred again during the summer of 1975.

Outflow hydrographs for the two drains are presented in Figure 7. Data for 1974 and 1975 are not included because outflow rates remained less than 3.1 gpm. Both drains displayed significant hydrograph peaks during the spring of 1972, followed by generally diminishing outflow rates through the remainder of 1972 and 1973. Such data show that seep activity is related to recent climatic and agronomic events and that hydraulic control of seeps can be accomplished quickly. If seep activity were the net result of many years of climatic and agronomic events, additional hydrograph peaks would have developed from the residue of those events; and several years might be needed to achieve hydraulic control.

These hydrographs along with analysis of precipitation data and consideration of agronomic treatment of the recharge areas show that when geologic conditions are appropriate for seep development, seep development depends on both climate and cultural practices. The principal climatic factor is precipitation. Precipitation data for Mott, North Dakota (18) are summarized in Table 1. Annual precipitation and April-May-June precipitation were both above normal during 1970, 1971, and 1972, below normal during 1973 and 1974, and above normal in 1975 (with only 8 months of data available). Precipitation during the 1971-1972 fall and winter season was nearly twice normal. Above-normal precipitation before the spring of 1972 coupled with above-normal spring precipitation in 1972 afforded maximum opportunity for the root zone to be overfilled and for deep percolation to occur. Below-normal precipitation the next two years produced less opportunity for deep percolation and hydrograph peaks did not develop.

Precipitation is shown across the bottom of Figure 7. These minor peaks on the hydrograph for drain A developed so soon after rainfall began that we concluded they developed because of leakage through the partially healed backfill that covered the drain. The same precipitation events did not produce comparable minor peaks in the drain B hydrograph. Drain B is only 150 ft long, and the land surface slopes such that there was much less opportunity for runoff to be intercepted by the partially healed backfill than there was for the longer drain at site A.

Hydrograph peak for drain B lagged behind the peak for drain A which suggests that the flow path is longer for drain B than for drain A. Landscape areas that represent principal recharge areas for each seep have not been precisely determined, so flow-path length can only be postulated. However, supporting inferences can be drawn from salinity data (Table 2). Electrical conductivity, and hence the salt concentration, of effluent from drain B was consistently higher than that of effluent from drain A. The higher salt concentration for drain B could easily have resulted because of a longer flow path which provided opportunity for more salts to be brought into solution.

Agronomic treatment of the recharge areas changed significantly during this time. About half of the recharge area for both seeps was fallow and about half was seeded to spring wheat in 1970. Most of the area was seeded to oats in 1971. During July 1971, before the oats were harvested, a mixture of bromegrass, crested wheatgrass, and intermediate wheatgrass was seeded by airplane on all of the recharge area for drain B and on all but about 20 acres of the recharge area for drain A. Those 20 acres remained in fallow-small grain rotation and were fallow during 1971, 1973, and 1975.

Above-normal precipitation during April-May-June of 1975 following below-normal precipitation during previous months caused the outflow rate for drain A to increase from 0 to 3.1 gpm. Drain B flowed continuously since it was installed, but the 1975 rains caused drain B outflow rate to fluctuate between 0.2 and 0.8 gpm. The response of drain A to the 1975 rain may be related to the part of the recharge area that is still in crop-fallow rotation. Conversely, stability of outflow rate from drain B probably resulted because perennial vegetation was well established on the recharge area and had used enough soil water that deep percolation did not occur at an increased rate, at least by the end of June. Since outflow from drain A started about May 1, outflow rate for drain B should have increased by the end of June if it were going to increase. A tornado destroyed the outlet structures on June 29, 1975, precluding collection of additional data.

Chemical composition of effluents from the two drains were similar throughout the study. Each average in Table 2 represents between 34 and 37 samples collected during 1971, 1972, and 1973. Principal dissolved salts were magnesium sulfate and sodium sulfate. Nitrate concentrations were consistently high and chloride concentrations were consistently low. As expected for effluents with low pH, carbonates were absent.

Water with nitrate concentrations exceeding 45 ppm (0.7 meq/liter) are not recommended for human consumption (12). Maximum nitrate concentrations in water recommended for livestock consumption have not been established, but concentrations of 4 to 6 meq/liter certainly represent a potential health hazard to livestock. The nitrate in the seep water had to be leached from within the local recharge system. Whether that soluble nitrate resulted from oxidation of exchangeable ammonium in the geologic materials, from mineralization of organic nitrogen in the root zone, or from some other source has not yet been established. However, Power et al. (17) have shown that nitrates of geologic origin are frequently found in subsurface strata of Fort Union shales.

The subsoils of this region are typically calcareous, and downward percolating soil water would have pH values greater than 7. Lignitic layers are characteristically acidic. These drains intercept water directly from the lignitic layers, so the effluent has low pH. However, seep waters that percolate to the soil surface through several feet of calcareous soil in southwestern North Dakota have pH values greater than 7.

Summary and Conclusions

Profile logs to depths greater than 50 ft at two sites in southwestern North Dakota showed that nearly horizontal lignitic layers extend for considerable distances beneath the landscape and that saline seeps occur where those layers have been truncated at shallow depths beneath hillside surfaces. The lignitic layers vary in thickness, and may not be continuous across the landscape. Several lignitic layers can occur at different elevations in the profile, and several seeps can occur on a single hillside.

Hydraulic-head data collected to depths greater than 44 ft at two sites showed that soil-water flow was consistently downward in the system. Hence, seeps are sustained by local recharge; i.e. by soil water that percolates past the root zone of adjacent, upslope landscape positions, is intercepted by the highly permeable lignitic layers, and is conducted horizontally to the hillside surface. If hydraulic conductivity of the fine-textured materials decreases with depth in the system, the potential for horizontal flow in the highly permeable lignitic layers, and for seep development, is increased.

Corrugated, perforated, plastic, interceptor drains installed with suitable gravel envelopes in 1971 provided hydraulic control for the conducting (lignitic) layers intercepted. Initial outflow rates were 27 and 60 gpm. Outflow hydrographs had significant peaks for both drains (21 and 24 gpm) in the spring of 1972 following winter outflow rates of less than 1 gpm. Following the maximum, outflow rates steadily diminished to less than 3 gpm by the winter of 1972-1973. Significant spring peaks did not develop during the next two years because (1) precipitation was less than normal and (2) perennial vegetation had been established on nearly all of the recharge area. Such data show that seep activity is related to recent climatic and agronomic events, and that hydraulic control can be affected quickly.

Downward percolating water dissolve salts from soil and geologic materials, so seeps are usually saline. Average electrical conductivities of effluents from two drains were 7.7 and 9.6 mmhos/cm. The predominant dissolved salts were sodium and magnesium sulfates. Calcium and chloride ion concentrations were characteristically low, and nitrate concentrations were consistently high enough to be potential health hazard to people and livestock.

Although hydraulic control can be quickly accomplished with interceptor drains, a suitable outlet must be available. Outlet considerations must include not only easement for transport of drainage water across intervening lands, but also the effects those drainage waters might have on the quality of streams or reservoirs that they might subsequently enter. Hydraulic control can also be affected agronomically by planting crops that use available soil water in the root zone where it is a nonsaline resource. This was essentially accomplished by seeding grass in the field that included the recharge area for site B. However, agronomic treatment of areas smaller than existing field units requires that the recharge areas be distinctly identified and that farmers and society be willing and able to adopt the new cultural practices needed for maximum soil-water use and minimum percolation.

Acknowledgement

The authors express sincere thanks to J. P. Harms, F. C. Jacober, G. D. Pfenning, E. P. Bickel, and R. M. Ballou, Agricultural Research Technicians, for their many contributions in the field and laboratory; and to the Soil Conservation Service for providing topographic data.

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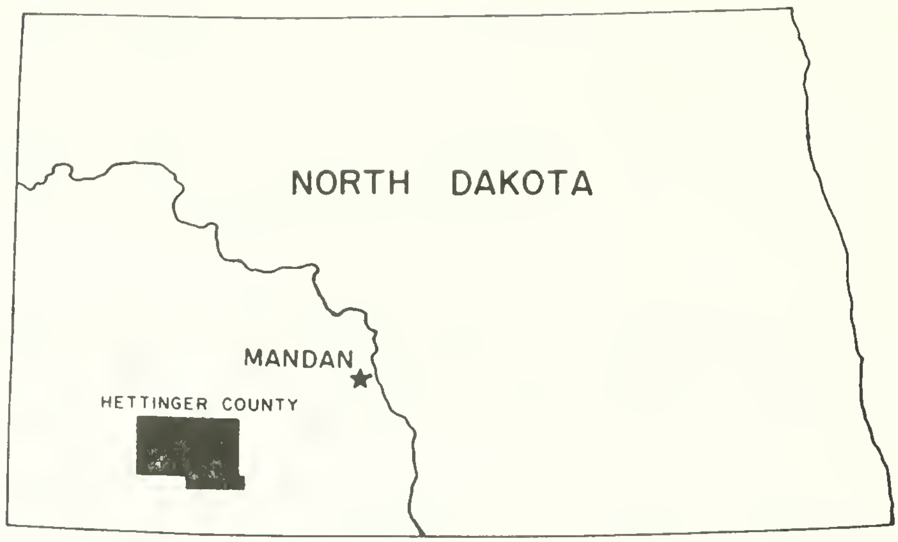


Figure 1. Map of North Dakota showing Hettinger County and Mandan.

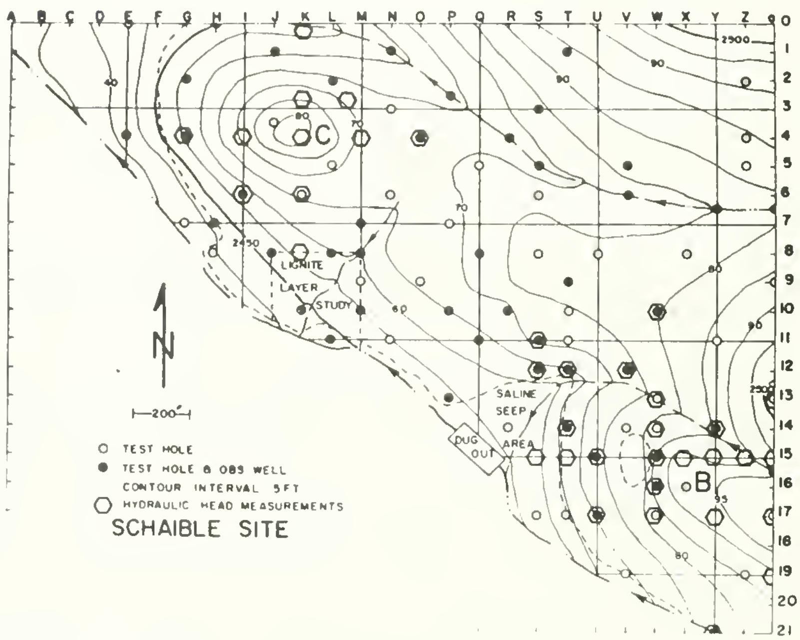


Figure 2. Detailed topographic map of hydrologic study sites B and C.

Figure 3. Topographic map of the 2 square mile study area showing the locations of 10 saline seeps with sites A, B, and C designated.

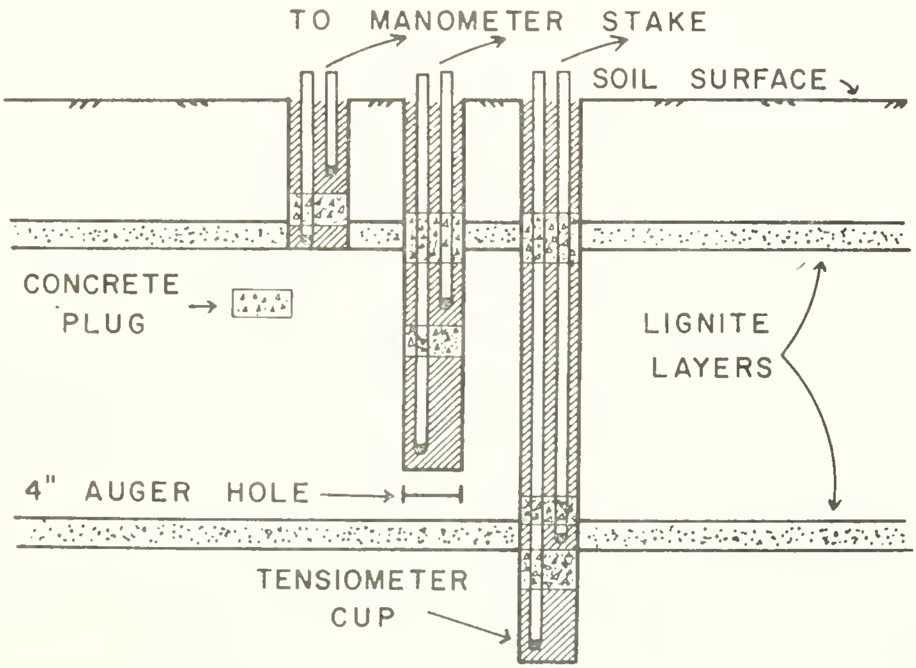


Figure 4. Sketch showing the location of concrete seals to isolate tensiometer and piezometer units.

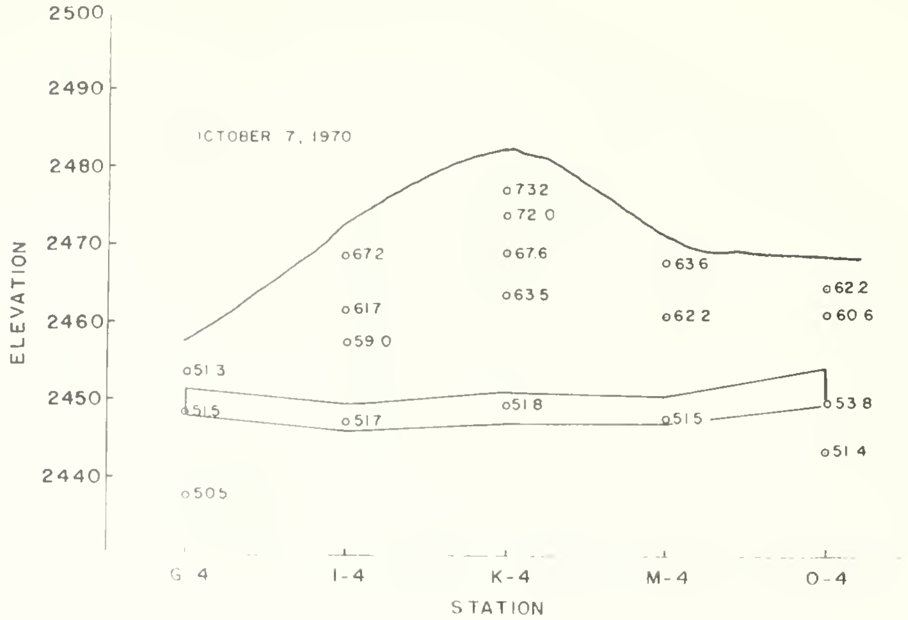


Figure 5. Profile cross-section along the 4-line in site C showing measured hydraulic head values minus 2400. Seep discharge is to the left of station G-4.

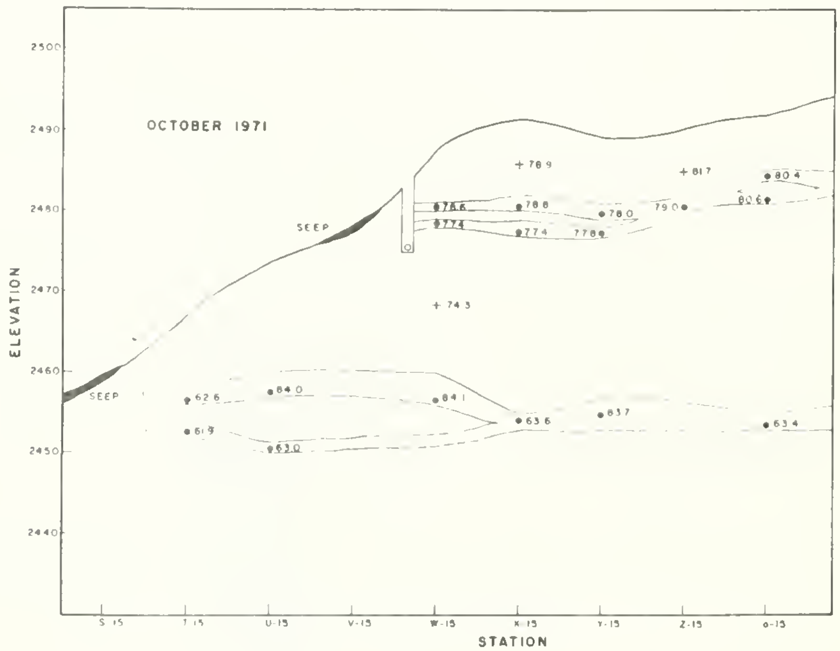


Figure 6. Profile cross-section along the 15-line at site B showing measured hydraulic head values minus 2400 about 40 days after the drain was installed in the upper seep.

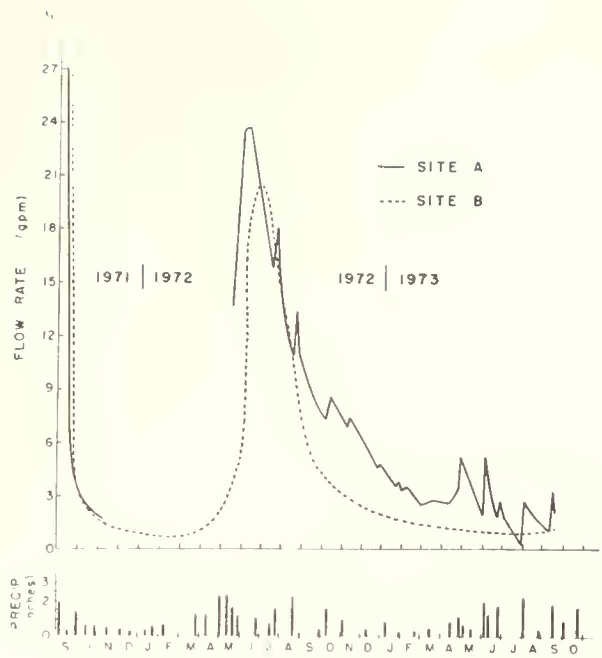


Figure 7. Drain hydrographs and precipitation at Mott, North Dakota.

Table 1. Precipitation data for Mott in Hettinger County, North Dakota.[1/]

	Annual (inches)	April, May, June (inches)
68-year average	15.4	7.7
1970	19.5	10.9
1971	19.2	11.0
1972	20.3	9.7
1973	15.0	7.2
1974	12.2	4.1
1975 [2/]	18.4	12.5

1/ U. S. Department of Commerce, National Oceanic and Atmospheric Administration. Climatological Data - North Dakota.

2/ January through August data only.

Table 2. Average chemical compositions of drain waters.

	Drain A	Drain B
Electrical conductivity (mmhos/cm)	7.7	9.6
Calcium (meq/liter)	19.	18.
Magnesium (meq/liter)	59.	71.
Sodium (meq/liter)	40.	59.
Sodium-Adsorption-ratio[1/]	6.4	8.8
pH	4.6	3.7
Carbonate (meq/liter)	0	0
Bicarbonate (meq/liter)	0	0
Chloride (meq/liter)	2.5	2.1
Nitrate (meq/liter)	4.7	5.7
Ammonia (meq/liter)	0.8	1.4
Sulfate[2/] (meq/liter)	110.	139.

1/ Sodium-adsorption ration - $Na/(\frac{Ca + Mg}{2})^{\frac{1}{2}}$ when chemical compositions are in meq/liter.

2/ Sulfate = (sum of cations) - (sum of determined anions).

PART C

PROJECTS OR PROGRAMS ANALYZED UNDER THE FOUR-ACCOUNT PRINCIPLES AND STANDARDS ANALYSIS

PROPOSED IRRIGATION UNITS--NORTH DAKOTA

YELLOWSTONE LEVEL B

prepared by Field Planning Branch
Division of Planning
Bureau of Reclamation
United States Department of the Interior

Upper Missouri Region
P.O. Box 2553, Billings, Montana 59103

December 1976

Influencing Factors

The individual unit discussions following this section of the report are presented in downstream order. These discussions will be better understood after this general coverage of the situation and the factors primarily influencing planning and, where applicable, the prospects for ultimate development.

The geologic history and resultant physiography is essentially the same with respect to all opportunities for irrigation by pumping along the Missouri River in North Dakota. Glacial alluvial deposits have been eroded by later meanderings of the river to form a wide trench flanked on each side by an almost continuous series of escarpments. In the course of these meanderings, occasional areas were left along the escarpments in the form of elevated benches or terraces and, more recently, the river has formed alluvial bottomlands within the present flood plain.

The climate is commonly considered to be semiarid because of the average annual precipitation of about 15 inches. This is misleading with respect to crop production, however, as there are frequent years of virtually no rainfall in late summer, and there are recurrent drought periods when annual precipitation is as little as 6 inches. During such periods even the spring rainfall is usually inadequate for crops. Temperatures are typical of the Northern Great Plains, with extremes of -40° to -50° F. in winter and 102° to 105° F. in summer. Summer temperatures usually vary between 70° and 95° F. Comparatively short growing seasons are imposed by late spring and early fall freezing temperatures, but this is largely offset by long summer days (latitude north of 46th parallel) with mostly clear skies.

Present agriculture under these climatic conditions, and particularly with respect to timely availability of moisture in the soils, is primarily limited to growing small grains. Non-tillable areas are mostly pastured in partial maintenance of livestock as a supplementary activity. With irrigation, even where limited in area, a wider range of crops can be successfully grown for greater support of the livestock, including alfalfa in particular and corn both for grain and silage. In addition, certain high-value cash crops, such as sugar beets and potatoes, would be adaptable and grown.

Irrigation will add to the requirements of investment. This would cover feed, seed, livestock, machinery and equipment, buildings, improvements and land development. Experience has shown, however, that irrigation permits the farm operator to exercise his managerial ability more efficiently through a wider choice of crops, the heavier use of fertilizers, the distribution of water, and timeliness of operations. Irrigation has also shown, through the stability it affords the farm operator, that net returns from irrigation are from two to four times those obtained from dryland farming.

Dependable water supplies are now assured by the Fort Peck and Garrison Reservoirs, but regulation of reservoir releases might impose additional design considerations at some of the pumpsites. Powerplants at the mainstem dams provide ample hydroelectric energy under authorization to supply Federal irrigation pumping projects at 2.5 mills per kilowatt/hour. A network of Federal, REA, and private transmission lines and related facilities serves most of the important cities of North Dakota and many of the rural areas.

Present transportation facilities are considered adequate to serve the developments under consideration. Each unit is crossed by an all-weather road, and railroad lines roughly parallel the river along both sides, passing through or near most of the units.

Settlement and development along the Missouri River are now essentially stabilized. With the exception of the cities of Williston and Bismarck, marketing centers are not large but are well-balanced in size and location to serve the agricultural areas. Disposal of excess irrigable lands in conformance with Federal reclamation law would provide some opportunities for new settlement or for local young people who might otherwise be attracted to the industrial cities in other states. Probably more important to the area than settlement, however, would be the increase in farm income and stabilizing effects, and the overall support to adjoining dryland farms, with broadened tax base and many other economic advantages.

Excess land holdings, of course, represent an important but not insurmountable problem. Most of the present-day farms and ranches are comparitively large, as generally necessary for adequate livelihoods under dryland farming. Although ownerships were not examined in detail, it is known that some of those along the river include lands classified as irrigable in amounts exceeding the limitations under Federal reclamation law. Regarding these limitations, however, it is believed that most of these landowners would recognize the advantages of irrigation, with assured crop production and therefore higher average yields, and with opportunity for greater farm diversification from the wider range of adaptable crops.

Local interest in irrigation has varied from time to time in North Dakota but, as would be expected, invariably increases during and following the recurrent periods of moderate to severe drought. During these periods advances are made in private developments. Although energy costs are high where pumping is required, these developments generally show sufficient success to be continued, and tend to stimulate further interest. The advantages of more permanent structures with lower maintenance costs, greater efficiency, and a low rate for pumping energy, may encourage these present operators to favor inclusion under Federal reclamation developments.

Strong local interest in Federal development will continue to be lacking in some areas until information relating to specific proposals has been presented. A primary purpose of this report, therefore, is to present such information as would be helpful in future discussions with prospective water users and others interested in land and water resource development.

Hazen-Stanton Unit

Location

The Hazen-Stanton Unit is located at the confluence of the Knife and Missouri Rivers on the south bank of the Knife River between the towns of Hazen and Stanton, North Dakota.

Plan of Development

Irrigation water would be supplied from the Missouri River by a 253 c.f.s. pumping plant with a total dynamic head of 54 feet. Four relift plants will also be required to serve the 12,650 irrigable acres of the unit. The relift plants have capacities and lifts as follows: 211 c.f.s. against a total dynamic head of 75 feet; 135 c.f.s., 115 feet; 36 c.f.s., 60 feet; and 13 c.f.s., 60 feet.

The delivery system arrangement would be somewhat complex because the area is divided by a highway throughout much of its length.

The Land

There has been no detailed soils classification done on this unit. The estimate of irrigable acreage (and therefore the entire design) is base on information from topographic and geologic maps.

Much of the project land is very sandy and would probably be best served by sprinkler irrigation.

Cost Estimate (Jan. 1975 prices)

Pumping Plants	$4,666,000
Discharge Lines	1,162,000
Canals and Laterals	9,867,000
Drains	3,289,000
Field Cost	$18,984,000
Other Costs	5,695,000
Settlers Assistance	127,000
Total Cost	$24,806,000

HAZEN-STANTON UNIT
December 1976
12,650 acres
$100
with beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$1,192,900
Total beneficial effects	$1,192,900
ADVERSE EFFECTS	
Investment	$1,736,100
OM&R	182,200
Total adverse effects	$1,918,300
NED BENEFICIAL EFFECTS	$ -725,400

HAZEN-STANTON UNIT
December 1976
12,650 acres
$66
without beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 787,300
Total Beneficial effects	$ 787,300
ADVERSE EFFECTS	
Investment	$1,736,100
OM&R	182,200
Total adverse effects	$1,918,300
NET BENEFICIAL EFFECTS	-$1,131,000

HAZEN-STANTON UNIT
December 1976
12,650 acres
$100
with beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	1,192,900			1,192,900
Regional benefits				
Employment	942,700	-377,100	-565,600	0
Induced & stemming	794,900	-318,000	-476,900	0
Total beneficial effects	$2,930,500	$-695,100	$-1,042,500	$1,192,900
ADVERSE EFFECTS				
Investment	$1,736,100	$	$	$1,736,100
OM&R	182,200			182,200
Total adverse effects	$1,918,300	$ 0	$ 0	$1,918,300
NET BENEFICIAL EFFECTS	$1,022,200	$-695,100	$-1,042,500	$ -725,400

HAZEN-STANTON UNIT
December 1976
12,650 acres
$66
without beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	787,300			787,300
Regional benefits				
Employment	942,700	-377,100	-565,600	0
Induced & stemming	470,400	-188,200	-282,200	0
Total beneficial effects	$2,200,400	$-565,300	$-847,800	787,300
ADVERSE EFFECTS				
Investment	$1,736,100	$	$	$1,736,100
OM&R	182,200			182,200
Total adverse effects	$1,918,300	$ 0	$ 0	$1,918,300
NET BENEFICIAL EFFECTS	$ 282,100	$-565,300	$-847,800	-$1,131,000

HAZEN-STANTON UNIT
December 1976
12,650 acres

INTEREST DURING CONSTRUCTION

Total Project Cost	$24,806,000
Interest Rate (.06375 x 1.5)	.09563
Interest During Construction	$ 2,372,198
Interest During Construction Rounded	$ 2,372,200

ANNUAL EQUIVALENT VALUE

Total Project Cost	$24,806,000
Interest During Construction	$ 2,372,200
Assigned Costs	
Total Costs	$27,178,200
Amortization Rate	.06388
Annual Equivalent Value	$ 1,736,143
Annual Equivalent Value Rounded	$ 1,736,100

HAZEN-STANTON UNIT

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: There will be a potential for improved upland game hunting, depending on the extent of clean farming practices and hunting accessibility.

Biological, geological, and ecological elements: Drains and canals would provide additional habitat for small furbearing aquatic animals and upland game birds. The exact locations of canals and drains have not been determined, but to irrigate the 12,650 acres of the Hazen-Stanton Unit it is estimated to take 51 miles of canals, 63 miles of drains, for a total of 114 miles of ditches and 126 acres of water.

Archeological, historical, and cultural elements: There is no known archeological, historical, cultural effects on the Hazen-Stanton Unit.

Water quality: None.

Air quality: Conversion of dryland farming acreage to irrigated cropland will help to reduce wind erosion on those lands.

Land quality: Irrigation will increase the value and productivity of the land due to the use of irrigation in the dry months.

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Irrigation and pumping plants, etc., will impose permanent visual intrusions in the area.

Biological, geological, and ecological elements: Change in terrain due to irrigation would destroy food and cover for some animals and birds.

Irreversible considerations: Some of the materials used in construction.

Water quality: Agricultural return flows will contribute additional pollutants to the Missouri River from dissolved solids, nutrients, pesticides, suspended solids, etc. The 12,650 irrigable acres would have 13,409 acre-feet in return flows. Assuming 1 ton of salt per acre-foot annually, this would be 13,409 tons of total dissolved solids annually.

Air quality: If some of the rangeland is plowed and cropped, this would expose more land surface to wind erosion. The increased agricultural production will increase farm machinery exhaust emissions and will contribute to area pollutants at the sites of agricultural processing plants.

*Concentration of total dissolved solids would be approximately 735 mg/1. Provided the salt yield would be at the assumed level, this TDS concentration would be less than the average TDS concentration of the Knife River (975 mg/1). The Missouri River at Pierce, South Dakota, carries an average daily load of 51,209 tons (USGS 1974). These units would add .2 percent to the Missouri River's annual TDS load.

BENEFICIAL EFFECTS

Stabilized population: The construction of the irrigation project is estimated to bring a maximum 298 additional people into the area during the period of construction, which is expected to be of a 3-year duration. This increase, and the result of the economic stabilization from the irrigation project, should increase employment and resulting populations in the service industries. The increased economic stabilization should also induce more young people to remain on the farm. Average construction family size is 3.1 people.

Distribution of income: Incomes are expected to increase, as there will be more choice as to what crops will be grown. Weather will also become less of a factor in determining incomes, causing the average annual income to increase. Incomes derived from the supply end of agriculture will also increase due to the change-over of farm equipment and the general stabilization of farmers income.

Stabilization of economic conditions: As the average annual income of farmers increases, this encourages increased services and populations in the farming community, which will aid in the stabilization of the local economy.

HAZEN-STANTON UNIT

SWB ACCOUNT

ADVERSE EFFECTS

Right of eminent domain: Although the precise acres to be used have not been determined, it is possible that some landowners may be inconvenienced with canals or other irrigation works crossing their land, even though they will not receive irrigation water.

Population impacts: The latest statistics indicate that the population in the Hazen-Stanton area is 1,757 people. The additional 298 people would have an impact if adequate housing, transportation, utilities, and school facilities were not available. The number of additional children in school is estimated to be 33. A possible solution to the housing problem would be house trailers.

The addition of the construction people could also put a strain on the sewer and water system.

Oliver-Sanger Unit

Location

The Oliver-Sanger Unit, some 11 miles long and containing approximately 8,000 acres of irrigable land, lies along the west bank of the Missouri River opposite the town of Washburn. The irrigable land occupies two benches, a recent river flood plain, and an old glacial stream terrace.

Plan of Development

Irrigation water would be furnished from the Missouri River by the main pumping plant, located near the upstream end of the unit, which would pump against a total dynamic head of 16 feet at a design capacity of 159 cfs. Six relift plants would be required to serve the 7,960 irrigable acres of the unit. The delivery system arrangement would be complex and difficult because the area is divided its entire length by a railroad and paralleling highway. Lifts (TDH) and capacities of the six relift plants are estimated as follows: 67 feet, 147 cfs; 50 feet, 15.6 cfs; 40 feet, 8.8 cfs; 60 feet, 19.2 cfs; 65 feet, 13.0 cfs; and 70 feet, 32.4 cfs.

The Land

The terrace lands are gently undulating to gently sloping with occasional isolations and depressions. The soils are alluvial and are largely deep and friable. Soil profiles usually show 4 feet of light friable silt underlain by gravelly loam or fine sandy loam. Alkalinity and salinity conditions are generally excellent.

The bottomland is characterized by long gentle undulations over a rather broad plane sloping toward the high terrace. The soils are stratified sands, silts, and clays. They are generally deep, open soils with good water-holding capacity and relatively free of soluble salts. Most of the arable areas have about a foot of light friable clay underlain by silt loam to loamy sand to a depth of about 5 feet, and this by loamy fine sand to sand.

Drainage is very favorable on the terraces where, except for some long narrow stringers, the subsoils are believed to be deep permeable sands and gravels. Interceptors would be required at the toe of the escarpment, at topographic breaks, and possibly on the longer slopes. The river bottomland has more complex drainage problems, as the lands are shallow above the normal river level, slope from the river to the terrace, and have only moderately permeable subsoils. Surface and relief drains would be required and would have a relatively flat gradient.

Cost Estimate (January 1975 prices)

Pumping Plants	$ 2,473,000
Discharge Lines	1,098,000
Canals and Laterals	6,225,000
Drains	2,038,000
Field Cost	$11,834,000
Other Costs	3,550,000
Settlers Assistance	80,000
Total Cost	$15,464,000

Energy Requirements

Power for pumping could be supplied from the existing Fort Clark Unit Substation with the construction of a 17-mile distribution line.

Using the average annual diversion requirement of 2.5 acre-feet per irrigable acre, the seven pumping plants will consume a total of approximately 3,250,000 kilowatt-hours per year at an annual cost of $8,120.

OLIVER-SANGER UNIT
December 1976

INTEREST DURING CONSTRUCTION

Total project cost	$15,464,000
Interest rate (.06375 x 1.5)	.09563
Interest during construction	$ 1,478,822
Interest during construction rounded	$ 1,478,800

ANNUAL EQUIVALENT VALUE

Total project cost	$15,464,000
Interest during construction	1,478,800
Total costs	$16,942,800
Amortization rate	.06388
Annual equivalent value	$ 1,082,306
Annual equivalent value rounded	$ 1,082,300

OLIVER-SANGER UNIT
December 1976
7,960 acres
$100
with beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 750,600
Total beneficial effects	$ 750,600
ADVERSE EFFECTS	
Investment	$ 1,082,300
OM&R	144,300
Total adverse effects	$ 1,226,600
NET BENEFICIAL EFFECTS	$ -476,000

OLIVER-SANGER UNIT
December 1976
7,960 acres
$66
without beans

BENEFICIAL EFFECTS	
Irrigation	$ 495,000
Total beneficial effects	$ 495,000
ADVERSE EFFECTS	
Investment	$1,082,300
OM&R	144,300
Total adverse effects	$1,226,600
NET BENEFICIAL EFFECTS	$ -731,200

OLIVER-SANGER UNIT
December 1976
7,960 acres
$100
with beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	750,600			750,600
Regional benefits				
Employment	587,700	-235,100	-352,600	0
Induced & stemming	501,100	-200,400	-300,700	0
Total beneficial effects	$1,839,400	$ -435,500	$ -653,300	$ 750,600
ADVERSE EFFECTS				
Investment	$1,082,200	$	$	$1,082,200
OM&R	144,300			144,300
Total adverse effects	$1,226,600	$ 0	$ 0	$1,226,600
NET BENEFICIAL EFFECTS	$ 612,800	$ 435,500	$ 653,300	$ -476,000

OLIVER-SANGER UNIT
December 1976
7,960 acres
$66
without beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	495,400			495,400
Regional benefits				
Employment	587,700	-235,100	-352,600	0
Induced & stemming	296,900	-118,800	-178,100	0
Total beneficial effects	$1,380,000	$ -353,900	$ -530,700	$ 495,400
ADVERSE EFFECTS				
Investment	$1,082,300	$	$	$1,082,300
OM&R	144,300			144,300
Total adverse effects	$1,226,600	$ 0	$ 0	$1,226,600
NET BENEFICIAL EFFECTS	$ 153,400	$ -353,900	$ -530,800	$ -731,200

OLIVER-SANGER UNIT

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: There will be a potential for improved upland game hunting, depending on the extent of clean farming practices and hunting accessibility.

Biological, geological, and ecological elements: Drain, canals, and other features of the irrigation systems will provide increased habitat for small aquatic furbearing animals and upland game birds. The exact locations of the canals and drains have not been determined, but to irrigate the 7,960 acres of the Oliver-Sanger Unit it is estimated to take 44 miles of canals and 32 miles of drains, for a total of 76 miles of ditches and 88 acres of water.

Archeological, historical, and cultural elements: There is no known archeological, historical, or cultural effects on the Oliver-Sanger Unit.

Water quality: None.

Air quality: Conversion of dryland farming acreage to irrigated cropland will help to reduce wind erosion on those lands.

Land quality: Irrigation will increase the value and productivity of the land due to the use of irrigation in the dry months.

Visual quality: None.

Sound quality: None.

OLIVER-SANGER UNIT

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Irrigation and pumping plants, etc., will impose permanent visual intrusions in the area.

Biological, geological, and ecological elements: Change in terrain due to irrigation and new farming methods would destroy natural habitat for wildlife, particularly for smaller animals and birds.

Archeological, historical, and cultural elements: There is no known adverse effects for archeological, historical, and cultural effects on the Oliver-Sanger Unit.

Irreversible considerations: Some of the materials used in construction.

Water quality: Agricultural return flows will contribute additional pollutants to the Missouri River from dissolved solids, nutrients, pesticides, suspended solids, etc. The 7,960 irrigable acres would have 8,438 acre-feet in return flows. Assuming 1 ton of salt per acre-foot annually, this would be 8,438 tons of total dissolved solids annually.

Air quality: The increased use of farm machinery will result in increased exhaust emissions. In addition, pollutants at the sites of agricultural processing plants.

Land quality: None.

Sound quality: Additional noise due to increased use of farm machinery.

*See the final paragraph on page 11.

OLIVER-SANGER UNIT

SWB ACCOUNT

BENEFICIAL EFFECTS

Stabilized population: The construction of the irrigation project is estimated to bring approximately a maximum of 186 people to the area during the period of construction, which is expected to be of a 3-year duration. The average size of the construction family is 3.1 people. This increase, and the result of the economic stabilization from the irrigation project should increase employment and the resulting populations in the service industries. The increased economic stabilization should also induce more young people to remain on the farm.

Distribution of income: Incomes are expected to increase, as there will be more choice as to what crops will be grown. Weather will also become less of a factor in determining incomes, causing the average annual income to increase. Incomes derived from the supply end of agriculture will also increase due to the changeover of farm equipment and the general stabilization of farmers income.

Stabilization of economic conditions: As the average annual income of farmers increases, this encourages increased services and populations in the farming community, which will aid in the stabilization of the local economy.

ADVERSE EFFECTS

Right of eminent domain: Although the precise acres to be used have not been determined, it is possible that some landowners may be inconvenienced with canals or other irrigation works crossing their land, even though they will not receive irrigation water.

Population impacts: The latest statistics indicate the population in the Washburn area is 804 people. The additional 186 people to the area will have an impact if adequate housing, transportation, utilities, law enforcement, hospital care, etc. are not available. The number of additional children in school is estimated to be 21.

Possibly, the major impact of the arrival of the construction people is a strain on the sewer and water system.

Upper Portion of Painted Woods Unit

Location

This unit originally consisted of approximately 3,500 acres of irrigable land in a rather compact body southeast of the town of Washburn. The land lies in successively higher positions above the Missouri River, beginning with the river flood plain and continuing to first and second benches of ancient glacial river origin. Since the time of the original study, however, most of the land in the flood plain and first bench has been privately developed leaving only 610 undeveloped acres on the upper bench above highway 83.

Plan of Development

Irrigation water for this unit would be furnished from the Missouri River by a river pumping plant which would pump against a total dynamic head of 185 feet at a design capacity of 13 cfs. The water would be delivered to the high point of the unit at elevation 1790 feet and distributed from there through a system of laterals.

Feasibility investigations should include the possibility of pumping from one of the existing canals in the bottomland which could result in considerable reductions in project costs.

The Land

The project land presently considered irrigable lies on a terrace, where the topography is gently rolling or undulating. The soils are alluvial and with rather uniform characteristics. A typical profile shows about 15 inches of dark brown silt loam topsoil grading into light brown loam or very fine sandy loam subsoil. Depths to a soft sandstone bedrock range from 5 to 20 feet. Infiltration and permeability rates are fairly good as well as water-holding capacity and drainability. The soils have an alkaline reaction with maximum pH readings of about 9.0, largely because of lime but with little or no gypsum. Total soluble salts are very low.

Drainage can be feasibly provided for the terrace. Soils are usually as shallow as 10 to 15 feet over barrier, and subsoils range from silt loams to sands and gravels. Interceptor drains would be required at topographic breaks, in places where permeability is reduced by changes in texture, and probably on the longer slopes.

Cost Estimate (January 1975 prices)

Pumping Plant	$ 145,000
Discharge Line	528,000
Canals and Laterals	137,000
Drains	230,000
Field Cost	$1,040,000
Other Costs	312,000
Settlers Assistance	6,000
Total Cost	$1,358,000

Energy Requirements

Power for pumping could be supplied from the existing Washburn (USBR) Substation with the construction of approximately 17 miles of distribution line.

Using the average annual diversion requirement of 2.5 acre-feet per irrigable acre, the pumping plant would consume approximately 413,000 kilowatt-hours per year at an annual cost of $1,040.

UPPER PORTION OF PAINTED WOODS UNIT
December 1976

INTEREST DURING CONSTRUCTION

Total project cost	$1,358,000
Interest rate	.06375
Interest during construction	$ 86,572
Interest during construction rounded	$ 86,600

ANNUAL EQUIVALENT VALUE

Total project cost	$1,358,000
Interest during construction	86,600
Total costs	$1,444,600
Amortization rate	.06388
Annual equivalent value	$ 92,281
Annual equivalent value rounded	$ 92,300

UPPER PORTION OF PAINTED WOODS UNIT
December 1976
610 acres
$100
with beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 59,200
Total beneficial effects	$ 59,200
ADVERSE EFFECTS	
Investment	$ 92,300
OM&R	9,000
Total adverse effects	$ 101,300
NET BENEFICIAL EFFECTS	$ -42,100

UPPER PORTION OF PAINTED WOODS UNIT
December 1976
610 acres
$66
without beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 39,100
Total beneficial effects	$ 39,100
ADVERSE EFFECTS	
Investment	$ 92,300
OM&R	$ 9,000
Total adverse effects	$ 101,300
NET BENEFICIAL EFFECTS	$ -62,200

UPPER PORTION OF PAINTED WOODS UNIT
December 1976
610 acres
$100
with beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	59,200			59,200
Regional benefits				
Employment	51,600	-20,000	-31,000	0
Induced & stemming	38,600	-15,400	-23,200	0
Total beneficial effects	$ 149,400	$ -36,000	$ -54,200	$ 59,200
ADVERSE EFFECTS				
Investment	$ 92,300	$	$	$ 92,300
OM&R	9,000			9,000
Total adverse effects	$ 101,300	$ 0	$ 0	$ 101,300
NET BENEFICIAL EFFECTS	$ 48,100	$ -36,000	$ -54,200	$ -42,100

UPPER PORTION OF PAINTED WOODS UNIT
December 1976
610 acres
$66
without beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	39,100			39,100
Regional benefits				
Employment	51,600	-20,600	-31,000	0
Induced & stemming	22,600	-9,000	-13,600	0
Total beneficial effects	$ 113,300	$-29,600	$ -44,600	$ 39,100
ADVERSE EFFECTS				
Investment	$ 92,300	$	$	$ 92,300
OM&R	9,000			9,000
Total adverse effects	$ 101,300	$ 0	$ 0	$ 101,300
NET BENEFICIAL EFFECTS	$ 12,000	$-29,600	$ -44,600	$ -62,200

UPPER PAINTED WOODS UNIT

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: There will be a potential for improved upland game hunting, depending on the extent of clean farming practices and hunting accessibility.

Biological, geological, and ecological elements: Drains, canals, and other features of the irrigation systems will provide increased habitat for small aquatic furbearing animals and upland game birds. The exact locations of the canals and drains have not been determined, but to irrigate the 610 acres of the Upper Painted Woods Unit it is estimated to take 2 miles of canals and 2 miles of drains, for a total of 4 miles of ditches and 5 acres of water.

Archeological, historical, and cultural elements: There is no known archeological, historical, or cultural effects on the Upper Painted Woods Unit.

Water quality: None.

Air quality: Conversion of dryland farming acreage to irrigated cropland will help to reduce wind erosion on those lands.

Land quality: Irrigation will increase the value and productivity of the land due to the use of irrigation in the dry months.

Visual quality: None.

Sound quality: None.

UPPER PORTION OF PAINTED WOODS UNIT

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Irrigation and pumping plants, etc., will impose permanent visual intrusions in the area.

Biological, geological, and ecological elements: Change in terrain due to irrigation and new farming methods would destroy natural habitat for wildlife, particularly for smaller animals and birds.

Archeological, historical, and cultural elements: There is no known adverse effects for archeological, historical, and cultural effects on the Upper Portion of Painted Woods Unit.

Irreversible considerations: Some of the materials used in construction.

Water quality: Agricultural return flows will contribute additional pollutants to the Missouri River from dissolved solids, nutrients, pesticides, suspended solids, etc. The 610 irrigable acres would have 647 acre-feet in return flows. Assuming 1 ton of salt per acre-foot, this would be 647 tons of totally dissolved solids annually.

Air quality: The increased use of farm machinery will result in increased exhaust emissions. In addition, pollutants at the sites of agricultural processing plants.

Land quality: None.

Sound quality: Additional noise due to increased use of farm machinery.

*See the final paragraph on page 11.

UPPER PORTION OF PAINTED WOODS UNIT

SWB ACCOUNT

BENEFICIAL EFFECTS

Stabilized population: The construction of the irrigation project is expected to bring in a maximum of 25 people during the construction period, which is expected to be less than 2 years. This increase, and the result of the economic stabilization from the irrigation project, should increase employment and resulting populations in the service industries. The increased economic stabilization should induce more young people to remain on the farm and increase the social well-being of the farm family.

Distribution of income: Incomes are expected to increase, as there will be more choice as to what crops will be grown. Weather will also become less of a factor in determining incomes, causing the average annual income to increase. Incomes derived from the supply end of agriculture will also increase due to the change-over of farm equipment and the general stabilization of farmers income.

Stabilization of economic conditions: As the average annual income of farmers increases, this encourages increased services and populations in the farming community, which will aid in the stabilization of the local economy.

ADVERSE EFFECTS

Right of eminent domain: Although the precise acres to be used have not been determined, it is possible that some landowners may be inconvenienced with canals or other irrigation works crossing their land, even though they will not receive irrigation benefits.

Population impacts: The latest statistics indicate that the number of people in the Wilton area is 695 people. The addition of 25 additional people would have an impact if adequate housing, transportation, utilities, and school facilities were not adequate. The additional school age children is estimated to be 3. A possible solution to the housing problem would be house trailers.

The addition of the construction prople could also put a strain on the sewer and water system.

Little Heart Unit

Location

The Little Heart Unit includes approximately 3100 acres of irrigable land forming a narrow 10-mile strip along the west bank of the Missouri River beginning about 5 miles south of Mandan. Most of this land lies on a terrace 40 to 75 feet above the river.

Plan of Development

Irrigation water would be delivered from the Missouri River by a pumping plant at the north end of the project which will pump against a total dynamic head of 86 feet at a design capacity of 62 cfs. A 12-mile canal would extend along the western edge of the unit area which would require a 19 cfs in-line relift plant with a total dynamic head of 50 feet to serve lands in the southern portion of the unit.

The Land

The irrigable land lies almost entirely on a glacial stream terrace or bench, where the topography is gently rolling to gently undulating, cut by occasional depressions and natural drainageways. There are small acreages of irrigable bottomland along the Little Heart River, which crosses the unit area near the center. The soils are generally open and permeable, having high fertility typical of alluvial soils. They vary from the heavier soils high on the bench, with about 1 foot of dark brown silt loam underlain by grayish clay loam, to those immediately above the flood plain with about 2 feet of dark brown loam to silt loam overlying gravels, fine sands, and silt. In most of the irrigable areas the alkalinity of the soil is moderately low.

The most favorable drainage characteristic of these lands is their scattered location in narrow parcels on a bench of the Little Heart and Missouri Rivers. Surface patterns are complex. Some lands slope toward the river and some toward lows on the bench that usually are not irrigable. Strata of terrace gravels are found intermittently on higher levels of the bench but have been eroded from the low-lying lands. Drainage would be required on the longer slopes and to protect the non-irrigable lows, and might be difficult to provide where the soils have heavy textures.

Most of the irrigable land is presently dryfarmed, mainly for small grains. No private irrigation developments have been undertaken.

Cost Estimate (January 1975 prices)

Pumping Plants	$ 742,000
Discharge Lines	86,000
Canals and Laterals	1,883,000
Drains	780,000
Field Cost	$3,491,000
Other Costs	1,047,000
Settlers Assistance	31,000
Total Cost	$4,569,000

Energy Requirements

Power for pumping could be provided by construction of an 8-mile distribution line and additions to the Custer Trail (USBR) Substation.

Using an average annual diversion requirement of 2.5 acre-feet per irrigable acre, the two pumping plants would consume a total of approximately 1,150,000 kilowatt-hours per year at an annual cost of $2,875.

LITTLE HEART UNIT
December 1976

INTEREST DURING CONSTRUCTION

Total project cost	$4,569,000
Interest rate	.06375
Interest during construction	$ 291,274
Interest during construction rounded	$ 291,300

ANNUAL EQUIVALENT VALUE

Total project cost	$4,569,000
Interest during construction	291,300
Total costs	$4,860,300
Amortization rate	.06388
Annual equivalent value	$ 310,476
Annual equivalent value rounded	$ 310,500

LITTLE HEART UNIT
December 1976
3,100 acres
$100
with beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 301,000
Total beneficial effects	$ 301,000
ADVERSE EFFECTS	
Investment	$ 310,500
OM&R	47,000
Total adverse effects	$ 357,500
NET BENEFICIAL EFFECTS	$ -56,500

LITTLE HEART UNIT
December 1976
3,100 acres
$66
without beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 198,700
Total beneficial effects	$ 198,700
ADVERSE EFFECTS	
Investment	$ 310,500
OM&R	47,000
Total adverse effects	$ 357,500
NET BENEFICIAL EFFECTS	$ -158,800

LITTLE HEART UNIT
December 1976
3,100 acres
$100
with beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	301,000			301,000
Regional benefits				
Employment	173,600	-69,400	-104,200	0
Induced & stemming	211,400	-84,600	-126,800	0
Total beneficial effects	$ 686,000	-$154,000	$ -231,000	$ 301,000
ADVERSE EFFECTS				
Investment	$ 310,500	$	$	$ 310,500
OM&R	47,000			47,000
Total adverse effects	$ 357,500	$ 0	$ 0	$ 357,500
NET BENEFICIAL EFFECTS	$ 328,500	$-154,000	$ -231,000	$ -56,500

LITTLE HEART UNIT
December 1976
3,100 acres
$66
without beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	198,700			198,700
Regional benefits				
Employment	173,600	-69,400	-104,200	0
Induced & stemming	129,600	-51,800	-77,800	0
Total beneficial effects	$ 501,900	$-121,200	$-182,000	$ 198,700
ADVERSE EFFECTS				
Investment	$ 310,500	$	$	$ 310,500
OM&R	47,000			47,000
Total adverse effects	$ 357,500	$ 0	$ 0	$ 357,500
NET BENEFICIAL EFFECTS	$ 144,400	$-121,200	$-182,000	$ -158,800

FORT YATES UNIT
December 1976

INTEREST DURING CONSTRUCTION

Total project cost	$6,365,000
Interest rate	.06375
Interest during construction	$ 405,769
Interest during construction rounded	$ 405,800

ANNUAL EQUIVALENT VALUE

Total project cost	$6,365,000
Interest during construction	405,800
Total costs	$6,770,800
Amortization rate	.06388
Annual equivalent value	$ 432,519
Annual equivalent value rounded	$ 432,500

FORT YATES UNIT
December 1976
4,260 acres
$100
with beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 413,600
Total beneficial effects	$ 413,600
ADVERSE EFFECTS	
Investment	$ 432,500
OM&R	85,800
Total adverse effects	$ 518,300
NET BENEFICIAL EFFECTS	$ -104,700

FORT YATES UNIT
December 1976
4,260 acres
$66
without beans

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 273,000
Total beneficial effects	$ 273,000
ADVERSE EFFECTS	
Investment	$ 432,500
OM&R	85,800
Total adverse effects	$ 518,300
NET BENEFICIAL EFFECTS	$ -245,300

FORT YATES UNIT
December 1976
4,260 acres
$100
with beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	413,600			413,600
Regional benefits				
Employment	241,800	-96,700	-145,100	0
Induced & stemming	290,000	-116,000	-174,000	0
Total beneficial effects	$ 945,400	$-212,700	$-319,100	$ 413,600
ADVERSE EFFECTS				
Investment	$ 432,500	$	$	$ 432,500
OM&R	85,800			85,800
Total adverse effects	$ 518,300	$ 0	$ 0	$ 518,300
NET BENEFICIAL EFFECTS	$ 427,100	$-212,700	$-319,100	$ -104,700

FORT YATES UNIT
December 1976
4,250 acres
$66
without beans

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	273,000			273,000
Regional benefits				
Employment	241,800	-96,700	-145,100	0
Induced & Stemming	177,500	-71,000	-106,500	0
Total beneficial effects	$ 692,300	$-167,700	$-251,600	$ 273,000
ADVERSE EFFECTS				
Investment	$ 432,500	$	$	$ 432,500
OM&R	85,800			85,800
Total adverse effects	$ 518,300	$ 0	$ 0	$ 518,300
NET BENEFICIAL EFFECTS	$ 174,000	$-167,700	$-251,600	$-245,300

FORT YATES UNIT

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: There will be a potential for improved upland game hunting, depending on the extent of clean farming practices and hunting accessibility.

Biological, geological, and ecological elements: Drains, canals, and other features of the irrigation systems will provide increased habitat for small aquatic furbearing animals and upland game birds. The exact locations of the canals and drains have not been determined, but to irrigate the 4,260 acres of the Fort Yates Unit it is estimated to take 21 miles of canals and 17 miles of drains, for a total of 38 miles of ditches and 45 acres of water.

Archeological, historical, and cultural elements: There is no known archeological, historical, or cultural effects on the Fort Yates Unit.

Water quality: None.

Air quality: Conversion of dryland farming acreage to irrigated cropland will help to reduce wind erosion on those lands.

Land quality: Irrigation will increase the value and productivity of the land due to the use of irrigation in the dry months.

FORT YATES UNIT

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Irrigation and pumping plants, etc., will impose permanent visual intrusions in the area.

Biological, geological, and ecological elements: Change in terrain due to irrigation would destroy food and cover for some animals and birds.

Irreversible considerations: Some of the materials used in construction.

Water quality: Agricultural return flows will contribute additional pollutants to the Missouri River from dissolved solids, nutrients, pesticides, suspended solids, etc. The 4,260 irrigable acres would have 4,516 acre-feet in return flows. Assuming 1 ton of salt per acre-foot, this would be 4,516 tons of totally dissolved solids annually.

Air quality: If some of the rangeland is plowed and cropped, this would expose more land surface to wind erosion. The increased agricultural production will increase farm machinery emissions and will contribute to area pollutants at the sites of agricultural processing plants.

*See the final paragraph on page 11.

FORT YATES UNIT

SWB ACCOUNT

BENEFICIAL EFFECTS

Stabilized population: The construction of the irrigation project is estimated to bring a maximum of 115 construction people to the area during the expected 2-year construction period. This increase, and the result of the economic stabilization from the irrigation project, should increase employment and the resulting populations in the service industries. This economic stabilization will improve the social well-being of the farm family.

Distribution of income: Incomes are expected to increase, as there will be more choice as to what crops will be grown. Weather will also become less of a factor in determining incomes, causing the average annual income to increase. Incomes derived from the supply end of agriculture will also increase due to the changeover of farm equipment and the general stabilization of farmers income.

Stabilization of economic conditions: The increase of the average annual income of farmers will encourage increased services and populations in the farming community, which will aid in the stabilization of the local economy.

ADVERSE EFFECTS

Right of eminent domain: Although the precise acres to be used have not been determined, it is possible that some landowners may be inconvenienced with canals and other irrigation works crossing their land, even though they will not receive irrigation water.

Population impacts: The latest statistics is that the population in the Fort Yates area is 1,153 people. The additional 115 people would have an impact if adequate housing, transportation, utilities, law enforcement, hospital and medical care, and schools were not available. The additional number of children in school is estimated to be 13.

A possible major impact of the construction people would be to put a strain on the sewer and water system.

Yellowstone Basin and Adjacent Coal Area Level B Study
North Dakota Tributaries Planning Area

POTENTIAL PROJECT EVALUATION

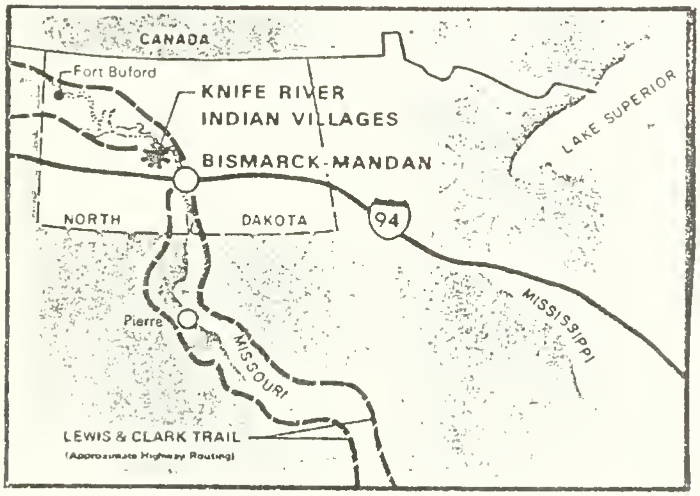
(Provided by Wayne Stufft,
Corps of Engineers, Omaha, Nebraska)

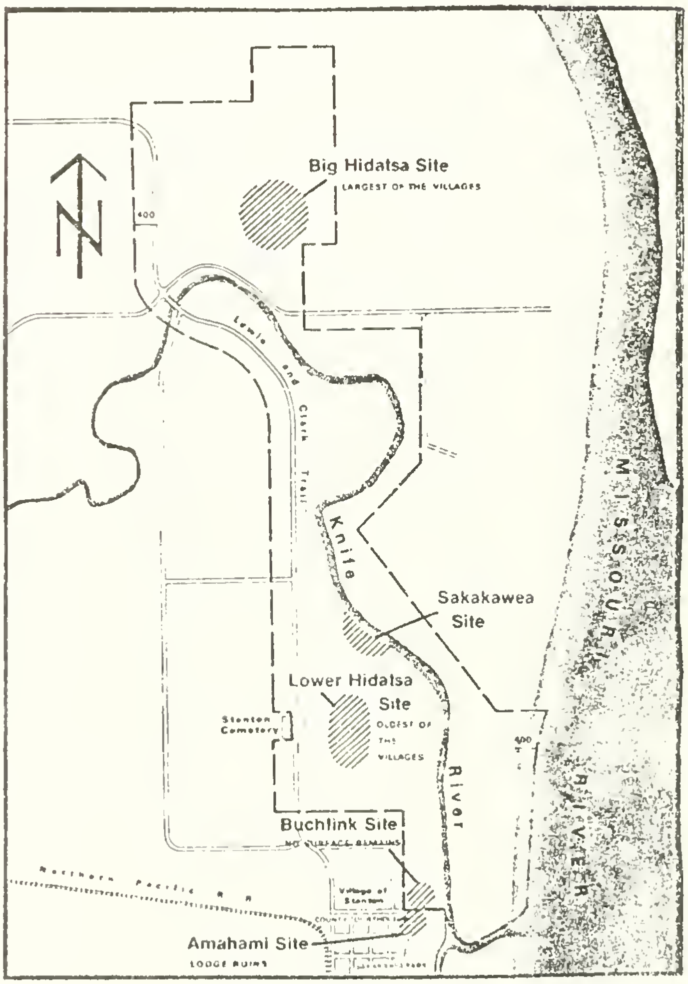
Problem: Streambank erosion at Knife River Indian Villages National Historic Site near Stanton, North Dakota

Potential Project: Construction of a berm and rock protection along an 1,800-foot reach of river bank at the Sakakawea Site.

Owner: The Knife River Indian Villages National Historic Stie near Stanton, North Dakota, is administered by the National Park Service. The superintendent of Theodore Roosevelt National Memorial Park at Medora, North Dakota, is in charge of the Stanton Site.

Location: Stanton, North Dakota (1970 population of 517) is located about fifty miles northwest of Bismarck, North Dakota, near the confluence of theKnife River and the Missouri River. The Knife River Indian Villages National Historic Site is located immediately north of Stanton and covers an area of about 1,200 acres (see maps). The streambank erosion problem is located along the Knife River at the Sakakawea Site.





Historical Background: The Hidatsa Indians, along with their Mandan and Arikara neighbors to the south, were village Indians living along the Missouri River at the time of the first Euro-American contact. They gardened and hunted along the Missouri River from the 10th through the 19th centuries. Preserved at the newly established Knife River Indian Villages National Historic Site are house rings of their earth lodges, cache pits and fortifications.

The villagers here on the Knife River were the northwestern-most effective gardeners in North America, but they were heavily dependent upon buffalo hunting and the use of other wild foods. Their ability to survive in this area was due in part to their use of other available foods in addition to the beans, sunflower seeds, squash and corn that they grew. Villages on the terrace rims were centrally located for fishing and flood plain horticulture. Buffalo, elk, deer, antelope, waterfowl, and various small game animals were hunted on the terraces and bluffs.

Indian settlers were well established by the 13th century in villages between the Knife and Heart Rivers. Their early rectangular lodges were clustered in small open villages. The Knife River Village of Buchfink (see map) is believed to be similar to these early sites.

By the late 15th-early 16th centuries, the small villages with rectangular houses were replaced by larger, compact and sometimes fortified villages with circular earth lodges. Such villages ranged in size from those with a few to those with over 100 lodges. In fact, when these villages were lived in, the population was likely greater than it is now in this area of North Dakota.

The earliest circular earth lodges at Lower Hidatsa (see map) were probably occupied by 1675. However, this early occupation may have been Mandan rather than Hidatsa. The Hidatsa cannot be distinguished from the Mandan in the prehistoric records. The key to this separation lies in part in the Knife River Villages and will have to be verified by archeological work at the site.

The first recorded Euro-American visit to the Missouri River Village tribes was made by an explorer la Verendrye in 1738 with a visit to the Mandan. The first documented contact with the Hidatsa was by the explorer David Thompson in 1797.

By the late 18th-early 19th centuries, the Knife River Villages were the main bastions of the Hidatso Indians. Intertribal trade was fortified and expanded by the influence and presence of Euro-Americans within the Villages. During this time the village tribes of the Missouri River rode a wave of prosperity and cultural changes. The Hidatsa and Mandan were middlemen, or brokers, in a trade network between the Crow of the upper Yellowstone; Cheyenne and Arapahoe of the Plains to the southwest; and Assiniboin, Cree, and Dakota of the northeastern Plains.

Although the patterns and objects of trade, resulting social interactions, and pressures changed through time, the trade networks themselves can be traced back through the prehistoric period.

The Lewis and Clark Expedition, arriving in October 1804 at the three Hidatsa villages on the Knife River, wintered through April of 1805 at Fort Mandan, a few miles below the Knife River Villages. Toussaint Charboneau and his Shoshone wife Sakakawea joined Lewis and Clark at Fort Mandan.

Current Conditions: The Knife River Indian Villages National Historic Site was authorized as part of the National Park System on 26 October 1974 to preserve and interpret the irreplaceable archeological resources of the area. The National Park Service is in the process of acquiring the needed land parcels for the National Historical Site. Of primary consideration and importance are the four or five Indian Village Sites, one of which is located along the bank of the Knife River. Due to meandering of the alluvial river, there has been considerable streambank erosion and some loss of the archeological resource at the river village site (Sakakawea). Therefore, the National Park Service requested the Omaha District Office of the Corps of Engineers to design some type of corrective action along that portion of the riverbank adjacent to the Sakakawea Site.

The rise and fall of the Knife River in this area is about 12 feet and the river width about 200 feet. The high earth bank where the village site is situated varies in height from about 20 to 32 feet. The opposite bank varies from only about 10 to 12 feet in height. This bank is much lower since it is actually part of the Missouri River overflow area. This low overbank area provides releif during high flows on the Knife River and reduces the flood threat at the Sakakawea Site.

Alternative Designs: Two physical constraints severely limit the options available for bank protection construction techniques: (1) the proximity of the Indian lodge sites to the river's high bank precludes any construction activity along the high bank, unless extensive measures are undertaken to protect and preserve the lodge sites during the construction activity; and (2) the large sandbar and delta formation at the Knife-Missouri confluence precludes consideration of floating plant to accomplish construction of any bank stabilization measures. In light of these restrictions, the placement of a narrow berm along the toe of the high bank would be essential to implement bank stabilization. Such a berm could be a temporary facility to be removed after construction of the bank stabilization structures. However, considering access for future structure maintenance, it would be desirable to incorporate a permanent berm into the protective system.

Four alternative protection designs were considered. Two of the designs incorporated a small permanent random-fill berm along the high bank toe and provided for riprap or gabion berm slope protection (Riprap consists of a layer of large stones, while gabions are wire baskets containing medim-sized stones). The other two designs indicated direct stabilization of the high bank with riprap or gabions. These latter two designs included the use of a temporary berm to facilitate construction. Gabions would function adequately but they require about the same quantity of stone as riprap protection and with added handling. Also, the wire baskets are susceptible to ice damage.

In addition to the above, piling and retaining wall cribbing stabilization measures were briefly considered. Any type of pile structure would be difficult and expensive to place, because of the numerous rock outcroppings and boulders in the bank and riverbed. Earth-fill timber or metal cribbing lack the flexibility necessary to conform to the irregular bank and bed shapes and to "self-mend" random scour holes. Both piling and cribbing structures are aesthetically and environmentally undesirable.

Based on a preliminary investigation, the typical section indicated on Sketch 1 was recommended as the best project option for the following reasons:

a. It is the most economical plan, considering the construction difficulty factor, as well as material quantities.

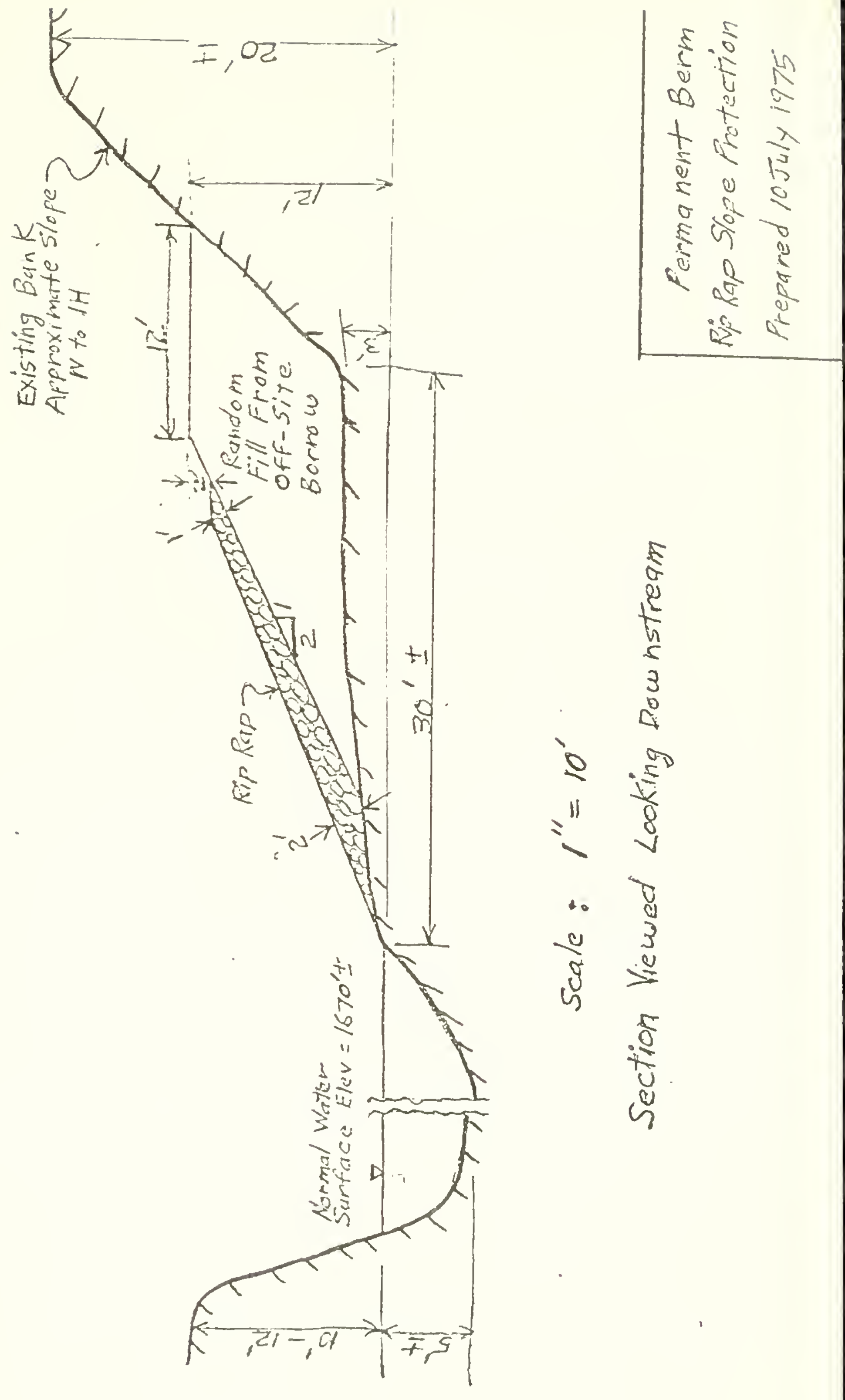
b. Required maintenance would be limited to basically simple, common procedures, such as occasional groundkeeping and the infrequent addition of minor amounts of stone to reinforce deteriorated segments and keep the riprap properly dressed to design line and grade.

c. Maintenance would be easily accomplished by using the permanent berm for access.

d. If desirable, the berm surface could be sufficiently upgraded to provide a public roadway access to the river for fishing or other recreational pursuits.

The following estimate reflects the cost (1975 price levels) anticipated for the Corps of Engineers to design and construct (by contract) 1,800 linear feet of the recommended structural system:

Item	Quantity	Unit	Unit Cost	Total Cost
Fill	12,600	c.y.	$ 2	$25,200
Riprap	3,600	tons	14	50,400
			Subtotal	$75,600
		* Contingencies (20%)		15,200
			Subtotal	$90,800
		Engineering & Design		7,100
		Supervision & Admin		7,100
			TOTAL	$105,000


Permanent Berm
Rip Rap Slope Protection
Prepared 10 July 1975
Existing Bank
Approximate Slope
1V to 1H
20'±
12'
12'
3'
Random
Fill From
Off-Site
Borrow
Rip Rap
1
2
2'
30'±
Normal Water
Surface Elev = 1670'±
10'-12'
5'±
Scale: 1" = 10'
Section Viewed Looking Downstream

Sketch #1

This estimate does not provide for anything other than design and constructionof the bank protection. All necessary supplemental actions, such as securing project funds and complying with the National Environmental Policy Act would be performed by the National Park Service.

Four-Account Analysis: The potential plan element is a rather simple case evaluated under the 4-account analysis. There are no measurable beneficial effects under the National Economic Development Account. The degree of tourist visitation would probably not be affected with the project, although the quality of the visitations would probably be enhanced. Adverse effects under the NED Account include the following:

Installation Cost: $105,000
Interest during Construction: none (short-term construction period)
Annual investment cost: $6,448 (6-1/8 percent for 100 years)
Annual OM&R: $525 (one-half of one percent)
Total Annual Cost = $6,973

With similar assumptions, there would be no measurable benefits under the Regional Development Account or the Social Well-Being Account, disregarding the tourism which probably would occur anyway, without the project. There might be a minor amount of undetermined increase in local employment during project construction and operation.

~~Obviously, this potential project belongs in the Environmental Quality Account~~ since it would help protect an area of archeological and historical significance. One of the principal purposes behind the establishment of the Knife River Indian Villages National Historical Site is to protect their archeological and historical resources. The national significance of the Hidatsa Villages was affirmed in 1964 when the Advisory Board on National Parks, Historic Sites, Buildings and Monuments certified the Big Hidatsa Village for designation as a viable National Historic Site. A primary objective of the area is to preserve the irreplaceable archeological resources and restore the natural setting of the period of historic importance; and to stabilize and reconstruct the historic scene to best protect the area and still provide adequate public access for the desired visitor experience.

It is believed that the Sakakawea Site on the southwest bank of the Knife River was built by the people of the Lower Hidatsa Village after the river changed its course and left the old village back from the river. Covering about 8 acres, the site was protected by a ditch and palisade (fence of long stakes). About 40 earth lodge sites can be identified today. Pottery, bone, stone, and other artifacts have been found at this site. The potsherds (pieces of earthenware) are decadent Mandan types and the lodges were circular. Considerable contact material and metal projectile points are found there. This is the village where the Shoshone Indian maiden, Sakakawea, was taken by a Hidatsa war party and where she married the French Trader Toussaint Charboneau who lived in the village.

PROJECT NAME: Hazen Flood Control and Highway By-Pass Project

LOCATION: State: North Dakota

County: Mercer

Vicinity: Hazen

IMPLEMENTATION: A joint effort of local (namely City of Hazen and County Water Management Board); state (State Highway Department and State Water Commission); and the federal government (Soil Conservation Service).

STATUS: This project is in the early planning stages with actual structural features and their costs undetermined and others in a planning stage and subject to change. For these reasons, the following "four account display" concerns only that portion of the plan that is for flood protection for the City of Hazen. This data is also preliminary and subject to change.

SOURCE OF INFORMATION: Completed by: Soil Conservation Service

Date Completed: December 8, 1976

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

COMPONENTS	MEASURES OF EFFECT (Average annual) 1/
BENEFICIAL EFFECTS:	
A. The value to users of increased outputs of goods and services.	
1. Flood Prevention	$40,000
TOTAL BENEFICIAL EFFECTS	$40,000
ADVERSE EFFECTS:	
A. The value of resources required for the plan.	
1. Flood protection dike	
Project installation	$13,594
Project administration	$ 1,631
OM&R	$ 1,875
TOTAL ADVERSE EFFECTS	$17,100
NET BENEFICIAL EFFECTS	$22,900

1/ 100 years at 6-3/8 percent interest.

STATE REGIONAL DEVELOPMENT ACCOUNT

COMPONENTS	MEASURE OF EFFECTS	
BENEFICIAL EFFECTS:	Region	Adjacent Region
	(Average annual) 1/	
Income:		
A. User benefits		
1. Flood prevention	$40,000	--
Employment:		
A. Increase in the number and type of jobs		
1. Employment impact 2/	$ 3,344	$-3,344
TOTAL BENEFICIAL EFFECTS	$43,344	$-3,344
ADVERSE EFFECTS:		
Income:		
A. Value of resources contributed from with the region to achieve the output.		
1. Project installation	$ 5,302	$ 8,292
2. Project administration	$ 32	$ 1,599
3. OM&R	$ 1,875	$ --
TOTAL ADVERSE EFFECTS	$ 7,209	$ 9,891
NET BENEFICIAL EFFECTS	$36,135	$-13,235

1/ 100 years at 6-3/8 percent interest

2/ Increased income attributed from the project. Labor costs estimated at 25 percent of installation

SOCIAL - FACTOR ACCOUNT

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
A. Real Income Distribution	1. Create 18 skilled jobs for 90 days and 30 man-days of part time employment fc local residents each year.
	2. Flood damage reduction would indirectly result in increased income being available to residents to spend on items other than flood damage repairs.
	3. Create regional income benefit distribution of $40,000 annually.
	4. Local costs to be borne by region total $7,209 annually.
B. Life, Health, and Safety	1. Provide an estimated 95 percent reduction of flood damages to the flood plan; thus increasing flood protection
	2. The quality of life would be enhanced by reducing the threat of flood damage. Property values would also be enhanced.

ENVIRONMENTAL QUALITY ACCOUNT

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
A. Areas of natural beauty	1. The visibility of the proposed structural measures may be displeasing to some.
B. Quality consideration of water, land, and air resource	1. Air pollution will be increased slightly during project construction.
C. Biological resources and selected ecosystems.	1. No wetland areas will be altered. 2. Reduced erosion and inundation on site during floods. 3. Channel relocation or realignment will cause a temporary increase in downstream bank erosion.
D. Irreversible and irretrievable commitments.	1. Labor, material and energy for construction of the project will be irretrievable.

Environmental Quality Component - Yellowstone Basin and Adjacent Coal Area Level B Study

North Dakota Tributaries - North Dakota

Yellowstone River - North Dakota-Montana State line to Missouri River - 22 miles.

Knife River - Beulah, North Dakota, to Missouri River - 36 miles.

Heart River - Heart Butte Dam, North Dakota to Missouri River -

Cannonball River - County Road South of Shields to North Dakota Bridge 1806 - 45 miles.

The above reaches are proposed as potential scenic or recreational rivers to be managed by the State of North Dakota. The North Dakota State Comprehensive Outdoor Recreation Plan (SCORP) has identified these segments of rivers as "some of the more extensively used canoeing streams in North Dakota."[1] The SCORP has also noted that canoeing "is one of the fastest growing activities in North Dakota."[1]

Preliminary information indicates that these segments of rivers possess values that would made them eligible for addition into a State rivers system. The rivers and their environments offer visitors recreation opportunities in fishing, hunting, camping, picnicking, sightseeing, canoeing, and other water-related activities.

These plans include acquisition of land in fee title for both major and minor access areas and acquisition of lands in easement for the protection of the rivers and their environments. It should be noted that the Yellowstone River segment is also the route of the Lewis and Clark and Old West Trails which is considered in the Environmental Quality Plan component.

The attached tables provide preliminary data for each individual river component. All figures are estimates provided for reconnaissance level study and are subject to revision.

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[1]North Dakota State Comprehensive Outdoor Recreation Plan (SCORP), 1975

ENVIRONMENTAL QUALITY COMPONENT
Yellowstone River - North Dakota-Montana State Line to Missouri River
(Scenic or Recreational River)

			Costs
Land Acquisition			
Fee Title	8 acres @ 1,000/acre		$ 8,000
Easement	4,480 acres @ 700/acre		3,136,000
Facility Development			
[1]Boater Access areas	2 sites	8 acres	$ 120,000

[1]Boater access developments will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

ENVIRONMENTAL QUALITY COMPONENTS
Yellowstone River - North Dakota-Montana State Line to Missouri River
(Scenic or Recreational River)

ACCOUNT COMPONENTS[1]

			Annual Recreation Days	Value Per Recreation Day	TOTAL
NED	Annual Benefits (excluding fishing and hunting)				
	Outdoor Recreation				
	Slow Boating, Canoeing, Rafting	On-River use	11,000	$6.00	$66,000
	Hiking, Camping, Picnicking, Sightseeing, Etc.	River associated but not on-river use	22,000	$2.00	$44,000
	Total Annual Benefits				$110,000
	Annual Cost (excluding fishing and hunting)		Annual Cost		
	Land Acquisition -$3,144,000 (100 year life)		$31,440		
	Facility Development -$120,000 (25 year repl.)		4,800		
	Administration, Operation, and Maintneance $1.60/Recreation Day ($1.60 x 33,000)		52,800		
	Total Annual Costs		$89,040		

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and State of Montana Fish and Game Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

EQ	Preservation of Areas of Natural Beauty	State management will preserve environment on about 4,500 acres of public and private lands.
	Preservation of Free Flowing Streams	Approximately 22 miles.

ENVIRONMENTAL QUALITY COMPONENTS
Yellowstone River - North Dakota-Montana State Line to Missouri River
(Scenic or Recreational River)

EQ
Cont'd

Preservation of Historical and Cultural Resources	High level of recreation is offset by protection of resources through State management. Interpretation enhances public use values. Protect historical and cultural values associated with Lewis and Clark and Old West Trails.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None Known - If any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options-loss of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices lost.

ENVIRONMENTAL QUALITY COMPONENTS
Knife River - Manning, North Dakota, to Missouri River
(Scenic or Recreational River)

			Costs
Land Acquisition			
Fee Title	76 acres @$1,000/acre		$ 72,000
Easement	16,720 acres @ 700/acre		11,704,000
Facility Development			
[1] Major Access sites	1 site	60 acres	$ 156,000
[2] Boater Access areas	3 sites	12 acres	180,000
			$ 366,000

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[1] Cost of major access sites are based on providing the following:

	Units	
Picnic Units - includes tables, parking, percent of interior road, sanitation, power signs, landscaping, etc.	20	$ 40,000
Camping Units - includes campsites, stoves, tables, and percent of supporting facilities as shown for picnicking	20	48,000
Administrative Unit -	1	50,000
Boat Launching Ramp - 1 lane and 30 graveled parking spaces		32,000
		$120,000
30% planning overhead and contingency	1	36,000
		$156,000

[2] Boater access developments will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

Environmental Quality Component
Knife River - Manning, North Dakota, to Missouri River
(Scenic or Recreational River)

ACCOUNT COMPONENTS[1]

NED

Annual Benefits (excluding fishing and hunting)		Annual Recreation Days	Value Per Recreation Day	TOTAL
Outdoor Recreation				
Slow Boating, Canoeing, Rafting	On-river use	38,000	$6.00	$228,000
Hiking, Camping, Picnicking, Sightseeing, Etc.	**River associated but not on-river use**	76,000	$2.00	$152,000
Total Annual Benefits				$380,000

Annual Cost (excluding fishing and hunting)	Annual Cost
Land Acquisition - 11,776,000 (100-year life)	$117,760
Facility Development - 336,000 (25-year repl.)	13,440
Administration, Operation, and Maintenance $1.60/Recreation Day ($1.60 x 114,000)	182,400
Total Annual Costs	$313,600

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and North Dakota State Game and Fish Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

EQ

Preservation of Areas of Natural Beauty	State management will preserve environment on about 17,000 acres of public and private lands.
Preservation of Free-Flowing Streams	Approximately 76 miles.

EQ
ont'd

ENVIRONMENTAL QUALITY COMPONENTS
Knife River - Manning, North Dakota, to Missouri River
(Scenic or Recreational River)

Preservation of Historical and Cultural Resources	High level of recreation is offset by protectio of resources through State management. Interpretation enhances public use values. Protect historical and cultural values associate with the river and its environment.
Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
Protection of Endangered or Threatened Vegetative Species	None known - if any are identified, they will be protected.
Preservation of Water Quality	State standards will be met.
Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - loss of development choices.
Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices lost.

ENVIRONMENTAL QUALITY COMPONENTS
Heart River - Heart Butte Dam to Missouri River
(Scenic or Recreational River)

			Costs
Land Acquisition			
Fee Title	76 acres @ 1,000/acre		$ 76,000
Easement	23,320 acres @ 700/acre		16,324,000
Facility Development			
[1]Major Access sites	1 site	60 acres	$ 156,000
[2]Boater Access areas	4 sites	16 acres	240,000
			$ 396,000

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[1] Cost of Major access sites are based on providing the following:

	Units	
Picnic Units includes tables, parking, percent of interior road, sanitation, power signs, landscaping, etc.	20	$ 40,000
Camping units - includes campsites, stoves, tables, and percent of supporting facilities as shown for picnicking	20	$ 48,000
Administrative unit -	1	$ 50,000
Boat Launching ramp - 1 lane and 30 graveled parking spaces	1	$ 32,000
		$120,000
30% Planning Overhead & Contingency		36,000
		$156,000

[2] Boater access developments will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

ENVIRONMENTAL QUALITY COMPONENTS
Heart River - Heart Butte Dam to Missouri River
(Scenic or Recreational River)

ACCOUNT COMPONENTS[1]

		Annual Recreation Days	Value Per Recreation Day	TOTAL
Annual Benefits (excluding fishing and hunting)				
Outdoor Recreation				
Slow Boating, Canoeing, Rafting	On-River use	53,000	$6.00	$318,000
Hiking, Camping, Picnicking, Sightseeing, Etc.	River associated but not on-river use	106,000	$2.00	$212,000
Total Annual Benefits				$530,000

	Annual Cost
Annual Cost (excluding fishing and hunting)	
Land Acquisition - 16,400,000 (100 year life)	$164,000
Facility Development - 396,000	15,840
Administration, Operation, and Maintenance $1.60/Recreation Day ($1.60 x 159,000)	245,400
Total Annual Costs	$425,240

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and State of Montana Fish and Game Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

Preservation of Areas of Natural Beauty	State management will preserve envoronment on about 23,400 acres of public and private lands.
Preservation of Free Flowing Streams	Approximately 106 miles

ENVIRONMENTAL QUALITY COMPONENT
Cannonball River - County Road South of Shields to North Dakota Bridge 1806
(Scenic or Recreational River)

Land Acquisition			Costs
Fee Title	68 acres @ 1,000/acre		$ 68,000
Easement	9,900 acres @ 700/acre		6,930,000
Facility Development			
[1]Major Access sites	1 site	60 acres	$ 156,000
[2]Boater Access areas	2 sites	8 acres	120,000
			$ 276,000

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[1] Cost of Major access sites are based on providing the following:

	Units	
Picnic Units includes tables, parking, percent of interior road, sanitation, power signs, landscaping, etc.	20	$ 40,000
Camping units - includes campsites, stoves, tables, and percent of supporting facilities as shown for picnicking	20	$ 48,000
Administrative unit -	1	$ 50,000
Boat Launching ramp - 1 lane and 30 graveled parking spaces	1	$ 32,000
		$120,000
30% Planning Overhead & Contingency		36,000
		$156,000

[2] Boater access developments will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

ENVIRONMENTAL QUALITY COMPONENTS
Cannonball River - County Road South of Shields to North Dakota Bridge 1806
(Scenic or Recreational River)

ACCOUNT COMPONENTS[1]

ED			Annual Recreation Days	Value Per Recreation Day	TOTAL
	Annual Benefits (excluding fishing and hunting)				
	Outdoor Recreation				
	Slow Boating, Canoeing, Rafting	On-River use	22,500	$6.00	$135,000
	Hiking, Camping, Picnicking, Sightseeing, Etc.	River associated but not on-river use	45,000	2.00	90,000
	Total Annual Benefits				$225,000
	Annual Cost (excluding fishing and hunting)		Annual Cost		
	Land Acquisition - 6,998,000 (100 year life)		$ 69,980		
	Facility Development - 276,000 (25 year repl.)		11,040		
	Administration, Operation, and Maintenance $1.60/Recreation Day ($1.60 x 67,500)		108,000		
172	Total Annual Costs		$189,020		

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and State of Montana Fish and Game Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

Q		
	Preservation of Areas of Natural Beauty	State management will preserve environment on about 10,000 acres of public and private lands.
	Preservation of Free Flowing Streams	Approximately 45 miles.

ENVIRONMENTAL QUALITY COMPONENTS
Cannonball River - County Road South of Shields to North Dakota Bridge 1806
(Scenic or Recreational River)

EQ Cont'd		
	Preservation of Historical and Cultural Resources	High level of recreation is offset by protection of resources through State management. Interpretatio enhances public use values. Protect historical and cultural values associated with the river and its environment.
	Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
	Protection of Endangered or Threatened Vegetative Species	None known - If any are identified, they will be protected.
	Preservation of Water Quality	State standards will be met.
	Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options-loss of development choices.
	Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices lost.

Environmental Quality Component - Yellowstone Basin and Adjacent Coal Area, Level B Study.

North Dakota Tributaries - North Dakota

Missouri River - The downstream public use area at Garrison Dam to mouth of Heart River, Fort Lincoln State Park - 86 miles

This 86 mile reach of the Missouri River from the downstream public use area at Garrison Dam to the mouth of the Heart River at Fort Lincoln State Park, North Dakota, is proposed as a potential river segment for possible inclusion into the National Wild and Scenic Rivers System. The "Missouri River Basin, Comprehensive Framework Study, Western Dakota Tributaries Subregion" (MRB Subregion 3) has identified this segment of the Missouri River as follows:

> "The 100-mile section of the Missouri River between Garrison Dam and the upper end of Oahe Reservoir is in a comparatively natural condition. This reach is the longest of only three such sections between the Montana border and St. Louis. Because of this, the free flowing river has special recreational and aesthetic appeal and potential. It is important that future planning and development consider this rather unique importance. This can be accomplished through retaining or enhancing the natural aspects of this section and through providing additional waterfront and water surface recreation opportunities."[1]

The preliminary information noted indicates that this segment of the Missouri River possesses values that may make it eligible for possible inclusion into the National Wild and Scenic Rivers System. The river and its environment offer visitors recreation opportunities in fishing, hunting, camping, picnicking, sightseeing, canoeing, rafting, and other water-related activities.

This plan includes acquisition of land in fee title for minor access areas and acquisition of lands in easement for the protection of the river and its environment. This river segment is also the route of the Lewis and Clark Trail which is considered in the Environmental Quality Plan component.

The attached tables provide preliminary data for this component. All figures are estimates provided for reconnaissance level study and are subject to revision..

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[1]Missouri River Basin, Comprehensive Framework Study, Western Dakota Tributaries Subregion (MRB Subregion 3), October 1967.

ENVIRONMENTAL QUALITY COMPONENT
Missouri River, Garrison Dam to Fort Lincoln State Park
(Wild, Scenic or Recreational River)

Land Acquisition

Fee Title	16 acres @ 1,000/acre		$ 16,000
Easement	18,920 acres @ 700/acre		13,244,000

Facility Development

[1]Boater Access Areas	4 sites	16 acres	$ 240,000

[1]Boater access development will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

ENVIRONMENTAL QUALITY COMPONENT
Missouri River, Garrison Dam to Fort Lincoln State Park
(Wild, Scenic, or Recreational River)

ACCOUNT COMPONENTS[1]

			Annual Recreation Days	Value Per Recreation Day	TOTAL
NED	Annual Benefits (excluding fishing and hunting)				
	Outdoor Recreation				
	Slow Boating, Canoeing, Rafting	On-River use	68,800	$15.00	1,032,000
	Hiking, Camping, Picnicking, Sightseeing, Etc.	River associated but not on-river use	172,000	$ 2.25	387,000
	Total Annual Benefits				1,419,000
	Annual Cost (excluding fishing and hunting)				
	Land Acquisition - 13,260,000 (100 year life)		$132,600		
	Facility Development - 240,000 (25 year repl.)		9,600		
	Administration, Operation, and Maintenance $1.60/Recreation Day ($1.60 x 240,800)		385,280		
	Total Annual Costs		$527,480		

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and State of Montana Fish and Game Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

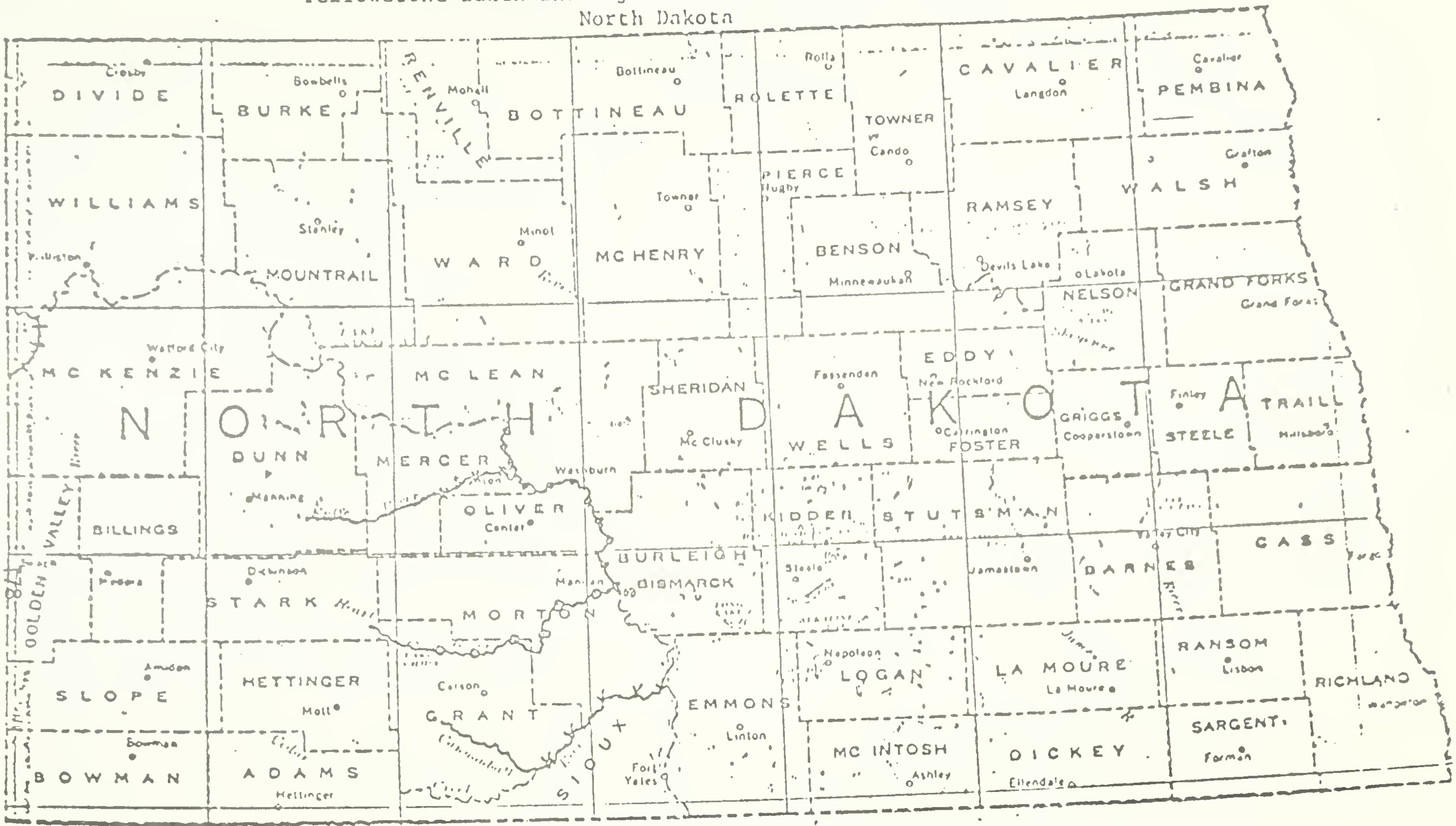
Q	Preservation of Areas of Natural Beauty	National Wild and Scenic River designation will preserve beauty on about 19,000 acres of public and private lands.
	Preservation of Free Flowing Streams	Approximately 86 miles.

ENVIRONMENTAL QUALITY COMPONENT
Missouri River, Garrison Dam to Fort Lincoln State Park
(Wild, Scenic or Recreational River)

EQ
Cont'd

	Preservation of Historical and Cultural Resources	Higher level of recreation is offset by protection of resources. Interpretation enhances public use value. Protect historical and cultural values associated with Fort Clark, Fort Manolan, Double Ditch, Slant Village, and Fort Lincoln
	Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
	Protection of Endangered or Threatened Vegetative Species	None known - If any are identified, they will be protected.
	Preservation of Water Quality	State standards will be met.
	Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - loss of development choices.
	Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices lost.

Yellowstone Basin and Adjacent Coal Area Level B Study
North Dakota



Missouri River - Garrison Dam Downstream Public Use area to Mouth of Heart River
Fort Lincoln State Park

Yellowstone River - North Dakota-Montana State Line to Missouri River

Knife River - Beulah to Missouri River

Heart River - Heart Butte Dam to Missouri River

Cannonball River - County Road South of Shields to North Dakota Bridge 1806

NED and Selected Plan Component - Yellowstone Basin and Adjacent Coal Area, Level B Study

North Dakota Tributaries - North Dakota

Missouri River - Eleven miles downstream from Garrison Dam to mouth of Heart River, Fort Lincoln State Park - 75 miles

This 75-mile reach of the Missouri River from the downstream public use area at Garrison Dam to the mouth of the Heart River at Fort Lincoln State Park, North Dakota, is proposed as a potential river segment for possible inclusion into the National Wild and Scenic Rivers System. The "Missouri River Basin, Comprehensive Framework Study, Western Dakota Tributaries Subregion" (MRB Subregion 3) has identified this segment of the Missouri River as follows:

> *The 100-mile section of the Missouri River between Garrison Dam and the upper end of Oahe Reservoir is in a comparatively natural condition. This reach is the longest of only three such sections between the Montana border and St. Louis. Because of this, the free flowing river has special recreational and aesthetic appeal and potential. It is important that future planning and development consider this rather unique importance. This can be accomplished through retaining or enhancing the natural aspects of this section and through providing additional waterfront and water surface recreation opportunities.*[1]

The preliminary information noted indicates that this segment of the Missouri River possesses values that may make it eligible for possible inclusion into the National Wild and Scenic Rivers System. The river and its environment offer visitors recreation opportunities in fishing, hunting, camping, picnicking, sightseeing, canoeing, rafting, and other water-related activities.

This plan includes acquisition of land in fee title for minor access areas and acquisition of lands in easement for the protection of the river and its environment. This river segment is also the route of the Lewis and Clark Trail which is considered in the Environmental Quality Plan component.

The attached tables provide preliminary data for this component. All figures are estimates provided for reconnaissance level study and are subject to revision.

[1]Missouri River Basin, Comprehensive Framework Study, Western Dakota Tributaries Subregion (MRB Subregion 3), October 1967.

NED and Selected Plan Component
Missouri River, Eleven Miles Downstream From
Garrison Dam to Fort Lincoln State Park
(Wild, Scenic or Recreational River)

Land Acquisition

Fee Title	16 acres @ 1,000/acre	$ 16,000
Easement	16,500 acres @ 700/acre	11,550,000

Facility Development

[1]Boater Access Areas	4 sites, 16 acres	$ 240,000

[1]Boater access development will consist of sanitation facilities and primitive type picnicking and overnite camping facilities. Cost figures do not include existing access sites considered adequate.

NED and Selected Plan Component
Missouri River, Eleven Miles Downstream From
Garrison Dam to Fort Lincoln State Park
(Wild, Scenic or Recreational River)

ACCOUNT COMPONENTS[1]

NED

Annual Benefits (excluding fishing and hunting)		Annual Recreation Days	Value Per Recreation Day	TOTAL
Outdoor Recreation				
Slow Boating, Canoeing, Rafting	On-River use	60,000	$15.00	$ 900,000
Hiking, Camping, Picnicking, Sightseeing, Etc.	River associated but not on-river use	150,000	$ 2.25	337,500
Total Annual Benefits				$1,237,500

Annual Cost (excluding fishing and hunting)	Annual Cost
Land Acquisition - 11,550,000 (100 year life)	$115,500
Facility Development - 240,000 (25 year repl.)	9,600
Administration, Operation, and Maintenance $1.60/Recreation Day ($1.60 x 210,000)	336,000
Total Annual Costs	$461,100

Fishing and hunting annual recreation days and unit day values will be calculated by United States Fish and Wildlife Service and State of Montana Fish and Game Department.

[1]All figures shown are estimates provided for reconnaissance level study and are subject to revision.

EQ

Preservation of Areas of Natural Beauty	National Wild and Scenic River designation will preserve beauty on about 17,000 acres of public and private lands.
Preservation of Free Flowing Streams	Approximately 75 miles.

NED and Selected Plan Component
Missouri River, Eleven Miles Downstream From
Garrison Dam to Fort Lincoln State Park
(Wild, Scenic or Recreational River)

EQ. cont'd	Preservation of Historical and Cultural Resources	Higher level of recreation is offset by protection of resources. Interpretation enhances public use value. Protect historical and cultural values associated with Fort Clark, Fort Manolan, Dougle Ditch, Slant Village, and Fort Lincoln.
	Protection of Endangered or Threatened Species of Wildlife	Present or future endangered or threatened species will be protected.
	Protection of Endangered or Threatened Vegetative Species	None known - If any are identified, they will be protected.
	Preservation of Water Quality	State standards will be met.
	Preservation of Freedom of Choice	Maintain scenic, recreation, wildlife options - loss of development choices.
	Avoid Irreversible or Irretrievable Effects	Scenic and recreational values preserved and enhanced. Future development choices lost.

EXHIBIT 1

NED ACCOUNT WORK SHEET
(Sheet 1 of 5)

Project name: PROTECTION OF CULTURAL SITES
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December13, 1976

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

Beneficial Effects

- Variety of recreation
- Visual attractriveness
- Preservation of natural system

Adverse Effects

- Limited access
- Restrictions on other activities
- Cost

Net Beneficial Effects

EXHIBIT 1

RD ACCOUNT WORKSHEET
(Sheet 2 of 5)

Project name: PROTECTION OF CULTURAL SITES
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

REGIONAL DEVELOPMENT ACCOUNT

Beneficial Effects

- Variety of recreation
- Visual Attractiveness
- Preservation of natural systems
- Tourism

Adverse Effects

- Limited access
- Restrictions on other activities
- Cost

Net Beneficial Effects

EXHIBIT 1

SOCIAL FACTORS ACCOUNT WORKSHEET

(Sheet 3 of 5)

Project name: PROTECTION OF CULTURAL SITES
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13,1976

SOCIAL FACTORS ACCOUNT

Beneficial Effects

Variety of recreation
Visual attractiveness
Preservation of natural systems
Educational value
Preservation of a life style

Adverse Effects

Limited access
Restrictions on other activities
Cost

Net Beneficial Effects

EXHIBIT 1

EQ ACCOUNT WORKSHEET
(Sheet 4 of 5)

Project name: PROTECTION OF CULTURAL SITES
Location:WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND
December 13, 1976

ENVIRONMENTAL ACCOUNT

Beneficial Effects
- Increased recreation values
- Visual attractiveness
- Preservation of natural systems

Adverse Effects
- Decreased access
- Restrictions on other activities
- Cost

Net Benefiical Effects

Environmental Impacts:

Sites are like "gold," where you find them. Impacts could be great, if development occurs. Most activities such as grazing, hunting, sightseeing have no impact at their present levels.

Favorable Environmental Effects:

The natural character of any sites can be enhanced by controlling surface occupancy. At the same time, other present economic activities such as grazing, sightseeing, hunting, etc., could continue while compatible with the character of the area. This is not expected to hinder the present way of life. The variety of recreation experience, and gene pools of the native plant and animal communities, will be preserved. Encouraged investigation and inventory of the historical-paleontological resources would aid in their preservation and value to human knowledge.

Adverse Environmental Effects Which Cannot Be Avoided:

On-site developments would have adverse impacts on the pristine values. Restricting surface development would adversely affect developers. Off-road vehicle users would be adversely affected, if travel is restricted.

Relationship Between Short-Term Uses of Man's Environment and the Maintenance of Long-Term Productivity:

If on-site development were stopped or restricted, it would preclude soil-disturbing activities. The option to develop at a later date would still be open, if it became necessary to do so.

Irreversible and Irretrievable Commitment of Resources:

Once surface development takes place the site is destroyed.

EXHIBIT 2

NED ACCOUNT WORK SHEET
(Sheet 1 of 5)

Project name: WILDLIFE HABITAT PROTECTION AND IMPROVEMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13,1976

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

Beneficial Effects
Minimized loss of habitat

Adverse Effects

Loss of other activities near wildlife habitat
Possible conflicts of use, interests, and of competing wildlife species

Net Beneficial Effects

EXHIBIT 2

RD ACCOUNT WORKSHEET
(Sheet 2 of 5)

Project name: WILDLIFE HABITAT PROTECTION AND IMPROVEMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

REGIONAL DEVELOPMENT ACCOUNT

Beneficial Effects

Protection of endangered or threatened or other wildlife habitat
Improved wildlife habitat
Improved hunting and recreation quality
Visual attractiveness
Possible reduction of flooding

Adverse Effects

Restrictions on agricultural industry
Restrictions on other activities

Net Beneficial Effects

EXHIBIT 2

SOCIAL FACTORS ACCOUNT WORKSHEET
(Sheet 3 of 5)

Project name: WILDLIFE HABITAT PROTECTION AND IMPROVEMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

SOCIAL FACTORS ACCOUNT

Beneficial Effects
- Protection of endangered or threatened or other wildlife species habitat
- Improved wildlife habitat
- Improved hunting and recreation quality
- Visual attractiveness
- Educational opportunities
- Indicator of quality of life

Adverse Effects

- Restrictions on agricultural industry
- Restrictions on other activities

Net Beneficial Effects

EXHIBIT 2
EQ ACCOUNT WORKSHEET
(Sheet 4 of 5)

Project name: WILDLIFE HABITAT PROTECTION AND IMPROVEMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

ENVIRONMENTAL ACCOUNT

Beneficial Effects

- Diversity of original native species
- Improved wildlife habitat
- Visual attractiveness
- Management options still open for the future
- Improved hunting and recreation quality
- Indicator of quality of life
- Reduction of soil erosion

Adverse Effects

- Restrictions on agricultural industry
- Restrictions on other activities
- Decreased agricultural production

Net Beneficial Effects

Environmental Impacts:

This activity is directed toward maintaining or increasing wildlife habitat. Where identifiable as specific areas on the land, habitat should be protected from encroachment by other conflicting activities. Game, non-game, and endangered or threatened species habitat should be considered. Waterfowl habitat improvements (small reservoirs) are possible in the area. Maintaining or increasing habitat would maintain or increase recreationist enjoyment in the area. The improvement of game habitat will also improve the habitat of other wildlife species. Increasing substantial habitat may decrease livestock production. Small grain food plots would impact the natural scenery.

Favorable Environmental Effects:

Identified habitat should be maintained and/or conflicting activities on the sites modified as necessary. Game, non-game, and endangered or threatened species habitat should be maintained and given protection. Maintained or improved habitat will enhance the natural visual resources. People enjoy seeing wildlife; therefore, the visual enjoyment of the area will be maintained with stable wildlife populations.

Adverse Environmental Effects Which Cannot Be Avoided:

Protecting or maintaining wildlife habitat would restrict certain other activities, or resource uses. Small grain food plots, when done, would adversely affect the naturalistic scenery.

Relationship Between Short-term Uses of Man's Environment and the Maintenance of Long-term Productivity:

Emphasis of waterfowl developments (small impoundments) provides longer-lived water developments. Thus, more livestock and waterfowl production per dollar invested can accrue over the long-term.

Long- and short-term productivity of wildlife will be reduced to the extent that any irreversible activity conflicting with habitat is conducted on the land.

Irreversible and Irretrievable Commitment of Resources:

EXHIBIT 3

NED ACCOUNT WORKSHEET
(Sheet 1 of 5)

Project name: TREE PROTECTION
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

Beneficial Effects

Visual attractiveness
Preservation of soil

Adverse Effects
Possible restrictions on property owners
Limit development

Net Beneficial Effects

EXHIBIT 3

RD ACCOUNT WORKSHEET
(Sheet 2 of 5)

Project name: TREE PROTECTION
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13,1976

REGIONAL DEVELOPMENT ACCOUNT

Beneficial Effects

Visual Attractiveness
Wildlife preservation
Soil conservation
Wind abatement
Prevention of erosion

Adverse Effects

Possible restrictions on property owners
Limit development

Net Beneficial Effects

EXHIBIT 3

RD ACCOUNT WORKSHEET
(Sheet 3 of 5)

Project name: TREE PROTECTION
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

REGIONAL DEVELOPMENT ACCOUNT

Beneficial Effects

Visual attractiveness
Eduacational opportunites
Recreational opportunites

Adverse Effects
Possible restrictions on property owners
Limit development

Net Beneficial Effects

EXHIBIT 3

EQ ACCOUNT WORKSHEET
(Sheet 4 of 5)

Project name: TREE PROTECTION
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13,1976

ENVIRONMENTAL ACCOUNT

Beneficial Effects

Visual attractiveness
Wildlife preservation
Soil conservation
Wind abatement
Prevention of erosion
Educational opportunities
Recreational opportunities

Adverse Effects

Possible restrictions on property owners
Limit development

Net Beneficial Effects

Information Sheet - Project: Tree Protection

Environmental Impacts:

Reduction of trees is discouraged. No significant impacts would occur.

Favorable Environmental Effects:

Most tree stands in the area will not be disturbed.

Adverse Environmental Effects Which Cannot Be Avoided:

Possible restrictions on landowners.

Relationship Between Short-term Uses of Man's Environment and the Maintenance of Long-term Productivity:

There is no short-term use; therefore, there is no limit to long-term productivity.

Irreversible and Irretrievable Commitment of Resources:

EXHIBIT 4

NED ACCOUNT WORKSHEET
(Sheet 1 of 6)

Project name: COAL DEVELOPMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13,1976

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

Beneficial Effects

Coal
Employment possibilities

Adverse Effects

Disruption of roads, pipelines
Recreation disruptions
Visual attractiveness
Wildlife habitat disrupted
Possibly peripheral plants
Ground water disruption
Quality of surface water
Air pollution
Noise pollution
Canal potential
Disruption of natural forage production for grazing
Disruption of range seeding
Potential soil erosion
Alteration of like style on adjacent private lands
Increased environmental degradation
Immediate use of coal

EXHIBIT 4

RD ACCOUNT WORKSHEET
(Sheet 2 of 6)

Project name: COAL DEVELOPMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

REGIONAL DEVELOPMENT ACCOUNT

Beneficial Effects

Coal
Jobs
Increased services

Adverse Effects

Disruption of roads, pipelines
Recreation disrupted
Visual attractiveness
Wildlife habitat dirupted
Peripheral vegatation
Ground water disruption
Quality of surface water
Air pollution
Noise pollution
Disruption of natural forage production for grazing
Potential soil erosion
Alteration of life style on adjacent private lands
Social impacts
Economic impacts locally
Commitment of water to industry
Immediate use of coal

Net Beneficial Effects

EXHIBIT 4

SOCIAL FACTORS WORKSHEET
(SHEET 3 of 6)

Project name: COAL DEVELOPMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

SOCIAL FACTORS ACCOUNT

Beneficial Effects

Coal
Jobs

Adverse Effects

Disruption of roads, pipelines
Recreation disrupted
Visual attractiveness
Wildlife habitat
Peripheral vegetation
Ground water disrution
Quality of surface water
Air pollution
Noise pollution
Disruption of natural forage production for grazing
Potential soil erosion
Alteration of life style on adjacent private lands
Social impacts
Economic impacts locally
Commitment of water to industry
Lose of quality of life

Net Beneficial Effects

EXHIBIT 4

EQ ACCOUNT WORKSHEET
(Sheet 4 of 6)

Project name: COAL DEVELOPMENT
Location: WESTERN NORTH DAKOTA
Completed by: BADLANDS ENVIRONMENTAL ASSOCIATION
DICKINSON, ND.
December 13, 1976

ENVIRONMENTAL ACCOUNT

Beneficial Effects

Environmental quality

Adverse Effects

No coal
Restrictions on coal owners

Net Beneficial Effects

Environmental Impacts:

With the large strippable coal deposits known and if mining occurred, the impacts of strip mining to natural and social systems would be tremendous. This impact could be reduced somewhat by stipulations. Natural ecosystems and their products (i.e. wildlife, native self-sustaining grasslands) would be totally altered. Air, noise, and water would be affected. Reclamation would be a must.

Jobs would be created, but export mines (most likely development) produce relatively few jobs. The local, social, and business structure would be impacted.

Favorable Environmental Effects:

Some favorable effects would be coal or coal-produced energy production and some jobs. The anticipated coal development would be coal mining for export. Other stimulation to the local urban business economy would occur. On areas being very intensively farmed at present, wildlife habitat might actually be improved. Strip mining would disturb the land; undesirable plants (from a domestic standpoint) may invade the surface; edge effects could be increased; rougher topography may be created, depending on the federal and/or state laws in effect at that time; all of which could improve wildlife habitat.

Adverse Environmental Effects Which Cannot Be Avoided:

All of the following would be adversely affected, disrupted or degraded immediately: roads, recreation, natural visual attraction, wildlife habitat, vegetation, ground water, air, quiet solitude, grazing, soil, and life-style. These effects would be greatly reduced, if limited and controlled by a multi-state regional development plan.

Over the long run, some of these effects might be reduced or eliminated. With present knowledge these effects cannot be avoided, with strip mining for coal or uranium.

Relationship Between Short-term Uses of Man's Environment and the Maintenance of Long-term Productivity:

The long-term productivity of undisturbed soil horizons of the land under natural or domestic vegetation (native grasslands or crops respectively) will be disrupted and adversely affected by strip mining. This statement is based upon strip mining and reclamation capability as we know it now; complete reclamation has not been proven. Complete reclamation to near former productivity, as we know it now, will probably take many years. If the reclamation (or lack of it) leaves dispersed tracts of land untillable and more rugged, escape cover and protection from weather would be provided for certain wildlife species. In these circumstances the present very intensively farmed land might be some improved wildlife habitat (compared to its present very low value to game species especially).

Irreversible and Irretrievable Commitment of Resources:

Coal strip mining and reclamation efforts would require almost complete commitment of resources to that activity, though it may someday be possible to reclaim the land for agriculture or wildlife habitat over a long period.

PROJECT FEATURES - PLANS 1

The project features of the plan selected for further study are described in the following sections:

Plan 1 - Broncho Reservoir (10,000 irrigable acres)

Locations of the dam and reservoir, pumping plants, laterals, and irrigable land are shown on drawing 658-603-6 and -7.

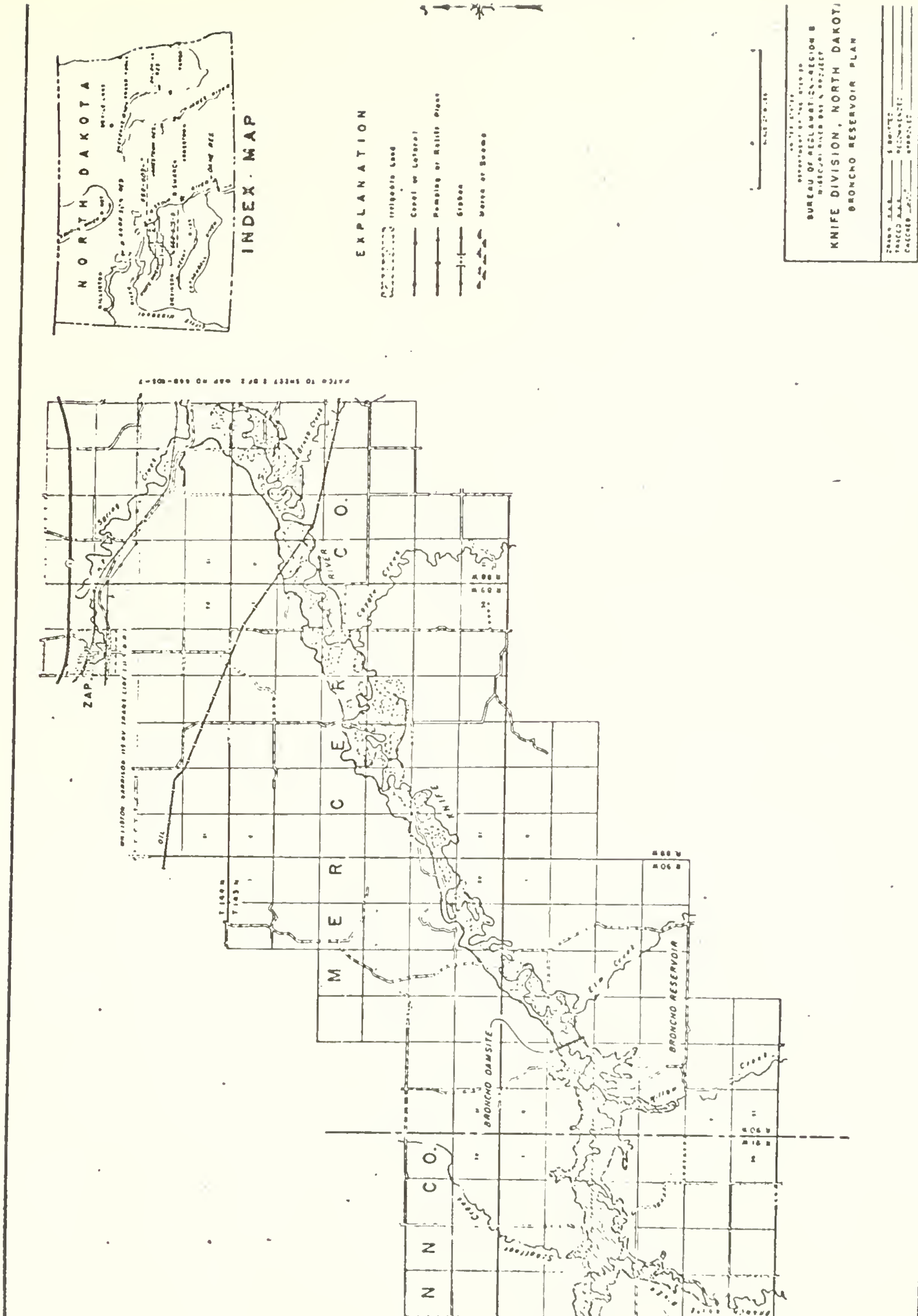
Dam and Reservoir

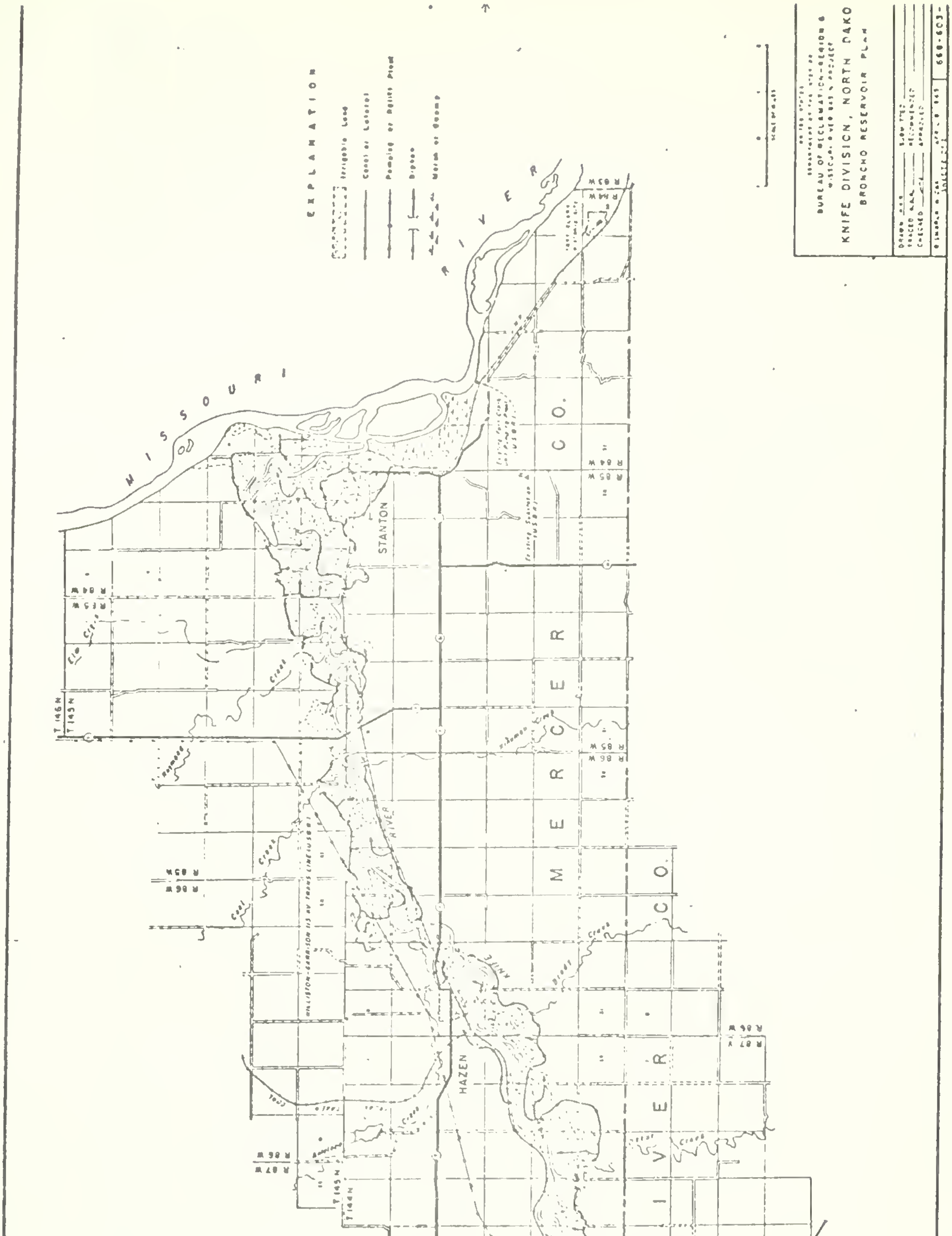
In the selected scheme for Broncho Dam and Reservoir, the dam would be a rolled earthfill embankment with a maximum height of 124 feet above streambed at crest elevation 1990 and a length of 9,450 feet. The outlet works to the Knife River would have a capacity of 1,000 c.f.s. For gravity service to adjacent downstream lands, two canal outlet works would be provided with capacities of 15 and 45 c.f.s. through the right and left abutments, respectively. To accommodate the inflow design flood, a morning-glory type spillway with crest elevation of 1941.5 would be provided. Maximum discharge would be 19,430 c.f.s. with a surcharge of 42.6 feet.

Water surface area at top of conservation storage would be 3,400 acres and at top of flood storage would be 4,650 acres. At maximum flood stage, about 12,800 acres would be inundated for a short interval.

Pumping Plants

Sixteen river pumping plants would be required to divert water from the Knife River to irrigable lands. Six of these would be fixed concrete structures with capacities and total dynamic heads ranging


KNIFE DIVISION, NORTH DAKOTA
BRONCHO RESERVOIR PLAN
BUREAU OF RECLAMATION - REGION 6
EXPLANATION
Irrigable Land
Canal or Lateral
Siphon
INDEX MAP
NORTH DAKOTA
MERCER CO.
DUNN CO.
ZAP
KNIFE RIVER
BRONCHO DAMSITE
BRONCHO RESERVOIR


KNIFE DIVISION, NORTH DAKO
BRONCHO RESERVOIR PLAN
EXPLANATION
MISSOURI
RIVER
MERCER CO.
OLIVER CO.
STANTON
HAZEN
KNIFE
RIVER

from 18 to 35 c.f.s. and 30 to 63 feet, respectively. Ten river pumping plants would be the portable type with capacities and total dynamic heads ranging from 5 to 12 c.f.s. and 30 to 68 feet, respectively. Four relift pumping plants with capacities ranging from 3.5 to 12 c.f.s. and total dynamic heads ranging from 10 to 32 feet are also planned.

Although exploratory holes were not drilled at each of the pump sites, the valley fill of alluvium is known to be consistently deep throughout the length from Broncho damsite to the Missouri River. Therefore, a conservative amount of piling and other foundation preparation were provided for in the estimates for the six river pumping plants with fixed, permanent concrete intake structures. No particular foundation problem is anticipated for the other pumping plants.

Laterals

All waterways to serve the irrigable land are classified as laterals. About 108 miles of lateral would be required. Twenty-one miles of lateral would divert water directly out of Broncho Reservoir, and the rest would be associated with pumping plants. All of the laterals would be under 50 c.f.s. capacity.

The main problems connected with lateral construction would be crossing the numerous abandoned oxbows of the Knife River to reach parcels of land in the center of the valley and constructing sections of lateral around steep escarpments formed by sharp meanders of the river which impinge and undercut the valley slopes. In these situations the river loops would probably be bypassed with cut-off channels, and benches could be formed around the steep areas. The benches would have to be well drained, and lateral seepage would have to be controlled. Such places are few and are comparatively short. Otherwise, no particularly difficult construction problems are anticipated in connection with laterals.

Drains

Drainage of project lands would require surface drains and structures to inlet surface flows to the nearest suitable natural channel, new or improved outlets for abandoned river channels and oxbows, and collector, interceptor, and relief drains.

Most lands would require only surface drains or surface inlet structures. Improvement or construction of outlets for abandoned river channels and oxbows is planned in locations where drainage water would be collected and ponded. In some locations, these channels can be improved to provide low cost interceptor or relief drains.

Subsurface relief and interceptor drains would be required only for about 10 percent of the lands. These lands consist usually of large parcels, but some areas have topographic relief which would cause seepage to occur in lower lands and others are fringe areas with heavier textured subsoils.

Costs for surface and subsurface drainage are considered as project costs. The plan provides initially for construction of surface drains and surface inlet structures, and improvement or construction of outlets for abandoned river channels and oxbows. Subsurface interceptor and relief drain construction would be deferred until the need and location can be more closely determined.

The estimated miles and cost of the drainage system for the 10,000-irrigable-acre project are as follows:

Type drain	Miles	Total cost
Surface drains	26.4 miles	$ 535,000
Improving and outletting abandoned channels	7.5 miles	117,000
Interceptor and relief drains	12.0 miles	576,000
Total cost		$1,228,000

Distribution Lines and Substations

To provide power for pumping, 51 miles of 12.5-kilovolt-ampere (k.v.a.) 3-phase transmission line would be constructed to the 20 pumping plants.

A substation to head the system would be required at the town of Hazen; power source would be the Bureau of Reclamation's existing 115-kilovolt (k.v.) Garrison-to-Williston transmission line. This substation would be constructed as a part of the Transmission Division of the Missouri River Basin Project.

In addition, 20 substations, ranging in capacity from 15 to 300 k.v.a., would be constructed adjacent to pumping plants to provide a usable voltage for each plant. Costs for these smaller substations are included as project costs.

Recreational Facilities

Preliminary studies by the Bureau of Outdoor Recreation show that a recreation area near each abutment of the dam would be desirable. These have been included in project plans and estimates.

Land would be acquired for about 60 acres. Other features would be access roads, parking areas, boat launching ramps, sanitary facilities, and installation of a potable water supply. Total estimated cost is $133,000.

Fish and Wildlife Facilities

Replacement of woody and herbaceous cover by the reservoir would require acquisition of about 640 acres of land at the head end of the reservoir. Total estimated cost is $133,000.

Cost Summary - Plan 1

Feature	Total cost (January 1975 prices)
Broncho Dam and Reservoir	$30,211,000
Pumping plants (20)	2,477,000
Laterals (108 miles)	7,046,000
Drains (45.9 miles)	1,228,000
Distribution lines (51 miles)	705,000
Substations (20)	174,000
General property	493,000
Recreational facilities	(133,000)
Fish and wildlife facilities	(133,000)
Project headquarters and equipment	(227,000)
Total construction cost	$42,392,000
Settlers' assistance	58,000
Total project cost	$42,450,000

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$1,100,000
Fish and wildlife	8,000
Recreation	8,000
Total beneficial effects	$1,116,000
ADVERSE EFFECTS	
Investment	$2,920,000
OM&R	92,000
Total adverse effects	$3,012,000
NET BENEFICIAL EFFECTS	-$1,896,000

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	1,100,000	--	--	1,100,000
Fish and wildlife	8,000	--	--	8,000
Recreation	8,000	--	--	8,000
Regional benefits				
Employment	1,512,000	-605,000	-907,000	0
Induced or stemming	770,000	-308,000	-462,000	0
Total beneficial effects	$3,398,000	-$913,000	-$1,369,000	$1,116,000
ADVERSE EFFECTS				
Investment	$2,920,000	$	$	$2,920,000
OM&R	92,000			92,000
Total adverse effects	$3,012,000			$3,012,000
NET BENEFICIAL EFFECTS	$ 386,000	-$913,000	-$1,369,000	-$1,896,000

BRONCHO DAM AND RESERVOIR

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: A 3,400 acre (conservation storage level) reservoir would be created, along with recreational facilities, including access roads, parking areas, picnicing and camping facilities, toilets, and boat ramps. This would provide for water-oriented recreational activities such as boating, fishing, and water contact sports. The quantity and quality of fishing in the Knife River below the dam would be slightly improved. Opportunities for pheasant hunting could improve, depending on the extent of clean farming practices, changes to natural areas, and hunter accessibility. A slight increase in waterfowl hunting opportunities would also be provided.

Biological, geological, and ecological elements: The potential for establishing a fishery in the reservoir would be fair. There would also be a slight improvement of the fishery in the Knife River below the dam. The reservoir would provide some resting habitat for waterfowl and other water-oriented birds. Irrigation development along the river would have the potential for providing a better interspersion of food and cover for pheasants, depending on the degree of clean farming practices. Some aquatic furbearers and waterfowl would also be benefitted by the creation of wet areas associated with irrigation development.

Archeological, historical, and cultural elements: There are no known archeological, historical, or cultural sites within the project area. However, a thorough archeological survey of the project area prior to construction activities could reveal the existence of some historic or prehistoric sites.

Water quality: The project would result in cooler water releases and reduced settleable solid concentrations in the river below the dam.

Air quality: The conversion of dryland farming acreage to irrigated cropland would help reduce wind erosion in those lands.

BRONCHO DAM AND RESERVOIR

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Up to 4,650 acres (at top of flood storage level) of natural grassland, farmland, and wooded riparian habitat would be inundated by the reservoir. Some additional natural areas would also be converted to croplands. New facilities such as the dam, recreational features, and exposed banklines during drawdown periods would be visual intrusions to the project area. In addition, irrigation facilities such as the 16 river pumping plants, power transmission lines and substations, irrigation and drainage conveyance facilities, and new access roads would also reduce the visual quality of the area. There would be some reduction in hunting opportunities for deer, antelope, and native grouse species in the reservoir and irrigation development areas.

Biological, geological, and ecological elements: There would be a loss of terrestrial flora and fauna on the lands (up to 4,650 acres) which would be inundated. In addition, there would be reductions in some big game, native grouse, and other indigenous wildlife populations if natural prairie habitat and wooded areas were to be converted to croplands. Several miles (10-20) of free-flowing stream habitat would be impounded. There are no economically recoverable coal or other mineral deposits within the reservoir area. Land levelling for irrigation development would alter the topography and natural drainage characteristics of the area. Irrigation and runoff and drainage into natural drainage channels would cause some erosion.

Irreversible considerations: Most materials used for construction would be irreversibly lost to further use. Reservoir evaporative losses and consumptive use of water for irrigation would be irreversible. Project implementation would result in increased energy demands as a result of pumping operations, irrigation, and more intensive farming operations.

Water quality: There would be heavy sedimentation in the reservoir. Some evaporative losses in the impoundment would contribute to the average salinity of the water downstream. Agricultural return flows would contribute additional pollutants to the Knife River, i.e., dissolved solids, nutrients, pesticides, suspended solids, etc.

Air quality: Construction activities would create some temporary dust and aerial exhaust emissions. Exposed reservoir banklines would be subject to wind erosion during drawdown periods. If native rangeland were to be plowed and cropped, this would expose more land surface to wind erosion. The increased agricultural production would result in increased exhaust emissions and dust caused by operation of farm machinery and would contribute to increases in aerial pollutants at sites of agricultural processing plants.

Alternate Plan for Broncho Reservoir

In the original plan, Broncho Reservoir was to be used as a water supply for 10,000 acres of irrigation and for minimum fish and wildlife and recreation facilities.

An alternative to this plan would be to use the reservoir as a water supply for municipal, rural, and industrial water, and 4,000 acres of irrigation, with minimum fish and wildlife facilities and recreation facilities.

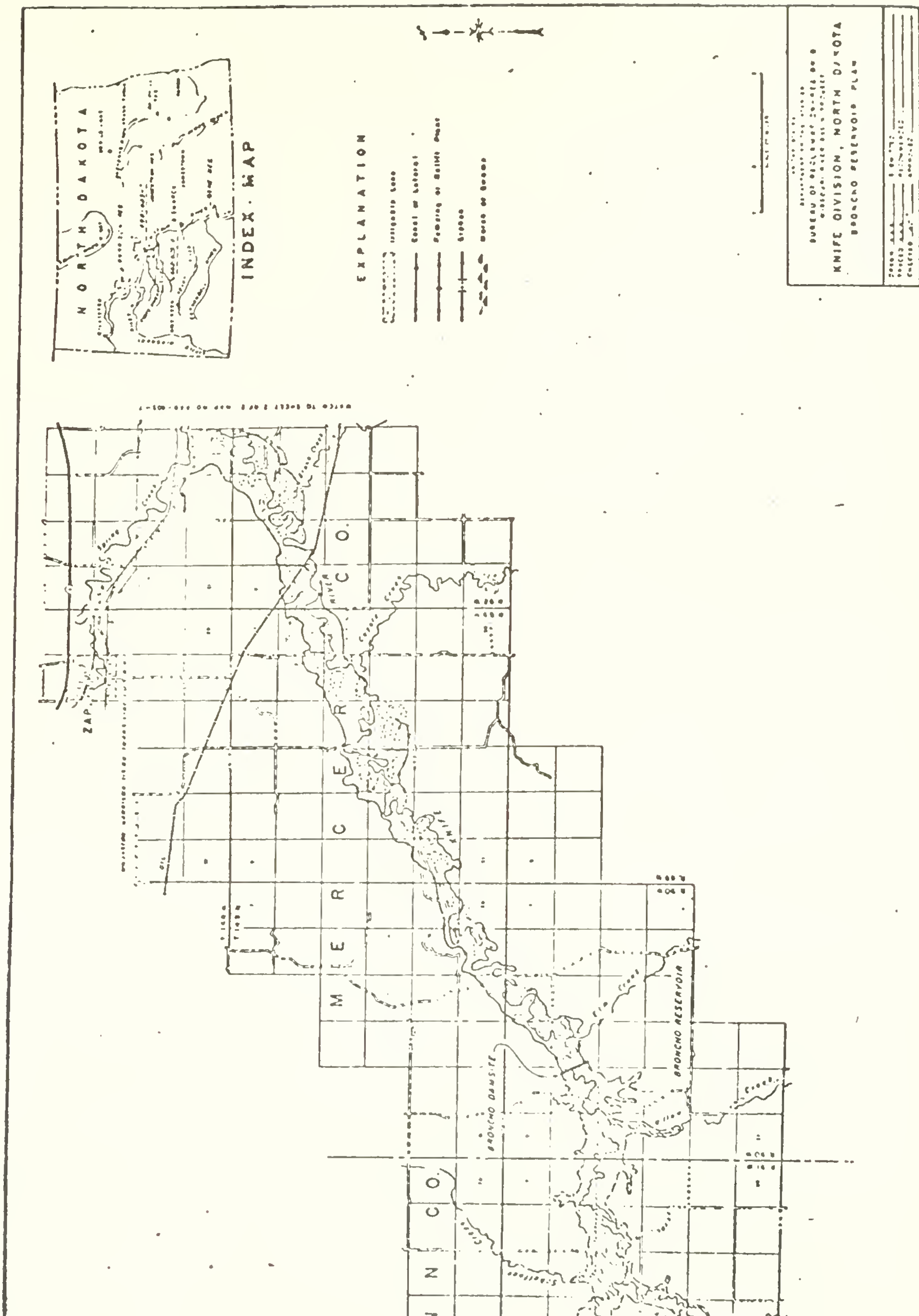
Dam and Reservoir

In the alternative plan for Broncho Dam and Reservoir, the dam would be a rolled earthfill embankment with a maximum height of 124 feet above streambed at a crest elevation of 1990 and a length of 9,450 feet. The outlet works to the Knife River would have a capacity of 1,000 ft^3/s. For gravity service to adjacent downstream lands, two canal outlet works would be provided with capacities of 15 and 45 ft^3/s through the right and left abutments, respectively. To accommodate the inflow design flood, a morning-glory-type spillway with crest elevation of 1941.5 would be provided. Maximum discharge would be 19,430 ft^3/s with a surcharge of 42.6 feet.

Water surface area at top of conservation storage would be 3,400 acres and at top of flood storage would be 4,650 acres. At maximum flood stage, above 12,800 acres would be inundated for a short interval.

Water Supply

The total storage of the reservoir is 106,000 acre-feet. This includes 11,000 acre-feet dead storage, 55,000 acre-feet conservation storage, and 40,000 acre-feet flood control storage. In this alternative the 55,000 acre-feet of conservation storage would provide a firm supply of 30,000 acre-feet. Fifteen thousand acre-feet would be used for municipal and industrial water, and the remaining


INDEX MAP
NORTH DAKOTA
EXPLANATION
KNIFE DIVISION, NORTH DAKOTA
BRONCHO RESERVOIR PLAN
MERCER CO.
DUNN CO.
BRONCHO RESERVOIR
BRONCHO DAMSITE
KNIFE
RIVER

15,000 acre-feet would be used to irrigate 5,000 acres of new land.

Pumping Plants

Four river pumping plants would be required to divert water from the Knife River to irrigable lands. These pumps would have capacities ranging from 18 to 35 ft^3/s and total dynamic heads ranging from 30 to 63 feet.

Although exploratory holes were not drilled at each of the pump sites, the valley fill of alluvium is known to be consistently deep throughout the length from Broncho damsite to Beulah. Therefore, a conservative amount of piling and other foundation preparation were provided for the estimates for the six river pumping plants with fixed, permanent concrete intake structures. No particular foundation problem is anticipated for the other pumping plants.

Laterals

All waterways to serve the irrigable land are classified as laterals. About 36 miles of lateral would be required. Twenty-one miles of lateral would divert water directly out of Broncho Reservoir, and the laterals would be associated with pumping plants. All of the laterals would be under 50 ft^3/s capacity.

The main problems connected with lateral construction would be crossing the numerous abandoned oxbows of the Knife River to reach parcels of land in the center of the valley, and constructing sections of lateral around steep escarpments formed by sharp meanders of the river which impinge and undercut the valley slopes. In these situations, the river loops would probably be bypassed with cut-off channels, and benches could be formed around the steep areas. The benches would have to be well-drained, and lateral seepage would have to be controlled. Such places are few and comparatively short. Otherwise, no particularly difficult construction problems are anticipated in connection with laterals.

Drains

Drainage of project lands would require surface drains and structures to inlet surface flows to the nearest suitable natural channel, new or improved outlets for abandoned river channels and oxbows, and collector, interceptor, and relief drains.

Most lands would require only surface drains or surface inlet structures. Improvement or construction of outlets for abandoned river channels and oxbows is planned in locations where drainage water would be collected and ponded. In some locations, these channels can be improved to provide low cost interceptor or relief drains.

Costs for surface and subsurface drainage are considered as project costs. The plan provides initially for construction of surface drains and surface inlet structures, and improvement or construction of outlets for abandoned river channels and oxbows. Subsurface interceptor and relief drain construction would be deferred until the need and location could be more closely determined.

Distribution Lines and Substations

To provide power for pumping, 17 miles of 12.5-kilovoltampere (kVA) 3-phase transmission line would be constructed to the 20 pumping plants.

A substation to head the system would be required at the town of Hazen; power source would be the Bureau of Reclamation's existing 115-kilovolt (kV) Garrison-to-Williston transmission line. This substation would be constructed as a part of the Transmission Division of the Missouri River Basin Project.

In addition, four substations, ranging in capacity from 15 to 300 kVA would be constructed adjacent to pumping plants to provide a usable voltage for each plant. Costs for these smaller substations are included as project costs.

Benefits

Irrigation benefits were developed from a with- and without-farm budget analysis for 5,000 acres of new land located downstream from the Broncho Reservoir. From this analysis, the per acre benefits for irrigation would be $109 after adjustment for a 5-year benefit accrual period using 6-3/8 percent interest. The direct irrigation benefits for 5,000 acres would be $545,000.

Flood control benefits, totaling $10,000 annually, are based on the flood protection to land and improvements in the valley by construction of Broncho Dam. In addition, regulation of 40,000 acre-feet of flood control storage for replacement of space currently allocated to flood control in the Missouri River main stem reservoirs would provide an annual benefit of $70,000.

The Bureau of Sport Fisheries and Wildlife (now the Fish and Wildlife Service) estimated that Broncho Reservoir would be expected to support a project use amounting to 6,400 fisherman-days annually, which was evaluated at $14,000.

The Bureau of Outdoor Recreation estimates that the recreational facilities at Broncho Dam and Reservoir would attract 10,000 recreation days of use. Benefits would amount to $22,000 annually.

Municipal and industrial water benefits were based on the costs of the single-purpose alternative of a well field and desalting plant. The cost would be $0.59 per 1,000 gallons or over $190 per acre-feet. The municipal and industrial annual benefits are $2,850,000 annually.

Annual Equivalent Value

The following tabulation presents the annual equivalent value for the

Recreational Facilities

Preliminary studies by the Bureau of Outdoor Recreation show that a recreation area near each abutment of the dam would be desirable. These have been included in project plans and estimates. Land would be acquired for about 60 acres. Other features would be access roads, parking areas, boat launching ramps, sanitary facilities, and installation of a potable water supply. Total estimated cost is $133,000.

Fish and Wildlife Facilities

Replacement of woody and herbaceous cover by the reservoir would require acquisition of about 640 acres of land at the head end of the reservoir. Total estimated cost is $133,000.

Cost Estimate

The following tabulation presents the estimated construction cost for the project using January 1975 prices.

Feature	Cost
Broncho Dam and Reservoir	$30,211,000
Pumping plants (3)	372,000
Laterals (36 miles)	2,340,000
Drains (15.3 miles)	413,000
Distribution lines (17.0 miles)	235,000
Substations (4)	35,000
General Property	379,000
Recreational facilities	(133,000)
Fish and wildlife facilities	(133,000)
Project headquarters and equipment	(133,000)
Total construction cost	$33,985,000
Settlers assistance	29,000
Total project cost	$34,014,000

Annual Equivalent Value

Total Project Cost	$34,014,000
Interest During Construction	4,851,000
Total Investment	$38,865,000
Amortization Rate	.06388
Annual Equivalent Value	$ 2,482,700
Annual Equivalent Value (Rounded)	$ 2,483,000

Multiobjective Four Accounts

The project is evaluated using the National Economic Development (NED), Regional Development (RD), Social Well Being (SWB), and Environmental Quality (EQ) Accounts.

	NED ACCOUNT	RD ACCOUNT			
BENEFICIAL EFFECTS		Region	Adjacent Region	Rest of Nation	Total
User Benefits					
Irrigation	$ 545,000	$ 545,000	-	-	$ 545,000
Municipal, Rural, & Industrial Water	2,850,000	2,850,000	-	-	2,850,000
Flood Control	80,000	80,000	-	-	80,000
Fish and Wildlife	14,000	14,000	-	-	14,000
Recreation	22,000	22,000	-	-	22,000
Regional Benefits					
Employment		1,735,000	-$ 694,000	-$1,041,000	0
Induced and Stemming		443,000	- 177,000	- 266,000	0
Total Beneficial Effects	$ 3,511,000	$5,689,000	-$ 871,000	-$1,307,000	$3,511,000
ADVERSE EFFECTS					
Annual Equivalent Value	$ 2,483,000	$2,483,000	-	-	$2,483,000
OM&R	44,000	44,000	-	-	44,000
Total Adverse Effects	$ 2,527,000	$2,527,000	-	-	$2,527,000
NET BENEFICIAL EFFECTS	$ 984,000	$3,162,000	-$ 871,000	-$1,307,000	$ 984,000

SWB Account

Beneficial Effects

Stabilized Population: The population of Mercer County declined from 6,805 in 1960 to 6,175 in 1970. However, the population of the cities in the county have shown increases in the same period. This indicates a migration from the farm to the cities. The addition of 4,000 irrigated acres would help stem the decrease in farm population. Assuming the new irrigated acres would go to farmers not presently owning land in the area, the 4,000 acres would represent approximately 100 new farms and 350 additional people. The construction period is 5 years and estimated to bring 80 on-the-job construction-related people into the area. Including the families of these workers, the total influx to the area would be 250.

Flood Control: The main stem flood area that would be protected by the project consists of 23,000 acres of bottom land along the Knife River from Broncho damsite to the mouth. About 10,000 of these acres have been inundated by major floods of record. Portions of Beulah, Hazen, and Stanton are subject to shallow flooding during extreme floods. During major flooding, portions of Northern Pacific Railway and stream crossings on State highways are subject to flooding. County roads traversing the flood plain are subject to overtopping, and their bridges are frequently damaged by iceflows and from approach washouts.

Recreation: Construction of the dam would give the people of the area additional sightseeing, picnicking, camping, boating, water skiing opportunities. Fishing downstream of the dam would improve.

Stabilization of Economic Development: Irrigation would aid in the stabilization of economic conditions by providing farmers with a larger selection of crops to plant also making them less dependent on the weather for the success of their crops. Both effects would increase the farmers average annual income. The effects of flood control, additional recreational opportunities, and M&I water would also aid in economic stabilization.

Municipal and Industrial Water: The project would supply 5,000 acre-feet of water per year for coal electric generation. This water would be sufficient for one thermal electric plant with capacity for 500 megawatts and 1,900 GWh/yr generation. The plant would supply jobs for 64 workers. Including their families, this would increase the local populations of Beulah by 200 people.

Distribution of Income: As farmers switched from dryland farming to irrigated farming, the incomes of those in the supply end of the industry would increase. The incomes of the area in general would increase due to the additional employment by the M&I water and new farmlands.

Adverse Effects

Right of Eminent Domain: Irrigation and dam-related works would affect some lands whose owners would not receive any benefits through the operation of the project.

Population Impact: Beulah, whose population in 1970 was 1,344, would receive the majority of the construction-related people. The addition of 450 people for 5 years, of which 200 people employed by the powerplant would be permanent, could put a strain on housing, sewer and water facilities, health and medical care, police protection and other social services. The additional number of construction-related school children is 90. Electric generation would result in an increase of 70 children, and an additional 120 farm children would enter the area.

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Up to 4,650 acres (at top of flood storage level) of natural grassland, farmland, and wooded riparian habitat would be inundated by the reservoir. Some additional natural areas would also be converted to croplands. New facilities such as the dam, recreational features, and exposed banklines during drawdown periods would be visual intrusions to the project area. In addition, irrigation facilities such as the 3 river pumping plants, power transmission lines and substations, irrigation and drainage conveyance facilities, and new access roads would also reduce the visual quality of the area. There would be some reduction in hunting opportunities for deer, antelope, and native grouse species in the reservoir and irrigation development areas.

Biological, geological, and ecological elements: There would be a loss of terrestrial flora and fauna on the lands (up to 4,650 acres) which would be inundated. In addition, there would be reductions in some big game, native grouse, and other indigenous wildlife populations if natural prairie habitat and wooded areas were to be converted to croplands. Several miles (10-20) of free-flowing stream habitat would be impounded. There are no economically recoverable coal or other mineral deposits within the reservoir area. Land levelling for irrigation development would alter the topography and natural drainage characteristics of the area. Irrigation and runoff and drainage into natural drainage channels would cause some erosion.

Irreversible considerations: Most materials used for construction would be irreversibly lost to further use. Reservoir evaporative losses and consumptive use of water for irrigation would be irreversible. Project implementation would result in increased energy demands as a result of pumping operations, irrigation, and more intensive farming operations.

Water quality: There would be heavy sedimentation in the reservoir. Some evaporative losses in the impoundment would contribute to the average salinity of the water downstream. Agricultural return flows would contribute additional pollutants to the Knife River, i.e., dissolved solids, nutrients, pesticides, suspended solids, etc.

Air quality: Construction activities would create some temporary dust and aerial exhaust emissions. Exposed reservoir banklines would be subject to wind erosion during drawdown periods. If native rangeland were to be plowed and cropped, this would expose more land surface to wind erosion. The increased agricultural production would result in increased exhaust emissions and dust caused by operation of farm machinery and would contribute to increases in aerial pollutants at sites of agricultural processing plants.

BRONCHO DAM AND RESERVOIR

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: A 3,400 acre (conservation storage level) reservoir would be created, along with recreational facilities, including access roads, parking areas, picnicing and camping facilities, toilets, and boat ramps. This would provide for water-oriented recreational activities such as boating, fishing, and water contact sports. The quantity and quality of fishing in the Knife River below the dam would be slightly improved. Opportunities for pheasant hunting could improve, depending on the extent of clean farming practices, changes to natural areas, and hunter accessibility. A slight increase in waterfowl hunting opportunities would also be provided.

Biological, geological, and ecological elements: The potential for establishing a fishery in the reservoir would be fair. There would also be a slight improvement of the fishery in the Knife River below the dam. The reservoir would provide some resting habitat for waterfowl and other water-oriented birds. Irrigation development along the river would have the potential for providing a better interspersion of food and cover for pheasants, depending on the degree of clean farming practices. Some aquatic furbearers and waterfowl would also be benefitted by the creation of wet areas associated with irrigation development.

Archeological, historical, and cultural elements: There are no known archeological, historical, or cultural sites within the project area. However, a thorough archeological survey of the project area prior to construction activities could reveal the existence of some historic or prehistoric sites.

Water quality: The project would result in cooler water releases and reduced settleable solid concentrations in the river below the dam.

Air quality: The conversion of dryland farming acreage to irrigated cropland would help reduce wind erosion in those lands.

CANNONBALL DIVISION

Location

The Cannonball Division, composed of the Cannonball, Thunderhawk, and Mott Units, includes three reservoirs and 21,000 irrigable acres in small parcels along the Cannonball River and Cedar Creek in southwestern North Dakota.

Plan of Development

Each unit of the Cannonball Division would include a storage dam and reservoir from which water would be released as required during the irrigation season, and pumped from the stream to laterals serving the scattered parcels of irrigated lands. A drainage system, where it is required, would convey the excess water back to the stream channel for downstream use. Energy for pumping would be supplied from the Missouri River Basin Project over transmission facilities constructed for that purpose.

Cannonball Dam would be of rolled earthfill construction with a crest length of 8,200 feet at elevation 2284. There would also be three dikes with a combined length of 5,600 feet, with crest elevation 2284. The glory-hole-type spillway, with crest elevation 2227.6, would have a maximum capacity of 3,478 cubic feet per second. The outlet works would have a capacity of 227 cubic feet per second at water surface elevation 2187.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead or silt	2172	350	2,000
Conservation	2227.6	2,800	78,000
Flood Control	2262.5	7,400	163,000
Super Storage	2278.3	11,400	146,100
Total		21,950	389,100

Thunderhawk Dam would be of rolled-earth construction with a crest length of 10,970 feet at elevation 2408.8. The spillway would be of the ungated drop-inlet-type with a crest elevation of 2357.3 and a maximum capacity of 4,200 cubic feet per second. The outlet works would have a capacity of approximately 85 cubic feet per second.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead and Inactive	2325	600	4,600
Conservation	2357.3	2,500	43,400
Flood Control	2397	9,200	210,000
Total		12,300	258,000

Mott Dam would be of rolled-earth construction with a crest length of 14,650 feet, including dike section, at elevation 2461.1. The spillway would be of the ungated drop-inlet-type with crest elevation 2422.5, and maximum capacity 4,200 cubic feet per second. The outlet works would discharge 100 cubic feet per second with the reservoir at elevation 2391.5.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead and Inactive	2391.5	400	3,300
Conservation	2422.5	3,000	44,700
Flood Control	2450.0	10,300	170,250
Total		13,700	218,250

The Land

The soils of these units are almost entirely alluvial. The principal soil series are Bank, Cheyenne, Havre, and Hall. Most of the arable land is permeable and sandy and underlain by sand or gravel. Very little land has alkalinity or salinity problems.

The units are of two major topographic types: the dissected river flood plains which have been influenced by frequent flooding of the river, and the gently rolling topography of the adjacent terraces. Both areas will require some leveling.

Adequate drainage could be readily accomplished on these units. The irrigable areas are small, and have very good relief over numerous nearby natural drainageways. Most of the soils have permeable sandy substrata. Project-type drainage requirements would probably be confined to the improvement of surface drainage on some upland areas, and installation of interceptor drains below terraces in a few localized areas.

Cost Estimate

Cannonball Unit	
Pumping Plants	$2,801,000
Discharge Line	521,000
Canals and Laterals	2,632,000
Drains	1,433,000
Field Cost	$7,387,000
Other Costs	2,216,000
Settlers Assistance	108,000
Total	$9,711,000
Thunderhawk Unit	
Pumping Plants	$1,389,000
Discharge Lines	237,000
Canals and Laterals	1,230,000
Drains	663,000
Field Cost	$3,519,000
Other Costs	1,056,000
Settlers Assistance	46,000
Total	$4,621,000
Mott Unit	
Pumping Plants	$1,393,000
Discharge Lines	451,000
Canals and Laterals	1,530,000
Drains	813,000
Field Cost	$4,187,000
Other Costs	1,256,000
Settlers Assistance	62,000
Total	$5,505,000

The estimated cost for the dams and reservoirs are as follows:

Cannonball Dam and Reservoir	$15,400,000
Mott Dam and Reservoir	$23,800,000
Thunderhawk Dam and Reservoir	$14,000,000

The total cost for each unit would be:

Mott Unit:

Mott Dam and Reservoir		$23,800,000
Irrigation facilities		5,505,000
Total		$29,305,000
Irrigated acres	5,800 acres	
Annual OM&R		$ 53,000

Thunderhawk Unit:

Thunderhawk Dam and Reservoir		$14,000,000
Irrigation facilities		4,621,000
Total		$18,621,000
Irrigated acres	4,900 acres	
Annual OM&R		$ 45,000

Cannonball Unit:

Cannonball Dam and Reservoir		$15,400,000
Irrigation facilities		9,711,000
Total		$25,111,000
Irrigated acres	10,000 acres	
Annual OM&R		$ 91,500

The interest during construction and the annual cost for each unit were computed:

MOTT UNIT

INTEREST DURING CONSTRUCTION

	Construction Years	Amount		
2.2%	1	$ 645,000	3.5	$ 2,257,500
25.2%	2	7,385,000	2.5	18,462,500
42.0%	3	12,308,000	1.5	18,462,000
30.7%	4	8,967,000	.6	4,483,500
		$ 29,305,000		$43,665,600
				x .06375
Interest during construction				$ 2,783,675
Interest during construction rounded				$ 2,784,000

ANNUAL COST

Dam and reservoir		$23,800,000
Irrigation facilities		5,505,000
Interest during construction		2,784,000
		$32,089,000
		x .06388
		$ 2,049,845
	rounded	$ 2,050,000
Annual OM&R		53,000
Total annual cost		$ 2,103,000

MOTT UNIT

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 638,000
Total beneficial effects	$ 638,000
ADVERSE EFFECTS	
Investment	$1,964,000
OM&R	53,000
Total adverse effects	$2,017,000
NET BENEFICIAL EFFECTS	-$1,379,000

MOTT UNIT

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	638,000			638,000
Regional benefits				
Employment	1,049,000	-420,000	-629,000	0
Induced & stemming	447,000	-179,000	-268,000	0
Total beneficial effects	$2,134,000	$-599,000	$-897,000	$ 638,000
ADVERSE EFFECTS				
Investment	$2,050,000	$	$	$2,050,000
OM&R	53,000			53,000
Total adverse effects	$2,103,000	$ 0	$ 0	$2,103,000
NET BENEFICIAL EFFECTS	$ 31,000	$-599,000	$-897,000	-$1,465,000

THUNDERHAWK UNIT

INTEREST DURING CONSTRUCTION

Construction Years	Amount		
1	$ 410,000	3.5	$ 1,435,000
2	4,692,000	2.5	11,730,000
3	7,821,000	1.5	11,731,500
4	5,698,000	.5	2,849,000
	$ 18,621,000		$27,745,500
			x .06375
Interest during construction			$ 1,768,776
Interest during construction rounded			$ 1,769,000

ANNUAL COST

Dam and reservoir		$14,000,000
Irrigation facilities		4,621,000
Interest during construction		1,769,000
		$20,390,000
		x .06388
		$ 1,302,513
	rounded	$ 1,303,000
Annual OM&R		45,000
Total annual cost		$ 1,348,000

THUNDERHAWK UNIT

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$ 539,000
Total beneficial effects	$ 539,000
ADVERSE EFFECTS	
Investment	$1,303,000
OM&R	45,000
Total adverse effects	$1,348,000
NET BENEFICIAL EFFECTS	$ -809,000

THUNDERHAWK UNIT

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	539,000			539,000
Regional benefits				
Employment	649,000	-260,000	-389,000	0
Induced & stemming	377,000	-151,000	-226,000	0
Total beneficial effects	$1,565,000	$-411,000	$-615,000	$ 539,000
ADVERSE EFFECTS				
Investment	$1,303,000	$	$	$1,303,000
OM&R	45,000			45,000
Total adverse effects	$1,348,000	$ 0	$ 0	$1,348,000
NET BENEFICIAL EFFECTS	$ 217,000	$-411,000	$-615,000	$ -809,000

CANNONBALL UNIT

INTEREST DURING CONSTRUCTION

Construction Years	Amount		
1	$ 552,000	3.5	$ 1,932,000
2	6,328,000	2.5	15,820,000
3	10,547,000	1.5	15,820,500
4	7,684,000	.5	3,842,000
	$25,111,000		$37,414,500
			x .06375
Interest during construction			$ 2,385,174
Interest during construction rounded			$ 2,385,000

ANNUAL COST

Dam and reservoir		$15,400,000
Irrigation facilities		9,711,000
Interest during construction		2,385,000
		27,496,000
		x .06388
		$ 1,756,444
	rounded	$ 1,756,000
Annual OM&R		91,500
Total annual cost		$ 1,847,500

CANNONBALL UNIT

NED ACCOUNT

BENEFICIAL EFFECTS	
Irrigation	$1,100,000
Total beneficial effects	$1,100,000
ADVERSE EFFECTS	
Investment	$1,847,500
OM&R	91,500
Total adverse effects	$1,939,000
NET BENEFICIAL EFFECTS	$ -839,000

CANNONBALL UNIT

RD ACCOUNT

BENEFICIAL EFFECTS	Region	Adjacent Region	Rest of Nation	Total
User benefits	$	$	$	$
Irrigation	1,100,000			1,100,000
Regional benefits				
Employment	923,000	-369,000	-554,000	0
Induced & stemming	770,000	-308,000	-462,000	0
Total beneficial effects	$2,793,000	$-677,000	$-1,016,000	$1,100,000
ADVERSE EFFECTS				
Investment	$1,847,500	$	$	$1,847,500
OM&R	91,500			91,500
Total adverse effects	$1,939,000	$ 0	$ 0	$1,939,000
NET BENEFICIAL EFFECTS	$ 854,000	$-677,000	$-1,016,000	$ -839,000

SWB ACCOUNT

BENEFICIAL EFFECTS

Stabilized Population: The estimated duration of each of the projects is 4 years. Since 1960, the population in the area has been in decline. The result of the increased economic stabilization due to the irrigation projects would encourage more people to remain on the farms.

Distribution of Income: Slight redistribution of income would result as farmers incomes become more stable which would result in increased incomes in the supply end of the industry. In addition, incomes in the supply end would also increase as farmers switched over from dryland farming to irrigated farming practices.

Stabilization of Economic Conditions: The incomes of dryland farmers who switched to irrigation would stablize due to their increase in choice of crops to grow and having to rely less on the weather for their incomes.

ADVERSE EFFECTS

Right of Eminent Domain: Irrigation features may cross land whose owners will not receive irrigation.

The relatively large number of construction workers in comparison to the local communities would put a strain on all social services. These would include housing, health and medical care, police protection, water and sewer systems, schools, etc. Any adjustment made to accommodate these problems would have to be of a temporary nature since at the conclusion of the projects the construction people would leave.

Table of Construction Population Impacts

Project Name	Construction Period Years	County	1970 Population of Affected Cities	Number of Construction Workers	Total Number Construction Related People	Additional School Children
Mott Unit	4	Hettinger	Mott City 1,368	84	263	89
Thunderhawk	4	Adams	Hettinger City-1,655	54	167	57
Cannonball	4	Grant	Elgin-839 Carson-466	73	225	77

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: Three reservoirs of 3,150 acres, 3,100 acres, and 3,400 acres (conservation storage level) would be created, along with recreational facilities, including access roads, parking areas, picnicking and camping facilities, toilets, and boat ramps. This would provide for water-oriented recreational activities such as boating, fishing, and other water contact sports. Opportunities for pheasant hunting could improve, depending on the extent of clean farming practices, changes to natural areas, and hunter accessibility. An increase in waterfowl hunting opportunities would also be provided.

Biological, geological and ecological elements: The potential for establishing a fishery in the reservoirs would be fair. There would be an improvement of the fishery in the streams below the reservoirs. The reservoirs would provide some nesting habitat for waterfowl and other water-oriented birds. Irrigation development would have the potential for providing a better interspersion of food and cover for pheasants, depending on the degree of clean farm practices. Some aquatic furbearers and waterfowl would also be benefited by the creation of wet areas associated with irrigation development.

Archeological, historical, and cultural elements: There are no known archeological, historical, or cultural sites within the project areas. However, a thorough archeological survey of the project area prior to construction activities could reveal the existence of some historic or prehistoric sites.

Water quality: The project would result in cooler water releases and reduced settleable solid concentrations in the river below the dam.

Air quality: The conversion of dryland farming acreage to irrigated cropland would reduce wind erosion in those lands.

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Three reservoirs would inundate up to 48,000 (at top of flood storage level) acres of natural grassland, farmland, and wooded riparian habitat. Some additional natural areas would be converted to croplands. New facilities such as the dam, recreational features, and exposed banklines during drawdown periods would be visual intrusions to the project area. Irrigation facilities such as the river pumping plants, power transmission lines and substations, irrigation and drainage conveyance facilities, and new access roads would also reduce the visual quality of the area. There would be a reduction in hunting opportunities for deer, antelope, and native grouse species in the reservoir areas.

Biological, geological, and ecological elements: There would be a loss of terrestrial flora and fauna on the lands (up to 48,000 acres) which would be inundated. In addition, there would be reductions in some big game, native grouse, and other indigenous wildlife populations if natural prairie habitat and wooded areas were to be converted to croplands. Several miles (30-50) of free-flowing stream habitat would be impounded. Land leveling for irrigation development would alter the topography and natural drainage characteristics of the area. Irrigation and runoff and drainage into natural drainage channels would cause some erosion.

Irreversible considerations: Most material used for construction would be irreversibly lost to further use. Reservoir evaporative losses and consumptive use of water for irrigation would be irreversible. Project implementation would result in increased energy demands as a result of pumping operations, irrigation and more intensive farming operations.

Water quality: There would be sedimentation in the reservoirs. Some evaporative losses in the impoundment would contribute to the average salinity of the water downstream. Irrigation return flows would contribute additional pollutants to the Cedar Creek and the Cannonball River, i.e., dissolved solids, nutrients, pesticides, suspended solids, etc.

Air quality: Construction activities would create some temporary dust and aerial exhaust emissions. Exposed reservoir banklines would be subject to wind erosion during drawdown periods. The increased agricultural production would result in increased exhaust emissions and dust caused by operation of farm machinery and would contribute to increases in aerial pollutants at sites of agricultural processing plants.

CANNONBALL DIVISION

Alternative No. 1

The Cannonball Division, Alternative No. 1, is composed of either the Cannonball, Thunderhawk, or Mott Units with reservoirs, irrigable acres in small parcels, municipal and industrial water, recreation, flood control, and fish and wildlife.

Plan of Development

Each unit of the Cannonball Division would have a storage dam and reservoir. The conservation pool in each reservoir would be used by irrigation and municipal and industrial water. Water would be released as required during the irrigation season, and pumped from the stream to laterals serving the scattered parcels of irrigated lands. A drainage system, where it is required, would convey the excess water back to the stream channel for downstream use. Energy for pumping would be supplied from the Missouri River Basin Project over transmission facilities constructed for that purpose.

Municipal and industrial water would be provided in each reservoir. It could be used to provide water for use by towns, rural farmers or industrial plants. The potential users would have to build their own conveyance system to the users of the water. Cannonball Dam would be of rolled earthfill construction with a crest of length of 8,200 feet at elevation 2284. There would be three dikes with a combined length of 5,600 feet, with crest elevation 2284. The glory-hole-type spillway, with crest elevation 2227.6 would have a maximum capacity of 3,478 cubic feet per second. The outlet works would have a capacity of 227 cubic feet per second at water surface elevation 2187.0.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead or Silt	2172.0	350	2,000
Conservation	2227.6	2,800	78,000
Flood Control	2262.5	7,400	163,000
Surcharge	2278.3	11,400	146,100
Total		21,950	389,100

Thunderhawk Dam would be of rolled-earth construction with a crest length of 10,970 feet at elevation 2408.8. The spillway would be of the ungated drop-inlet-type with a crest elevation of 2357.3 and a maximum capacity of approximately 85 cubic feet per second.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead and Inactive	2325.0	600	4,600
Conservation	2357.3	2,500	43,400
Flood Control	2397.0	9,200	210,000
		12,300	258,000

Mott Dam would be of rolled-earth construction with a crest length of 14,650 feet, including dike section, at elevation 2461.1. The spillway would be of the ungated drop-inlet-type with crest elevation 2422.5, and maximum capacity of 4,200 cubic feet per second. The outlet works would discharge 100 cubic feet per second with the reservoir at elevation 2391.5.

Reservoir storage would be as follows:

	Elevation (feet)	Area (acres)	Capacity (acre-feet)
Dead and Inactive	2391.5	400	3,300
Conservation	2422.5	3,000	44,700
Flood Control	2450.0	10,300	170,250
Total		13,700	218,250

Land

The soils of these units are almost entirely alluvial. The principal soil series are Bank, Cheyenne, Havre, and Hall. Most of the arable land is permeable and sandy and underlain by sand or gravel. Very little land has alkalinity or salinity problems. The units are of two major topographic types: the dissected river flood plains which have been influenced by frequent flooding of the river, and the gently rolling topography of the adjacent terraces. Both areas will require some leveling.

Adequate drainage could be readily accomplished on these units. The irrigable areas are small, and have very good relief over numerous nearby natural drainageways. Most of the soils have permeable sandy substrata. Project-type drainage requirements would probably be confined to the improvement of surface drainage on some upland areas, and installation of interceptor drains below terraces in a few localized areas.

The irrigable acres for each unit are as follows:

	Acres
Mott Unit	2,900
Cannonball Unit	5,000
Thunderhawk Unit	2,400
Total	10,300

Water Supply

The average annual flow at the Cannonball Dam site is 54,500 acre-feet, 31,800 acre-feet at the Thunderhawk Dam site, and 31,800 acre-feet at the Mott Dam site for the period 1928-1950.

The maximum and minimum flows at the damsites are as follows:

Damsite	Maximum (acre-feet)	Minimum (acre-feet)
Cannonball	236,200	1,500
Thunderhawk	169,600	300
Mott	138,000	1,000

Reservoir operation studies show that a full water supply can be provided for both irrigation and municipal and industrial water demands 21 out of 22 years (based on diversion requirements for the 5 driest years of record). Irrigation and municipal and industrial (M&I) needs share the water supply, with M&I having first priority; consequently, the irrigable acres would have only a 50 percent supply 1 out of every 22 years or 4.5 percent of the 100-year life of the project. Municipal and industrial water would have a full supply over the 100 years. Mott and Cannonball Units compete for the water. Therefore, one or the other would be built based on preference of the local people.

Cost Estimate

The cost estimate for the three units are as follows. These are costs in this estimate for a delivery system to the municipal and industrial water users.

Item	Cannonball Unit	Thunderhawk Unit	Mott Unit
Dam and Reservoir	$15,400,000	$14,000,000	$23,800,000
Irrigation Facilities			
Pumping Plants	1,400,000	694,000	696,000
Dicharge Line	260,000	118,000	226,000
Canals and Laterals	1,316,000	615,000	765,000
Drains	716,000	332,000	406,000
Field Cost	$19,092,000	$15,759,000	$25,893,000
Other Costs	1,108,000	528,000	628,000
Settlers Assistance	54,000	23,000	31,000
Total	$20,254,000	$16,310,000	$26,552,000

The following tabulation presents the interest during construction and the annual equivalent value for the project costs. The MOP four account analyses of the projects follows the tabulation.

Cannonball Unit

Interest during construction:

Year	Expenditures		Interest-bearing expenditures
1	$ 445,000	3.5	$ 1,557,500
2	5,104,000	2.5	12,760,000
3	8,507,000	1.5	12,760,500
4	6,198,000	0.5	3,099,000
	$20,254,000		$30,177,000
			x .06375
	Interest during construction		$ 1,923,784
		Rounded	$ 1,924,000

Annual equivalent cost:

Construction Cost	$20,254,000
Interest during Construction	1,924,000
Project Cost	$22,178,000
	x .06388
Annual Equivalent Value	$ 1,416,731
Rounded	$ 1,417,000
OM&R	91,500
Total Annual Equivalent Cost	$ 1,508,500

Thunderhawk Unit

Interest during construction:

Year	Expenditures		Interest-bearing expenditures
1	$ 359,000	3.5	$ 1,256,500
2	4,110,000	2.5	10,275,000
3	6,850,000	1.5	10,275,000
4	4,991,000	0.5	2,495,500
	$16,310,000		$24,302,000
			x .06375
		Interest during Construction	$ 1,549,252
		Rounded	$ 1,549,000

Annual Equivalent Cost:

Construction Cost	$16,310,000
Interest during Construction	1,549,000
	$17,859,000
	x .06388
Annual Equivalent Cost	$ 1,140,832
Rounded	$ 1,141,000
OM&R	45,000
Total Annual Equivalent Cost	$ 1,186,000

Mott Unit

Interest during construction:

Year	Expenditures		Interest-bearing expenditures
1	$ 584,000	3.5	$ 2,044,000
2	6,691,000	2.5	16,727,500
3	11,152,00	1.5	16,728,000
4	8,125,000	0.5	4,062,500
	$26,552,000		$39,562,000
			x .06375
		Interest during Construction	$ 2,522,078
		Rounded	$ 2,522,000

Annual Equivalent Cost:

Construction Cost	$26,552,000
Interest during Construction	2,522,000
Project Cost	$29,074,000
	x .06388
Annual Equivalent Value	$ 1,857,247
Rounded	$ 1,857,000
OM&R	53,000
Total Annual Equivalent Cost	$ 1,910,000

Benefits

Benefits for irrigation were developed using a farm budget analysis with and without irrigation development. From this analysis, the per acre benefits would be $109 after adjustment for a 5-year benefit accrual period using 6-3/8 percent interest. The annual irrigation benefits would be as follows:

	Acres	Direct Benefits
Mott Unit	2,900	$316,000
Cannonball Unit	5,000	545,000
Thunderhawk Unit	2,400	262,000
	10,300	

Recreation values would be associated with the reservoirs, and the Bureau of Outdoor Recreation was requested to make preliminary appraisals. One of their findings was that recreation needs in the Cannonball River basin and vicinity are now largely satisfied by three nearby Bureau of Reclamation reservoirs: Lake Tschida above Heart Butte Dam; Edward Arthur Patterson Lake above Dickinson Dam; and Shadehill Reservoir. It was recognized that the potential reservoirs under consideration would receive some public use, primarily because of nearness to some residents. The visitor-day use and annual benefits for the three reservoirs are as follows:

	Acres	Direct Benefits
Mott Reservoir	12,000	$27,000
Cannonball Reservoir	8,000	18,000
Thunderhawk Reservoir	4,000	9,000

Fish and wildlife benefits and the special costs involved were estimated on the reconnaissance basis by the Bureau of Sport Fisheries and Wildlife. The following discussion was taken from the report Reappraisal of Cannonball Division Missouri River Basin Project dated January 1964. "Plans for habitat replacement, development, acquisition, and proper management of lands within the reservoir flood pools were recommended to mitigate wildlife losses." Benefits to wildlife within the irrigation areas were estimated, as well as additional benefits to both fish and wildlife from investments in impoundments or other features on some of the natural drainageway or in connection with irrigation facilities. Estimates of benefits and costs are itemized as follows:

Annual Benefits	Mott Unit	Cannonball Unit	Thunderhawk Unit
Fishery - with three reservoirs	$23,000	$21,000	$19,000
Wildlife in irrigation areas	1,000	2,000	1,000
Fish and Wildife from special impoundments, etc., in irrigation areas	10,000	19,000	14,000
Total	$34,000	$42,000	$34,000

Municipal, rural and industrial water benefits were based on the costs of a single-purpose alternative of a well field and desalting plant. The cost would be $0.59 per 1,000 gallons or over $190 per acre-foot. The municipal, rural, and industrial annual benefits are as follows:

	Acre-feet	Annual Benefits
Mott Unit	10,000	$1,900,000
Cannonball Unit	19,000	3,610,000
Thunderhawk Unit	11,000	2,090,000
	$40,000	$7,600,000

Annual flood control benefits were computed in the Reappraisal of Cannonball Division, January 1964 done by the Bureau of Reclamation. The Corps of Engineers estimated the benefits for each reservoir. These values would only be realized if one reservoir was built.

The benefits are Mott Reservoir-$132,000; Cannonball Reservoir - $152,000; and Thunderhawk Reservoir - $46,000. These values are higher than those shown in the Bureau of Reclamation's 1964 report because they have been updated to reflect current conditions.

THUNDERHAWK UNIT

	NED ACCOUNT	RD ACCOUNT			
BENEFICIAL EFFECTS		Region	Adjacent Nation	Rest of Nation	Total
User Benefits					
Irrigation	$ 262,000	$ 262,000	-	-	$ 262,000
Municipal, Rural and Industrial Water	2,090,000	2,090,000	-	-	2,090,000
Flood Control	46,000	46,000	-	-	46,000
Fish and Wildlife	34,000	34,000	-	-	34,000
Recreation	9,000	9,000	-	-	9,000
Regional Benefits					
Employment	-	749,000	$-300,000	$-449,000	0
Induced and Stemming	-	183,000	- 73,000	-110,000	0
Total Beneficial Effects	$2,441,000	$3,373,000	$-373,000	$-559,000	$2,441,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,441,000	$1,441,000	-	-	$1,441,000
OM&R	45,000	45,000	-	-	45,000
Total Adverse Effects	$1,486,000	$1,486,000	-	-	$1,486,000
NET BENEFICIAL EFFECTS	$ 955,000	$1,887,000	$-373,000	$-559,000	$ 955,000

MOTT UNIT

	NED ACCOUNT	RD ACCOUNT			
		Region	Adjacent Region	Rest of Nation	Total
BENEFICIAL EFFECTS					
User Benefits					
Irrigation	$ 316,000	$ 316,000	-	-	$ 316,000
Municipal, Rural and Industrial Water	1,900,000	1,900,000	-	-	1,900,000
Flood Control	132,000	132,000	-	-	132,000
Fish and Wildlife	34,000	34,000	-	-	34,000
Recreation	27,000	27,000	-	-	27,000
Regional Benefits					
Employment	-	$ 966,000	$-386,000	$-580,000	0
Induced and Stemming	-	221,000	- 88,000	-133,000	0
Total Beneficial Effects	$2,409,000	$3,596,000	$-474,000	$-713,000	$2,409,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,857,000	$1,857,000	-	-	$1,857,000
OM&R	53,000	53,000	-	-	53,000
Total Adverse Effects	$1,910,000	$1,910,000	-	-	$1,910,000
NET BENEFICIAL EFFECTS	$ 499,000	$1,686,000	$-474,000	$-713,000	$ 499,000

CANNONBALL UNIT

	NED ACCOUNT	RD ACCOUNT			
BENEFICIAL EFFECTS		Region	Adjacent Region	Rest of Nation	Total
User Benefits					
Irrigation	$ 545,000	$ 545,000	-	-	$ 545,000
Municipal, Rural and Industrial Water	3,610,000	3,610,000	-	-	3,610,000
Flood Control	152,000	152,000	-	-	152,000
Fish and Wildlife	42,000	42,000	-	-	42,000
Recreation	18,000	18,000	-	-	18,000
Regional Benefits					
Employment	-	730,000	$-295,000	$-435,000	0
Induced and Stemming	-	382,000	-153,000	-229,000	0
Total Beneficial Effects	$4,367,000	$5,479,000	$-448,000	$-664,000	$4,367,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,417,000	$1,417,000	-	-	$1,417,000
OM&R	91,500	91,500	-	-	91,500
Total Adverse Effects	$1,508,500	$1,508,500	-	-	$1,508,500
NET BENEFICIAL EFFECTS	$2,858,500	$3,970,500	$-448,000	$-664,000	$2,858,500

CANNONBALL, MOTT, AND THUNDERHAWK UNITS

EQ ACCOUNT

BENEFICIAL EFFECTS

Areas of natural beauty and human enjoyment: Three reservoirs of 9,650 acres (conservation storage level) would be created, along with recreational facilities, including access roads, parking areas, picnicking and camping facilities, toilets, and boat ramps. This would provide for water-oriented recreational activities such as boating, fishing, and water contact sports. The quantity and quality of fishing in the river below the dams would be slightly improved. Opportunities for pheasant hunting could improve, depending on the extent of clean farming practices, changes to natural areas, and hunter accessibility. An increase in waterfowl hunting opportunities would also be provided.

Biological, geological, and ecological elements: There would be a fishery in the reservoirs. There would also be a slight improvement of the fishery in the river below the dams. The reservoirs would provide resting habitat for waterfowl and other water-oriented birds. Irrigation development along the river would have the potential for providing a better interspersion of food and cover for pheasants, depending on the degree of clean farming practices. Some aquatic furbearers and waterfowl would also be benefited by the creation of wet areas associated with irrigation development.

Archeological, historical, and cultural elements: There are no known archeological, historical, or cultural sites within the project area. However, a thorough archeological survey of the project area prior to construction activities could reveal the existence of some historic or prehistoric sites.

Water quality: The project would result in cooler water releases and reduced settleable solid concentrations in the river below the dam.

Air quality: The conversion of dryland farming acreage to irrigated cropland would help reduce wind erosion in those lands.

CANNONBALL, MOTT, AND THUNDERHAWK UNITS

EQ ACCOUNT

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: The three reservoirs would inundate 47,950 acres (at top of flood storage level) of natural grassland, farmland, and wooded riparian habitat. Some additional natural areas would also be converted to croplands. New facilities such as the dam, recreational features, and exposed banklines during drawdown periods would be visual intrusions to the project area. In addition, irrigation facilities such as river pumping plants, power transmission lines and substations, irrigation and drainage conveyance facilities, and new access roads would also reduce the visual quality of the area. There would be a reduction in hunting opportunities for deer, antelope, and native grouse species in the reservoir and irrigation development areas.

Biological, geological, and ecological elements: There would be a loss of terrestrial flora and fauna on the lands (up to 48,000 acres) which would be inundated. In addition, there would be reductions in some big game, native grouse, and other indigenous wildlife populations if natural prairie habitat and wooded areas were to be converted to croplands. Several miles (10-40) of free-flowing stream habitat would be impounded. There are no economically recoverable coal or other mineral deposits within the reservoir area. Land leveling for irrigation development would alter the topography and natural drainage characteristics of the area. Irrigation and runoff and drainage into natural drainage channels would cause some erosion.

Irreversible considerations: Most materials used for construction would be irreversibly lost to further use. Reservoir evaporative losses and consumptive use of water for irrigation would be irreversible. Project implementation would result in increased energy demands as a result of pumping operations, irrigation, and more intensive farming operations.

Water quality: There would be heavy sedimentation in the reservoir. Some evaporative losses in the impoundment would contribute to the average salinity of the water downstream. Agricultural return flows would contribute additional pollutants to the Knife River, i.e., dissolved solids, nutrients, pesticides, suspended solids, etc.

Air quality: Construction activities would create some temporary dust and aerial exhaust emissions. Exposed reservoir banklines would be subject to wind erosion during drawdown periods. If native rangeland were to be plowed and cropped, this would expose more land surface to wind erosion. The increased agricultural production would result in increased exhaust emissions and dust caused by operation of farm machinery and would contribute to increases in aerial pollutants at sites of agricultural processing plants.

Cannonball, Mott, and Thunderhawk Units

SOCIAL-WELL-BEING ACCOUNT

BENEFICIAL EFFECTS

Stabilized Population: The estimated duration of each of the projects is 4 years. Since 1960, the population in the area has been in decline. The result of the increased economic stabilization due to the irrigation projects would encourage more people to remain on the farms.

Distribution of Income: Slight redistribution of income would result as farmers' incomes become more stable which would result in increased incomes in the supply end of the industry. In addition, incomes in the supply end would also increase as farmers switched over from dryland farming to irrigated farming practices.

Flood Control: The Cannonball River and Cedar Creek main stem flood areas that would be protected by the units consist of agricultural land and property, railroad bridges, and roadbeds. Railway and stream crossings on State highways are subject to flooding. County roads traversing the flood plain are subject to overtopping, and their bridges are frequently damaged by iceflows and from approach washouts.

Recreation: Construction of the dam would give the people of the area additional sightseeing, picnicking, camping, boating, and water skiing opportunities. Fishing downstream of the dam would improve.

Stabilization of Economic Development: Irrigation would aid in the stabilization of economic conditions by providing farmers with a larger selection of crops to plant, also making them less dependent on the weather for the success of their crops. Both effects would increase the farmers' average annual income. The effects of flood control, additional recreational opportunities, and M&I water would also aid in economic stabilization.

Municipal and Industrial Water: The project would supply water for coal electric generation and coal gasification. A thermal electric plant with capacity for 500 megawatts and 1,900 GWh/yr generation and requiring 5,000 acre-feet of water would supply jobs for 60 workers. Including their families, this would increase the local populations by 200 people. A gasification plant with capacity of 250,000 million cubic feet per day and requiring 10,000 acre-feet of water would supply jobs for 620 workers. Including their families, this would increase local populations by 1,900 people.

Distribution of Income: As farmers switched from dryland farming to irrigated farming, the incomes of those in the supply end of the industry would increase. The incomes of the area in general would increase due to the additional employment by the M&I water and new farmlands.

ADVERSE EFFECTS

Right of Eminent Domain: Irrigation features may cross land whose owners will not receive irrigation.

The relatively large number of construction workers in comparison to the local communities would put a strain on all social services. These would include housing, health and medical care, police protection, water and sewer systems, schools, etc. Any adjustment made to accommodate these problems would have to be of a temporary nature since at the conclusion of the projects the construction people would leave.

Table of Construction Population Impacts

Project Name	Construction Period Years	County	1970 Population of Affected Cities	Number of Construction Workers	Total Number of Construction Related People	Additional School Children
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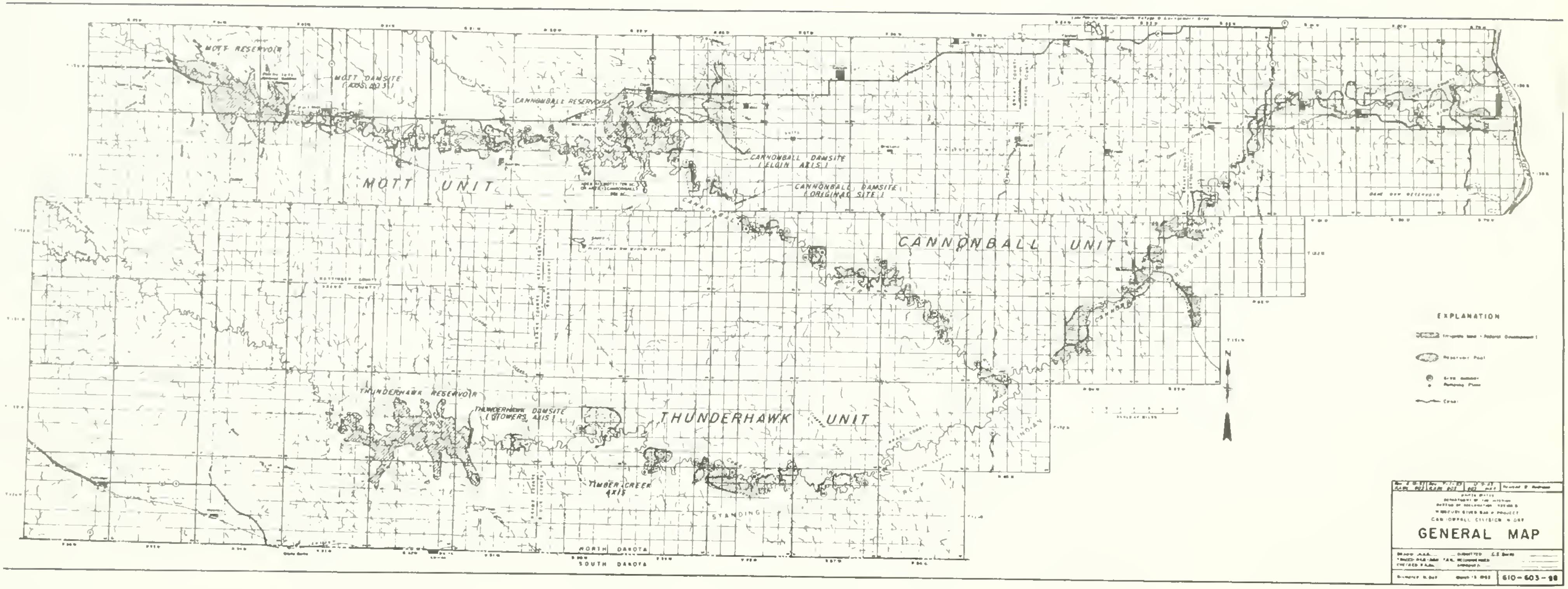

MOTT RESERVOIR
MOTT DAMSITE
CANNONBALL RESERVOIR
CANNONBALL DAMSITE (ELGIN AXIS)
CANNONBALL DAMSITE (ORIGINAL SITE)
MOTT UNIT
CANNONBALL UNIT
THUNDERHAWK RESERVOIR
THUNDERHAWK DAMSITE (STOWERS AXIS)
THUNDERHAWK UNIT
TIMBER CREEK AXIS
STANDING
NORTH DAKOTA
SOUTH DAKOTA
EXPLANATION
GENERAL MAP

Benefits Lost From a Reservoir

Land Value

Cost for land is a project cost. For example, the land required for Broncho Reservoir is 12,800 acres. Using a value of $100 per acre, the land cost would be $1,280,000.

If the landowner took his money and deposited it to draw 7 percent interest, the $100 per acre would have the following values.

Year 10	$ 197
Year 25	543
Year 50	2,946
Year 100	$86,772

By paying income tax on the interest earned each year at the 25 percent tax rate, the $100 per acre would have the following values.

Year 10	$ 173
Year 25	393
Year 50	1,543
Year 100	$23,805

Assuming the 7 percent was equal to the inflation rate for land and the land was sold and income tax paid in Year 100, a loss to the landowner could be computed. This loss would be the difference between the sale of the land in Year 100 and the 100-year value when the land was sold and money deposited and income tax paid each year.

The following shows the computation of the loss:

$86,772 x 25% = $21,680
$86,772 - $21,680 = $65,092
$65,092 - $23,805 = $41,287

The per acre annual equivalent value lost each year would be $41,287 x 100-year present worth factor for 6-3/8 percent (.00207) x 100-year annual equivalent value factor for 6-3/8 percent (.06388) = $5.46 per acre.

Net Income and Induced and Stemming From

Budget studies for a 1,200 acre farm in southwestern North Dakota show a net income to farmers of $5.62 per acre. Net income would be the annual benefits loss based on net income after the land is sold. The induced and stemming from benefits loss for the region would be $3.37 per acre.

Summary

The National Economic Development (NED) and Regional Development (RD) benefits lost by building Broncho Reservoir would be:

NED benefits = 12,800 acres x $ 5.62 =		$ 71,936
	Rounded	$ 72,000
RD benefits = 12,800 acres x $14.45 =		$184,960
	Rounded	$185,000

These benefits lost would show as income loss under the adverse effects in the four account analysis of the Broncho Unit.

The per acre values computed here will be used for Broncho, Thunderhawk, Cannonball, and Mott Reservoirs.

BRONCHO RESERVOIR

	NED ACCOUNT	RD ACCOUNT			
		Region	Adjacent Region	Rest of Nation	Total
BENEFICIAL EFFECTS					
User Benefits					
Irrigation	$ 545,000	$ 545,000	-	-	$ 545,000
Municipal, Rural, & Industrial Water	2,850,000	2,850,000	-	-	2,850,000
Flood Control	80,000	80,000	-	-	80,000
Fish and Wildlife	14,000	14,000	-	-	14,000
Recreation	22,000	22,000	-	-	22,000
Regional Benefits					
Employment		1,735,000	-$ 694,000	-$1,041,000	0
Induced and Stemming		443,000	- 177,000	- 266,000	0
Total Beneficial Effects	$ 3,511,000	$5,689,000	-$ 871,000	-$1,307,000	$3,511,000
ADVERSE EFFECTS					
Annual Equivalent Value	$ 2,483,000	$2,483,000	-	-	$2,483,000
OM&R	44,000	44,000	-	-	44,000
Income Loss	72,000	185,000	-45,000	-68,000	72,000
Total Adverse Effects	$ 2,599,000	$2,712,000	-$ 45,000	-$ 68,000	$2,599,000
NET BENEFICIAL EFFECTS	$ 912,000	$2,977,000	-$ 826,000	-$1,239,000	$ 912,000

THUNDERHAWK UNIT

	NED ACCOUNT	RD ACCOUNT			
BENEFICIAL EFFECTS		Region	Adjacent Nation	Rest of Nation	Total
User Benefits					
Irrigation	$ 262,000	$ 262,000	-	-	$ 262,000
Municipal, Rural and Industrial Water	2,090,000	2,090,000	-	-	2,090,000
Flood Control	46,000	46,000	-	-	46,000
Fish and Wildlife	34,000	34,000	-	-	34,000
Recreation	9,000	9,000	-	-	9,000
Regional Benefits					
Employment	-	749,000	$-300,000	$-449,000	0
Induced and Stemming	-	183,000	- 73,000	-110,000	0
Total Beneficial Effects	$2,441,000	$3,373,000	$-373,000	$-559,000	$2,441,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,441,000	$1,441,000	-	-	$1,441,000
OM&R	45,000	45,000	-	-	45,000
Income Loss	69,000	178,000	-44,000	-65,000	69,000
Total Adverse Effects	$1,555,000	$1,664,000	$ -44,000	$ -65,000	$1,555,000
NET BENEFICIAL EFFECTS	$ 886,000	$1,709,000	$-329,000	$-494.000	$ 886,000

MOTT UNIT

	NED ACCOUNT	RD ACCOUNT			
		Region	Adjacent Region	Rest of Nation	Total
BENEFICIAL EFFECTS					
User Benefits					
Irrigation	$ 316,000	$ 316,000	-	-	$ 316,000
Municipal, Rural and Industrial Water	1,900,000	1,900,000	-	-	1,900,000
Flood Control	132,000	132,000		-	132,000
Fish and Wildlife	34,000	34,000	-	-	34,000
Recreation	27,000	27,000	-	-	27,000
Regional Benefits					
Employment	-	$ 966,000	$-386,000	$-580,000	0
Induced and Stemming	-	221,000	- 88,000	-133,000	0
Total Beneficial Effects	$2,409,000	$3,596,000	$-474,000	$-713,000	$2,409,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,857,000	$1,857,000	-	-	$1,857,000
OM&R	53,000	53.000	-	-	53,000
Income Loss	77,000	198,000	-48,000	-73,000	77,000
Total Adverse Effects	$1,987,000	$2,108,000	$ -48,000	$ -73,000	$1,987,000
NET BENEFICIAL EFFECTS	$ 422,000	$1,488,000	$-426,000	$-640,000	$ 422,000

CANNONBALL UNIT

	NED ACCOUNT	RD ACCOUNT			
		Region	Adjacent Region	Rest of Nation	Total
BENEFICIAL EFFECTS					
User Benefits					
Irrigation	$ 545,000	$ 545,000	-	-	$ 545,000
Municipal, Rural and Industrial Water	3,610,000	3,610,000	-	-	3,610,000
Flood Control	152,000	152,000	-	-	152,000
Fish and Wildlife	42,000	42,000	-	-	42,000
Recreation	18,000	18,000	-	-	18,000
Regional Benefits					
Employment	-	730,000	$-295,000	$-435,000	0
Induced and Stemming	-	382,000	-153,000	-229,000	0
Total Beneficial Effects	$4,367,000	$5,479,000	$-448,000	$-664,000	$4,367,000
ADVERSE EFFECTS					
Annual Equivalent Cost	$1,417,000	$1,417,000	-	-	$1,417,000
OM&R	91,500	91,500	-	-	91,500
Income Loss	123,000	3,173,000	-78,000	-116,000	123,000
Total Adverse Effects	$1,631,500	$1,825,500	$ -78,000	$-116,000	$1,631,500
NET BENEFICIAL EFFECTS	$2,735,500	$3,653,500	$-370,000	$-548,000	$2,735,500

Yellowstone Basin And Adjacent Coal Area Level B Study

Missouri River Basin Commission

Donald Ohnstad • Assistant Study Manager
601 East Bismarck Avenue, Room 16 • Bismarck, ND 58501
(701) ~~255-4516~~ • FTS 783-4516

MEMORANDUM

TO: State Study Team Members

FROM: Don Ohnstad, Assistant Study Manager, North Dakota

SUBJECT: Instream Flows

DATE: April 19, 1977

Attached for your information are two levels of instream flow that we can consider for inclusion in our NED or EQ alternative plans and in our recommended plan.

In summary these instream flows represent the following quantities of water;

Stream and Location	90% Exceedance Level Acre-Feet	Modified Level Acre-Feet
North Fork Grand River at Haley, North Dakota	366	8536
Cannonball River at Breien	9316	68884
Little Missouri near Watford City	39490	186326
Knife River at Hazen	11820	62238
Heart River near Mandan	16838	70628

Instream Flow

Under the Federal Fish and Wildlife Coordination Act, conservation of fish and wildlife resources receive equal consideration with other features of water resources projects. For the most part controversy on a project or program developes from lack of knowledge on the effect these proposals may have on the area resources.

With certain exceptions the data base for fish and wildlife resources as compared to water resources data are quite limited, as are methodologies for projecting or simulating the possible effects on fish and wildlife from various proposed actions. However, to date little has been done by federal and state agencies or special interest groups in pre and post construction assessment of impacts to obtain facts.

In areas beyond the scope of federal law, state laws apply. Under North Dakota water law (61-01-01.1) the priority of water use in the case of conflicts has been established by the following order of priority;

1. domestic
2. livestock
3. irrigation and industry
4. fish, wildlife and other outdoor recreational uses

Under North Dakota law, between appropriation for the same use, priority in time has the better right. It would appear that under North Dakota water law, instream flows could be a beneficial use, however, they would be subordinate to other high priority users irrespective of the date of any instream flow permit. In the study area in North Dakota several water right permits have been issued for joint fish, wildlife, and stockwater purposes. In addition permits have been issued for fish, wildlife and recreational purposes. The largest of these are in conjunction with Spring Creek, Crown Butte, Fish Creek, Sweetbriar, Cedar Creek, Sheep Creek, and Indian Creek. All tributary creeks to the western Dakota tributary streams. The existing appropriations for fish and wildlife use within the North Dakota portions of the study area totals approximately 25,000 acre feet of storage and 10,000 acre feet of annual use, these do however, include use for stockwater purposes and do not include instream flow per se.

Instream Flow Methodologies, Past Studies

In the Northern Great Plains Resource Program, instream flow needs were defined "as minimum amounts of water required in a stream (seasonable) to maintain essentially the existing aquatic resources and associated wildlife and riparian habitat." Some of the basic assumptions in the methodology used under this approach were;

1. The amounts of water flowing past a gaging station represented the flows supporting present levels of aquatic and related resources.
2. Water quality would remain relatively unchanged.
3. The natural hydrologic cycle or pattern of flow should be maintained
4. The 10 percentile flow or in other words the flow exceeded 90% of the time was considered as the initial estimate of instreams flow need.

A four step methodology was developed to estimate the instream needs of average hydrological conditions as follows;

1. Based on hydrologic stream flow data, the average monthly flow for three conditions; representing 1.) dry, 2.) average and, 3.) wet years were determined.
2. The 10 percentile flow was determined
3. The instream estimates above were adjusted on quantities of water entering or leaving the stream system.
4. Estimates were modified based on specific species requirements.

Deviations from this methodology were as follows;

1. For stream reaches involving natural trout habitat, a 50% percentile flow requirement based on average daily flows were used.
2. For the Powder River and Western Dakota tributaries were large variations in flow are "normal" the percentile flow selected was varied for those months in which the monthly flow averaged less than 10%, from 10 to 50%;

50 to 100%, and for those months exceeding 100% of the mean monthly flow. Other methodologies for estimating instream flow needs have been used in various studies conducted by state and federal agencies.

For the stream in the North Dakota study area the instream flows for the 90% exceedance level is shown in Table IV-8. The modified flow for these streams as determined using the above criteria are shown in Table IV-9.

Table IV-10. Instream Water (cfs) for Selected Rivers in North Dakota, 90% Exceedance Level

tream and Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
orth Fork Grand River												
t Haley, N.D.	0	0	1	2	1	1	1	0	0	0	0	0
annonball River												
t Regent, N.D.	1	0	5	7	4	6	2	1	2	2	2	2
elow Bentley, N.D.	1	1	7	16	9	12	5	4	3	5	6	4
t Breien, N.D.	0	0	22	60	24	21	6	13	1	1	3	2
edar Creek near Haynes, N.D. Tributary)	1	1	2	4	2	1	0	0	0	1	1	1
edar Creek near Pretty Rock, .D. (Tributary)	0	0	0	5	5	3	2	0	0	0	2	2
edar Creek near Raleigh, .D. (Tributary)	0	0	0	13	7	36	12	0	0	0	0	0
ittle Missouri River												
t Marmouth, N.D.	0	0	68	75	31	70	48	25	6	5	5	1
t Medora, N.D.	0	0	0	8	36	68	70	4	4	2	0	0
ear Watford City, N.D.	0	0	158	204	86	165	139	44	18	7	5	1
nife River												
t Manning, N.D.	0	0	0	0	0	0	0	0	1	1	1	1
ear Golden Valley, N.D.	0	0	0	12	9	9	8	2	2	1	4	4
t Hazen, N.D.	3	1	14	56	21	17	18	9	13	17	15	10

Table IV-10. Instream Water (cfs) for Selected Rivers in North Dakota, 90% Exceedance Level (Continued)

eam and Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
rt River												
ow Dickinson Dam, near kinson, N.D.	0	0	0	0	0	1	0	0	0	0	0	0
r Richardton, N.D.	0	0	2	18	7	15	5	1	0	3	3	3
ow Heart Butte Dam near n Ullin, N.D.	3	2	3	0	6	37	37	33	23	13	13	6
r Lark, N.D.	1	0	16	36	18	49	36	42	31	30	19	11
r Mandan, N.D.	0	0	0	65	35	40	39	31	16	23	16	11
en River near Gladstone, . (Tributary)	1	0	6	7	2	2	2	0	0	1	2	2

Table IV-11. Instream Water (cfs) for Selected Rivers in North Dakota, Modified Level

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
North Fork Grand River												
at Haley, N.D.	1	2	45	29	19	35	4	1	1	1	1	1
Cannonball River												
at Regent, N.D.	1	5	45	20	20	44	14	6	4	1	3	3
Below Bently,N.D.	4	15	121	45	47	78	24	11	9	7	9	6
at Breien, N.D.	6	39	313	233	129	236	90	25	15	16	18	11
Cedar Creek near Haynes, N.D. (Tributary)	2	4	33	26	24	51	14	8	2	2	3	2
Cedar Creek near Pretty Rock, N.D. (Tributary)	2	14	91	72	28	61	22	7	3	2	3	3
Cedar Creek near Raleigh, N.D. (Tributary)	1	8	95	62	114	96	34	7	9	2	2	3
Little Missouri River												
at Marmarth, N.D.	4	160	445	250	196	360	137	47	25	33	20	7
at Medora, N.D.	2	75	528	370	300	400	180	64	30	29	18	7
near Watford City, N.D.	1	187	939	497	299	583	270	122	59	68	28	8
Knife River												
at Manning, N.D.	1	6	44	55	19	28	21	3	6	2	2	2
near Golden Valley,N.D.	6	27	190	138	54	83	31	14	7	7	9	6

Table IV-11. Instream Water (cfs) for Selected Rivers in North Dakota, (cont'd)
Modified Level

Stream and Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Knife River												
at Hazen, N.D.	16	51	316	222	53	167	73	28	25	26	27	19
Spring Creek near Zap, N.D. (tributary)	3	13	69	63	22	28	14	5	7	7	7	5
Heart River												
near South Heart, N.D.	1	8	56	25	20	27	5	6	1	1	1	1
below Dickinson Dam, near Dickinson, N.D.	1	1	35	30	14	31	12	6	2	1	1	1
near Richardton, N.D.	3	15	180	97	53	78	42	9	8	6	7	6
below Heart Butte Dam near Glen Ullin, N.D.	23	16	62	157	50	62	67	55	54	47	34	26
near Lark, N.D.	19	23	230	186	57	139	81	67	32	49	39	28
near Mandan, N.D.	13	23	283	243	71	165	96	77	65	55	42	25
Green River near New Hradec, N.D. (tributary)	1	1	42	43	12	11	12	1	1	1	1	1
Green River near Gladstone, N.D. (tributary)	2	7	73	58	13	25	21	4	3	3	4	3

YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREAS

Montana, Wyoming, and North Dakota

LEVEL B STUDY

FLOOD CONTROL AND STREAMBANK EROSION CONTROL ALONG MAIN STEM REACHES

Position Paper By
Corps of Engineers
Missouri River Division
February 1977

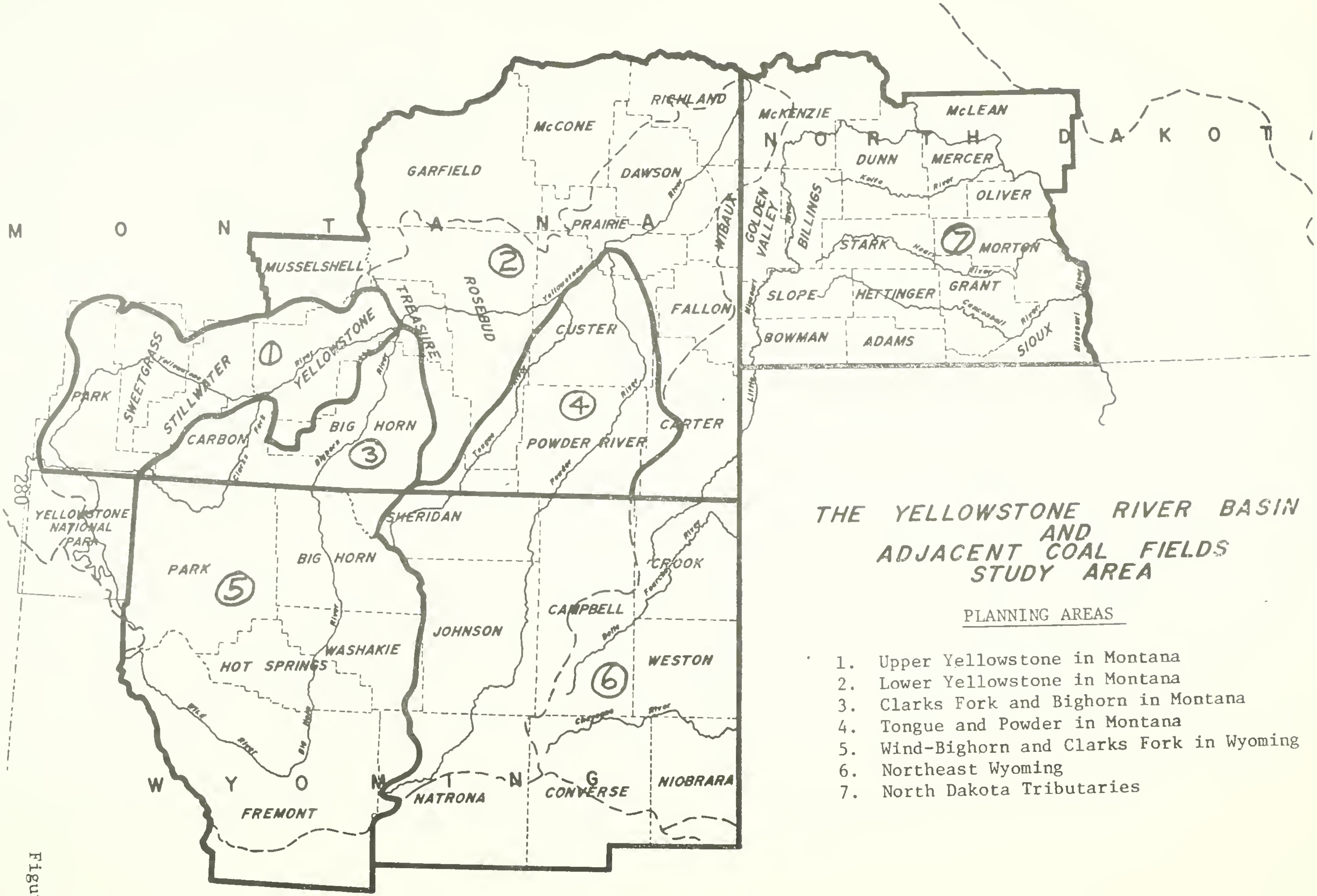
The Yellowstone River originates in the cool green reaches of Yellowstone National Park. It travels some 600 miles before joining the Missouri River just across the Montana border in North Dakota. Indians named this stream "Rock Yellow River." The name probably originated from the yellowish rimrocks and bluffs which are evident along the river's lower reaches.

The Yellowstone River system drains one-fourth of Montana's land area and one-third of Wyoming's. Its main tributaries are the Shields, Boulder, Stillwater, Clarks Fork, Bighorn, Tongue, and Powder rivers. All except the Shields River flow in from the south. Swift water is the rule for the upper river, for it drops from an elevation of 7,564 feet above sea level at Yellowstone Lake to 2,831 feet at the mouth of the Bighorn River (an average slope of 15 feet per mile). From its source, the Yellowstone runs through steep-walled canyons almost due north to its confluence with the Shields River. This is a most scenic spot with high mountain ranges appearing at nearly every point.

From its junction with the Shields River, the Yellowstone takes an eastward direction. The river bottom widens and benchlands dotted with cottonwoods, juniper, and scrubby ponderosa pine look down on the valley. Water in the upper river runs clear and sparkling, but silt from tributaries burdens it as it proceeds eastward. By the time the Bighorn and Powder rivers have added their silty cargos, it seems almost a different stream.

The Yellowstone Valley is, in effect, an extended finger of the Great Plains!

(Above description partially extracted from an article in Midland Empire News Journal).



THE YELLOWSTONE RIVER BASIN AND ADJACENT COAL FIELDS STUDY AREA

PLANNING AREAS

1. Upper Yellowstone in Montana
2. Lower Yellowstone in Montana
3. Clarks Fork and Bighorn in Montana
4. Tongue and Powder in Montana
5. Wind-Bighorn and Clarks Fork in Wyoming
6. Northeast Wyoming
7. North Dakota Tributaries

Figure 1

BACKGROUND

During the early phase of the Yellowstone Level B Study, specific tasks were assigned to various agency representatives (federal, state, and local), with a given knowledge and capability to perform the assignments. Each group was to prepare a report describing the 1975 base condition and projected needs remaining to be met in the years 1985 and 2000. Work item No. 6 was assigned to the Corps of Engineers. That task involved updating (1) flood damages from the Missouri River Basin Framework Study and (2) streambank erosion damages from the National Streambank Erosion Assessment. The Corps was given responsibility for main stem reaches having at least 400 square miles of drainage area. The Soil Conservation Service was given responsibility for tributaries having less than 400 square miles of drainage area (Work Item No. 7).

Estimates of flood damages and streambank erosion damages for the main stem reaches were printed in a technical paper distributed in May 1976. That report contains a summary of the primary background material used in developing this position paper which presents potential projects to reduce damages from flooding and streambank erosion. The projections of future flood damages were based on the assumption that current trends toward increased flood plain regulation would continue into the future. Therefore, the flood damage estimates reflect increased flood plain regulation, but no additional structural measures, and would best fit the "without plan" condition. The Without Plan is defined as a baseline of projects and programs that will exist in the absence of future additional federal or state action. This condition establishes a benchmark for comparison against which to measure the beneficial and adverse effects of the National Economic Development (NED), Environmental Quality (EQ), or other alternative plans.

PLANNING AREA DESCRIPTIONS

The Yellowstone River Basin and adjacent coal areas in Montana, Wyoming, and North Dakota cover over 127,000 square miles. The study area was divided into seven planning areas along a combination of hydrologic and state boundaries as shown on Figure 1. The seven planning areas were named and described as follows:

1. UPPER YELLOWSTONE IN MONTANA - The Yellowstone River and its tributaries, except Clarks Fork, located above the mouth of the Bighorn River.

2. LOWER YELLOWSTONE IN MONTANA - The Yellowstone River and its tributaries, except the Tongue and Powder rivers, located below the mouth of the Bighorn River. (Includes the Little Missouri River portion within Montana).

3. CLARKS FORK AND BIGHORN IN MONTANA - The Clarks Fork and Bighorn rivers and their tributaries.

4. TONGUE AND POWDER IN MONTANA - The Tongue and Powder rivers and their tributaries.

5. WIND-BIGHORN AND CLARKS FORK IN WYOMING - The Wind-Bighorn and Clarks Fork rivers and their tributaries.

6. NORTHEAST WYOMING - The Tongue, Powder, Little Missouri, Belle Fourche, and Cheyenne rivers and their tributaries.

7. NORTH DAKOTA TRIBUTARIES - The Yellowstone, Little Missouri, Knife, Heart, Cannonball, and Grand rivers and their tributaries.

AREA OF RESPONSIBILITY

The division of responsibility between the Corps of Engineers and the Soil Conservation Service for developing flood damage estimates and evaluating potential projects was based on the procedure used in the Missouri River Basin Framework Study. Because there are significant differences in flood characteristics and the type of remedial measures needed to reduce flood damages, a general division of flood plain areas was based on the size of contributing drainage areas. Flood plains having drainage areas of less than 400 square miles were designated as "tributary" or upper watershed areas while those having more than 400 square miles were designated as "main stem" reaches.

FUTURE PROSPECTS WITHOUT A PLAN

The means of preventing or reducing flood damages fall into two classes - structural and non-structural. Structural means include:

(1) Dams

(2) Channel modification

(3) Levees

(4) Floodways

(5) Diversions

Structural measures for flood protection could be provided by modifying existing projects and by development of major storage reservoirs, small watershed projects, local protection projects for urban communities, or by channel improvements and rural levees along streams. Non-structural means include:

(1) Flood forecasting

(2) Flood fighting

(3) Floodway regulation

(4) Flood plain management and zoning (including flood insurance)

(5) Land conservation treatment measures

(6) Public purchase of flood plains

(7) Flood proofing of structures

Existing flood forecasting and flood fighting activities will continue and are reflected in loss estimates under existing and future conditions. By definition, the future without plan assumes no major federal or state expenditures for new construction. In other words, lacking plans for future structural measures, the means of reducing flood losses are limited to those nonstructural measures already in force. The States are already implementing flood plain management and zoning to prevent further buildup and increased damage in the flood plain. Strong federal impetus in this direction was added by the Flood Disaster Protection Act of 1973 which requires communities with special flood hazards to undertake prudent flood plain management measures or lose any financial assistance involving federal or federally guaranteed funds. It also provides for flood insurance. As a result, accelerated urban flood plain zoning and regulation seem assured.

STUDY PROCEDURES

The damage estimates were reviewed before various flood control alternatives were evaluated. Proposed projects from the Missouri River Basin Comprehensive Framework Plan, completed in 1971, were considered along with other agency studies undertaken in the past. In addition, an attempt was made to identify any new potential projects or new alternatives through input by local interests. Possible changes to existing projects, either structural or operational, were also considered. All of these potential solutions were then evaluated on a single-purpose basis using the costs and damage reductions (benefits) which would be provided by structures or improved management.

Planning involves a screening process. Planners cannot possibly make a detailed investigation of every conceivable alternative project. Therefore, many projects which would obviously be economically infeasible or physically impracticable are "screened out" of the evaluation process. Since the Yellowstone Level B Study is a reconnaissance level study, many of the remaining potential projects may be deleted during a later detailed investigation (Level C). Even though some of the potential projects are infeasible because of economic reasons or lack local support, they are still presented here for consideration by the State Study Teams. Some day,there may be another source of financial support (such as the States) or environmental considerations (such as with streambank protection) that may dictate a need for construction, even though economic costs far outweigh measurable monetary benefits.

EVALUATION OF POTENTIAL SOLUTIONS

A review of historical flood data indicates that total damages continue to increase, even though a large number of flood control programs have been implemented. There are two reasons for this paradox. First, long term economic trends have resulted in higher values for property, materials, and labor so that the value of improvements subject to flooding also continues to increase and flood losses themselves are consequently higher. Secondly, continuing economic expansion creates demands for land on which new improvements can be located. In many instances this has resulted in substantial encroachments onto the flood plains and additional sets of improvements subject to flood damage.

It is apparent that a need exists for flood plain management. With proper management of the water and the land subject to inundation by flood waters, the trend of increasing flood damages can be slowed materially, if not reversed. However, this is not a simple task. Studies can be made to determine the best use of the flood plain lands, recognizing the flood risk, but implementation of flood plain regulations involves property rights. Thus, legal authority must exist to initiate any planned regulation, and planned regulation of future flood plain development should be accomplished by all planning groups - federal, state, and local. This means that planning should not stop at flood control structures but should incorporate to some degree land use analysis reflecting local requirements for regulation and management of appropriate flood plain development.

Plan formulation during this study incorporated the assumption that proper urban flood plain regulation would occur under future conditions without any resource development plan. This conclusion was based on the fact that flood plain regulation is directed and is being implemented under existing State statutes and federal laws.

FLOOD CONTROL CRITERIA

The general criteria adopted for control of floods and the prevention of losses caused by floods included consideration of the types of areas subject to flood, the amount of average annual flood damage projected over the the long term, and generalized probabilities of flooding. The criteria also included the recognition that flood damage prevention could be achieved to varying degrees by structural and nonstructural means.

Structural measures for control of floods were considered to be important to the economic and social well-being of those urban areas where the existing level of flood damage is realtively high, where extensive improvements have already taken place on the flood plain, and where a large number of people are affected by recurring floods. To test for feasibility, structural measures were formulated for all urban areas having at least $15,000 in average annual flood damages to provide protection against floods having an exceedance frequency of 100 years. It was recognized that during future detailed studies, a more infrequent design discharge would probably be used for urban levees to provide a higher degree of safety. This criterion does not preclude flood plain land use regulation in conjuction with structural measures as a means of limiting future damage levels. In the urban areas where the flood problem is currently relatively minor, non-structural measures are proposed to keep the problem from increasing in intensity.

The application of structural measures to protect rural areas was determined by such basic indices as values in the areas and flood damages being sustained. Generally, the control of floods over relatively long reaches of principal streams would require reservoir regulation of high flows, but experience in the water resources field has shown that it is nearly impossible to justify major reservoirs for flood control in rural areas of the Great Plains because of the relatively low agricultural damages.

The benefits from structures for flood control and flood damage prevention are measured in terms of annual flood losses prevented, areas protected and managed, and land enhancement values created. In relation to other functional water resource developments, structural measures for flood control compete only with preservation of the existing environment. Generally, control of flood flows is a non-consumptive water use and, therefore, is compatible with other in-stream functions.

STREAMBANK EROSION

Bank cutting is the most common form of stream erosion and is most noticeable on the outside of river bends. It is a producer of stream-transported sediment. In many cases, however, partial replacement of soil loss from streambank erosion occurs through deposition on the inside curve in the same general reach. As the process grows more severe, the looping oxbows, typical of an alluvial stream, are formed. While balanced generally in terms of the entire river regime and while resulting in some high fish and wildlife habitat plus fertile floodplains, imposition on private land ownership patterns and damages to these lands are a serious problem.

Streambank erosion is a contributor of sediment which degrades the river water and causes a loss of productive land each year. The erosion is greatest on streams that in the past have been straightened and are now eroding to widen the channel, and on streams with sandy banks. Where streambank erosion is severe, it causes both economic and environmental losses. Past investigations have shown that construction of conventional streambank erosion control works on a broad scale for economic return cannot be justified. Further, it is not possible to compute the environmental benefits.

Under Section 32 of the Streambank Erosion Control and Demonstration Act of 1974, as amended by the Water Resources Development Act of 1976, authority for work under this act has been expanded to include the Yellowstone River from Intake, Montana to its mouth. The original act authorized work on the Missouri River in the reach below Garrison Dam and in the reach between Fort Randall dam and Sioux City. The intent of this program is to develop a demonstration of structural means for controlling bank erosion with a view toward developing the most cost effective and environmentally acceptable means. Several sites have been initially selected along the Missouri River in Nebraska, South Dakota, and North Dakota. Additional sites will be selected on both the Missouri and Yellowstone Rivers as funding and scheduling permit.

FLOOD CONTROL AND STREAMBANK EROSION CONTROL ALTERNATIVES

The updated estimates of current and future flood and streambank erosion damages prepared for this study permitted a re-evaluation of the alternatives which were considered in the past plus any new potentials. The major problem was one of economics - formulating a project whose benefits would exceed its costs. Higher interest rates and rapidly rising construction costs have made this task increasingly difficult despite higher crop prices and property values.

Cost estimates were based on 1975 levels and included all costs associated with development such as land, labor, materials, equipment, contingencies, and costs for engineering, design,and supervision. A general guide to the type and extent of costs which were considered included the following:

(1) Dams and Reservoirs - Primary costs involved right-of-way, relocations, embankment, spillway, outlet works, access roads, and facilities for recreation and fish and wildlife.

(2) Levees - Cost estimates included right-of-way, relocations, embankment, bridge raises, and interior drainage structures.

(3) Channel Modifications - Costs included right-of-way, relocations, excavation and spoil, riprap protection, bridge alterations, control structures, and access roads for operation and maintenance.

(4) Streambank Protection - Costs included right-of-way, earthwork, riprap and revetments, plus access required for operation and maintenance.

Average annual costs were based on 6-3/8 percent interest rate and a 50-year economic life of the project. Estimates of annual operation, maintenance, and replacement costs were also included for each potential project.

Flood control benefits were based on both current and future levels of economic development with future benefits being discounted back to the year when the project was assumed to be operational, in order to obtain the equivalent current benefits. The discount factors used for computing equivalent annual benefits were based on: (1) a straight-line growth between target years, (2) a 50-year economic life, and (3) a 6-3/8 percent interest rate. As it happened, all projects which showed economic justification did so in the near future time period and consequently were evaluated on benefits discounted to 1985. The remaining projects were evaluated under conditions projected for the year 2000, which was the most distant date for which detailed solutions were to be evaluated in accordance with the adopted criteria.

The following section contains a summary of information relative to existing projects, authorized projects, and potential projects for each of the seven planning areas within the Yellowstone River Basin and adjacent coal areas. In addition, the potential projects are presented under the 4-account system of evaluation. Several of the authorized projects are either economically infeasible or lack local support. Some have even been recommended for deauthorization. However, all Corps of Engineers projects which had been authorized in the past, but not constructed, were re-evaluated on a current economic basis and presented here for study team information.

1. UPPER YELLOWSTONE IN MONTANA

A. Existing Projects

Location: Upstream of Big Timber, Montana
Stream: Yellowstone River
Type of Protection: Bank protection upstream of county bridge.
Description: 0.25 miles of riprap along right bank.
Year Completed: 1973
Federal Cost: $49,000

Location: Downstream of Clyde Park, Montana
Stream: Shields River
Type of Protection: Bank protection upstream of Highway 89 bridge.
Description: 0.5 miles of riprapped channel improvement, plus right bank levee.
Year Completed: 1950
Federal Cost: $26,000

B. Authorized Projects

Location: Billings, Montana
Stream: Yellowstone River and tributaries.
Type of Protection: Levees, channels, diversion and drainage structures.
Description: 3 units (see below)
Year Authorized: 1950
Total Cost: $4,595,000

Billings Unit	Stream	Type of Protection	Total Cost
Eastern	Alkali Creek	Channel & levee along right bank	$ 395,000
Southern	Yellowstone R.	Levee & drainage structures	580,000
Western	Hogans Slough plus drainage ditches	Channel & levee diversion along Shiloh Road to Canyon Creek & Yellowstone River	3,620,000

STATUS: Both Eastern and Southern Units recommended for deauthorization in 1975 due to lack of economic justification and local support. A restudy of Western Unit was completed in 1970 which required relocation three miles west due to encroachment on authorized alinement. Feasible project at that time, but local interests couldn't contribute their share of costs ($1,120,000). The City of Billings and Yellowstone County were notified on 23 March 1976 that authorization would expire 5 years from that date unless they can provide required local cooperation.

C. Potential Projects

(1) Billings, Montana Western Unit
(2) Livingston, Montana levee

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Tributary flooding in western Billings, Montana
Potential Project: Construction of a diversion project consisting of a conduit, channels, levees, and a drop structure parallel to Shiloh Road (4.7 miles in length).

National Economic Development Account

Beneficial Effects:

Average annual benefits: $334,000

Adverse Effects:

Installation cost: $3,620,000
Interest during construction: None (short-term construction period)
Annual Investment Cost: $241,700
Annual operation, maintenance, and replacement: $5,300
Total annual Cost: $247,000

Benefit/Cost Ratio: 1.4

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

4 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$534,000 regional growth per year resulting from flood protection;
$362,000 added business created by construction activity.

Adverse Effects:

$247,000 total annual cost: 197 acres lost to land base;
$32,000 average annual residual damages.

Social Well-Being Account

Beneficial Effects:

Protects 2,080 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 60,000 residents;
Encourages more orderly development in protected areas.

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Livingston, Montana
Potential Project: Construction of a 2.5 mile levee along the left bank of the Yellowstone River.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $62,000

Adverse Effects:

Installation cost: $1,000,000
Interest during construction: none (short-term construction period)
Annual investment cost: $67,000
Annual operation, maintenance, and replacement: $3,000
Total annual cost: $70,000

Benefit/Cost Ratio: 0.9

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

10 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$99,000 regional growth per year resulting from flood protection;
$100,000 added business created by construction activity.

Adverse Effects:

$70,000 total annual cost; 20 acres lost to land base;
$11,000 average annual residual damages.

Social Well-Being Account

Beneficial Effects:

Protects 300 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 6,000 residents;
Encourages more orderly development in protected areas.

2. LOWER YELLOWSTONE IN MONTANA

A. Existing Projects

Location: Forsyth, Montana
Stream: Yellowstone River
Type of Protection: Levee and bank protection along right bank
Description: 2.5 mile levee
Year Completed: 1948
Federal Cost: $255,000

Location: Upstream of Miles City, Montana
Stream: Yellowstone River
Type of Protection: Raised road embankment for bridge
Description: 0.5 mile levee and riprap
Year Completed: 1950
Federal Cost: $24,000

Location: West Glendive, Montana
Stream: Yellowstone River
Type of Protection: Levee and diversion channel along left bank
Description: 2.2 mile levèe and 0.2 mile new channel
Year Completed: 1959
Federal Cost: $230,000

B. Authorized Projects

Miles City, Montana local protection project (See Tongue and Powder Planning Area in Montana for details)

C. Potential Projects

(1) Miles City, Montana levee (See Tongue and Powder Planning Area in Montana for details)
(2) Lower Yellowstone streambank protection

POTENTIAL PROJECT EVALUATION

Type: Streambank Protection

Problem: Streambank erosion along the lower Yellowstone River between Intake, Montana, and the mouth of the river in North Dakota.

Potential Project: Installation of selective river management techniques using variations of several different types of structural bank protection measures at 24 key locations (Streambank Erosion Control Evaluation and Demonstration Act of 1974 plus amendments).

National Economic Development Account

Beneficial Effects:

Protection for extensive areas of irrigated land and irrigation facilities such as intakes, pumping plants, headgates, and pipelines along a 70-mile reach of the Yellowstone River. Because of the innovative and unproven techniques to be tested in this program, Congress has imposed no requirement for a display of economic feasibility and no attempt is made here to do so.

Adverse Effects:

Installation cost: $5,600,000
Annual investment cost: $374,000
Annual operation, maintenance, and replacement: $56,000
Total annual cost: $430,000

Environmental Quality Account

Beneficial Effects:

Elimination of a major source of sediment which will reduce turbidity levels.

Adverse Effects:

Temporary turbidity of river water at construction site. Disruption of vegetative cover on quarry sites to be used during construction. Conversion of some river fringe woodland to cultivated crops will reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

Stabilization of the location of high river banks along the valley lands reducing risk to dwellings, outbuildings, and cultivation activities. This eliminates a significant source of land damage that affects productivity and on-farm stability.

Adverse Effects:

Temporary loss of crop production at construction sites.

Social Well-Being Account

Beneficial Effects:

Protects livelihood of landowners affected. Improved water quality for all uses and general aesthetics of lands and streams.

3. CLARKS FORK AND BIGHORN IN MONTANA

A. Existing Projects

Yellowtail Dam and Reservoir (constructed by the Bureau of Reclamation) is located on the Bighorn River upstream of Hardin, Montana. It was completed in 1966 and has 500,000 acre-feet of flood control storage, of which 250,000 acre-feet is for joint use. This flood control storage benefits those people living along the lower Bighorn River valley plus those located on the flood plain along the lower Yellowstone River.

B. Authorized Projects

(None)

C. Potential Projects

(None)

4. TONGUE AND POWDER IN MONTANA

A. Existing Projects

Tongue River Dam and Reservoir (constructed by State of Montana in 1939) is located on the Tongue River north of Decker, Montana near the Wyoming State line. The reservoir has no storage reserved exclusively for flood control. However, flood damages from specific events may be reduced significantly, depending on the available storage in the reservoir at the time of the flood occurrence. This varies with the seasonal operating plan for the facility.

B. Authorized Projects

Location: Miles City, Montana
Stream: Tongue and Yellowstone Rivers
Type of Protection: Levee along right bank of both streams
Description: 3.0 mile levee
Year Authorized: 1950
Total Cost: $2,367,000
Status: Current study indicates feasibility and local support. The Phase I Advanced Engineering and Design Study is in progress and scheduled to be submitted to Washington in late 1977.

C. Potential Projects

(1) Miles City, Montana levee

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Miles City, Montana
Potential Project: Construction of a 3.0 mile levee along the right bank of both the Yellowstone and Tongue Rivers.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $232,000

Adverse Effects:

Installation cost: $2,367,000
Interest during construction: None (short-term construction period)
Annual investment cost: $158,000
Annual operation, maintenance, and replacement: $12,000
Total annual cost: $170,000

Benefit/Cost Ratio: 1.4

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

18 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$371,000 regional growth per year resulting from flood protection;
$236,000 added business created by construction activity.

Adverse Effects:

$170,000 total annual cost: 73 acres lost to land base;
$58,000 average annual residual damages.

Social Well-Being Account

Beneficial Effects:

Protects 1,300 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 9,000 residents;
Encourages more orderly development in protected areas.

5. WIND-BIGHORN AND CLARKS FORK IN WYOMING

A. Existing Projects

Location: Greybull, Wyoming
Stream: Bighorn River
Type of Protection: Levee along left bank
Description: 2.5 mile levee
Year Completed: 1959
Federal Cost: $249,000

Location: Upstream of Lovell, Wyoming
Stream: Shoshone River
Type of Protection: Bank protection between Highway 310 and Burlington Northern Railroad bridges to protect city intake structure.
Description: 0.3 miles of riprap along right bank
Year Completed: 1963
Federal cost: $31,000

Boysen Dam and Reservoir (constructed by Bureau of Reclamation) is located on the Bighorn River upstream of Thermopolis, Wyoming. It was completed in 1952 and has 150,000 acre-feet of storage reserved for flood control plus an additional 150,000 acre-feet of storage for joint conservation and flood-control use.

Buffalo Bill Dam and Reservoir (constructed by Bureau of Reclamation) is located on the Shoshone River upstream of Cody, Wyoming. The reservoir has no storage reserved exclusively for flood control. However, flood damages from specific events may be reduced significantly, depending on the available storage in the reservoir at the time of the flood occurrence.

B. Authorized Projects

(None)

C. Potential Projects

(None)

6. NORTHEAST WYOMING

A. Existing Projects

Location: Sheridan, Wyoming
Stream: Goose and Little Goose creeks
Type of Protection: Levees, channel cutoffs, floodwalls, drop structures, and paved chute.
Description: 6.4 miles of intermittent levees and channel improvements
Year Completed: 1963 (Stage I), 1966 (Stage II)
Federal Cost: $1,967,000

Keyhole Dam and Reservoir (constructed by the Bureau of Reclamation) is located on the Belle Fourche River about 20 miles west of Sundance, Wyoming. It was completed in 1952 and has 140,000 acre-feet of storage reserved for flood control plus 130,000 acre-feet of storage for joint irrigation, flood control, and maintenance of low flows.

B. Authorized Projects

Location: Sheridan, Wyoming (Stage III)
Stream: Goose Creek
Type of Protection: Channel cutoffs, floodwall, and levees upstream of Stage I
Description: 2.4 miles of intermittent levees and channel improvements
Year Authorized: 1950
Total Cost: $894,000
Status: Lacked local financing. The City of Sheridan was notified on 12 December 1975 that authorization would expire 5 years from that date unless they can provide required local cooperation.

Location: Buffalo, Wyoming
Stream: Clear Creek
Type of Protection: Diversion dam one mile upstream from Buffalo with new overflow channel connecting to existing drainage.
Description: Earthen dam and 0.4 mile diversion channel
Year Authorized: 1950
Total Cost: $2,679,000
Status: Considered for deauthorization because it is economically infeasible.

Location: Dayton, Wyoming
Stream: Tongue and Little Tongue Rivers

Type of Protection: Right bank levee on Tongue River plus tie-back levees along Little Tongue River plus some channel straightening.
Description: 2.1 miles of levee and 0.5 mile of channel improvements
Year Authorized: 1950
Total Cost: $497,000
Status: Recommended for deauthorization in 1974 because it is economically infeasible.

C. Potential Projects

(1) Sheridan, Wyoming levees and channel improvement (Stage III)
(2) Buffalo, Wyoming diversion dam and overflow channel
(3) Dayton, Wyoming levee

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Sheridan, Wyoming
Potential Project: Construction of 2.4 miles of intermittent levees and channel improvements along Goose Creek upstream of Stage I.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $43,000

Adverse Effects:

Installation cost: $894,000
Interest during construction: None (short-term construction period).
Annual investment cost: $60,000
Annual operation, maintenance, and replacement: $1,000
Total annual cost: $61,000

Benefit/Cost Ratio: 0.7

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

14 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$69,000 regional growth per year resulting from flood protection; $89,000 added business created by construction activity.

Adverse Effects:

$61,000 total annual cost; 31 acres lost to land base;
$7,700 average annual residual damages

Social Well-Being Account

Beneficial Effects:

Protects 200 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 10,000 residents;
Encourages more orderly development in protected areas.

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Buffalo, Wyoming
Potential Project: Construction of a diversion dam and overflow channel on Clear Creek.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $149,000

Adverse Effects:

Installation cost: $2,679,000
Interest during construction: None (short-term construction period).
Annual investment cost: $179,000
Annual operation, maintenance, and replacement: $8,000
Total annual cost: $187,000

Benefit/Cost Ratio: 0.8

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

14 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$238,000 regional growth per year resulting from flood protection;
$268,000 added business created by construction activity.

Adverse Effects:

$187,000 total annual cost; 37 acres lost to land base;
$1,000 average annual residual damages.

Social Well-Being Account

Beneficial Effects:

Protects 100 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 3,000 residents;
Encourages more orderly development in protected areas.

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Dayton, Wyoming
Potential Project: Construction of 2.1 miles of levees and channel improvements along the Tongue and Little Tongue Rivers.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $19,600

Adverse Effects:

Installation cost: $497,000
Interest during construction: None (short-term construction period).
Annual investment cost: $33,200
Annual operation, maintenance, and replacement: $500
Total annual cost: $33,700

Benefit/Cost Ratio: 0.6

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

11 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$31,000 regional growth per year resulting from flood protection;
$49,000 added business created by construction activity.

Adverse Effects:

$33,700 total annual cost; 13 acres lost to land base;
$1,000 average annual residual damages

<u>Social Well-Being Account</u>

Beneficial Effects:

Protects 60 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 400 residents;
Encourages more orderly development in protected areas.

7. NORTH DAKOTA TRIBUTARIES

A. Existing Projects

Location: Marmarth, North Dakota
Stream: Little Missouri River and Little Beaver Creek
Type of Protection: Raised levee along left bank of both streams
Description: 2.4 miles of levees
Year Completed: 1959
Federal Cost: $170,000

Location: Mandan, North Dakota
Stream: Heart River
Type of Protection: Left bank levee and channel cut-off for Mandan and right bank levee for Training School
Description: 4.4 miles of levee and 0.5 mile channel cut-off
Year Completed: 1959
Federal Cost: $677,000

Location: Mandan, North Dakota
Stream: Lower Heart River
Type of Protection: Additional channel and levee work both upstream and downstream of Mandan
Description: 3.8 miles of levees, drainage structures, and 1.5 miles of channel relocation.
Year Completed: 1963
Federal Cost: $1,961,200

Location: Scranton, North Dakota
Stream: Buffalo Creek
Type of Protecton: Channel straightening and levees along both banks
Description: 1.0 mile of channel improvement plus 0.5 mile of dual levees.
Year Completed: 1959
Federal Cost: $103,000

Location: Haley, North Dakota (6 miles upstream)
Stream: North Fork of Grand River
Type of Protection: Bowman-Haley Dam and Reservoir
Description: 73,200 acre-feet of flood control storage
Year Completed: 1970
Federal Cost: $4,372,000

Location: Riverdale, North Dakota
Stream: Missouri River
Type of Protection: Garrison Dam and Reservoir
Description: 1,500,000 acre-feet of exclusive flood control storage.
Year Completed: 1955
Federal Cost: $300,000,000

Location: Garrison Dam to Lake Oahe
Stream: Missouri River
Type of Protection: Streambank stabilization
Description: Dikes and revetments at seven critical locations
Year Completed: Under construction (80 percent complete)
Federal Cost: $9,200,000

Heart Butte Dam and Reservoir (constructed by the Bureau of Reclamation) is located on the Heart River about 15 miles south of Glen Ullin, North Dakota. It was completed in 1949 and has 150,000 acre-feet of storage reserved for flood control.

B. Authorized Projects

Location: Mott, North Dakota
Stream: Cannonball River
Types of Protection: Channel improvement and levees along both banks.
Description: 2.0 miles of levees and 0.6 mile channel improvement.
Year Authorized: 1958
Total Cost: $2,215,000
Status: Considered for deauthorization because it is economically infeasible.

C. Potential Projects

(1) Mott, North Dakota levee
(2) Lower Yellowstone Streambank Protection (see Lower Yellowstone Planning Area in Montana for details)
(3) Buford-Trenton Irrigation District - interior drainage
(4) Missouri River streambank protection
(5) Knife River National Historic Site - streambank protection

POTENTIAL PROJECT EVALUATION

Type: Local Protection Project
Problem: Flooding at Mott, North Dakota
Potential Project: Construction of a 2-mile levee and channel improvements along both banks of the Cannonball River.

National Economic Development Account

Beneficial Effects:

Average annual benefits: $112,000

Adverse Effects:

Installation cost: $2,215,000
Interest during construction: None (short-term construction period).
Annual investment cost: $147,900
Annual operation, maintenance, and replacement: $5,100
Total annual cost: $153,000

Benefit/Cost Ratio: 0.7

Environmental Quality Account

Beneficial Effects:

Improved human environment through weed reduction, better drainage, and mosquito control.

Adverse Effects:

3 acres of clearing and grubbing would reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

$179,000 regional growth per year resulting from flood protection;
$221,000 added business created by construction activity.

Adverse Effects:

$153,000 total annual cost; 54 acres lost to land base;
$15,000 average annual residual damages.

Social Well-Being Account

Beneficial Effects:

Protects 140 acres of urban land and improvements from flooding;
Enhances the health and social well-being of 1,300 residents;
Encourages more orderly development in protected areas.

POTENTIAL PROJECT EVALUATION

Type: Interior drainage
Problem: Waterlogging at the Buford-Trenton Irrigation District which is located upstream of Williston, North Dakota along the left bank of the Missouri River (near the upstream end of Lake Sakakawea).
Potential Project: Construction of an earth-fill block for the riverward end of the main drain in the West Bottoms, with a gated conduit to permit gravity drainage during low Missouri River stages. When stages are higher, the gates will be closed and the water level in the main drain will be regulated by two 3,600 gallon per minute pumps discharging over the earth block into the Missouri River. A similar installation is proposed for the Middle Bottoms[redacted]

This plan has been presented by the Corps during formal meetings of the Buford-Trenton Irrigation District in April and July of 1976 and has been indorsed both times as much preferable to land acquisition and meriting a trial. The Corps concluded these works could be designed and accomplished within existing authorities at the Garrison project and has proceeded with the task. It is planned to have the facilities operational by the start of 1978 irrigation season. Total cost of the plan is estimated at $500,000.

Since the solution is implementable within existing Corps authority and no need exists for recommended further action at this time, the on-going planning for improvement of interior drainage need not be included in the Recommended Plan.

POTENTIAL PROJECT EVALUATION

Type: Streambank Protection
Problem: Streambank erosion along the Missouri River between Garrision Dam and Lake Oahe.
Potential Project: Installation of selective river management techniques using variations of several different types of structural bank protection measures at 21 key locations (Streambank Erosion Control Evaluation and Demonstration Act of 1974 plus amendments).

National Economic Development Account

Beneficial Effects:

Prevention of the permanent loss of 60 acres per year of valley lands along the 80-mile reach of the Missouri River downstream from Garrison Dam. Because of the innovative and unproven techniques to be tested in this program, Congress has imposed no requirement for a display of economic feasibility and no attempt is made here to do so.

Adverse Effects:

Installation cost: $7,100,000
Annual investment cost: $474,000
Annual operation, maintenance, and replacement: $71,000
Total annual cost: $545,000

Environmental Quality Account

Beneficial Effects:

Elimination of a major source of sediment which will reduce turbidity levels.

Adverse Effects:

Temporary turbidity of river water at construction site. Disruption of vegetative cover on quarry sites to be used during construction. Conversion of some river fringe woodland to cultivated crops will reduce wildlife habitat.

Regional Development Account

Beneficial Effects:

Stabilization of the location of high river banks along the valley lands reducing risk to dwellings, outbuildings, and cultivation activities. This eliminates a significant source of land damage that affects productivity and on-farm stability.

Adverse Effects:

Temporary loss of crop production at construction sites.

Social Well-Being Account

Beneficial Effects:

Protects livelihood of landowners affected. Improved water quality for all uses and general aesthetics of land and streams.

CHARGE:	PRESERVATION OF PRISTINE PRAIRIE
MODIFIED TO:	PRESERVATION OF NEAR-CLIMAX RANGE CONDITION
FOUR ACCOUNT ANALYSIS	BASED ON AN INDIVIDUAL ACRE OF RANGELAND IN NEAR-CLIMAX CONDITION
INFORMATION COMPILED BY:	SOIL CONSERVATION SERVICE DECEMBER 10, 1976

PRISTINE RANGE: Approximately 52 acres identified. Areas are located in the Badlands.

Rangeland in the 15 county area: 1/

OWNERSHIP	TOTAL ACREAGE	ACREAGE IN NON-CLIMAX CONDITION	STOCKING RATE OF NEAR-CLIMAX RANGE
Private & State	5,846,000 2/	1,788,400	Moderate Use
Public Grasslands	1,028,000 3/	884,000	Moderate Use
Other Public Lands	100,000	74,100	Light or no domestic use
TOTALS	6,974,000	2,746,500	

1/ All acreages are approximate and rounded.

2/ Acreages are based on Conservation Needs Inventory by the Soil Conservation Service

3/ Includes the Little Missouri Grasslands, Custer Grasslands, and Sioux County.

DEFINITIONS:

Pristine Range - Natural areas used by wildlife where there has been little or no grazing by domestic livestock.

The Forest Service has identified about 52 acres total which exist on some 16 buttes scattered throughout the Badlands. Vegetation has been studied on Big Top and Two Tops Mesa.

Near-Climax Condition - Rangeland is approaching the highest state of development of the natural plant community that is perpetuated under the prevailing climate and soil conditions. Rangeland in near climax condition that is grazed by wildlife and/or livestock using good range management.

(note: Example - Theodore Roosevelt National Park - A sizeable amount of both private and public land should be recognized in addition to the above in the 15 county study area.)

Climax Condition - The highest state of development of the natural plant community that is perpetuated under the prevailing climate and soil conditions.

(note - scientific study and experience has shown that protection of ranges over long periods from natural influences such as grazing, fire, insects, and drought does not always typify the climax vegetation. Example: Usually the natural area is invaded by bromegrass and Kentucky Bluegrass. There may be a die out of several climax grasses and flowering plants. Maybe an increase of one or more native woody plants such as sagebrush, buckbrush or silverberry.

NATIONAL ECONOMIC DEVELOPMENT ACCOUNT

COMPONENTS	MEASURES OF EFFECT (Average Annual) 1/
BENEFICIAL EFFECTS:	
A. Value to user of outputs of goods and services.	
1. Agricultural (Rangeland leased to private individuals; with stocking rate managed by public to insure near-climax condition is maintained.	3.18 2/
2. Recreation Use	.30
TOTAL BENEFICIAL EFFECTS	3.48
ADVERSE EFFECTS:	
A. The value of resources to assure preservation.	
1. Project Installation (Land Acquisition)	7.67
2. OM & R	.80
TOTAL ADVERSE EFFECTS	8.47
NET BENEFICIAL EFFECTS	-4.99

1/ 100 years at 6-3/8 percent interest

2/ Net return to rangeland on lease arrangement less operating expenses $7.00 base lease rate per acre per animal unit month, with 7 months of grazing.

STATE REGIONAL DEVELOPMENT ACCOUNT

COMPONENTS	MEASURE OF EFFECTS	
BENEFICIAL EFFECTS:	Region	Adjacent Region
	(Average Annual) 1/	
A. User Benefits		
1. Agricultural	3.18	--
2. Recreational Use	.30	--
TOTAL BENEFICIAL EFFECTS	3.48	--
ADVERSE EFFECTS:		
A. Value of resources contributed from the region to achieve the output.		
1. Land Acquisition	7.67	--
2. Management	.80	--
TOTAL ADVERSE EFFECTS	8.47	--
NET BENEFICIAL EFFECTS	-4.99	--

1/ 100 years at 6-3/8 percent interest

SOCIAL - FACTOR ACCOUNT

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
1. Regional Employment	Preservation and management of rangeland will tend to stabilize employment relating businesses associated with agriculture and recreation.
2. Recreation Opportunities	Will help maintain recreational vistor-day activities.
3. Life, Health, and Safety	Preserve opportunities for observing wildlife in its natural habitat.

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
A. Scenic and Natural Areas	Maintaining and managing native prairie retains diversity of flora and fauna for maximum human enjoyment. These areas also contain the land forms most attractive and scenic which tend to draw people to them. Examples are the prairie communities or those with unique vegetation or scenery such as the pine areas, columnar juniper, badlands, buttes, canyons, and hardwood draws. Open space is an added attraction of the prairie.
B. Biological Resources	Climax and near climax prairie supports the major part of the observable wildlife of the area. Heavily used range or cropland is used by wildlife rather sporadically and does not generally provide critical habitat. Species dependant on range include mule deer, white-tailed deer, pronghorn, sage

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
	grouse, sharp-tailed grouse,western meadowlark, grasshopper sparrow, chestnut collared longspur, and ferruginous hawk. This part of the state contains a number of rare or relict plant species assoc-lated with rangeland or unique land forms
C. Water Quality	Retaining prairie and managing at a high level assures lowest possible levels of sediment in runoff, which in turn compli-ments receiving waters as well as its uses for recreation, irrigation, fisherie or municipal water.
D. Ground Water	Retaining range or prairie in high quality assures the least change in underground water regimes. Converting to other uses may disrupt under ground water supplies or produce saline seeps which in turn may degrade runoff water.

BENEFICIAL AND ADVERSE EFFECTS	MEASURE OF EFFECTS
E. Geological, archeological, paleontological and historical resources	Retention of native prairie provides the best opportunity to preserve areas of high human interest, history and places for study. The Little Missouri Grassland Study located in the western part of the adjacent coal area counties 36 archeological sites, 17 paleontologi sites and 25 historical sites not inclu ing historic trails.

DEPARTMENT OF THE ARMY
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
P. O. BOX 103, DOWNTOWN STATION
OMAHA, NEBRASKA 68101

MRDPD 16 May 1977

MEMORANDUM TO: Don Ohnstad, Assistant Study Manager, North Dakota

FROM: Wayne Stufft, Corps of Engineers

SUBJECT: Additional Hydro-Electric Power at Garrison Dam

As I understand it, two basic questions came up during your last State Study Team meeting in Bismarck regarding a BOR proposal for a recreation river downstream of Garrison Dam. The questions were as follows:

1. How would a potential Corps' re-regulating structure downstream of Garrison Dam affect the "recreation river" proposal?

2. How would the proposed Corps' bank protection measures downstream of Garrision affect the recreation river?

First, let me go into a little of the background. As you know, the Corps of Engineers recently completed a draft report based on a study of the Missouri River from Sioux City, Iowa, to Three Forks, Montana. The draft report, commonly known as the "Umbrella Report," is currently undergoing extensive review by all interested parties.

The tentative recommendations of the draft "Umbrella Report" include a proposal to construct additional hydro-electric power units at Garrison Dam. The three new units would have an installed capacity of 272 megawatts and would cost about $70 million. A westward extension of the existing powerhouse would utilize three modified flood control tunnels, thereby permitting a large saving in construction costs. The plan selected in the Umbrella Report did not include a re-regulation dam, primarily because of economics. This does not mean that one can't be added later on. If a re-regulation structure was included, it would probably be built about 11 miles downstream of Garrison Dam, but upstream of the mouth of the Knife River.

I've inclosed a "potential project evaluation" for the Garrison addition, similar in format to the previous proposals for flood control and streambank protection. You will probably want to send copies to your State Study Team members before the next meeting. You might also send them a copy of this memo, if you want to.

Getting back to the original questions - I think a "recreation river" would probably be in conflict with the existing Garrison project because of the wide fluctuations in water surface elevations, not even considering the additional power units.

This can be checked with BOR, the agency having jurisdiction over "National Recreation River" designation, to see if such designation would meet the criteria. However, we are at the present time considering the need to provide a re-regulating structure below Garrison if additional units were to be installed. It may well be that with re-regulation, the river below this structure could meet the criteria for Recreation River designation. As noted below, we do not believe bank stabilization measures would detract from such designation. Again, this would have to be pursued further with BOR.

The Corps of Engineers has proposed a recreation river downstream of Gavins Point Dam, but releases there have always been relatively uniform because the dam was located the farthest downstream and was designed with re-regulation in mind. The streambank protection proposed under the Evaluation and Demonstration Act of 1974 should be compatible with a recreation river since the Missouri River would be maintained in its current alinement and would not be channelized like it is downstream of Sioux City, Iowa, for navigation purposes.

Wayne Stufft
WAYNE STUFFT

POTENTIAL PROJECT EVALUATION

Type: Hydro-Electric Power

Need: Future Peaking Power

Potential Project: Three additional hydro-electric power units at Garrison Dam utilizing existing flood control tunnels. The three new units would have an installed capacity of 272 megawatts. (This alternative does not include a re-regulation structure).

National Economic Development Account

Beneficial Effects:
Average annual benefits: $9,579,000

Adverse Effects:
Installation Cost: $64,100,000
Interest during construction: $6,000,000
Annual investment cost: $4,478,000
Annual operation, maintenance, and replacement: $232,000
Annual recreation loss: $80,000
Total annual cost: $4,790,000

Benefit/Cost Ratio: 2.0

Environmental Quality Account

Beneficial Effects:
None

Adverse Effects:
Increased river stage fluctuations downstream from Garrison Dam. Loss of about 190 acres of terrestrial habitat bordering the river due to a one-time bank slope adjustment. This loss will be mitigated by acquisition of 285 acres of similar habitat.

Regional Development Account

Beneficial Effects:
Power marketing: $5,186,000
Peak construction employment: 290
Operation and maintenance employment: 5
Value of housing temporarily inflated in nearby communities

Adverse Effects:
About $1,200 in taxes lost per year on agricultural land.
About $8,000 income lost per year from agricultural land use.

Social Well-Being Account

Beneficial Effects:

Retail and service activities stimulated by construction
National goal of energy self-sufficiency enhanced.

Adverse Effects:

Drastic daily fluctuations in stage greatly reduce recreation opportunities immediately below dam.

285 acres acquired for wildlife mitigation unavailable for any other uses.

Construction workers and families may place some stress on local community services and facilities.

RURAL AND MUNICIPAL WATER FOR NORTH DAKOTA

The Bureau of Reclamation was asked to look at the possibility of delivering municipal and industrial water to Dickinson, North Dakota, from the Missouri River. Farms and towns along the way would also be served. Two routes were investigated and designed to serve the population expected in the year 2025. Route 1 would bring water down from Lake Sakakawea. The service area is shown in blue on the map. The total investment cost would be $56,121,000 at January 1975 prices. The cost per thousand gallons would be $1.73. Route 2 would bring water west from Mandan, North Dakota. The service area is shown in red on the map. The total investment cost would be $73,226,900 and the water would cost $2.28 per thousand gallons.

Route 2 is more expensive because it is longer and the water must be lifted higher. In both cases it was assumed that all of the towns would take water but only 40 percent of the rural people would want to be included. Enough was allowed to irrigate lawns and gardens, provide stock water, and water for business and industry.

The Route 1 annual cost is estimated at $320 for a rural family and $220 for a town or city family. If Route 2 were selected, the annual cost would be $420 for a rural family and $290 for a town or city family. The difference between rural and city costs is due to stock watering and larger gardens.

RURAL AND MUNICIPAL WATER FOR NORTH DAKOTA

Route 1

Maximum flow	30 ft^3/s
Number of main line pumping plants	3 each
Total dynamic head - main line	1,420 feet
Main line diameter	30 inches
Main line length	55 miles
Treatment plant size	17 Mgal/d

Route 2

Maximum flow	29 ft^3/s
Number of main line pumping plants	3 each
Total dynamic head - main line	2,100 feet
Main line diameter	30 inches
Main line length	90 miles
Treatment plant size	17 Mgal/d

The Use of Ground Water in a Rural Water System

Most farms and ranches in southwestern North Dakota obtain their water supply from bedrock aquifers. These aquifers usually yield adequate quantities of water but the quality is often poor. For these reasons rural water systems for southwest North Dakota have become a topic of discussion.

The typical glacial-alluvial deposits usually found in southwest North Dakota yield water of higher quality and quantities than the yields from bedrock formations. However, in this region of the state, the glacial aquifers are quite variable and test drilling becomes necessary to locate a suitable source. Glacial aquifers are also sparsely located and usually limited to the stream valleys. The water found is often hard and may require softening.

It is questionable if untreated water from a bedrock aquifer would be feasible for use in a rural water system. Rural water systems require substantially more water than most shallow bedrock aquifers can produce. It may be necessary to develop a well field for a water system in deeper formations, such as Hell Creek or Fox Hills. The water produced from these formations is not on the average superior to what the average farm is currently using. Therefore, it would be of little value to distribute water of this quantity.

Desalting ground water has been studied and is a future possibility. The UND Experiment Station prepared a report in 1974 on the "Feasibility of Using Ion Exchange Techniques in North Dakota. The report analyzed treating ground water supplies for several North Dakota cities. All waters were treated to recommended Health Standard limits.

Summary results of the cities within the study area are shown below.

CITY	ION-EXCHANGE COSTS* (cents per 1000 gallons)	DESIGN CAPACITY (gallons per day)
Beach	105	275,000
Hebron	198	150,000
Dickinson	40	2,000,000

*These costs do not include the well costs, although this cost should not increase the total cost by more than 10%.

Costs per 1000 gallons increase significantly as the size of the treatment plant decreases. Therefore, costs would need to be developed for each individual system. Possibly, future rural water studies should compare the use of treated ground water to diverted surface water supplies.

REMAINING NEEDS - LAND CONSERVATION

In addition to the land conservation measures that have been projected for installation by ongoing programs, there will be sizeable areas that will not be treated by the year 2000. These areas are classified as "Remaining Needs" that should be evaluated to determine if it would be desirable to accelerate the installation of land conservation measures. These remaining needs need to be considered for both the National Economic Development and Environmental Quality objectives. It can then be determined if any of these needs should be included in the recommended plan.

It is estimated that there will be 3,609,200 acres of land in the planning area still needing treatment in the year 2000 if there is no acceleration of the ongoing programs. This includes 33,500 acres of untreated lands in federal ownership and 3,575,700 acres in the non-federal sector. The remaining costs to treat these lands have been estimated to be $2,238,000 for federal lands and $99,146,000 for non-federal lands. A breakdown of the remaining needs by land use and ownership is as follows:

Remaining Land Conservation Needs

Land Use and Ownership	Acres	Dollars
Non-irrigated cropland	1,584,500	87,148,000
Federal	0	0
Non-federal	1,584,500	87,148,000
Irrigated cropland	21,500	2,482,000
Federal	0	0
Non-federal	21,500	2,482,000
Non-irrigated Pasture	112,100	2,524,000
Federal	0	0
Non-federal	112,100	2,524,000
Irrigated Pasture	0	0
Federal	0	0
Non-federal	0	0
Range	1,880,500	9,184,000
Federal	33,500	2,238,000
Non-federal	1,847,000	6,946,000

Remaining Land Conservation Needs (Continued)

Land Use and Ownership	Acres	Dollars
Forest-Commercial	6,400	16,000
Federal	0	0
Non-federal	6,400	16,000
Forest-Non-commercial	4,200	30,000
Federal	0	0
Non-federal	4,200	30,000
Other	0	0
Federal	0	0
Non-federal	0	0
Total	3,609,200	102,384,000
Federal	33,500	2,238,000
Non-federal	3,575,700	99,146,000

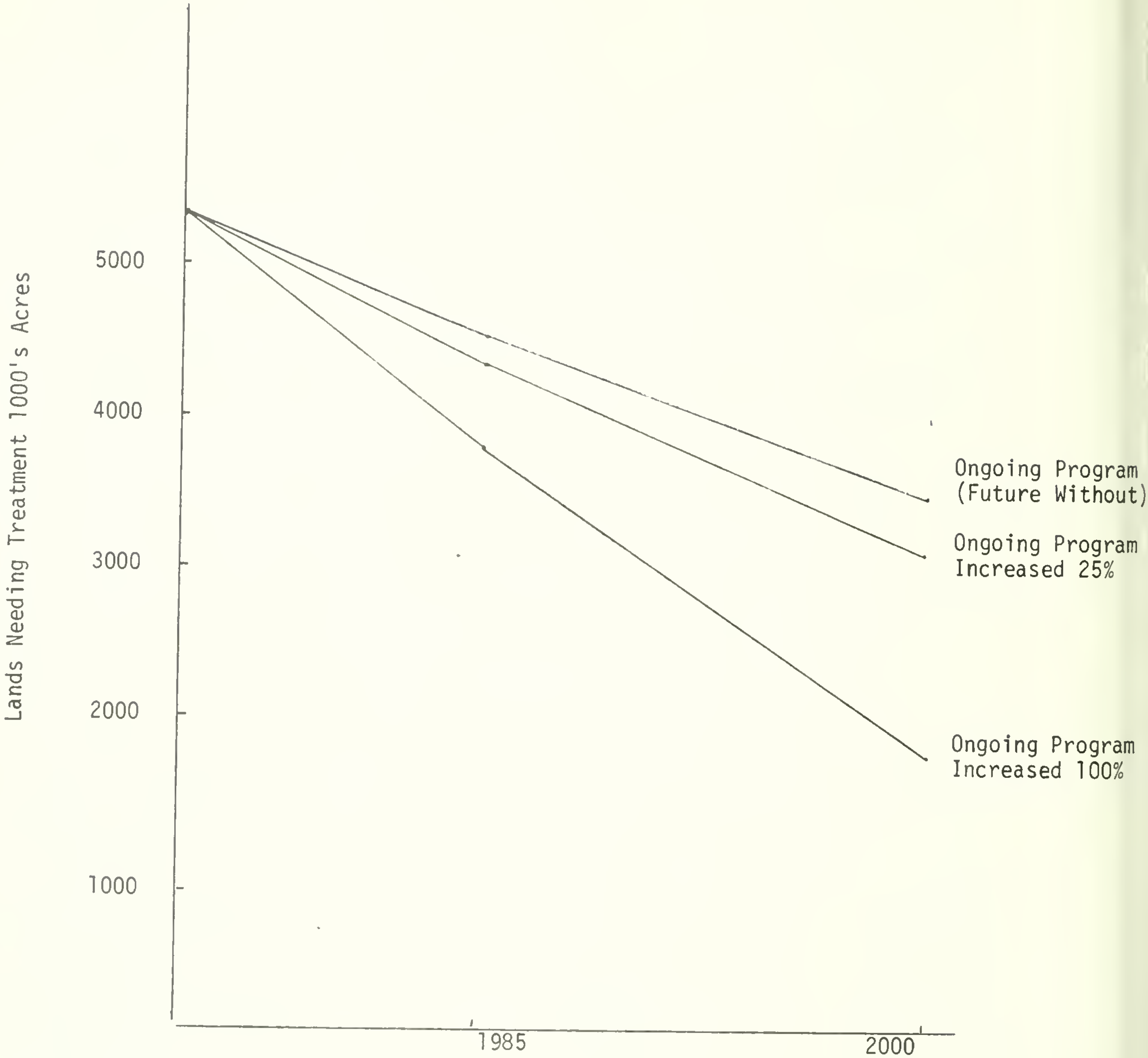


Figure V-6 . Comparison of Land Conservation Alternatives
Non-Federal Land, Remaining Treatment Needs (Acres)

ENVIRONMENTAL QUALITY PLAN; NORTH DAKOTA TRIBS Planning Area

PLAN ELEMENT	ACCOUNT: NATIONAL ECONOMIC DEVELOPMENT	ACCOUNT: ENVIRONMENTAL QUALITY	ACCOUNT: STATE-REGIONAL DEVELOPMENT	ACCOUNT: SOCIAL WELL-BEING
Accelerate Land Conservation a. State and Private Lands 1,787,000 Acres b. National Resource Lands 14,000 Acres c. Forest Service Lands 5,500 Acres	a. Cap. Cost $49,573,000 *Ann. Equiv. Cost $4,017,400 b. Cap. Cost $140,000 *Ann. Equiv. Cost $11,300 c. Cap. Cost $1,198,000 *Ann. Equiv. Cost $97,100 Annual Benefits - Not computed - assumed to be at least equal to costs.	1. Additional reduction of soil loss and sediment yield above future-without condition. 2. Increased vegetative cover resulting from improved management of existing resources. 3. Additional depletion of streams due to increased consumptive use by added vegetative cover. 4. Improved quality of Fish and Wildlife habitat, including cover, forage, watering places, waterfowl nesting sites, and establishment of fisheries. 5. Increased depletion of water resulting from added surface evaporation from ponds. 6. Reduce soil nutrients from entering streams and the underground water table. 7. Reduction of undesirable return flows to streams. 8. Increased fire hazard from added production of forage plant species.	1. Maintain and/or enhance the output of goods and services to users in the region. 2. Provide additional employment in the application and maintenance of proposed measures. 3. Provide additional permanent employment in processing increased goods and services.	1. Improved downstream water quality for all uses. 2. Improve general aesthetics of the land.

*6 3/8 percent interest for 25 years.

YELLOWSTONE LEVEL B

PLAN FORMULATION

CHARGE: Protection and management of unique woodland areas

LOCATION: Little Missouri National Grassland and Slope County, Western North Dakota Planning Area

IMPLEMENTATION: U. S. Forest Service and county or State governement

SOURCE OF INFORMATION: Management Prescription for the Badlands Planning Unit, Little Missouri National Grasslands. 1974. USDA, Forest Service, Custer National Forest, Billings, Montana.

DATE COMPILED: 4/18/77

CONTACT PERSON: Fred Martin, U.S. Forest Service, Missoula, Montana

PROPOSAL: To protect and manage the unique values of 10,270 acres of ponderosa pine, 735 acres of limber pine, and 100 acres of columnar juniper and adjacent areas by administrative action on Federal lands and through acquisition of easements on private lands.

PRESENT STATUS: The above lands have been identified as having unique values. Action on the Federal lands has been taken through the unit planning process to restrict and control development that could deteriorate existing plant communities. None of the Federal land has received administrative designation, but the limber pines area, 735 acres, is being evaluated as a Research Natural Area. Action on the private lands consists of grazing controls under direction of local grazing associations, in conjunction with the Little Missouri National Grasslands. Management practices on the private lands are currently adequate to protect these plant communities. No immediate threat is perceived for these areas, but surface disturbances from mineral exploration or development could occur during the planning period, especially in the ponderosa pines area.

RESOURCE DESCRIPTION: About 735 acres of limber pine (Pinus flexilis) are located in western Slope County, of which 532 acres are in Federal ownership and 203 acres are privately owned. No other native stands are found in North Dakota or eastern Montana. It is thought that their origin may have been from seeds brought by the Indians from stands in the Black Hills, and accidentally, or purposely, were seeded around a campsite in the area.

About 10,270 acres of ponderosa pine (Pinus ponderosa) are found along the Little Missouri River, of which 2,849 acres are Federally owned and 7,430 acres are privately owned. The largest area of ponderosa pine is found in north central Slope County. Their presence is thought to be due to the soil and physiographic conditions of the area. The ponderosa pine in the area represents the northeastern extreme of its range and it is the only native ponderosa pine in North Dakota.

A small stand of columnar juniper (Juniperus scopulorum) is located in the proximity of the Burning Coal Vein northwest of Amidon, North Dakota, occupying 100 acres, all in Federal ownership. Their unique form is popularly attributed to the sulfur fumes emitted from the burning lignite in the area, but the columnar form is actually a genetic variation within the species. Small areas of columnar juniper have also been reported in Montana and Utah.

NED ACCOUNT:

Beneficial Effects

No quantifiable NED effects have been identified.

Adverse Effects

Cost of protection on the private lands
Easement acquisition on 7,633 acres

$40/acre on 7,633 acres[1/]	$20,000[2/]	
Net Effects		-$20,000

SRD ACCOUNT:

Beneficial Effects

No quantifiable SRD effects have been identified.

Adverse Effects

Easement acquisition on 7,633 acres	$20,000	
Net Effects		-$20,000

SOCIAL WELL-BEING ACCOUNT:

Beneficial Effects

1. Educational, cultural, and recreational values would be maintained and enhanced through protection of vegetation and esthetic values.

2. Economic base would be maintained as current land use practices would be continued at current rates, thus tending to stabilize employment and related business activity.

3. Livestock cover would be preserved, eliminating need for artificial structures requiring capital investment.

4. Local watershed values would be maintained along with protection of ground water resources.

5. Opportunities to landowners for partial gifting of easements permitting estate tax advantages for maintaining family farm units would be created.

6. Elimination of the need for governmental land use controls such as zoning.

7. No reduction in county tax base because existing land use and ownership would not change.

Adverse Effects

1. No measureable adverse effects on regional employment have been identified because current land use practices would be maintained.

2. No measureable adverse effects on population increases or decrease have been identified.

3. No increase in recreational use is anticipated because the proposal does not include recreational development orj management.

4. Future projects requiring land disturbance would have to be located elsewhere, possibly at greater expense. Future land use changes might require modification, or be prevented, resulting in some potential constraints on private landowners. This proposal, however, provides compensation to the landowner through public purchase of these potential development rights. These adverse effects may never materializae and are unlikely to occur within the planning period.

EQ ACCOUNT:

Beneficial Effects

1. The natural beauty of these woodland stands would be maintained and protected in an area generally devoid of forest vegetation.

2. Archeological, historical, and cultural sites would be protected as a result of the proposal.

3. The native diversity of the flora and fauna, valuable for human enjoyment and scientific inquiry, would be protected and managed to maintain its unique values.

4. Maintenance of woodland vegetation provides important cover for wildlife in the area. Local watershed and climate relief values would be maintained along with the conservation of soil resources.

5. These woodland areas are unique to western North Dakota, and if destroyed cannot be naturally replaced, and may indeed be irreplaceable at any cost.

6. Actions affecting the integrity of these vegetation stands, especially the limber pines, are irreversible during the planning period, and may be irreversible regardless of the time period considered.

Adverse Effects

No adverse effects to the environment have been identified.

1/ Total cost of acquiring protective easements calculated as one-third of current market value, including administrative and legal expenses. Protective easements would consist of public purchase of rights to control: 1) off-road vehicle use; 2) surface alteration and tree cutting, and 3) surface disturbance from mineral exploration or development. Rights purchased would not include mineral rights or public access provisions such as rights-of-ways. No condemnation of land is proposed or implied.

2/ Annual equivalent calculated at 6 3/8 percent for 100 years. Average market value estimated at $120 for these areas of marginal agricultural value.

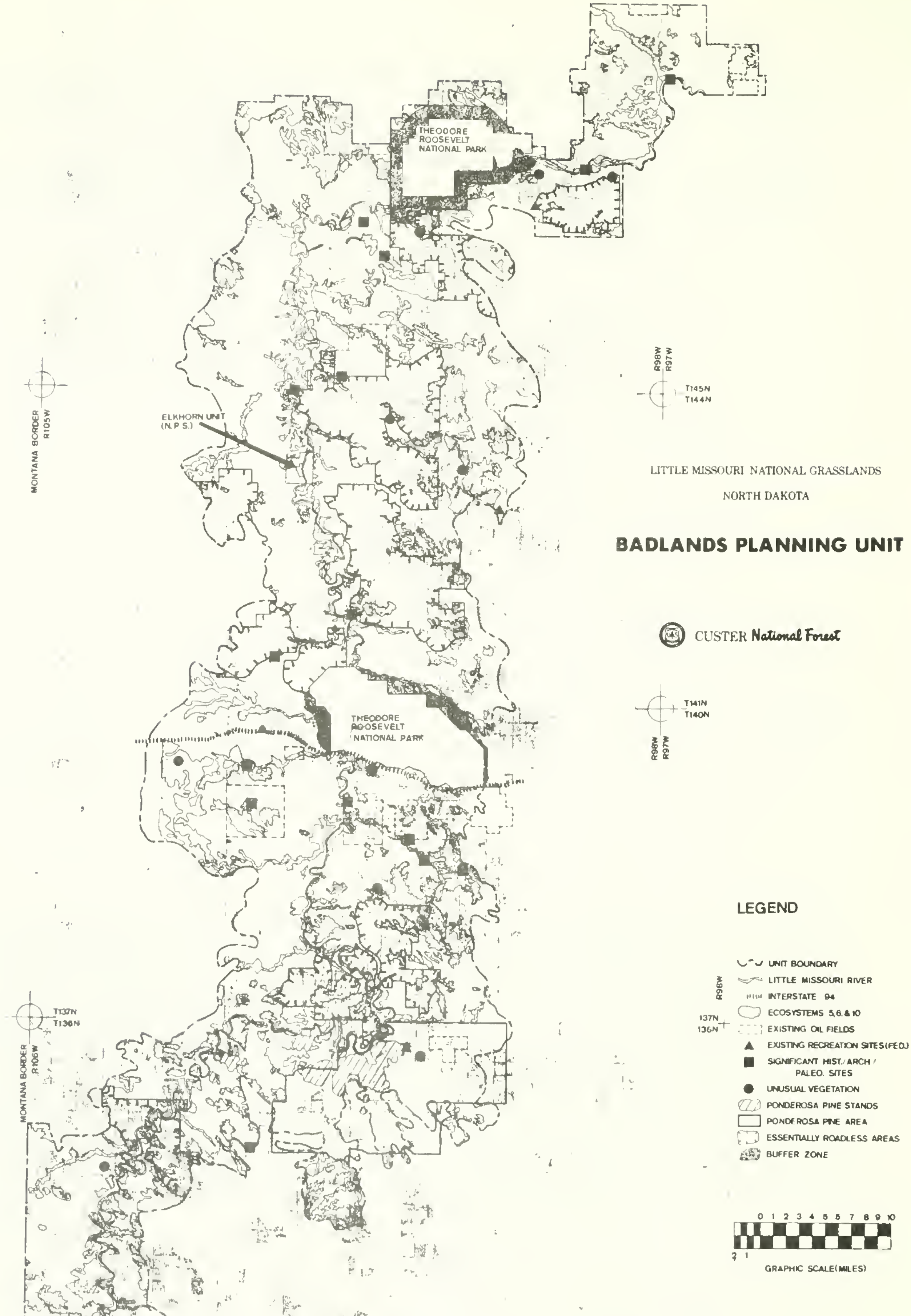


Figure 5

Management Prescription Map

DAKOTAS PLANNING TEAM 1974

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
R-1

REPLY TO: 3520 River Basin Programs

June 16, 1977

SUBJECT: Protection of Unique Woodland Vegetation

TO: Donald Ohnstad
Missouri River Basin Commission
601 E. Bismarck Ave., Rm. 16
Bismarck, ND 58501

At the last Yellowstone Level B North Dakota State Study Team meeting, the addition of NED, dollar, recreation benefits accruing from our proposal to protect unique woodland vegetation was suggested. After further reviewing this proposal, our position remains essentially the same as expressed at the Dickinson meeting. That is, we do not believe that under Principles and Standards, direct NED values accruing from this proposal can be identified. The reasons for this situation are:

1. We are not proposing an increase in recreational use above and beyond that which would occur without the proposal.

2. In fact, our proposal is concentrated on protecting unique vegetation, which may require regulation of recreational use to levels lower than would naturally occur, should such use deteriorate these vegetation communities.

3. Our proposal is for the protection of these areas from unforeseen and unpredictable disturbances. The social and environmental values of these areas are great enough to warrant protective investment as measured by the acquisition costs, despite the fact that no immediate threat is foreseen. We do not believe, however, that we can use undeterminable future threats to these areas as a basis for stating the annual equivalent value of recreational benefits.

In order to provide a quantification of existing NED values, we suggest that the following footnote be made a part of our proposal under the Beneficial NED account:

> "Although the future NED benefits cannot be quantified at this time, the following values indicate that potential dollar losses may result should these unique woodland areas be destroyed.

"Existing recreational use associated with these areas is estimated at 11,500 visitor days per year. Each visitor day is estimated to have a dollar value of $9.10. Current NED value accruing from these areas is $104,650 per year."

We hope that the above comments will be helpful in addressing the issue raised by the State Study Team.

Glenn Roloff

For SAMUEL BECKER
Director
Area Planning & Development

Enclosure

cc: Darrell Harrison, District Ranger, Medora RD

QUANTIFICATION OF RECREATIONAL USE VALUES FOR UNIQUE WOODLAND VEGETATION IN NORTH DAKOTA

EXISTING VISITOR DAYS (VD)

Limber Pines Area	=	100 VD
Columnar Juniper Area	=	2,000 VD
Ponderosa Pines Area (18,800 VD in Slope County of which 50% estimated associated with the Ponderosa Pine Area).	=	9,400 VD
Total VD	=	11,500 VD

EXISTING USE CHARACTERISTICS

Each VD estimated to include:

One recreational day of camping for 8 hours.

One recreational day of enjoying unique environments for 4 hours.

VALUES FOR EXISTING USE

1 recreational day of camping = \$2.10

1 recreational day of enjoying unique environments = \$7.00

Total recreational day value for 12 hours = \$9.10

Total Value = 11,500 VD @ \$9.10/VD = \$104,650

Sources: RIM Reports
Darroll Harrison, Medora District Ranger
Recreation Economic Analysis Letter of 3/7/75

Explanation of NED Account for
High Energy Scenario
in North Dakota Tributaries

Total benefits for electrical generation are based on the discounted (at 6-3/8 percent) total operating costs as developed by Harza. The Harza estimates include an internal rate of return of 15 percent, interest on equity, interest on debt and depreciation; consequently, the operating costs allow for capital recovery and a fair rate of return. FPC rate structure probably would permit a firm to base its rates on total costs; therefore, total operating costs as calculated by Harza would be equivalent to the price for power. Based on these calculations the price for power would be about 10.5 mills per kilowatt hour. The benefits were discounted over a 30-year time period.

The yearly costs were also based on the Harza numbers, but reduced by the 15 percent internal rate of return. Costs included coal at $7.69 per ton, plant operating costs and water at $250 per acre foot.

Export coal was treated similar to electricity. Harza's total mining costs (selling price) which includes all taxes, were used to estimate benefits. These were then reduced by 15 percent to estimate costs.

Coal gas was treated differently. Benefits were estimated at

$2.03 per thousand cubic feet (Harza, p. C-8). Costs were estimated at $3.15 per thousand cubic feet which is $3.70 less 15 percent for internal profit that is included in the $3.70.

The costs due to loss of agricultural land fall into two categories. The first category involves land that is purchased for plant sites and mining equipment sites. The value of that loss is contained in the costs of the power plant and mines since their costs include land acquisition. Land values reflect the agricultural productivity of the land as well as other items.

The second category of costs to society is due to lost agricultural production from stripped areas which varies by crop. For a given crop the loss can be estimated by determining the gross value of the crop loss. However, since the crop will no longer be produced, resources, e.g., fuel and fertilizer, will be released which is a gain (benefit) to society. The net loss per acre to society, therefore, is the relevant figure. An estimate of that net value is provided by ERS's Firm Enterprise Data System. This system provides budgets by crop by state and area within each state. The budgets show net returns to land, overhead, risk and management which was used for estimating the net loss (cost) to society from loss of the agricultural production of the land. The crop in the area that had the highest return in the 1974 budgets was used, consequently, the estimate per acre is a maximum.

It was further assumed that each stripped acre would be out of production five years. That assumption is an oversimplification but one that seems reasonable.

The acres lost to strip mining each year were determined by the scheduled on line capacity of the mines. The number of acres times the proper value provided a yearly cost. These costs were discounted to 1975. The total discounted value was amortized over the appropriate time period to arrive at a yearly cost for the loss of agricultural production.

NED Account for High Energy Scenario in North Dakota Tributaries[1/]

Yearly Benefits	(Millions of $)
Electricity	304.4
Export Coal	118.8
Coal Gasification	511.3
Total Gross Benefits	$933.7
Yearly Costs	
Electricity	258.7
Export Coal	100.3
Coal Gasification	793.5
Loss of Agricultural Production[2/]	.44
Total Costs	$1,152.94
Net Benefits Per Year	$-219.24

1/ Based on data in Analysis of Energy Projections and Implications for Resource Requirements, by Harza Engineering Company, December 1976, and backup data provided by Harza to study management.

2/ Estimate based on Durum wheat following fallow which nets $76 per cropped acre to the land, overhead, risk and management. Since it requires one acre of idle land for fallow, the effective return is $38 per acre.

ENERGY STUDY OF YELLOWSTONE RIVER BASIN
AND ADJACENT COAL AREAS

Environmental Quality Account
at
High Level of Development

BENEFICIAL EFFECTS

Energy development will have no significant beneficial effects on the environmental quality of the study area.

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Energy-related facilities will impose definite long term obtrusions to the visual quality of the areas they are in. Such facilities include the coal mines; coal gasification plants; coal-fired electric generating plants; electric transmission lines; synthetic gas, water, and slurry pipelines; and additions to railroads and highway systems. The anticipated increases in number of major facilities from 1975 to 2000 are as follows:

State	Coal Mines	Gasification Plants	Electric Plants
North Dakota	30	10	11

Land requirements for these facility sites will range from 10,992 acres in 1985 to 18,663 acres in the year 2000. In addition, strip mining activities will affect from 2,072 acres/year in 1985 to 6,061 acres/year in 2000. Rights-of-way for new energy transportation systems and pipelines will also affect a significant amount of acreage. Use of these lands will preclude their use for recreational and other human activities for a long period of time. Energy development will also result in a sizeable expansion of urban centers within the study area and especially those towns and cities closest to the major energy facility sites.

Increased rail and highway traffic will also be an annoyance in the study area and beyond. Noise created by mining, transportation, and energy conversion of the coal resources will be disturbing to nearby rural inhabitants and population centers.

Aerial emissions from energy production will also be esthetically displeasing, not only at the immediate sites of major facilities, but smokestack emissions will have a significant effect for long distances downwind from sites of energy conversion plants.

Biological, geological, and ecological elements: Vegetation removal from sites of major energy production facilities will amount to from 10,992 acres (1985) to 18,663 acres (2000) of natural grassland and cultivated cropland. These areas will remain unvegetated for the life of the facilities. Strip mining activities will additionally destroy vegetative communities at the rate of about 2,072 acres per year (1985) to 6,061 acres per year (2000). Reclamation of these lands will take from 3 to 5 years under normal climatic conditions. Under a continuous reclamation program, the number of acres of lands being reclaimed at any one time will amount to 3 to 5 times the amount of those lands being strip mined during any 1-year period. However, the potential for fully or even partially reclaiming some of the strip mined lands to natural vegetation or to cropland is still very questionable.

Natural vegetation and crops on the areas surrounding, and downwind from, energy conversion plants will be subjected to low levels of aerial contaminants over a long period of time. Such exposure may cause acute or chronic injury to such vegetation and may also inhibit growth.

Lands used for major energy facility sites will be lost as wildlife habitat for the life of the facilities. Strip mined lands will also be lost as wildlife habitat unless or until they are reclaimed to some degree. The habitat value of the reclaimed lands will be dependent on the level of success of the reclamation program. Wildlife populations which will most likely be reduced or otherwise adversely affected by habitat losses and habitat deterioration or fragmentation include pronghorn antelope, deer, native grouse, coyotes, and small grassland birds, mammals, and reptiles. Also, as long as the affected lands are in an unvegetated or sparsely vegetated condition, they will be unavailable to domestic livestock for grazing.

Depletion of water supplies and potential degradation of water quality, caused by energy production, will have harmful effects on aquatic life in the streams and impoundments which will be drawn from.

Strip mining will disturb the natural topography of the landscape. Natural surface drainages as well as ground water levels and flows will be altered. Disturbance of soils will result in changes in soil permeability and will expose earth surfaces which contain high concentrations of salts, nutrients, and trace elements. Although topsoils may be removed during the mining process and saved, the remaining soil strata may be so disturbed that the resultant soil configuration may not produce vegetation.

Irreversible considerations: Mining activities within the study area will produce hundreds of millions of tons of coal per year. Utilization of this resource for energy production within and outside of the study area will be a permanent irreversible use of a nonrenewable resource. Water requirements for mining, slurry pipelines, and for energy conversion will amount to hundreds of thousands of acre-feet per year. This will be an irreversible use of water resources on a yearly basis. Combined coal production and water requirements for the study area are as follows:

Coal Production
million tons/year

North Dakota

1985	2000
54.1	158.26

Water Requirements
acre-feet/year

North Dakota

1985	2000
115,987	224,779

Due to the large area which will be affected by the mining and other energy-related activities, there may be significant disturbance or destruction of archeological or historical sites, especially of unidentified sites. Loss or destruction of such cultural resources is often irreversible depending on the location and nature of the site.

Water quality: The quality of both surface and ground water in the study area and adjacent areas will most likely suffer some degradation. Strip mining activities will result in increased runoff and erosion from land surfaces, thus causing increased siltation of surface waters. Leaching of exposed earth surfaces such as spoil piles and coal stockpiles will result in increased mineralization of surface and ground waters. Potential dewatering of mine and plant excavations into natural waterways will add to the TDS concentration of receiving waters. Withdrawal of water for energy development activities, and not returning same, will also tend to increase the TDS concentrations in the respective streams, water impoundments, and ground water aquifers which will be drawn from.

Aerial emissions from energy conversion plants will have a degrading effect on surface and ground waters. Salts from cooling tower drift and fly ash, sulfur and nitrogen oxides, and trace elements will eventually precipitate out of the atmosphere and fall on soil or water surfaces. Contaminants which are deposited on soil surfaces will be rewetted by precipitation and will then enter ground or surface waters. The end result will be increased mineral, acid, and nutrient concentrations in these waters.

Air quality: Strip mining activities such as excavating, blasting, loading, and hauling, will create significant levels of dust and exhaust emissions at the mining sites and along coal transportation corridors. Wind erosion of disturbed land surfaces, as well as potential coal refuse fires, will create air pollution problems in the mining areas.

Stack emissions from energy conversion plants will have the most profound effect on air quality of the study area. The major aerial pollutants emitted by the coal fired generating plants and coal gasification plants will be fly ash, sulfur and nitrogen oxides, and trace elements. The predicted levels of air pollutant emissions are as follows: (See following page).

The impacts of these aerial emissions will extend beyond the study area. The level of impact will decrease proportionately to the increase in distance from the emission sites.

Expansion of urban centers as a result of energy development will also contribute to the degradation of air quality in the study area.

Emissions Tons/year	North Dakota 1985	2000
Particulates	18,114	30,655
Sulfur Oxides	216,331	357,363
Nitrogen Oxides	178,435	279,211
Totals	412,880	667,229

ENERGY STUDY OF YELLOWSTONE RIVER BASIN
AND ADJACENT COAL AREAS

Environmental Quality Account
at
NED Energy Development Scenario

BENEFICIAL EFFECTS

Energy development will have no significant beneficial effects on the non-human environmental quality of the study area.

ADVERSE EFFECTS

Areas of natural beauty and human enjoyment: Energy-related facilities impose definite long-term obtrusions to the visual quality of the areas they are in. Such facilities include the coal mines; coal-fired electric generating plants; electric transmission lines; and water supply. The anticipated number of major facilities in 1985 and 2000 are as follows:

State	Coal Mines 1985	Coal Mines 2000	Electric Plants 1985	Electric Plants 2000
North Dakota	6	32	16	18

Land requirements for these facility sites range from 17,334 acres in 1985 to 27,638 acres in the year 2000. In addition, strip mining activities will affect 793 acres in 1985 and 6,315 acres in 2000. Use of these lands will preclude their use for recreational and other human activities for a long period of time. Energy development has resulted in expansion of urban centers within the study area and especially those towns and cities closest to the major energy facility sites.

Increased rail and highway traffic is an annoyance in the study area. Noise created by mining, transportation, and energy conversion of the coal resources is disturbing to nearby rural inhabitants and population centers.

Rights-of-way for new energy transportation system and pipelines will affect a significant amount of acreage

Aerial emissions from energy production are esthetically displeasing, not only at the immediate sites of major facilities, but smokestack emissions have a significant effect for long distances downwind from sites of energy conversion plants.

Biological, geological, and ecological elements: Vegetation removal from sites of major energy production facilities will amount to from 17,334 acres (1985) to 27,638 acres (2000) of natural grassland and cultivated cropland. These areas remain unvegetated for the life of the facilities. Strip mining activities destroy additional vegetative communities at the rate of about 793 acres in 1985 and 6,315 acres in 2000. Reclamation of these lands takes from 3 to 5 years under normal climatic conditions. Under a continuous reclamation program, the number of acres of lands being reclaimed at any one time during the time frame will amount to three to five times the amount of those lands being strip mined during any 1-year period.. However, the potential for fully or even partially reclaiming some of the strip mined lands to natural vegetation or to cropland is still questionable.

Natural vegetation and crops on the grass surrounding, and downwind from, energy conversion plants are and will be subjected to low levels of aerial contaminants over a long period of time. Such exposure may cause acute or chronic injury to such vegetation and may also inhibit growth.

Lands used for major energy facility sites are lost as wildlife habitat for the life of the facilities. Strip mined lands are also lost as wildlife habitat until they are reclaimed. The habitat value of the reclaimed lands will be dependent on the level of success of the reclamation program. Wildlife populations most likely reduced by habitat losses and habitat deterioration or fragmentation include pronghorn antelope, deer, native grouse, coyotes, and small grassland birds, mammals, and reptiles. Also, as long as the affected lands are in an unvegetated or sparsely vegetated condition, they will be unavailable to domestic livestock for grazing.

Depletion of water supplies and potential degradation of water quality, caused by energy production, have and will have, harmful effects on aquatic life in the streams and impoundments from which supplies are drawn from.

Strip mining disturbs the natural topography of the landscape. Natural surface drainages as well as ground water levels and flows are altered. Disturbance of soils results in changes in soil permeability and exposes earth surfaces which contain high concentrations of salts, nutrients, and trace elements. Although topsoils may be removed during the mining process and saved, the remaining soil strata may be so disturbed that the resultant soil configuration may not produce vegetation of equal quantity or quality.

Irreversible considerations: Mining activities within the study area produce millions of tons of coal per year. Utilization of this resource for energy production within and outside of the study area is a permanent irreversible use of a nonrenewable resource. Water requirements for mining, and for energy conversion amount to thousands of acre-feet per year. This is an irreversible use of some water resources on a yearly basis. Combined coal production and water requirements for the study area are as follows:

Coal Production
(million tons/year)

North Dakota

1985	2000
21	165

Water Requirements
(acre-feet/year)

North Dakota

1985	2000
74,331	210,628

Significant disturbance or destruction of archeological or historical sites, especially of unidentified sites, may occur. Loss of destruction of such cultural resources is often irreversible depending on the location and nature of the site.

Water quality: The quality of both surface and ground water in the study area and adjacent areas most likely suffer some degradation. Strip mining activities result in increased runoff and erosion from land surfaces, thus causing increased siltation of surface waters. Leaching of exposed earth surfaces such as spoil piles and coal stockpiles can result in increased mineralization of surface and ground waters. Potential dewatering of mine and plant excavations into natural waterways add to the TDS concentration of receiving waters. Withdrawal of water for energy development activities, and not returning same, also tend to increase the TDS concentrations in the respective streams, water impoundments, and ground water aquifers.

Aerial emissions from energy conversion plants have a degrading effect on surface and ground waters. Salts from cooling tower drift and fly ash, sulfur and nitrogen oxides, and trace elements eventually precipitate out of the atmosphere and fall on soil or water surfaces. Contaminants which are deposited on soil surfaces may be rewetted by precipitation and then enter ground or surface waters. The end result is increased mineral, acid, and nutrient concentrations in these waters.

Air quality: Strip mining activities, such as excavating, blasting, loading, and hauling, create significant levels of dust and exhaust emissions at the mining sites and along coal transportation corridors. Wind erosion of disturbed land surfaces, as well as potential coal refuse fires, create air pollution problems in the mining areas.

Stack emissions from energy conversion plants have an effect on air quality of the study area. The major aerial pollutants emitted by the coal-fired generating plants and coal gasification plants is fly ash, sulfur and nitrogen oxides, and trace elements. The predicted levels of air pollutant emissions are as follows: (see following page).

The impacts of these aerial emissions may extend beyond the study area. The level of impact decreases proportionately to the increase in distance from the emission sites.

Expansion of urban centers as a result of energy development also contributes to the degradation of air quality in the study area.

Emissions (Tons/Year)	North Dakota 1985	North Dakota 2000
Particulates	14,166	20,403
Sulfur Oxides	169,996	244,835
Nitrogen Oxides	141,663	204,029
Total	325,825	469,267

NED Account for NED Energy Plan
North Dakota Tributaries 1/

Yearly Benefits	Millions of $
Electrical Generation	$294.9
Export Coal	289.6
Total Gross Benefits	584.5
Yearly Costs	
Electrical Generation	250.7
Export Coal	246.2
Loss of Agricultural Production 2/	.34
	497.24
Net Benefits Per Year	$ 87.26

1/ Based on Extensive Development Without Gasification run of Harza model and information contained in Analysis of Energy Projections and Implications for Resource Requirements by Harza Engineering Company, December 1976.

2/ Estimate based on Durum wheat following fallow which nets $76 per cropped acre to land, overhead, risk and management. Since it requires one acre of idle land for fallow for each cropped acre, the effective return is $38/acre.

Explanation of NED Account for Environmental
Quality Energy Development Scenario
in North Dakota Tributaries

Total benefits for the area electrical generation are based on the discounted (at 6-3/8 percent) total operating costs as developed by Harza. The Harza estimates include an internal rate of return of 15 percent, interest on equity, interest on debt and depreciation; consequently, the operating costs allow for capital recovery and a fair rate of return. FPC rate structure probably would permit a firm to base its rates on total costs; therefore, total operating costs as calculated by Harza would be equivalent to the price for the power. Based on these discounted and then amortized benefits the price for the power would average about 10.6 mills per kilowatt hour which is about an average of current rates in the area. The benefits were discounted over a 30-year period and then amortized for 30 years to get the total discounted value to a yearly basis.

The yearly costs are also based on the Harza Numbers, but reduced by the 15 percent internal return. The costs were also discounted over a 30-year period and then amortized at 6-3/8 to get yearly figures.

The costs for the power include the plant operating costs, coal costs at $7.69 per ton and water costs at $250 per acre foot. The water cost is strictly arbitrary since Harza indicated that the same amounts of water would be used up to $450 per acre foot.

The costs and benefits were discounted and then amortized since the flows of electricity and coal use vary through time. If the yearly benefits and costs were the same each year there would be no need for discounting and amortization.

Similar procedures were followed for export coal mining; however, since yearly benefits and costs did not vary over time it was not necessary to discount and amortize them.

The costs due to loss of agricultural land fall into two categories. The first category involves land that is purchased for plant sites and mining equipment sites. The value of that loss is contained in the costs of the power plant and mines since their costs include land acquisition. Land values reflect the agricultural productivity of the land as well as other items.

The second category of costs to society is due to lost agricultural production from stripped areas which varies by crop. For a given crop the loss can be estimated by determining the gross value of the crop loss. However, since the crop will no longer be produced, resources, e.g., fuel and fertilizer, will be released which is a gain (benefit) to society. The net loss per acre to society, therefore, is the relevant figure. An estimate of that net value is provided by ERS's Firm Enterprise Data System. This system provides budgets by crop by state and area within each state. The budgets show net returns to land, overhead, risk and management which was used for estimating the net loss (cost) to society from loss of the agricultural production of the land. The crop in the area that had the highest return in the 1974 budgets was used; consequently, the estimate per acre is a maximum.

It was further assumed that each stripped acre would be out of production five years. That assumption is an oversimplification, but one that seems reasonable.

The acres lost to strip mining each year were determined by the scheduled on line capacity of the mines. The number of acres times the proper value provided a yearly cost. These costs were discounted to 1975. The total discounted value was amortized over the appropriate time period to arrive at a yearly cost for the loss of agricultural production.

NED Account for Environmental Quality
Energy Development Scenario in
North Dakota Tributaries[1/]

Yearly Benefits	(Millions of $)
Electricity Generated	162.3
Export Coal (2/5mm tons)	19.2
Total Gross Benefits	$181.5
Yearly Costs	
Electricity Generation	137.9
Mine for Export Coal	16.4
Loss of Agricultural Production[2/]	.12
Total Costs	$154.42
Net Benefits Per Year	$ 27.08

1/ Based on data in Analysis of Energy Projections and Implications for Resource Requirements, by Harza Engineering Company, December 1976, and backup data provided by Harza to study management.

2/ Based on Durum wheat following fallow which nets to land, overhead, risk and management $76 per cropped acre. Since it requires one acre of idle land for fallow the effective return is $38 per acre.

ENERGY STUDY OF YELLOWSTONE RIVER BASIN AND ADJACENT COAL AREAS

Environmental Quality Account

EQ Energy Development Scenario

BENEFICIAL EFFECTS

Energy development will have no significant beneficial effects on the non-human environmental quality of the study area.

ADVERSE EFFECTS

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State	Coal Mines		Electric Plants	
	1985	2000	1985	2000
North Dakota	6	6	6	6

Land requirements for these facility sites range from 3,815 acres in 1985 to 3,800 acres in the year 2000. In addition, strip mining activities will affect 729 acres in 1985 and 2000. Use of these lands will preclude their use for recreational and other human activities for a long period of time. Energy development has resulted in expansion of urban centers within the study area and especially those towns and cities closest to the major energy facility sites.

Increased Rail and highway traffic is an annoyance in the study area. Noise created by mining, transportation, and energy conversion of the coal resources is disturbing to nearby rural inhabitants and population centers.

Aerial emissions from energy production are esthetically displeasing, not only at the immediate sites of major facilities, but smokestack emissions have a significant effect for long distances downwind from sites of energy conversion plants.

Biological, geological, and ecological elements: Vegetation removal from sites of major energy production facilities will amount to from 3,815 acres (1985) to 3,800 acres (2000) of natural grassland and cultivated cropland. These areas remain unvegetated for the life of the facilities. Strip mining activities destroy additional vegetative communities at the rate of about 728 acres per year (1985 and 2000). Reclamation of these lands take from 3 to 5 years under normal climatic conditions. Under a continuous reclamation program, the number of acres of lands being reclaimed at any one time during the time frame will about to three to five times the amount of those lands being strip mined during any 1-year period. However, the potential for fully or even partially reclaiming some of the strip mined lands to natural vegetation or to cropland is still questionable.

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Coal Production (million tons/year)	
North Dakota	
1985	2000
19	19

Water Requirements (acre-feet/year)	
North Dakota	
1985	2000
41,798	41,568

Significant disturbance or destruction of archeological or historical sites, especially of unidentified sites may occur. Loss of destruction of such cultural resources is often irreversible depending on the location and nature of the site.

Water quality: The quality of both surface and ground water in the study area and adjacent areas most likely suffer some degradation. Strip mining activites result in increased runoff and erosion from land surfaces, thus causing increased siltation of surface waters. Leaching of exposed earth surfaces such as spoil piles and coal stockpiles can result in increased mineralization of surface and ground waters. Potential dewatering of mine and plant excavations into natural waterways add to the TDS concentration of receiving waters. Withdrawal of water for energy development activites, and not returning same, also tend to increase the TDS concentrations in the respective streams, water impoundments, and ground water aquifers.

Aerial emissions from energy conversion plants have a degrading effect on surface and ground waters. Salts from cooling tower drift and fly ash, sulfur and nitrogen oxides, and trace elements eventually precipitate out of the atmosphere and fall on soil or

Emissions (Tons/Year)	North Dakota 1985	2000
Particulates	7,717	7,671
Sulfur Oxides	92,604	92,052
Nitrogen Oxides	77,170	76,710
Total	177,491	176,433

water surfaces. Contaminants which are deposited on soil surfaces may be rewetted by precipitation and then enter ground or surface waters. The end result is increased mineral, acid, and nutrient concentrations in these waters.

Air quality: Strip mining activities, such as excavating, blasting, loading, and hauling, create significant levels of dust and exhaust emissions at the mining sites and along coal transportation corridors. Wind erosion of disturbed land surfaces, as well as potential coal refuse fires, create air pollution problems in the mining areas.

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