DEPARTMENT OF THE INTERIOR, CANADA

RECLAMATION SERVICE

IRRIGATION DIVISION

BULLETIN No. 5

Peters, F.H.

FARM WATER SUPPLY

OTTAWA
J. de LABROQUERIE TACHÉ,
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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BY
F. H. PETERS
Commissioner and Chief Engineer of Irrigation

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This bulletin has been prepared for distribution among the farmers in what may perhaps still be properly described as the semi-arid districts of Alberta and Saskatchewan, with a view to aiding them in procuring a sufficient domestic water supply to allow of properly carrying on their industry of agriculture. While a good deal of the subject matter deals with questions of a technical nature usually dealt with in technical works, a special endeavour has been made to avoid the use of all technical terms, which might not be readily understood by a farmer and to deal with the subject in a practical common-sense manner, but even so, you may find after you have sized everything up yourself that you want some advice about just what is the best plan, how to go about building a dam, what certain work will cost, or something of this sort. If you do, any enquiry addressed to the Commissioner of Irrigation, Department of the Interior, Calgary, will receive prompt attention, and an earnest endeavour will be made to give you all the assistance possible in helping to solve any of your problems.

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FARM WATER SUPPLY

The western prairies constitute one of the greatest agricultural areas in the world and have been blessed with a favourable climate and a fertility of soil that is nowhere surpassed. But two great things are lacking which are closely inter-related—a natural growth of trees and an ample supply of surface water. Tree plantations can be created by following the proper methods as described in various bulletins issued by the Forestry Branch of this Department.

If there is not a sufficient perennial supply of water existing naturally, water may be obtained from shallow wells, deep wells—artesian or pumping, or by saving and storing water from intermittent surface supplies. This bulletin will deal only with the saving and storing of surface supplies which means, in general, reservoirs and rain catchers.

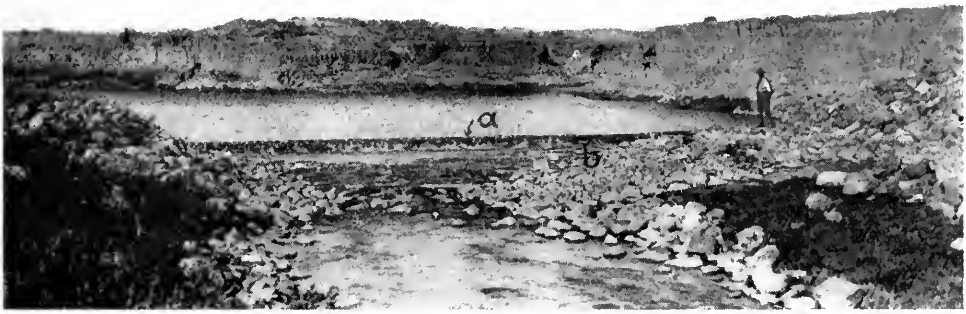
In the semi-arid district there will nearly always be available good earth or clay material for building dams or reservoirs; gravel and sand for making good concrete may or may not be available, and the same is true of rock which is always so useful for riprap or lining work. Generally there is no timber available, and when it is found in some stream or river bottom it is usually soft, quick to decay, and therefore not suitable to use in building dams, spillways, etc.

GENERAL PROBLEM

The general problem is this: First of all you know you are short of water. The first thing is to figure out how much you need to make up this shortage. Don't be afraid at the start that this is going to be too hard a problem, because you need not figure it down to a gallon or a barrel full—you can't afford to risk being short of water, so you want to figure well on the safe side. The best way is to figure as close as you can and then add on a certain percentage as a "factor of safety".

Usually you have some kind of a supply already and you can figure pretty closely how long this lasts you. But remember this—it is the very dry year that catches you the worst, and so you must figure on how your well or pond or creek holds out in the dry years. And this is particularly true if you are using a lot of your water for stock—you can't afford to be caught by the dry years which usually means selling off your stock when a lot of other people are doing the same thing for the same reason, and therefore the prices are down. Well then, you figure how long your new supply has got to last to make up the shortage. Then you must figure how much you will require for this time. Probably you have a pretty good idea of how much you need for a day or a week and you can figure on this basis. If not, use the figures which are quoted under the heading below "Quantity Required" which will serve as a very good guide. Figure out separately what you need for household use and what you need for your stock, because if you have a lot of stock, they will require the most of the water, and again, the stock can use water for drinking that wouldn't be fit for use in the house. So you may have to figure on a pretty big supply of just water for your stock and in addition a smaller supply of good water that is fit for use in the house.

Now when you have a general idea of how much water you need for each purpose—or perhaps one supply will do for both—you should figure in a general way where on the farm you have the best chance of getting it. Possibly if it is just a supply for the house you require, the best and cheapest way to save the water may be to catch the water that runs to waste off the roofs of your buildings during rain storms. By figuring the size of your roofs and then reading the matter under the heading "Rain Catchers" you can soon get a good idea of what you can do in this way. But don't forget that the biggest expense with the rain catchers will usually be the cost of providing tanks of some kind to store the water in, so don't stop at the figures showing how much water you can catch, but read on further and get an idea of what the tanks



General view of a wood and rock dam forming a reservoir in a creek bed. The whole length of the top of this dam acts as a spillway. Some of the rocks have been washed away from behind the wood by a big flood. (a) Row of strong sheet piling driven right across the creek and running well into the banks. This sheet piling is practically water-tight and does not leak any water. (b) Large rocks piled up behind the sheet piling and on the banks at each side. This supports the sheet piling and prevents the heavy floods and ice from scouring out the bottom and banks of the creek below the dam.

will cost to store the water in. If you require a larger quantity of water for stock, it will generally be necessary to make an earth reservoir to store water, in some natural depression, in a coulee, or in some natural watercourse. If you already have a slough or a reservoir, it may be possible to improve the supply from it by making it deeper and smaller in area. This will not catch any more water, but it may save a great deal of loss from seepage and evaporation. Reservoirs are taken up in more detail under that separate heading.

Quantity Required

The following table will be a useful guide in figuring how much water you need. The quantity used in different farm houses will vary a great deal, depending mainly on whether you carry water into the house for use, or whether you have it piped in. If water has to be carried in, the use of it is naturally very sparing and careful. If you have it piped in, say just to the kitchen, you naturally use more. Then, if you have full plumbing, with a bath tub and water-closet, a great deal more is used. The quantities for stock should be ample, taking an average over the year, but, of course, the stock drink a great deal more at certain times than at others. By using the figures in this table, reckoning the number of people, and the numbers of the different kind of stock, and the number of days the water supply has to last, you can reckon the total number of gallons you need to store for actual use, not counting the losses during storage in the reservoir if it is an earth one. Whenever the word gallon is used in this bulletin, it means an imperial gallon which is the legal measure in Canada.

Farm house without plumbing 1 person per day	8	gallons.
Farm house with plumbing 1 person per day	20	"
1 horse per day	10	"
1 steer per day	10	"
1 milk cow per day	15	"
1 pig per day	2	"
1 sheep per day	2	"

To convert gallons into acre-feet, 271, 472 gallons equal 1 acre-foot which simply means 1 foot deep of water over 1 acre.

Quantity of Water Available

If you are figuring on saving the water from your roofs, it is quite easy to reckon up about what you can expect to catch and this is dealt with under the heading " Rain Catchers." If you are figuring on an earth reservoir, the question becomes very complicated and cannot be figured closely except by

General view of rock-filled crib dam. This is a good type where timber and rock are plentiful. Photo shows the type of construction with square timber. Round timber notched out at the joints makes just as good a dam. This dam has a wood spillway, but the whole top can be made level and to act as a spillway. The water side of the dam has to be faced with planks or banked up with earth to stop leakage.

an engineer who has experience in this line. We will just discuss in a general way all the points that come up, and this will give some ideas that will be useful.

If there are any farmers in the neighbourhood who have built dams, the very best way of getting an idea of what you can do, is to take good notice of the dams that have already been built, and by sizing these up carefully as to how big the watershed is and how big the reservoir is, figure about what you can do on your own place. The quantity of water that can be stored in a reservoir depends on how much watershed area there is to catch from, how much rain and snow falls on it, and how much of this runs off before it soaks into the ground. You can get pretty close to how much rain and snow falls by getting these records and taking the average amount, but how much of this runs off is very hard to tell. The steeper the slope of the ground is and the heavier the soil, the more water will run off and contrariwise, on flat sandy lands nearly all the rain and snow will sink into the ground. On the virgin prairie with fair slopes, a lot of water will run off into the hollows, but when the land is ploughed and cultivated, it nearly all runs into the ground.

Then you must remember that you have got to store a good deal more water in the reservoir than you actually need for use, because you must figure on losses of water out of the reservoir caused by seepage into the ground and evaporation into the air. In other words, the quantity you need to store is the sum of the quantity you actually require for use, plus the estimated quantity of seepage, plus the estimated quantity of evaporation. The seepage and evaporation will, of course, go on from the time the reservoir is filled until it is emptied. The amount of seepage will depend on the kind of soil and how tight it is and will be about the same all year around, but the reservoir will tend to get tighter each year it is used, because usually some mud or silt settles out of the water each time the reservoir is filled, and this tends to make the bottom of the reservoir more water tight. The amount of evaporation will vary according to climatic conditions in different places, and will of course be much greater in summer than in winter. The two things that cause a big evaporation are wind and heat. Probably of the two the wind has the greater effect, and during the hot summer days a high wind makes a very great difference in the evaporation. You cannot control the heat but you can check the effects of the wind by planting trees all round the reservoir.

In the following table the losses due to seepage and evaporation are added together and called absorption losses. These are meant to be figured fairly high, so as to be on the safe side.

Absorption Losses

Clay or heavy loam	3	inches in	depth per	month.
Loam	5	"	"	"
Sandy soil or light sandy loam	8	"	"	"
Very sandy or gravelly	12	"	"	"

To use this table accurately, a lot of complicated figuring is necessary that would require making up a plan of the reservoir and getting the wetted area and capacity of the reservoir. As a rough rule, however, it will do to determine what kind of soil you have at the reservoir site, and then by multiplying the loss in depth per month by the number of months that the water has to be stored, you will have a good idea of the total depth in inches that you are going to lose out of the reservoir. This in turn, will give a good idea of how high the dam has got to be to store enough water to cover absorption losses, and leave enough for actual use.

In figuring what kind of soil you have for your reservoir, don't be satisfied to just look at the surface, but use a post hole digger or a shovel, and dig down at least three feet and see what it is like underneath. If you have three feet of tight clay on top, this will hold the water, even if there is gravel or sand underneath, and again, if you have a foot or two of light soil on top and clay underneath, you can figure it as clay soil because the light soil will soon fill up, and then the clay will hold the water.

The best kind of a reservoir is one where you will have a small area of water surface, but very deep water. This will have much smaller losses from seepage and evaporation than a big shallow reservoir, and also there is not the same danger of freezing to the bottom in winter.

General view from down-stream side of rock and brush dam built across a creek. The dam is built up of alternate layers of brush and rock. The rock works down into the brush and so does not show up much in the photo. Note that the dam is started on a broad base and then gets narrower towards the top. This kind of dam is leaky until it gets filled up in front with mud and silt. This dam has flash boards placed on top of the crest but these are not necessary for the ordinary farmer's reservoir. This kind of dam is liable to be damaged if heavy ice comes down in the floods and is not as good as the wood and rock type of dam.

Because of all these things that are so hard to figure closely, the best practical course for a farmer to follow is to choose the best place he has on the farm to build a reservoir, figuring on the best watershed area and the best place for a dam. Then build the highest dam you can with one season's work, and find out by actual experience whether your reservoir holds enough water or not. You may find that the dam is high enough to hold all the water that runs into it, without this being enough water to fill your requirements. In this case the only thing to do is to build another dam in another coulee. If you find the dam is not high enough to hold all the water, and does not hold enough for your requirements, you can add to it and build it higher the next year. You must, of course, provide a spillway at the same time as you build the dam. It wouldn't do to figure on leaving the dam without any spillway for a year or two.

Earth Reservoirs

Just how good a reservoir you can make on your farm will largely depend on what the natural conditions are. We will mention here the ideal conditions for an ordinary small reservoir, and then you must select the place that best fills most of the conditions. You will not likely have a reservoir site that fills all of them.

HANDY LOCATION FOR USE.—This is mentioned first, because you must think of this all the time. It is assumed that in most cases the farmer will have his buildings and corrals already up and cannot move them, so it means a great deal to have the reservoir as handy as possible to his buildings. Bear in mind that for watering stock a reservoir some distance away from the buildings means a lot of time wasted all through the year in watering work stock and milk cows. For this reason it will often pay to build the dam not at the most favourable location, but at some other place that is handier to the buildings. If the main use of the reservoir is to be in connection with the winter feeding of the stock, it will mean a great deal to have it close to where there is good natural shelter or a suitable location for building a shelter shed and feed racks. In this case it is not so important to be near to the house and general buildings.

WATER SUPPLY.—Leaving other questions aside, the best reservoir site will, of course, be in the coulee or depression which runs the most water. If there is any question about this, select the place that has a watershed above it that you are most unlikely to plough and crop, because land left in its natural state, or sowed down to grass, will run off much more water than land that you summer-fallow and crop.

RESERVOIR SITE.—The best natural reservoir site is one where the sides of a coulee or draw widen out with a fairly flat bottom and then narrow in again. This gives a big area to store the water in, and at the same time a narrow place at the lower end to build the dam across. The reservoir site should be as flat as possible, because the flatter it is, the farther back the dam will back the water up and the bigger the capacity of the reservoir will be. This idea, however, must not be carried too far without using common-sense, because a big shallow reservoir is not good on account of having such big absorption losses. If there is a natural depression, pothole, or pond anywhere, this can often be developed into an ideal reservoir.

TIGHTNESS OF SOIL.—The kind of soil often varies in a short distance, and you should have your reservoir in the tightest soil possible, so as to avoid seepage losses. Test the soil with a shovel or post hole digger and make sure what it is like. The loss through seepage in sandy soil will be surprisingly great, and to have a reservoir that leaks badly is most discouraging, and with a large reservoir it is impracticable to stop this, unless the water coming down is very muddy and will naturally silt up the bottom of the reservoir. If you cannot get a reservoir with fairly tight soil, it will be better to make a dugout, so as to confine the water in the smallest space possible, and then line it so as to stop the seepage.

DAM SITE.—Naturally the best dam site is where there is the smallest gap to fill up. In addition to this you want a good solid foundation for the dam, material in the side hills, or somewhere else that is close by to build the dam out of, and if possible a natural site for a spillway. It is much better to have the spillway or overflow some little distance to one side of the dam, than to have to build a spillway over or through the dam.

DUGOUTS.—This is a local name, originating in the province of Saskatchewan, for a reservoir that is made by excavating an area in the ground, rather than by backing the water up with a dam. It will require a lot more work to make a reservoir with a dugout than with a dam in a coulee, but the dugout has the great advantage that you get a good even depth, and confine the water in a small area, so that the absorption losses can be kept down to a minimum. The dugout is the best type where you have a very small supply of water and cannot afford to lose much by absorption. If you have a very open or leaky soil, it is the best plan to build a dugout, because with the same capacity you confine the water in a much smaller space, and make it practicable to put in a lining and stop the leakage. On the other hand, before you excavate a dugout in what appears to be a tight soil on the surface, you should explore down with a post hole digger or soil auger a few feet deeper than you propose to excavate, because you might find a leaky soil after you got down six or eight feet, which would let the water leak out at the bottom. A very good plan in many cases is to make a reservoir with a combined dam and dugout. The excavation from the dugout builds the dam, and it is not much more work to do this than to get the earth

This shows the type of dugout which has been used successfully in Saskatchewan. The fence is built not only because it keeps out stock but also because it catches a lot of snow during the winter which melts and helps to fill up the reservoir in the spring. This dugout was started without first testing the kind of soil, and the bottom is in such sandy soil that the water leaks out.

for the dam say from the high ground at each end of the dam. At the same time you get the advantage of very deep water in the dugout, which prevents any danger of freezing to the bottom in the winter.

LINING FOR RESERVOIR.—The idea of lining a reservoir is to make it tight against leakage. If it is possible, you should select a location where there is a good tight soil, and lining will be unnecessary. If the soil is not very tight but has a covering of grass or sod, it is best not to disturb this, because it will make a tighter bottom than the soil with the sod taken off. Concrete makes the best lining for a reservoir, but the expense will be very heavy, and in this country there is great danger from heaving and cracking by frost, unless it is very carefully laid. The tank or cistern, described under the heading of rain catchers, is really a deep reservoir lined with concrete. Asphalt is cheaper and has been used, but gets very hard in winter and would also be likely to suffer from frost. When oil is found in commercial quantities in Alberta, crude oil may prove a good, cheap method of treating a reservoir to make it tight. At the present time the lining recommended for farmers' use is a clay puddle. The clay puddle should be at least six inches thick, and to ensure it being of an even thickness, the reservoir bottom and sides should be carefully smoothed before the puddle is put on. The best puddle is heavy, gravelly clay. The pure clay is much improved by mixing in some fine gravel with sharp sand in it. To make the best puddle out of clay and gravel, the materials used should be thoroughly mixed before being laid in the reservoir. This, however, takes a lot of work. The mixing may be done by first spreading the clay over the bottom and sides of the reservoir, and then putting in a layer of gravel, say a quarter as thick as the clay. This will get mixed in, during the puddling process. The clay must be kept wet while it is being puddled. The best way to do the puddling is by tramping the clay all over by stock with small hoofs—sheep, hogs, cattle and horses are the best, in order mentioned. The clay must be **thoroughly** tramped all over to make a good puddle. The best way is to drive a herd of sheep all over it, and keep doing this until the lining is all thoroughly tramped down. Some people recommend putting up a temporary fence and keeping and feeding the stock in the reservoir until they have it all well puddled. A reservoir built in moderately tight clay can be improved by puddling the bottom and sides as described above. If the clay lining gets dried out and cracked at any time, it must be puddled again to make it tight.

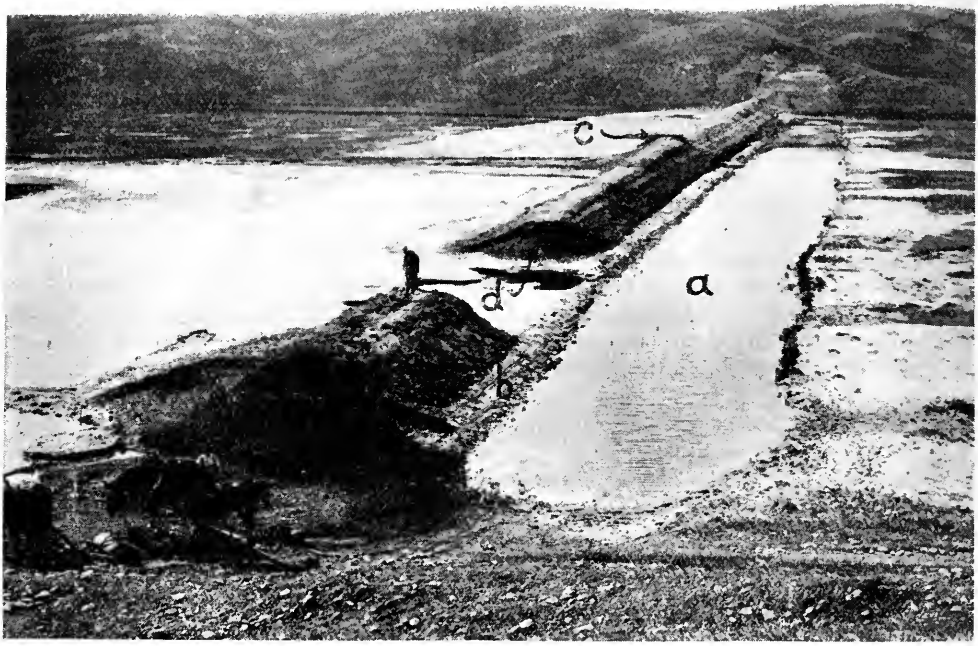
EVAPORATION.—Speaking generally of the southern parts of Alberta and Saskatchewan, a depth of about two feet of water will be lost during the year by evaporation from an open reservoir. The evaporation can be checked a good deal by planting a thick belt of trees around the reservoir, thus protecting it from the effects of wind. In the early days in southern Saskatchewan where water was very scarce and they had to depend on very small reservoirs, they used to stop the evaporation by pouring oil on the small reservoirs. This spreads out into a thin coating all over the surface of the water, and stops evaporation. They used to pump the water out of the reservoir from underneath the oil, and thus got clear water. The oil will not settle down or mix with the water, but of course, it would spoil the reservoir for stock watering .purposes. It is not a good plan under ordinary circumstances, but it may serve in some cases to save a very small supply of water before some better plan can be adopted.

DAMS

It is not hard to build a good earth dam if you study the matter out and follow a few simple rules. It is a very common thing to find small farmers' dams that are washed out, and nearly always the cause is that the spillway has not been made big enough, and the water has run over the top of the dam and then cut it out. We will take up the building of a dam under several headings, but this one point is mentioned first because it is such a common fault and the tendency always seems to be to make the spillway too small. Generally an earth dam will be the one that it is best and cheapest to build on the prairies, and so the suggestions following will all be made with particular reference to this form of construction. Photographs are inserted to show some other types of dams which might prove more suitable in certain places.

FOUNDATION.—The foundation for the dam, that is the ground on which you are going to build it, should be solid and tight soil; there is no use building a tight dam if the water is going to run underneath it. The next thing is to get a good tight joint between the foundation and the dam. If you are building an earth dam, and build right on top of the sod, you will not get a tight joint and the water will be likely to creep along beneath the earth in the dam and the top of the old sod. To get a good joint, you should plough up all the sod that is going to be under the dam. Even if you build the dam right on top of the ploughed sod, it will make a pretty good bond. To make a better job of it, you should carry away three or four widths of sod right across the whole length of the dam, and plough once more underneath where this sod was. To make a better job still, scrape all the sod away to one side and put it back on top of the dam when it is finished. This has the added advantage of getting a good growth of sod started on the finished dam.

DIMENSIONS OF EARTH DAM.—An earth dam must be high enough so that there is no possibility of water running over the top of it, thick enough so that the water will not leak through it, and heavy enough so that the pressure of the water will not cause it to slide out. The height of the dam depends upon the depth of water to be held up, which in turn is fixed by the height or elevation of the spillway. The first thing is to decide on how high you ordinarily want to hold the water behind the dam, and then put the bottom of your spillway at this height. Then, when the spring freshets are on, you must figure that there will be some depth of water running in the spillway, which will raise the height of the water behind the dam above the ordinary level. And then, the dam should be two or three feet higher than the highest level that the water



General view of an earth dam built across a wide flat coulee. (a) shows the idea of making a combined dugout and reservoir by building the dam entirely from excavation from one borrow pit in the bottom of the reservoir. (b) shows the "berm" between the toe of the dam and the borrow pit. This is too narrow and the dam would be stronger if the excavation was a little further away; this is a common fault and should be guarded against. (c) Wood spillway through centre of dam. (d) The face of this break gives a good idea of what the cross-section of this dam is, showing the top and bottom widths and the side slopes.

may rise to behind the dam when the freshets are on. This is necessary as a matter of safety, and this additional height is called "freeboard". It is recommended that the "freeboard" be made not less than three feet. If the reservoir is very small, so that it is impossible for wave action to start, two feet might do; but if there is a long clear sweep above the dam so that the waves may get high, the freeboard should be more than three feet.

The pressure of the water on the dam depends upon the depth of the water, and so the dam must be built much wider at the bottom than at the top. An earth dam should have a top width of eight feet and then have a slope of three to one on the water side, and a slope of two to one on the dry side. If the dam is less than eight feet high, the top width may be cut down to six feet. A slope of three to one means that in dropping one foot, the slope runs out horizontally three feet. And similarly with a two to one slope. For example, to find the bottom width of a dam that is going to be ten feet high, the water slope is going to run out ten by three, or thirty feet, and the dry slope is going to run out ten by two, or twenty feet, and these must both be added to the top width of eight feet, so that you get a bottom width of fifty-eight feet. It may seem that these dimensions for an earth dam are too great and would make too much work. There are lots of small dams holding up water which are not so thick as that which is recommended, but it is not real economy to build them. If a dam is built as recommended, it will stand for all time and if the stock start tramping it or the waves get higher than you expected, you need not worry about it and won't have to be making little repairs every year.

In order to prepare the foundations for the dam, you must figure out the bottom width of the dam. To do this, start by marking the centre line of the dam, across the gap to be filled in, with stakes say ten feet apart. Set the first stake at one side where the top of the dam is going to come. Then sight across with a level, a carpenter's level will do, and mark the height from the level line to the ground at each ten-foot stake. The last stake fixing the other end of the dam will come where your level line hits the other side hill or slope. Then at each ten-foot stake, figure out from the height marked what the bottom width will be and then mark out half this width on each side of the centre line and at right angles to it with slope pegs. When you are finished, the area marked out by the slope pegs will show the foundation for the dam and it will be shaped like a big willow leaf, broad in the middle where the dam is going to be highest, and coming to a point eight feet wide at each end.

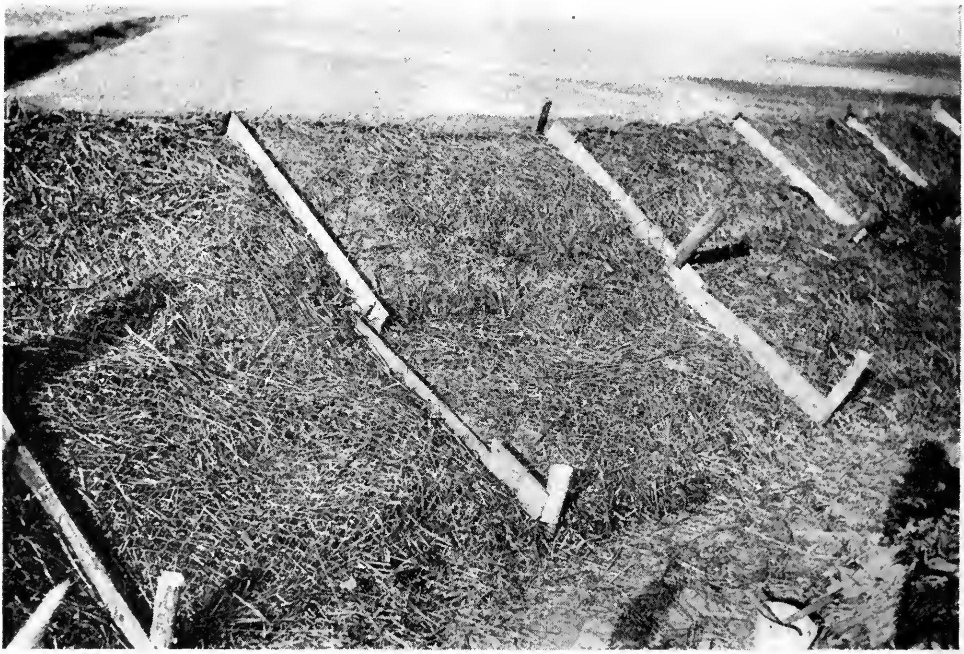
If the material for building the dam is taken out of borrow pits, it is of course a great advantage in moving the earth to have the pits as close as possible to the dam. The borrow pits, however, must be kept far enough away, so as not to weaken the foundation of the dam. A good wide strip of undisturbed ground should always be left between the dam foundations and the pits. This is called leaving a good berm. The width of the berm should always be eight or ten feet, both on the wet and the dry side of the dam. In the case of making borrow pits over two feet deep, such as when you are making a dugout in the bottom of the reservoir, the berm should be left at least three times as wide as the depth of the excavation.

MATERIAL FOR, AND BUILDING DAM.—The dam will, of course, have to be built out of whatever material is at hand. The aim should be to get the material that will pack down into the most solid mass possible. Clay makes very good material, and coarse sand very poor material, but any ordinary material from clay down to a pretty light sandy soil, will make a safe dam if the dimensions as recommended are used. In placing the material it is important to get it packed down as much as possible, so that the dam should be started over the whole foundation and then built up in thin layers, driving the horses over the dam as much as possible all the time. This keeps the earth well packed down and solid.

The wrong way to build a dam is by starting a dump at one side, and working it across the dump. This does not allow of packing the earth tight.

Particularly if the material is clayey it will be a great advantage if it is damp or even fairly wet. This makes it tramp down much better, and if the material is very dry and water is available, it will pay to draw water and sprinkle or pour it over the material as it is built up in the dam. All material, such as sods and sticks, which will rot in the course of time should be kept out of the dam. Sods should be saved and put back on top of the finished dam. If you have mixed material, such as pockets of gravel or sand in a clay soil, it will be a great advantage to build up the water side of the dam with the clay or other tight material and put all the gravel or sand near the dry side of the dam. Stones, if all well separated by earth, are all right in the dam, but would be more valuable if saved and used later for riprapping.

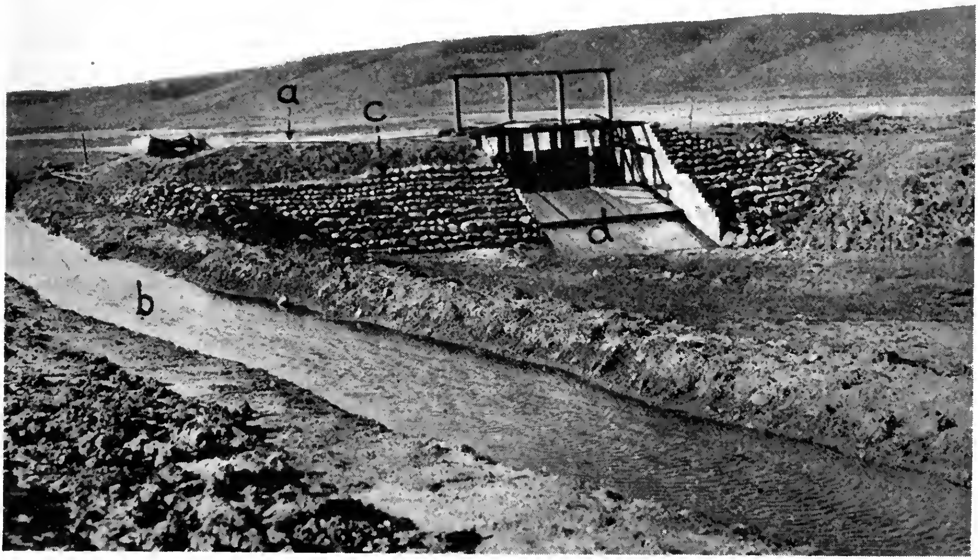
PROTECTING THE WATER SIDE OF THE DAM.—While, of course, there is a great difference with different kinds of earth, all earth material is very quickly cut out by water in motion. No matter how small the reservoir is there is sure to be some motion in the water at the surface, due to the wind and wave action. These waves, even if they are small, continually tend to pull the material out of the face of the dam and wash it down to the bottom. In order to stop this and make the dam safe, the water slope must be protected. The amount of protection required will depend upon how big the waves are liable to get on the reservoir. The best kind of protection is rock riprap. In doing really good riprap work, the rock is started from the solid bottom and then worked up, the rock being placed by hand, all fitted as snugly as possible. That is, the rock is all laid on edge and not laid flat. This kind of real riprap



Close up view of an earth dam protected on the wet side with riprap made of straw held down with chicken wire and wood posts driven into the earth. Old boards have been nailed between the wood posts instead of using wire.

is very satisfactory and will not easily be washed out. Another rough and ready way is to just dump the rock on the face of the dam. This is not so satisfactory and the rocks will tend to wash or slip down to the bottom. The rock used in either case should be large enough so as not to be easily washed out, but as a rule you must take the rocks as they come, and if they are properly laid, they will be much more secure against washing out. If rock is not available for riprap, the protection is generally made of some lighter material secured to the earth slope. One common method is to lay a good thick covering of straw on the slope, cover this with chicken wire-netting, and tie this down with good stout stakes driven into the earth slope. Buck brush or small willow brush might be used instead of straw. Another common method is to cover the straw or other fine material with long heavy brush instead of chicken wire, and then tie this down with plenty of hay wire stretched between stout stakes driven into the earth slope. Sometimes sods of marsh grass that will live under water for quite a long time, can be used to advantage. The wet slope of the dam usually has to be protected from the top down to the bottom because as the water is used and drops down from the high water level, the waves keep attacking the earth at all heights from top to bottom. If, however, the water surface in the reservoir does not vary more than three or four feet, the wave action may be controlled by building a fence which will stand up in the water in front of the dam.

SPILLWAY.—This is probably the most important part of the dam, and, as said before, the part where the average farmer usually makes a mistake. You **must** have a good big spillway with an earth dam, or else sometime or another an extra big flood will come along, and the water will rise over the top of your dam, and then it is sure to be washed out. The spillway should, if possible, be kept away from the dam and otherwise build it in the solid earth at one end of the dam. If, however, you build a spillway of wood or concrete



General view of earth dam. (a) Reservoir behind dam. (b) Ditch out of reservoir showing proper location for spillway channel around end of dam. (c) Rock riprap placed on dry side of dam to stop erosion by water running through wood spillway during floods. (d) Wood spillway through centre of dam. This shows the general idea but a straight drop is recommended. The height of the top of the dam above water surface in ditch represents the free board of the dam.

which drops the water straight down over a prepared fall, this is generally placed at the highest part of the dam, so that the water can be dropped straight down to the lowest ground below the dam. Figure out, as nearly as you can, how wide the spillway should be, and then build it twice as wide and be on the safe side. An open overflow spillway is much the best kind, because it is always ready to run the water away whenever it comes. With some kinds of a spillway where a gate or a valve has to be opened, it is often the case that the gate is forgotten or the valve gets jammed and won't open, and you have no time to do anything when the flood has started, and out goes the dam. The height at which you put the bottom of the spillway controls the height of water behind the dam, and the bottom of the spillway should always be at least three feet lower than the top of the dam. Then where the intake of the spillway is, there should be some protection by rock riprap or by some other means, so that the water will not cut out the bottom of the spillway and lower it. The next difficulty is to drop the water down to the bottom of the coulee at the dry side of the dam, without letting the swift running water do too much damage. The water can be dropped straight down over a prepared fall, or else run down a rock rapid, which means a wide, shallow ditch with a heavy fall to it, and all well lined with rock. If rock is not available, it may be necessary to use planks or boards. If the spillway is over one end of the dam, or anywhere near the dam, you must take special care that the escaping water does not swirl round somewhere and cut out on the dry side of the dam. The rock rapid is recommended, but if plank or boards have to be used in any case, on account of the absence of rock, it may be desirable to build a straight drop somewhere near the middle of the dam. If this is going to be done, the farmer will be well advised to get a proper plan of how to build the wood drop before he starts in to build the dam, because if the dam is any great height, such drops are difficult and expensive to build.

RAIN CATCHERS

The idea of saving and storing for use the water which ordinarily runs to waste off the roofs of the farm buildings, has much to commend it, and may prove in many localities to be the best solution of the problem of water shortage. As yet this plan has not been developed on the farms in Alberta and Saskatchewan, much beyond the stage of a barrel or two catching rain water, especially for washing purposes, and so the more complete development is largely a matter of experiment to be worked out in the future. The points of great advantage are that the water as it falls from the sky is pure, soft, free from mineral salts and is handy to where you want to use it at your buildings. On the other hand, a study of the question shows that there are some practical difficulties in collecting the water and storing it at a central point, without running into an expense that is too great for the average farmer. The two main points of practical difficulty are these: First, the available supply is limited in quantity and will have to be stored for a long time, so that the storage tanks must be made tight against leakage, and this means going to considerable expense; second, there are some practical difficulties after catching the water from several buildings, in running it to a central point for storage. Before going into the question as applied to our own conditions, it might be well to note briefly that there are in some of the very dry countries, localities where they have worked this system out successfully, and where they depend almost entirely upon this source for their water supply. In these localities they not only catch all the water off the roofs, but build special works for catching the rain water and running it into storage tanks. We will first explain under several headings how to build a complete system which is made up of the eavestroughs, conducting pipes, a central stand-by, filter, and storage tanks. This explanation will cover all the different points that have to be kept in mind, and will show how to plan things out. The whole outfit will be rather expensive, and so with a view to keeping away from too much expense at the start, we will later suggest how the storage tanks can be built in small units, and how the filter can be left out at the start.

SEASONAL QUANTITY AVAILABLE.—The best way to get an idea of how much rain can be caught in your district, is to study the table below and work from the figures given for the place nearest to your own location. This table shows for the places noted, the precipitation to the nearest half-inch from May 1st to September 30th.

	Period covered by records Years.	Precipitation in inches.		
		Average.	Smallest.	Largest.
Calgary	1885–1917	12	6	31
Lethbridge	1902–1917	12	4	24½
Medicine Hat	1883–1917	9	4	16
Swift Current	1886–1917	10½	5	16½
Chaplin	1883–1917	7	½	16
Moosejaw	1895–1917	11	3	16
Regina	1883–1917	9	½	16
Qu'Appelle	1895–1917	13½	7	20
Edmonton	1895–1917	13	5	21
Battleford	1891–1917	10½	4½	17
Saskatoon	1904–1917	10	6	13
Prince Albert	1895–1917	11½	4	21½

Figures for converting rainfall into gallons:

One-inch depth of rain on 1 square foot = nearly ½ gallon.
Six-inch depth of rain on 1 square foot = nearly 3⅛ gallons.
Twelve-inch depth of rain on 1 square foot = nearly 6¼ gallons.

The table above needs to be studied before you decide just how much storage you are going to provide in your tanks. It will be noted that there is a great difference between the average precipitation for a number of years, the smallest precipitation that has been recorded during the driest year and the largest during the wettest year. The figures that are the most important are the "average" and the "smallest." We will take an assumed case and study it just to show how this works out. Suppose you live near Medicine Hat, and want to store five thousand gallons. If you decide you want to be sure of getting this in the driest years you would figure on a four-inch rainfall. This rainfall will produce two gallons per square foot of roof area. So you would have to connect up two thousand five hundred square feet of roof area. Then in an average year when you had a rainfall of nine inches, you would get four and one-half gallons per square foot or eleven thousand two hundred and fifty gallons, which would be more than twice as much as your tank would hold, and a lot of the run-off from your roof would have to be wasted. On the other hand if you build a five thousand gallon tank, and figure on the average rainfall of nine inches, you would only need to connect up about one thousand one hundred square feet of roof, but when the very dry year comes with only four inches of rain, you would only get about two thousand two hundred gallons or not quite half enough to fill the tank. And so you can work this out to suit yourself. To be on the safe side and provide for the varying seasons, you should figure the size of the roof area to connect up on the basis of the smallest rainfall and then figure the size of your tanks on the basis of the average rainfall, or a little higher. It is suggested that for ordinary cases, you figure your roof area on the basis of six inches rainfall producing three and one-eighth gallons per square foot, and figure your tank capacity on the basis of twelve inches rainfall requiring six and one-quarter gallons storage per square foot of roof. Remember this one point in figuring your roof area; the rainfall is based on each square foot reduced to the horizontal. So in figuring your roof area you must only figure on the area of the ground covered (that is practically the floor area of the building) without taking into account the extra area of the roof due to its slope.

EAVES-TROUGHS.—The water is caught from the roof by putting on eaves-troughs which should be connected up across one end of the building, so that the water from both sides of the roof can be delivered into one conducting pipe.

Eaves-troughs can be bought made up of galvanized iron. These are the best and can easily be put on to any ordinary house or barn. Eaves-troughs can be made by using a V made up of two boards each five or six inches wide, but these are usually leaky and also hard to keep clean.

CONDUCTING PIPES.—One of the difficult problems in this business is to carry the water from probably several buildings, through pipes to one central set of filter and tanks. Anyone laying out a system of this kind would probably want to have the tanks near the house or possibly near the barn. Then the water has got to be piped from all or several of the buildings to this one spot. If the location for the tank happened to be the lowest spot about your buildings, the piping would be easy. But generally the house and the barn are placed on rather high spots and so the tank generally would not be in a low spot, but rather in a high spot. It is recommended later on that the filter be built two feet above the ground, and this fact together with the necessity of overcoming slopes, that probably exist in the average farm yard, makes the question of piping the water to the tank more difficult than it appears at first sight.

If you happen to have a barnyard that is nearly level or has even slopes running the right way, the cheapest kind of pipes will be three-inch glazed sewer pipe. The pipe lines would have to be made water-tight by jointing the pipes with cement, and this is a hard thing to do. It is necessary not only to avoid water wasting out of the pipes, but also to avoid foul water from the barnyard or elsewhere draining into the pipes and then into your tanks. It is also more difficult to arrange for draining these pipes in winter, which is a necessity, as they will generally be above the frost line and sure to freeze up.

Taking everything into consideration, it seems that it will be much better to use galvanized iron pipes to run the water in. The great advantage of this is that by running the iron pipes up the sides of the buildings you can easily get a little pressure in the pipes, and then it won't matter whether you lay the pipes running uphill or downhill. Always lay your pipe on a smooth, even grade, however, so that when you open up a stop-cock at the lowest end, the whole pipe will drain out and prevent winter bursting. Now, galvanized iron pipe is quite expensive, so you don't want to use any bigger pipe than is necessary. At the same time you must have a pipe big enough to handle all the water that runs off a roof during the heavy rain storms. The rainfall records for the last ten years at Medicine Hat and Swift Current show that the biggest rainfall in twenty-four hours has been 2·07 inches. The average for the two places for ten years of the biggest rain in each year is $1\frac{1}{4}$ inches in twenty-four hours. What we want to know is the heaviest rate of rainfall that we might get say in any one hour, and it is suggested that it will be quite safe to use three-quarters of an inch rain in one hour. There might be short periods of twenty minutes or so, where these pipes would not carry all the rain, but a little waste like this would be better than the extra expense of the bigger pipe. Figuring on this basis you must have pipe capacity for 0·65 or thirteen-twentieths of a gallon per minute for each 100 square feet of roof area.

Now the idea is this:—You figure the roof area for any building, and then reckon the number of gallons per minute that the conducting pipe must carry on the basis above. Then you must find out what size pipe is required. To do this, study the friction table below. The flow of water in a pipe depends on how much pressure you have in it and how long the pipe is. The pressure depends on how much higher one end of the pipe is above the other. In this case you can get whatever pressure you want, by simply running the galvanized iron pipe up the side of the building, and taking the water from the eaves into your conducting pipe at a certain height above the ground instead of down at the ground. Of course, you can't go higher than the height of the eaves-trough, but this will usually be high enough to allow of using a fairly small pipe, unless you put your tank in a very high spot as compared to the rest of the buildings. The table below shows different sizes of pipe, and for a length of 100 feet, the height in feet that one end has to be raised above the other in order to get a certain flow in gallons per minute. Study the table and select the size of pipe that is going to be suitable, and then figure how high you must run one end up the side of the building to get the right flow. Any pipe shorter than 100 feet should be counted as 100 feet, but for longer pipes you must give additional head or height in proportion to the additional length. It would not be advisable to use any pipe less than three-quarters of an inch because it would be liable to get choked with rust or dirt.

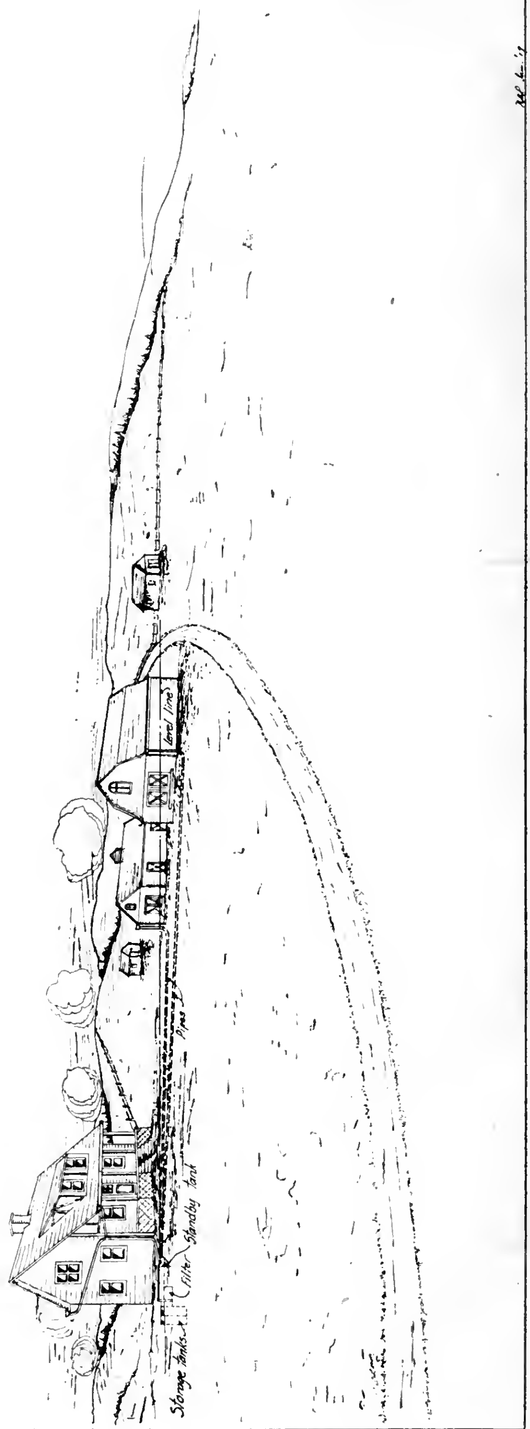
FRICTION IN WROUGHT IRON PIPES.

Discharge in Imperial gallons per minute	Diameter of pipes in inches							
	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
	Friction losses in feet of head for each 100 feet length of pipe							
1	3·20							
2	10·3	2·75						
3	22·6	5·75	1·76					
4	38·3	9·85	3·05	0·80	0·35			
5		14·7	4·55	1·20	0·55	0·20		
6		20·5	6·45	1·70	0·80	0·30		
8		35·5	10·95	2·85	1·35	0·45	0·15	
10			16·4	4·30	2·01	0·70	0·24	
12			23·3	6·00	2·80	0·98	0·32	
14				8·00	3·72	1·30	0·43	
16				10·25	4·75	1·68	0·57	
18				12·85	6·00	2·10	0·70	
20				15·45	7·30	2·55	0·85	0·35
25				23·50	11·00	3·84	1·30	0·55
30					15·45	5·38	1·80	0·78
35					20·45	7·23	2·40	1·00
40						9·20	3·08	1·29
45						11·47	3·85	1·57
50						13·90	4·65	1·92
60						19·50	6·52	2·70
70							8·65	3·62
80							11·10	4·58
90							13·90	5·75
100							16·80	7·00
110							20·09	8·34
120								9·73
140								13·00
160								16·58
180								20·71
200								25·10

Table prepared from Hydraulic tables, Williams and Hazen, New York, 1911. Coefficient used 100.

For example, you have a barn sixty feet long by thirty feet wide. This gives you a roof area of 1,800 square feet. The necessary pipe capacity would be 1,800 by 0.65 equals 12 gallons per minute (nearly). Now one end of your pipe has to empty into the stand-by tank, and setting your carpenter's level at this height, you sight on your barn eighty feet away and mark the level line on the side of the barn. Then you find that your eaves-trough on the barn is eight feet higher than the level line. This means you can get a head of eight feet if you want it. Turning to the table you pick out twelve gallons in the discharge column. Then following this line across the table you find the head that is necessary to produce the discharge of twelve gallons with different sizes of pipe. You find you can use 1¼ inch pipe with a head of six feet, or you

PLATE No. 1



can use $1\frac{1}{2}$ inch pipe with a head of only 2.8 feet (nearly three feet). If you decide on $1\frac{1}{4}$ inch pipe, then you mark six feet above the level line on the barn, and when the pipe is laid with one end at this mark and the other end emptying into the stand-by tank, it will run twelve gallons, and sufficient to take care of all ordinary rain storms.

STAND-BY TANK.—Before going into the storage tanks the water should be filtered. This is a slow process. Therefore you must have a stand-by tank to catch the water as it rushes down off the roofs, and hold it for a day or two until it has time to pass through the filter into the storage tank. The stand-by should be big enough to hold all the rain that may fall in twenty-four hours, or according to the records for Medicine Hat and Swift Current already quoted, about $1\frac{1}{2}$ inches. This means a capacity of seventy-eight gallons for each 100 square feet of roof area. It is recommended to use a stand-by tank that is elevated a little above the ground in order to allow of getting depth enough to operate the filter, and at the same time be able to fill the storage tank nearly to the top. This saves a lot of lost space in your storage tank. The water does not remain very long in the stand-by tank, and so it is not so important that it be absolutely leak proof. The layout suggested in plates No. 2 and 3. was designed to cut down the expense as much as possible. The earth excavated for the tanks will make the banks for the stand-by tank, and the sloping sides make it practicable to make the concrete lining very thin. The banks should be well tamped and settled before the concrete lining is laid. The stand-by tank shown has a capacity of 168 gallons for each foot in length. The area over the filter holds 840 gallons to start with, and then you make the stand-by tank as much longer as you need, to get the additional capacity required.

FILTER.—The rain falling from the heavens is pure, but the roofs and the eaves-troughs collect a great deal of dust and dirt which of course is washed down by the rain water. This would not be such a serious matter if the water was going to be used up quickly, but when you store this water with perhaps only a little dirt in it, for a long time, the water gets to have a bad taste and is disagreeable to drink. To avoid this difficulty it is necessary to filter the water before it is run into the storage tank. The essential feature of the filter is to have a depth of from two to three feet of clean, sharp sand and have the water run slowly through. The sand should be about the size of No. 10 bird shot. Too fine sand makes the filter too slow and liable to clog, and too coarse sand makes the filter too fast and does not throughly clean the water. The water ought to go through the filter at a rate of forty to fifty gallons per twenty-four hours for each square foot of area of filter, and when you have a sand that will produce this result with from two to three feet of water on top of the filter, you will know that you have a good filter. Plates No. 2 and 3 show the suggested layout for a sand filter three feet deep. The area is thirty square feet, which should filter from 1,200 to 1,500 gallons in twenty-four hours. You should wash all the sand put in the filter very clean, or else the first water run through it will be dirty and have to be wasted. After a time the filter will tend to clog up by dirt settling on the top. When you find this, carefully scrape off the top one-half or one inch of the sand in the filter, and either wash it and put back or replace it with new clean sand. The time that you get the most dirt off the roof is from the first water that comes down in a rain storm, particularly after a long dry spell. It is a good plan to have some kind of a switch in the pipe from the eaves-trough, so that the first water which washes down most of the dust can be wasted, and then after the roof is washed off, run the cleaner water into the conducting pipes. Before the winter sets in you must be sure and dry the filter by pumping all the water out of the small well between the filter proper and the storage tank as shown in the plate.

STORAGE TANKS.—A good storage tank should be able to hold water for a long time without leaking any water out, and without giving the water a bad taste (like, for instance, an old wood lining will do). It seems that much the

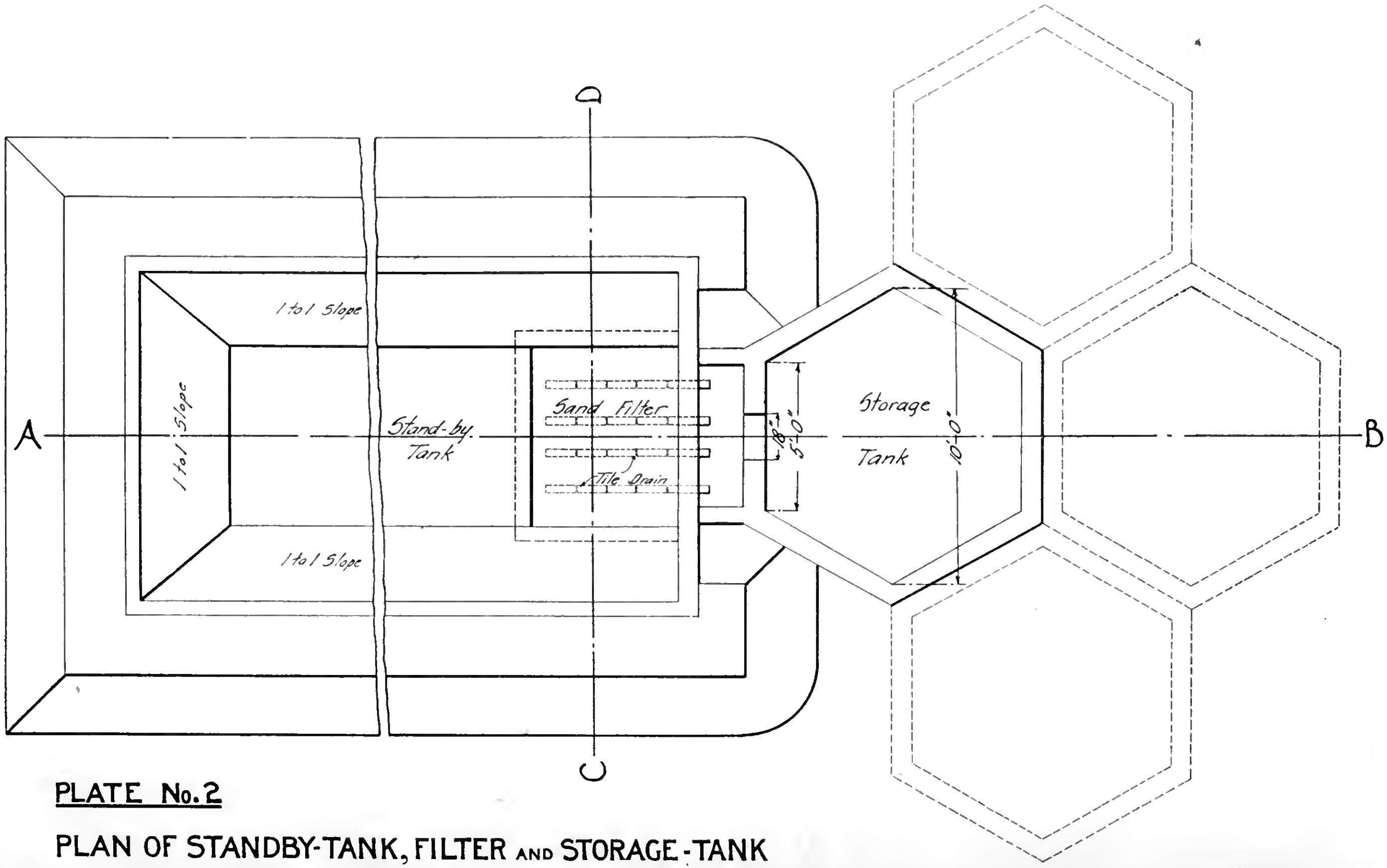


PLATE No. 2

PLAN OF STANDBY-TANK, FILTER AND STORAGE-TANK

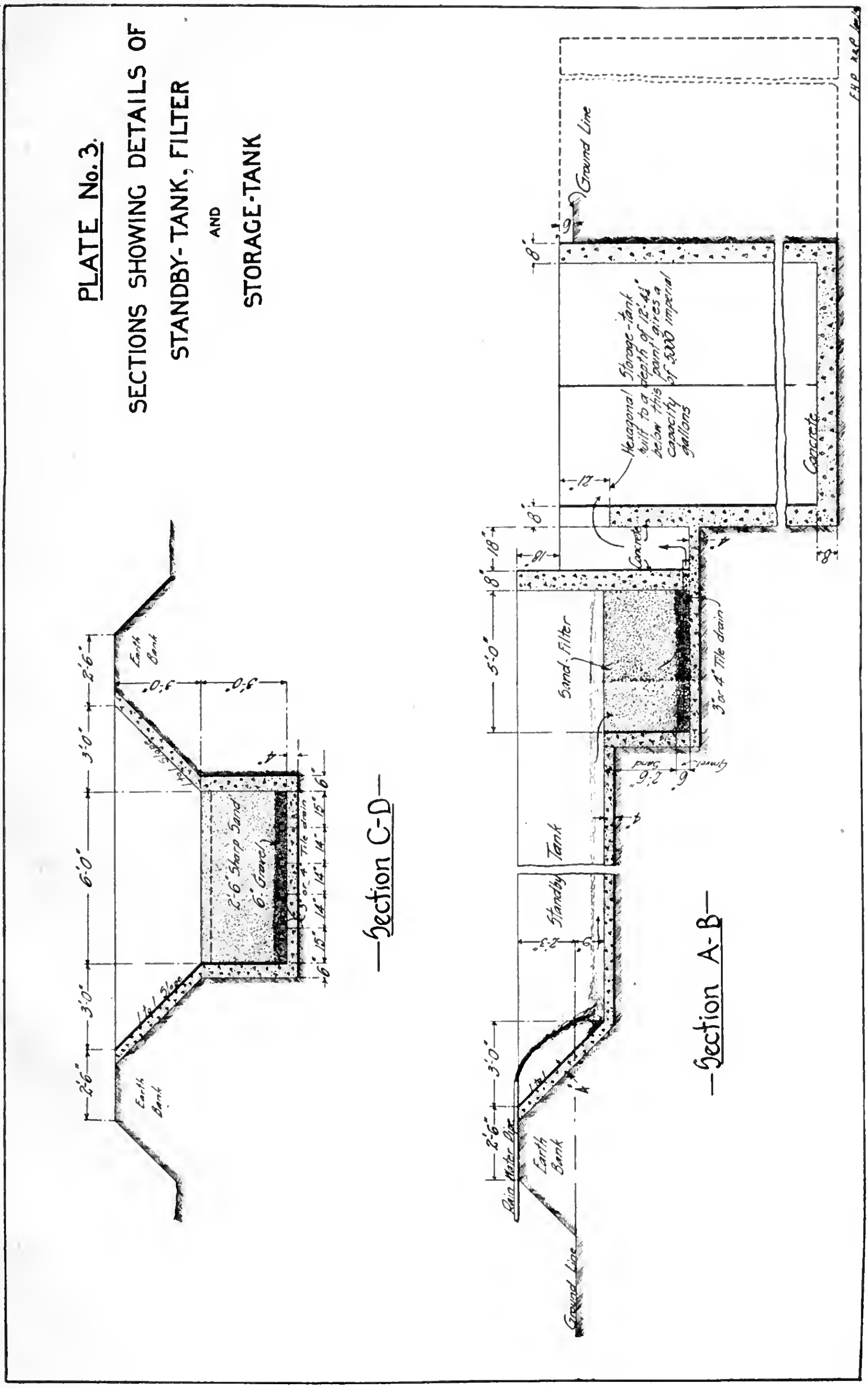


PLATE No. 3.
SECTIONS SHOWING DETAILS OF
STANDBY-TANK, FILTER
AND
STORAGE-TANK
Earth Bank
2'6"
3'0"
6'0"
1½ to 1 Slope
2'6" Sharp Sand
6" Gravel
3" or 4" Tile drain
Section C-D
Ground Line
Rain Water Dit.
Earth Bank
Standby
Tank
Sand Filter
3" or 4" Tile drain
5'0"
Concrete
Hexagonal Storage-tank built to a depth of 12'4½" below this point gives a capacity of 5000 imperial gallons
Section A-B
F.H.P. & R.P. del.

best material to use is concrete. If any farmer is used to this kind of work, or can hire some person who is, it is possible to make a good job by using bricks well plastered on the inside with cement, or with stones set in cement mortar. Wood is objectionable because it is liable to taste the water. Galvanized iron tanks might prove successful in some cases, but they are big bulky things for shipping.

The use of concrete is recommended. The only difficulty to be expected with the concrete construction is the liability to crack, which of course will make leaks. It is difficult to keep large, plane areas of thin concrete from cracking unless steel reinforcement is used, and the use of steel in concrete makes the work rather complicated. To get away from this difficulty, building the tanks on the unit system is recommended. That is, adopt a standard tank to hold say 5,000 gallons, and then build as many of them as you need to get the required capacity. It is much easier to build the tanks small in plan, and get capacity by making them deep. But this is objectionable because you have so far to pump the water out of the tank, and so a middle course seems to be the best idea. A circular tank is the strongest and takes the least material as compared with the storage capacity. The objections are, the difficulty of making circular forms for the concrete, and also the different units will not fit close together. The plan suggested is to use standard six-sided tanks with a capacity of 5,000 gallons. These tanks as shown in Plates Nos. 2 and 3 will not have any wide walls that are liable to crack; they are built with straight forms, and as units are added they all fit close together, without any loss of space. The forms will be as easy to make and handle as if the tanks were built square in plan. The six-sided tank with each side five feet inside, has a capacity of 404.6 gallons for each foot of depth. A depth of 12 feet 4½ inches gives nearly 5,000 gallons. The inside angles, instead of being right angles or 90°, are each equal to one right angle and one-third or 120°.

The tanks should be covered tight so as to keep out all dust, dirt, or animals such as field-mice, etc. It is recommended that these be made of concrete, cast separately close to the tank and then when hard, after setting at least two weeks, put in place. A small man-hole should be left in one corner and later fitted with a tight wood cover.

If the ground where you are going to sink your tanks is heavily impregnated with alkali, there is danger that this may eat out the concrete and spoil the tank. If you have this condition to contend with, we suggest that you write an enquiry as to special means that should be taken to protect the concrete against the alkali.

GENERAL.—The water in the tanks must be kept from freezing in winter by some sort of protection. There is always liable to be some water leak out of the stand-by or filter, which would keep the earth about them wet. If this freezes in winter, it will heave and crack the concrete in the stand-by and filter. It will therefore be advisable to cover the stand-by and filter and tanks with a shed, and so protect them from the very severe frosts. This will also keep the stand-by and filter free from dust and dirt.

If the complete outfit costs too much at the start, you can get along by starting in with perhaps one tank, adding another one or two when you can, and doing without the stand-by and filter. Later on when you are able, the stand-by and filter can be added. If you do without the filter in the start, it is particularly important to have the cut-off in your rain-pipe, so that the first dirty water off the roof can be wasted. Without the filter, the water in the tanks will certainly get smelly and taste bad after a while, but at this it should be better for drinking than water out of any ordinary small earth reservoir. In some cases it might be advantageous to combine the idea of the earth reservoir with the concrete storage tanks. For example, it might pay in same cases to run water out of an earth reservoir, or from a small stream that runs in the spring, through a good filter and into concrete tanks, by which plan you could store enough good, pure water to always have a sufficient supply for household use.

Methods of Purifying Water.

Absolutely pure water is not found in nature. As it falls as rain or snow it gathers impurities from the air and from whatever surface is used to collect it. So too, as water flows over the land or through the soil, it picks up a great variety of substances which it can hold in solution or which can be suspended in it. The Canadian prairies are not yet thickly populated, so that ordinarily the surface waters are not badly polluted. In certain areas the surface waters may be polluted, or at certain times there may be epidemics of water-borne diseases. In such cases the only safe course is to avoid drinking water unless it has been filtered or sterilized by boiling or by the use of chemicals.

BOILING.—Boiling is probably the simplest and safest method or treating bad water. If water is boiled for twenty minutes, it will kill practically every germ that is likely to be found in any water in this country. Boiled water has a flat, dead taste for drinking, due to lack of air in the water. This can be readily overcome by pouring the water from one vessel into another, through a colander or sieve, so as to introduce air.

CHEMICAL TREATMENT.—Another easy way to treat water, that will kill all germs and make it safe for drinking, is by the addition of some chemical. The safest chemical and the easiest to use is chlorine. The easiest form to handle it in is ordinary chloride of lime or bleaching powder. This preparation deteriorates rapidly if exposed to air, light, or moisture, and should be kept in a tin with a tight top. The dose recommended to make water quite safe is twenty-five grains to one hundred gallons of water. A handy way of getting this dose for use in the house, is to dissolve one level teaspoonful of fresh chloride of lime in one quart of water. Keep this solution tightly corked in a bottle and away from the light. Then to disinfect water, add one teaspoonful of the solution to two gallons of water, and after thorough mixing by stirring, allow it to stand for fifteen minutes before drinking. Or you may add one-half a level teaspoonful of chloride of lime, first dissolved in a quart of water, to a forty gallon cask full of water. This will give a little stronger dose.

FILTRATION.—Filtration is a good all-round method of getting water that is pleasant to drink, and also fairly well cleared of all dangerous germs. Where water is piped into the house under pressure, there are a number of excellent filters that are supplied by the trade. Where the water is not piped in, some form of gravity filter has to be used. Plate No. 4 shows a very efficient home-made filter, made out of two casks. If casks are not obtainable, two galvanized iron containers could be used instead. The charcoal is the most important part of this filter. It is a purifying agent which helps to oxidize organic matter, and will take out any taste or smell due to decayed vegetable matter. The charcoal must be well broken up and rammed very tight. Animal charcoal, which really consists of burnt bones, is much better than wood charcoal. The ordinary druggist probably does not stock this in large quantities, but should be able to procure it on short notice from the local wholesale houses. If the filter clogs up, carefully scrape off the top layer of sand which catches most of the dirt out of the water. The materials in the filter must be kept clean by taking them out and washing whenever necessary—at least once a year. The sand or gravel, after thorough washing and drying in the sun, is as good as new, and can be replaced. Animal charcoal, if not used too long and allowed to get too dirty, can be similarly treated and used several times. Wood charcoal should be thrown away when it gets dirty and replaced with a fresh supply.

STILLS.—Distilled water is absolutely pure, and the use of a still may be satisfactory in certain cases. The disadvantage of a still is that the process, which consists of boiling the water and then condensing the steam, is necessarily rather slow. However, if your water has mineral salts in it such as alkali or, so called soda, distillation is the only way of making it pure. Neither filtration nor any simple chemical treatment will remove salts from the water. Space does not permit of describing water stills fully in this bulletin, but diagrams and photographs are available showing a water still designed for farm use, and will be supplied on request, by the Commissioner of Irrigation, Department of the Interior, Calgary. The diagrams and photographs show all details so that the still can be made up from them by any ordinary tinsmith at a small cost.

All surface water in the provinces of Alberta and Saskatchewan belongs to the Crown. Every person who has a stream or lake within or bordering his land, is entitled to use as much of the water as is required for domestic purposes, which includes household use, watering of stock, and the working of agricultural machinery. It is necessary under the law to obtain authorization and license for the construction of works, such as dams and ditches, for storing or diverting any surface water. Small farmers' dams have been built without authorization or license and are still in existence. If dams or any other works are authorized and licensed under the Irrigation Act, then their legal status is assured, and the farmer's water right is fully protected. If dams or any other works are **not** authorized and licensed, they have no legal status and the water right is not protected.

Any person wishing to make application for the construction of any works and a licensed water right, should apply to the Commissioner of Irrigation, Department of the Interior, Calgary.

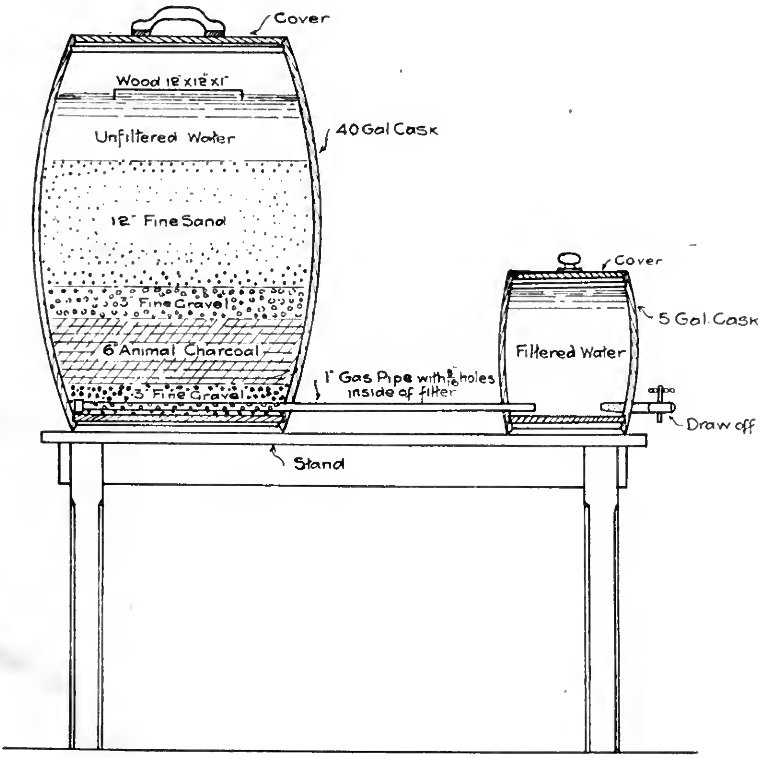
Department of the Interior

Reclamation Service

CALGARY

SKETCH OF WATER FILTER

Scale 1 INCH = 1 FOOT



SECTION

Plate No. 4