Treating Farm Pond Water For Domestic Use

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Bulletin No. B-408   August, 1953

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Treating
Farm Pond Water
For Domestic Use

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Experience shows that the use of water increases greatly when running water is installed on a farm. The usual type of shallow well is often unable to supply the need. Deep wells are expensive, and underground water is not available in some areas; thus a farm pond is often the only satisfactory and economical source.

The major problem in using surface water stored in a pond is treatment to insure its purity and clarity. Therefore, in 1951 the Experiment Station began a study of equipment and methods for such treatment.

A design for a unit-type water-treating plant was developed, and plants built from this design were constructed at two rural locations near Stillwater. Assistance was given in installing two other systems of a somewhat different type; and still other installations, both commercial and home-made, were studied.

This bulletin describes the unit-type plant in detail, and also the essential elements in two other systems. The Station's research on this subject is not completed; but the demand for information is so great, this progress report has been prepared to answer inquiries.

General information on farm water systems, including various sources of water and types of pumps, is given in Oklahoma Extension Circular E-473, "Water Systems for the Farm Home."

Several manufacturers now sell "packaged" water treatment and pumping systems designed for farms. Several of these have been observed, and appear to be giving excellent results. Most of the commercial systems are designed for water with a turbidity of less than 50 parts per million, and the manufacturers recommend additional treatment where the water supply has a higher turbidity.

On Grade A dairy farms, the plant to be purchased or built should be approved ahead of time by the local milk inspector.

Location and Size of Pond

The location and size of a pond used as a water source should be considered first in installing a farm water-treating plant. The drainage area which supplies the pond must be large enough to keep the pond filled during dry weather. The surface soil must be free of chemicals which would make the water "hard" and therefore difficult to treat. An area which provides reasonably clear water is desirable, as muddy water requires more chemical treatment for clarification.

The pond should be near the farmstead because long lines of pipe are expensive.

Size of pond and size of watershed depend upon how much water will be used in a year and how much runoff can be expected. Both are hard to calculate with accuracy. Information useful in calculating the amount of water needed for the home, for livestock, and for garden irrigation is given in Extension Circular E-473.

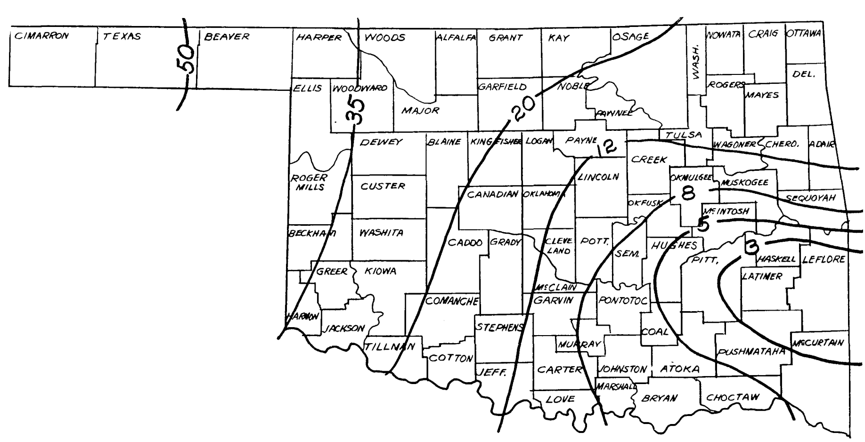

Figure 1.—Estimated drainage area, in acres, needed to obtain one acre-foot of water in a storage pond in various parts of Oklahoma. (See text, page 7.) The estimates are based on average annual rainfall figures for Oklahoma, and information given in U.S.D.A. Farmers Bulletin 1859.

The pond must be large enough to store not only the water which will be treated and used, but also that which will be lost through evaporation and seepage. More information is being secured on this subject; meanwhile the experience on one dairy farm, reported on page 9 of this bulletin, may be helpful.

Size of the watershed needed can be estimated with the help of Figure 1. For example, if the water needed annually for use, evaporation, and seepage is one acre foot (approximately 326,000 gallons), a watershed of only three acres probably will be large enough in Latimer, Leflore, southern Haskell and northern McCurtain counties. In the Panhandle, a watershed of about 50 acres would be needed.

Principal Steps in Water Treatment

The parts which make up a complete water-treating plant, and the steps in the treating process, are shown in Figure 2.

The three principal steps in producing pure, clear water from a surface supply are flocculation, filtering, and chlorination. Under some conditions, flocculation and chlorination may be omitted; but a filter is always needed.

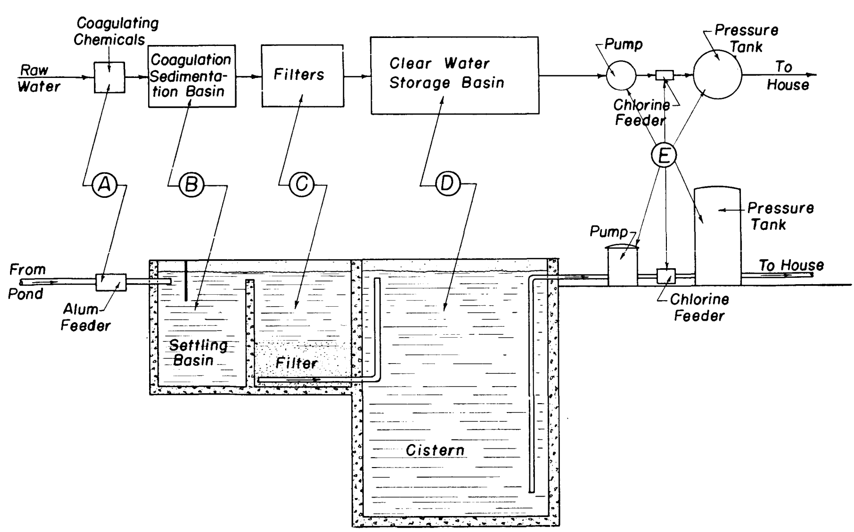

Figure 2.—Steps in a complete water-treating process (at top), and the corresponding units in a treating plant. The principal steps in water treatment are described on page 7.

FLOCCULATION

The first step in treating raw water ("A" in Figure 2) is to add a chemical which will bring together any suspended tiny particles, such as mud and vegetable matter, so that large particles will form and settle to the bottom. Alum is usually used as the coagulating chemical which causes this flocculation. Hydrated lime is sometimes added to offset the acidifying effect of the alum.

After the coagulating chemical is added, the water must be allowed to stand long enough for flocculation to occur; therefore, the next stage in a treating plant is a settling basin ("B"). Water should remain here at least two hours for best results. Sediment which drops to the bottom of the settling tank should be cleaned out periodically; every six months is sufficient according to available data.

FILTERING

From the settling basin, the water moves to a filter ("C"). This is usually a layer of sand. As the water moves downward through the sand, the flocculated particles that did not settle out are trapped and held. Clear water flows from the bottom of the filter through small holes drilled in a series of pipes. Pea-sized gravel is placed around these pipes to keep sand from clogging the holes.

The upper portion of the filter gradually becomes clogged with muddy particles, and it must be cleaned from time to time. This can

Figure 3.—Aerial view of farmstead and storage pond on Grade A dairy farm where first unit water-treating plant was installed. Arrow points to the treating plant location, adjacent to the dairy barn.

be done by lowering the water level in the filter and scraping off the muddy layer. If the water pump is large enough, the filter can be cleaned by backwashing—that is, pumping treated water in at the bottom of the filter and allowing it to run out a waste pipe at the top until it is clear. However, pumps used in home water systems seldom have enough capacity to make backwashing feasible with a sand filter; and the extra piping and valves needed add to the complexity of the treating plant.

The filtered water goes to a storage tank or cistern ("D"), where it is held until pulled out by the pump. Considerable storage capacity is needed to avoid moving the water too rapidly through the settling basin and filter, especially when a large amount of water is being used.

CHLORINATION

Except for chlorination, the remainder of a treated-water system is the same as a well-pump system, with the storage tank replacing the well. Chlorine is added by an automatic feeder ("E") connected into the line between the pump and the pressure tank.

Chlorination is often omitted in plants serving a single residence; but it is good insurance, and is required for plants serving a Grade A dairy. Proper chlorination destroys harmful bacteria which may get into the storage tank when the settling basin and filter are not operating properly.

Unit Water-treating Plant

A water-treating plant which can be built as a unit was designed at the Oklahoma Agricultural Experiment Station in 1951. It is essentially the same as plants used to treat city water except that it is smaller and less complicated. The first plant using this design was built on a Grade A dairy farm near Stillwater. Later, a second plant of the same type was constructed at the Stillwater Municipal Golf Course.

DESCRIPTION

Figure 3 shows the pond and farmstead layout at the dairy farm. The pond lies uphill from the barn. This prevents barn drainage from reaching the pond, and it also permits gravity flow of water from pond to treating plant. The plant is located adjacent to the milk room of the dairy barn, making it convenient for operation and servicing. A pump with a capacity of 1,200 gallons per hour supplies all the water needed on the farmstead, including an average of 45 milking cows and the young stock.

The Pond

The pond holds 2½ acre-feet of water, or 816,000 gallons. It was designed for maximum capacity and a minimum surface area to reduce loss by surface evaporation and ground seepage. The pond surface is roughly circular, with a diameter of approximately 140 feet. Greatest depth of water is 14 feet.

The watershed includes 12.1 acres for each acre-foot stored, or a total of 30.3 acres. It is covered with grass and timberland.

Cattle were fenced from the pond. No fish or plant life was put into the water.

Figure 4.—Construction of intake at pond on dairy farm. The concrete blocks were built up to a level slightly above the top of the perforated and capped intake pipe. The other pipe is not connected; it merely extends above the water surface to aid in checking the level of water in the pond.

Figure 4 shows construction of the intake leading to the treating plant.

The Treating Plant

Construction and arrangement of the treating plant are shown in Figures 5 and 6. Figure 7 shows the plant installed at the Stillwater golf course. Figure 8 shows the reinforcing used in the concrete work at the dairy farm.

Coagulant Feeder and Settling Basin

Three different devices for feeding alum were tried. The one shown in Figure 9 proved the most satisfactory.

Water level in the settling basin is controlled by a float valve. Water entering the basin strikes the baffle partition shown in Figure 6.

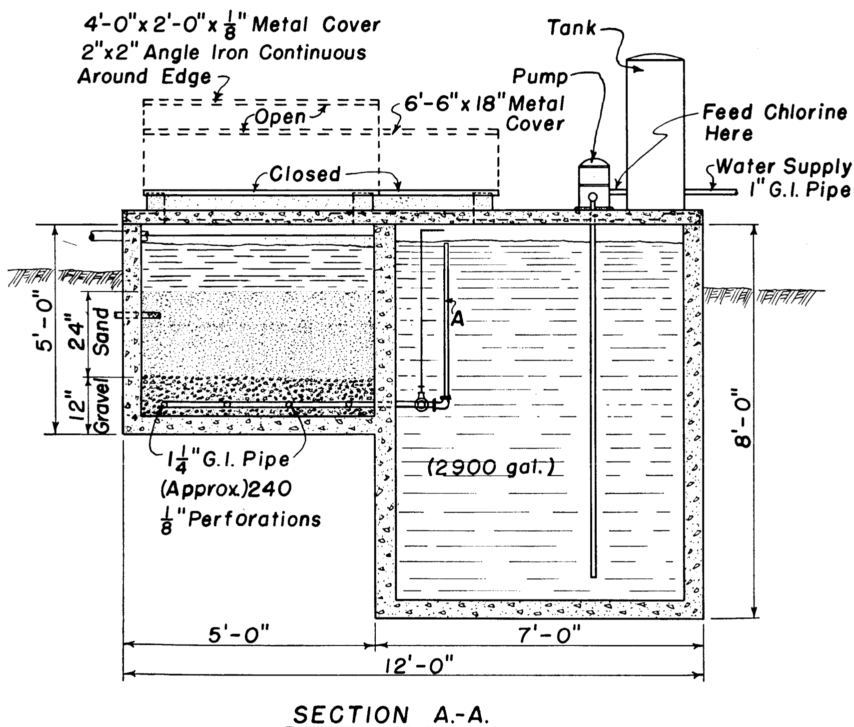

Figure 5.—Cross-section of unit water-treating plant, at "A-A" in Figure 6. Persons unfamiliar with water treatment systems can identify the various parts by referring to Figure 2.

This helps mix the alum thoroughly with the water, and also prevents the water from running across the top of the settling basin into the filter.

Filter

Depth of water over the sand in the filter is controlled by the swinging ell inlet to the storage tank ("A" in Figures 5 and 6). Since the rate of flow through the filter is controlled by the "head" or depth of water above the sand, it can be controlled by raising or lowering the end of inlet pipe "A".

Clean builder's sand was used in the filter. It was passed through a ¼-inch mesh screen. This gave a coefficient of uniformity of 1.63, and a grain size ranging from .36 millimeter to .52 millimeter. This grain size is recommended by standard water treatment handbooks as giving

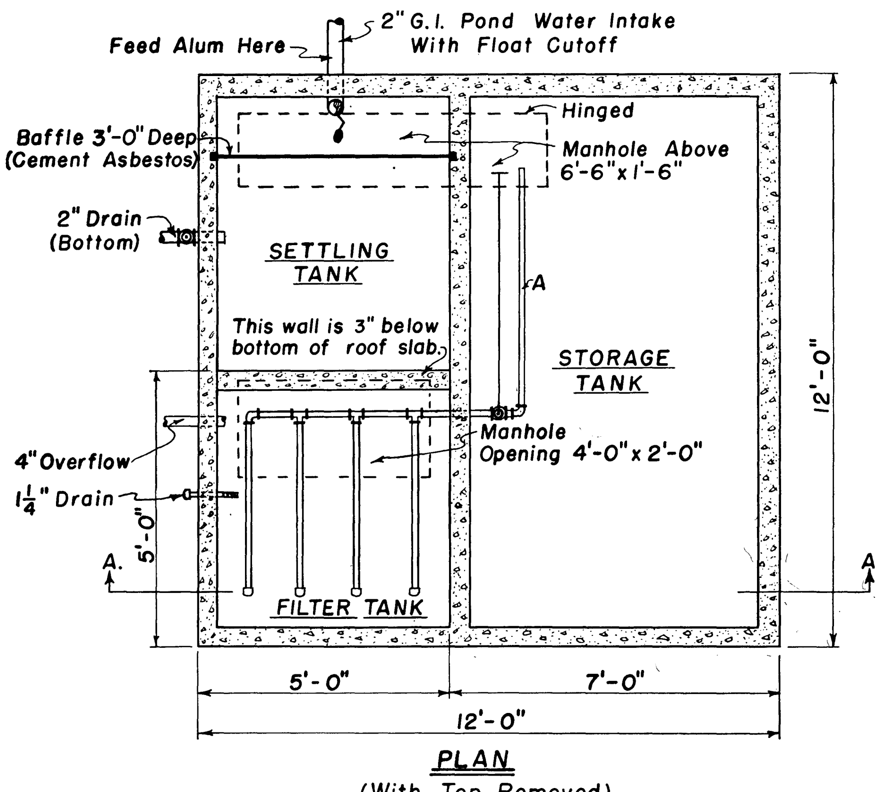

Figure 6.—Plan of unit water-treating plant.

the greatest clarity and purity of water in slow sand filters, the type used in this plant.

Chlorinator

A chlorine feeder approved by the Oklahoma State Health Department is installed between the pump and the pressure tank. A list of manufacturers of such feeders is available upon request from the Department of Agricultural Engineering at Oklahoma A. & M. College.

In installations not requiring approval of the State Health Department, a feeder of the type shown in Figure 9 could be used, and should prove satisfactory.

OBSERVATIONS ON PLANT OPERATION

Pond

Turbidity of the impounded water averaged 190 parts per million immediately after the pond filled. Within 90 days, the foreign matter in the water had partially settled, and the turbidity dropped to about 100 parts per million. It remained more or less constant at that figure thereafter.

The pond held a total of 816,000 gallons at the end of September, 1951. At mid-August of 1952, calculation showed 174,500 gallons remaining. The year had been exceptionally dry, so no water had been added by runoff. Therefore, a total of 641,500 gallons had disappeared from the pond during 10½ months.

A meter installed for experimental purposes showed 236,600 gallons of water had been used on the farm. Evaporation pan records at Stillwater indicated loss by evaporation from this pond during the 10½

Figure 7.—Exterior view of unit water-treating plant as built at Stillwater golf course. A separate manhole is used for each of the three compartments. The extension at the right, not shown in Figure 6, contains the chemical feeder shown in Figure 9.

months probably had been about 315,000 gallons. The remaining 90,000 gallons (approximately) which disappeared presumably was lost by seepage. Seepage loss should be less in the future, since this was the first time the pond had contained water.

In this case, at least, the watershed ratio shown in Figure 1 worked out almost exactly. The pond's ratio is 12.1 acres of watershed per acre-foot stored, and Payne county is on the 12-acre line in Figure 1. After 10½ months of use, with no runoff, enough water remained in the pond for another 2½ months at the same rate of usage.

Alum Feeder

Three different alum feeders were tried. The one finally adopted is shown in Figure 9.

Alum was purchased from a city water-treating plant. The solution was made by mixing one part of alum and three parts of water, as measured by weight.

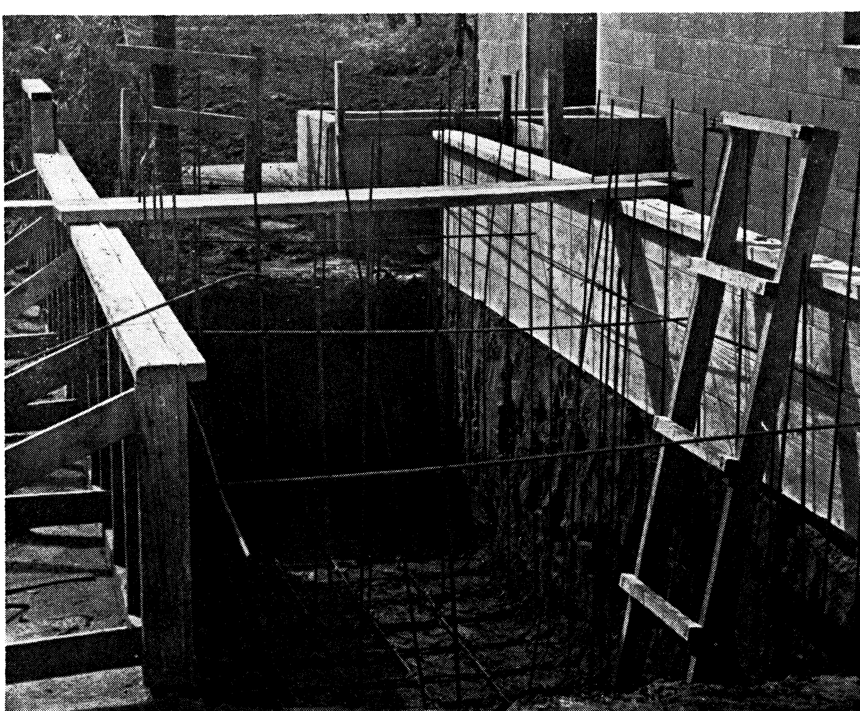

Figure 8.—Unit water-treating plant at dairy farm during construction, with reinforcing rod in place.

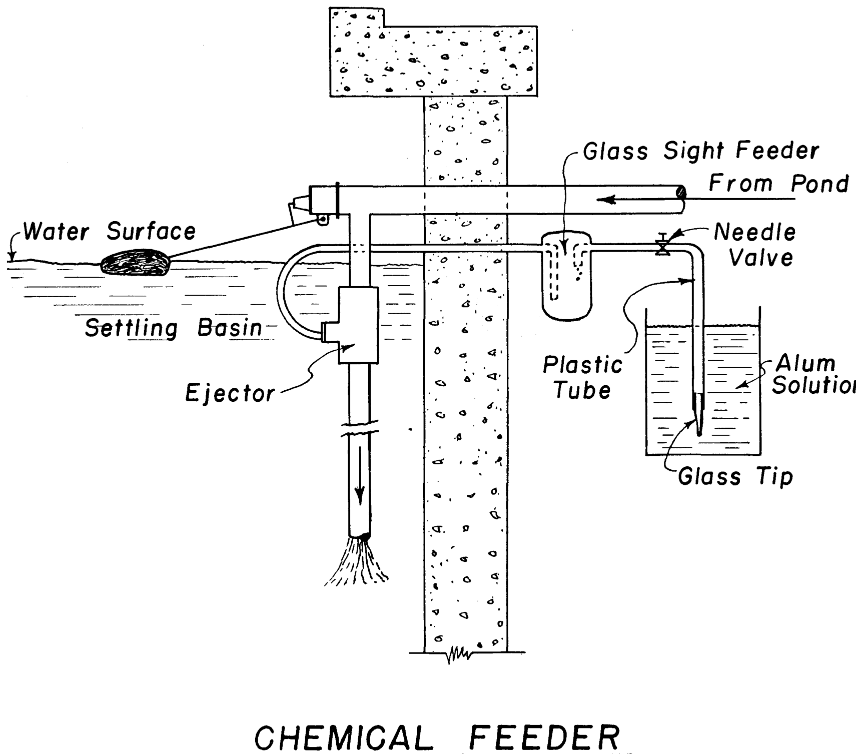

Figure 9.—Type of alum feeder found most satisfactory in treating plant at dairy farm. This same type of feeder could also be used to feed chlorine between pump and pressure tank.

The feeder gave best results when adjusted to supply about one pound of alum for each 1,000 gallons of water. This made the water slightly more acid (the pH was lowered approximately 0.2), but this is not considered objectionable in a farm water supply. Jar tests indicated that about one-half pound of alum was needed to properly clear 1,000 gallons of water having a turbidity of 120 to 150 parts per million.

The first feeder installed was the off-set parallel type shown in Figures 10 and 11. Flow through the feeder is controlled by putting a perforated plate between two gaskets in the inlet union. This feeder worked satisfactorily as long as the alum solution in the feeder was below the saturation point; but beyond that, the solution became a sirupy mass, too sticky to flow.

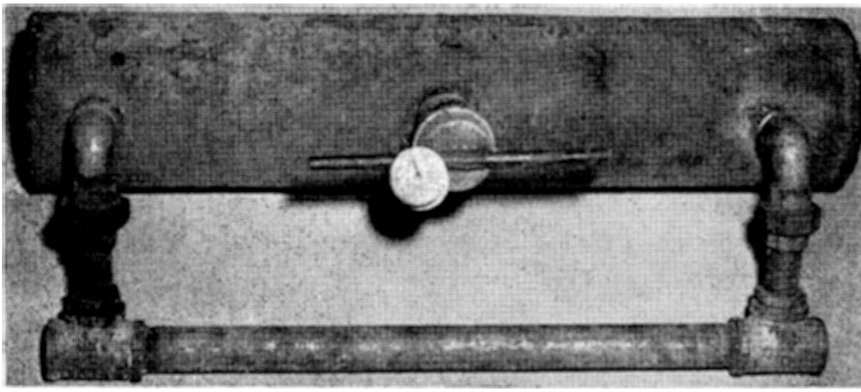

Figure 10.—Home-made off-set parallel type feeder for alum. This feeder is simpler than the one shown in Figure 9, but was difficult to adjust properly (See page 15). A commercially-manufactured feeder of this type worked satisfactorily, but was so small that frequent refilling was needed.

A commercial feeder of the off-set parallel type was installed next. It worked satisfactorily except that it held less than 13 ounces of alum and had to be refilled frequently.

Settling Basin

The settling basin was designed to hold the water for about four hours, which appeared to be satisfactory. Thus the 1,000-gallon tank had an effective capacity of 250 gallons per hour or 6,000 gallons per day.

Filter

The filter was cleaned by partially draining it (by lowering the swinging ell in the storage tank) and removing the surface layer of sand which had become clogged with silty particles removed from the water. About two inches of the surface layer was removed at each cleaning. The sand does not need to be replaced until the layer becomes too thin to be effective (about 16 inches).

Periods between cleanings varied, depending on how well the alum was mixed with the water and the length of time water remained in the settling basin. Under best conditions, as much as 3,500 gallons per square foot of surface flowed through the filter before cleaning was necessary. When water was not well flocculated, as little as 500 gallons per square foot was obtained between cleanings. Thus the range of this filter with 20 square feet of surface was from 10,000 to 70,000 gallons per cleaning.

The filter operated most satisfactorily, with longest period between cleanings, when the level of the water in the filter tank was kept about five feet above the level of the water in the storage tank.

Attempts were made to clean the filter by backwashing it in sections, but the pump did not supply water rapidly enough. Water treatment handbooks indicate that a rise of 24 inches per minute is necessary for properly backwashing a filter of this type.

Quality of Water Produced

Freedom from Bacteria

Water samples were taken from the storage tank at irregular intervals (that is, prior to chlorination) by the county milk inspector. Samples classified as unsafe for drinking were sometimes produced when there was incomplete flocculation or too rapid flow through the filter. However, chlorination of the water as it left the pump assured safe drinking water at all times.

Taste and Odor

Undesirable taste and odor appeared in the water during the fall months. At that time of year, lower air temperatures cool the surface water and cause the warmer water at the bottom of the pond to rise. A similar "turn over" of water occurs in the spring, but usually takes

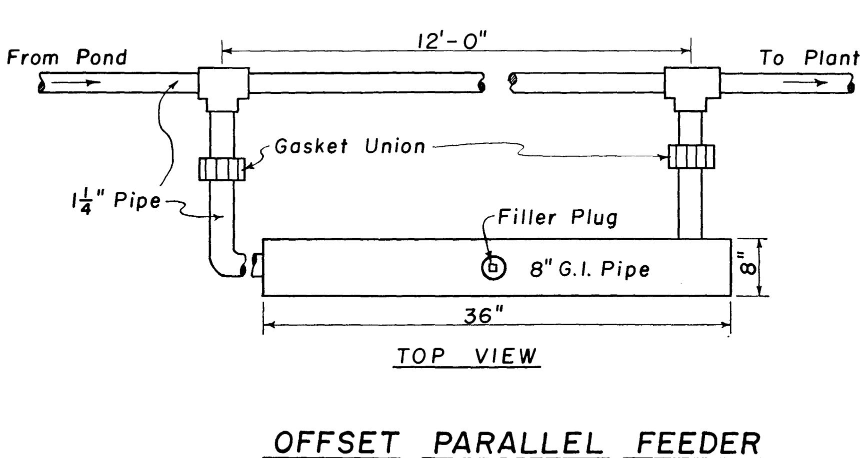

Figure 11.—Construction details of off-set parallel type alum feeder.

place more rapidly. During these periods, decaying vegetable and other organic matter is stirred up from the bottom of the pond.

At the dairy farm, this problem was partially solved by placing a layer of granulated, activated charcoal on the surface of the filter and in the settling basin. Ordinarily, charcoal is not recommended. Where

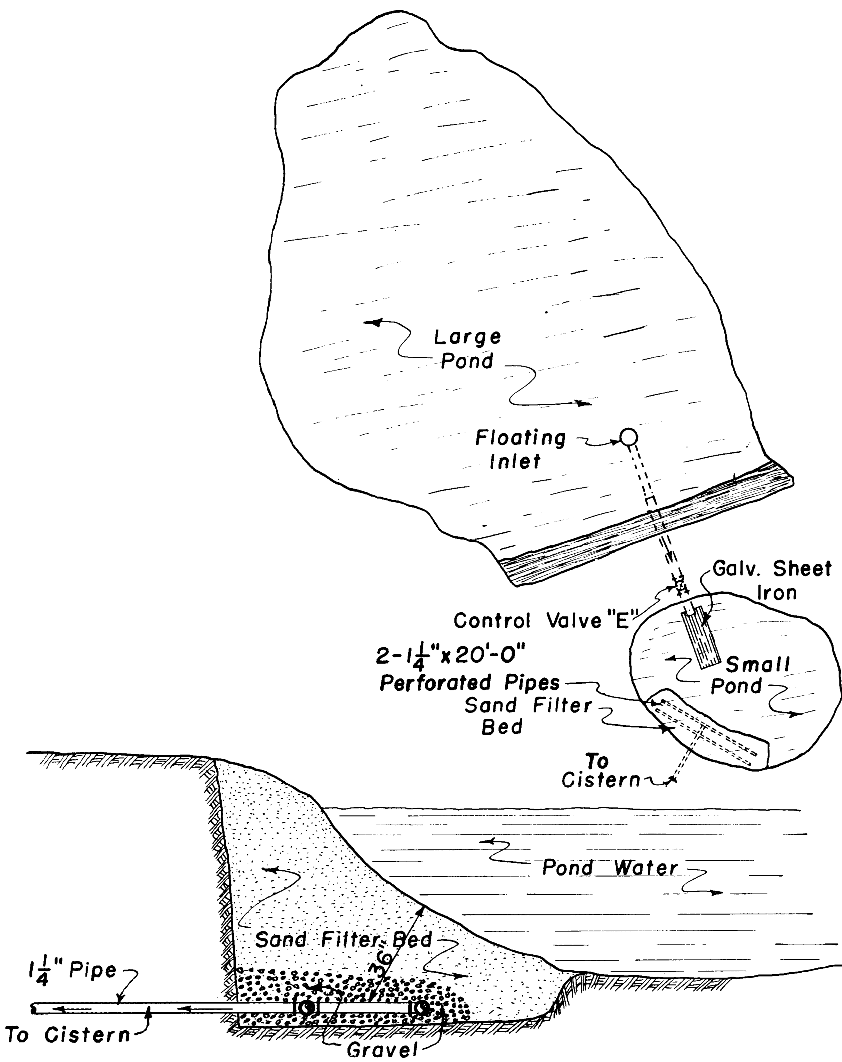

Figure 12.—A small pond used as settling basin. Coagulating chemicals are added as water flows from valve "E," and the sand filter is built into the side of the pond.

the taste and odor problem is severe, the activated charcoal could also be put loosely into a porous cloth bag and the bag hung in the storage tank.

During the hot summer months, water samples were taken regularly at different depths in the pond and analyzed for clarity and chemical content. These analyses showed that the pond water was in layers, with decomposition of organic matter occurring chiefly in the lower strata. The top layer contained oxygen, and little or no taste or odor was present. This observation led to the suggestion that a floating inlet to the treating plant, instead of a submerged one as shown in Figure 4, would help eliminate objectionable taste and odor except during the spring and fall "turn over" periods.

Clarity

Application of superphosphate fertilizer to the pond watershed area at the dairy farm helped clear the runoff water before it reached the pond, and thereby reduced the amount of turbidity.

Two other methods are sometimes advocated for clearing pond water. One is the growing of vegetation in the pond, or the addition of vegetable matter such as green sunflowers, hay, or other similar material. The other is to add lime, gypsum, alum or other chemicals to the water in the pond. The latter, by clarifying the water, encourages plant growth. Either method, by increasing the amount of vegetable matter, is likely to produce more undesirable taste and odor in the water than a pond with no plant and animal life. Most city water-treating plants depend on proper flocculation and filtering to remove turbidity, rather than attempting to reduce turbidity in the raw water supply.

Other Types of Installations

The Experiment Station also assisted with the construction of, and observed the operation of, two other systems for treating surface water. One of these uses a small pond as the settling basin; the other uses a cistern at the edge of the pond to collect filtered water.

SMALL POND AS SETTLING BASIN

Figure 12 shows the essential elements in a water-treating system built at a rural consolidated school near Stillwater. In this system, water flows by gravity from the large storage pond to a smaller pond which serves as the settling basin. This smaller pond is 40 feet in diameter and 9 feet deep, holding approximately 28,000 gallons. It is built so no surface water can flow into it. Figure 13 is an aerial view of the ponds.

Water from the storage pond is taken through a floating inlet, as suggested on page 12.

A control valve ("E" in Figure 12) is used to refill the small pond from the large pond whenever necessary. Water entering the small pond strikes a sheet of corrugated metal as shown in Figures 12 and 14. Coagulating chemicals are added by putting them in a muslin sack and placing the sack on the corrugated metal where the incoming water will flow over it.

The chemical used in this case is a mixture of two parts powdered alum and one part hydrated lime. The alum and lime are stored separately and mixed just before using. A new batch is mixed and placed each time the small pond is refilled; approximately one pound of this mixture is dissolved into the water for every 1,000 gallons. The muddy water clarifies to less than 30 parts per million within 24 hours.

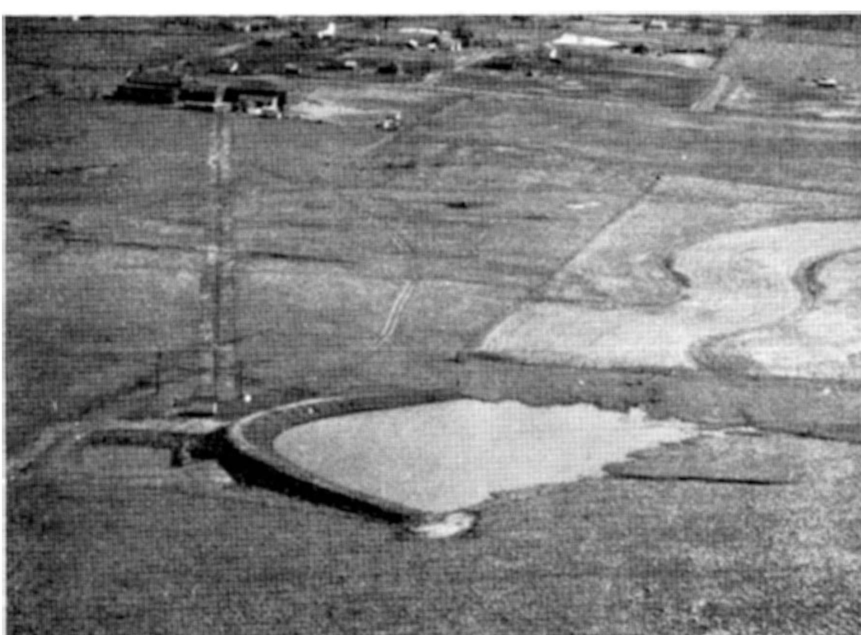

Figure 13.—Aerial view of water-treating system using a small pond as settling basin.

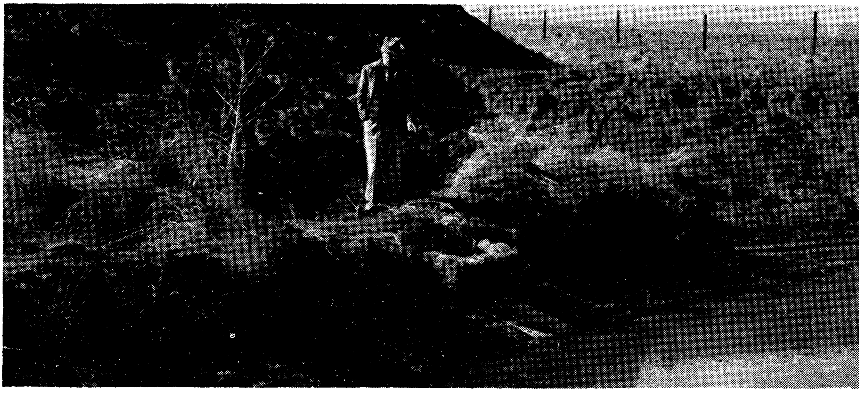

Figure 14.—Inlet from storage pond to small pond used as settling basin. The corrugated metal sheet prevents erosion and also provides a place where coagulating chemicals can be added.

A sand filter was built into the edge of the settling pond, as shown in Figure 12.

A pump near the small pond forces the water to the school building some 1,500 feet away. Chlorine is added at the pump to meet state health requirements.

CISTERN AT SIDE OF POND

Figure 15 shows an installation in which a cistern located at one side of the pond is used to accumulate clear water. Water from the pond filters through a fill of sand between the pond and the cistern, and then through the porous brick wall of the cistern itself. Clean, ungraded sand is used for the fill.

This system was designed to serve a single private residence. No flocculating chemicals are used, therefore no settling basin is needed. Neither is there a chlorinator, though use of one might be good health insurance.

This system was observed during its first year of operation. During that time, turbidity in the pond averaged above 200 parts per million, but there was no noticeable taste or odor in the filtered water at any time. A pump rated at 800 gallons per hour operated for as long as four hours at a time without pumping dry the 2,000-gallon cistern.

A similar system at another rural home near Stillwater has operated about 18 years without cleaning or changing the sand. However, there is a slight "marshy" taste in the water during late summer months.

Comparison of the Three Systems

UNIT TREATING PLANT

The unit treating plant requires little space, is easy to service, and can be located wherever convenient. The filter is easily cleaned. Freezing is not a problem, and there is little evaporation loss. The system can be designed large enough to provide a high rate of water treatment where the demand is heavy; yet the relatively small amount of water treated at one time makes it easier to deal with taste and odor problems.

The principal disadvantages of the unit treating plant are the higher initial cost and the greater skill needed in building the reinforced concrete structure.

SMALL POND AS SETTLING BASIN

When a small pond is used as a settling basin, the cistern is the ony reinforced concrete work needed, and it is relatively simple to

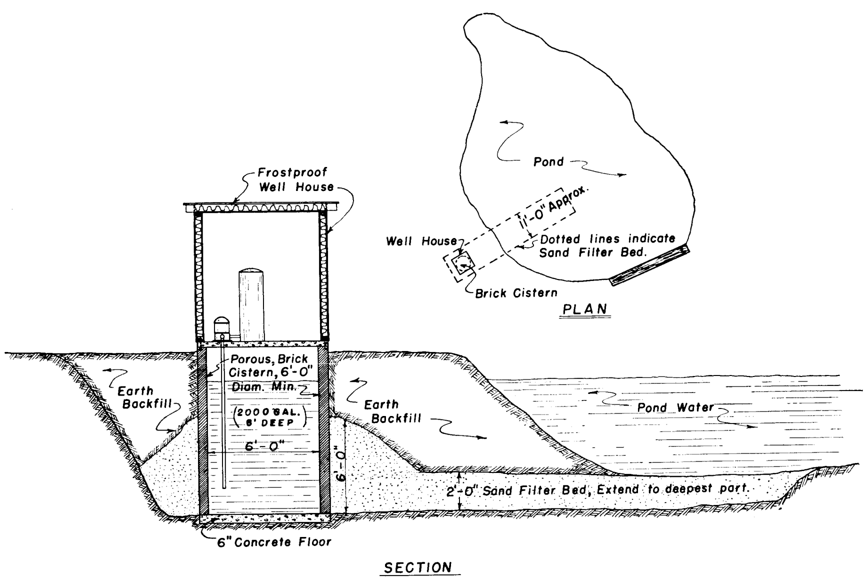

Figure 15.—Arrangement of system using cistern at side of pond. A sand fill and the porus brick wall of the cistern provide filtering. There is no other treatment of the water. This arrangement would not be approved for a Grade A dairy or a public place such as a school, but it is giving satisfactory service for rural residences.

build. The method of adding flocculating chemicals is also simplified, and the alum-lime ratio may be varied to control the pH (acidity or alkalinity) of the water. (If lime is to be used with the unit-type plant, two feeders will be needed, one for alum and one for lime.)

There is noticeable evaporation loss from the small pond in hot, dry weather. Each time the settling pond is refilled, the water must be allowed to settle 12 to 24 hours before it is run into the storage cistern.

CISTERN AT SIDE OF POND

Little maintenance is needed for the system using a cistern at the side of a storage pond. However, some difficulty might be encountered in removing silt from the filter surface if that should become necessary.

Taste and odor are likely to be a problem because the water inlet from pond to cistern is from the bottom of the pond. Inflow to the cistern is slow, and becomes slower as the water level in the pond becomes lower. There may be a possibility that the porous brick wall of the cistern might eventually become clogged, but no definite information is available.