A System for
POND WATER PURIFICATION

UNIVERSITY OF MISSOURI
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Appreciation is expressed to the Extension Agricultural Engineers, University of Missouri for much of the material concerning pond and watershed management and pond water inlet construction details.

UNIVERSITY OF MISSOURI
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
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NOTES ON USE OF SYSTEM

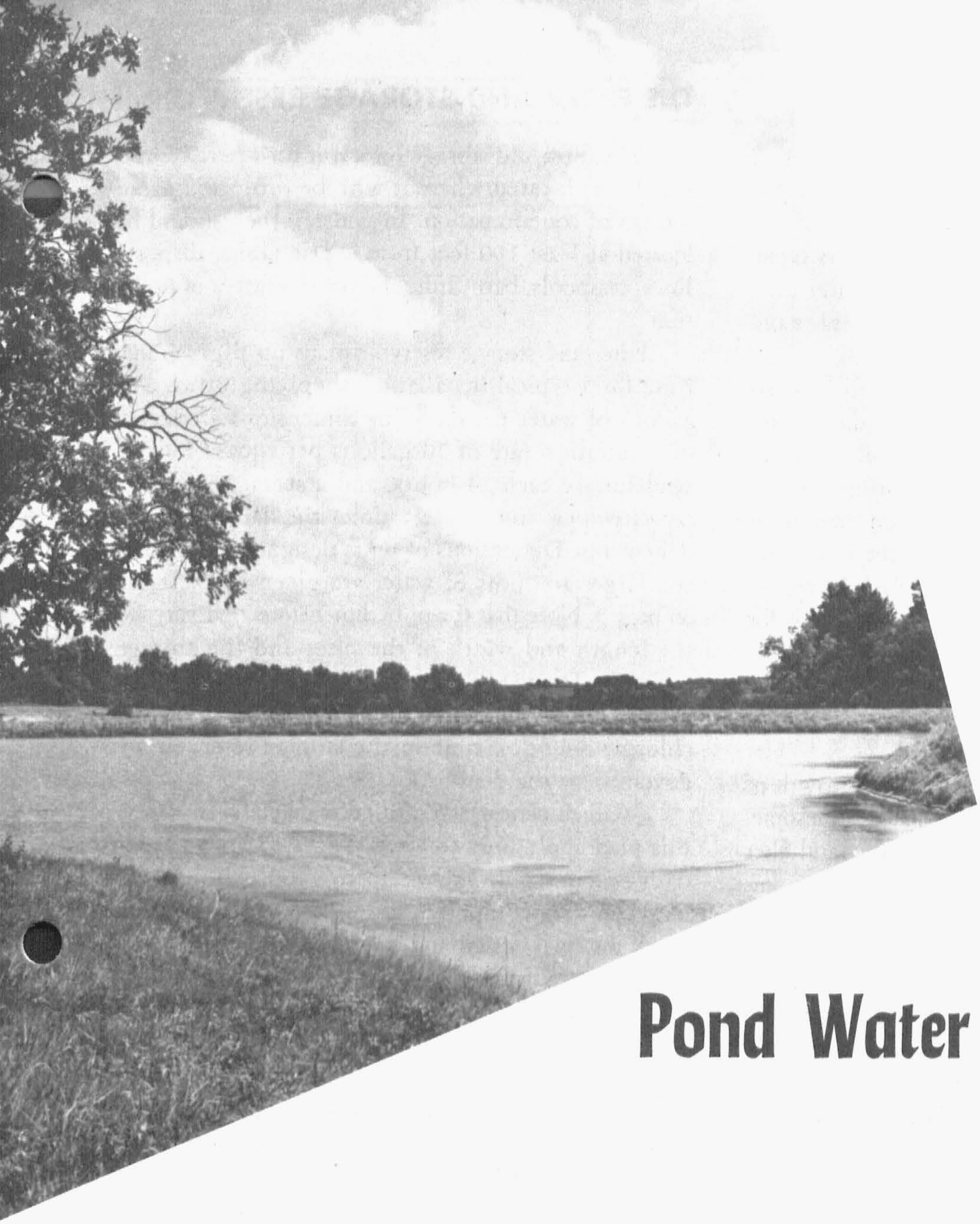
In many rural areas farmers cannot obtain good well water. In these areas it is often necessary to collect surface water in ponds for home use. The water treating system described in this bulletin is recommended for use with pond water on individual farms. It is not proposed as a substitute for a good well, nor is it recommended for rural or suburban housing developments.

Each part of the system performs an important function in the treating of pond water to make it safe for domestic use; therefore, it is essential that every part be carefully planned and properly installed.

The system described is a typical one. Varying conditions will require changes in certain details. The principles of the system, however, should be followed very closely.

Publications of value in planning and building a water system are listed in the appendix.

CONTENTS



First requirement — a pond that collects relatively clean water from a meadow or pasture.

A System for Pond Water Purification

THE SURFACE RESERVOIR

Pond location and size are two highly important items for satisfactory water supplies.

The location should offer as much freedom from contamination as possible. Water supplies that are not properly located and handled may be a serious health hazard. Dysentery, diarrhea, typhoid fever, and other intestinal diseases are often transmitted by water which has become contaminated by human or animal wastes.

The size should be sufficient to provide for all anticipated household and livestock needs plus evaporation and seepage losses. The smallest pond recommended is one that will furnish a minimum of 630 gallons of water per day. It should be designed to meet the following requirements:

1. **Minimum capacity, 4 acre-feet.**
2. **Minimum depth, 8 feet.**
3. **Area of the deepest part, at least 1/16 the total surface area.**

This capacity is designed to include a 4-foot reserve at the end of a two-year period in which no appreciable run-off occurs.

A location should be chosen as near the farmstead as practical with drainage only from controlled pasture or meadow land. Water from barnyards or other areas with large concentrations of livestock should never drain into ponds used for domestic water sources. The pond should be fenced so that livestock will not have direct access to the water.

CLEARING POND WATER

Even when a pond is supplied by a well-grassed watershed, the water is frequently clouded with suspended clay, silt, or organic matter. Such water is called turbid. Highly turbid water clogs filters rapidly, necessitating frequent cleaning of the filter unit. In general, the lower the turbidity, the less maintenance required.

Water which has no more than 20 to 25 parts per million of turbidity is considered satisfactory for filtering. Water of greater turbidity should be treated before filtering. One method of clearing water is to use coagulating chemicals in a sedimentation chamber placed immediately ahead of the filter unit. However, in most cases, adding agricultural gypsum directly to the pond at a rate of about 12 pounds for each 1000 cubic feet of pond storage capacity will reduce the turbidity to a sufficiently low level. The gypsum may be scattered over the water surface from the pond banks.

After the water has been cleared the growth of algae and other plant life may become troublesome. A heavy concentration of algae can clog the sand filter quickly; in addition, the decaying plant life may impart tastes and odors to the water that are not likely to be removed in the filtering process. Plant life can be controlled by applying copper sulfate to the water at a rate of no more than 1 ounce for each 4200 cubic feet of water. The Division of Health is opposed to the use of the pond for swimming or *any* other recreational purpose that would increase turbidity or contribute to contamination.

THE FILTER AND STORAGE RESERVOIR

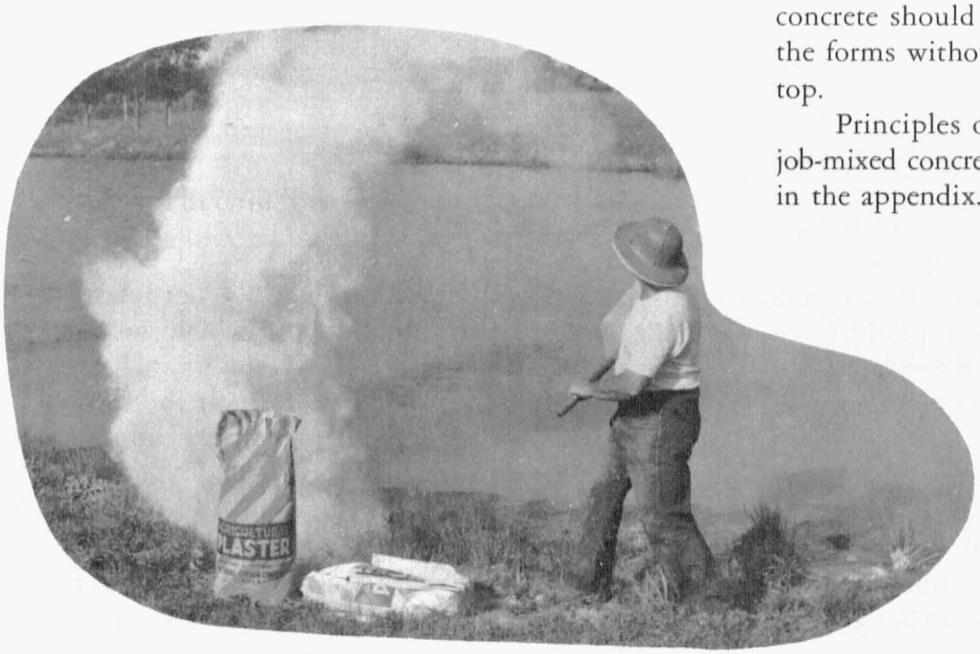
The filter and storage reservoir for filtered water should be located where it will be protected from sources of contamination. In general, they should be located at least 100 feet from septic tanks, disposal lines, cesspools, barnyards, and other sources of pollution.

Filter and storage reservoir plans on pages 6 and 7 are for a typical installation supplying up to 840 gallons of water per day. The dimensions are based on a filtration rate of 70 gallons per square foot of sand surface each 24 hours, and a storage reservoir capacity approximately 2½ times the daily water requirements. Dimensions of units designed for smaller and larger amounts of water are given in the table on page 5. Note that the only dimensions that vary are the length and width of the filter and the storage reservoir. The depth must remain constant since the rate of filtration through the sand filter and the chlorine retention time in the storage reservoir are governed by the depth.

Wall thickness and reinforcing details shown in this plan apply only to sizes suggested (page 5) for daily water requirements up to 1400 gallons. For larger units a competent engineer should make or check the final design and supervise the construction.

The strength, durability, and watertightness of concrete are largely determined by the amount of water used per sack of cement. For watertight concrete, no more than six gallons of water can be used per sack of cement. When using ready-mix, this requirement should be made clear to the company. The concrete should be stiff enough to be worked into the forms without the fine materials coming to the top.

Principles of designing rectangular tanks and job-mixed concrete are covered in publications listed in the appendix.



Gypsum at 12 pounds per 1000 cubic feet usually clears pond water sufficiently.

Water Needed Gallons/Day	Filter*			Storage Reservoir**		
	Filter Surface Sq. Ft.	Dimensions-Ft. C	Dimensions-Ft. D	Storage Capacity Gallons	Dimensions-Ft. A	Dimensions-Ft. B
630	9***	4	4	1250	7	5
840	12	4	5	1860	8	6
1120	16	5	5	2260	8	7
1400	20	5	6	3060	8	9
1680	24	5	7	† 4260	8	12
2450	35	6	8	† 5530	10	12
3430	49	8	8	† 6800	12	12

*Filter size based on filtering rate of approximately 70 gallons of water per square foot of filter surface per 24 hours.

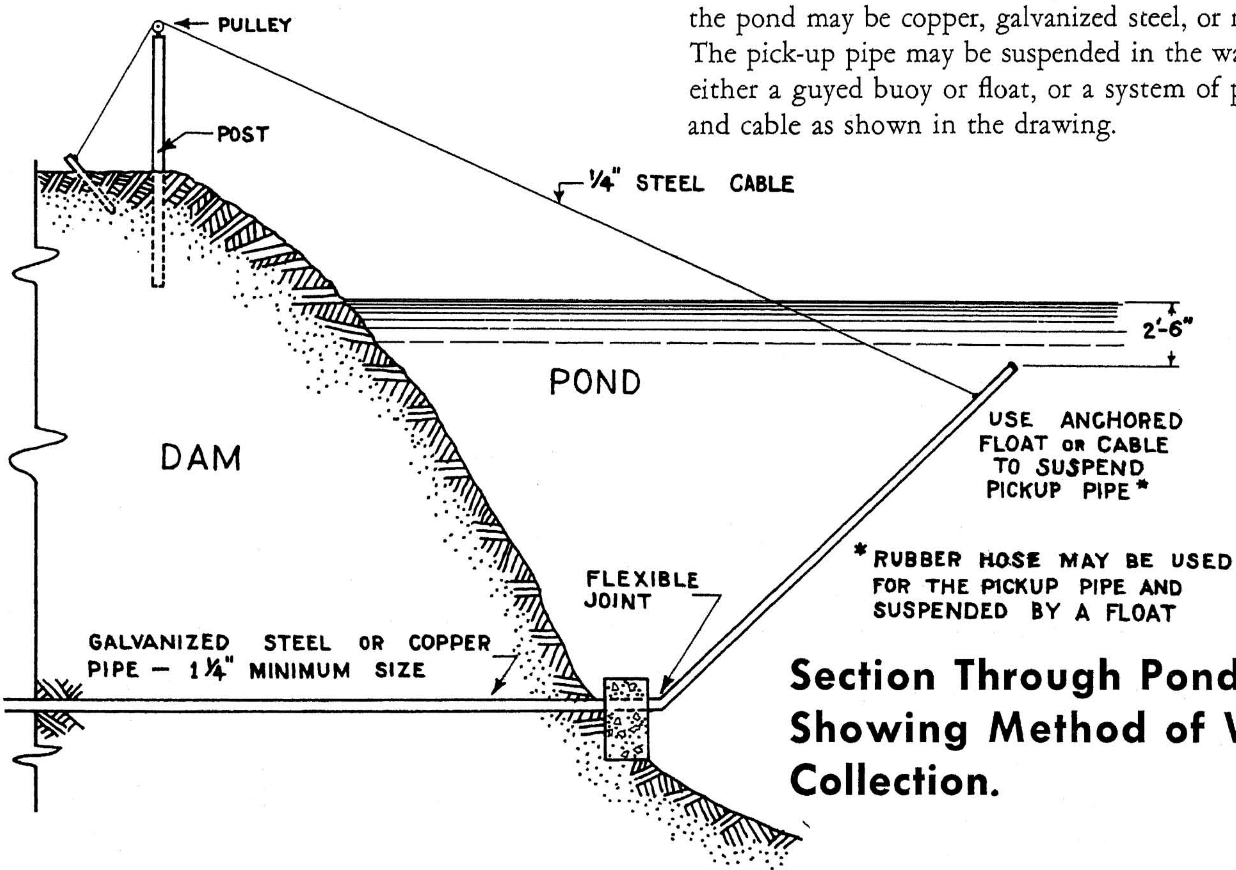
**Storage reservoir sizes based on approximate storage capacity of 2½ times the daily needs. This reserve is desirable for emergency use and also tends to even out the filtering rate as well as allowing adequate retention time for the chlorine.

***Minimum recommended sizes.

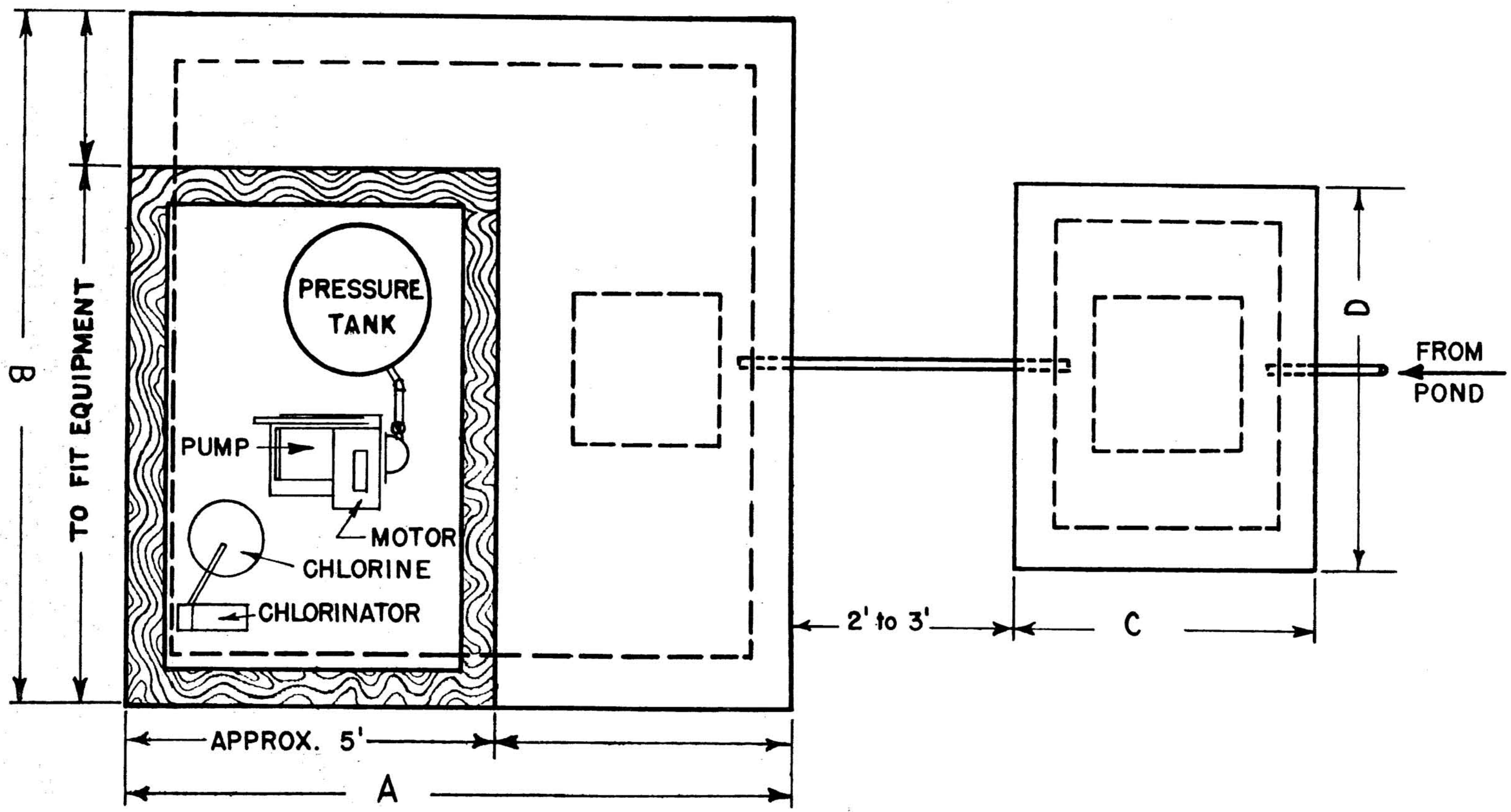
†Wall thickness and reinforcing specified in drawings on pages 6 and 7 do not apply to reservoirs of these capacities.

CONSTRUCTION DETAILS

Pond Water Inlet: Water should be collected well away from the pond dam and 2 to 3 feet below the water surface. This can be accomplished in many ways (See drawing below and methods of suspending intake, page 8). The pipe through the dam must be rigid, of galvanized steel or copper, and of a minimum size of 1¼ inches. The portion of the pipe in the pond may be copper, galvanized steel, or rubber. The pick-up pipe may be suspended in the water by either a guyed buoy or float, or a system of pulleys and cable as shown in the drawing.

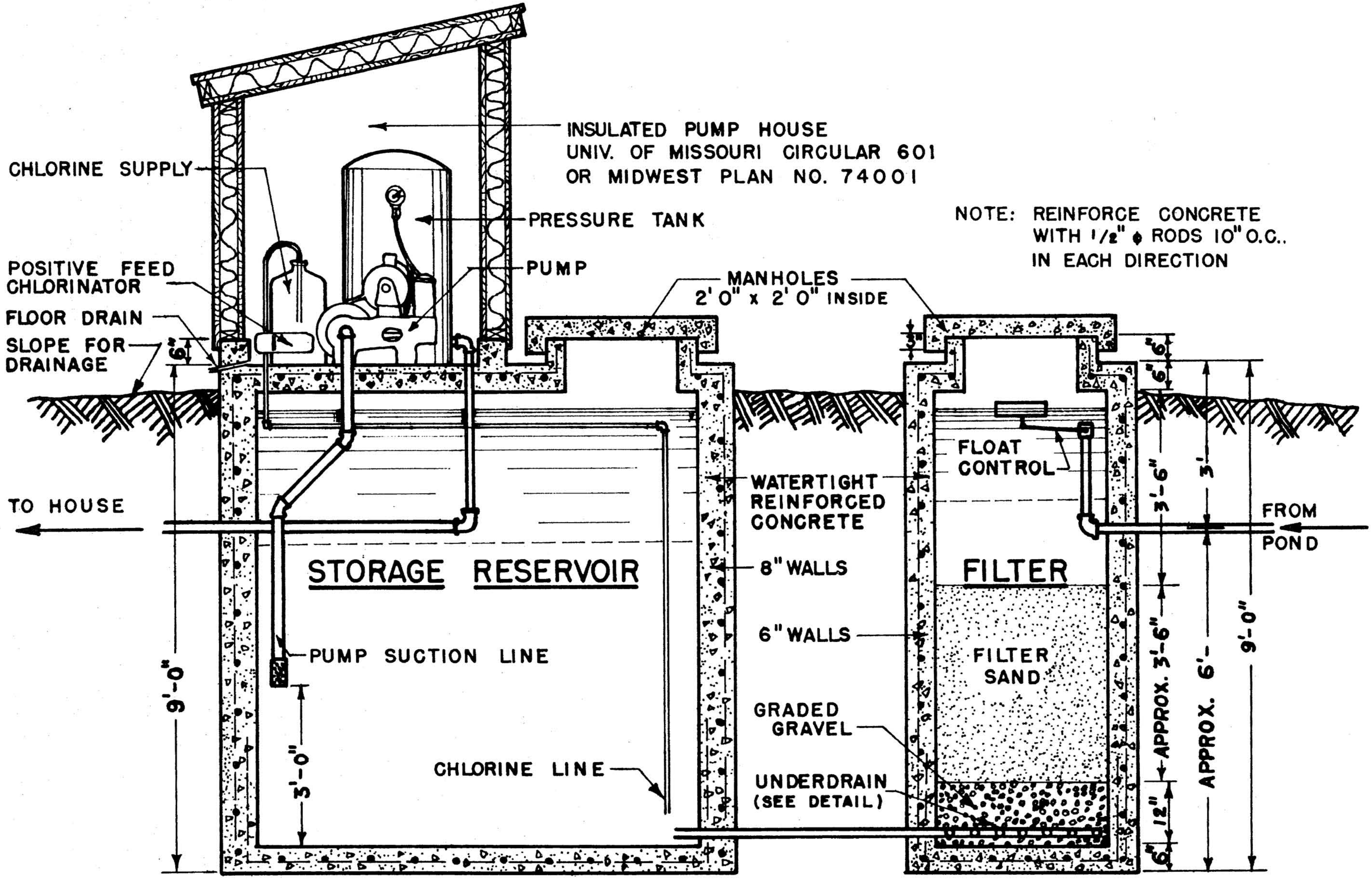


Section Through Pond dam Showing Method of Water Collection.

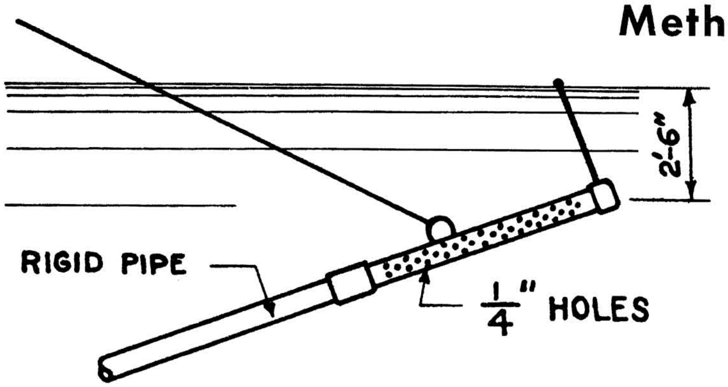


Plan of Filter and Storage Reservoir.

A, B, C, D—refer to table, page 5

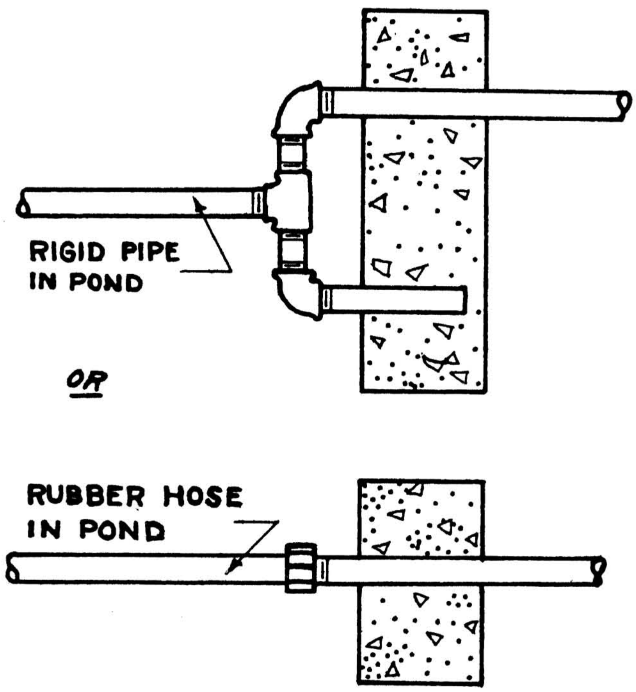


Section Through Filter and Storage Reservoir.



CABLE TO POND DAM

Top View of Flexible Joints.



Filter Water Level: The water level in the filter should be maintained at a depth of about 3 feet above the surface of the filter sand. If the water flows by gravity from the pond to the filter, the water level can be maintained by a simple float-controlled valve. If the location of the pond requires that the water be pumped to the filter, the pump motor may be controlled by a float-operated switch, adjusted to start and stop with no more than a 6-inch difference in water levels between the "on" and "off" positions of the switch.

Underdrain: Details of the underdrain are shown on page 9. The assembled underdrain is placed on a layer of 1-inch gravel, 2-inches thick, with the perforations downward. On top of the underdrain is placed a 12-inch layer of gravel, graded from 1-inch size next to the underdrain to ¼-inch (pea) size at the top. The filter sand is then placed on top of the ¼-inch gravel. The layer of graded gravel prevents the filtering sand from entering and clogging the underdrain. The portion retained on the 18-mesh screen when the filtering sand is screened may be used as the smallest size of gravel in the graded gravel layer. (See "The Filtering Sand," page 10.)

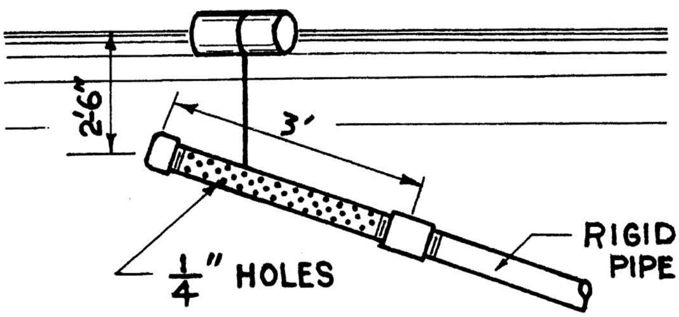
Pump House and Plumbing: It is preferable to locate the pump house over the storage reservoir so that all of the water lines which carry treated water underground will be under pressure rather than suction. If it seems desirable to locate the pump house near but not above the storage reservoir, the suction line to the pump should be placed inside a larger pipe or conduit to minimize the danger of pollution if leaks should occur.

Since the pump house must protect the pump, chlorinator, water lines, and other parts against freezing in the winter, it should be well insulated. Thermostatically controlled heat lamps should be installed to maintain above-freezing temperatures. Midwest Plan Service Plan No. 74001 and Missouri Extension Circular 601 give construction details for insulated pump houses. The size of the house will depend upon the size of the equipment selected. Should it be necessary to pump water from the pond to the filter the raw water pump may also be located in the pump house. However, the pump house should never be used for general storage.

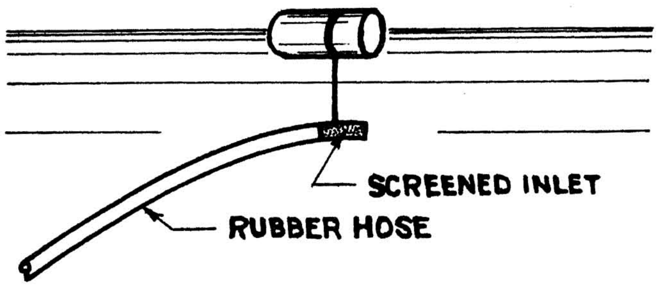
The end of the pump suction line should be at least 3 feet above the bottom of the storage reservoir and located opposite the chlorine line (see drawings, pages 6 & 7). This assures that the chlorine applied by the chlorinator will have ample time to mix with and disinfect the water. This arrangement also prevents the water from flowing too rapidly through the filter by controlling the maximum difference between water levels in the filter and storage reservoir.

The chlorinator discharge pipe must terminate directly above the line connecting the filter underdrain to the storage reservoir (see drawing, page 7). These two pipes should be very close together so that the incoming water from the filter will aid in distributing the chlorine solution.

of Suspending Pond Water Intake Pipe.

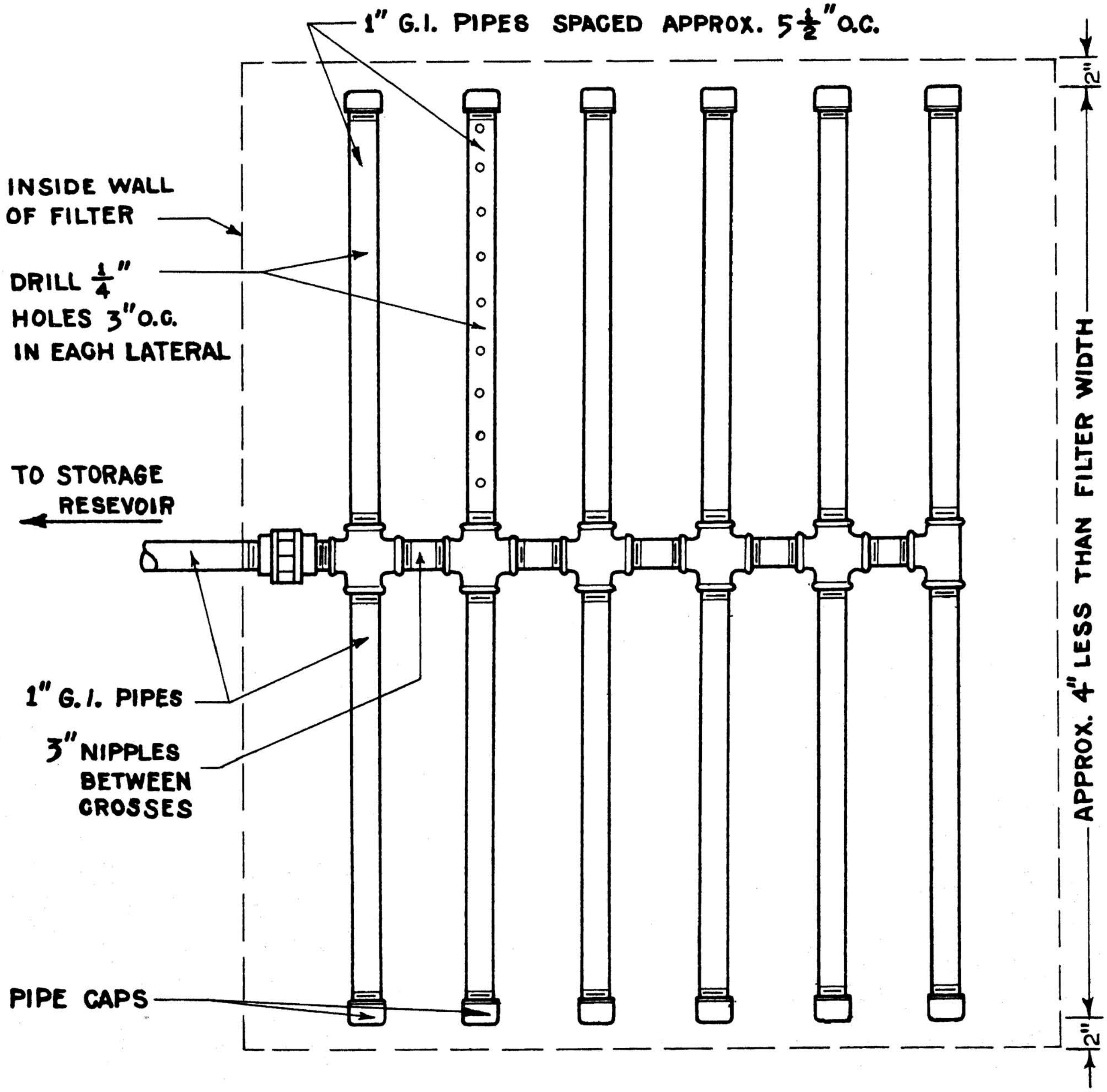


ANCHORED FLOAT



ANCHORED FLOAT

Piping View of Underdrain; Holes Must Be Underneath.



THE FILTERING SAND

Satisfactory filtration can be accomplished only when a high quality filtering sand is used. Perhaps the best way to be sure of getting a good filtering sand is to buy it from a sand and gravel company which can supply the sand to specifications. These specifications are listed in the appendix.

In localities where it is not feasible to purchase sand having these specifications, a fairly good filtering sand can be obtained by screening *washed* sand through a screen with 18 meshes per inch (ordinary window screen). In such cases, all the sand passing through the 18-mesh screen is used in the filter.

Use of a sand not meeting these specifications results in an inferior filter. Since the expense of obtaining good sand is a very small part of the total filter cost and filtration is governed almost entirely by the sand's quality it is senseless to use a sand which does not meet the specifications.

MAINTENANCE OF THE FILTER

The suspended matter from the water collects on the surface of the sand causing a reduction in the rate of filtration. Thus, it is occasionally necessary to clean the filter by removing the top ½ to 2 inches of sand. After 6 inches of sand have been removed by repeated cleanings, the sand should be brought back to its original level with additional properly screened sand.

CHLORINATION

The sand filter alone cannot be depended upon to remove bacteria. Filtered water in the storage reservoir cannot be considered safe for human consumption until it has been disinfected by chlorination.

In selecting a chlorinator, only those having positive feed, that is, those mechanically linked to the pump motor or having a separate motor for operating the chlorinator, should be considered. A list of manufacturers of acceptable chlorinators can be obtained from either the Department of Agricultural Engineering, University of Missouri or the Department of Public Health and Welfare of Missouri, Division of Health, Jefferson City, Missouri. Chlorinators that depend upon hydraulic suction for operating power cannot be considered acceptable in their present stage of development.

A 1 percent chlorine solution is used by most small chlorinators, and a five-gallon jug or crock may be used as a reservoir for the solution. Since chlorine is extremely corrosive to metals, metal containers should not be used for storing the chlorine solution. The amounts of several different materials needed to prepare five gallons of a 1 percent solution are listed below.

Material	% Chlorine in Material	Amount of Material to Add to 1000 Gallons of Water to Produce a Concentration of 50 Parts per Million OR Amount of Material Required to Produce 5 Gallons of a 1% Solution
Purex or Clorox (liquid laundry bleach)	5.25	1 gallon
Sodium Hypochlorite (liquid)	12	7 cups
B-K Powder	50	1-1/2 cups
H.T.H. Perchloron, etc. (powder)	70	1-1/8 cups

Note: 16 Tablespoons equal 1 cup; 1 cu. ft. water equals 7-1/2 gallons.

The amount of chlorine solution necessary to disinfect the water varies according to the condition of the water. The rate at which the chlorine solution is discharged into the storage reservoir is determined by testing the water for the presence of chlorine. It is therefore essential that the water in the storage reservoir be tested daily. A simple color-comparison test, in which a sample of faucet water is mixed with orthotolidin and then matched with a set of standard colors will determine the amount of chlorine in the water. The test is a simple one requiring but a few seconds time. If the amount is found to be too little or too great, the chlorinator is adjusted accordingly. The proper concentration of chlorine is approximately 1 part per million. Testing kits are available from chlorinator suppliers.

PLACING THE FILTER IN OPERATION

Before placing the sand in the filter, the walls of the filter and the storage reservoir should be washed with a strong solution of baking soda and water, and then rinsed with clear water. This is to prevent "lime" taste. If the lime taste persists after the storage reservoir has been filled, a solution of baking soda and water may be added to the storage reservoir.

Enough chlorine should be added to the first filling to produce a concentration of 50 parts per million (see table, page 10). This assures disinfection of the reservoir. After 24 hours the reservoir should be emptied and allowed to refill with the chlorinator operating. Once the pump and the chlorinator are in operation, regulation of the chlorinator will insure application of the proper amount of chlorine.

APPENDIX

Filter Sand Specifications.

The sand used in slow sand filters must meet certain requirements for *effective size* and *uniformity coefficient:*

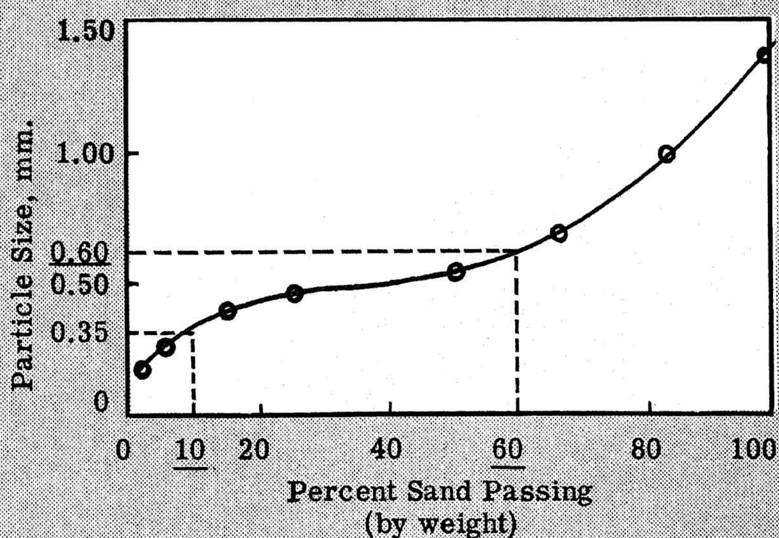
The *effective size* of a sample of sand is defined as the size of grain that is larger by weight than 10 percent of the particles in the sample and smaller by weight than 90 percent of them. *The effective size of the sand should not be less than 0.2 mm and not greater than 0.4 mm.* It is usually specified as 0.3 mm.

The *uniformity coefficient* is defined as the ratio of the size of grain which has 60 percent of the sample finer than itself to the size which has 10 percent finer than itself. *The uniformity coefficient should be no greater than 2.5.*

As an example, the effective size and uniformity coefficient for a sand with a sieve analysis as shown in the graph below are 0.35 and 1.7, respectively. The effective size is found by observing the theoretical screen size through which 10 percent of the sand would pass, which in this example is 0.35 mm. The graph also shows that 60 percent of the sand passed through a theoretical screen size of 0.6 mm. Dividing 0.6 by 0.35 gives the uniformity coefficient of 1.7.

Typical Sieve Analysis of a 1000-gram Sample of Sand.

U.S.S.-ASTM Sieve Size	Sieve Opening mm	Grams Passing	% Passing
100	0.149	20	2
60	0.250	60	6
45	0.350	150	15
40	0.420	250	25
35	0.500	500	50
25	0.710	660%	66
18	1.000	820	82
(18 Mesh Window Screen)	1.4	1000	100



Publications Helpful in Planning and Building a Water System.

Missouri Agricultural Extension Circular 601, "Water Systems of Farm Houses".

Missouri Agricultural Experiment Station Bulletin 566, "Characteristics of Farm Ponds".

Missouri Agricultural Extension Circular 583, "Farm Ponds in Missouri".

State of Missouri, Division of Health Form E 2.14. "Disinfection of Contaminated Wells and Cisterns", Jefferson City, Missouri.

R. P. Beasley and J. C. Wooley, *Farm Water Management for Erosion Control.* Lucas Brothers Publishers, Columbia, Missouri, 1957.

Publications for Designing Rectangular Storage Reservoirs and Job-mixed Concrete. These publications are available from the Portland Cement Association, 33 West Grand Avenue, Chicago, Illinois.

"Rectangular Concrete Tanks".

"Underground Concrete Tanks".

"Water Tight Concrete".

"Making Good Concrete".

"Design and Control of Concrete Mixtures".