Stretching Water for Irrigation
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EAST LANSING

Stretching

Water for Irrigation

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Michigan is more fortunate than most states in having a good water supply. However, surface and ground water resources are not uniformly available throughout the state. Many farmers may feel their individual supply of water fails to meet irrigation needs, especially during periods of drought when irrigation requirements are greatest. They would like more water or would like to stretch their present supply to cover more needs.

This publication tells you how to build a holding pond to stretch your water supply for irrigation. When operated in combination with a small low-capacity pump (a small pump – one with a capacity of 10 to 200 gallons per minute), a holding pond will provide a continuous flow of water when needed to irrigate your cropland. Included are figures on storage capacity for such a holding pond and for pump and holding pond capacity requirements and drought periods.

Conservation and best use of available water is already of vital importance in many states. Full use of surface water supplies is essential to good farm management in Michigan. The facts in the following pages show how to get the most from your water supply.

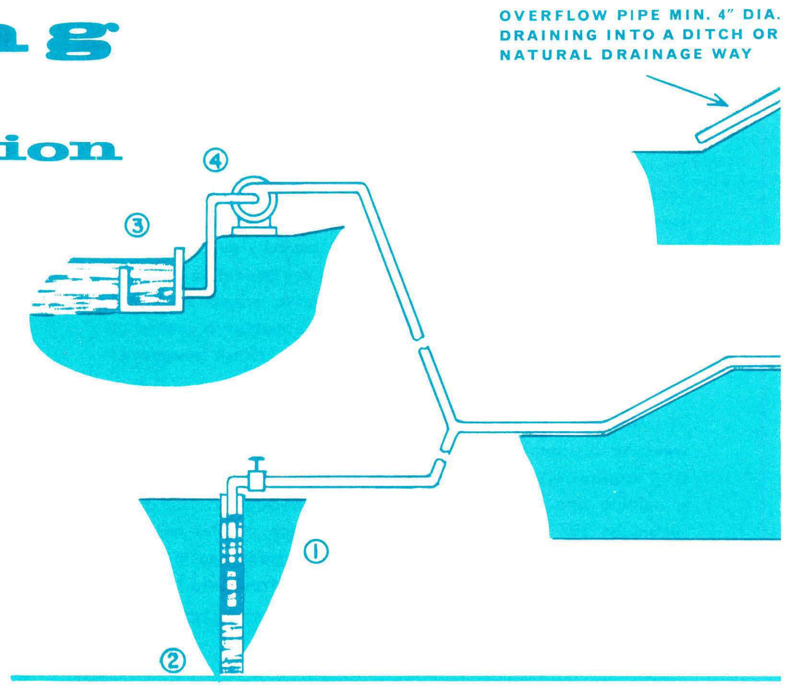
Facts to Know

If you are concerned about an adequate surface water supply for irrigation or feel that large diameter wells of 6 to 14 inches in diameter are too costly, then you should know the following basic facts:

1. *A holding pond may help you* stretch available water enough for all your irrigation needs. A continuous flow of 3 to 4 gallons per minute provided by a small capacity pump and stored in a holding pond supplies sufficient water to irrigate one acre of cropland.

2. *You can even-out the pumping load* on small streams by using a small pump of low capacity over a long period of time. This will make more water available for irrigation, waste dilution, and municipal uses when it is needed most.

3. *Many irrigation wells* that farmers have had drilled are of a large diameter (6 to 14 inches). Pumps are turned on *only* when the irrigation system is operating. The result is a large capacity well and a large capacity pumping plant.



4. *Special management* of small diameter wells can provide sufficient water for irrigation of sizeable acreages.

5. *The small diameter wells,* in many instances, can be used for domestic purposes in addition to providing water for irrigation.

6. *Small pump holding installations* are often more economical than "direct pumping" systems, depending upon the relative locations of the water sources and the field irrigated, the capacity of the irrigation system, and other factors.

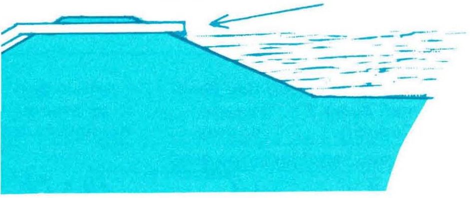
HOLDING POND

Holding ponds are planned to fit specific situations. They may be built square or circular for economy. They can provide adequate storage for sprinkler irrigation systems without being excessively large.

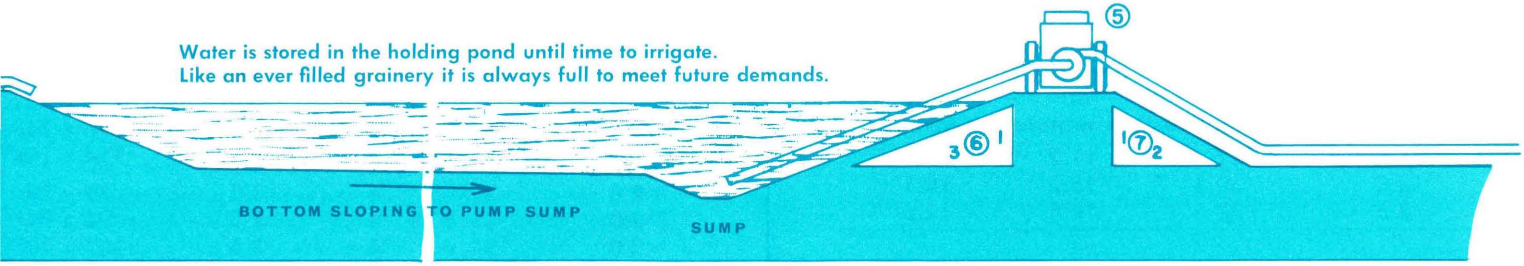
Size, or capacity, depends on the crop requirement and acreage irrigated, but they should be at least 6 feet deep when full.

A pond about 175 feet square at the bottom with banks 7½ feet high stores 60 acre-inches of water. With a small pump capacity of 150 gallons per minute to feed, this size holding pond satisfies an irrigation requirement of 1.5 inches per week for a drought period of 3 weeks duration on 50 acres of land.

INSTALL DRAINAGE OUTLET PIPE AT THE LEVEL OF WATER STORAGE DESIRED BY OWNER



1. A small diameter well (2-4 inches in diameter). A small low capacity jet or turbine pump.
2. Water supply from a surface source or water supply from a ground water source.
3. Concrete pumping basin; top feed prevents siltation.
4. A small capacity centrifugal pump moves the water from a stream or lake to a holding pond.
5. A centrifugal irrigation pump unit moves the water from the reservoir to the sprinkler system. (Select this pump carefully to fit capacity and pressure requirements.)
6. 3 foot horizontal to 1 foot vertical.
7. 2 foot horizontal to 1 foot vertical.



Pond bottom must be sealed if soil material is loose and permeable. Clay soil may be used effectively as a seal. (See Water Research Report No. 1 referred to below.)

HOW A HOLDING POND WORKS

Storage water in the holding pond may come from a surface source (lake or stream) or a small well. A small capacity pump moves the water from either the surface source or the well to the holding pond. Water is stored in the holding pond until time to irrigate. A centrifugal irrigation pump moves the water from the holding pond to the sprinkler system. As soon as water is taken from the pond, the small pump starts operating to refill the pond.

One of the big advantages of this arrangement is the freedom it gives the farmer to operate his irrigation system without affecting the rate of withdrawal from the stream.

The small pump holding pond combination and the irrigation system should both be designed to satisfy crop needs. They will therefore pump the same quantity of water over a period of time. The irrigation pump can, however, operate intermittently while the small capacity inflow pump will operate continuously until the holding pond is full.

USES SINGLE PHASE MOTOR

The small pump can also be operated easily by a standard single phase electric motor. An electric motor is recommended because:

1. It is an economical source of power.
2. It is adapted to continuous operation.
3. It can easily be made to operate automatically with a float activated switch and so turn itself on when the water level drops below the desired refill level.

Small pumps are also readily available because of their common use for ordinary household water supply systems.

STORAGE POND

Plan storage and small pump capacities to fit your particular situation. If you have questions regarding the capacities you should use, contact the Agricultural Engineering Department of Michigan State University through your County Extension Agent.

The pond should be a built-up type using dikes rather than an excavated type unless it is located in clay soil which will hold water. The bottom of a built-up pond should be slightly below the original ground level with only enough material removed to construct the dike. The dike should be at least 7½ feet high. (See section on Pond Design.)

If the dike is constructed of sandy porous material, special sealing precautions must be taken to prevent leakage. Only surface-constructed dike ponds can be satisfactorily sealed. If an excavated pond is sealed, a high ground water table occurring at the time the pond is empty may force the seal from the bottom and sides, destroying its effectiveness and requiring considerable repair work.

For details concerning sealing methods and material for dikes and ponds, see Water Research Report No. 1, "Controlling Seepage in Holding Ponds Constructed of Porous Material," Department of Resource Development, Michigan State University. Copies may be consulted at the office of your County Extension Director or obtained from the Department of Resource Development, Michigan State University.

Example of Storage

The following example shows how storage is provided with a small pump delivering 3 gallons per minute for each acre irrigated during a drought period of three weeks duration with an irrigation requirement of 1½ inches per week. (Figures are for each acre irrigated.)

ACRE-INCHES

1.2	**1.2 acre inches** are stored in the pond for each acre irrigated. (This amount should be stored and available from the pond in order to meet the water needs for a 1.5 inch application of water per week for 3 continuous weeks. As soon as withdrawal commences, the small pump starts to replace the water.)
+1.1	**+1.1 acre-inches** are *added* to the holding pond the first week for each acre irrigated. (This is added to the pond the first week by the small refill pump.)
2.3	**2.3 acre-inches.** (2.3 inches is the total water available the first week. It includes the storage (1.2 inches), plus the water pumped into the pond the first week (1.1 inches).
—1.5	**—1.5 acre-inches** are *removed* from the holding pond the first week for each acre irrigated. (1.5 inches is the weekly requirement for many irrigated crops in Michigan.)
.8	**.8 acre-inches** *remains* in the holding pond after the first week of operation for each acre irrigated.
+1.1	**+1.1 acre-inches** per irrigated acre are added to the holding pond the second week.
1.9	**1.9 acre-inches** available the second week
—1.5	**—1.5 acre-inches** per irrigated acre are removed from the holding pond the second week.
.4	**.4 acre-inches** per irrigated acre remain in the holding pond after the second week.
+1.1	**+1.1 acre-inches** per irrigated acre are added the third week.
1.5	**1.5 acre-inches** available the third week
—1.5	**—1.5 acre-inches** per irrigated acre are removed the third week.
0.0	**0.0 acre-inches** remain after the third week.

This example illustrates how adequate capacity is provided for a farm with diversified crops which do not need peak irrigation at the same time. If *all* the irrigated land is planted to a single crop, such as potatoes, the irrigation requirement could possibly be 2.0 inches per week.

ADDED WATER NEEDS

The additional water requirement can be met by either:

1. Installing a pump of larger capacity
2. Increasing the capacity of the holding pond
3. A combination of the two.

In the table (P. 9-10) approximate figures have been worked out for pump and pond capacities needed for various irrigation and drought conditions.

DESIGN

A built-up pond should be square or circular for maximum economy. Either shape offers maximum water storage with minimum dike construction. It should have the following general cross-section:

The bottom of the pond should slope slightly (6 to 12 inches) to the irrigation pumping site.

When the pond is full, water should be at least 6 feet deep to minimize evaporation losses, plus another 1½ feet for freeboard and evaporation allowance. A pond storing 60 acre-inches is about 175 feet square at the bottom with banks 7½ feet high.

Determine pond dimensions for the capacity you need in accordance with the table given – that is, acres to be irrigated, application rate, etc. Then, add 6 inches to the depth to take care of evaporation losses and 12 inches for freeboard so that water will not spill over the dike and cause erosion.

A built-up pond does not need a drain as it can be emptied quite easily with a siphon or pump. It actually need never be emptied except for periodic inspection, maintenance or for safety reasons. For instance, a farmer with small children may want to drain the pond after the growing season to avoid the threat of an attractive nuisance.

The following pipe sizes from the small pump to the holding pond are suggested. Pipes smaller than recommended may result in excessive power costs.

Gallons Per Minute Pumped	Pipe Diameter
0 to 40	2 inches
30 to 125	3 inches
90 to 250	4 inches

Minimum Capacities

The following examples illustrate some minimum pump capacities required to meet specific irrigation needs with various types of irrigation programs. The type of operation for which the system is designed has a direct effect upon the total cost of the sprinkler system. In other words, the design and operation of a sprinkler system can be either expensive or economical.

For Continuous Operation (24 hours per day, 7 days per week)

The following minimum pump capacities are required to meet specific irrigation requirements when pumping direct from stream or well *is continuous.*

Weekly Irrigation Requirement (Inches)	Pump Capacity (gal./min./acre)
1.5	4.0
2.0	5.4
2.5	6.7

For Part Time Operation (a specified number of hours)

The following pump capacities are required for specific irrigation requirements when pumping is *non-continuous,* that is, weekly pumping periods. This is also based on pumping direct from stream or well. (Note total inches requirement is the same.)

Weekly Irrigation Requirement (inches)	Hours Irrigation Pump is Operated per Week (gallons per minute per acre) 30	60	90
1.5	22.2	11.2	7.5
2.0	30.4	15.2	10.1
2.5	37.6	18.8	12.5

Continuous operation requires a pump capacity of 4 gallons per minute to deliver 1.5 inches of water to one acre in one week.

Part time operation requires a pump capacity of 22.2 gallons per minute to deliver 1.5 inches of water to one acre in one week if the pump operates only 30 hours during the week.

As noted, the gallons per minute required for *part time* operation are much greater than for *continuous* operation. Continuous operation may utilize a smaller capacity pump (with water stored in the holding pond). The small pump holding pond combination allows complete freedom in operating the irrigation system without affecting rate of withdrawal from the stream or well.

For Solid Coverage (an entire field is covered by a single irrigation set up in the spring and taken down in the fall. All of the system is operated at once.)

Sprinklers with 5/32 inch single nozzles operating at a pressure of 50 pounds per square inch and spaced 40′ x 40′ require 134 gallons per minute for each acre irrigated at one time. They apply water at a rate of 0.30 inches per hour.

Sprinklers with 5/32 inch single nozzles operating at a pressure of 50 pounds per square inch and spaced 60′ x 60′ require 60 gallons per minute for each acre irrigated at one time. They apply water at a rate of 0.14 inches per hour.

Sprinklers with 3/32 inch single nozzles operating at a pressure of 45 pounds per square inch and spaced 40′ x 40′ require 45 gallons per minute for each acre irrigated at one time. They apply water at a rate of 0.1 inches per hour. This small nozzle requires *clean water.* (Silt from stream water may plug these small nozzles.)

PUMP CAPACITIES

Pump and holding pond capacity requirements for various weekly irrigation requirements and drought periods.

Irrigation Requirement (in./week)	Drought Period (weeks)	Small Pump Capacity (gal./min./acre)	Holding Pond Storage Capacity (acre in./acre)	Bottom Size of Square Holding Pond* (feet)
1.5	3	3	1.2	70 x 70
1.5	4	3	1.6	82 x 82
1.5	5	3	2.0	94 x 94
1.5	6	3	2.4	105 x 105
2.0	3	3	2.7	112 x 112
2.0	4	3	3.6	131 x 131
2.0	5	3	4.5	148 x 148
2.0	6	3	5.4	164 x 164
2.0	3	4	1.5	79 x 79
2.0	4	4	2.0	94 x 94
2.0	5	4	2.5	107 x 107
2.0	6	4	3.0	119 x 119

*For irrigating 10 acres.

EXAMPLE No. 1. An irrigation requirement of 1.5 inches per week for a drought period of 5 weeks duration requires a small pump capacity of 3 gallons per minute and a holding pond storage capacity of 2.0 acre-inches for each acre irrigated. Ten acres requires 30 gallons per minute pumping capacity and 20.0 acre-inches storage capacity. The pond should be 94 feet square and 7½ feet deep. (Water required for irrigation would be 6 feet deep as the basic minimum. In addition, another 6 inches of water is needed for evaporation losses plus a 12 inch freeboard.)

EXAMPLE No. 2. An irrigation requirement of 2.0 inches per week for a drought period of 5 weeks duration on ten acres of land requires a small pump capacity of 4 gallons per minute and a holding pond storage capacity of 25 acre-inches. The pond should be 107 feet square and 7½ feet deep. (Water required for irrigation would be 6 feet deep plus an additional 6 inches of water for evaporation losses and a 12 inch freeboard.)

SOLID COVERAGE AND HOLDING POND

Solid coverage systems are adapted to the "holding pond" concept if they have low application rates (0.1 inches per hour) or if only part of the system is used at one time. (This will also require smaller and less expensive irrigation pumping plants and mainlines.)

The examples illustrate the importance of spacing and nozzle size in the system design. The 0.1 inches-per-hour application rate provides adequate water for both irrigation and frost protection.

Hours Pump Operation per night	Successive Nights Protection Required	Small Pump Capacity Gallons per Minute per Acre Irrigated	Capacity Holding Pond Acre Inches per Acre Irrigated
10	any number	45	0
10	2	3 or 4	1.8
10	4	3 or 4	3.6
10	6	3 or 4	5.4
10	8	3 or 4	7.2

The table indicates small pump and pond capacity requirements for frost protection with "solid systems" but can also be used for irrigation. An application rate of 0.1 inches per hour is roughly ten times as fast as the crop takes water from the soil based on a 24 hour period. An application rate of 0.1 inches per hour is assumed in this table.

SMALL STREAMS

A small stream that can not withstand the impact of "surge demands" of large capacity pumps can meet requirements of small pumps. Through the procedure described in this bulletin, low capacity water sources can be effectively utilized.

Furthermore, a farmer who pumps periodically with a high capacity pump (surge withdrawal) is openly inviting criticism and possible legal action because of the resultant effect on irregular stream flow. By using the small pump — holding pond combination the same farmer may be able to withdraw water slowly from the small stream over a longer period of time without inciting restraining action since he is leaving the stream in a better condition for other irrigation withdrawals, fish life, and municipal and other uses.

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