Water Harvesting for Irrigation: Developing an Adequate Water Supply

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Alabama farmers are becoming increasingly aware of irrigation as a tool for optimizing production. When all other management practices are carried out efficiently, irrigation can help the farmer achieve the top yields and quality demanded in today's markets.

However, many farmers have been unable to irrigate because they lack an adequate water source. Surface water sources, such as streams, often do not have sufficient flow during the growing season to provide irrigation water. And, in many areas of Alabama, ground water sources are either inadequate or impractical to develop for irrigation.

An alternative approach to securing irrigation water is to collect and store surface water during the off-season, when rainfall and stream flows are high. This practice is called **water harvesting.** Where direct pumping is not feasible, either from streams or lakes or from wells, water harvesting can make irrigation possible where it was previously impossible.

Traditional Water Use For Irrigation

The quantity of water needed for irrigation is significant. Different crops have different water needs, and each irrigation system should be designed to provide adequate water for the crop to be irrigated. However, the minimum storage capacity for most situations is 1 acre-foot of water stored (or available) for each acre irrigated. One acre-foot is equivalent to 1 acre of water 1 foot deep. This quantity of water will ensure an adequate irrigation water supply for most crops in all but the most extreme drought conditions.

To get the needed water, about one-fourth of Alabama irrigators use wells, while three-fourths use surface water sources. Readily available surface water sources include spring-fed ponds or lakes as well as streams that flow through or are adjacent to farms. In addition, some farmers have constructed reservoirs on streams crossing their farm property.

One serious limitation on the use of streams for irrigation has been that most pumping takes place in June, July, and August, when stream flows are at their lowest. As more farmers pump water from the same stream, downstream flow diminishes to the point that no further pumping for irrigation is possible. Also, detrimental environmental effects to the stream are possible.

Most stream flows in Alabama are highest from January through April. A reservoir built on an on-farm stream captures and holds some of this winter and spring stream flow for use in the summer--this is an example of water harvesting. However, this practice has been limited in some areas of Alabama for two reasons:

- Many streams are not located on drainage basins with topography suitable for reservoir construction.
- Stream flows are often so high during the maximum run-off periods that dams of the size and complexity needed are not economically feasible.

As a result of all these factors, many locations in Alabama lack sufficient water for irrigation at the time it is needed, even though adequate water is available on an annual basis.

Harvesting Winter-Spring Runoff

One way to greatly expand irrigation capability in Alabama is to build reservoirs that are not on primary drainage basins but are located off-stream, either on smaller drainage basins or on other land with terrain suitable for building water storage facilities.

The simplest example of this is a case where a large creek or stream flows by a farm, and a drainage basin leading into that creek has a site that would hold enough water to irrigate the farm if a dam were built across it. This drainage basin need not be able to fill the reservoir on its own. Water can be pumped from the large creek or stream into the reservoir during the winter and spring, filling it and saving the water for summer use. This practice is feasible and has already been put into effect at some sites in Alabama.

A more difficult case is the situation where there is no suitable off-stream drainage basin that can be dammed in the traditional way to provide storage for an adequate quantity of water. In this case a non-traditional type of reservoir is called for. A good example of this type is a hillside reservoir where an earth embankment is constructed on two or three sides, or in a curved shape, to hold the desired amount of water. Again, water can be pumped from the nearby stream in winter and spring to fill the reservoir. Some recharge from natural drainage can be expected, depending on site topography, but this is likely to be slight.

The most extreme case would be a circular or four-sided reservoir built on essentially flat land. This is the most expensive reservoir to build and would depend entirely on pumping from the nearby stream, as there would be practically no natural recharge.

Design and Construction of Reservoirs

Determining design feasibility and construction and equipment details requires careful analysis of characteristics of both the site and the stream to be used. Site terrain must be suitable for construction of a reservoir large enough to store at least 1 acre-foot of water for each acre to be irrigated. The stream must provide enough excess water to fill the reservoir.

Topographic maps should be used to evaluate the site terrain and identify the most suitable area for reservoir construction. An engineering evaluation of the site is required to assess the permeability of the soil to determine whether a clay or plastic liner will be needed to prevent excess loss due to seepage. The engineering analysis also covers construction requirements, including the following:

- The amount of land clearing and excavation required.
- The type and nature of a cutoff trench needed to prevent seepage.
- The availability of and feasibility of moving clay or other suitable soil material into the cutoff trench.
- The nature of the embankment (height, top width, side slopes, and total cubic yards required).
- The specifications for the spillway or overflow pipe, if needed, and for drainage around the reservoir.

Design analysis must also consider the pump station and the pipe line from the stream to the reservoir. Pump station requirements will depend on the quantity of water pumped and the time for pumping. For example, a pump station designed to fill the reservoir in 2 months must have twice the flow rate of a pump station designed to fill the reservoir in 4 months.

The pipe line from the pump station to the reservoir is selected based on the flow rate required to fill the reservoir in the specified pumping time. Since pumping must take place during the high stream flow conditions existing during winter months, the stream flow should be carefully evaluated to determine a reasonable length of time for the pump station to operate. The Alabama Geological Survey has data and analytical methods for evaluating flows for some streams in Alabama. Methods to better forecast water availability from streams are being developed through research at Auburn University. In some cases, stream flow will have to be estimated from personal observation, with the advice of a consulting engineer. A good estimate will require knowledge of the stream extending over several years.

The figure below shows a typical water harvesting reservoir and pumping station, with important features indicated. Table 1 indicates the number of days needed to fill reservoirs of varying capacities at various typical pumping rates. See Table 2 for pump horsepower requirements for various pumping situations.

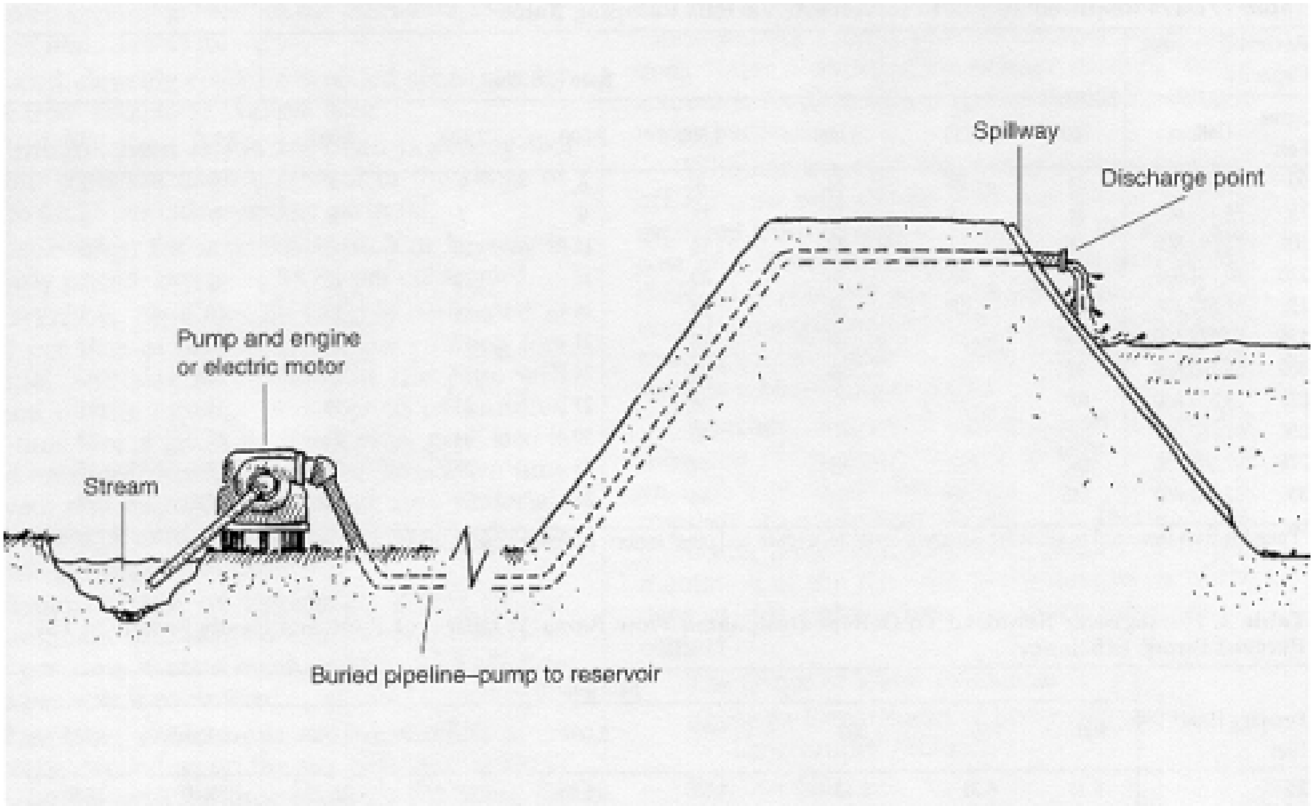

Table 1. Days Required to Fill Reservoirs at Various Pumping Rates.*

Reservoir Storage Capacity		Rate (gal. / min.)								
Acre-Feet	Gallons	500	750	1,000	1,500	2,000	2,500	3,000	3,500	4,000
50	16,292,400	24	16	12	8	6	5	4	3	3
75	24,438,600	36	24	18	12	9	7	6	5	3
100	32,584,800	48	32	24	16	12	10	8	7	6
125	40,731,000	50	40	30	20	15	12	10	8	7
150	48,877,200	71	48	36	24	18	14	12	10	9
175	57,023,400	83	55	42	28	21	17	14	12	10

200	65,169,600	94	63	48	32	24	19	16	14	12
225	73,315,800	107	71	53	36	27	21	18	15	13
250	81,462,000	119	79	59	40	30	24	20	17	15
275	89,608,200	131	87	65	44	33	26	22	19	16
300	97,754,400	143	95	71	48	36	29	24	20	18

*** Pumping time increased to allow for 5-percent losses to seepage and other factors. Pumping time based on 24 hr. per day operation.**

Table 2. Horsepower Required to Deliver Designated Flow Rates at Different Pumping Heads Based on 75-Percent Pump Efficiency

Pumping Head* Feet	Rate (gal./min.)								
	500	750	1,000	1,500	2,000	2,500	3,000	3,500	4,000
25	4.21	6.31	8.42	12.63	16.84	21.04	25.25	29.46	33.67
50	8.42	12.63	16.84	25.25	33.67	42.09	50.51	58.92	67.34
75	12.63	18.94	25.25	37.88	50.51	63.13	75.76	88.38	101.01
100	16.84	25.25	33.67	50.51	67.34	84.18	101.01	117.85	134.68
125	21.04	31.57	42.09	63.13	84.18	105.22	126.26	147.31	168.35
150	25.25	37.88	50.51	75.76	101.01	126.26	151.52	176.77	202.02
175	29.46	44.19	58.92	88.38	117.85	147.31	176.77	206.23	235.69
200	33.67	50.51	67.34	101.01	134.68	168.35	202.02	235.69	269.36
225	37.88	56.82	78.76	113.64	151.52	189.39	227.27	265.15	303.03
250	42.09	63.13	84.18	126.26	168.35	210.44	252.53	294.61	336.70
275	46.30	69.44	92.59	138.89	185.19	231.48	277.78	324.07	370.37

***Pumping head equals the elevation difference between the water source and the reservoir plus friction losses in pipe and fittings.**

Cost Factors

Costs of water harvesting reservoir systems vary greatly, as local contractor prices differ from one area to another. However, costs will usually depend primarily on site conditions. Topography dictates the length and height of the embankment, the area to be cleared, and the spillway size. Geology will establish embankment side slopes, cutoff trench dimensions, and the need for possible reservoir sealing. The desired storage capacity establishes the reservoir dimensions and pumping requirements, which in turn relate to cost.

The costs cited in the following paragraphs are typical averages for Alabama in 1994. Your actual costs may vary.

For a typical simplest-case embankment-type structure, a cost range of $400 to $600 per acre-foot of storage can be expected. Two- and three-sided structures will be slightly higher. Four-sided or levee type structures are most expensive. Costs can be held down by excavating embankment material from the reservoir and considering this volume as a portion of the desired storage capacity. If the geology of the site requires the entire reservoir to be sealed, this can drastically increase the total cost.

Some general guidelines for estimating costs of specific items are as follows:

Land clearing costs for wooded areas usually range from $ 500 to $ 1,000 per acre.

Embankment dams are often priced by the job, but costs are usually figured in the range of $.75 to $1.25 per cubic yard of earth fill.

Excavation for a cutoff trench or keyway is similarly priced, averaging $ 1.00 per cubic yard.

Overflow pipe can be roughly estimated at $ 1.00 per inch of pipe diameter per running foot of pipe. The size and length of the pipe will depend on the amount of water to be handled over time. For a given drainage area, pipe size is based on runoff storage available, drawdown time allowed, and emergency spillway size. Materials can be new or used steel (solid or corrugated), aluminum, plastic, or concrete.

Regeneration of vegetative cover on the embankment and disturbed areas can cost from $200 per acre, if done by the owner, to $1,000 or more per acre if contracted.

Pumping equipment and operating costs also vary, depending on the site terrain, the size of the reservoir, and the time available for filling the reservoir. Table 3 shows fuel requirements per acre-foot to fill reservoirs at various elevations above the water source.

Table 3. Estimated Diesel Fuel Required to Pump 1 Acre-Foot of Water at Different Pumping Heads.

Pumping Head* Feet	Fuel Required** Gallons
25	2.88

50	5.76
75	8.64
100	11.52
125	14.41
150	17.29
175	20.17
200	23.05
225	25.93
250	28.81
275	31.69

***Pumping head equals the elevation difference between the water source and the reservoir plus friction losses in pipe and fittings.**
****Assumes 75-percent pump efficiency, 5-percent additional water pumped, and 16.66 horsepower-hours per gallon of diesel fuel.**

Is Water Harvesting for You?

If you already grow or would like to begin growing irrigated crops, you should first investigate pumping from available surface water or drilling a well if surface water is inadequate. These sources usually provide cheaper water than does water harvesting. If neither of these water sources is feasible, however, you should investigate water harvesting.

Whether a water harvesting system can pay off for you will depend on the added returns expected from irrigation. Because of the scale and cost of a water harvesting program, you should thoroughly research and plan your project, considering both engineering feasibility and costs, before making any commitment. You may need the services of a consulting engineer.

Another factor to be considered is that the Alabama Water Resources Act of 1993 established an Office of Water Resources, with authority to regulate all large-scale water use in the state, including irrigation. However, details of implementation of the new law were unclear as of the date of this publication. For more information, contact

The Office of Water Resources
Alabama Department of Economic and Community Affairs
P.O. Box 5690
Montgomery, AL 36103-5690.

For further technical information and assistance, contact the Alabama Geological Survey and the Soil Conservation Service. Your county Extension agent also can help you find more information.

For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

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