

Excavated Pond Construction in Florida ¹

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INTRODUCTION

A pond can be a convenient and economical source of water for agricultural use. Ponds can provide the necessary water storage for irrigation, livestock and fish production, fire protection or other purposes (for more information see IFAS Bulletin No. 257, *Farm Ponds in Florida Irrigation Systems*). The two basic types of ponds are embankment ponds and excavated ponds.

A classical embankment pond can be formed by constructing a dam or embankment across a stream or watercourse where the depression is deep enough to provide a water depth of at least 6 ft (1.8 m). An excavated pond can be constructed by digging a pit or a dugout area, typically in relatively flat topography areas. Excavated ponds are generally small since their capacity is obtained almost entirely by digging. Because Florida's natural topography lacks significant differences in slope, especially in the southern portion of the state, excavated ponds are necessary to provide adequate storage volumes for given surface areas. However, in some parts of Florida the natural rolling topography can be used to construct an embankment pond. Even in those areas where the land may be gentle to moderately sloping

the required pond capacity is frequently obtained by both excavation and embankment. Some ponds required by local regulatory agencies are used as retention areas for runoff control, surface water quality control, wetland preservation, and recharge of the shallow aquifer. These retention ponds may be created by constructing dikes across natural depressions and are a type of embankment pond. In some areas of Florida where naturally high water table conditions exist, such as in South Florida, retention ponds are created by building a dike around proposed pond areas to provide the necessary storage.

This publication will provide information on excavated ponds and will emphasize planning, site investigation, construction and management considerations.

EXCAVATED PONDS

Excavation is a pond construction method used in relatively flat topography. The natural slope at the site should not exceed 4 percent. Because all material must be removed to obtain the desired capacity, the size of a pond constructed by excavation will be limited by excavation costs and site conditions.

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Excavated ponds can be classified by the way water enters the pond. An excavated pond can be supplied by surface runoff, by water diverted from a stream or a river, by water pumped from a well by surficial aquifer sources (water table), by shallow water table seepage, or by any combination of the above sources. In Florida, shallow natural water tables (surficial aquifer) and heavy rainfalls combine to provide most of the water supply for excavated ponds.

Excavated ponds which are supplied by surface runoff should be located in natural depressions, in broad natural drainage swales or paths, or to one side of the drainage swales where the runoff can be diverted into the pond. If the pond is constructed in or near a natural drainage swale, excess runoff from a full pond may be discharged through natural drainage paths and construction of a spillway may not be necessary.

Excavated ponds supplied by surficial groundwater aquifers (natural high water tables) must be located in flat or nearly flat topography. A prevailing, reliable water table should be within 1 m (3 ft) of the ground surface. The level of the water table indicates the water level in the completed pond. In addition, the shallow aquifer must be sufficiently large and permeable to yield water at a rate that satisfies the maximum expected demand for water. However, in most Florida locations the yield is usually not a limiting factor.

When the water table and surface runoff cannot provide a sufficient supply of water, an additional water supply such as a well or a diversion from a nearby stream may be necessary. If the water level in the pond is above the level of the natural water table, significant losses can occur through subsurface flow (Fig. 1). These losses can be significant in Florida sandy soils and will depend on the permeability of the bank material and on the difference in height between the pond surface and the surrounding water table.

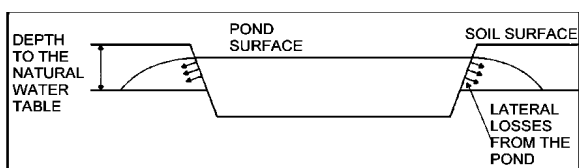


Figure 1. Losses from the pond due to the high water level.

PLANNING AN EXCAVATED POND

Design of an excavated pond is based on the required storage capacity, depth to the water table, other available water sources, and the stability of the side-slope materials. The topographic conditions at the site must allow economical construction. Cost is a direct function of the volume of excavated material required to obtain a certain storage capacity in the pond. This method of construction results in the limited practical size of excavated ponds. However, these ponds can be designed to minimize evaporation losses by decreasing pond surface area in proportion to stored volume.

A rectangular shape is usually the most convenient for excavation equipment. The size of the pond is determined by the purpose for which water is needed, the site conditions, and the amount of inflow that can be expected. The required capacity of an excavated pond fed by a shallow water table is difficult to determine since the estimated rate of inflow into the pond can rarely be estimated with reasonable accuracy. Long narrow ponds will yield (or lose) more water from (or to) the surrounding area than square ponds. In some cases it may be necessary to augment the pond volume with water pumped from a nearby well or other water source. More information on pond sizing can be found in IFAS Extension Bulletin 257.

The proposed pond site should be thoroughly investigated prior to design and construction. Core samples of the soil profile should be obtained to provide information on the permeability of the material within all depths and below the bottom of the proposed pond. Permeability requirements for pond construction vary with the type of water supply into the excavated area. For a pond supplied by a surficial aquifer source the permeability of the surrounding soil must be high to assure sufficient inflow into the pond. Conversely, a pond supplied with water from another source as discussed above must be located in an area with low permeability soils in order to avoid seepage losses.

Permeability is defined as the readiness with which soil transmits water under standard field conditions. It depends primarily on the size and shape

of the soil grains, the porosity of the soil, the shape and arrangement of the pores, and the degree of saturation. There are several laboratory methods to determine permeability for a given soil.

Indications of soil permeability can also be obtained at the sites by filling test holes with water and observing the seepage characteristics of the material. Permeability tests performed in the field are frequently more representative of the actual site conditions since the soil is not disturbed as much as when the samples are transferred from the field to the laboratory. The simplest method used in the field in the presence of high water table is to dig an auger hole into the soil below the water table. First determine the elevation of the existing natural water table by allowing the water surface in the hole to reach equilibrium with the surrounding area. Next, the water in the auger hole is pumped out to lower the elevation of the water surface in the hole, then the rate of rise of water in the hole is measured. From this measurement soil permeability can be calculated.

At sites without natural water tables, other permeability tests must be used. An infiltration test over a large area (13 ft or 4 m in diameter) may be used as a field test. This avoids the soil compression that is inherent in core sampling, which is necessary for the lab samples. The area is diked with a ring of soil and filled with water to form a shallow pond. A circular pond is recommended rather than a rectangular one because the circular pond has less lateral and undesirable seepage loss per unit area than a rectangular one. To perform this test water is added to the pond area as needed to saturate the soil in the surrounding area, and then the falling water level of the pond in the absence of added water is observed and used to determine permeability. This rate should be a measure of the ability of the soil to pass water into and through the observed soil layer.

When excavated ponds are supplied by surface runoff or by water pumped from a well, relatively impervious soils at the site are essential to avoid excess seepage losses. Soil materials must be available to provide a stable, impervious fill where needed. Clays and silty clays are the most desirable; however sandy clays may also be satisfactory. In some regions of the Florida Panhandle, the soils

contain sufficient clay to allow pond construction without adding soil amendments or artificially lining the pond. Unfortunately, most of the soils in peninsula Florida are very sandy, and additional measures to prevent seepage are necessary for pond construction. In some cases the only solution may be an artificial lining material. An artificial lining is expensive but should be considered at sites where soils are porous or are underlined by sands or gravel. Methods of pond sealing are discussed in IFAS Extension Circular 870, *Selecting a Method for Sealing Ponds in Florida*.

In addition to permeability tests, the core sample holes may be used to determine the existing level of the water table from the shallow aquifer. The depth to the water table generally varies throughout the year. Therefore, several observations may be necessary to help with design. The performance of other nearby ponds may provide useful information with respect to the suitability of the proposed site and for design purposes.

Larger ponds should be equipped with some drainage facilities. A drain pipe is necessary to facilitate maintenance and fish management. On flat topography a pump may be necessary to drain the pond.

EXCAVATED POND CONSTRUCTION

Proper construction practices should be followed to ensure safety and to reduce potential problems. After the pond site has been selected, an area or areas for spoil placement (excavated material) should be located. Stake the boundaries of the pond and spoil placement locations with the depth of cut from the ground surface to the pond sides or bottom clearly marked on the stakes. All woody vegetation should be cleared from these areas.

The type of excavating equipment for construction will depend on availability, climate, and physical conditions at the site. During dry periods most types of equipment can be used. The most common are tractor-pulled wheeled scrapers, draglines, and bulldozers. Inefficiency in transporting material limits the use of a bulldozer for excavation to relatively small ponds. Dragline excavators are

commonly used for pond construction in the high natural water table areas of Florida. This is the only type of equipment that will operate under saturated soil conditions.

It is desirable to keep topsoil separated from subsoil materials during excavation. Place topsoil material in a location where it can be accessed after excavation has been completed. After excavation, this material should be placed on the surface of the side slopes, berms, spoil banks and spillways. These areas should be seeded or plugged with a grass or other cover material for erosion control. The grass or cover material should require minimal maintenance, be tolerant to local drought or wet conditions, and be relatively easy to establish.

INLETS

If the runoff is entering the pond through a confined channel or ditch rather than through a broad shallow waterway or watercourse, the pond inlet must be protected against erosion. A steel or concrete culvert can be placed in the ditch and extended over the side of the excavation (see Fig. 2). The extended portion of the pipe should be either cantilevered or supported with timbers. Pipe diameters depend on the peak rate of inflow and must be appropriately sized (see Table 1). If the water is carrying significant amounts of silt or suspended particles, a sedimentation area or filtration strip planted with grass should be provided above the pond to remove the sediment before water enters the pond.

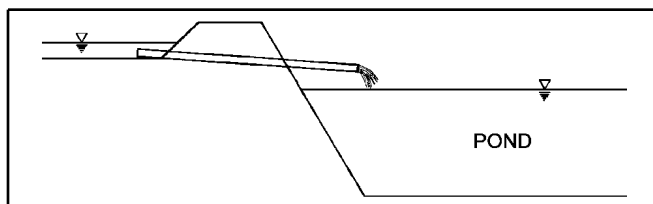


Figure 2. Cantilvered pipe delivering runoff to the pond.

SPILLWAYS

It may be necessary to provide a system which can be used to drain the pond as both a management and maintenance practice. If gravity drainage is not possible, a pumping system will be necessary. In addition, surface drainage may be necessary to properly route excessive water inflows. This may be accomplished through drainage culverts or grassed

spillways. Concrete spillways are expensive but may be necessary on larger ponds and where excessive flows may be expected. An emergency spillway is not required on ponds with no runoff discharging into them.

Table 1. The diameter of the inlet pipe or pipes based on the peak rate of runoff that can be expected into excavated ponds*.

| Pipe diameter (inches)** | Pond inflow Q (ft ³ /sec) | GPM |
|--------------------------|--------------------------------------|------------------|
| 15 | 0 to 6 | 0 to 2694 (2700) |
| 18 | 6 to 9 | 2700 to 4000 |
| 21 | 9 to 13 | 4000 to 5800 |
| 24 | 13 to 18 | 5800 to 8100 |
| 30 | 18 to 30 | 8100 to 13500*** |

*After SCS Engineering Field Manual.
 **Inlet pipe size based on a free outlet and a minimum pipe slope of 1.0 percent with the water level 0.5 foot above the top of the pipe at the upstream end.
 ***It is recommended that for larger flow rates a design expert be consulted before inlet construction.

If an excavated pond is located on sloping terrain, part of the excavated material can be used to build a small dam on the lower side of the pond to increase the pond's capacity. Care must be taken that failure of this dike does not result in adverse downstream impacts. An emergency earth spillway is necessary to pass excess storm runoff around the small dam. If the pond is being supplied by surface runoff, the capacity of the emergency spillway should be sufficient to discharge the maximum outflow expected for a rainfall frequency of once in 25 years. For large ponds the design rainfall is 100 years. The emergency spillway may consist of a concrete or vegetated earthen spillway, a conduit (pipe), or a combination of a vegetated spillway and a conduit. If a vegetated spillway is used, the crest of the spillway should be at least .06 m (.2 ft) above the normal reservoir water elevation.

A trickle spillway is usually designed to provide flood protection or to reduce the frequency of operation of the emergency spillway. For more detail

on sizing requirements of spillways, the reader is advised to contact a licensed engineer or consult with the local Natural Resources Conservation Service.

FILTER STRIP DESIGN

Sediment leaving agricultural land is often a significant source of pond nonpoint pollution. This sediment delivery can be reduced by grass filter strips near the edge of the field or the disturbed area. Filter strips increase the hydraulic roughness of the flow surface, reducing the flow velocity and thus the transport capacity. Since concentrated flows tend to submerge the grass and decrease the roughness, filter strips are most effective when flow is shallow and enters the strip uniformly along its length. Thus, care in placement and maintenance of filter strips is advised. Assistance in the design of filter strips is available through the Natural Resources Conservation Service.

SEALING PONDS

The selection of a sealing method depends largely on the proportions of coarse grained sand and gravel and fine materials like silt and clay in the soil. A soil scientist should be consulted before a sealing method is selected. In some cases it may be necessary to perform a laboratory test of the materials from the selected site. For more information of pond sealing methods the reader is referred to IFAS Extension Circular 870.

ALGAE CONTROL

Excessive algae growth often occurs within ponds and can result in many problems. The algae can be effectively treated with copper sulfate (CuSO_4). Applications of 1 to 2 ppm (1.4 to 2.7 pounds per acre foot) CuSO_4 are sufficient and safe to treat algae growth and should be applied when the pond water temperature is above 60° F. Treatments may be repeated at 2- to 4-week intervals, depending on the nutrient load in the pond. Copper sulfate should be thoroughly mixed into the pond (i.e., sprinkled into the wake of a boat). As with other biocides, distribution into surface water must be in compliance with EPA regulations.

Copper sulfate can be harmful to fish if alkalinity, a measure of the water's capacity to neutralize acid, is low. Alkalinity is measured volumetrically by titration with sulfuric acid (H_2SO_4) and is reported in terms of equivalent calcium carbonate (CaCO_3). Table 2 provides a reference for determining the amount of copper sulfate to add given different alkalinity levels. Repeated use of copper sulfate can result in a toxic accumulation of copper for aquatic plants.

Table 2. Copper Sulfate (CuSO_4) Levels Safe for fish.

| Alkalinity Value (CaCO_3 , mg/l) | Addition of Copper Sulfate |
|--|-----------------------------|
| below 40 | do not use |
| 40-60 | 1.0 lb per acre-ft of water |
| 60-100 | 1.3 lb per acre-ft of water |
| over 100 | 2.7 lb per acre-ft of water |
| 1 ppm = 2.7 lb per acre-ft (Dupress and Huner, 1984) | |

SUMMARY

Construction of excavated ponds in Florida, with emphasis on planning, site investigation, and management considerations, was presented. Due to the relatively flat topography in many parts of Florida, excavated ponds are constructed quite frequently throughout the state. Ponds can provide a convenient and economical source of water for agricultural use. However, proper management and maintenance may be necessary to avoid pond degradation due to erosion, seepage losses, algae blooms, or other undesirable conditions.

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