Construction and Repair of Watershed Fish Ponds in Kentucky.

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INTRODUCTION

It is estimated that Kentucky has over 100,000 ponds throughout the commonwealth (Prather, 1990). These ponds are used for many purposes including: irrigation, flood control, collecting sediment, watering livestock, recreation, sources of domestic water, rural fire control, and fish production. This article will focus largely on ponds designed for fish production, fee fishing and recreational fishing. First, an outline of the proper steps for watershed pond site selection and construction will be presented. Methods for repairing established ponds will be discussed in later paragraphs. However, these two subjects should not be considered separately. Ponds which are improperly located or poorly constructed often do not hold water. There are no statistics to estimate the number of Kentucky ponds which leak or do not hold water at all. Many state and federal agencies frequently receive complaints and information requests regarding this subject.

Kentucky is largely comprised of rolling hills to mountainous land. In these regions, the terrain necessitates the construction of watershed ponds. Watershed, or hill ponds are constructed by building a dam across a valley which fills with water. Rainfall fills these ponds by drainage provided from the surrounding land or watershed. Watershed ponds differ greatly from the shallow, levee-style ponds which are used in the channel catfish industry in the Mississippi River Delta region. These flat-land ponds are filled with ground water from wells or surface water from streams and rivers. In addition to uneven land, most of Kentucky has limited supplies of ground water. Fish production in levee ponds would largely be restricted to a few western Kentucky counties bordering the Ohio river.

Many of Kentucky's currently established watershed ponds may be suitable for fish production. Proper site selection is critical to the successful construction and management of watershed fish production ponds. Fish production and harvesting is more difficult in watershed ponds than in levee ponds. This is due to factors which include: unreliable water supplies, irregular pond shapes, uneven pond basins, and excessive depths. As a result of these features, the amount of fish produced per surface acre of watershed pond is generally less than the amount of fish produced per surface acre of levee pond. However, watershed ponds are generally less expensive to construct than levee ponds since less earth must be moved (Jensen, 1989). Pond construction costs in Kentucky are estimated at $3,500 or more per acre. Perspective pond owners and fish producers should contact the county Soil Conservation Service, county Cooperative Extension agent or aquaculture extension specialist **before** construction begins. These offices will be able to provide regulatory information as well as technical assistance.

WATER SOURCES

Watershed ponds are filled and maintained primarily from watershed runoff. Some ponds may have supplemental water sources such as ground water pumped from wells. Surface water may be pumped or diverted from rivers and streams. Many Kentucky ponds are fed by underground springs. Kentucky receives an average annual rainfall of 40-50 inches. The watershed should be large enough to fill the pond during the rainy winter season. During the summer months, water levels should not drop more than 2 feet in fish production ponds (Jensen, 1989). In Kentucky, 1-2 acres of watershed are required for each acre foot of pond volume. Soil type and the nature of the watershed's vegetation will affect runoff (Matson, 1991). Less watershed may be required for terraced ponds, or if a supplemental water source is available. Terraced, or "stair-stepped" ponds, constructed in a valley, allows the gravity flow of water through a series of ponds (Jensen, 1989).

Watersheds which contain acid soils are likely to supply pond water which is low in alkalinity. Alkalinity is the quantity of base present in water. Alkalinity is expressed as mg/l $CaCO^3$; which is the measure of the amount of acid water can buffer before reaching a designated pH (Wurts and Durborow, in press). Water which has alkalinities of 50 to 300 mg/l is best for fish production (Jensen, 1989). Acid soils are frequently found in portions of eastern, western and southern KY. Liming can neutralize most acid pond soils, depending on the soil's lime requirement. Application rates of 1 to 7 tons per surface acre are often required.

SITE SELECTION AND POND CONSTRUCTION

The land's topography will determine the size and shape of a watershed pond (Jensen, 1989). Ponds between 0.5 and 10 surface acres would be most suitable for fish production. A pond which is constructed in a steep valley may have a water volume equal to a more shallow pond, but will have less surface acreage. The productivity of a fish culture pond is more dependent on the amount of surface area it possesses than on the volume of water it contains. Costs are likely to be greater for ponds constructed in steep terrain since larger dams are often required.

If possible, watershed fish production ponds should have a maximum depth of 8 to 10 feet. Deeper ponds must be partially drained to allow complete fish removal by seining. Watershed ponds with two or three levees may be built into a gently sloped hillside. Two or three-sided ponds allow better management of the watershed and may decrease pond depth (Jensen, 1989).

Soils which contain 20-25% clay are required for building dams and spillways. Clay, silty clay, sandy clay loam and sandy loam soils are appropriate. A layer of 12 to 18 inches of compacted clay soils may be required to seal a pond basin where soils are porous. The ideal site is located where a tight soil layer lies near the entire surface of the proposed pond basin (Hadden, 1988). Frequent sample borings should be taken along the proposed dam site to check for a clay base. Rock formations and sand or gravel areas should not be exposed in the pond basin (Jensen, 1989). Kentucky has many counties which contain underground limestone or karst formations. A list of Kentucky counties with karst formations is presented in Table 1

(McGrain and Currens, 1978).

TABLE 1.

Kentucky Counties Which Contain Karst Areas		
Adair	Grayson	Pulaski
Allen	Hardin	Rockcastle
Barren	Jessamine	Simpson
Breckinridge	Larue	Todd
Caldwell	Logan	Trigg
Christian	Lyon	Warren
Clinton	Meade	Woodford
Crittenden	Metcalfe	Edmonson
Monroe		

These eroded limestone formations may contain fissures, sinkholes, underground streams and caverns. In karst areas, ponds which appear to be properly located and constructed may still fail to hold water. Soils should be bored to check the soil quality in the pond basin. Four borings per acre should be adequate, provided the soil types do not vary in the pond basin (Jensen, 1989). A good pond site will allow borings of 4 to 8 feet and should reveal the presence of stable soils. Late summer and early fall months are best for soil testing. Soil testing during spring could lead to overestimates of runoff and soil impermeability (Matson, 1991). A pond dam is constructed by digging a core trench 3 feet deep and one third the width of the finished dam. The core trench must be dug in good quality clay soil to prevent water seepage after the pond is filled. Remove all tree roots, brush and topsoil from the dam site and pond basin. Clay soils should be backfilled into the trench in 6 to 12 inch layers and compacted with a sheepsfoot roller or a bulldozer. Moist clay soils will provide the best compaction. Clay soils which form a small ball when molded by hand, but are not sticky, are best. Quality clay soils must be compacted in the center of the dam from its base to its top. Inside and outside dam slopes should be 3:1. The top of the dam will require a 12 to 16 foot wide, gravel road to allow year-round vehicle access (Jensen, 1989). A freeboard of 1 to 2 feet above the pond's water level is a sufficient dam height. Grass should be established on the dam slopes as soon as possible. Roots from trees and brush can loosen the soils causing seepage. Frequent mowing will discourage the establishment of wooded vegetation. Minimum pond depths of 2.5 to 3 feet will help prevent the establishment of rooted aquatic vegetation.

A smooth pond bottom allows the efficient removal of fish by seining. A pond standpipe and drain structure is essential for effectively harvesting fish in watershed ponds which exceed 8 feet in depth. A 90 degree, swivel fitting is used to connect the standpipe to the drainpipe. Water levels in the pond may be regulated by tilting the standpipe. The standpipe and drain are located in the deepest portion of the pond basin. A properly sized drain structure will allow the pond to be completely emptied in a few days. A sleeve placed around the standpipe will remove poor quality water from the pond bottom, as fresh water enters the pond (Jensen, 1989). The sleeve must extend within several feet of the pond bottom and rise approximately 1 foot over the standpipe.

Antiseep collars help prevent water movement along the outside of the drainpipe which weakens the dam. Two antiseep collars should be installed and sealed around the drainpipe in dams which exceed 8 feet in height (Matson, 1991). The drain structure is then buried and compacted in clay soils.

An emergency spillway allows large volumes of water to leave the pond during heavy rains. Earthen dams may be weakened or destroyed by excessive water inflow during flooding. Generally, these spillways have widths of 10 to 100 feet and are stabilized with grasses. Emergency spillways are often constructed where the dam joins the natural terrain. Riprap, 3 inches in diameter, will prevent the spillway channel from eroding as water exits the pond (Matson, 1991). Fish barriers may be installed on the spillway to prevent large fish from escaping during periods of flooding. These barriers must be kept free of debris if the emergency spillway is to function properly and the pond is to remain safe (Jensen, 1989).

REPAIRING PONDS

Repairing pond leaks, or excessive water seepage, is the most difficult pond management task (Matson, 1991). All ponds seep to some degree. Properly located, well constructed ponds will likely seep less than those of poorer quality. Moderate seepage in new watershed ponds should be carefully watched for the first 1 to 2 years following construction. Many pond basins will seal from the weight of the water volume after filling. Accumulated vegetation and organic matter will often reduce seepage. Low pool levels may result from insufficient watershed inflow, pond seepage, or both. Make allowances for water loss due to evaporation during the summer months. Compare pool levels with those of neighboring ponds. Ponds with noticeably reduced water volumes throughout the year probably leak. Before attempts are made to repair a leaking pond, evaluate the severity of the leak and possible sources of supplemental water. In some instances, additional water may be pumped from a well or diverted from a stream to the pond. A shallow well or a water diversion structure may cost less than repairing the pond (Matson, 1991).

Drain structures in pond dams are often responsible for leaks. Pipe seams, welds, joints, gaskets and valves all have the potential to leak and should be inspected. Antiseep collars may be added to existing pond drain structures; however, the integrity of the dam's clay core will be disturbed during excavation. Efforts to restore proper soil compaction around the drainpipe may not be successful (Matson, 1991). A dam may seep from between its base and the ground. This type of seepage often indicates the absence of a core trench inside the dam. A dam not anchored to the ground by a core trench is unreliable and unsafe.

Prolonged seepage often creates wet areas behind a pond dam. These wet soils often support aquatic plants such as willows, alders, cattails, sedges and rushes. Chemically inert dyes have been used to detect leaks in ponds, but often with limited success. Gradual seepage may be difficult to detect with dye, while large leaks are often easily located.

REDUCING POND SEEPAGE WITH BENTONITE AND CHEMICALS

Bentonite clays have the ability to absorb water and expand from 10 to 15 times their original volume. This allows the plugging of pores in the soils and prevents water seepage. Wet clay will not withstand water pressure unless it is mixed with supporting soils. Bentonite clays are most effective on coarse-grained, sandy or silty soils. No more than one-half of the soils should be able to pass through a No. 200 sieve. Pond basins which have been sealed with bentonite should not be exposed to trampling by livestock (Hadden, 1989).

Bentonite clays are most effective when applied to a relatively dry pond basin. All debris must be removed from the pond bottom. The "blanket method," which uses a pulverized grade bentonite, is the most effective technique. The top 4 to 6 inches of pond soil is carefully removed from the basin. Holes and crevices are filled with a mixture of 1 part bentonite to 5 parts soil. The pond bottom is smoothed with a roller or drag. Exposed surface are covered with an even layer of bentonite.

Sectioning the pond basin into a grid pattern which consists of 10 x 10 feet squares, will assist in the even distribution of bentonite. The 4 to 6 inch layer of soil is carefully replaced without disturbing the layer of bentonite. These layers should be moderately compacted with a roller. As the pond fills, the bentonite will swell and plug the pores in the soil (Keese, 1988).

With the "mixed blanket method," the pond basin is lightly plowed or disked, and then dragged smooth. Bentonite is spread evenly and mixed into the top 4 to 6 inches of pond soil. Bentonite may be evenly applied to the entire pond basin using a 10 x 10 foot grid pattern. Soils may be mixed with a disk, a spike-toothed harrow, or raked by hand. For water depths up to 8 feet, the mixed blanket should be at least 4 inches thick. The soils should then be moistened and compacted with a sheepsfoot roller. This method is generally less reliable than the blanket method due to the difficulty of evenly mixing bentonite with pond soils. Uneven mixing of the bentonite and support soils may leave weaknesses or gaps in the sealed basin (Keese, 1988).

Bentonite may be added to a pond which contains water when draining is not practical. Granular bentonite may be distributed from a boat over the entire pond surface or over leaking areas. Powdered bentonite may be mixed with water to form a slurry which may also be poured over the surface of the pond. This solution will sink to the pond bottom. Either application method will allow the expanding clay particles to plug crevices and soil pores by the pressure of the seeping water. Best results are obtained when the clay can be mixed with the bottom soils (Keese, 1988). Mixing bentonite into the bottom soils of a pond which contains water may be difficult. This technique is less effective in reducing pond seepage and may not be economically practical when an entire pond must be sealed.

Field performance or laboratory test data will provide the best data for bentonite application rates. Minimum application rates for Louisiana (Hadden, 1989) are provided in table 2.

TABLE 2.

Minimum Bentonite Application Rates for Louisiana		
Previous Soil Type	**Application Method**	**Application Rate ***
Clay	Pure Membrane or mixed layer	1.0 - 1.5 lb./sq. ft.
Sandy silt	Mixed layer	1.0 - 1.5 lb./sq. ft.
Silty sand	Mixed layer	1.5 2.0 lb./sq. ft.
Clean sand	Mixed layer	2.0 - 2.5 lb./sq. ft.
Open rock or gravel	Clay or sand mixed layer	2.5 - 3.0 lb./sq. ft.

***** One lb./sq. Ft. equals 43,560 lbs./acre

Sodium polyphosphates are used to disperse or break down the pond soil. Small clay-size particles which are contained in the soils are dispersed and seal the pores which reduces seepage. Soil dispersion should be attempted only where the soil mantle is thick. Since polyphosphates break down the soil particles which support the clay; only 3 or 4 feet of water can be supported over the thin soil mantle. Experimental data has shown polyphosphates perform best in soils which contain more than 15% clay-size particles. Polyphosphates work poorly in sandy or silty soils which contain little clay. These chemicals have been used successfully in sealing ponds which are located in the limestone regions of the northeast. Where conditions are appropriate, pond sealing with polyphosphates may cost less than using bentonite (Hadden, 1988).

Polyphosphates are mixed into relatively dry pond basins. Debris should be removed from the pond bottom. Rock, sand or gravel areas should be covered with 2 to 3 feet of good quality soil. Soils over entire pond basin should be disked to a depth of 6 to 8 inches. Tetrasodium pyrophosphate (TSPP) or sodium tripolyphosphate (STPP) may be applied by a fertilizer spreader or evenly broadcasted by hand. The chemical is mixed into the soil in one direction during the first mixing. The second mixing should follow a course perpendicular to the first. Soil should be compacted with a sheepsfoot roller and protected against erosion until the pond is filled. A minimum blanket thickness of 6 inches is required for 8 feet of pond depth. For greater depths, two, 6- inch blankets must be compacted in the pond basin. Vertical pond banks within the zone of water fluctuation require a 12- inch, blanket covering (Hadden, 1988). Other soil dispersants include soda ash (technical grade 90 - 100% sodium carbonate), and granulated sodium chloride (salt). Commercial phosphatic fertilizer is not effective for sealing ponds. Minimum, dispersant application rates for Louisiana (Hadden, 1988) are presented in Table 3.

TABLE 3.

Minimum dispersant application rates for Louisana (Hadden, 1988).	
Sodium Polyphosphate	5 to 10 lbs./100 sq. ft.
Soda Ash (Sodium Carbonate)	10 to 20 lbs./100 sq. ft.
Sodium Chloride (Salt)	20 to 33 lbs./100 sq. ft.

LINING PONDS WITH PLASTIC OR RUBBER LINERS

Ponds may be effectively sealed with various plastic or rubber lining materials. Pond liners are constructed of rubber, polyvinyl chloride (PVC) and different polyethylene plastics.

Liners must be constructed of pigmented polyvinyl or polyethylene materials, which are resistant to breakdown by bacteria. Manufacturers will recommend specific liners designed for lining aquaculture ponds. Pond basins which contain sandy soils should be lined with materials with the following minimum thicknesses: 8 mil plastic sheeting, 20 mil nylon-reinforced rubber sheeting, or 30 mil unreinforced rubber sheeting. For soils which contain gravel, liners with the following thicknesses will be required: 12 mil plastic sheeting, 30 mil nylon-reinforced rubber sheeting, and 30 mil unreinforced rubber sheeting. Reinforced liners should contain synthetic fiber (Hadden, 1988).

The pond basin should be dry and smooth before the lining material is installed. A disinfectant may be used over the pond area, depending on the manufacturer's recommendations. Pond banks should be no steeper than 2.5 : 1 for liners which are covered by soil. An anchor trench must be dug around the entire perimeter of the pond to anchor the top of the lining material. This trench should measure about 10- inches deep and 12- inches wide. Approximately, the top 8- inches of the lining material should be buried in the trench under compacted soils. The liner is spread loosely over the pond basin. Polyethylene plastic may contract approximately 5% when installed in hot weather. Liner seams must be sealed or welded water-tight in the manner recommended by the manufacturer. All plastic liners must be covered with 6- inches of soil to prevent the breakdown of the plasticizer by ultra-violet sunlight. Plastic and rubber liners which will be trampled by livestock must be covered with a minimum of 12- inches of soil. Protective cover soils must be free of sharp objects and large clods which could puncture the lining. The bottom 3- inches of the cover soil should consist of silty sand or finer material. This fine soil layer will prevent the puncture of the liner when the pond is filled (Hadden, 1988).

Liners suitable for most ponds are usually extremely expensive. The economics of lining a watershed pond for the purposes of fish production should be carefully evaluated.

For a list of lining material suppliers contact your county extension office or aquaculture extension specialist.

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