Managing Ponds and Lakes for Aquaculture and Fisheries in Missouri

Pond Construction and Management Considerations

A properly planned and constructed pond or lake can be a great asset on your property (see Figure 1). Private ponds and lakes can be used for recreation, fishing, hunting, boating, swimming and other water sports. They can also be used as a water source for livestock, fire protection, irrigation and production of fish for food or sale. A pond that provides these benefits and consistently produces good catches of fish is a result of proper planning, construction and management.

Properly constructed ponds benefit from even a minimal level of management. The fundamental considerations for managing a pond for fishing include:

- proper pond construction and watershed management;
- fish species selection and stocking;
- determining fertility needs;
- managing for a balanced fishery;
- proper harvesting and record-keeping;
- managing water quality and understanding pond dynamics; and
- aquatic plant management.

There are two pond construction styles used in Missouri, depending on a pond's intended purpose and the availability of water. The first is the watershed pond, so named because it takes advantage of the topography of the surrounding land to collect and store water. In some cases, a single dam may be all that is necessary to construct such a pond. Using runoff water will typically reduce the need for digging a well for water supply. The second common style of pond in Missouri is referred to as a levee pond. Levee ponds are commonly used for commercial aquaculture production in locations where well water is economically feasible, and these ponds are generally more expensive to build and maintain.

Because watershed ponds are generally cheaper to build and maintain, they account for most of the farm ponds in Missouri. Therefore, this publication will focus on construction and management of watershed ponds.

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Figure 1. Private ponds can have many uses and provide a wealth of recreational opportunities, though a pond's primary purpose should be determined prior to construction.

Setting objectives

Clearly define your objectives for the pond well before construction begins. Site selection, design and construction of a pond require the creation of a proper management plan that outlines the maintenance and upkeep activities that will be necessary for your pond.

For example, management and day-to-day maintenance will often differ depending on your primary objective for the pond. Sport fishing and aquaculture production will require different activities, such as:

- Producing a balanced fishery to catch good numbers and sizes of bass and bluegill.
- Producing trophy bass or for trophy bluegill.
- Fishing for catching channel catfish.
- Fishing for hybrid sunfish.
- Producing a balanced fishery for sport fishing but also allowing for cage culture.
- Commercial aquaculture production.

Consider the topography

Site selection will determine the size and function of a pond. The topography of your property will directly affect building costs and can dictate potential uses and management objectives. Ponds need a source of high-quality water, so the best sites tend to be higher up within a watershed. Choose a site that requires the least amount of soil to construct the dam and will provide enough depth; at least 6 to 7 feet at the deepest area. Under the best of conditions, more than 50 percent of the pond should have

a depth of 5 feet or greater. The best site is an area that will hold the most water relative to the dam height.

Construct a dam across a narrow section of a steep valley in a location where the slope allows you to flood a large area. Also avoid locations with flowing creeks or streams, as they flush the pond and make it difficult to manage water chemistry.

Most streams and springs are regulated by Missouri Department of Natural Resources and may not be obstructed for the formation of a private lake or pond. Contact the Soil and Water Conservation District, Missouri Department of Natural Resources or the Missouri Department of Conservation (MDC) for information on regulations pertaining to pond construction.

Figure 2. Take special care during the design and construction phases to ensure that the amount of watershed matches the desired pond size.

Consider the surrounding watershed

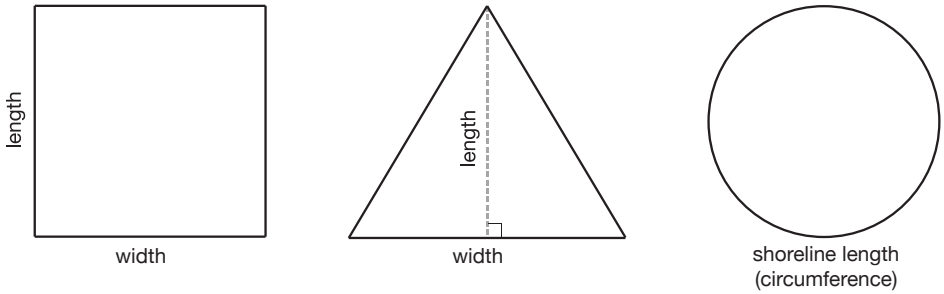
Pond size and amount of water storage is determined by the overall acreage of the surrounding land that provides runoff to the pond, commonly known as the watershed (see Figure 2). In Missouri, especially in dry years, you should try to maintain a watershed ratio of 10–20 acres of land to 1 surface acre of water. Although many ponds have been constructed in areas with smaller watershed ratios, most will dry up during periods of extended drought. Some sites may be unsuitable simply because of topography, geology or soil conditions. Many areas in Missouri are too rocky because of exposed bedrock, which poses many problems for pond construction and maintenance.

Other factors to consider include the soil type, vegetation and ongoing land-use activities that occur within the watershed of the pond or lake. For example, a pond should not be constructed below an intensive animal production area, especially if runoff from the area will drain directly into the constructed lake. Animal wastes will overload the pond with increased nutrients — primarily nitrogen and phosphorus — that will cause an overabundance of aquatic plants. The added nutrient load will cause oxygen depletions, which are the primary cause of fish kills.

The quality of the watershed is extremely important to the health of the pond and affects what management activities will be necessary. Watersheds consisting of high-quality grasslands or pastures provide high-quality runoff water. Grasslands and pastures tend to trap sediments, reduce the influx of nutrient overload and are often consistently limed. An ideal pH for inflow water is between 7.0 and 8.0, which is slightly alkaline. Water with a higher alkalinity tends to be more conducive to a robust fish population. Runoff from watersheds with woodlands and forests tends to be more acidic, and therefore not as good a source of quality runoff water. Deciduous trees (e.g., oak and hickory) lose their leaves annually and tend to build up acidic conditions in the soil.

In Missouri, there are two common types of sedimentary rock formations: sandstone and limestone (dolomite). Runoff from limestone is best, because the calcium and magnesium carbonate produce higher alkalinity levels in the water.

Monitoring and maintaining a proper level of akalinity in your pond or lake serves several purposes. It stabilizes the water's pH and prevents large swings from low pH (acidic) to higher pH (alkaline) naturally caused by the ongoing biological processes within the pond. Algae and other types of aquatic plants absorb carbon dioxide during photosynthesis to produce sugars and oxygen. An adequate alkalinity level will act as a buffer against changes in pH level due to naturally occuring processes.



(length × width) / 43,560

½(width at dam × length) / 43,560

(shoreline length)^2 / 547,390

Note: One surface acre contains 43,560 square feet. All dimensions should be measured in feet when using these formulas.
Dividing by 43,560 (547,390 in the case of the circle) will give you a figure in acres, and this step is included in the formulas provided.

Figure 3. Obtain a rough estimate of your pond's surface area using these formulas for common pond shapes.

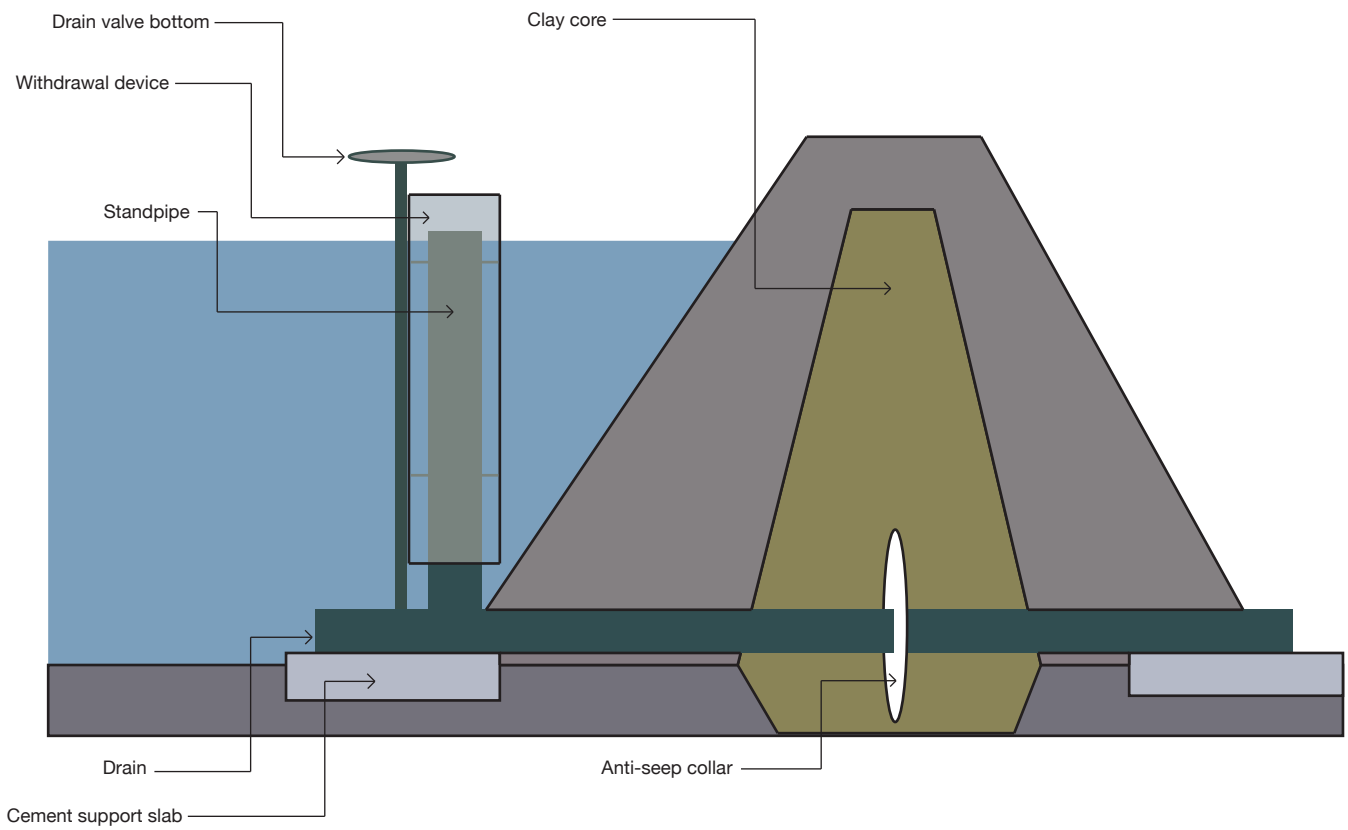


Figure 4. Diagram of a pond dam with drainage and water control structures. This design is common among irrigation lakes and levee ponds.

Consider the soil characteristics

Soil should be one of the main considerations when selecting your pond site. Soil consistency is extremely important, and soil with suitable amounts of clay is necessary for sealing the dam or levee. Clay may also be necessary for sealing the basin of the pond; soil with a consistency of at least 20 percent clay is necessary to hold water.

The cost of building a pond is often determined by how much soil must be moved to construct the dam. Costs can escalate rapidly if there aren't adequate amounts of soil at the site. The U.S. Department of Agriculture's Natural Resources Conservation Service office provides expertise in evaluating soils capable of holding water for a pond. They provide technical assistance with design and construction, and may also provide cost-share assistance (see the *Additional resources* section for more details).

When to build

Ponds can be constructed at any time of year, but summer is best, because weather and soil conditions usually allow the use of heavy equipment (see Figure 2). Fall and winter rainfall will fill the pond, which allows you to stock fish at the ideal time of year.

Pond size

The size of your pond will directly affect your management goals and objectives. Small ponds (1 to 5 acres) provide excellent fishing opportunities. Larger ponds and lakes can also provide excellent fishing but have other potential uses, such as irrigation, swimming, boating and hunting. Additionally, they are less susceptible to changes in water level. For surface runoff ponds and lakes, the area of land that flows into the pond will determine its size. For each surface acre of pond water, 10 to 20 acres of drainage area is usually required.

Pond size will dictate how many fish to stock if sport fishing is the primary goal. Many people have difficulty estimating the surface area of their ponds. It is easy to overestimate the surface area, which can lead to overstocking and other management issues. If your pond's surface area fluctuates considerably, it should be stocked based on the average annual low-water surface area. See the formulas for calculating the surface area (in acres) of common pond shapes provided in Figure 3 to assist you in determining the size of your pond.

The Missouri Department of Conservation has developed a pond area estimator to help with this (***http://mdc.mo.gov/node/5990***). Recent advances in global positioning system (GPS) technology allow you to easily calculate pond surface acreage with a commercially available handheld GPS unit with area calculation programming.

Depth

Ponds should have an average depth of 5 to 6 feet but not exceed 10 to 12 feet. At least half of the pond should have a depth of 4 to 5 feet so fish can forage on the pond

bottom, even during the summer months when low oxygen concentrations are common in deeper water. This depth also sustains fish populations during times of drought. During the summer, water evaporation can reduce water levels by up to a half-inch per day, and ponds can potentially lose 2 to 3 feet of water depth. Additionally, the bank surrounding the pond should drop quickly to at least 3 feet deep to minimize the risk of aquatic plants taking root.

Pond dam and water control structures

Dams should be at least 8 to 12 feet wide at the top, depending on the height of the dam. If a dam is less than 12 feet tall, it will require an 8-foot top width, and dams taller than 15 feet will require a 12-foot top width. If you use the top of the dam as a road, it should be at least 16 feet wide across the top.

Figure 4 provides a diagram of a recommended pond dam (levee) and an appropriate water control structure. The combination of drain and overflow pipes and an emergency spillway make pond management an easier task. Placing the drainpipe on the pond bottom allows you to completely drain the pond and efficiently manage the water level.

Many areas of Missouri have soil that requires dams be cored with clay to prevent seepage. The slope of the dam should not be steeper than 1:3 on the waterside (a 1-foot rise for every 3 horizontal feet). On the backside, a 1:4 slope will allow you to safely maintain the vegetation on the dam.

Estimate the volume of material that will need to be moved to construct the dam and pond. This will comprise a significant portion of the cost of construction. Below is a simplified method of estimating the volume of material necessary to construct a dam for your site.

Volume (cubic yards) = 0.216HL (2C+HS)

- ***H is the estimated height of the dam (must include 1 foot freeboard for outlet pipe and 1 foot additional freeboard at emergency spillway elevation).***
- ***L is the length of the dam in yards.***
- ***C is the width of the top of the dam in yards.***
- ***S is the combined slope value (slope value is determined by inside ratio at 1:3 and outside ratio 1:4). In this example, S = 7.***

This is an approximation, but it can be useful in determining construction costs. A more precise estimate will require that you properly survey and calculate the expected dam height, width and slope.

Figure 5 shows another recommended pond dam and water control structure, the bottom draw-off device. This design is less costly to implement and uses a trickle tube to remove excess water from the pond during periods of normal runoff, which serves to preserve the emergency spillway.

Having an adequate amount of freeboard, or the distance from the water's surface to the top of the dam, not only makes the dam safer but also ensures that it will not be topped by the water. One foot of freeboard is necessary at the standpipe, also known as an overflow pipe, which drains normal runoff when the pond is full. The drain pipe, also known as the outlet pipe, should be large enough to drain normal runoff before it reaches the spillway (usually about 3 to 6 inches in diameter). This pipe can be straight but usually has a hood or canopy inlet and must be large enough to keep the emergency spillway dry. You may want to install a pipe on the bottom of the structure to serve as a supply for livestock water or to draw down water levels for controlling aquatic vegetation or conducting pond basin maintenance. All pipes in the dam structure should have anti-seep collars on the upper and lower sides of the dam. The anti-seep collars prevent water from seeping out along the pipe and eroding the dam structure. Pipes can be made of corrugated metal, aluminum, steel or polyvinyl chloride (PVC); however, some materials may be more durable than others.

It may also be a good idea to fit a larger pipe over the standpipe to draw water from deeper areas of the pond where oxygen levels may be low. The base of the pipe should be 18 inches off the pond floor and extended 12 inches above the water's surface (see Figure 6). This will circulate water from the deeper areas of the pond to improve water quality, increase available fish habitat and reduce the risk of a fish kill by removing low-oxygen water.

The overflow pipe is used as the outlet for normal water flow through the pond. The emergency spillway is an area lower than the top of the dam that runs on one side to safely release excessive runoff resulting from heavy rainfall.

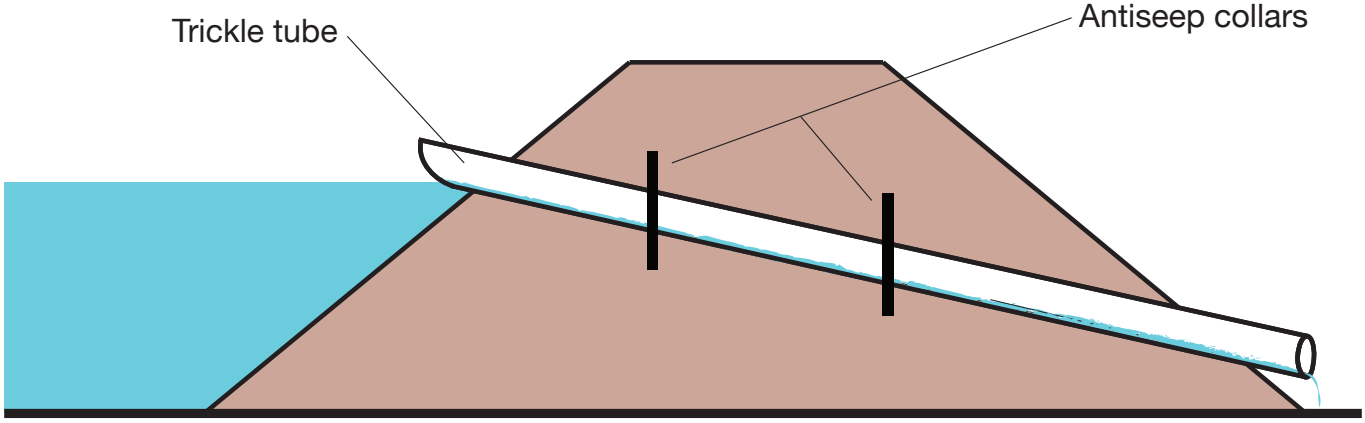


Figure 5. The hooded trickle tube drains and removes excess water from the pond during periods of normal runoff.

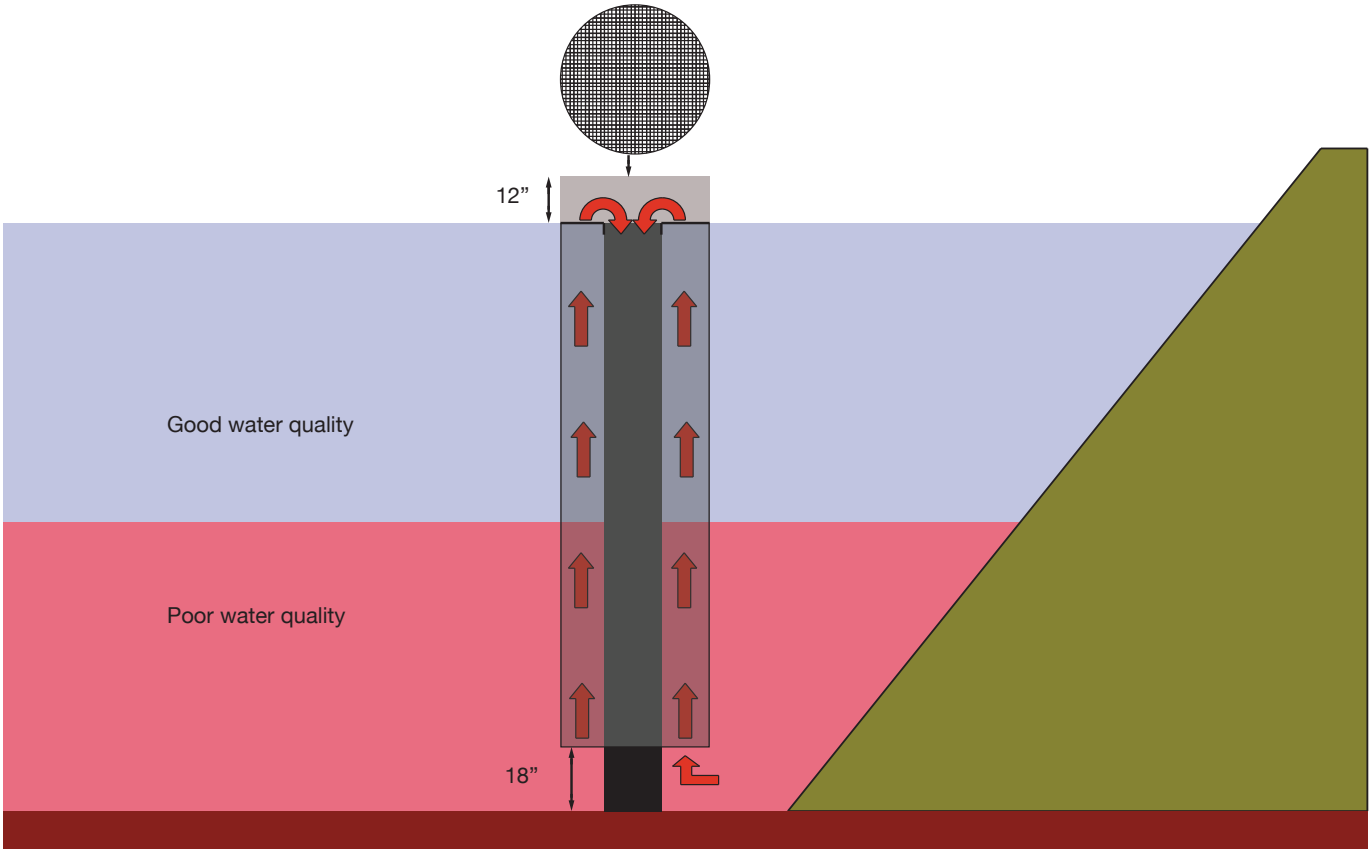


Figure 6. An example of a bottom draw-off device that can be used to remove deep, low-oxygen water to improve the water quality and enhance available habitat within the pond.

Seeding and establishing a stand of grass stabilizes the soil within the spillway and minimizes the risk of erosion. Flow through the spillway should be slow and shallow to prevent erosion near the dam structure, and it should not meander near the dam base but end in an area where the water can spread out and any current will dissipate. The spillway should be large enough to handle a historic downpour and should be protected with vegetation or riprap.

Seepage below the dam is a common problem if the site is incorrectly prepared, but an excavated cutoff or core trench addresses this issue. The trench should be at least12 inches deep and excavated to impermeable materials below the natural soil level. The trench should be excavated along the center of the dam and as far up the sides as there is permeable material. If the trench breaches an existing channel or old streambed, excavation must go below any rock or gravel to impermeable material.

Soil type and compaction are principle factors that affect dam safety and permanence. Only about 6 to 8 inches of soil should be added before compaction with heavy equipment such as a sheepsfoot roller. A bulldozer alone will not provide adequate compaction. The soil around the spillway and water supply pipes must be compacted separately using power or hand compactors. This is a slow process that is usually done as new levels of material are added and compacted during construction.

You can find helpful illustrations of a properly constructed pond dam, spillway and water control structures in the MDC Missouri Pond Handbook (see the *Additional resources* section).

Vegetation management

Establish perennial vegetation on the dam as soon as possible to prevent erosion, muddy water and maintenance problems. Tall fescue, a nonnative perennial cool-season grass, is a common choice, because it is a quick-establishing turf grass that tolerates frequent mowing. Native warm-season grasses, such as switchgrass or big bluestem, are also excellent choices as they have deep root systems and provide higher quality wildlife habitat. Native warm-season grasses also require less frequent mowing and tolerate drought conditions better than nonnative grasses. Do not mow these grasses shorter than 6 inches.

If the dam construction is completed before or after planting dates for these grasses, establish a temporary cover to limit soil erosion until more permanent grass cover is established. Winter wheat, oats and rye are good choices. Lime, fertilize and seed at recommended rates as soon as construction is completed.

Trees and shrubs should not be allowed to grow on the pond dam. They will weaken the dam and increase the likelihood of a leak or failure. However, leave in place any large trees already growing on an existing pond dam, as decaying root systems from a felled tree may weaken the dam.

Laws and regulatory concerns

There are laws in place to ensure the safety of dams constructed in Missouri. These laws will generally apply only to dams larger than those used for the small ponds or lakes described in this guide, but it may be beneficial to be aware of them anyway.

Jurisdictional dams are defined as any artificial or manmade barrier that does or may impound water and is 35 feet or more in height, which require permits of approval prior to construction. However, most dams constructed for small private ponds and lakes are exempt, because they are usually smaller than 35 feet tall. Dam height is defined as the difference in the elevation of either the natural bed of the stream or watercourse, or the lowest point on the toe of the dam and the dam crest elevation.

Refer to this Lincoln University aquaculture publication for an overview of various regulations and permits for additional information: *http://moaquaculture.org/regs/aquaculturepoliciesandpermits.pdf*

Pond basin

During construction is the best time to decide how you will manage the pond basin. Inspect the pond basin and take soil samples after all other digging and dirt work is complete. The University of Missouri Soil and Plant Testing Laboratory (***http://soilplantlab.missouri.edu/soil/***) can test the sample to determine whether the soil pH needs to be adjusted. In many cases, the pH may be low and you will need to add lime to help ensure the productivity of your pond. Before filling the pond, you can also establish winter wheat, rye, millet or other suitable grasses on the pond bottom to reduce erosion and siltation and to enhance the production of a variety of aquatic species that are important food items for fish once the pond is stocked.

If fishing is your goal, leave some trees, bushes and brushpiles to serve as fish attractors. These structures provide habitats for many species that provide important food sources for fish as well as cover for largemouth bass and bluegill.

As much as 10 to 25 percent of the pond basin should have some type of cover available. Trees and brush should not be left in shallow areas, in narrow coves or along the pond bank, as these areas will be more difficult to fish and aquatic plant problems will eventually develop.

Fish attractors can be established in ponds that have no trees or brush available for cover. Refer to the Missouri Pond Handbook and information on fish attractors for more detailed information.

Conclusion

With proper planning and design, watershed ponds can offer many opportunities for sport fishing, recreation and fish production. Decide prior to construction how the pond will be used so an appropriate management plan can be implemented. Keep in mind that compromises may be necessary in determining the objectives for your pond.

Once a pond is completed, its success or failure will depend on a variety of management practices that include establishing and maintaining good fish populations. Stocking the correct species and numbers of fish at the appropriate time of year, achieving a balanced harvest, water quality management and aquatic vegetation management are a few of the basics that will need to be taken into consideration and are discussed in subsequent guides.

In addition, seek advice from the Missouri Department of Conservation and the USDA Natural Resources Conservation Service. These organizations provide excellent technical information on pond construction and management resources.

Additional resources

Agricultural Handbook No. 590, *Ponds — Planning, Design, Construction*. USDA NRCS, ***http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_030362.pdf***

Renovating Leaky Ponds. USDA Southern Regional Aquaculture Center. ***https://srac.tamu.edu/index.cfm/getFactSheet/whichfactsheet/6/***

2011 Missouri Pond Handbook. Missouri Department of Conservation. ***http://mdc.mo.gov/sites/default/files/resources/2010/05/mopondhandbook_2011.pdf***

Pond improvements, pond construction, maintenance and complete aquaguide series of fact sheets. Missouri Department of Conservation. 2013. ***http://mdc.mo.gov/your-property/improve-your-property/pond-improvements***

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