K-STATE Kansas State University

WATER QUALITY SERIES

Wastewater Pond Design and Construction

Two types of private onsite treatment systems are in general use in Kansas, septic tank-soil absorption systems and wastewater stabilization ponds or lagoons. Where soil is sandy or loamy, the septic tank-soil absorption system is the best choice. Where soil is clayey with poor drainage and space is available, wastewater ponds are often the best alternative for treatment and disposal.

A wastewater pond is among the least expensive onsite treatment options, and maintenance is not excessive. A pond should be the first consideration for wastewater systems where soils have severe limitations for soil absorption systems but are well suited for pond construction and enough area is available to meet separation distance requirements.

When soil, site conditions, or closely spaced homes make a septic system or wastewater pond unsuitable, enhanced treatment methods such as sand or media filter, rock-plant filter, mound, aerated tank, or other method should be considered. Surface discharge for individual homes is not legal in Kansas.

This bulletin presents design and construction information about wastewater ponds for sanitarians, contractors, owners, and others. Operation, maintenance, and repair needs for wastewater ponds are presented in another bulletin.

A wastewater pond is a small fenced water body with a 3 to 5 foot liquid depth that receives sewage. Pond size is determined by the number of occupants, size of home, the amount of wastewater, evaporation, and soil. Sewage enters the pond by a pipe below the surface but above the bottom, near the center of the pond. Ponds must be nondischarging, meaning no overflow. Water is disposed of by percolation and evaporation.

How Wastewater Ponds Work

A wastewater pond is a nutrient enriched complex ecosystem. Bacteria and other microorganisms consume oxygen as they feed on sewage components and give off carbon dioxide used by algae. Unlike other ponds, a wastewater pond's water should be green, because microscopic plants (algae) produce much of the needed oxygen. Oxygen also enters as air blows across the water surface.

Wastes are broken down by microorganisms into water, gasses, and residual solids, which settle and accumulate in the pond. Properly-sized, carefully-constructed, well-operated, and routinely-maintained ponds have no offensive odor.

Although odor from a good pond is rare, when it occurs, it is usually because the natural biological system is upset. Upsets can be caused by chemicals that disrupt the natural system, organic overload from highly concentrated or too much waste, or accumulation of too much sludge. Extended cloudy weather and spring or fall turnover also may contribute to temporary odor.

All trees should be at least 30 feet and shrubs 15 feet outside of the of embankment. Because sunlight is essential for algae to produce oxygen, the east, south and west sides of the pond should not be shaded. Vegetation no taller than a 22 degree angle ($2^1/_2$:1 slope) from the berm is recommended, see Figure 1. The minimum setback distance d in feet from the berm to plant trees or shrubs that reach a height of h in feet is given by the formula $d = 2^1/_2 \times h$. For example, a screen of lilac bushes will reach 12 feet tall so they should not be planted closer than $2^1/_2 \times 12 = 30$ feet from the berm.

In a properly sized pond, solids are spread over a large area, so it should take at least 15 years before sludge removal is required. Tree leaves, plant debris, or wildlife in or near the pond will contribute to faster sludge accumulation.

Wastewater Pond Location

A pond is best located down slope and away from the house so the sewer line to the pond flows by gravity at the correct slope. When choosing the site, nuisance conditions, which could result from odors or accidental discharge should be considered. Odors would least likely affect the owner when a pond is located northeast or east of the house.

Select an inconspicuous place 100 feet or more from the house and property lines, 50 feet from any surface water, 30 feet from potable water lines, out of 100-year flood plain, and away from easements or rights-of-away. Separation distances from surface water, wells, property lines, public water lines and such must be followed from local codes or Kansas Department of Health and Environment (KDHE) Bulletin 4-2. A site plan showing all physical features—surface and buried—and contour elevations will help to locate and design a pond. The bottom of the pond should be at least 4 feet above highest groundwater level.

The top of the pond embankment should be below the lowest drain or clean out in the house. Sometimes the pond must be located upgrade of the house. This is more expensive because a pump chamber and pump are required and pumps are also subject to failure. When pumping is required, it is advisable to add a septic tank and have the system designed by an experienced person.

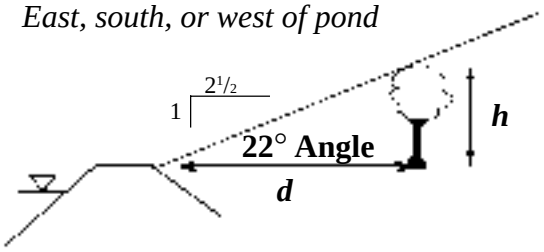


Figure 1. *Maximum vegetation height to limit shading of pond.*

Wastewater Pond Appearance

Some people don't want a wastewater pond because it is visible. Ponds need not be ugly, nevertheless many are. A well designed, constructed, and landscaped pond can be pleasing in appearance or inconspicuous. **Maintenance of the pond and fence are essential to keep them attractive.** Hints to make a pond more attractive include:

- Locate pond to blend in with existing topography and landscape. Do not place in center of large open meadow.
- Where possible, dig pond into ground (if clearance to groundwater allows) with low berms to prevent surface inflow rather than making it shallow with high berms.
- Use trees, shrubs, and landscaping berm in line-of-sight or to draw attention away from the pond.
- Use round, oval, or other shape pond rather than square.
- Incorporate wood or other natural material in the fence or use colored fencing so pond is less visible.
- When a high berm is needed, locate fence at the outside toe of the berm, so it does not add to the overall height.

Size of Wastewater Pond

Size and design of the pond involve several considerations. The water surface area must be large enough to provide adequate oxygen to keep the pond aerobic, an area of 165 square feet per person, with a minimum of 900 square feet, is usually considered adequate for oxygen transfer.

Kansas law prohibits discharge from private ponds, so they must hold all wastewater. Losses are through leakage or seepage (maximum of 1/4 inch per day) and evaporation. Maximum losses total 14 feet in southwest Kansas to 10 feet or less in eastern Kansas per year.

A 5-foot water depth with 2 feet of freeboard is ideal for easy maintenance of vegetation between the water level and top of embankment. The minimum depth to prevent rooted aquatic growth in the pond and exposure of the inlet pipe is 3 feet.

Table 1 lists wastewater pond guidelines for three household sizes and three locations in Kansas. Wastewater flow must be considered and may require a larger or smaller pond than these sizes. Experience and advice from contractors and agencies will help determine the best size. Table 1 shows the side length for square and diameter for round ponds. Other shapes may be used but length should not exceed twice the width.

Maintaining Water Balance

Sometimes additional water is required to maintain sufficient water depth and surface area. A post with depth markings located near the center is recommended to monitor water depth.

One or more downspouts from the roof can be added to the pond. These connections should be easily diverted because periods of excess rainfall may add too much water to the pond. Subsurface drains and sump pumps should not be connected to the system unless a way is provided to easily divert this water from the pond during wet periods. Where a septic tank is used, excess water must be connected to the effluent line following the tank.

Sewer Line to Pond

Use at least a 4 inch diameter line from the house to the pond. All joints must be water tight as leaks attract tree roots that will clog the line, causing a sewer backup. Schedule 40 thermoplastic sewer pipe with solvent welded joints is durable, easy to lay, and recommended.

Ideal line slope is 2 percent or 2 feet per 100 feet (1/4 inch per foot). Vary from this slope as little as terrain permits. A minimum of 1 foot and a maximum of 3 feet per 100 feet (1/8 to 3/8 inch per foot) are recommended to avoid solids accumulation in the pipe. Care in laying the line results in less maintenance and fewer problems.

At least two cleanouts should be used, one just outside the house and a second near the pond where the ground surface is 6 inches above the embankment (see Figure 2) for access to unplug the line. A cleanout at each change in direction and every 100 feet is also recommended. Cleanouts may be a Tee or "Y" the same size as the sewer line, but cleaning is easier if access in each direction is possible.

The line must enter the pond below the water surface to prevent freezing and ice problems, be above the bottom at least 20 inches, and should extend to near the center of the pond. The end of the pipe should be anchored by posts, steel support, or concrete blocks attached to a concrete slab at least 2 feet × 2 feet × 4 inches thick to help prevent damage to the discharge line.

Permits

In counties with sanitary codes, a permit for onsite wastewater systems is required, usually through the local health department. In counties with no sanitary code, contact the local health department or KDHE for design and construction recommendations. When waste from other than domestic sources enters a pond, KDHE must be contacted and a state permit may be required.

Leaky Pond

Occasionally, a pond either will not hold water initially or will develop a leak. Excessive seepage (more than 1/4 inch per day) can contaminate groundwater or surface water so care in construction is essential. Materials that can be used to seal the bottom and sides of leaking ponds include bentonite clay, treatment additives for native clay or membrane lining. Recommendations for using these materials may be obtained from county Extension office or Natural Resource Conservation Service. See *Reducing Pond Water Losses*, available from K-State Research and Extension, Biological and Agricultural Engineering, 237 Seaton Hall, Manhattan, KS 66506-2917.

Table 1. *Recommended sizes of square and round wastewater ponds.*

	Side Length or Diameter (ft)		Area (sq ft)	Volume (1,000s gal)	
	square	*round*		*pond*[a]	*per mo*[b]
Western					
Small	35	40	1,225	18	4
Medium	40	45	1,600	26	5.5
Large	45	51	2,025	32	7
East Central					
Small	40	45	1,600	26	4
Medium	45	51	2,025	32	5
Large	50	56	2,500	43	6
Eastern					
Small	45	51	2,025	32	3
Medium	50	56	2,500	43	4
Large	55	62	3,025	56	5

Small = 3 or fewer people; Medium = 3 to 5; Large = 6 or more

[a]*Contents at 5 foot depth* [b]*Minimum flow to maintain 3 foot depth*

Wastewater Pond Fence

Drowning is the second leading cause of accidental death of children. Fencing of wastewater ponds is essential to protect children, pets, and other animals. These ponds contain sewage that can easily spread disease and when unfenced they are a health hazard and a liability. State standards and county codes require that they be fenced.

The fence should preferably be located at least 3 feet outside the embankment toe. Here it makes mowing the embankment easier and looks more pleasing. The fences should never be on the water side of the embankment because it makes controlling vegetation very difficult. A fence on top of the berm although not recommended, should be at least 4 feet from inside edge to make mowing the embankment and slopes easier. A large (at least 4 feet wide) rigid-frame, hinged gate should be provided to allow easy access. When livestock are around the pond, the fence must be beyond the outside toe of the embankment slope to prevent erosion and damage to embankment. The fence should be at least 4 feet tall but may need to be taller.

Fence openings should be no larger than about eight square inches (2×4 or $2^3/_4$ x $2^3/_4$ inches) or vertical slots no wider than $1^1/_2$ inch. The material should be strong enough to stand up to children, wildlife, and livestock if present. The kind and size of animals must be considered in selecting the fence material.

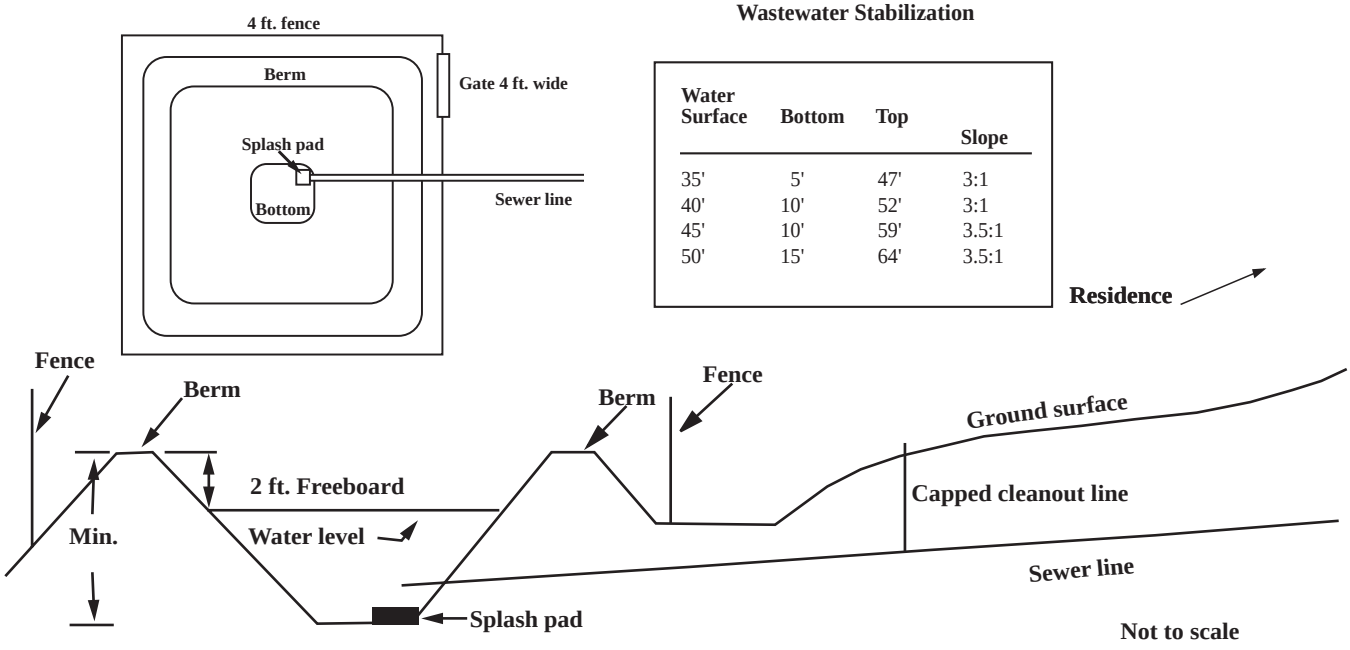
A wood fence can completely hide the wastewater pond from view except from above but should not extend more than 2 feet above the top of the embankment. Corners with two 45° bends 8 to 12 feet apart can be attractive. One barb wire strand must be placed at the bottom edge of the fence to discourage animals from going under. One barbed wire strand should top the fence, but when livestock are present use at least 2 strands on top.

Use of a Septic Tank

Sometimes a septic tank should be installed ahead of a wastewater pond. There are both advantages and disadvantages for using the tank so there is no single recommendation. Advantages include: reduces organic strength by 40 percent; reduces solids load which allows a small diameter effluent line, an effluent pump, increased distance between clean outs, greater variability in sewer grade and greater flexibility for placement; reduced likelihood of odors; and reduced sludge accumulation in pond. Disadvantages include: increased construction cost, anaerobic wastewater discharge to pond, and added maintenance for the tank.

Situations where a tank may be a benefit include when a pond must be at a higher elevation than the residence, requiring pumping; the sewer line grade must be outside the 1 to 3 percent slope range; or the needed minimal maintenance of the pond is unlikely. When a tank is used, it must be pumped regularly to avoid solids carry over that could block the effluent line.

Figure 2. *Wastewater lagoon plan, dimensions and cross-section*



Large House with Few People

The most difficult problem for wastewater pond sizing is a large house (several bedrooms) with only a few occupants. Design practice for individual wastewater systems is based on two people per bedroom and assumes flows of 75 gallons per person (150 gallons per bedroom) per day. Excess unused capacity is no problem for a conventional soil absorption system. However, low flow into a pond causes shallow depth, rooted vegetation, habitat for vectors that can transmit disease, poor operation, and often odor. Options that help remedy these problems include:

1. Use a two cell pond with the first cell sized for the minimum number of occupants and the two cells together for the full size of the home. Use an over flow pipe that maintains at least three feet of water in the first cell before over flow to the second cell. Ideally, water should rise to at least $4^1/_2$ feet deep and then be drawn down to no less than three feet. This balances water in the two cells. Both cells must be fenced.
2. Size a cell for the minimum number of occupants with an over flow pipe at the 5 feet depth. Construct a second shallow (maximum 3 feet deep) wetland cell to receive the overflow. Select plants that do not have seed easily transported by wind or birds. Fence both cells.
3. Size the pond for the number of bedrooms but dig the bottom deeper so the bottom is the same size as a pond for only a few people.

Constructing Wastewater Pond System

A small bulldozer or front loader is ideal for building a pond. Make side slopes no steeper than 3:1, provide a freeboard of at least 2 feet above the normal depth and a minimum berm top width of 5 feet. Divert surface water from the pond with the embankment or a diversion on the upslope side. Finish the berm to a uniform surface above the water line for ease in mowing. Figure 3 shows a well constructed pond and a great fence.

Figure 3. *A fine new wastewater pond. This chainlink fence will have a long life and requires little maintenance.*

Many soils have a topsoil layer that is more permeable than the high clay subsoil. When constructing a pond the permeable (topsoil) layer must be stripped from the surface and embankment base before excavating the bottom and forming the embankments. Compact undisturbed sides in place. Embankment fill should be compacted in layers no more than 6 inches thick. When rock is encountered in excavation, the hole must be overexcavated by at least 1 foot to remove rock, then fill and compact at least 1 foot of clay material.

Compaction has a wide range of meanings depending on viewpoint. A minimum is to consolidate and fill large openings by running over the fill with construction machinery. The best method is to compact moist 6-inch fill layers, sides, and bottom, with a sheep's foot roller until it walks out (compacts enough that spikes no longer penetrate).

Moisture content has more effect on compaction than the type of machinery used. When the soil is muddy, it is too wet to compact well. The best condition is when the soil is moist enough to easily work into a ball. The more the soil is manipulated at this moisture condition the more voids will be worked out of it and the less permeable it will be. Careful compaction is important for soil that is borderline for wastewater ponds.

Finally after the embankment berms are complete, replace the topsoil over the outside, top and upper few feet of the inside of the embankment. Seed the embankment to perennial grass and apply and anchor a straw cover or erosion blanket for soil protection.

The sewer line trench bottom should be undisturbed soil and free of rocks that could break the line. Back fill and compact around the sides and over the pipe until 2 inches of fill cover the pipe. Compact the remainder of the trench fill in 6-inch layers. Finally mound over the trench about 6 inches to allow for settling of the trench fill.

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