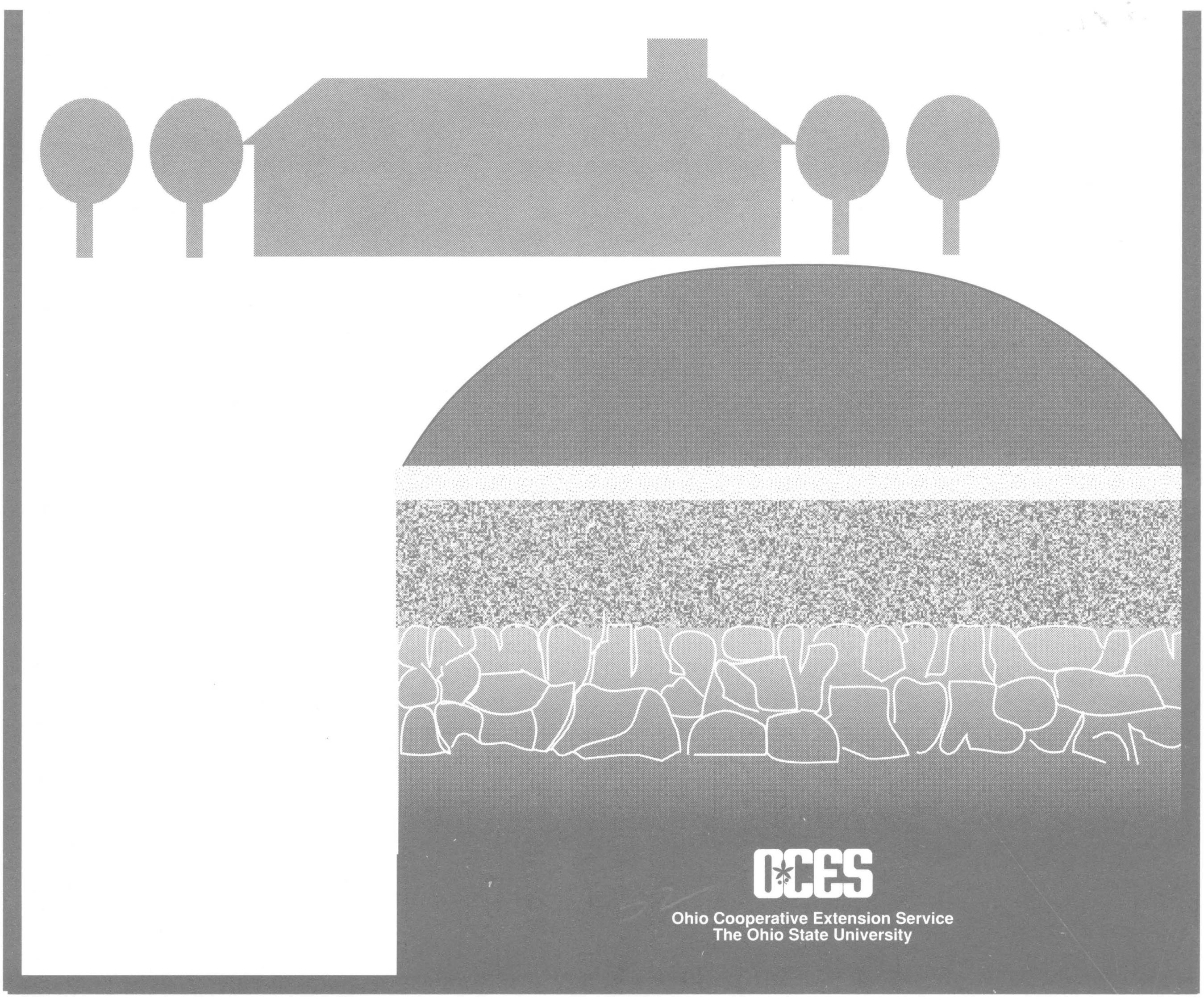
Bulletin 813

Mound Systems for On-Site Wastewater Treatment

Siting, Design, and Construction in Ohio



Mound Systems for On-site Wastewater Treatment

Siting, Design and Construction in Ohio

Adapted for Ohio by:

David Widrig
Graduate Research Assistant, Agricultural Engineering

and

Karen Mancl
Water Quality Specialist, Agricultural Engineering
The Ohio State University

Based on:

Wisconsin Mound Soil Absorption System ... Siting, Design and Construction Manual
By James C. Converse
Professor, Agricultural Engineering
and
E. Jerry Tyler, Professor, Soil Science
College of Agricultural and Life Sciences, University of Wisconsin-Madison

T · H · E OHIO STATE UNIVERSITY

Project financed in part by a grant from the U.S. Environmental Protection Agency.

For Sale Publication

12/90 — 2M — 81901

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Bobby D. Moser, Director of the Ohio Cooperative Extension Service, The Ohio State University.

The mound system is a soil absorption system constructed above grade that uses sand fill to enhance treatment before wastewater enters the natural soil at the site. Sites that may be unsuitable for a conventional soil absorption system may be suitable for a mound system.

Current Ohio regulation concerning household wastewater treatment and disposal on unsewered lands requires a minimum of four feet of unsaturated soil beneath any subsurface disposal system (Figure 1a). Many areas of the state do not have this condition naturally, and the mound system may be the most suitable disposal system.

The principal advantage of the mound system is that it extends the soil and site limitations of a conventional soil absorption system. Mound systems have successfully been used on:

- slowly permeable soils;
- shallow permeable soils over bedrock; and
- permeable soils with seasonal high water tables.

The mound system was developed in the early 1970s at the University of Wisconsin. The system has been widely accepted across the United States and written into many state regulations. The mound system is one of several alternatives for treatment and disposal of residential and commercial wastewater. It is not suited for all sites. The Household Sewage Disposal Rules (Chapter 3701-29, Ohio Administrative Code) has no specific regulations on mound system installations, but many mound systems are now operating in the state. They can be installed "by variance" after approval of the design by the Ohio Department of Health.

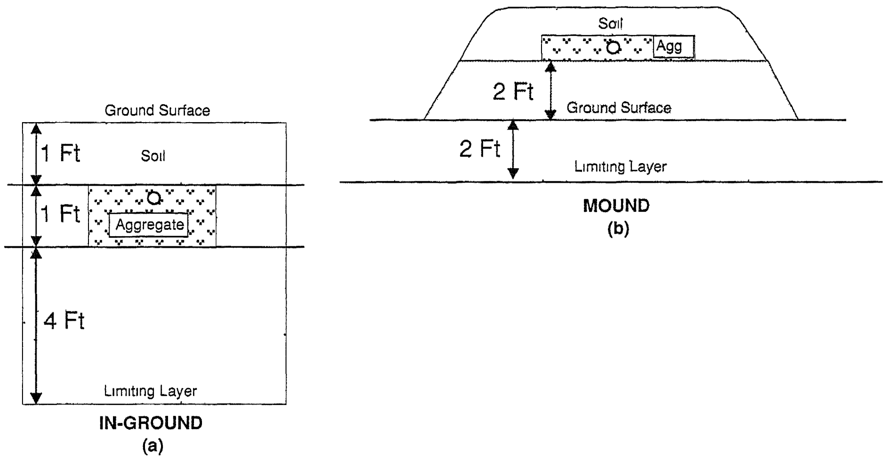


Figure 1 Cross section of conventional soil absorption unit (a) and the Mound System (b) in relation to ground surface and limiting conditions
(after Converse and Tyler 1990 Wisconsin Mound Soil Absorption System Siting, Design and Construction Manual. University of Wisconsin, Madison)

This bulletin describes the siting, design and construction of the mound system in Ohio for single family homes. It does not address the special considerations for commercial establishments and systems serving several homes.

The main components of a mound system are a septic tank for pretreatment, a dosing chamber to provide pressure distribution of effluent, and the mound. Figure 2 illustrates the system.

The purpose of the septic tank is to remove settleable and floatable solids from wastewater. The septic tank also provides a place for degradation of some solids and holds nondegradable solids until they can be pumped out. The dosing tank follows the septic tank and contains a pump for pressure distribution of effluent to the mound. The mound's purpose is to infiltrate septic tank effluent, and along with the natural soil, treat the wastewater to acceptable standards to prevent groundwater contamination. The mound consists of layers of suitable sand and aggregate, a pressure distribution system of small diameter perforated pipe, and soil cover.

Siting

For any soil absorption system, the Ohio Household Sewage Disposal Rules require a minimum

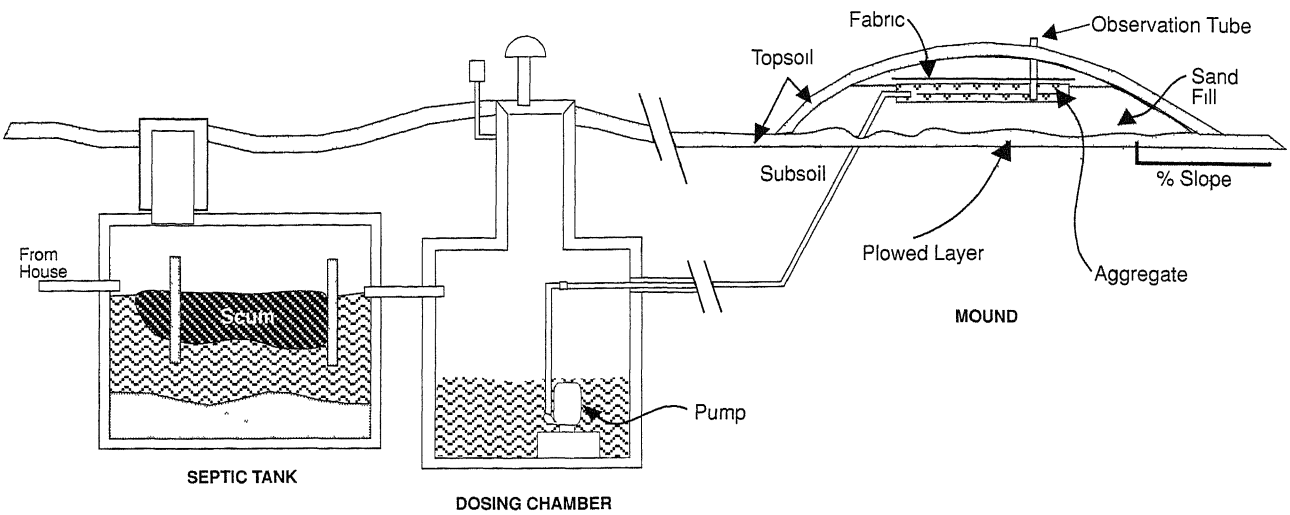


Figure 2 Schematic of the Mound System
(after Converse and Tyler 1990)

separation distance of 4 feet between the bottom of a wastewater distribution system and a limiting condition. This depth is considered necessary to treat wastewater to acceptable standards. Sufficient depth of suitable unsaturated soil exists in some areas of the state, allowing installation of a conventional soil absorption system. If the proposed site does not provide this depth naturally, suitable sand fill in a mound may make up the difference. Figure 1b is an illustration of site conditions where conventional soil absorption systems and mound systems could be used.

Before a mound system is designed, a site evaluation must be performed by a qualified soil scientist or sanitarian (soil evaluator). The most important information from a site evaluation will be an identification of limiting conditions at the site and a basic understanding of how wastewater will move away from the system.

Figure 3 shows a schematic of effluent movement within and away from mound systems for various soil profiles. Depending on limiting conditions in the profile, effluent moves away from the site vertically, horizontally, or a combination of both. Common limiting conditions are impermeable or slowly permeable subsoil layers, shallow depth to bedrock and seasonal high water table.

Figure 3a shows an impermeable layer beneath the mound. In this case effluent moves freely into the topsoil, but then moves horizontally away from the system upon reaching the impermeable layer.

In figure 3b effluent moves downward through the mound and into the surface horizon. Upon reaching a semipermeable soil layer, a portion of the effluent is diverted horizontally away while some effluent continues to infiltrate vertically.

Figure 3c shows effluent moving primarily downward towards and then into creviced or porous bedrock. Figure 3d illustrates effluent moving vertically to a mounded high water table, and then horizontally away within the water table.

Mound systems may be appropriate for all of these profiles, however, the situations illustrated in Figures 3a and 3d represent more restrictive sitings than those in Figures 3b and 3c. Whenever a significant portion of effluent movement away from the mound is horizontal, as in Figures 3a and 3d, the mound should be designed longer and narrower. This reduces the effluent loading rate per linear foot of the system and decreases chances of surface seepage.

The determination of mound dimensions will depend upon an understanding of effluent movement away from the mound. This includes both the direction of effluent movement and the rate of movement. Note that the configuration of any soil absorption system is based on these concepts. The information needed is obtained during the site evaluation. The soil evaluator should work with the designer and installers for best performance of the system.

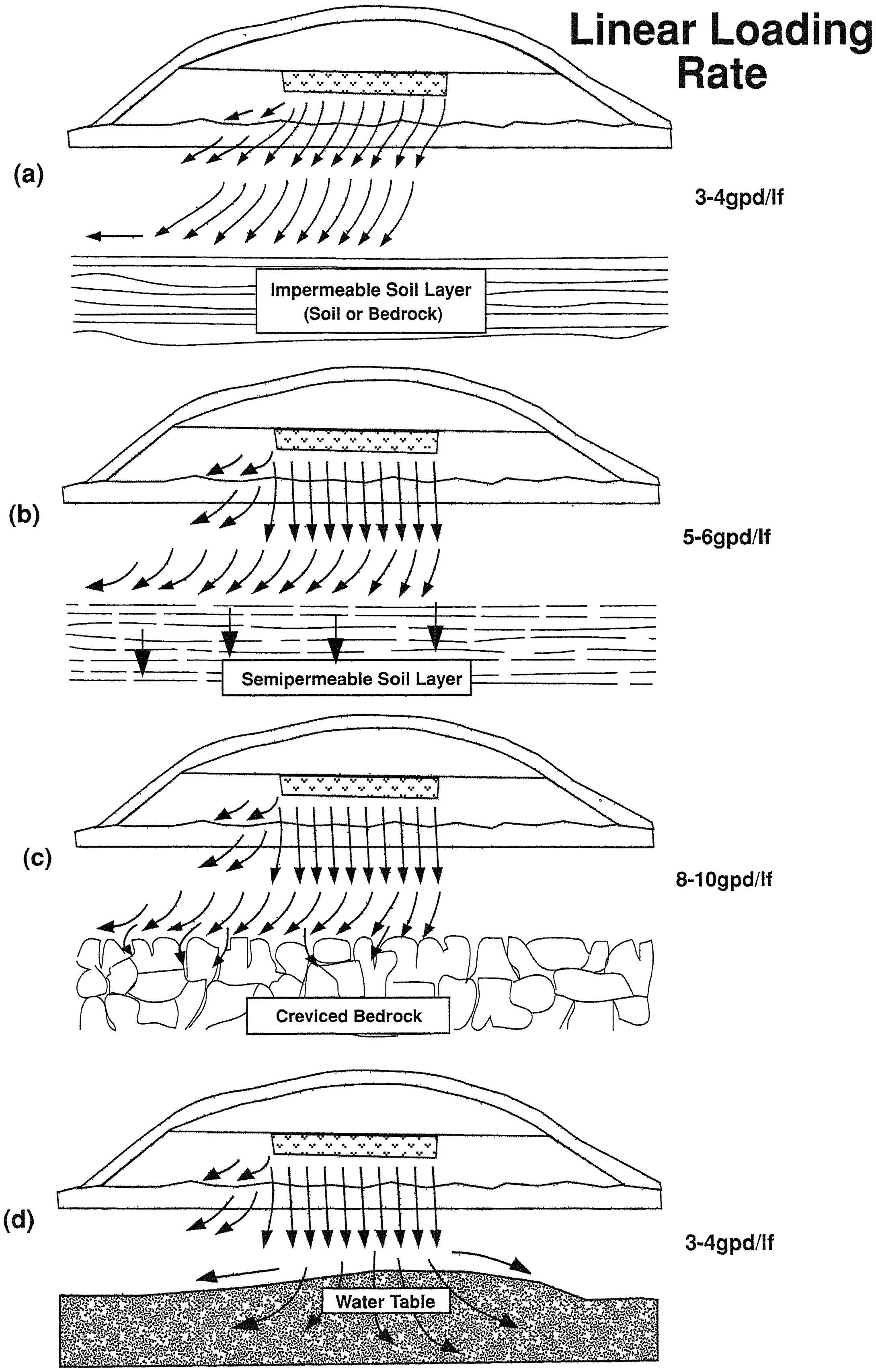


Figure 3 Effluent movement within and away from the Mound and four different types of soil profiles (after Converse and Tyler 1990)

Table 1. Recommended soil and site criteria for the Mound System in Ohio

Depth to Bedrock	minimum of 2 feet
Depth to Seasonal High Water Table	minimum of 2 feet
Permeability of Surface Horizon	moderately low
Site Slope	maximum of 15%

Specific recommendations for Ohio of soil and site limitations for the mound system are shown in Table 1. The restricting factors are: a) depth to bedrock; b) depth to seasonal high water table; c) soil permeability; and d) slope.

Depth to Bedrock

A minimum of two feet of natural soil depth is recommended for mound systems constructed over shallow bedrock. With this minimum depth of soil a mound system would also require at least a two-foot depth of sand fill. The Ohio Household Sewage Disposal Rules require 4 feet of separation distance between the bottom of a distribution system and the limiting condition. It is assumed that very little treatment occurs in the bedrock. If the bedrock is creviced as shown in Figure 3c, effluent movement will continue vertically downward away from the system. In a very slowly permeable or impermeable bedrock (Figure 3a), effluent movement will be principally horizontal once it reaches the bedrock. In semi-permeable bedrocks, such as sandstones, flow will be both vertical and horizontal (Figure 3b).

Depth to Seasonal High Water Table

The depth to a seasonal high water table should be at least two feet below ground surface at the proposed site. If a seasonal or permanent high water table exists at a depth shallower than this, the site is not recommended for a mound system. Depth to seasonal high water table is determined by direct observation of a test hole or small diameter observation well, or by interpretation of soil mottling.

Soil Permeability

One of the main steps in the design of a mound system is the determination of the basal loading rate. The basal area is the area of the sand/soil interface. The basal loading rate is really the design infiltration rate of the soil's surface horizon. It is dependent upon soil texture and structure. Table 2 gives a range of basal loading rates depending on soil morphological conditions. These soil conditions are determined on-site by digging a test hole.

The first four soil conditions shown in Table 2 are assigned a loading rate of 0.0 gallons/day/ft^2 since those soils are not suitable for construction of a mound system. A layer of gravelly coarse sand will not treat wastewater to acceptable standards, while a soil with cemented or massive structure will not infiltrate effluent at an acceptable rate.

Table 2. Estimated wastewater design basal loading rates for the surface horizon based on soil morphological conditions for Mound Systems. (after: Converse and Tyler. 1990.)

(Instructions: Read questions in sequence. Each refers to the soil condition of the surface horizon at the sand/soil interface. When the conditions of your soil match the question, use that loading rate and do not go further).

	If YES, the basal loading rate in gpd/ft^2 is:
A. Is the horizon gravelly coarse sand or coarser?	0.0
B. Is consistence stronger than firm or hard, or any cemented class?	0.0
C. Is texture sandy clay, clay or silty clay of high clay content and structure massive or weak, or silt loam and structure massive?	0.0
D. Is texture sandy clay loam, clay loam or silty clay loam and structure massive?	0.0
E. Is texture sandy clay, clay or silty clay of low clay content and structure moderate or strong?	0.2
F. Is texture sandy clay loam, clay loam or silty clay loam and structure weak?	0.2
G. Is texture sandy clay loam, clay loam or silty clay loam and structure moderate or strong?	0.4
H. Is texture sandy loam, loam, or silt loam and structure weak?	0.4
I. Is texture sandy loam, loam, or silt loam and structure moderate or strong?	0.6
J. Is texture fine sand, very fine sand, loamy fine sand, or loamy very fine sand?	0.6
K. Is texture coarse sand with single grain structure?	0.8

Slope

As with subsurface systems in Ohio, mounds can be placed on sites with slopes up to 15%. Mound systems must be constructed carefully along the contour to maintain consistent mound height and to ensure even distribution of effluent. On steep slopes over slowly permeable soils, mounds should be longer and narrower. This reduces the possibility of seepage at the toe or downslope side of the mound. On steeper slopes, construction safety is a concern. It is difficult to operate equipment on steep slopes and installers should be warned about construction hazards.

Separating distances as outlined in the Ohio Household Sewage Disposal Rules (Sections 3701-29-01 to 21) must be regarded as for any subsurface disposal system. The most important separation distance is from a well as shown in Figure 4. On level sites, separation distances are measured from the outside edges of the mound at the original soil surface. On sloping sites the upslope and end distances should be measured from the upslope edge or ends of the aggregate layer to the respective features. The downslope separation distance should be measured from the downslope toe of the mound to the respective features. On sloping sites with primarily horizontal flow away from the mound, a greater downslope separation distance might be considered to avoid seepage into a ditch or basement that may be located downslope.

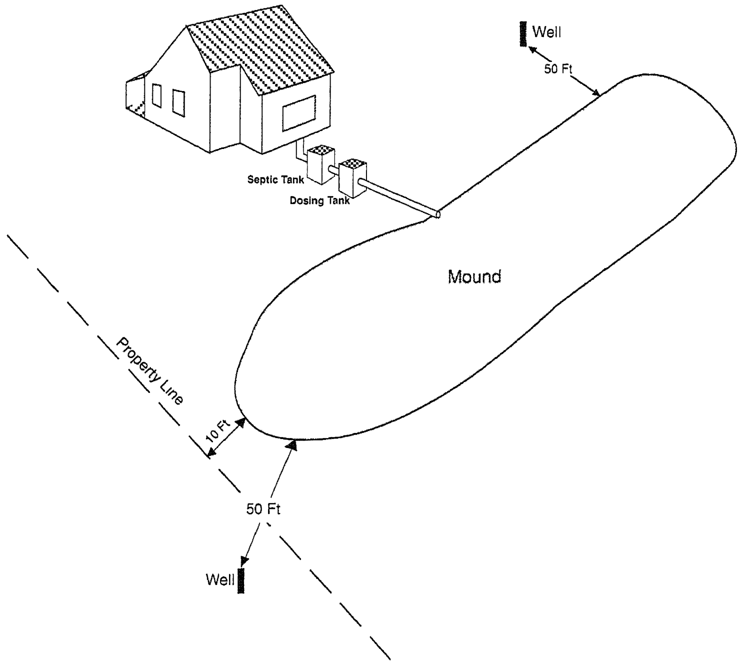


Figure 4. Separating distances for the siting of subsurface wastewater disposal systems, including the Mound System.

Mound Design

As with any soil absorption system, a mound system must be sized and configured to match the soil and site conditions and the volume and quality of wastewater applied to it. A designer needs to understand the mound operating principles and how effluent will move away from the system. Thus it is imperative that the designer has sufficient information about soil and site features, especially limiting conditions, and the quantity and quality of effluent that will be applied. The mound should be sized to accept the daily wastewater flow without causing surface seepage. Further, the basal area of the mound, which is the area of the sand fill/natural soil interface, must be sufficiently large to conduct the effluent into the natural soil.

The design of the mound system involves estimating the:

(1) daily wastewater load;

(2) sand fill loading rate;

(3) soil (or basal area) loading rate; and

(4) linear loading rate.

Once these are determined the mound can be sized for the site. Figures 5 and 6 show the cross section and plan layout of mound systems for sloping and level sites, respectively, and the dimensions that must be determined. The final steps are the design of the effluent distribution network and a pumping system.

Daily Wastewater Load

For design of residential soil absorption systems, daily wastewater volume is often based on the number of bedrooms in a house. The Ohio Household Sewage Disposal Rules recommend a design wastewater volume of 120 gallons/day/bedroom. This value includes a factor of safety in that it is an estimate based on home size, which is fixed, and not on number of people in a home, which may change. It assumes that there will never be more than two people per bedroom, for which

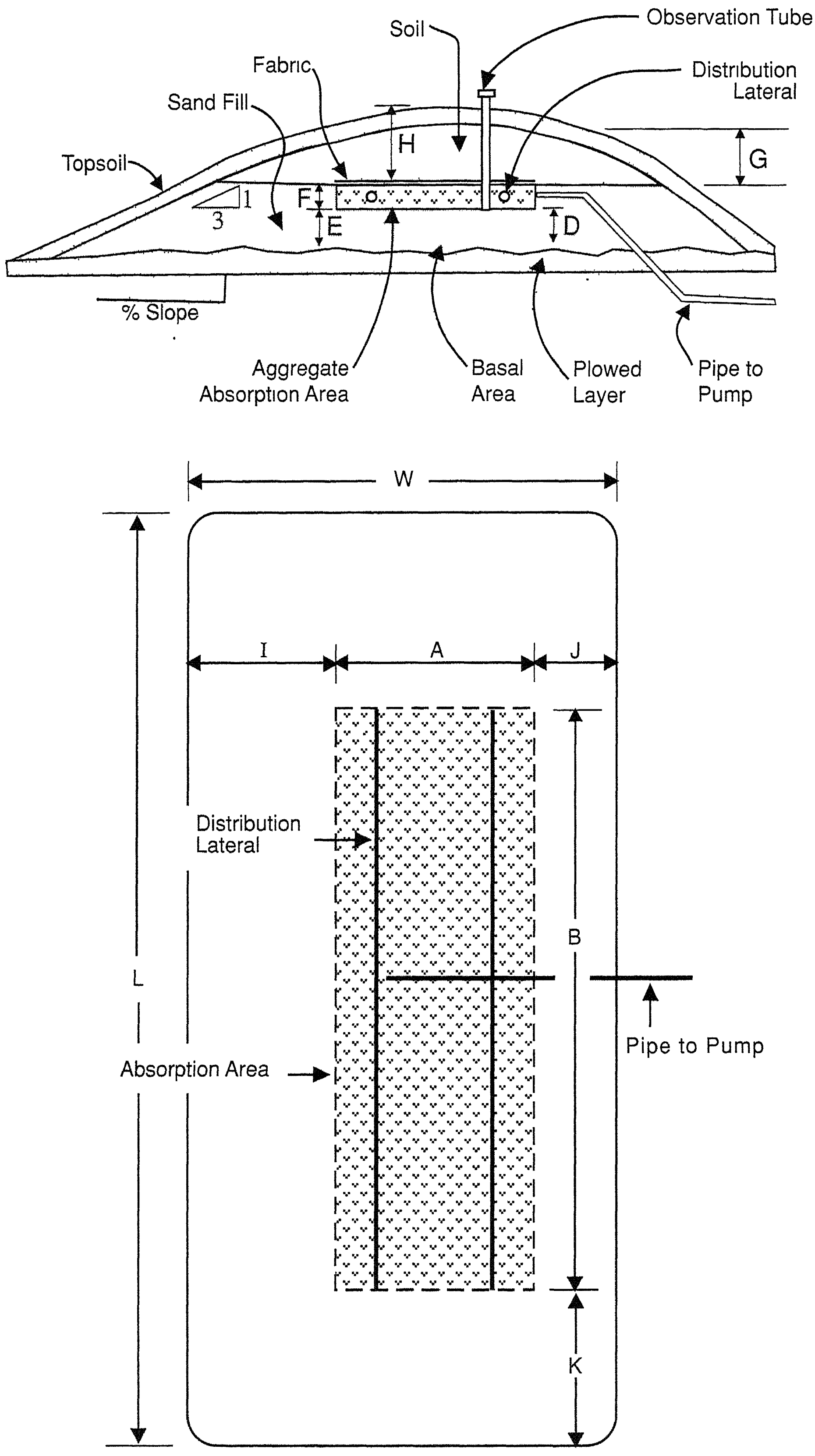
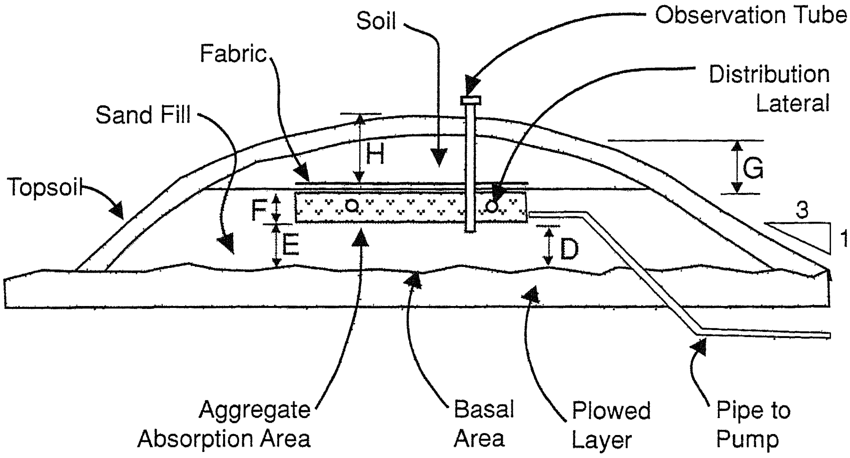


Figure 5 Cross section and plan view of a Mound System on a sloping site
(after Converse and Tyler 1990)



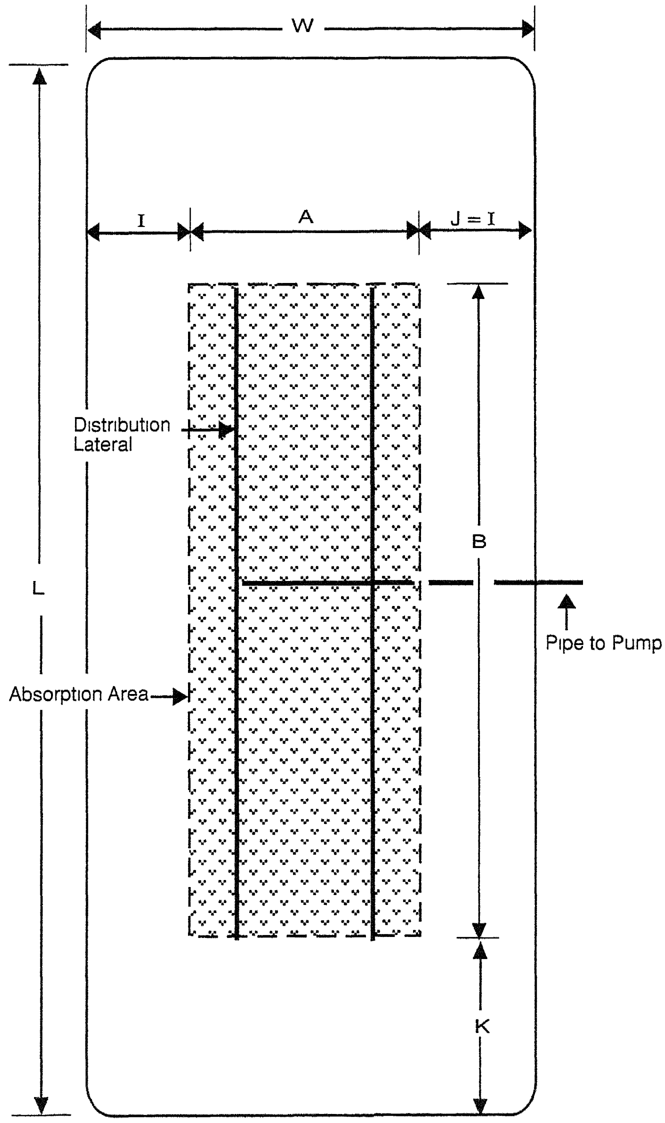


Figure 6 Cross section and plan view of a Mound System on a level site
(after Converse and Tyler 1990)

120 gallons/day/bedroom is a safe estimate. It should be noted that this estimate is for residential septic tank effluent.

Sand Fill Loading Rate

The selection of sand fill material is critical to good performance of the mound system. The purpose of the sand fill is to accept effluent from the absorption area of the mound and partially treat the wastewater before infiltration into the natural soil. A suitable sand is one that can be loaded at a reasonable rate and will provide satisfactory treatment. Generally, the finer the sand the better the treatment and the slower the wastewater infiltration into the absorption bed. Too coarse a sand will allow effluent to pass through the mound with little removal of impurities. Too fine a sand cannot be loaded at an acceptable rate and may cause severe clogging of the sand, and thus failure of the mound.

Following the USDA system of classification, a *coarse* sand is suitable. However, this is subject to the following two conditions: that no more than 20% by weight is gravel (>2mm), and that no more than 5% by weight is silt and clay (<0.053mm). It should be noted that some sands may be classified as coarse sand by the USDA system and not meet these two conditions. Therefore, it is important to perform a sieve analysis on a proposed sand to check these criteria. *Concrete sand* is produced by many sand and gravel quarries in Ohio and generally meets the criteria for the very coarse and very fine fractions. However, any concrete sand that is considered for use should be checked to meet these guidelines. Although *mason sand* is also commonly available, it is a finer sand than concrete sand and not recommended.

Sand specifications are sometimes given in terms of effective size and uniformity coefficient. When using these criteria, select a sand with an effective size in or very near the range of 0.15-0.30 mm, and with a uniformity coefficient in or very near the range of 4-6.

When using a sand that meets the guidelines above, the recommended design sand fill loading rate is 1.0 gpd/ft² if the wastewater is typical domestic septic tank effluent. If the effluent is from a commercial establishment, the wastewater quality should be evaluated and the sand fill loading rate adjusted. When treating higher strength wastewater, the sand fill loading rate should be reduced.

Basal Loading Rate

The basal area is the area of the sand fill/natural soil interface. The soil at the base on the mound accepts the effluent from the fill, assist the fill in treating the effluent, and transfers the effluent to the subsoil beneath the mound or laterally to the subsoil outside of the mound. The basal area is the area enclosed by B*(A+I) for sloping sites from Figure 5, and B*(A+I+J) for level sites from Figure 6 (note J=I for level sites). It is sized according to the long-term infiltration rate at the sand/soil interface. Basal loading rates are given in Table 2 and depend on soil texture and structure. These values assume a clogging mat will form at the sand/soil interface. However, the interface receives relatively clean effluent since wastewater has already infiltrated through the sand fill, and so a clogging mat usually does not develop there. Thus the basal area is oversized and a factor of safety is included. Additional oversizing usually results because the distance required to maintain a 3:1 mound side slope is greater than that required for the infiltration basal width, except for perhaps over very slowly permeable soils or on very steep sites. A sideslope of no steeper than 3:1 is recommended for safety if grass planted on the mound is to be mowed.

A check of the basal area required is made by dividing the daily wastewater volume by the design basal loading rate and comparing it to the basal area available from mound design. For a level site, the entire mound-natural soil interface is the basal area available for infiltration. For a sloping site, only the area beneath and downslope of the absorption bed should be considered.

Linear Loading Rate

The linear loading rate is defined as the amount of effluent (gallons) applied per day per linear foot of the system (gpd/lf). The linear loading rate is a function of the direction and rate of effluent flow away from the mound system. If the movement is primarily vertical (Figure 3c), the linear loading rate is not as critical as when the flow is primarily horizontal (Figures 3a and 3d).

Recommended linear loading rates are shown in Figure 3 according to the soil profile. In Figure 3c, effluent flow is primarily vertical in creviced bedrock and the recommended linear loading rate is 8-10 gpd/lf. This loading rate represents the upper limit for keeping a reasonable width of the absorption area (aggregate/sand interface). The recommended maximum width of the absorption area is 10 feet. These systems are the smallest ones overall.

In figures 3a and 3d effluent flow is primarily vertical to the limiting condition, and then primarily horizontal upon reaching it. This is because effluent cannot infiltrate an impermeable layer or move vertically into a water table without also moving horizontally away. Linear loading rates for these situations should be in the range of 3-4 gpd/lf. These mound systems are the largest and are long and narrow.

Figure 3b represents an intermediate condition since some effluent continues to move vertically upon reaching the semipermeable soil layer while the rest moves away horizontally. The recommended linear loading rate is 5-6 gpd/lf for this situation. In general, the more that effluent flow becomes horizontal, the lower the recommended linear loading rate.

Dimensioning the Mound

Figures 5 and 6 show the cross section and plan view of the mound for sloping and level sites. The dimensions of a mound system are based on wastewater load, sand fill loading rate, basal area loading rate, and linear loading rate. Following is a brief description of each mound dimension that must be determined. The design example afterwards illustrates how calculations are performed.

Absorption Area (A*B): The absorption area is the part of the mound that accepts septic tank effluent from the distribution network. This area will enclose the effluent piping in a layer of coarse aggregate (1/2"–2" diameter) as shown in Figures 5 and 6. It is critical during construction to make certain that the aggregate-sand fill interface is level. Even loading of the sand fill will not occur otherwise.

The recommended configuration of the absorption area is a rectangular bed.

Absorption Area Width (A): The width of the absorption area is a function of the linear loading rate and the design loading rate of the sand fill selected.

Absorption Area Length (B): The length of the absorption area is a function of the design wastewater loading rate (gpd), the sand fill loading rate (gpd/ft^2), and the width of the absorption area (A).

Basal Length and Width: For sloping and level sites, the basal width is (A+I) and (A+I+J), respectively, and the basal length is (B). The width is determined by the linear loading rate and the infiltration rate for the surface soil horizon (sand/soil interface).

Slope Width (I) and (J): For sloping sites, the downslope width (I) is a function of the basal width (A+I) and the absorption area width (A). Upslope width (J) is a function of the 3:1 recommended side slope and is dependent upon the depth of the mound and the slope of the site. A typical dimension for (J) is 8 to 10 feet but can be greater or lesser depending on the desired mound side slope and the slope of the site. For level sites, the slope widths (J) and (I) are equal and are a function of the required basal width or the minimum recommended mound side slopes, whichever is greater.

End Slope Length (K): The end slope length (K) is a function of the mound depth and the desired mound end slope. The recommended end slope is 3:1 but can be greater. Steeper mound side slopes are not recommended as they can become a safety hazard if the mound is to be mowed. Typical dimensions are 10-15 feet.

Depth (D): This depth is a function of the suitable soil separation distance required by code and the depth of the limiting condition below the soil surface. The required separation distance from the absorption surface to the limiting condition, such as bedrock or high water table, is 4 feet in Ohio. If the limiting condition is, for example, 2 ft beneath the ground surface, then (D) must be a minimum of 2 ft.

Depth (E): This depth is a function of the site slope and the width of the absorption area (A) since the absorption area must be level.

Depth (F): This depth is at least 9 in. with a minimum of 6 in. of aggregate beneath the distribution pipes, approximately 2 in. for the distribution pipe and 1 in. of aggregate over the pipe.

Depth (G) and (H): The recommended depths for (G) and (H) are 12 in. and 18 in., respectively, to provide frost protection for the distribution system. The depth of (H) must be greater than the depth of (G) to promote runoff on the top of the mound.

The geometry of the mound's overall width and length can be calculated from dimensions determined so far, and a recommended side slope of no steeper than 3:1.

Distribution System

The design of a pressure distribution system to transfer wastewater to the mound involves a procedure of its own. Although a step-by-step design procedure is not described here, it is useful to understand several facts. For a fully developed design procedure of pressure distribution systems for soil absorption units the reader is referred to Otis (1981) or Converse and Tyler (1990). (References are listed on page 20.)

The main components of a pressure distribution system are a dosing tank and pump with controls, a force main from the dosing tank to the mound, and the small diameter piping within the mound that distributes septic tank effluent to the absorption area. The design of the system is an integrative process. The components selected depend upon the other components of the system. Generally, the design procedure is divided into two sections. The first part consists of sizing the distribution network that distributes the effluent within the aggregate. This part of the design consists of selecting lateral diameter and length, perforation size and spacing, and manifold diameter. An illustration of this portion of the system is shown in Figure 7. The second part of the design consists of sizing the force main, pump and dose chamber, and selecting the controls.

Small diameter pipe is recommended for the mound's pressure system. The 4 inch perforated pipe used in conventional soil absorption systems is not suitable for mound systems since it does not provide uniform distribution of effluent to the absorption area. Pipe size depends on absorption bed length and size and spacing of holes in the pipe. These values must be matched with the flow rate to the network. Up to three laterals are used in beds, with a maximum spacing of 3 feet. For small systems, such as for a three-bedroom residence, typical lateral diameters range from 1–3 inches depending upon lateral lengths, perforation diameter and perforation spacing. Figure 8 shows the relationships between these factors. Laterals are placed so that perforations are to the bottom.

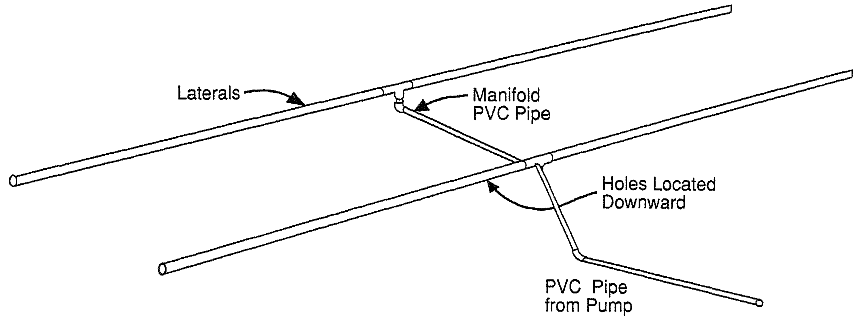


Figure 7. Manifold and laterals of the wastewater distribution network, to be located within the aggregate layer (also called the absorption bed).

Pumping System

The pumping system is housed in a watertight pumping or dosing chamber and the main compo-

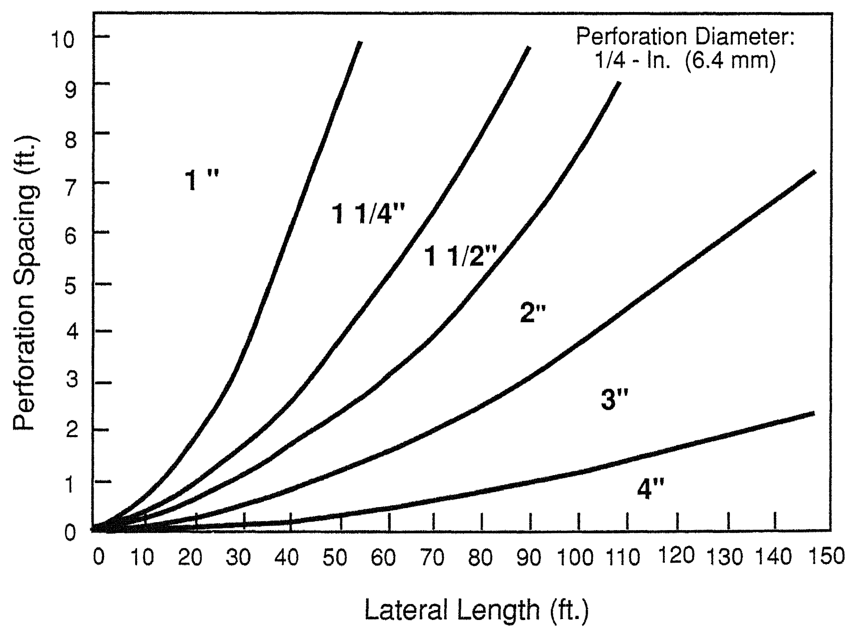


Figure 8. Minimum lateral diameter for PVC pipe versus perforation spacing and lateral length for 1/4" diameter perforations.
(after: Otis, 1981. Design of Pressure Distribution Networks for Septic Tank-Soil Absorption Systems. No. 9.6.)

nents of the system are shown in Figure 9. It is important to keep the electrical controls outside of the dosing chamber because of the corrosive environment. Centrifugal pumps are typically used for pressurizing distribution networks. Some models have been designed specifically for septic tank effluent and should be used. Clear water sump pumps will not last very long. The best way to select the pump is to first evaluate the system performance curve (head versus flow rate). Then, using pump performance curves, select the pump that best matches the required flow rate at the operating head. When selecting a pump and dosing chamber, choose a combination of these that gives the desired quantity of effluent per dose. This dose volume depends on the lateral pipe volume, which again illustrates the integrative design process. The recommended dose volume is roughly 5 to 10 times the lateral pipe volume to ensure even distribution of effluent throughout the piping during pumping. A design dosing frequency of four times per day is recommended for best treatment, though variations in water use make it impossible to maintain a given frequency.

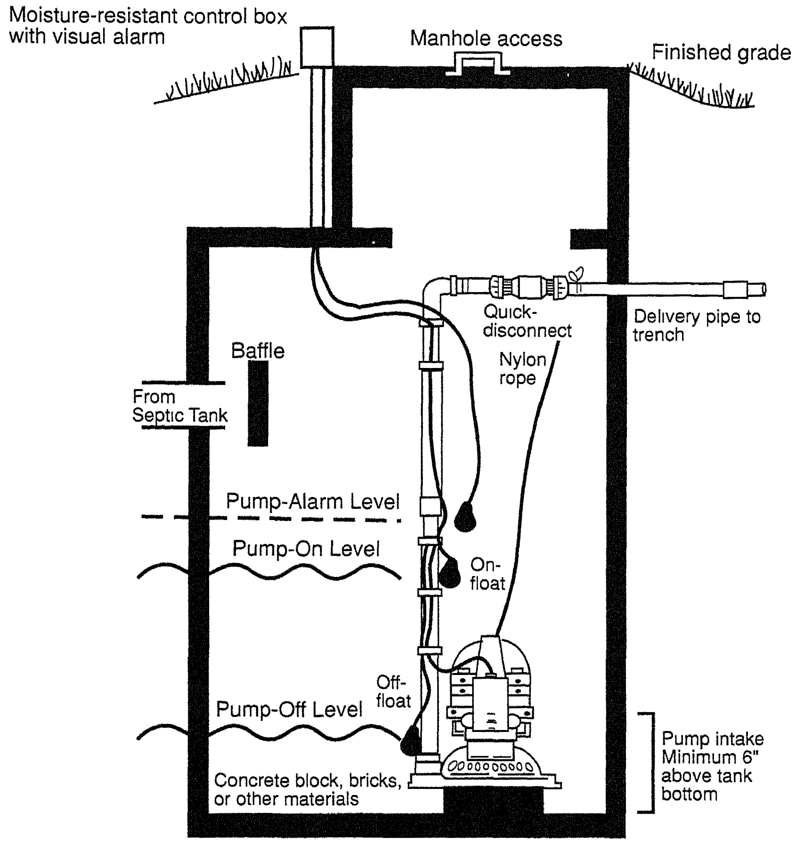


Figure 9. Cross section of a dosing tank with pump and automatic controls. (after: Makuch, Sharpe, and Jarret. 1984. Two Remedies for Failing Septic Systems EC 302. Penn State University, University Park.)

The dosing chamber must be large enough to provide:

a. The dose volume.

b. The average daily volume if a single pumping is used.

c. The dead space resulting from placement of the pump on a concrete block. This allows room for settleable solids carried over from the septic tank.

d. A few inches (at least 6 inches) of head space.

Quality controls and alarms should always be used in dosing chambers. Mercury control floats are superior to all other types of switches.

Observation Tubes

It is essential for all soil absorption systems to have observation tubes extending from the infiltrative surface (aggregate/sand interface) to or above the ground surface for the purpose of observing infiltration into the mound. The tubes provide an easy access to the absorption area to see if ponding is occurring. PVC piping of 4 inch diameter works well for observation tubes. Tubes should be placed at 1/6, 1/2 and 5/6 points along the length of the absorption area. All observation tubes must be securely anchored. Figure 10 illustrates three methods of anchoring the observation tubes. Slip or screw caps can be used on the tops. If brought to the surface, they should be recessed slightly to prevent lawn mowers from destroying the caps. If brought above ground surface, schedule 40 PVC pipe is recommended.

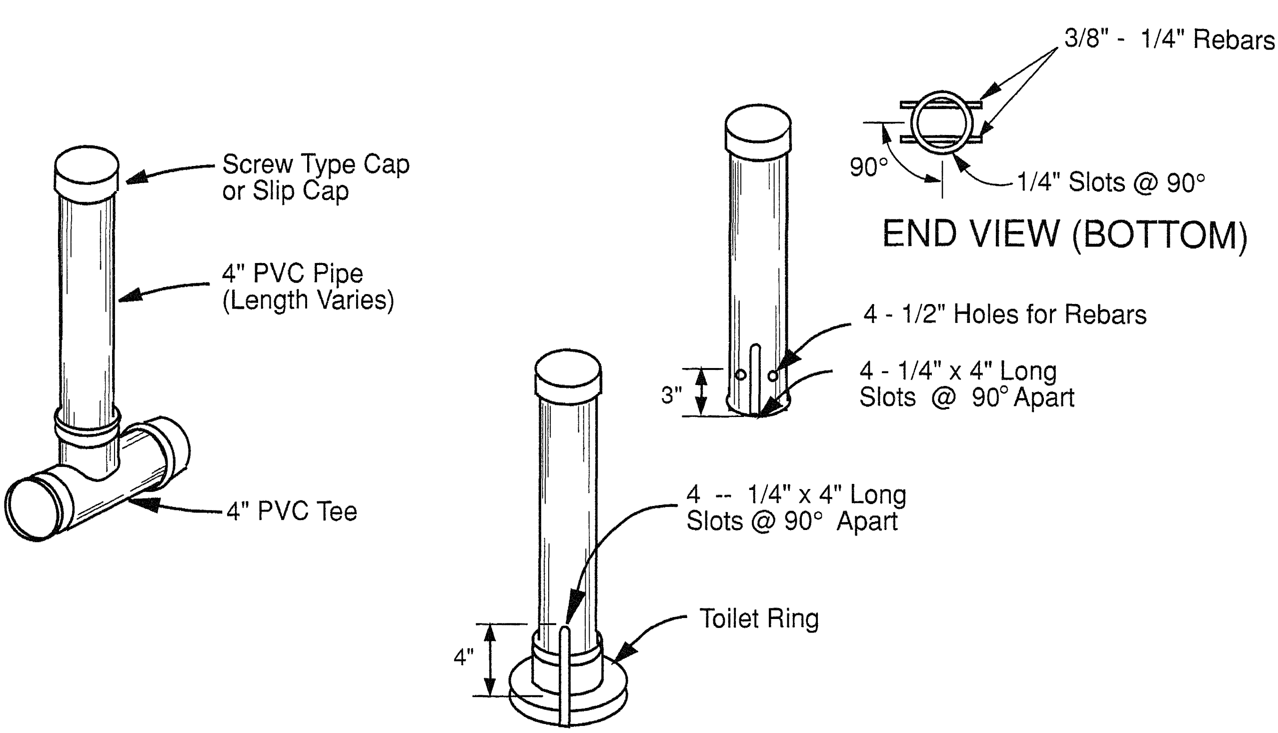


Figure 10. Three methods of stabilizing observation tubes.
(after: Converse and Tyler 1990.)

Construction

The mound system requires attention to proper construction techniques in order to perform optimally. A good design that is poorly constructed will result in weak performance and maybe failure. The most important thing to remember is to protect the downslope side of the mound during construction. Equipment traffic on the downslope side will compact the soil, which is serving as the treatment medium once wastewater leaves the mound. On sloping sites all construction should occur from the upslope side or the ends of the mound. On level sites construction should be done from the ends if possible, with minimum disturbance of the sides.

For a successful installation it is crucial to develop a clear understanding between the site evaluator, designer, contractor and inspector. All of these people should understand the principles of operation of the mound system, otherwise the system may not perform as intended. In Ohio, a household sewage disposal system can only be installed by a licensed installer holding a permit issued by the County Board of Health.

Construction should begin only when soil moisture conditions are satisfactory. If the soil is too wet, compaction and smearing may occur, resulting in lower infiltration capacity. An outlook on the upcoming weather is also advised. Once the basal area is tilled, it is important to place sand fill and the aggregate layer before any rainfall. During construction small track type tractors are recommended over wheeled tractors since they are more maneuverable and don't leave ruts in the fill material.

The following step-by-step procedure is tried and proven for mound system construction:

1. On a site that meets the criteria of Table 1, establish the contour of the lot and mound area. Stake out the mound so that the absorption bed runs parallel to the contour. Mounds must be on the contour to maintain constant mound height and to ensure even distribution of effluent. Use reference stakes in case corner stakes are disturbed.
2. Find the ground surface elevation at the upslope edge of the absorption bed, so the bed elevation can be deter-

mined. Determine the bottom elevation of the mound. This information will be used to determine the amount of fill needed.

3 Cut trees and remove vegetation from the site close to ground level. It is not necessary to remove stumps. However, if there are an excessive number of stumps or boulders, then the basal area should be enlarged or another site found.

4 Trench and lay the force main from pumping chamber to mound. The procedure is illustrated is Figure 11. Bring it into the center on the upslope side. If it must be brought in from the downslope side, it should be brought in perpendicular to the side of the mound with minimal disturbance to the downslope area. Cut and cap the pipe one foot beneath the ground surface and mark its location. Lay pipe below frost line or else sloping uniformly back to the pumping chamber so that it drains after dosing. Backfill and compact soil around pipe to prevent back seepage of effluent along pipe. This step must be done before plowing to avoid compacting and disturbance of surface.

5 Till the basal area of the mound to improve infiltration at the sand/soil interface. Be sure to check soil moisture several inches deep first. Plowing may be done with a moldboard or chisel plow and should always be done along the contour, never up and down slope. *Backhoe bucket teeth are not satisfactory and should not be used.*

6 Extend the effluent pipe to several feet above the ground surface.

7 Place the fill material, which has been properly selected, around the edge of the plowed area. Keep wheels of truck off plowed areas. Minimize traffic on the downslope side of mound. Work from the ends and upslope side.

8 Move the fill material into place with tractor's blade. Always keep a minimum of 6 inches of sand beneath tracks to prevent compaction of the natural soil. Place the fill material to the required depth at the top of the absorption bed. Shape sides to the desired slope.

9 Form the bed with the blade of the tractor. The bottom of the absorption bed should be hand-leveled and checked with a surveyor's level.

10 Place the coarse aggregate in the bed to a minimum depth of 6 inches and level. Place the distribution system on the aggregate, connecting to the pipe from dosing chamber Make sure the laterals are as level as possible. Place 2 inches more of aggregate over the distribution system. Soft limestone should not be used since it dissolves and flakes with time.

11 Place a layer of synthetic fabric, such as Typar, Mirafi or the equivalent over aggregate. The fabric prevents soil particles from migrating through the aggregate to the aggregate/sand interface.

12 Place soil on top of the bed to a depth of 1 foot in center and 6 inches at outer edge of bed This may be a subsoil or topsoil.

13 Place an additional 6 inches of good quality top soil over the entire mound surface. This will raise the elevation at the center of the mound to a minimum of 1.5 feet and the outside edges of bed 1 foot above top of absorption bed

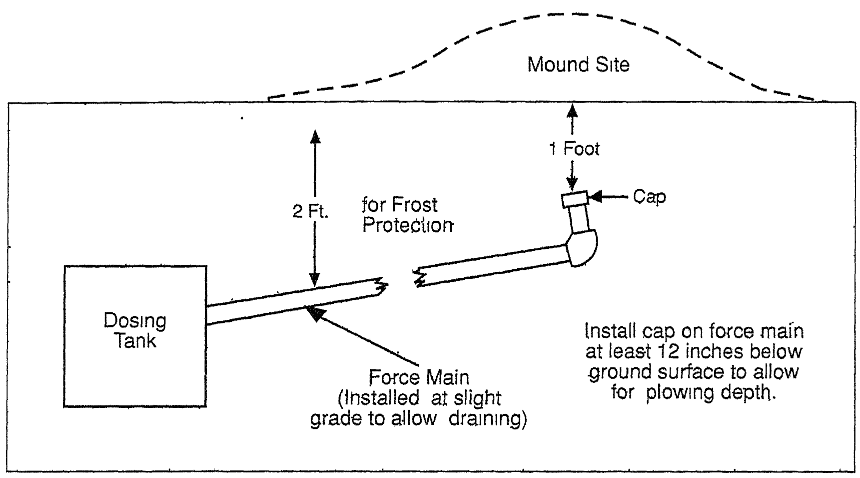


Figure 11. Installation of force main from dosing tank to mound area prior to mound construction.

Finally, grade the mound and area with light-weight equipment so that surface water moves away from the mound and does not accumulate on the upslope side of the mound.

14 Landscape the mound by planting grass, using the best vegetation adaptable to the area. A mixture of 90% birdsfoot treefoil and 10% timothy may be desirable if the mound is not manicured. If manicuring is desired, a combination of 60% bluegrass, 30% creeping red fescue and 10% annual rye grass may be used. Shrubs can be planted around the base and up the side-slopes. They should be somewhat moisture-tolerant since the toe of the mound may be moist during parts of the year.

Mound System Maintenance

Maintenance of the mound system involves pumping the septic tank and dosing tank about every three years to avoid carry-over of solids into the mound (see *Septic Tank Maintenance*, Ohio Cooperative Extension Service fact sheet AEX 740 for recommendation). When pumping the septic tank, inspect the condition of the baffles and any filters.

Warning: Never enter the septic tank or dosing tank without special equipment. They contain toxic gases and little or no oxygen. People have died in these tanks.

Other than pumping the tanks, the mound system will mostly take care of itself. However, the system should be monitored to ensure proper operation. Inspect controls of the dosing chamber. If the pump is running frequently, especially during wet weather, check to make sure the septic tank and pumping chamber are watertight.

Occasionally take a look in the observation tubes to see if there is standing effluent. If effluent stands in observation tubes after dosing, begin to investigate. Under seasonally saturated conditions there is the possibility of leakage from the toe of the mound for a few days. This effluent is usually very low in fecal bacteria and is not dangerous.

A mound can fail either at the 1) aggregate/sand interface due to a clogging mat or 2) at the sand/soil interface due to the inability of the soil to accept the effluent. For more information on the mechanisms that may cause failure and methods to rectify the problems, consult "Inspecting and Troubleshooting Wisconsin Mounds" by Converse and Tyler (1988).

A good water conservation plan within the house assures that the mound system will not be overloaded. Low-flow shower heads and faucet flow control aerators are easy to install. Also consider low-flow toilets and water saving washing machines when purchasing new or replacement fixtures and appliances. Avoid excess traffic in mound area, especially downslope. Winter traffic on mound should be avoided to minimize frost penetration.

Example Mound System Design

A soil absorption system is proposed for treatment and disposal of domestic wastewater from a three-bedroom residence. A visit to the site has yielded the soil and site information given below. Evaluate these conditions and design an appropriate soil absorption system for the site.

1. Soil Profile: summary of three soil pit evaluations:
   - 0-10 inches .... silt loam texture; strong, moderate, angular blocky structure; friable consistence
   - 10-26 inches .... sandy clay loam texture; moderate structure: friable consistence
   - 26-36 inches .... clay loam texture; moderate, fine platy structure; firm consistence
   - 36 inches .... shale bedrock
2. Site Slope is 12%
3. The area available is 160 ft along the contour and 50 ft along the slope. There are three medium-sized trees in the area.

Step 1. Evaluate the quantity and quality of wastewater generated.

The soil absorption system to be designed is for a residence. The system will include a septic tank for pretreatment, and unless there is reason to consider otherwise, the effluent quality will be typical of that from a domestic septic tank. The design daily wastewater volume, based on the Ohio Household Sewage Disposal Rules, is 120 gallons/bedroom/day. For a three-bedroom residence this is 360 gallons/day (gpd). This figure has a built-in factor of safety and includes peak flows. If the residence is already constructed and has a metered water supply, then a reasonable design daily wastewater volume would be 360 gpd or twice the *average* daily volume, whichever is larger.

Step 2. Evaluate the soil profile and site description for design linear loading rate and basal area loading rate.

A minimum of three soil evaluations should be done on the site. If great variability is evident among the three soil profiles, then more evaluations may be required. In evaluating this soil profile the following comments can be made:

- The silt loam horizon is relatively permeable because of its texture, structure and consistence. The effluent flow through this surface horizon should be primarily vertical.
- The sandy clay loam horizon will continue to accept effluent flow vertically for the same reasons as above, but perhaps at a slower rate due to the finer textured soil. A portion of effluent will flow horizontally at the textural change interface as it passes through this layer.
- The clay loam horizon has a platy structure and strong consistence. The consistence will slow effluent flow and the platy structure will impede vertical flow and cause the flow to move horizontally in the soil layer above. The flow through this soil profile will be similar to the profile shown in Figure 3b. Note that the structure and consistence of this clay loam layer has the greater effect in causing horizontal flow in the sandy clay layer above than the nature of the sandy clay layer itself.
- An impermeable bedrock is found at an average depth of 36 inches below ground surface. This represents the principal limiting condition of the site. At this point in the profile, effluent movement is horizontal, as represented in Figure 3a.

Since bedrock is reached at 36 inch depth, the site is not suitable for a conventional in-ground soil absorption system. The Ohio Household Sewage Disposal Rules requires a minimum separation distance of 4 feet between the bottom of the distribution network and the limiting condition. However, based on experience, a properly designed mound system should function on this site. It meets the minimum site recommendations found in Table 1.

Linear Loading Rate:

Based on this profile and the probable movement of effluent away from the mound, the linear loading rate must be in the range of 3 – 4 gpd/lf as limited by the bedrock layer (Figure 3a). Select Linear Loading Rate = 4 gpd/lf.

Basal Loading Rate:

A loading rate for the soil horizon in contact with the sand fill (basal area) is selected based on the surface horizon. Using Table 2 for silt loam soil with moderate structure, the design basal loading rate is found under item I. Select Basal Loading Rate = 0.6 gpd/ft^2.

Step 3. Select the Sand Fill Loading Rate.

The selection of suitable sand fill is critical to good performance of the mound. The recommendations earlier in this document under *Sand Fill Loading Rate* should be followed. For a sand that meets those guidelines, the Design Sand Fill Loading Rate is 1.0 gpd/ft^2. Only those sands are recommended.

Step 4. Determine the Absorption Area Width (A).

A = Linear Loading Rate / Sand Fill Loading Rate
= 4gpd/lf / 1.0 gpd/ft^2
= 4 ft

Step 5. Determine the Absorption Area Length (B).

For an illustration of this dimension and the ones following, refer to Figure 5 for a mound system constructed on a sloping site.

B = Design Wastewater Loading Rate / Linear Loading Rate
= 360 gpd / 4 gpd/lf
= 90 ft

Step 6. Determine the Basal Width (A+I).

The basal area required to absorb the effluent into the natural soil is based on the soil at the sand/soil interface and not on the lower horizons in the profile. From Step 2, the basal loading rate is 0.6 gpd/ft^2.

A + I = Linear Loading Rate / Basal Loading Rate
= 4 gpd/lf / 0.6 gpd/ft^2
= 6.7 ft

Since A = 4 ft, then I = 6.7 - 4 = 2.7 ft. However, (I) will actually be larger due to selected 3:1 mound side slope.

Step 7. Determine Mound Fill Depth (D).

The Ohio Household Sewage Disposal Rules require 4 feet (48 inches) of suitable soil for soil absorption systems. In this case, the silt loam and sandy clay loam layers are considered suitable. The clay loam soil is not suitable due to its platy structure. The soil profile indicates 26 inches of suitable soil, so:

D = 48 inches required depth - depth of suitable soil
D = 48 inches - 26 inches
= 22 inches

Step 8. Determine Mound Fill Depth (E).

The bottom of the absorption area must be constructed level. For a 12% slope:
E = Depth of sand at upslope edge + lot slope * bed width
E = D + 0.12 * A
= 22 inches + 0.12 * 48 inches
= 28 inches

Step 9. Determine Mound Depths (F), (G), and (H).

F = 9 inches (6 in. of aggregate below, 2 in. for pipe, and 1 in. aggregate above distribution system)
G = 12 inches
H = 18 inches

Step 10. Determine the Upslope Width (J).

Using the recommended mound side slope of 3:1, then:

J = 3 * (depth of sand at upslope edge of absorption bed
+ depth of aggregate + depth of soil cover)

J = 3 * (D + F + G)
= 3 * (22 inches + 9 inches + 12 inches)
= 129 inches
= 10.75 ft (However, the actual width will be less because of the site slope)

Step 11. Determine the End Slope Length (K).

Using the recommended mound end slope of 3:1, then:

K = end slope * (average depth of sand fill under absorption area
+ depth of aggregate + depth of soil cover at mound crest)

K = 3 * ((D + E)/2 + F + H)
= 3 * ((22 in. + 28 in.)/2 + 9 in. + 18 in.)
= 156 inches
= 13 ft

Step 12. Determine the Downslope Width (I).

Using the recommended mound side slope of 3:1, then:

I = side slope* (sand fill depth at downslope edge of absorption area + depth of aggregate + depth of soil cover)

I = 3 * (E + F + G)
= 3 * (28 in. + 9 in. + 12 in.)
= 147 inches
= 12.25 ft (Actual width may be greater because of the site slope)

Note that this value of (I) is greater than (I) calculated in Step 6, and is the recommended width to use.

Step 13. Overall Length and Width (L and W).

L = absorption bed length + 2 * end slope length

L = B + 2 * K
= 90 ft + 2 * 13 ft
= 116 ft

W = absorption bed width + downslope width + upslope width

W = A + I + J
= 4 ft + 12.25 ft + 10.75 ft
= 27 ft

The overall dimensions of this mound system (27 ft * 116 ft) fit within the proposed site area (50 ft * 160 ft). The trees at the site should be cut to ground level if the mound cannot be situated to avoid them.

Note that if this site was level, then (I) would equal (J). Also, for soil profiles allowing more vertical flow, the linear loading rate could approach 10 gpd/lf and the mound would be wider and shorter.

Step 14. Design a Pressure Distribution Network.

A pressure distribution network system must be designed, including the distribution piping, dosing chamber and pump. The reader is referred to Otis (1981) or Converse and Tyler (1990) for design procedure and examples.

References

Converse, James C., and E. Jerry Tyler. 1990. Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual. Small Scale Waste Management Project, 240 Agricultural Hall, University of Wisconsin-Madison, Madison, WI. 53706.

Converse, J.C., and E.J. Tyler. 1988. Inspecting and Troubleshooting Wisconsin Mounds. G3406. Agricultural Bulletin, Rm 245, 30 North Murray Street, Madison, WI. 53715.

Mancl, Karen M. 1988. Septic Tank Maintenance. Ohio Cooperative Extension Service, The Ohio State University. Agricultural Engineering Department, 590 Woody Hayes Drive, Columbus, OH. 43210.

Ohio Administrative Code, Household Sewage Disposal Rules, Chapter 3701-29-01 to 3701-29-21. Ohio Department of Health, July 1, 1977.

Otis, R.J. 1981. Design of Pressure Distribution Networks for Septic Tank-Soil Absorption Systems. No. 9.6.

Technical Manual for Sewage Enforcement Officers, Commonwealth of Pennsylvania, Department of Environmental Resources, 1983.

U.S. Environmental Protection Agency. 1980. Design Manual: Onsite Wastewater Treatment and Disposal Systems. Office of Water Program Operations, Washington, DC. 20460. Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH. 45268.