



GEORGIA DEPARTMENT OF PUBLIC HEALTH

# Manual for On-Site Sewage Management Systems

SECTION O | APPENDIX

Environmental Health Section

## SECTION O – APPENDIX

### 1) Appendix 1 - Pressure Distribution Network Design

Septic tank effluent or other pretreated effluent can be distributed in a soil treatment/dispersal unit either by trickle, dosing or uniform distribution. Trickle flow, known as gravity flow, occurs each time wastewater enters the system through 4" perforated pipe. The pipe does not distribute the effluent uniformly but concentrates it in several areas of the absorption unit. Dosing is defined as pumping or siphoning a large quantity of effluent into the 4" inch perforated pipe for distribution within the soil absorption area. It does not give uniform distribution but does spread the effluent over a larger area than does gravity flow. Uniform distribution, known as pressure distribution, distributes the effluent somewhat uniformly throughout the absorption area. This is accomplished by pressurizing relatively small diameter pipes containing small diameter perforations spaced uniformly throughout the network and matching a pump to the network.

This material has been extracted and modified from a paper entitled "Design of Pressure Distribution Networks for Septic Tank- Soil Absorption Systems" by Otis, 1981. It also includes material from the "Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems" by the State of Wisconsin, Department of Commerce, 1999.

The design procedure is divided into two sections. The first part consists of sizing the distribution network which distributes the effluent in the aggregate and consists of the laterals, perforations, and manifold. The second part consists of sizing the force main, pump, dose chamber, and suitable controls.

#### A. Design of the Distribution Network:

**Step 1: Configuration of the network.** The configuration and size of the absorption field must meet all soil and site criteria. Once any limitations have been established, the distribution network can be designed.

**Step 2: Determine the length of the laterals.** Lateral lengths are defined as the distance length from the manifold to the end of the lateral. For a center manifold it is approximately one half the length of the absorption area. For end manifolds it is approximately the length of the absorption area. The lateral should end about 6" to 12" from the end of the absorption bed.

**Step 3: Determine the perforation size, spacing, and position.** The size of the perforation or orifices, spacing of the orifices and the number of orifices must be matched with the flow rate to the network.

**Size:** The typical perforation diameter has been 1/4", but with the requirement of Class I effluent, carry-over particles have been greatly reduced allowing smaller diameter orifices

to be used. Orifices as small as 1/8" are commonly used in sand filter design, however orifice shields are generally used to protect the orifice from being compromised by the aggregate. Smaller diameter perforations are also at risk from burrs when drilling. Shop drilling the orifices under tight specifications reduces the concern. A sharp drill bit will drill a much more uniform orifice than a dull drill. Replace drills often. Remove all burrs and filing from pipe before assembling it. As a compromise, one might consider using 5/32" or 3/16" diameter orifices which will allow for more orifices than if 1/4" orifices were used.

**Spacing:** It is important to distribute the effluent as uniformly as possible over the system to increase effluent/soil contact time and maximize treatment efficiency. Typical spacing has been 30-36" but some designers have set spacing further apart to reduce pipe and pump sizes. Typical spacing for beds has been 6 ft<sup>2</sup>/orifice (J.C.Converse; 2000).

**Positioning:** In cold climates, it is essential that the laterals drain after each dose event to prevent freezing. Because of the longer laterals normally encountered in mounds, the orifices are typically placed downward for draining as it is much more difficult to slope the lateral toward the manifold/force main because of their greater length.

**Step 4: Determine the lateral pipe diameter.** Based on the selected perforation size and spacing, Figures A-1a through A-3b should be used to select the lateral diameter. Lateral diameter is also used to determine dose volume. (Table O.1.5).

**Step 5: Determine the number of perforations per lateral.**

Use:  $N = (p/x) + 0.5$       for center feed/center manifold  
 $N = (p/x) + 1$       for end fed/end manifold

Where:

N = number of perforations,

p = lateral length in feet and

x = perforation spacing in feet.

Round number off to the nearest whole number.

**Step 6: Determine the lateral discharge rate.** Based on the distal pressure selected, Table O.1.1 gives the perforation discharge rate. The designer must choose an operational pressure (in units of feet) at a distal point. This is the starting point of selecting a pump and determining if the system has equal distribution.

**Step 7: Determine the number of laterals and the spacing between laterals.** Since the criteria of 6 ft<sup>2</sup>/orifice is the guideline, the orifice spacing and laterals spacing are interrelated. For absorption area widths of 3 ft, one distribution pipe along the length of trench requires an orifice spacing of 2 ft. For a 6 ft wide absorption area with the same configuration it would require orifice spacing of 1 ft. or the system could utilize a manifold with several laterals and have better coverage. **Ideally, the best option is to position the**

perforations to serve a square such as a 2.5' by 2.5' area but that may be difficult to do but a 2' by 3' is much better than a 6' by 1' area.

**Step 8:** Calculate the manifold size and length. The manifold length is the length pipe between the outer laterals. For smaller systems assume the manifold size is the same as the force main diameter since the manifold is an extension of the force main. There are procedures for determining the manifold size for larger systems (Table O.1.2) from Otis, 1981.

**Step 9:** Determine the network discharge rate. This value is used to size the pump. Take the lateral discharge rate and multiply it by the number of laterals or take the perforation discharge rate and multiply it by the number of perforations.

## **B. Design and Selection of the Force Main, Pump, Dose Chamber and Controls.**

**Step 1:** Develop a system performance curve. The system performance curve predicts how the distribution system performs under various flow rates and heads. The flow rate is a function of the total head that the pump works against. As the head becomes larger, the flow rate decreases but the flow rate determines the network pressure and thus the relative uniformity of discharge throughout the distribution network. The best way to select the pump is to evaluate the system performance curve and the pump performance curve. Where the two curves cross, is the point where the system operates relative to flow rate and head.

The total dynamic head that the pump must work against is the:

1. System network head (1.3 x distal pressure)
2. Elevation difference between the pump and the highest point in the system.
3. Friction loss in the force main.

The system network head is the pressure maintained in the system during operation to assure relatively uniform flow through the orifices. The 1.3 multiplier relates to the friction loss in the manifold and laterals which assumes that the laterals and manifold are sized correctly.

The elevation difference is between the pump and the highest point in the system in feet (the pump industry uses the bottom of the pump tank).

The friction loss in the force main between the pump tank and the inlet to the network is determined by using Table O.1.3. Equivalent length for fittings should be included. Equivalent lengths are found in Table O.1.4.

**Step 2: Determine the force main diameter.** The force main diameter is determined from Table O.1.2. The number of laterals and/or length of manifold should not exceed these maximums.

**Step 3: Select the pressurization unit.** Using pump performance curves, select the pump that best matches the required flow rate at the operating head. Plot the pump performance curve on the system curve. Then determine if the pump will produce the flow rate at the required head. Do not undersize the pump. It can be oversized but will be costlier.

**Step 4: Determine the dose volume required.** The lateral pipe void volume determines the minimum dose volume. The recommended dose volume is 10 times the lateral volume. It is required that the system be timed dosed daily based on the design flow. Small doses need to be applied; however, sufficient volume is needed to distribute the effluent uniformly across the network. Table O.1.5 gives the void volume for various size pipes.

**Step 5: Size the dose tank.** For residential applications, the dose tank must be large enough to provide for:

- a. The dose volume.
- b. The dead space resulting from placement of the pump on a concrete block.
- c. A few inches of head space for floats
- d. 24 hour reserve capacity based on 150 gallons per bedroom.

The pump tank must have sufficient surge capacity to allow for timed dosing. See Section E of the manual for additional information and requirements for dosing other applications.

**Step 6: Select controls and alarms.** Select quality controls and alarms. Follow electrical code for electrical connections.

### **Design Example 1 - Pressure Distribution Network for Bed and Mound Applications**

This example will follow these steps to design a pressure distribution network for a bed system. All requirements found in Section F; *Absorption Field Methods and Guidelines for Class I Effluent* of the manual must be followed.

The bed absorption area is 452 ft<sup>2</sup> (113 ft long by 4 ft wide). The force main is 125 ft long and the elevation difference is 9 ft with three 90° elbows. Central manifold distribution system will be used.

#### **A. Design of the distribution network.**

##### **1. Configuration of the network.**

This is a narrow absorption bed on a sloping site. ( $4' \times 113' = 452 \text{ ft}^2$ )

## 2. Determine the lateral length.

Use a center feed, the lateral length is:

$$\begin{aligned} \text{Lateral Length} &= (B / 2) - 0.5 \text{ ft} && \text{Where: B = bed absorption length.} \\ &= (113 / 2) - 0.5 \text{ ft} \\ &= \mathbf{56 \text{ ft}} \end{aligned}$$

## 3. Determine the perforation spacing and size.

### Perforation spacing:

It is recommended that each perforation covers a maximum area of  $6 \text{ ft}^2$ . The absorption area is 4 ft wide.

Two laterals on each side of the center.

$$\begin{aligned} \text{Spacing} &= (\text{area/orifice} \times \text{no. of laterals}) / (\text{absorption area width}) \\ &= (6 \text{ ft}^2 \times 2) / (4 \text{ ft}) \\ &= \mathbf{3 \text{ ft.}} \end{aligned}$$

**Best option:** Ideally, the best option is to position the perforations to serve a square but that may be difficult to do. In this example, each perforation serves a 2' by 3' rectangular area. With an absorption area of 6 ft wide with one lateral down the center, perforation spacing would be 1 ft apart and the perforation would serve an area of 6 by 1 ft which would be undesirable.

### Perforation size:

Smaller diameter perforations may reduce system discharge flow rate, reduced pump requirements, at the same time increasing the number of orifices benefitting equal distribution through out the system. This example uses **3/16" perforations**.

## 4. Determine the lateral diameter.

Using **Fig. A-2a (3/16")** to determine the minimum lateral diameter:

The laterals on each side of the center manifold each has the length of 56 ft with 3 ft spacing between orifices, these point to a **lateral diameter of 1.5"**.

## 5. Determine number of perforations per lateral and number of perforations.

Using 3.0 ft spacing in 56 ft a lateral yields 19 perforations each:

$$N = (p/x) + 0.5 = (56 / 3.0) + 0.5 = 19 \text{ perforations/lateral}$$

$$\text{Number of perforations} = 4 \text{ lateral} \times 19 \text{ perforations/lateral} = 76$$

**Check** - Maximum of 6 ft<sup>2</sup>/ perforation =

$$\text{Number of perforations} = 412 \text{ sqft}/6 \text{ ft}^2 = 75; (76 > 75, \text{ is okay})$$

### **6. Determine lateral discharge rate (LDR).**

Using network pressure (distal) pressure of 3.5 ft and 3/16" diameter perforations, Table O.1.1 gives a discharge rate of 0.78 gpm, regardless of the number of laterals.

$$\text{LDR} = 0.78 \text{ gpm/perforation} \times 19 \text{ perforations} = \mathbf{14.8 \text{ gpm/lateral}}$$

### **7. Determine the number of laterals.**

This was determined in Step 3 and 4.

Two laterals on each side of center feed = **4 laterals spaced 2 ft apart.**

### **8. Calculate the manifold size.**

The force main diameter is determined from Table O.1.2 on the manual. The manifold is generally the same size as force main as it is an extension of the force main or it could be one size smaller. This example will use a **2" manifold.**

### **9. Determine network discharge rate (NDR)**

$$\text{NDR} = 4 \text{ laterals} \times 14.8 \text{ gpm/lateral} = 59.2 \text{ or } \mathbf{60 \text{ gpm}}$$

Pump has to discharge a minimum of 60 gpm against a total dynamic head yet to be determined.

### **10. Total dynamic head.**

Sum of the following:

$$\begin{aligned} \text{System head} &= 1.3 \times \text{distal head (ft)} \\ &= 1.3 \times 3.5 \text{ ft} \\ &= \mathbf{4.5 \text{ ft}} \end{aligned}$$

**Elevation head = 9.0 ft** (Pump shut off to network elevation)

**Head Loss in Force Main** = Tables O.1.4 and O.1.4 for 60 gallons and 125 ft of force main and 3 elbows.

Equivalent length of pipe for fittings can be found in Table O.1.3

3- 2" 90° elbows @ 9.0 ft each = **27 ft** of pipe equivalent.

Head Loss through 100' of PVC pipe can be found in Table O.1.2

125' of 2" force main plus the head loss in the fittings equals

$$= 7.0 (125 \text{ ft} + 27 \text{ ft})/100 = \mathbf{10.6 \text{ ft}}$$

**Total Dynamic Head (TDH) = Sum of the three**

TDH = System head + Elevation head + Head Loss in Force Main

$$4.5 + 9 + 10.6 = 24.1 \text{ ft (2" force main)} = \mathbf{24 \text{ ft of head}}$$

## 11. Pump Summary

Pump must discharge **60 gpm** against a head of **24 ft** with 2" force main.

These are the calculated flow and head values. The actual flow and head will be determined by the pump selected. A system performance curve plotted against the pump performance curve will give a better estimate of the flow rate and total dynamic head the system will operate under.

## 12. Select the Pump

Using a performance curve from the pump manufacture, the point where the flow rate intersects (60 gpm) the total dynamic head (24 ft) should fall under the pump curve. A pump can be over sized, but undersized pumps will lead to failure in performance and/or longevity.

### 4. Determine the dose volume.

Determine the pipe void volume from Table O.1.5. Use 10 times the lateral void volume.

**Dose Volume = 10 x length of lateral x number of laterals x Void volume**

Lateral diameter =	1.5"
Lateral Length =	56'
No. of laterals =	4
Void volume =	0.092 gal/ft

$$10 \times 56 \times 4 \times 0.092 = \mathbf{206 \text{ gal./dose}}$$

## 5. Size the dose tank.

The pump tank size should be based on the dose volume, 24 hour storage volume, and room for a block beneath the pump and control space. This example is for a residential application, additional information on dosing requirements can be found in Section E of the manual.

## 6. Select controls and alarm.

**Time Dosing:** The advantage of time dosing provides more frequent doses and levels out peak flows to the bed.

### Design Example 2 - Pressure Distribution Network for Trench Applications

Design a pressure network for a trench absorption field consisting of five trenches, each 3 ft wide by 40 ft. long, and spaced 9 ft apart center to center.

**Step 1:** Select lateral length. Two layouts are suitable for this system: central manifold or end manifold (Table O.1.2). For a central manifold design, ten 20-ft laterals are used; for an end manifold design, five 40-ft laterals are required. The end manifold design is used in this example.

**Step 2:** Select hole diameter and hole spacing for laterals. For this example, ¼ in. diameter holes spaced every 30 in. are used, although other combinations could be used.

**Step 3:** Select lateral diameter. For ¼-in. hole diameter, 30-in. hole spacing, and 40-ft length, either a 1¼-in. diameter or 1½-in diameter lateral could be used. The 1½-in. diameter is selected for this example.

**Step 4:** Calculate lateral discharge rate. By maintaining higher pressures in the lateral, small variations in elevation along the length of the lateral and between laterals do not significantly affect the rates of discharge from each hole. This reduces construction costs but increases pump size. For this example, a 2-ft head is to be maintained in the lateral. For a ¼-in. hole at 2 ft. of head. Table O.1.6 shows the hole discharge rate to be 1.04 gpm.

40-ft lateral length with holes spaced 30 inches apart:

$$\begin{aligned} \text{Number of holes/lateral} &= 40 \text{ ft. lateral length} / 2.5 \text{ ft. hole spacing} \\ &= 16 \text{ holes} \\ \text{Lateral discharge rate} &= (16 \text{ holes/lateral}) \times (1.04 \text{ gpm/hole}) \\ &= 16.6 \text{ gpm/lateral} \end{aligned}$$

**Step 5:** Select manifold size. There are to be five laterals spaced 9ft apart. A manifold length of 36 ft is therefore required. For five laterals and 16.6 gpm/lateral, Table O.1.1 indicates that a 3-in. diameter manifold is required.

**Step 6:** Determine minimum dose volume (Table 23.O).

With:	lateral diameter	= 1½ in.
	lateral length	= 40 ft.
	number of laterals	= 5
Then:	pipe volume	= 3.7 gal
Minimum	dose volume	= approx. 200 gal.

The final dose volume may be larger than this minimum depending on the desired number of doses per day

**Step 7:** Determine minimum discharge rate.

Minimum discharge rate	= (5 laterals) x (16.6 gpm/lateral)
	= 83 gpm

See Figure 21.F for distribution network designed for a trench system.

**Step 8:** Select proper pump or siphon.

For a pump system, the total pumping head of the network must be calculated. This is equal to the elevation difference between the pump and the distribution lateral inverts, plus friction loss in the pipe that delivers the wastewater from the pump to the network at the required rate, plus the desired pressure to be maintained in the network (the velocity head is neglected). A pump is then selected that is able to discharge the minimum rate (83 gpm) at the calculated pumping head.

For a siphon system, the siphon discharge must be elevated above the lateral inverts at a distance equal to the friction losses and velocity head in the pipe that delivers the wastewater from the siphon to the network at the required rate, plus the desired pressure to be maintained in the network.

For this example, assume the dosing tank is located 25 ft from the network inlet, and the difference in elevation between the pump and the inverts of the distribution laterals is 5 feet.

➤ Pump Option Calculation (assume 3-in. diameter delivery pipe):

Friction loss in 3-in. pipe at 83 gpm (from Table O.1.7)	= 1.38 + 3/10 (1.73 - 1.38)
	= 1.49 ft/100ft
Friction loss in 25ft	= 1.49 ft/100 ft x 25ft
	= 0.4ft
Elevation Head	= 5.0ft
Pressure to maintain	= 2.0ft.
Total pumping head	= 7.4 ft

Therefore, a pump capable of delivering at least 83 gpm against 7.4 feet of head is required. This information is found in pump curves.

➤ Siphon Option Calculation (assume 4-in. Diameter delivery pipe)

$$\begin{aligned} \text{Friction loss in 4-in pipe at 83 gpm (from Table O.1.7):} \\ &= 0.37 + 3/10 (0.46 - 0.37) \\ &= 0.4\text{ft}/100 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Friction loss in 25ft} &= (0.4 \text{ ft}/100 \text{ ft}) \times (25 \text{ ft}) \\ &= 0.10 \text{ ft} \end{aligned}$$

Velocity head in delivery pipe:

$$\text{Discharge rate} \quad (@ 83 \text{ gpm}) = 0.185 \text{ ft}^3/\text{sec}$$

$$\text{Area} = (\frac{1}{4})\pi (4/12)^2 = 0.087 \text{ ft}^2$$

$$\text{Velocity} = 0.185 \text{ ft}^3/\text{sec} = 2.13\text{ft}/\text{sec}$$

$$\begin{aligned} \text{Velocity Head} &= \frac{(\text{Velocity})^2}{2g} \\ &= \frac{(2.13 \text{ ft}/\text{sec})^2}{2 (32.3 \text{ ft}/\text{sec})} \\ &= 0.07 \text{ ft} \end{aligned}$$

$$\text{Pressure to maintain} = 2.0 \text{ ft.}$$

$$\text{Total} = 2.2 \text{ ft}$$

Minimum elevation of the siphon discharge invert above the lateral inverts must be 2.2 ft.

In summary, the final network design consists of five 40-ft laterals 1½-in. in diameter connected with a 36-ft end manifold 3-in. in diameter, with the inlet from the dosing tank at one end of the manifold. The inverts of the laterals are perforated with ¼-in. holes spaced every 30 in.

## CONSTRUCTION AND MAINTENANCE

Good common sense should prevail when constructing and maintaining these systems. Water tight construction practices must be employed for all tanks. Surface runoff must be diverted away from the system. Any settling around the tanks must be filled with the soil brought to grade or slightly above to divert surface waters.

**Table O.1.1 Perforation Discharge Rates (GPM)**

Distal Pressure (ft)	Perforation Diameter (in)					
	1/8	5/32	3/16	1/4	5/16	3/8
	-----GPM-----					
1.0	0.18	0.29	0.41	0.74	1.15	1.66
1.5	0.23	0.35	0.50	0.90	1.41	2.03
2.0	0.26	0.41	0.58	1.04	1.63	2.34
2.5	0.29	0.45	0.66	1.17	1.82	2.62
3.0	0.32	0.50	0.72	1.28	1.99	2.87
3.5	0.34	0.54	0.78	1.38	2.15	3.10
4.0	0.37	0.57	0.83	1.47	2.30	3.32
4.5	0.39	0.61	0.88	1.56	2.44	3.52
5.0	0.41	0.64	0.93	1.65	2.57	3.71

Values were calculated as:  $gpm = (11.79 \times d^2 \times \sqrt{h})$   
 Where: d = orifice dia. in inches and h = head feet.

**Table O.1.2 Maximum Manifold Length (ft) For Various Manifold Diameters Given the Lateral Discharge Rate and Lateral Spacing (from: Otis, 1981)**

Lateral Discharge Rate End Manifold / Center Manifold	Manifold Diameter = 1¼"	Manifold Diameter = 1½"	Manifold Diameter = 2"	Manifold Diameter = 3"	Manifold Diameter = 4"	Manifold Diameter = 5"				
	Lateral Spacing (ft)					Lateral Spacing (ft)				
	2 4 6 8 10	2 4 6 8 10	2 4 6 8 10	2 4 6 8 10	2 4 6 8 10	2 4 6 8 10	2 4 6 8 10			
10 / 5	4 8 6 8 10	10 8 12 16 20	12 16 24 24 30	26 40 48 56 70	42 64 84 96 110	84 134 174 200 240				
20 / 10	4 4 6	4 4 6 8 10	6 8 12 16 20	16 24 30 32 40	26 40 54 64 70	54 84 106 128 150				
30 / 15	2	2 4 6	4 8 6 8 10	12 16 24 24 30	20 26 36 48 60	42 64 84 96 110				
40 / 20			4 4 6 8 10	10 12 18 16 20	16 24 30 32 40	34 52 66 80 90				
50 / 25			2 4 6 8	8 12 12 16 20	14 20 24 32 40	30 44 60 72 80				
60 / 30			2 4	8 12 18 16 20	12 16 24 24 30	26 40 48 64 70				
70 / 35			2	6 8 12 8 10	10 16 18 24 30	24 36 48 56 60				
80 / 40			2	6 8 6 8 10	10 12 18 16 20	22 32 42 46 60				
90 / 45			2	4 8 6 8 10	8 12 18 16 20	20 28 42 46 50				
100 / 50				4 4 6 8 10	8 12 12 16 20	18 28 36 40 50				
110 / 55				4 4 6 8 10	8 12 12 16 20	16 24 36 40 40				
120 / 60				4 4 6 8 10	6 8 12 16 10	16 24 30 32 40				
130 / 65				4 4 6 8 10	6 8 12 16 10	14 24 30 32 40				
140 / 70				2 4 6 8	6 8 12 8 10	14 20 24 32 40				
150 / 75				2 4 6	6 8 12 8 10	14 20 24 32 30				
160 / 80				2 4 6	6 8 6 8 10	12 20 24 32 30				
170 / 85				2 4 6	4 8 6 8 10	12 20 24 24 30				
180 / 90				2 4	4 8 6 8 10	12 16 24 24 30				
190 / 95				2 4	4 8 6 8 10	12 16 18 24 30				
200 / 100				2 4	4 4 6 8 10	10 16 18 24 30				

**Table O.1.3 Friction Loss in Schedule 40 Plastic Pipe**  
(ft/100 ft), Based on Hazan-Williams; C = 150

Flow (GPM)	Pipe Diameter (Inches)								
	1"	1 ¼"	1 ½"	2"	3"	4"	6"	8"	10"
1	0.07								
2	0.28	0.07							
3	0.60	0.16	0.07						
4	1.01	0.25	0.12						
5	1.52	0.39	0.18						
6	2.14	0.55	0.25	0.07			Velocities in this area are below 2 ft/sec.		
7	2.89	0.76	0.36	0.10					
8	3.63	0.97	0.46	0.14					
9	4.57	1.21	0.58	0.17					
10	5.50	1.46	0.70	0.21					
11		1.77	0.84	0.25					
12		2.09	1.01	0.30					
13		2.42	1.17	0.35					
14		2.74	1.33	0.39					
15		3.06	1.45	0.44	0.07				
16		3.49	1.65	0.50	0.08				
17		3.93	1.86	0.56	0.09				
18		4.37	2.07	0.62	0.10				
19		4.81	2.28	0.68	0.11				
20		5.23	2.46	0.74	0.12				
25			3.75	1.10	0.16				
30			5.22	1.54	0.23				
35				2.05	0.30	0.07			
40				2.62	0.39	0.09			
45				3.27	0.48	0.12			
50				3.98	0.58	0.16			
60					0.81	0.21			
70					1.06	0.28			
80					1.38	0.37			
90					1.73	0.46			
100					2.09	0.55	0.07		
150						1.17	0.16		
200							0.28	0.07	
250							0.41	0.11	
300							0.58	0.16	
350							0.78	0.20	0.07
400							0.99	0.26	0.09
450							1.22	0.32	0.11
500								0.38	0.14
600								0.54	0.18
700								0.72	0.24
800									0.32
900									0.38
1000									0.46

**Table O.1.4 Friction losses through plastic fittings in terms of equivalent lengths of pipe**  
(Sump and Sewage Pump Manufacturers, 1998)

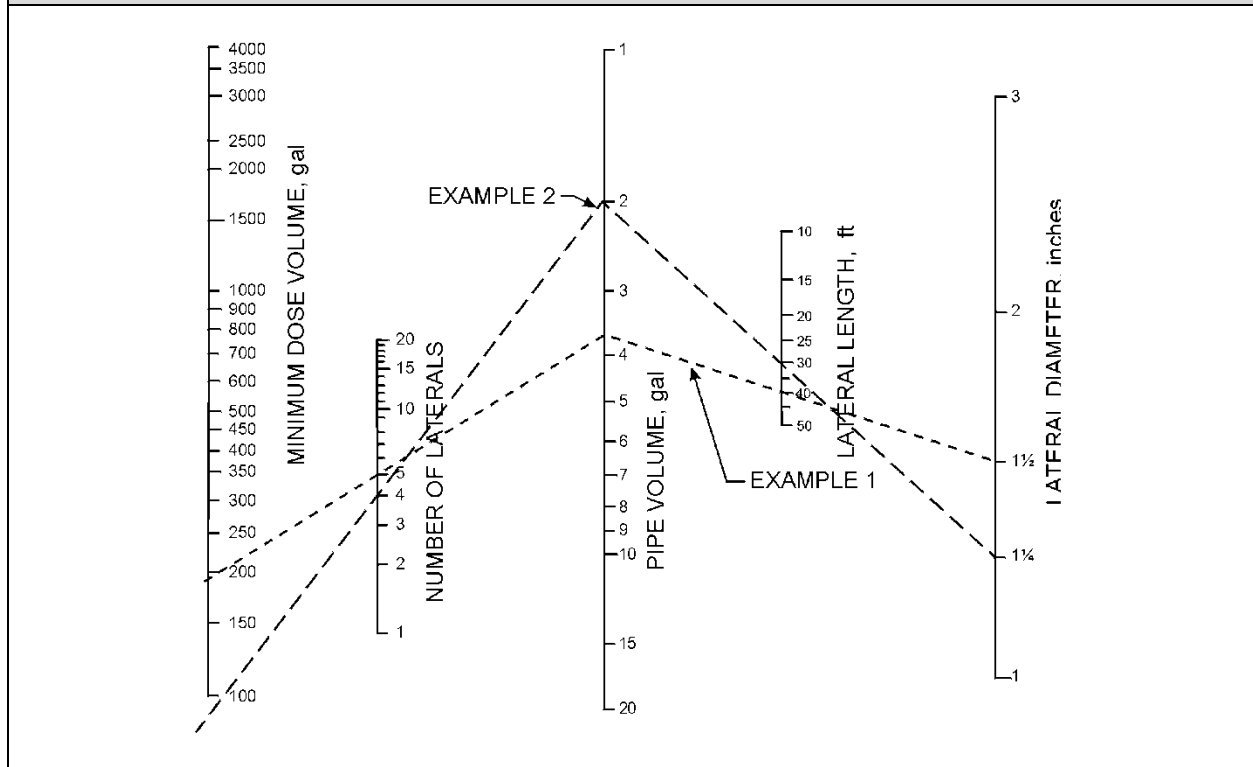
Type of Fitting	-----Nominal size fitting and pipe -----					
	1¼	1½	2	2½	3	4
90° Elbow	7.0	8.0	9.0	10.0	12.0	14.0
45° Elbow	3.0	3.0	4.0	4.0	6.0	8.0
STD. Tee (Diversion)	7.0	9.0	11.0	14.0	17.0	22.0
Check Valve Coupling/	11.0	13.0	17.0	21.0	26.0	33.0
Quick Disconnect	1.0	1.0	2.0	3.0	4.0	5.0
Gate Valve	0.9	1.1	1.4	1.7	2.0	2.3

**Table O.1.5 Void volume for various diameter pipes.**

Nominal Pipe Size (In.)	Void Volume (gal./ft)
¾	0.023
1	0.041
1¼	0.064
1½	0.092
2	0.163
3	0.367
4	0.650
6	1.469

**Table O.1.6      Nomograph for Determining the Minimum Dose Volume**

Nomograph for Determining the Minimum Dose Volume for a Given Lateral Length and Diameter, and Number of Laterals (See Section O-VII; for Additional Dose Calculations)





**Figures for Lateral Diameter Based on Orifice Spacing**  
**Fig. A-1a – A4b**

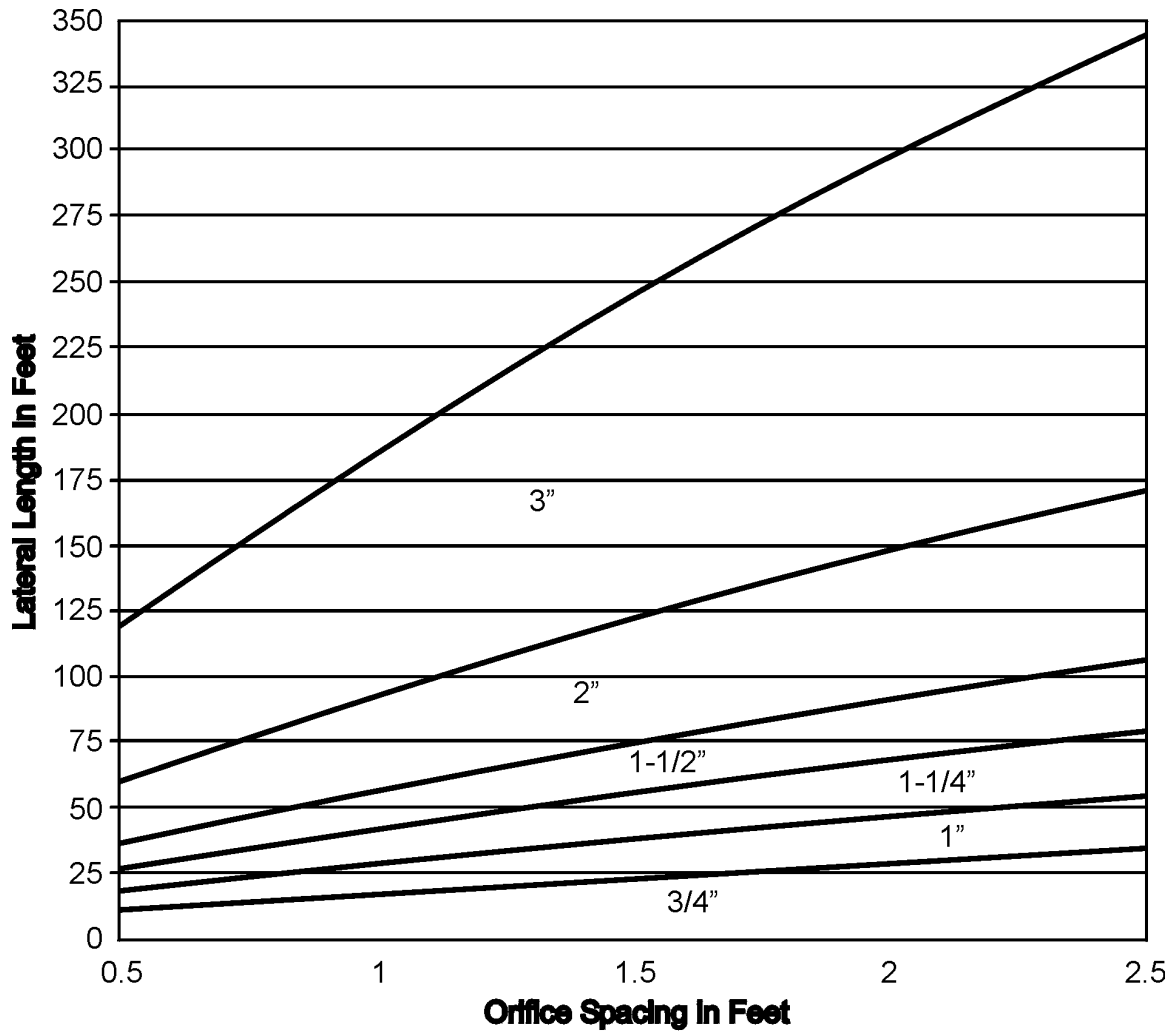


Fig. A-1a. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

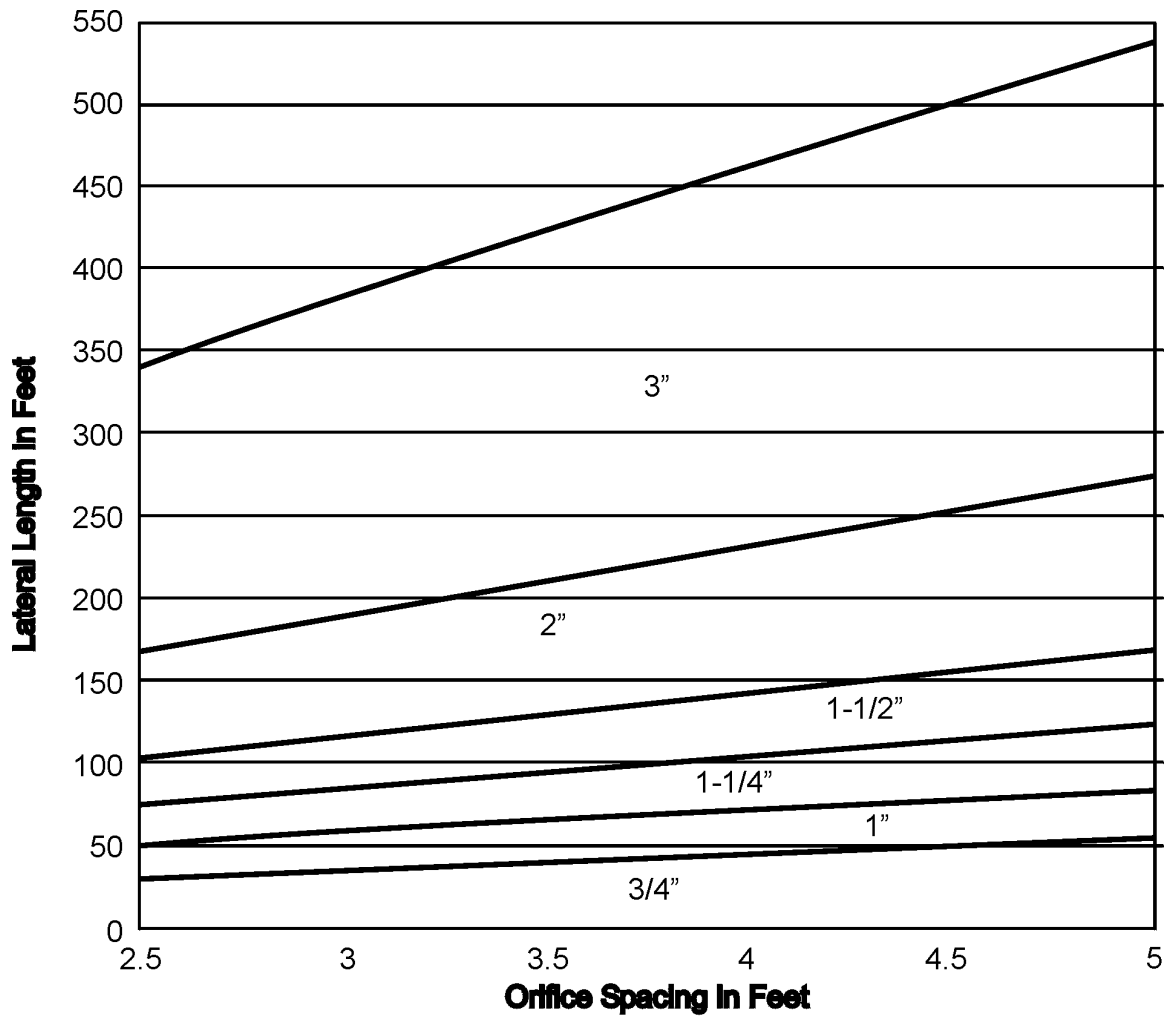


Fig. A-1b. Minimum lateral diameter based on orifice spacing for 1/8 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

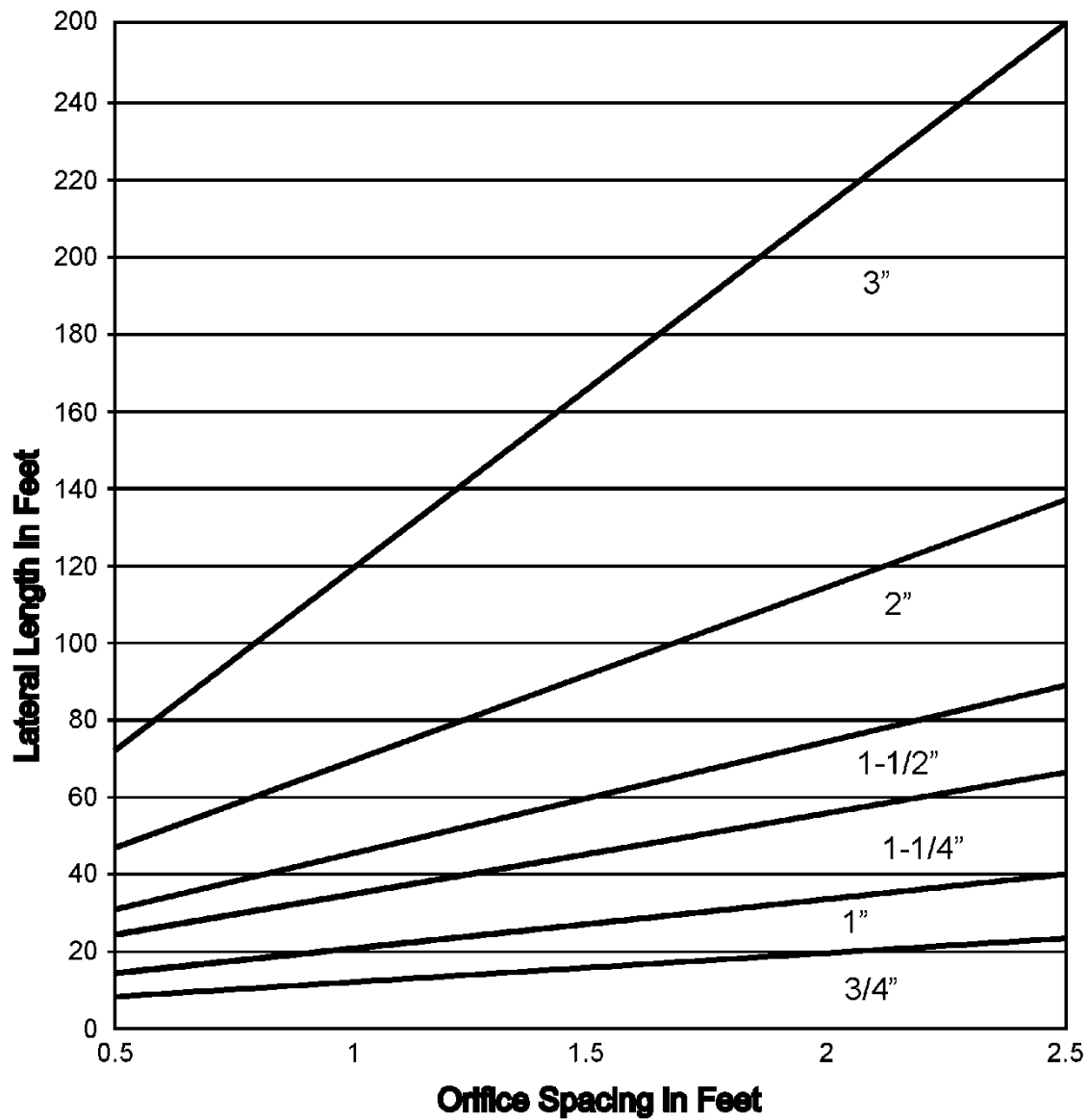


Fig. A-2a. Minimum lateral diameter based on orifice spacing for 5/32 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

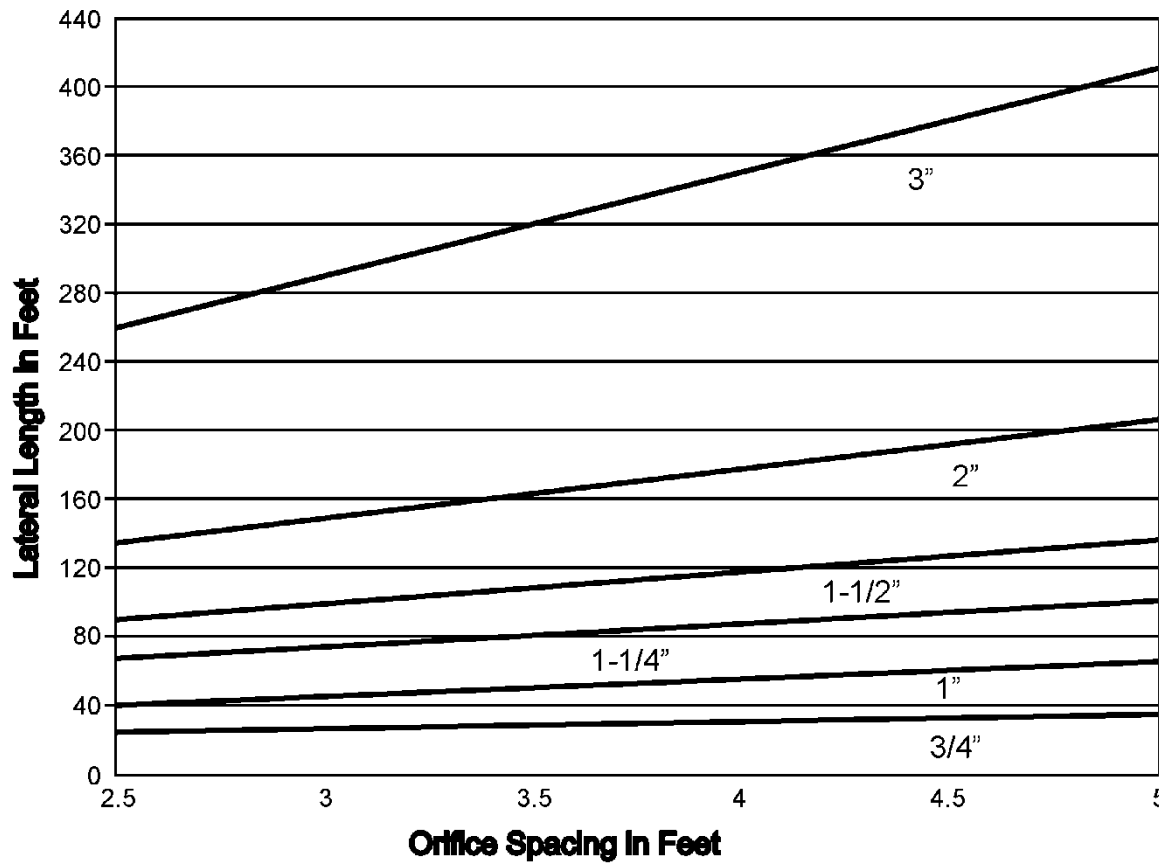


Fig. A-2b. Minimum lateral diameter based on orifice spacing for 5/32 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

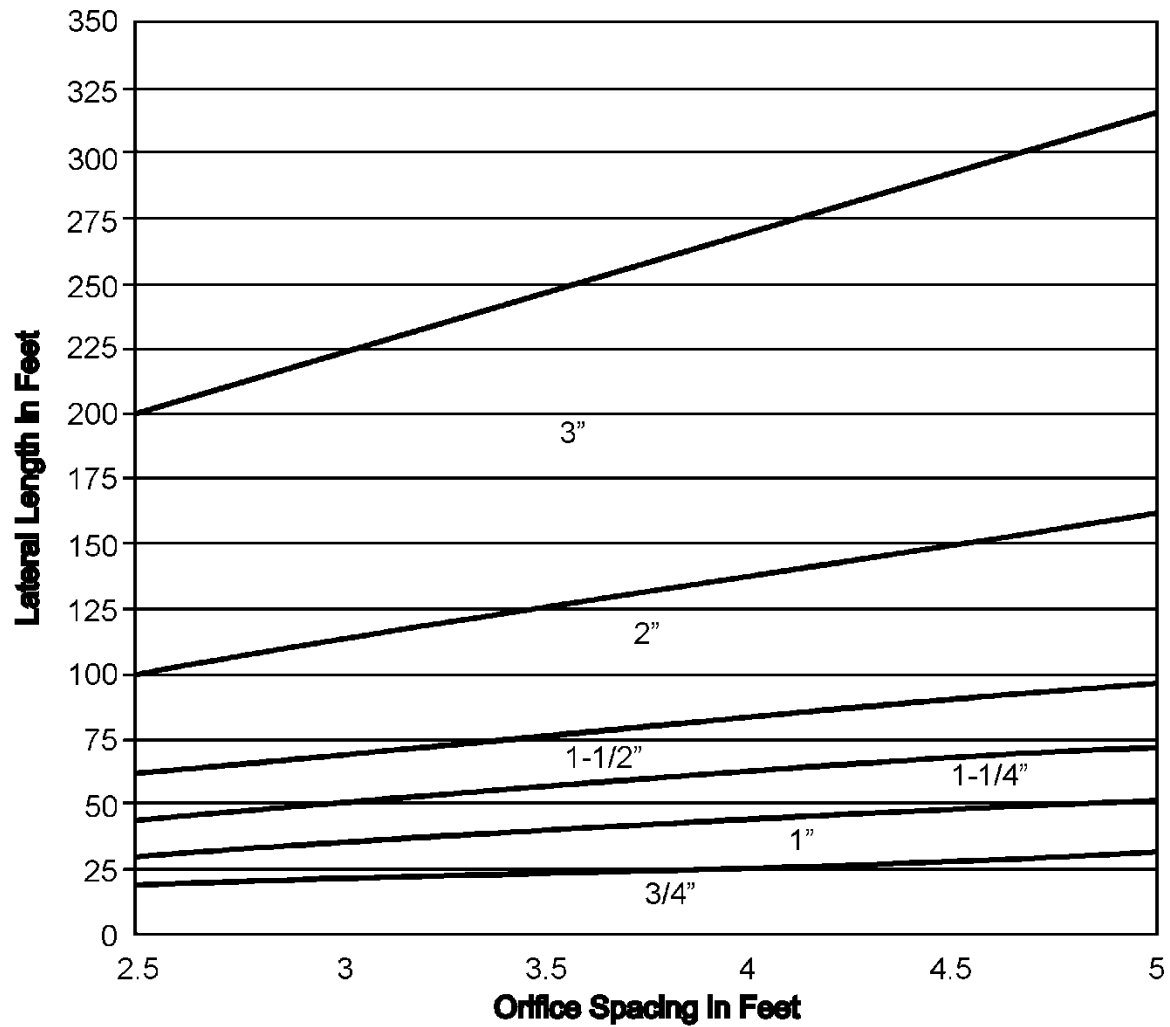


Fig. A-3a. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

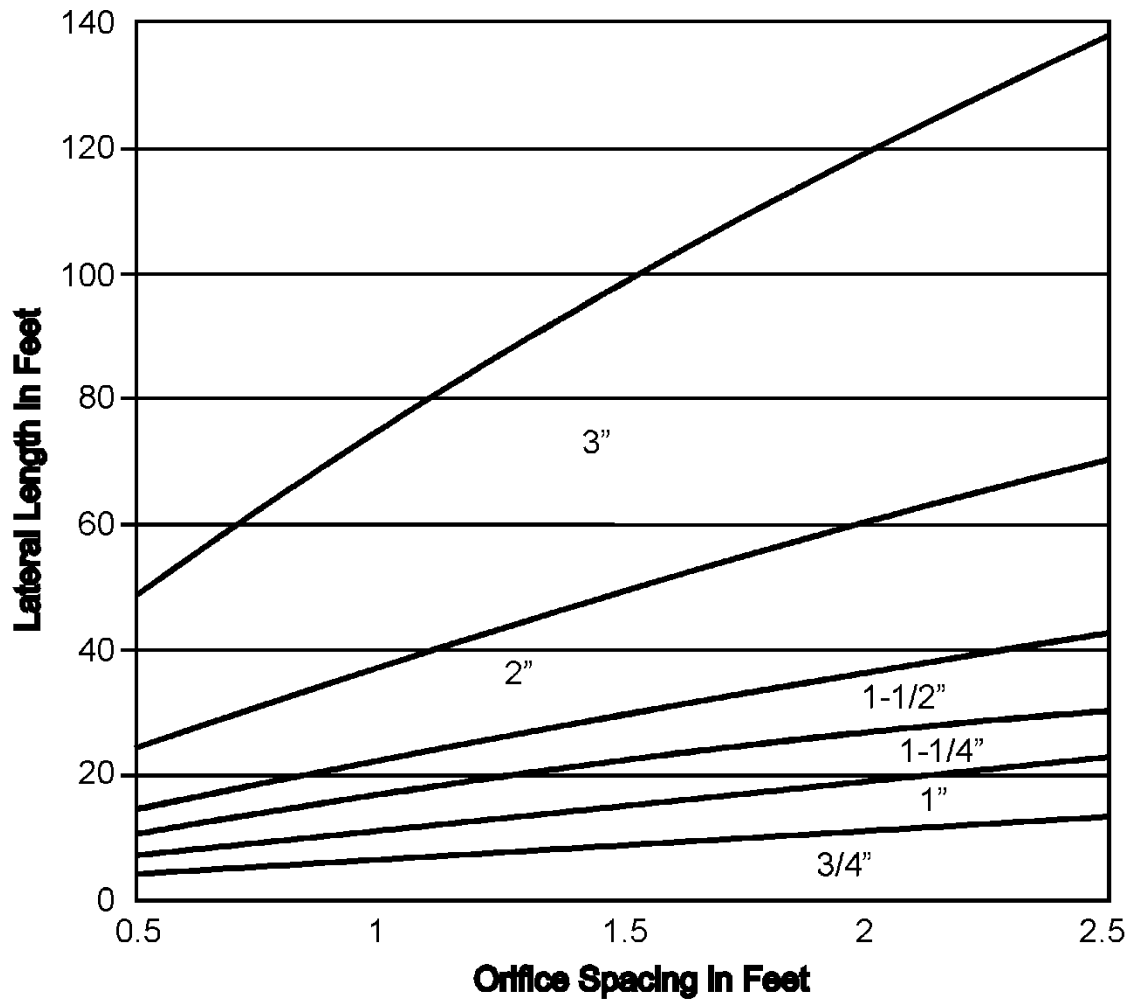


Fig. A-3b. Minimum lateral diameter based on orifice spacing for 3/16 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

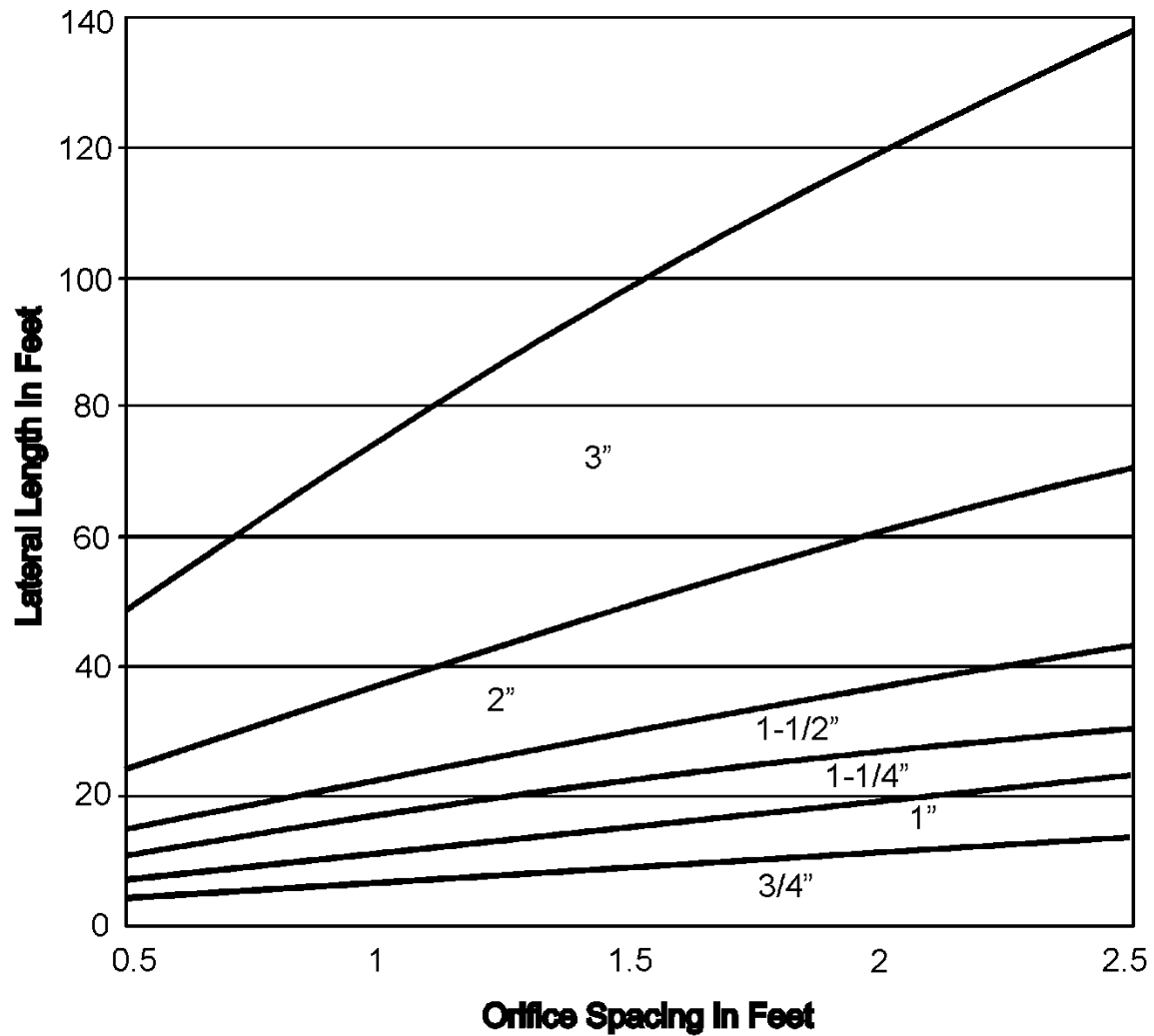


Fig. A-4a. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

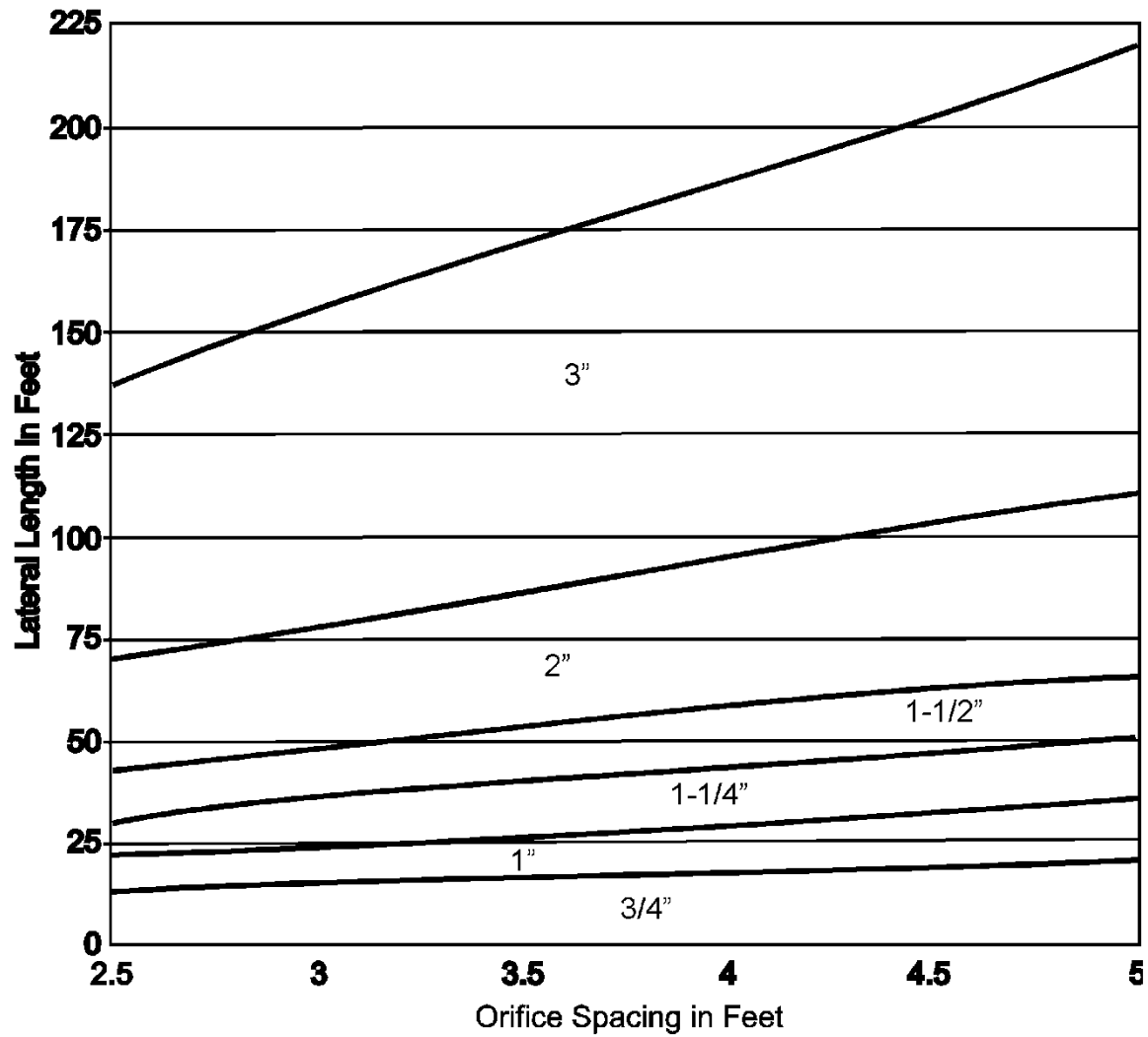


Fig. A-4b. Minimum lateral diameter based on orifice spacing for 1/4 in. diameter orifices (Wisc. Dept. Of Commerce, 1999)

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## SECTION O – APPENDIX 2

**2) Appendix 2 - Wisconsin Mound Design Example**

This example will follow steps to design a Wisconsin Mound. All requirements found in Section F, Absorption Field Methods, of the Manual must be followed.

*Design Example* – Evaluate the following soil profile and site conditions for a soil absorption system. Design an appropriate soil absorption system for the site.

Soil Profile - Summary of 3 soil pit evaluations.

0 - 6 in.	sil; 10YR 6/4 2/1; strong, moderate, angular blocky structure; friable consistence.
6 - 11 in.	sil; 10YR 5/3; moderate, fine platy structure; firm consistence.
11-20 in.	sic; 10YR6/3; moderate, fine, subangular blocky structure; firm consistence; few, medium, distinct mottles starting at 11".
20-36 in.	sic; 10YR5/3; massive structure; very firm consistence; many, medium, prominent mottles.

- Slope - 15%
- The area available consists of 180 ft long along the contour and 50 ft along the slope. There are 3 medium sized trees in the area.
- The establishment generates about 300 gallons of wastewater of domestic septic tank effluent quality per day based on meter readings.

1. *Evaluate the Quantity and Quality of Wastewater Generated.*

For all on-site systems a careful evaluation must be done on the quantity of wastewater generated. As indicated earlier, most code values have a built-in safety factor and includes peak flows. Thus, these values can be used directly in the design calculations. However, it is appropriate for the designer to assess if the establishment is typical for the code values assigned to it. If metered values are used, it is recommended to double the average daily flow rate for design purposes. However, the average flow rate should be based on a realistic period of time and not be, for example, an average of six months of very low daily flow rates and 6 months of very high flow rates. If that is the case, then the high flow rates should be used for design.

The quality of the wastewater must also be assessed. If it is typical domestic septic tank effluent, these sizing criteria may be used. However, if it is commercial septic tank effluent, lower soil loading rates are recommended (Siegrist, et al., 1985).

Design Loading Rate - 600 gpd.

2. *Evaluate the Soil Profile and Site Description for Design Linear Loading Rate and Soil Loading Rate.*

For this example and convenience the one soil profile description is representative of the site. A minimum of 3 evaluations must be done on the site. More may be required depending on the variability of the soil. The Soil Classifier must do as many borings as

required to assure that the evaluation is representative of the site. In evaluating this soil profile the following comments can be made:

The silt loam (A) horizon (0 - 6 in.) is relatively permeable because of its texture, structure and consistence. The effluent flow through this horizon should be primarily vertical.

The silt loam (E) horizon (6 - 11 in.) has a platy structure and strong consistence. The consistence will slow the flow up and the platy structure will impede vertical flow and cause the flow to move horizontally. However, if this layer is tilled, the platy structure will be rearranged and the flow will be primarily vertical. Thus, tillage must be done at least 12 in. on this site to rearrange the platy structure.

The silty clay loam (B) horizon (11 - 20 in.) is slowly permeable because of the texture and firm consistence. The flow will be a combination of vertical and horizontal in the upper portions and primarily horizontal flow in the lower portion of the horizon due to the nature of the next lower horizon. During wet weather the (B) horizon may be saturated with flow moving horizontally.

The silty clay (C) horizon (20 - 36 in.) will accept some vertical flow as the effluent moves down slope horizontally in the upper horizons. The flow through this profile will be similar to the profile shown in Figure 24.F.

Based on experience a properly designed mound system should function on this site. It meets the minimum site recommendations found in Table 5.F.

Linear Loading Rate:

Based on this soil profile and discussion under the Linear Loading Rate section, the linear loading rate must be in the range of 3 - 4 gpd/1f.

Linear Loading Rate = 4 gpd/1f.

Soil (Basal) Loading Rate:

A soil loading rate for the soil horizon in contact with the sand (basal area) is selected based on the surface horizon (A). Use Table 6.F to determine the design soil loading rate, which, for silt loam soil with moderate structure, is found under item (I), provided the platy structure is tilled.

Soil (Basal) Load Rate = 0.6 gpd/ft<sup>2</sup>

3. Select the Sand Fill Loading Rate.

The section entitled “Sand Fill Loading Rate” and Figure 26.F gives guidelines for selecting a suitable sand fill quality for the Wisconsin mound system. Other fills may be used but caution should be used as performance data is very limited with other fills.

Design Sand Loading Rate = 1.0 gpd/ft<sup>2</sup>

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

$$\begin{aligned} A &= \text{Linear Loading Rate} / \text{Sand Loading Rate} \\ &= 4 \text{ gpd/1f} / 1.0 \text{ gpd/ft}^2 \\ &= 4 \text{ ft} \end{aligned}$$

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

$$B = \text{Design Flow Rate} / \text{Linear Loading Rate}$$

$$= 600 \text{ gpd}/4\text{gpd}/1\text{f}$$

$$= 150 \text{ ft}$$

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. An assessment of the lower horizons was done in step 2 when the linear loading rate was estimated. As discussed in Step 2, the soil (basal) loading rate is 0.6 gpd/ft<sup>2</sup>.

$$(A + I) = \text{Linear Loading rate} / \text{Soil Loading Rate}$$

$$= 4 \text{ gpd}/\text{ft} / 0.6 \text{ gpd}/\text{ft}^2$$

$$= 6.7 \text{ ft}$$

$$\text{Since } A = 4 \text{ ft}$$

$$I = 6.7' - 4' = 2.7 \text{ ft (will be larger due to mound side slope)}$$

7. *Determine Mound Fill Depth (D).*

Assuming the code requires 3 ft of suitable soil and soil profile indicates 11 in. of suitable soil then:

$$D = 36" - 11" = 25 \text{ in.}$$

8. *Determine Mound Fill Depth (E).*

For a 15% slope with the bottom of the absorption area level then:

$$E = D + 0.15 (A)$$

$$= 25" + 0.15 (48")$$

$$= 32 \text{ in.}$$

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

$$F = 9 \text{ in. (6 in. of aggregate, 2 in. for pipe, and 1 in. aggregate)}$$

$$G = 12 \text{ in. (6 in. in warmer climates)}$$

$$H = 18 \text{ in. (12 in. in warmer climates)}$$

10. *Determine the Upslope Width (J).*

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

$$J = 3 (D + F + G)$$

$$J = 3 (25" + 9" + 12")$$

$$= 11.5 \text{ ft.}$$

(Actual width will be less because of the site slope)

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

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

$$K = 3 ( (D+E)/2 + F + H )$$

$$= 3 ( (25" + 32")/2 + 9" + 18" )$$

$$= 14 \text{ ft.}$$

12. *Determine the Down Slope Width (I).*

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

$$\begin{aligned} I &= 3 (E + F + G) \\ &= 3 (32'' + 9'' + 12'') \\ &= 13 \text{ ft} \end{aligned}$$

(Actual width may be greater because of the site slope)

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

13. *Overall Length and Width (L + W).*

$$\begin{aligned} L &= B + 2K \\ &= 150' + 2 (14') \\ &= 178 \text{ ft.} \end{aligned}$$

$$\begin{aligned} W &= A + I + J \\ &= 4 + 13 + 12 \\ &= 29 \text{ ft} \end{aligned}$$

If this site was level, then  $I = J$ . For soil profiles allowing more vertical flow, the linear loading rate could approach 10 gpd/1f and the mound would be shorter and wider.

14. *Design a Pressure Distribution Network.*

A pressure distribution network system, including the distribution piping, dosing chamber and pump or siphons, must be designed (See Section O).

## SECTION O – APPENDIX 3

**3) Appendix 3 - Inspecting Wisconsin Mound**

By James C. Converse and E. Jerry Tyler

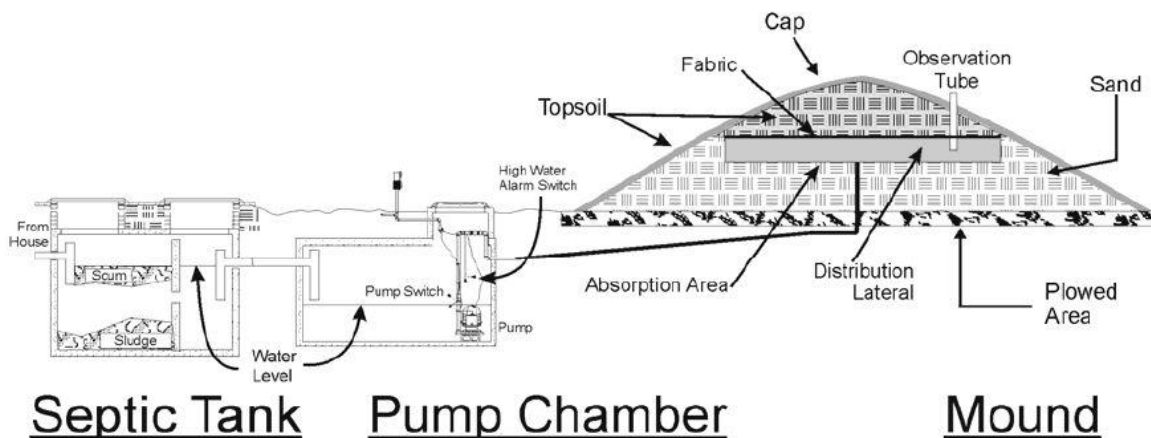
The Wisconsin mounds system was developed in the 1970s to overcome some soil site limitations for on-site disposal of septic tank effluent. A recent survey of Wisconsin counties found the mound system to be performing very well. However, the owner or inspector must identify potential problems early and diagnose them correctly, with a minimum of time and expense. This publication outlines potential problems, their symptoms, and solutions. It also presents a systematic method of inspecting and evaluating the system.

Below is a cross-section view of an entire system. To analyze problems, you must know the location of each portion of your system. Keep a scale drawing of your system handy.

The septic tank and dose chamber of the on-site system must be pumped periodically to remove accumulated solids. The tank and chamber should be pumped at least every 3 years in year-round residences. Seasonally used systems, e.g. in summer cottages and camps, require less frequent pumping.

Heavily used systems, e.g. in restaurants, require more frequent pumping. If you use one of these systems, work closely with an experienced hauler to establish a long-term pumping frequency to help minimize carry-over of solids to the soil absorption unit.

Conserve water when using a soil absorption system. Low-flow toilets, low-volume shower heads, front-loading washers, elimination of garbage grinders, and other techniques can reduce waste water with minimal inconvenience.

**Cross-section of a Wisconsin Mound System**

When you have completed inspecting and troubleshooting your Wisconsin mounds, all of the below questions should have been answered.

**Questions to be answered when inspecting a mound system.**

- |     |    |  |
|-----|----|--|
| Yes | No | 1. Is the alarm system operating properly?                         |
| Yes | No | 2. Does waste water ever back up into the house?                   |
| Yes | No | 3. Do the toilets ever flush slowly?                               |
| Yes | No | 4. Does the liquid level in the septic tank appear abnormal?       |
| Yes | No | 5. Is there a thick scum mat on the surface in the septic tank?    |
| Yes | No | 6. Is the liquid level in the dose chamber within operating range? |
| Yes | No | 7. Are there a lot of solids in the bottom of the dose chamber?    |
| Yes | No | 8. Is there standing water in the observation tubes in the mound?  |
| Yes | No | 9. Are there spongy spots on the top or side areas of the mound?   |
| Yes | No | 10. Is there seepage on the side slopes of the mound?              |
| Yes | No | 11. Are there spongy spots in the toe area of the mound?           |
| Yes | No | 12. Is there leakage at the toe of the mound?                      |

If you answered no to all of the questions, your mound system should be operating properly. If you answered yes to any of the questions, refer to the text for explanations, causes, and solutions.

**Warning: Do Not Enter the Tank or Chamber!!!**

**Never enter a septic tank or dose chamber without special equipment. People have died in septic tanks and dose chambers. They contain toxic gasses and little or no oxygen. Homeowners do not have the necessary equipment or the experience to safely enter tanks.**

Following is a list of symptoms, followed by an explanation of the problem, probable causes, and possible solutions. Make sure you investigate all possible causes before you attempt a repair.

Most of these solutions require an experienced plumber, installer or electrician. Most homeowners don't have the tools or expertise for this work. Untrained do-it-yourselfers may cause further damage and expense.

**SECTION O – APPENDIX 4****4) Appendix 4 - Troubleshooting Wisconsin Mound Systems****Symptom 1: Waste Water Backing Up at the House or Source**

Explanation: Toilets may flush very slowly; waste water may back up in the floor drain.

Causes: If the toilet flushes slowly, the roof vent may be frosted over. If waste water backs up in the floor drain and slowly seeps away, tree roots or accumulated solids may be clogging the sewer line to the septic tank. The restriction is often at the inlet to the septic tank. Over time, the blockage prevents waste-water flow from the house. The outlet from the septic tank to the dose chamber may be plugged; or the pump or controls may have failed, causing water to back up into the house.

Solution: Check the water level in the septic tank and dose chamber. If the dose chamber is full, the problem is a faulty control unit or pump or a blockage in the force main or mound. The alarm should have sounded. If not, check the alarm system. Inspect the circuit breaker. It may have tripped. If the liquid level is normal in the dose chamber, but higher than normal in the septic tank, the pipe connecting the septic tank and the dose chamber is plugged. Call a septic tank hauler or plumber to unplug the pipe and check the septic-tank baffles.

If the septic tank level is normal, the inlet to the septic tank or the pipe between the house and the septic tank is plugged. Take care when unplugging the inlet or the pipe.

**Symptom 2: Alarm from Dose Chamber**

Explanation: When the liquid level in the dose chamber reaches a set height above the wastewater level normally needed to activate the pump, it trips an audible alarm or light in the house.

Causes: Faulty pump or pump controls, or a malfunctioning alarm. Blockage in the force main or distribution system of the mound keeps the pump from moving water to the mound.

Solution: If the problem appears to be a faulty pump or controls, see Symptom 1. If the pump runs but the water level doesn't drop, then the force main or distribution laterals are plugged. See Symptom 10.

**Symptom 3: Excessive Solids Accumulating in the Dose Chamber**

Explanation: Settled solids should be removed in the septic tank. Solids carried to the dose chamber will be pumped to the mound and may plug the distribution system or the mound infiltrative surface.

Causes: Not pumping the septic tank often enough. Broken baffles in septic tank. Excessive solids introduced into the system.

Solutions: Pump the septic tank on a regular basis and have baffles checked after

each pumping. Don't use in-sink garbage grinders. They add too many solids to the septic tank.

#### Symptom 4: Ponding in the Absorption Area of the Mound

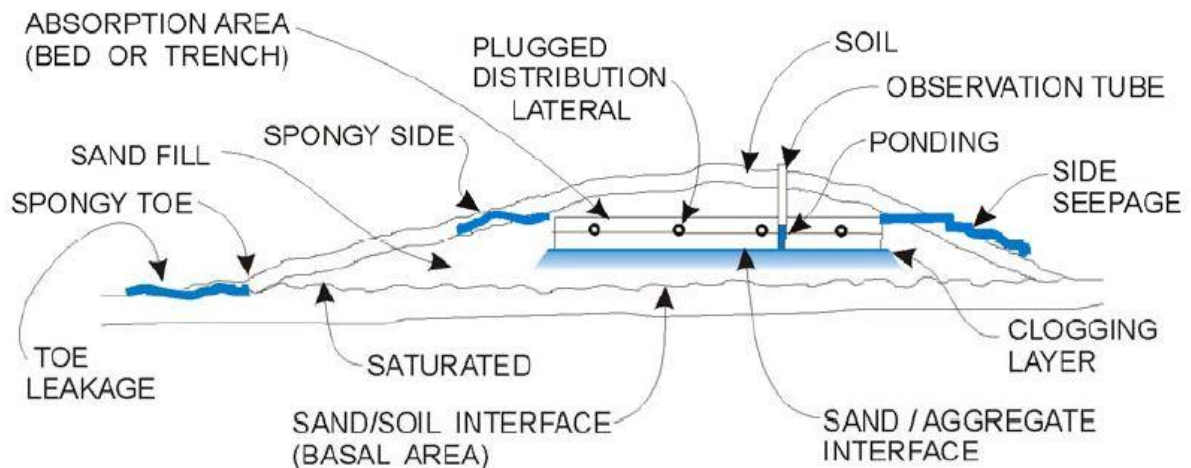
Explanation: If you see waste water in the observation tubes (Figure 25.F) you have ponding at the sand/aggregate interface. It may be 1) ponding during dosing, 2) seasonal ponding, or 3) permanent ponding.

Ponding during dosing is very temporary and usually disappears shortly after the pump stops. Seasonal ponding occurs over the winter but usually disappears by early summer. Low bacterial activity allows a clogging layer to develop at the sand/aggregate interface, which reduces the infiltration rate across the interface. As the weather warms, bacterial activity increases, reducing the clogging mat and increasing the infiltration rate. Seasonal ponding rarely causes problems.

Although not itself a failure, permanent ponding (waste water always visible in the observation tubes) may lead to failure.

Causes: Permanent ponding is the result of a clogging mat at the sand/aggregate interface. It may be caused by overloading of septic tank effluent and/or too fine a sand fill.

Solutions: Check the observation tubes every 3 months to see if permanent ponding is occurring in the mound's absorption area. If the ponding appears to be permanent, reduce water use in your home to reduce the load to the system. This often reduces permanent ponding.



#### Symptom 5: Seepage Out the Side of the Mound

Explanation: Seepage out the side of the mound is usually black and smelly. It is primarily septic tank effluent that has been pumped into the mound. The breakout normally occurs around an observation tube or at other locations near the top of the mound. The effluent flows down the side of the mound (as shown in above figure).

Causes: A clogging mat prevents effluent from infiltrating into the sand as quickly as it's pumped into the mound. Effluent is then forced to the surface of the mound. The clogging mat appears as a black layer at the sand/aggregate interface. The sand several inches below the interface is usually dry and clean.

Temporary or continuous overloading also causes seepage out the side of the mound, even though a clogging mat may not be causing permanent ponding.

Solutions: Estimate the effluent entering the system. Look for 1) excessive water use in the home, and 2) groundwater entering the dose chamber. Reduce the loading to the mound by conserving water in the home and/or eliminating infiltration through joints in the riser into the dose chamber. To eliminate infiltration, re-caulk all the joints on the outside of the riser including the joint between the riser and the tank cover.

Determine the quality of fill. Sample the sand at several locations and have it analyzed for particle size. (Some experienced people can estimate sand texture in the field.) If the sand beneath the absorption area is fine sand, medium sand with a lot of fines in it, or coarse sand containing a lot of fine and very fine sand plus silt and clay, the mound may have to be partially rebuilt.

To partially rebuild the mound:

- 1) remove the soil above the absorption area,
- 2) remove the distribution system and aggregate,
- 3) remove the sand beneath the absorption area down to the natural soil,
- 4) replace it with an approved sand fill,
- 5) replace the distribution system,
- 6) cover with a synthetic fabric,
- 7) replace, seed and mulch the topsoil.

Another approach may be to lengthen the mound, if you have the space:

- 1) remove the topsoil on the end slope,
- 2) till the natural soil,
- 3) place the proper-quality sand fill,
- 4) place the aggregate in the absorption area and extend the laterals,
- 5) place fabric on the aggregate,
- 6) place topsoil on the mound extension,
- 7) seed and mulch.

Note that making the absorption area wider may cause leakage, especially on slowly permeable soils. Prior to extending the mound, determine if pump or siphon will provide sufficient head at the end of the distribution laterals.

### **Symptom 6: Spongy Area on the Side or Top of Mound**

Explanation: A small amount of effluent seepage from the absorption area may cause soft spongy areas on the side or top of the mound.

Causes: Spongy areas indicate ponding in the absorption area—the result of nearly saturated soil materials.

Solutions: See Symptom 5. Spongy areas usually precede seepage.

### **Symptom 7: Leakage at the Toe of the Mound**

Explanation: Effluent leakage at the toe of the mound may be seasonal or permanent. Extremely wet weather can saturate the toe area, causing leakage. Leakage usually stops a few days after the wet period. In extreme cases the toe may leak continuously, even during dry weather. Research has shown that the water is of high quality with no odor and few if any fecal bacteria. This leakage is often indistinguishable from natural surface water.

Causes: Leakage at the toe may be caused by 1) overloading of the mound due to excessive water use or groundwater infiltration, 2) overestimating the infiltration rate and hydraulic conductivity of the natural soil during design, 3) hydrophobic soils that do not readily accept water, and 4) soil compaction during construction.

Solutions: Conserve water to add less waste water to the system. If the soil accepts the waste water, but more slowly than anticipated, extending the toe sometimes eliminates the leakage.

To extend the toe:

1) remove the existing toe, 2) allow the soil to dry, 3) till downslope soil area, 4) place sand on the tilled area, 5) place topsoil over the sand, 6) seed and mulch the topsoil.

If the natural soil beneath the mound is dry even though the sand fill above is saturated, the natural soil is hydrophobic, compacted or accepts the waste water very slowly. The waste water is moving horizontally at the sand/soil interface, rather than downward.

Extending the basal area downslope may help. You may also have to increase the length of the mound. This reduces the linear loading rate and reduces the loading at the toe. A combination of both may be required.

In extreme situations, place an interceptor drain at the downslope toe to move leakage away from the toe of the mound to a drainage ditch. Many states prohibit surface disposal of this water, so this approach may not be feasible.

If you know that groundwater is moving laterally downslope on sloping sites, place an interceptor drain on the upslope edge of the mound to intercept the groundwater. This allows the effluent to infiltrate into the soil and replace the intercepted groundwater.

### **Symptom 8: Spongy Area at the Toe of the Mound**

Explanation: Saturated sand fill and nearly saturated cover soil at the toe makes it soft and spongy.

Causes: Causes are similar to those of Symptom 7, though not as extreme.

Solutions: Same as Symptom 7.

**Symptom 9: Too Much Effluent Flows Back into the Dose Chamber after the Pump Shuts Off.**

Explanation: The pump pressurizes the absorption area by forcing effluent into the aggregate and soil above the distribution laterals. When the pump shuts off, the effluent flows back into the dose chamber until the effluent level in the absorption area is below the distribution laterals. Side seepage may or may not occur.

Causes: Permanent ponding fills the aggregate below the laterals. Verify this by checking for effluent in the observation wells. Rapidly overloading the system may also cause excessive flowback.

Solutions: Same as Symptom 5.

**Symptom 10: The Pump Runs Continuously with No Drop in the Liquid Level in the Dose Tank.**

Explanation: The observation tubes indicate that the absorption area is not ponded, but the mound does not accept waste water satisfactorily.

Causes: Solids plug the small-diameter holes in the distribution system, and effluent can't flow into the absorption area. Items such as disposable wash towelettes or sanitary napkins will not settle out in the septic tank and are carried over into the dose chamber and forced into the distribution pipes.

Solutions: Pump septic tank and dose chamber. (Every 3 years for residential units; more often for heavily used systems.)

Do not flush towelettes and similar materials down the toilets.

If system is plugged, remove the end caps to the distribution lateral and sand flush out the solids using a high-volume, high-pressure pump. Recap the laterals and force water or air into the distribution system to unplug the holes. Septic tank pumpers, when pressurized, force water into the laterals to remove the accumulated solids and force water out the holes to unplug them.

Consider installing a 1/8-inch screen around the pump or siphon to keep larger solids out of the system. Other types of filters may also minimize the solids carried over to the dose tank.

**Symptom 11: Occasional Septic Odors**

**Explanation:** Biological activity in the septic tank and dose chamber produces ammonia, hydrogen sulfide and other foul-smelling gases. These gases escape from the dose tank via the vent and possibly the house vent stack.

**Causes:** Odors generated in the septic tank and dose chamber can circulate to occupied areas under certain humidity and wind conditions.

**Solution:** There is no easy solution to this problem, because the odors are usually emitted through the vent of the dose chamber. Extending the dose chamber vent to roof level may minimize these unpleasant odors. If the dose chamber is vented back through the septic tank and house stack, you may be able to plug the dose tank vent during warm weather. Occasionally the odors may be caused by gases emitted through the house stack. In this case, nothing can be done.

**References:**

Converse, J. C. and E. J. Tyler, 1986. Wisconsin Mound Performance, Small Scale Waste-Management Project, College of Agricultural and Life Sciences, 240 Agriculture Hall, University of Wisconsin-Madison.

**Symptoms, probable causes and solution index.**

<b>Inspection Point</b>	<b>Symptom</b>	<b>Probable Cause</b>	<b>Symptom #</b>
1. Alarm	sounding	pump failure alarm switch failure	2
	non-functioning	circuit breaker thrown faulty alarm 2	2
2. Floor drain	waste on floor	house sewer plugged septic tank inlet plugged septic tank outlet plugged pump failed distribution laterals plugged	1, 2, 10
3. Septic tank	liquid waste level above normal	outlet plugged pump failed distribution laterals plugged	2,10
	excess solids	excess solids added garbage disposal	3
4. Dose chamber	liquid level above high-water pump switch	pump failure control failure plugged laterals	9, 10
	excess solids	solids carry-over septic tank baffle missing	3
	groundwater inflow	high groundwater leaky joints	5
	odors	pump chamber emitting odors	11
5. Mound	water in observation tubes	soil absorption area plugged excessive water use	4
	seepage of raw sewage on side or top of mound	soil absorption area plugged system overloaded sand fill too fine	4
	spongy on side and top of mound	same as seepage of raw sewage (above)	5
	leakage at toe	slowly permeable soil compaction during construction soil damaged during construction overloading of system	6
	spongy at toe	same as leakage at toe (above)	7

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## SECTION O – APPENDIX 5

## 5) Appendix 5 - Pathogenic Microorganisms in Domestic Wastewater and the Diseases They Cause

Microorganism	Disease(s) Caused
<b>BACTERIA:</b>	
Salmonella species	Typhoid, paratyphoid, gastroenteritis
Shigella	Bacillary dysentery
Yersinia	Gastroenteritis
Mycobacterium	Tuberculosis
Leptospira	Leptospirosis
Campylobacter jejuni	Gastroenteritis
Pathogenic coliforms (e.g. E. coli)	Gastroenteritis, urinary tract infections
Yersinia enterocolitica	Gastroenteritis
Pseudomonas	Respiratory and burn infections, diarrhea
Klebsiella	Pneumonia, bronchitis
Serratia	Respiratory and urinary tract infections, summer diarrhea
<b>VIRUSES:</b>	
polioviruse	Poliomyelitis
hepatitis A	Infectious hepatitis
echoviruses	Respiratory disease, aseptic meningitis, diarrhea, fever
Coxackie viruses	Respiratory disease, aseptic meningitis, myocarditis
noroviruses	Gastroenteritis
rotaviruses	Gastroenteritis
adenoviruses	Respiratory disease, eye infections
<b>PARASITES:</b>	
Entamoeba histolytica	Amoebic dysentery
Giardia lamblia	Giardiasis (“backpacker’s diarrhea”)
Balantidium coli	Dysentery, gastroenteriti
Ascaris ova	Pneumonitis, intestinal and nervous system disorders
Trichuris	Chronic gastroenteriti
Enterobius vermicularis	Enterobaisis
Cestode ova	Chronic gastroenteriti
Coccidia	Diarrhea, toxoplasmosis

\* (Adapted from Kreissl, 1983, Fitzgerald, 1983, and sobsey, 1983a)

**SECTION O – APPENDIX 6****6) Appendix 6 - Septic Tank System Failure**

April 1997

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**About the Author**

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**Synopsis**

It is well known fact that wastewater disposal, when done improperly, can pose a threat to the environment and public health. In order to protect people and environment, wastewater must be well disposed of in a manner that controls waterborne diseases and prevents contamination of surface water and underground water. It is the aim of this document to:

- Enhance public health protection, and
- Provide public health professionals, engineers, scientists, environmentalists, septic tank installers and pumpers, and others with first hand knowledge to make competent decisions whenever a septic tank system fails.

It must be noted that this document is not a panacea for all septic tank system problems. It is only an aid to solving some of the problems.

**Acknowledgements**

I would like to express my appreciation to LaTonya-Blount for her help in making this document possible. All county environmental health specialists in the State of Georgia are gratefully acknowledged for all their efforts, energy and self-motivation.

**Disclaimer!!** Mention of trade names or commercial products do not constitute endorsement by the author. Moreover, the views expressed herein are entirely the author's and do not represent the official policy of the Georgia Department of Public Health.

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## PART I

### Introduction

In the State of Georgia, over 30,000 new septic tank systems are installed each year for new housing, commercial and industrial development adding to over 600,000 systems that are already in use. These systems contribute over 75 million gallons of wastewater into the environment every day. Most of these systems function satisfactorily, but approximately 10,000 systems are repaired each year because of failure. Accordingly, the system failures and installation of septic tank systems on unsuitable sites can create serious threats to public health and significant economic impact. Properly designed and located septic tank systems are now a permanent means of wastewater disposal that can function reliably with minimum maintenance and cost.

### Why Use a Septic Tank System?

The septic tank system is an effective method for collecting, treating and disposing of sewage mostly from rural and suburban homes. In other words, whenever the municipal or community sewage treatment plants are inaccessible, the septic tank system is used. It is an on-site sewage management system designed to safely treat and dispose of wastewater from toilet, shower, bathtub, handwash sink, kitchen, and laundry. This wastewater usually contains disease causing germs and pollutants that must be treated to protect human health and the environment.

### How Does a Septic Tank System Work?

Wastewater from the home is collected in a water-tight tank called a septic tank. Bacterial action takes place in the septic tank where the end products are mainly water (mixed with some other components that are not readily consumed by bacterial action). Gases and undigested material called sludge that sinks to the bottom of the tank and scum that floats to the top of the tank.

The septic tank contains a baffle that prevents any scum that floats to the surface and sludge that settles to the bottom from passing out of the tank. The gases that are generated vent to the atmosphere via the plumbing vent.

The segregated and relatively clear liquid in the tank will fill the outlet level, which is located on the opposite side of the tank from the inlet. As wastewater enters the tank, an equal volume of the liquid flows from the septic tank through the outlet into a small distribution box where it is then metered out to several perforated pipes or some other disposal system. These perforated pipes then deliver the liquid to a large subsurface area called the drainfield, nitrification field or soil absorption field.

The major function of the drainfield is to deliver the effluent to the soil. The soil purifies the effluent by removing the germs, solids and chemicals that may be carried along with the effluent before they reach the groundwater.

### **What Septic Tank System Design Practices Are Improper?**

Many of the problems of septic tank system result from Improper design procedures which can be avoided. Some of these procedures include:

- relying solely on published soils information from the local county soil survey rather than performing actual field tests at the site.
- poor site evaluations, including failure to-assess impacts of surface runoff and internal groundwater movement,
- poor soil profile description made by nonqualified personnel who fail to detect seasonal high water tables and who fail to locate and properly describe restrictive features, e.g., slowly permeable layers and fractured rock,
- failure to design treatment units and absorption system for long-term performance. Systems are designed typically by using State Regulations and Codes as the sole basis of design; these guidelines are often only meant to serve as guidelines for establishing minimum requirements,
- failure to correlate soil characteristics with permeability test results,
- failure of designers to fully adapt a wastewater system to the site. Errors are made with mismatching absorption system geometry with site conditions which often result in localized overloading of the soil and possible groundwater mounding and flooding.
- improper installation of the system in an area not previously tested or with insufficient separation from water supplies such as wells, springs or other water ways,
- designers sometimes fail to understand the impact of soil characteristics relating to installation. Such potential problems during installation include:
  - installation at a less-preferred location than designed (e.g., a location with
  - concave slopes).
  - excessive deep installation of any soil absorption system,
  - high soil moisture during installation,
  - backfilling causing damage to pipes, tanks, or other buried structure
  - compaction of soil in and around the down slope area, once the pipes or tanks are in place,
  - not adhering to specifications such as placement of coarse material beneath pipes or tanks, or leveling of in-ground facilities,

- site damage following preliminary evaluation and design (e.g., soil removal, compaction),
- inadequate depths or protection to avoid freezing in-ground facilities,
- lack of field testing following installation but prior to the contractor leaving the site (e.g., pressure testing pumps and siphons or water testing a level distribution box), or
- insufficient diversion of runoff to avoid infiltration and possible hydraulic overloading.
- failure of designers to consider techniques which can be implemented in the field to make gravity-feed systems perform better (e.g., specifying discharge hole diameters and spacing for wastewater distribution network),
- improper siting (e.g., up slope of a water supply well or within poorly drained soil), or
- failure to project flow inputs for the life of the proposed facility.

### **What are the Signs of a Failing Septic Tank System?**

Unfortunately, it is not uncommon to find a septic tank system that is failing. In most cases, the failure starts as a small problem and continues growing until the problem is too large to ignore.

The signs of a failing system include:

- Surfacing or ponding of the septic tank effluent on the ground surface. This effluent may contain many disease-causing bacteria, viruses, and dysentery, hepatitis, giardiasis, cryptosporidiosis, hookworm, tapeworm and other diseases that have plagued mankind for years. Children are most likely to play in the pools or wet soil, but adults may have to walk through or work in the area, and once the effluent gets on a person, the germs can spread to the mouth or nose where they are swallowed or inhaled.
- Slow drains or sewage backing up into the house. The cause could be from failure or any part of the system.
- Smell of sewage odor outside the house where drainfield is not saturated and there is no back-up. This may cause fly infestations and isolated outbreaks of water-borne diseases.

## **PART II**

### **Rehabilitating a Failing Septic Tank System**

Source: State of North Carolina On-Site Wastewater Management Guidance **Manual**

#### **Problem Identification**

Whenever a septic tank system fails, the key to rehabilitation of the system is to use a systematic approach to identify the problem. The basic idea is to check the easy things first and then go to the more difficult items. The following steps are used to determine why a septic system is failing.

1. Determine the type of failure

The type of failure can indicate, to a large extent, what is causing the problem. To properly determine the type of failure, a field inspection must be done.

- Surface discharges can indicate which part of the system is failing. Note where the discharge is and appears to be coming from. Is the discharge:
  - over the septic tank?
  - over the pump tank?
  - over the distribution box?
  - over the treatment or disposal field? What part of the field?
  - Are drains backing up into the house?
- Do fixtures in the house drain slowly?
- Is the problem occurring only in the wet season, after heavy rains,
- or throughout the year?
- Does the problem occur only on weekends, or every day?
- Is the effluent flowing at the failure site or is it a small wet spot that soaks back into the ground?
- Has the system operated well for a number of years and failed just recently, or has it been failing for a long time?

## 2. Check the easy things first

The cause of the septic tank system failure often can be determined easily without complicated tests. Some failures may mean that complicated tests must be done, but many problems can be solved by checking the easy things.

- If the water is backing up into the house or the toilets are flushing slowly, check for clogged plumbing first. A clog in the drain or house sewer going to the septic tank may be the problem.
- Plugged plumbing vents, located on the roof of the house, also cause slow drains. Once the vent pipes are cleared, it may be helpful to put a screen over the vent pipe to keep out insects, rodents and birds.
- If the house drains and roof vents are not plugged, check the septic tank. Uncover the access hatches and check for a clogged inlet or outlet.
- If the inlet is clogged with solids, the house sewer coming into the tank may need a larger pipe or may have collapsed and need replacing.
- A clogged outlet may mean that the outlet has broken or that the solids need to be pumped out. If the tank is completely full of solids and scum, it must be pumped. The residents must be informed that septic tanks should be pumped on a regular schedule. Pumping the tank keeps it from plugging and protects the treatment and disposal field from clogging with solids.
- Distribution boxes can also be easily checked. Uncover the distribution box and check for clogs and excessive solids in the box and for unequal distribution of flow to the outlets.
- Check to see if the distribution box is out of level. Re-level as needed.
- Distribution boxes can help determine which part of the system is having the problem.
- Clear water flowing through the distribution box may indicate leaking fixtures and excessive water use.

- Solids in the distribution box mean that the septic tank outlet is not keeping the solids in the tank or that the tank is too full of solids and needs to be pumped.
- If no effluent is flowing to the distribution box, then there is a clog in the conveyance pipe to the distribution box, in the septic tank, or in the house plumbing.
- If the box is flooded, the effluent is not flowing out of the box to the drainfield, indicating the problem is either in the conveyance pipes going to the drainfield or in the drainfield.
- In systems that pump to drainfield, check to see if the pump is working.

If these quick checks do not indicate what the problem is, then the following may help determine why the septic tank system is failing.

### 3. Determine the sewage volume

The volume or total daily flow of sewage going to a system can cause it to fail if the system was designed for a smaller flow.

- Find the original design flow or expected daily flow of sewage. This information should be on the permit or other approval forms.
- There are several ways to find the actual flow into the septic tank system. An easy way is to check the water bills for records of water used. This is a good indication of how much water is going into the septic tank system unless there is a leak that drains somewhere else, such as under the house.
- If the water bills do not help, keep a record of the water meter reading over a period of time, say a month or two. If you are keeping records of the water meter reading, be sure that the plumbing is not leaking into the ground outside the house. Water from a leak outside the house will not go into the septic tank system.
- The water meter should be checked as frequently as possible; once each day may be necessary. If the water meter is a dial or pointer that indicates small volumes, see if it turns when no water is being used. This is a sure sign of a leak.
- Study the records of water use to find if there has been an increase in flow to the system. Leaking faucets and toilets can add large amounts of water to the daily flow of sewage, causing the septic system to fail.
- Has a water-using appliance be installed or added to the household recently? A system that was not designed for high flows may fail when a washing machine or dishwasher is added.
- Has the water use habits in the home changed? A new baby can greatly increase the amount of water used in washing clothes, or teenagers can spend long amounts of time in-showers, which increases the total sewage flow.
- Have the residents changed the use of the washing machine? Are they washing clothes once per day when they used to wash once per week? Sometimes a septic system fails if the residents take in additional washing or if they wash all of their laundry on one day of the week. The residents can try washing one load each day, as opposed to all loads in one day.
- Has the use of the home changed? For instance, has a business that uses large quantities of water been started? Businesses such as day care centers, beauty shops and hobbies such as photography processing can cause problems.
- Has water been added to the daily sewage flow in other ways? Examples are:

- Sump pump installation which discharges into sanitary drain,
- Roof runoff from downspouts connected to sanitary drains,
- Foundation drainage flowing into sanitary drain,
- Heat pump discharging ground water into sanitary drain,
- Water softener recharge brine flows into septic tank,
- Swimming pool filter backwash water discharged into septic tank,
- Ice machine adds to daily sewage flow,
- Industrial wastewater added to domestic wastewater flow, and
- Floor drains adding water to daily sewage flow.

#### 4. Check topographic and landscape factors

A number of features of the land can cause a septic tank system to fail.

- Study the topographic position of the failing system. Is it at the base of a hill where surface drainage from the hill could flow onto the drainfield area? On long slopes, water can flow several hundred feet through the soil and flood the drainfield area.
- Is the drainfield downstream from a large drainage area where water drains onto it?
- Do roadside ditches, swales, or other channels drain water onto the drainfield?
- Does ground water flow into the drainfield or does the water table rise in wet weather, causing a failure?

#### 5. Investigate the septic tank

Determine if the septic tank is causing the problem.

- Inspect the septic tank inlet. Check the inlet to see if it is clogged and make sure sewage is flowing to the septic tank. A clogged inlet or crushed inlet pipe will cause sewage to back up into the house.
- Inspect the septic tank outlet. Is the outlet broken or clogged?
- Is the outlet working properly, holding back the solids, grease, and scum? Measure the depth of the scum layer and the solids to see if either is flowing into the outlet.
- If the outlet is full of solids and grease because too many solids and too much grease have accumulated in the tank, then the tank must be pumped out.
- Check the depth to the top of the tank. If the tank is too deep, the effluent may have to flow uphill to reach the drainfield, causing the sewage to back up in the septic tank. This problem occurs only in new systems; if the system has worked for a number of years, this condition should not be present.

#### 6. Find the drainfield trenches and determine the amount of ponding.

Many septic tank systems failures occur because the drainfield is not handling the effluent properly.

- Do not dig an open hole in a trench and leave it open. Open holes can spread bacteria and disease.

- Observation tubes can be installed to check the water level in the trenches. These tubes are vertical, open-ended pipes with one end in the trench and the other end sticking above the ground and covered by a removable cap. By removing the cap and looking or measuring down the observation tube, the water level in the trench can be easily observed and measured. By measuring the depth of water and how long the water stays in the trench, you can get an idea of whether the trenches are clogged.
- If the water level in the trench rises quickly and drops rapidly, the trenches are not clogged. The drainfield is being overdosed with effluent and some of the effluent is ponding.
- If the water level rises quickly and drops very slowly or continues to rise, then the trenches are clogged and will need to be repaired or replaced.
- Use the observation tubes to determine if the trenches are flooded permanently or only temporarily.
- If effluent is ponding on the ground surface, find out if the ponding is permanent or if it only happens during wet periods, after heavy use, during certain days of the week, etc.
- Is one part of the drainfield being overloaded? A distribution box that has shifted may direct all the effluent to one trench.
- Look for changes in the soil across the drainfield especially for soil types that cannot absorb much effluent.
- Are the trenches too deep? Have the trenches been installed below the seasonal high water table? Is there a perched water table under the drainfield that may restrict the flow of effluent away from the trenches?
- Have the trenches been installed so that they run up a hill or are not on the contour? Is there too much fall on the trenches so that the effluent runs to the end of the trenches?
- In areas with very uneven ground, be sure that the trenches have been placed deep enough so that the trench is not too shallow in low spots.
- If effluent is surfacing somewhere other than over the drainfield, it may mean that an utility trench has been cut across the drainfield. Effluent flows through the loose backfill in underground electrical, cable TV, telephone or water lines, and surfaces in a low spot along utility trenches. The utility trench should be moved so that it does not cross the drainfield.

#### 7. Determine the rate of absorption of wastewater by the soil.

A method to determine the absorption rate of the soil in the trenches is presented below. This technique is useful because it gives a value of the treatment and disposal rate for the trenches as they really are. Once the treatment and disposal rate has been found, you can better understand why the system is failing.

- A. Determine the daily usage of water by reading the water meter. Take readings for at least a week or longer to be sure that you have a good idea of the amount of water being used.
- B. Install observation tubes in the trenches.
- C. To begin the test, mark the level of water in the trenches as seen through the observation tubes.
- D. Use no water in the house for at least eight hours. The water at the meter should be turned off so that the residents will not use the water.
- E. Read the water meter after it has been turned off. This reading will be used to find how much water can be absorbed by the system over the eight hour period.

- F. Watch the water level in the trenches drop over the eight hour period. At the end of the eight hour period, measure the level of water in the trenches.
- G. Turn the water on and let the water flow so that the trenches fill to the same level as at the beginning of the eight-hour period. When the trenches have filled to the level at the beginning of the test, turn off the water at the faucet and read the water meter.
- H. Subtract the water meter reading at the beginning of the eight hour test from the meter reading at the end of the test to find the total volume of water used to fill the trench back to the water level at the beginning of the test. This volume of water is also the volume of water absorbed in eight hours.
- I. Take the volume of water absorbed in eight hours and multiply it by three to get the volume of wastewater absorbed in one day.
- J. If the rate of wastewater treatment and disposal per day, through the soil, is less than the amount of water used per day, then the system is being overloaded. Determine the percentage that the system is overloaded using the following equation:

$$\text{Percent overloaded} = \frac{\text{GPD use} - \text{GPD Wastewater absorbed} \times 100}{\text{GPD Wastewater absorbed}}$$

- If the system is less than 35% overloaded, then the residents may be able to correct the system failure by water conservation. Water conservation includes using low-flow showerheads, low-flush toilets, flow restrictors on all faucets, and other methods to reduce the volume of water flowing to the septic tank system. Installation of these devices is much cheaper than rebuilding a septic tank system.
- If the plumbing system has a pressure-regulating valve, the pressure in the house can be reduced somewhat, which will help lower water usage. On drinking water well systems, the pressure switch for the well pump can be set to operate over a cycle of 30 to 50 psi rather than the usual 40 to 60 psi setting.
- The residents can lower their water use by a number of simple actions. Shutting off the water while shaving or brushing teeth, taking short showers, and taking laundry to a Laundromat are all ways to decrease water use.
- For large overloads, the system may have to be expanded or a replacement system installed.

#### 8. Evaluate site and soil properties.

Information from a proper soil evaluation can determine if the site can be used to repair a drainfield that has failed.

- Determine the types of soil present. Use soil borings, textural determination, and other techniques to determine the type of soil.
- Complete a soil evaluation and fill out an evaluation sheet.
- Determine the appropriate loading rate, or acceptance rate, for the soil. This is the volume of effluent the soil can absorb in a day. Check the following items:
  - Soil depth,
  - Soil wetness,
  - Soil characteristics or morphology, restrictive horizons, changes in soil characteristics either with depth or over the drainfield area,

- Loading rate for the trench bottoms, loading rate for the entire area of the drainfield, which is the volume of effluent per square foot of the field, and
- Loading rate along trench length, volume of effluent per foot of trench.
- Determine which type of on-site system will fit the site and soil conditions and the available area.

#### 9. Note cut or excavated areas.

If topsoil has been removed in an area, the septic tank system will not operate properly. Usually, these areas have much less capacity to absorb and treat the effluent once the topsoil is gone.

- Try to find out if the system was placed in an area that had been excavated and the soil removed. Subsoils and saprolite are not the best soils for septic tank systems.
- Check for cut or excavated areas downslope from the system. Effluent may be coming to the surface in the cut area after it flows downhill from the drainfield.
- Old farming terraces upslope can trap rainwater causing the soil downslope to become saturated.

#### 10. Interpret information gathered.

At this stage, you should have most of the information that can be obtained. The information must be interpreted to determine the cause of the problem and whether the problem can be corrected. Some failing systems cannot be corrected.

- See if the information points to the cause of the problem. Keep well organized files of the information you have gathered. This information may help decide what is causing the problem.
- Discuss the situation and the information you have with your county environmentalists. Environmental health professionals have experience with septic tank systems.

### **Taking Corrective Action**

- If the problem has been identified, then it is time for corrective action. The following list contains actions that will correct many problems.
- The best thing to do in any system failure is to start a schedule of regular maintenance and operation checks. Homeowners rarely maintain their septic tank systems properly and maintenance can easily make the difference between a system with problems and one that functions well.
- If the plumbing or conveyance pipes are clogged, clean them out.
- If water leaks are overloading the septic tank system, then repair the leaking plumbing fixtures or pipes.
- If seasonal high water table saturates the soil around the drainfield, use subsurface tile drainage to lower the water table.
- If the system is being flooded by runoff from roof downspouts, change the downspouts to direct the runoff away from the drainfield.

- In situations where the tank is plugged with solids or the inlet or outlet is clogged because of solids in the tank, pumping the septic tank will help the system to function properly again.
- If mechanical or electrical parts have broken, replace the parts.
- If pipes have collapsed or trenches have filled in, then the pipes should be replaced and reinstalled.
- Broken conveyance pipes or laterals on pumped systems must be replaced.
- Leaking septic tanks and pump tanks must be repaired or replaced.
- In some cases, nothing can be done to correct the existing septic tank system, which means that the homeowner is in for big changes and probably high costs. There are some alternative to consider when whole systems must be repaired.
- The owner may be able to obtain an easement for use of a neighbor's property for an expanded or additional drainfield. This option depends greatly on the type of neighborhood and how close the houses are to each other.
- Be certain that smaller corrections will not fix the system before you go to larger system repairs. For instance, if there is only a small failure where water is ponding on the surface, then adding one or two trenches of the same size as the original trenches may be enough.
- If there is a large failure over most of the drainfield, the entire field will have to be replaced. Sometimes the old field will recover if it is not used for six months or a year, and is then put back into service.
- Another alternative is to install dual alternating drainfields, alternating the flow between the old field and the new field. The old field may recover in a few months and be ready for use when the flow is turned on again.
- Another piece of land may be purchased to install another or an expanded drainfield.
- Alternative wastewater disposal methods that might work on the property can be investigated.

After the system has been rehabilitated, follow-up on how the repaired system is functioning is necessary. Here are a few ideas for follow-up.

- Inspect the repaired system and review the operation and maintenance of the system. If the system is not being maintained or operated properly, it will fail again.
- Try to educate the owner and users of the system so that the system is not abused. Education can prevent another failed system.
- Be sure that the owners and users know what maintenance is necessary for the system. Try to find out if the maintenance is being done.
- Inspect the system periodically to check for recurring problems.
- Continue keeping records on the system for future needs. Keep well-organized files of all information. These files may help you or someone else in another situation with a failing system.

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7) Appendix 7 - Pipe Fittings

