Water for the World

Designing Subsurface Absorption Systems

Technical Note No. SAN. 2.D.1

A subsurface absorption system is a trench, series of trenches, field or pit that receives effluent from a septic tank and allows it to soak safely into the ground. Designing an absorption system involves selecting a location, deciding on the type and size of the system, and determining the labor, materials, and tools needed to construct it. The products of the design process are: (1) a location map, (2) technical drawings of the system, and (3) detailed materials list. These products should be given to the construction supervisor before construction begins.

This technical note describes how to design a subsurface absorption system and produce the three end-products. Read the entire technical note before starting the design process.

Useful Definitions

ALLOWABLE RATE OF SEWAGE APPLICATION - The amount of effluent that the soil in a particular area will absorb in one day, expressed in liters per square meter per day (lpd/m^2).

EFFLUENT - Settled sewage.

GROUNDWATER LEVEL - The level to which subsurface water rises during any given time of year.

PERVIOUS - Allowing liquid to pass through.

Materials Needed

Measuring tape - To obtain accurate field information for a location map.

Ruler - To draw a location map.

Location

A subsurface absorption system must be downhill and at least:

30m from the nearest water supply;
6m from the nearest building;
3m from any property line;
3m from bushes or trees.

Do not put the system in an area where surface water will stand on it or flow over it. Locate the system so that there is a straight line from the building served, through the septic tank, to the absorption system.

After a proposed site has been selected, it must be tested for soil suitability (see "Determining Soil Suitability," SAN.2.P.3). The test is conducted in two steps:

Step 1. Determine if the highest groundwater level and level of impervious layers are suitable for the system. The bottom of an absorption system must be at least 1m above these levels. If these conditions are not acceptable, select another site. If no acceptable site can be found, and the proposed system is a pit, it may be possible to substitute a trench, series of trenches, or absorption field, since these systems are shallower than a pit. If not, design either a non-conventional system (see "Designing Non-conventional Excreta and Washwater Disposal Systems," SAN.2.D.8) or a sewer system (see "Designing Sewer Systems," SAN.2.D.4 and "Designing Stabilization Ponds," SAN.2.D.5).

If the groundwater and impervious layers are acceptable for the system, proceed to the second step.

Step 2. Determine the allowable rate of sewage application by conducting a soil percolation test (see "Determining Soil Suitability," SAN.2.P.3). The test should be conducted at the same depth of a proposed trench, series of trenches, or field, and at both one-half the depth and the full depth of a proposed pit. If the results of the percolation tests are unacceptable for the proposed systems, select another site and repeat Step 1. If no acceptable site can be found, design either a non-conventional system or a sewer system.

When an acceptable site for an absorption system has been found, draw a location map similar to Figure 1 showing distances from the system to the septic tank, buildings, water supplies, property lines, vegetation, and any other structures or prominent geographical features. Give this map to the construction supervisor before construction begins.

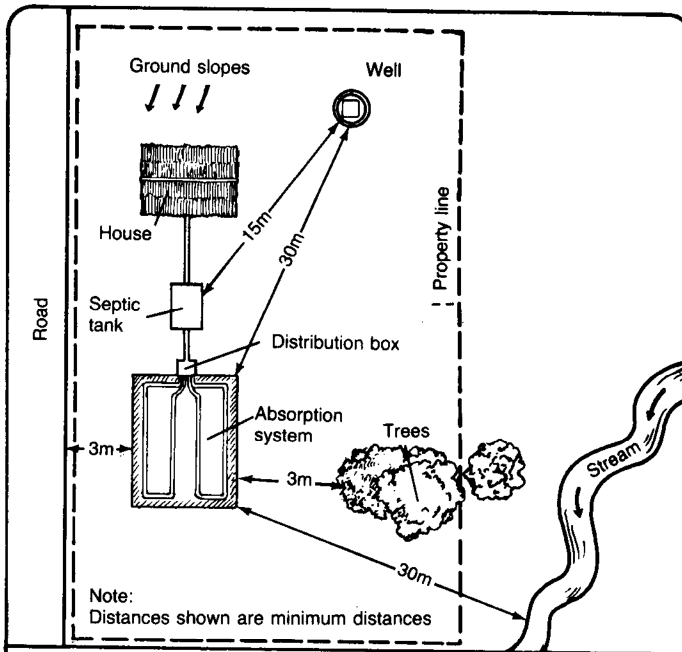

Figure 1. Location Map

Determining the Type and Size of the System

The type of subsurface absorption system selected is affected by groundwater level, size of lot, contour of the terrain, availability of materials, and personal preference.

For example, if the groundwater level is low, a pit may be the choice. If the lot is long and narrow, a single trench may be best. If the lot is flat and level, a field may be the most reasonable option. If the terrain is uneven, an open-end system of trenches may be the wisest selection. Table 1 will help in selecting a system:

Table 1. Comparison of Absorption Systems

System	Advantages	Disadvantages
Pit	Only a small area is needed; can be used if drainpipe is not available.	Can be used only in areas of low groundwater levels; may be difficult to excavate.
Trench	Can be used in areas of high groundwater levels and on uneven and sloped terrain.	May require large or elongated areas and large quantities of drainpipe.
Field	Can be used in areas of high groundwater levels; only a small area is needed.	Terrain must be fairly level.

When the type of system has been selected, determine its size. The size depends on the configuration of the system, such as a long trench or square field, and the area of absorbent earth needed. The required area depends on the allowable rate of sewage application, already determined by the soil suitability test, and the estimated daily flow of sewage effluent. The daily flow can be estimated by several methods (see "Estimating Sewage or Washwater Flows," SAN.2.P.2). Use the same daily flow estimate to design the absorption system that was used to design the adjoining septic tank or cesspool.

The estimated daily flow, expressed in liters per day, is divided by the allowable rate of sewage application, expressed in liters per square meter per day, to find the required area of absorbent earth, expressed in square meters. See Worksheet A, Lines 1, 2, and 3. Worksheet A is a sample showing how to calculate the size of an absorption system. You should develop a similar worksheet for your own use.

$$\frac{\text{estimated daily flow (liters per day)}}{\text{allowable rate of sewage application (liters per square meters per day)}} = \text{required area (square meters)}$$

For example, suppose that from "Determining Soil Suitability," SAN.2.P.3, the allowable rate of sewage application is 61.1 liters per square meter per day and from "Estimating Sewage or Washwater Flows," SAN.2.P.2, the estimated daily flow of sewage effluent is 1700 liters per day.

Then the required area of absorbent earth is:

$$\frac{1700 \text{ l/d}}{61.1 \text{ l/m}^2\text{/d}} = 27.8\text{m}^2$$

The area of absorbent earth required determines the size of the system. This area equals the bottom area of a trench, or trenches; the bottom area of a field; or the bottom area plus the area of the vertical earth walls below the inlet of a pit.

Determining Trench Size

The width of a trench must be 300 to 600mm. The length must be no more than 46m because a trench any longer loses its effectiveness. The size of the trench is determined by the area of the bottom. This area must be no less than the required area of absorbent earth. See Worksheet A, Lines 4 and 5.

For example, suppose the required area of absorbent earth is 27.8m^2 and the desired trench width is 600mm. To find the necessary trench length, divide the area by the width.

$$\frac{27.8\text{m}^2}{0.6\text{m}} = 46\text{m}$$

The trench must be 46m long.

Suppose, for the same example, there is not enough room for a single trench 46m long. Design two or more trenches whose combined lengths equal 46m. For example you could use two trenches each 23m long. See Worksheet A, Lines 6 and 7.

The final dimensions should be written on the technical drawings similar to Figures 2 and 3 and given to the construction supervisor.

Determining Field Size

Absorption fields are usually square or rectangular. The size of the field is determined by the area of the bottom. This area must be no less than the required area of absorbent earth. See Worksheet A, Lines 8 and 9.

For example, if the required area of absorbent earth is 27.8m^2, then a square field would be 5.3m on each side:

$$5.3\text{m} \times 5.3\text{m} = 27.8\text{m}^2$$

A rectangular field could be 3.1m wide and 9.1m long:

$$3.1\text{m} \times 9.1\text{m} = 27.8\text{m}^2$$

The final dimensions should be written on a technical drawing similar to Figure 4 and given to the construction supervisor.

Worksheet A. Calculating the Size of an Absorption System

System Type (check one): [X] trench [X] field [X] pit

Line 1. Allowable rate of sewage application: 61.1 lpd/m^2

Line 2. Estimated daily flow: 1700 lpd

Line 3. Required area of absorbent earth = $\frac{\text{Line 2}}{\text{Line 1}}$ = 27.8 m^2

If System is a Trench:

Line 4. Proposed trench width: 0.6 m

Line 5. Necessary trench length = $\frac{\text{Line 3}}{\text{Line 4}}$ = 46 m

If more than one trench is required (or desired):

Line 6. Number of trenches: 2

Line 7. Necessary length of each trench = $\frac{\text{Line 5}}{\text{Line 6}}$ = 23 m

If System is a Field:

Line 8. Proposed field width: 5.3 m

Line 9. Necessary length = $\frac{\text{Line 3}}{\text{Line 8}}$ = 5.3 m

If System is a Pit:

Pit Type (check one): [X] square [X] rectangular [X] circular

If pit is square:

Line 10. Proposed length of each side: 2.4 m

Line 11. Bottom area = Line 10 times Line 10 = 5.7 m^2

Line 12. Total wall area = Line 3 minus Line 11 = 22.1 m^2

Line 13. Necessary depth below inlet = $\frac{\text{Line 12}}{4 \times \text{Line 10}}$ = 2.3 m

If pit is rectangular:

Line 14. Proposed length of pit: 2.6 m

Line 15. Proposed width of pit: 2.2 m

Line 16. Bottom area = Line 14 x Line 15 = 5.7 m^2

Line 17. Total wall area = Line 3 minus Line 16 = 22.1 m^2

Line 18. Necessary depth below inlet = $\frac{\text{Line 17}}{2 \times \text{Line 14} + 2 \times \text{Line 15}}$ = 2.3 m

If pit is circular:

Line 19. Proposed diameter: 2.8 m

Line 20. Radius of pit = $\frac{\text{Line 19}}{2}$ = 1.4 m

Line 21. Circumference = 2 x 3.1 x Line 20 = 8.7 m

Line 22. Bottom area = 3.1 x Line 20 x Line 20 = 6.1 m^2

Line 23. Area of circular wall = Line 3 minus Line 22 = 21.7 m^2

Line 24. Necessary depth below inlet = $\frac{\text{Line 23}}{\text{Line 21}}$ = 2.5 m

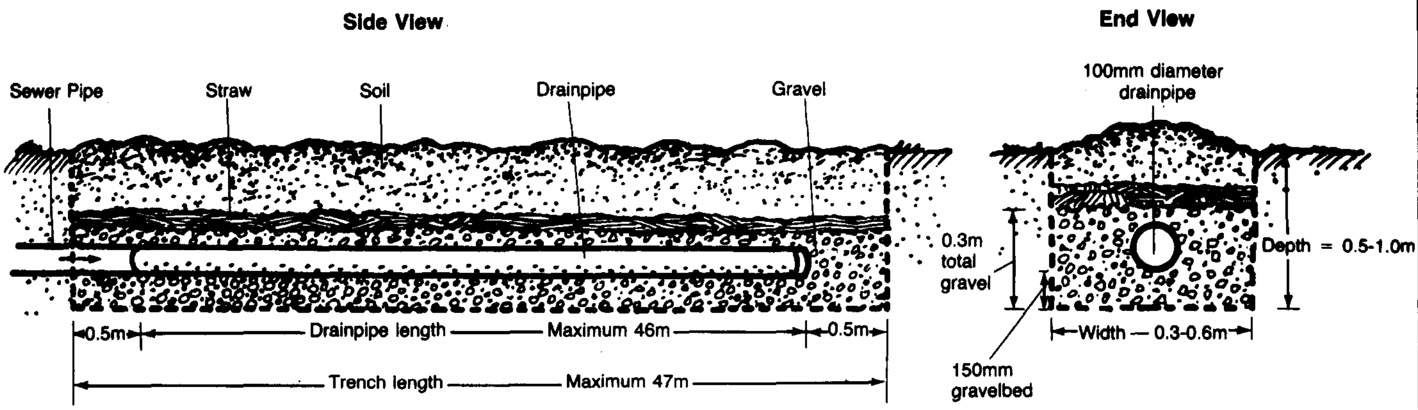

Figure 2. Absorption Trench

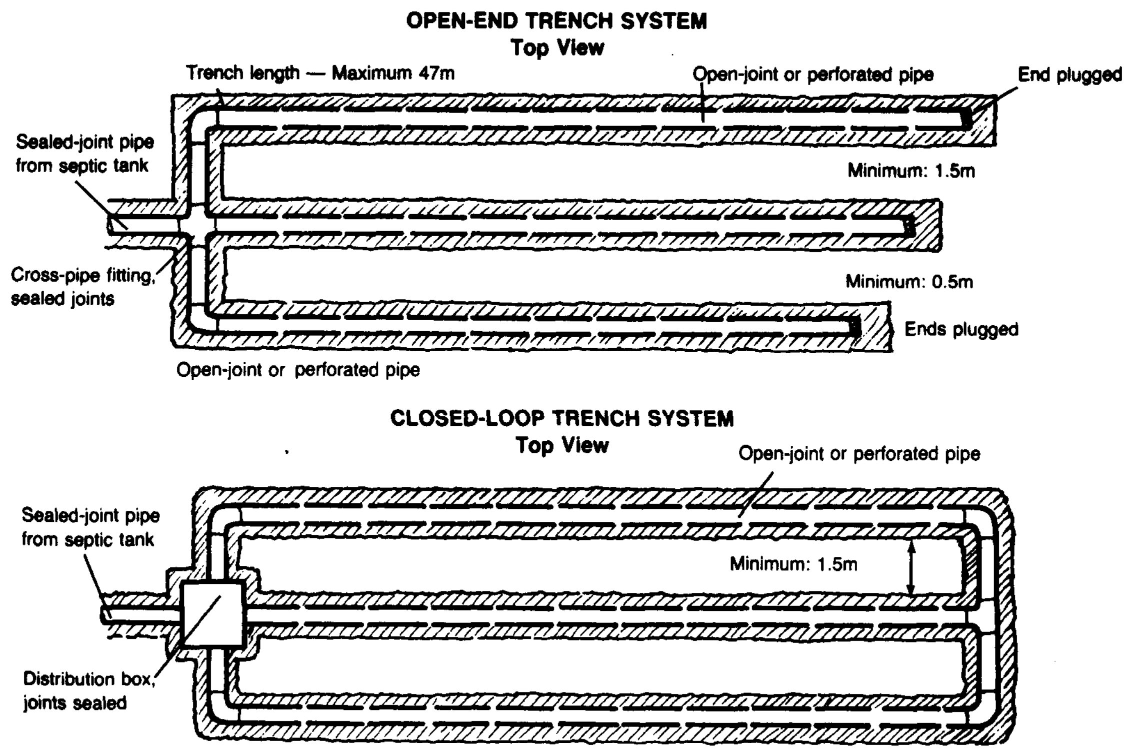

Figure 3. Multiple Trench Systems

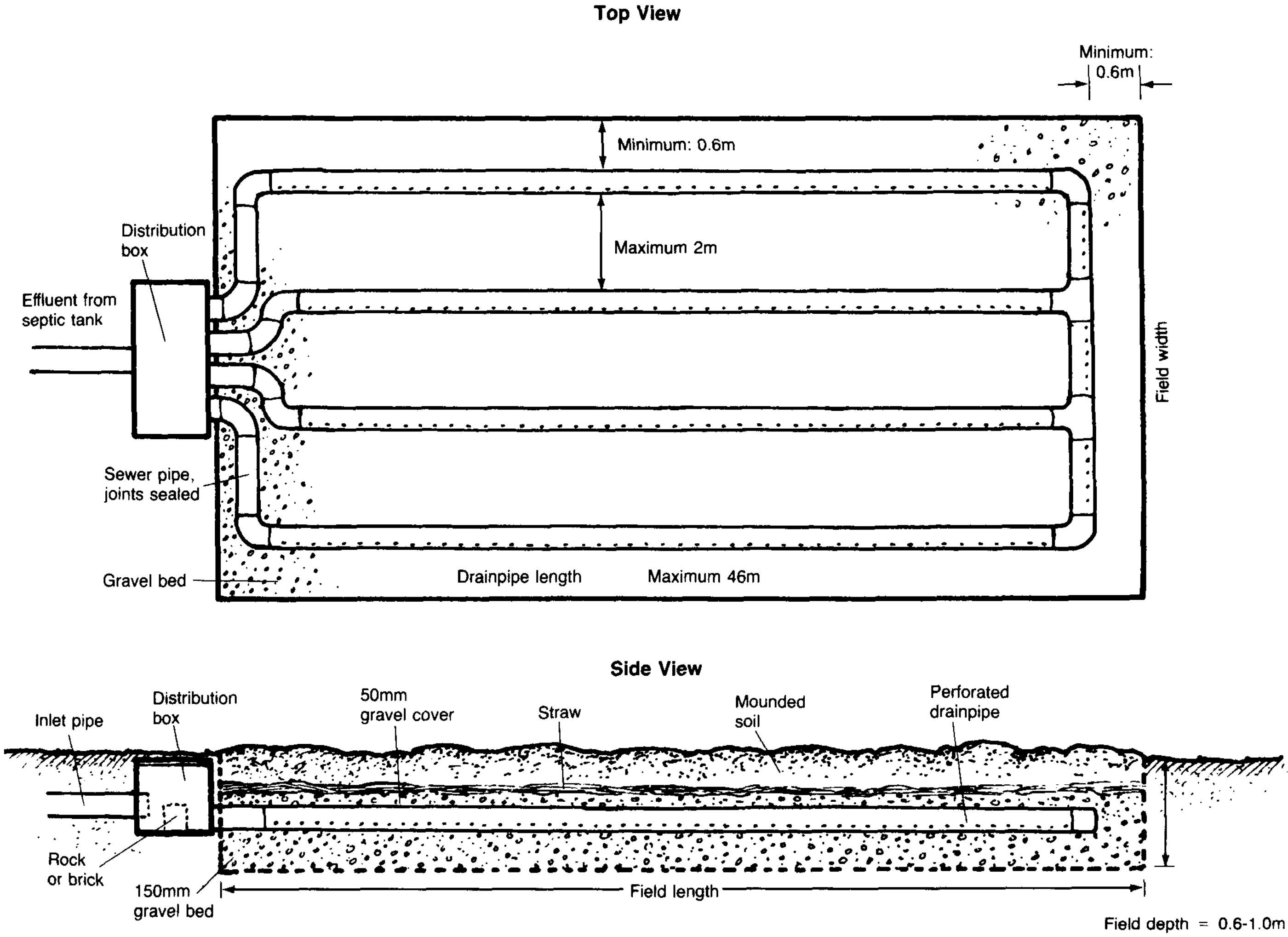

Figure 4. Absorption Field

Determining the Pit Size

A pit may be square, rectangular or round. The area of the pit below the inlet must be no less than the required area of absorbent earth. If the pit is square or rectangular, determine the area by adding the areas of the four earth walls below the inlet and the area of the bottom. If the pit is round, determine the area by adding the area of the circular earth wall below the inlet and the area of the bottom.

When calculating the area of a circular pit, the following information will be helpful:

d = diameter

r = radius

c = circumference

$r = \frac{d}{2}$

$c = 2 \times 3.1 \times r$

$3.1 \times r^2$ = area of bottom

c times depth below inlet = area of circular wall

For example, if the required area of absorbent earth is $27.8m^2$, then the area of the pit below the inlet must be at least this much. It can be more.

A square pit could be 2.4m on each side and 2.3m deep below the inlet. See Worksheet A, Lines 10, 11, 12 and 13. Thus:

area of four sides = 2.4m x 2.3m x 4 = 22.1m^2

area of bottom = 2.4m x 2.4m = 5.7m^2

total area = sides + bottom = 27.8m^2

A rectangular pit could be 2.6m long by 2.2m wide and 2.3m deep below the inlet. See Worksheet A, Lines 14, 15, 16, 17, and 18. Thus:

area of two sides = 2.6m x 2.3m x 2 = 12.0m^2

area of two ends = 2.2m x 2.3m x 2 = 10.1m^2

area of bottom = 2.2m x 2.6m = 5.7m^2

total area = sides + ends + bottom = 27.8m^2

A circular pit could be 2.8m in diameter and 2.5m deep below the inlet. See Worksheet A, Lines 19, 20, 21, 22, 23, and 24. Thus:

area of bottom = 3.1 x r^2 = 3.1 x 1.4m x 1.4m = 6.1m^2

area of wall = 2 x 3.1 x r x depth below inlet = 2 x 3.1 x 1.4m x 2.5m = 21.7m^2

total area = bottom + circular wall = 27.8m^2

The final dimensions should be written on a technical drawing similar to Figure 5 and given to the construction supervisor. In addition to showing dimensions, the technical drawing of a trench, series of trenches, field or pit will contain other design information.

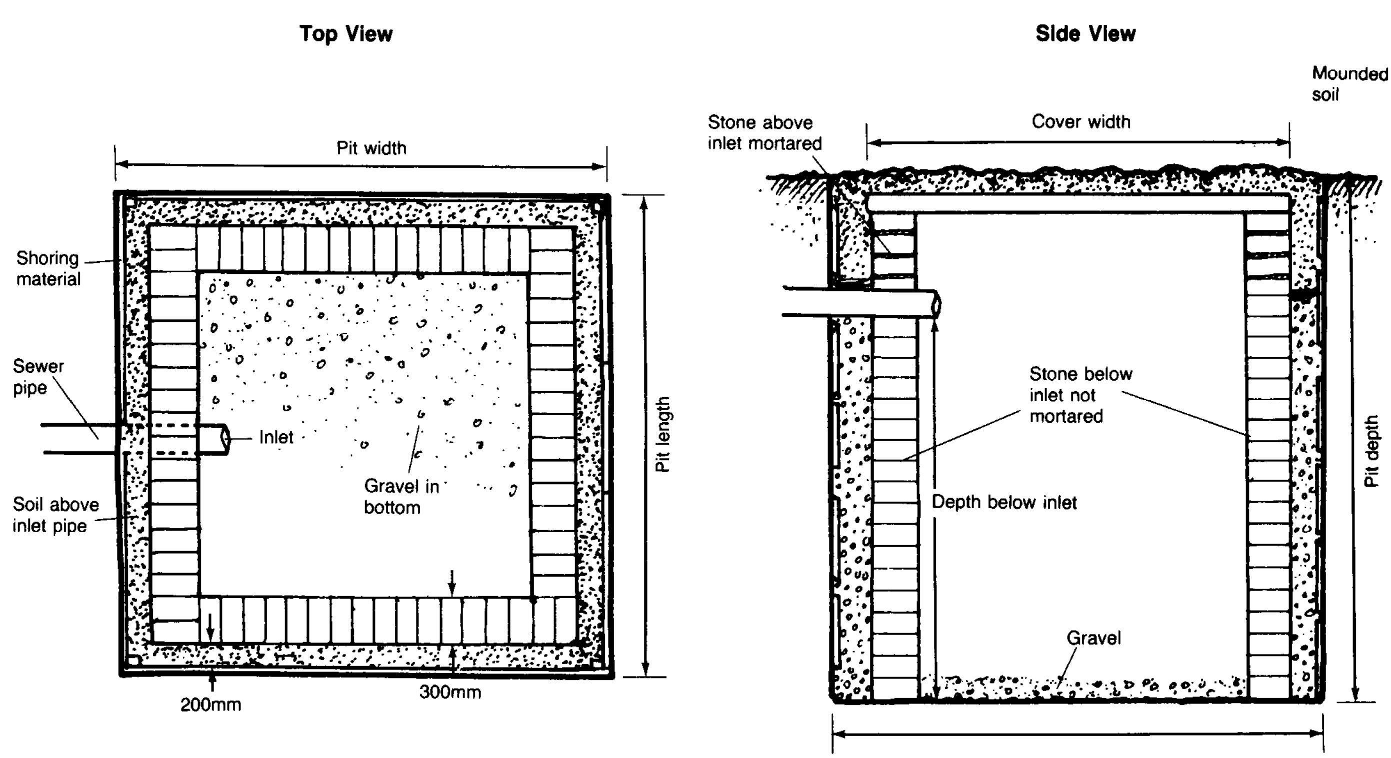

Figure 5. Absorption Pit

Design Information for a Trench or Series of Trenches

A trench must be 0.3 to 0.6m wide, and no more than 1.0m deep. It must not be longer than 46m. If there are two or more trenches, they must be at least 1.5m apart. Each trench should have a grade no steeper than one in 200. This means the trench drops one unit in elevation for every 200 units of length.

About 150mm of clean gravel or crushed rock must be laid in the bottom of the entire length of the trench or trenches. Drainpipe is laid on the gravel in the center of the trench. The pipe should be 100mm in diameter. It may be made of clay, concrete, perforated tile, plain or perforated plastic, or bell-and-spigot glazed tile. Pipe sections are usually 0.3 to 1.0m long. If the pipe is not perforated, pipe sections must be laid end to end but not mortared, so the effluent can seep between the sections into the gravel. Building or tar paper must be laid over the open joints to prevent gravel from filling in the open space.

The drainpipe must be covered with about 50mm of clean gravel or crushed rock. The gravel or crushed rock must be covered with a pervious material such as untreated paper, straw, hay, or grass. This material will prevent cover dirt from sifting down into the gravel and clogging it. The entire trench must be filled and mounded with dirt. The dirt must not be tamped.

Prepare a technical drawing similar to Figure 2, showing the end and side views of the trench with the correct dimensions written in. Give this drawing to the construction supervisor prior to beginning work.

If two or more trenches are being used, they may be joined at the ends (closed-loop), or not joined (open-end). If they are open-ended trenches, the end of the last pipe section must be plugged with concrete or other material that will not decay. The trench lines should be parallel and the pipelines must be no closer together than 1.5m. Figure 3 shows some typical configurations for series of trenches.

Prepare a technical drawing similar to Figure 3 showing the length of each trench and the distances between pipelines. This is in addition to the technical drawings similar to Figure 2. Give this drawing to the construction supervisor before construction begins.

If two or more trenches are being used, there must also be a distribution box or equivalent. The box receives effluent from the septic tank and distributes in evenly to all trenches. It must be watertight and have a cover. If there are only two or three trenches, a sewer tile "cross" or "T" may be substituted for a distribution box.

A distribution box is usually concrete, but it may be brick and mortar, metal, or wood. The box must have minimum inside dimensions of 450mm by 450mm. The depth of the box, as well as the depth of the absorption trenches, will depend on the depth of the outlet pipe from the septic tank and the slope of the ground, but should not be much more than 1m.

The bottom of the box must be level. The sewer pipe from the septic tank must enter the box 100 to 150mm above the floor. The pipes going out to the trenches must be level with the floor, and they must all be the same elevation to ensure an even distribution of effluent. A brick or stone is usually placed in the center of the box to prevent effluent from flowing straight across the floor and out one pipe only. All pipe joints in and out of the distribution box must be mortared.

If you are designing a distribution box, prepare a technical drawing similar to Figure 6, showing the width, length, and depth of the box, the distance from inlet pipe to floor, and the thickness of the walls if they are concrete. Give this drawing to the construction supervisor before construction begins.

Design Information for an Absorption Field

An absorption field is usually square or rectangular. It must be nearly level, with a depth of 0.6m to

1.0m. About 150mm of clean gravel or crushed rock must be spread over the entire bottom of the field.

Drainpipes are laid on the gravel similar to a closed-loop series of trenches. The pipes must be parallel, no more than 2m apart, and no closer than 0.6m from the sides of ends of the field. The drainpipe may be perforated or open-joint.

Building or tar paper must be laid over the open joints to prevent gravel from filling in the open spaces. Clean gravel or crushed rock is spread over the pipe to a depth of 50mm. The gravel must be covered with untreated paper, straw, hay, or grass. The entire field is covered with dirt and mounded, but not tamped. The distribution box is designed in the same way as the one for a series of trenches.

Prepare a technical drawing similar to Figure 4 showing top and side views of the field with the correct dimensions written in. Also, prepare a technical drawing similar to Figure 6, showing the width, length, and depth of the distribution box, the distance from the inlet pipe to the floor, and the thickness of the walls if they are concrete. Give both these drawings to the construction supervisor before construction begins.

Design Information for a Pit

An absorption pit may be square, rectangular or circular.

The constructed side walls should be about 300mm thick and made of field stones, cinder blocks, precast perforated wall sections, or bricks. The side walls should be mortared above the inlet for strength. They must not be mortared below the inlet so the effluent can soak through.

Leave a space of about 200mm between the earth walls of the pit and the constructed side walls. This space must be filled with clean gravel or crushed rock. The inlet pipe must be extended 100 to 150mm inside the constructed side wall to prevent sewage effluent from running down the wall.

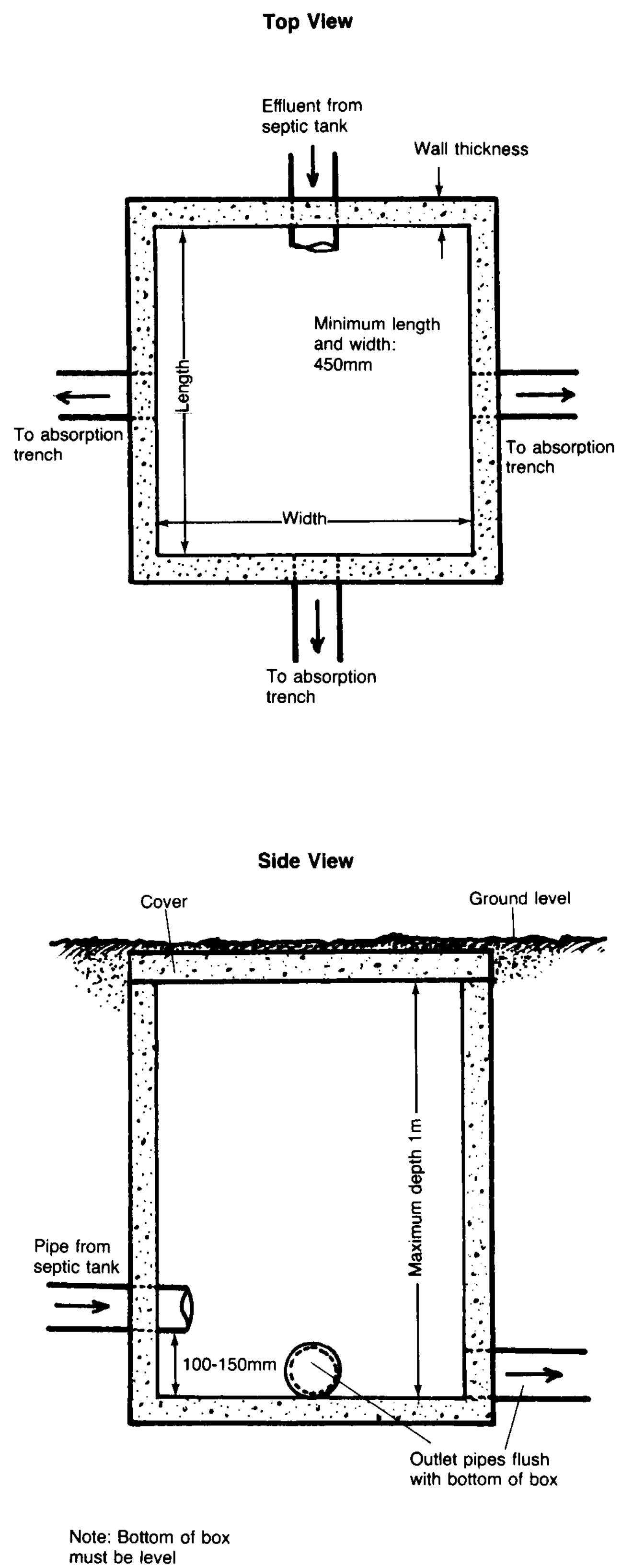

Figure 6. Distribution Box

Design a well-fitting, strong, watertight cover for the pit. It may be in one piece or in sections. It must prevent a person from falling into the pit, prevent the entry of water or animals, and support the weight of the earth that will cover it.

Prepare a technical drawing similar to Figure 5 showing top and side views of the pit with the correct dimensions written in, including the length, width, and depth below ground level, the depth below the inlet, the thickness of the side walls and the space between the earth walls and the side walls. Give this drawing to the construction supervisor before construction begins.

Design Information for Sewer Pipe from Septic Tank to Absorption System

The trench for a sewer pipe should be as straight as possible. It can be as shallow as 300mm deep, as narrow as 300mm wide, and should have an even and continuous downward slope toward the absorption system of about one in 100. Sewer pipe is usually 100mm in diameter and is made of clay, concrete, or plastic.

Prepare a drawing similar to Figure 7 and write in the correct trench width, depth, and slope; the pipeline length from the septic tank (see "Designing Septic Tanks," SAN.2.D.3) to the distribution box, if any; and from the box to the absorption system. Give this drawing to the construction supervisor before construction begins.

Materials List

In addition to the location map and the technical drawings, provide a materials list for the construction supervisor similar to the sample shown in Table 2. The list must include labor requirements, types and quantities of materials and tools, and the estimated funds needed to construct the system. This technical note provides the means of calculating most quantities. Those remaining will have to be determined by the project designer or the construction supervisor.

Labor. All absorption systems require unskilled manual laborers to dig a trench, field, or pit. One worker must be familiar with cement mortar, or similar material, used to mortar pipe joints. If the system has

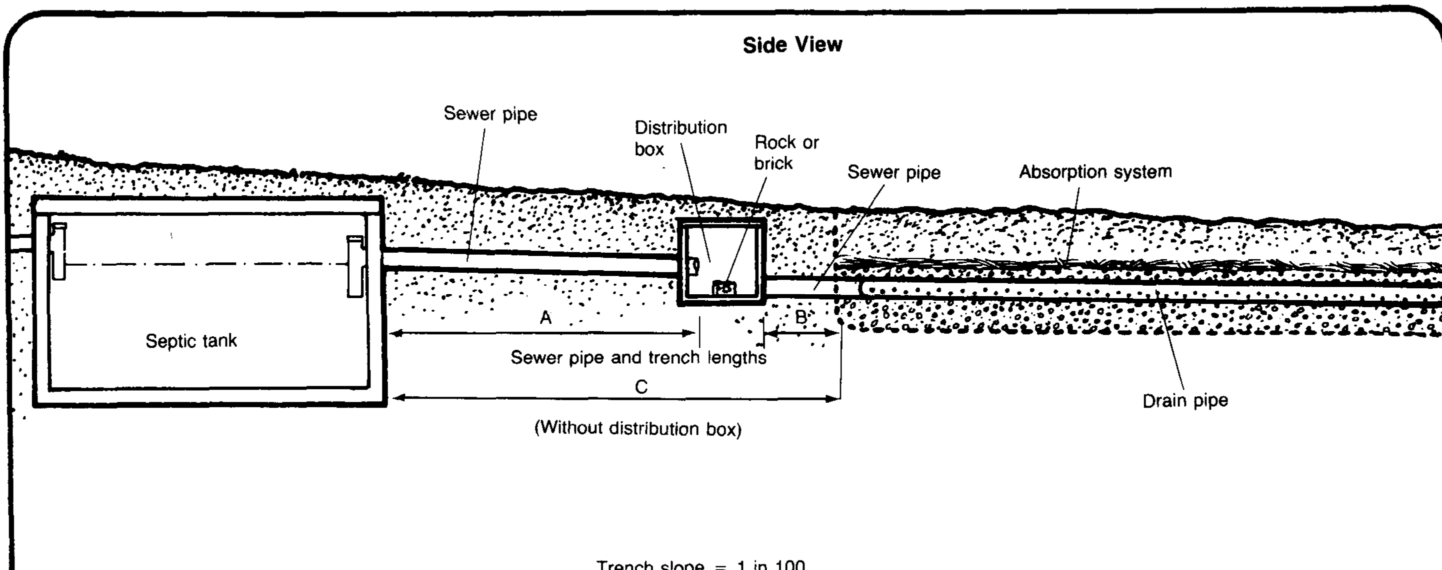

Figure 7. Sewer Pipe from Absorption Tank to Absorption System

Table 2. Sample Materials List for Absorption System

Item	Description	Quantity	Estimated Cost
Labor	Foreman	1	____
	Laborers (one experienced with concrete or mortar, if applicable)	2 (at least)	____
Supplies	Wooden stakes for marking out system	____	____
	Sewer pipe; 100mm diameter, clay, concrete, or plastic	____m, enough to reach from septic tank to absorption system	____
	Drainpipe; 100mm diameter, perforated or open-joint sewer pipe (open-joint sections 0.5m long)	____m, enough to construct trench, trenches or field	____
	Gravel or crushed rock; clean, size from 12 to 50mm	____m^3, enough to fill trenches or field or wall space in pit	____
	Tar, mortar, or oakum (for sealing pipe joints)	____	____
	Tar paper or building paper (for covering open joints)	____m^2, enough to cover all joints	____
	Untreated paper, straw, hay, or grass (for covering gravel)	____	____
	If pit:		
	Wood, poles, bamboo, or other material for shoring sides	____	____
	If distribution box:		
	Cement: portland	____m^3	____
	Sand: clean, fine to 6mm	____m^3	____
	Gravel: clean, 6 to 38mm	____m3	____
	Water: clear, enough to make stiff mix	____liters	____
	Wooden boards (for building forms)	____	____
	Nails (for building forms)	____	____
	Other	____	____
Tools	Rake or hoe	1	____
	Measuring tape	1	____
	Shovels	2 (at least one per worker)	____
	Wheelbarrow	1	____
	Carpenter's level or equivalent	1	____
	If pit or distribution box:		
	Hammer	1	____
	Saw	1	____
	If concrete distribution box:		
	Container (for mixing)	1	____
	Trowel	1	____
	Other	____	____

Total Estimated Cost= ____

a distribution box made from concrete, or if the system is a pit with a concrete cover, one worker must be experienced with mixing and pouring concrete, positioning reinforcing material, and building forms. If the system is a pit, one worker must be experienced with mixing mortar and laying bricks.

Sewer pipe. This is needed for all absorption systems. The pipe is usually 100mm in diameter and made from noncorrosive material such as vitrified clay, concrete, or special plastic. The quantity of pipe depends on the layout of the system and is equal to the distance from the septic tank to the absorption system.

Drainpipe. This is needed for trench and field absorption systems. It can be perforated or open-joint pipe and it must be noncorrosive such as vitrified clay, concrete or plastic. If non-perforated plastic pipe is available, it can be used as (a) perforated pipe by drilling 12mm holes 150mm apart in two parallel rows along the bottom of the pipe, or (b) as open-joint pipe by sawing it into 450mm sections. The amount of pipe needed depends on the length and number of trenches or the size of the field.

For a trench, the amount of drainpipe needed equals the length of the trench. For example, if the trench is 30m long, then 30m of drainpipe is needed.

For a series of trenches, the amount of pipe needed equals the sum of the lengths of all trenches. For example, if there are three trenches whose lengths are 25m, 30m, and 35m, then the amount of drainpipe needed is 25m+ 30+ 35m = 90m.

For a field, the amount of pipe needed depends on the length and the number of drainpipes within the field. Since the length and number of pipes depend on: the size of the field, the distance between the lines, and the distance between the outside lines and the sides of the field, it is difficult to calculate the amount of drainpipe needed. The best way to determine the amount is to consult the technical drawing similar to Figure 5 and add the lengths of the pipelines shown there.

Mortar. This is needed for all systems. It is used to seal all sewer pipe joints and some drainpipe joints, to plug the end of drainpipes in open-end trench systems, and to mortar side walls above the inlet in pit systems. The amount will vary depending on the type of mortar, type and size of system, and so on. For cement mortar (one part portland cement to three parts clean sand and enough clear water to make a workable mix), 0.028 cubic meters may be enough to mortar all necessary pipe joints. A similar amount may be enough to mortar the side walls above the inlet in a pit system.

Concrete. This is needed if the design calls for a concrete distribution box or a concrete cover for a pit. A common concrete mix is one part cement to two parts sand to three parts gravel and enough water to make a fairly stiff mix. See "Designing Septic Tanks," SAN.2.D.3, for details on estimating quantities of concrete mix and reinforcing materials.

Gravel or crushed rock. This is needed for all systems. It may range in size from 12 to 50mm. The amount will depend on the type and size of the system and can be estimated as follows:

for a trench system: length of trench times width of trench times depth of gravel (0.3m)

___(m) x ___(m) x 0.3m = ___(m^3)

for a series of trenches: calculate the amount for each trench and add them together:

___(trench 1) + ___(trench 2) + ___(trench 3) + etc. = ___(m^3)

for a field: length of field times width of field times depth of gravel (0.3m):

___(m) x ___(m) x 0.3m = (m^3)

for a pit: total wall area (from Worksheet A, Line 12, 17, or 23) times space between side wall and earth wall (0.2m):

___(m^2) x 0.2m = (m^3)

Example 1 - a trench 0.6m wide and 40m long:

gravel = 0.6m x 40m x 0.3m = $7.2m^3$.

Example 2 - three trenches identical to the trench in Example 1:

gravel = $7.2m^3$ + $7.2m^3$ + $7.2m^3$ = $21.6m^3$.

Example 3 - a field 12m long by 8m wide:

gravel = 12m x 8m x 0.3m = $28.8m^3$.

Example 4 - a pit with a wall area of $22m^2$:

gravel = $22m^2$ x 0.2m = $4.4m^3$.

Other Materials. The quantities of some materials are best estimated according to local conditions, type of material, availability, and local construction methods. Some of these materials are building or tar paper to cover pipe joints; boards, poles, bamboo or other material used to shore up sides of pit; wood and nails used to build concrete forms for distribution box; wire mesh or steel rods used to reinforce concrete; and tar, mortar, or oakum used to seal pipe joints.

Tools. The tools needed will vary according to the type of system and local construction practices. All systems require one or more shovels or other digging implements to excavate the trench, field, or pit. Other tools that may be useful include a wheelbarrow to cart gravel; hammer, saw, and nails to build shoring for pit walls and to build forms for concrete distribution box; shovel, container, and trowel for mixing, pouring, and smoothing concrete; and carpenter's level and stringline, or equivalent, to check slope of trench. Make your best estimate based on local conditions.

Cost. The cost of the system depends on such things as which materials are already available and which must be purchased; how much labor will be volunteered and how much must be paid; and prices and wage rates. Make your best estimate based on local conditions.

When all calculations, determinations, and estimates have been made, prepare a materials list similar to Table 2 and give it to the construction supervisor.

In summary, give the construction supervisor: (1) a location map similar to Figure 1, showing the absorption system in relation to all nearby manmade structures and geological features; (2) technical drawings similar to Figure 7 (for all systems), Figure 2 (for a trench system), Figures 2 and 3 (for a series of trenches), Figure 4 (for a field system), Figure 5 (for a pit system), and Figure 6 (if there is to be a distribution box); and (3) a materials list similar to Table 2 showing labor, materials, tools, and money needed to construct the system.