Water for the World

Determining Soil Suitability

Technical Note No. SAN. 2.P.3

Determining soil suitability for disposal of excreta, washwater, sewage, or sewage effluent is important because some soils cannot safely be used for disposal systems. Systems in unacceptable soils can cause serious health hazards, including contaminated drinking water. Determining soil suitability involves: (1) evaluating soil types, (2) locating groundwater and bedrock levels, (3) determining soil permeability, and (4) determining the allowable rate of sewage effluent application.

Useful Definitions

CONTAMINATE - To make unclean by introducing an infectious disease-causing impurity, such as bacteria from excreta.

EFFLUENT - Settled sewage.

EXCRETA - Human body wastes.

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

IMPERVIOUS - Not allowing liquid to pass through.

PERCOLATION RATE - The speed at which water flows through the soil, usually measured in minutes per 25mm.

PERMEABLE - Allowing liquid to soak in.

SEWAGE - All washwater, excreta, and water used to flush excreta that flows from a building or buildings through a sewer pipe and into a septic tank, cesspool, or stabilization pond.

WASHWATER - Water that has been used for bathing or washing clothes, dishes, or kitchen utensils.

WASTE LIQUID - Sewage effluent, sewage, washwater, or liquid from excreta.

Materials Needed

Shovel
Watch or other timepiece
Measuring tape or ruler
Lath, slat, or straight stick about 1m long
Board or piece of lumber about 0.6m long
Pencil
Auger with extension handles (optional; although not essential, this is an extremely useful tool for digging test holes)

Evaluating Soil Types

An important question concerning soil is how fast it will allow waste liquid to percolate or flow into it. If the waste liquid percolates too fast, the soil will not have a chance to treat it by removing disease-causing substances or agents, and the waste liquid may seep into and contaminate the groundwater. If the waste liquid does not percolate fast enough, it may overflow to the ground surface, causing serious health hazards.

Different types of soils percolate waste liquid at different rates. Some types of soil are acceptable for disposal systems; others are not.

Identifying Soil Types. The six basic types of soil are: (1) sand, (2) sandy loam, (3) loam, (4) silt loam, (5) clay loam, and (6) clay. They can be identified by sight and feel. When testing soil by feel, test it when both dry and moist.

(1) Sand. Individual grains easily seen and felt. A handful of sand squeezed when dry will not hold its shape; squeezed when moist, it will barely hold its shape, crumbling when touched.

(2) Sandy Loam. Contains a large percentage of sand so that sand grains can be seen and felt. Squeezed when dry, a handful of sandy loam will not hold its shape; squeezed when moist, it holds its shape and forms a cast that will not break when handled carefully.

(3) Loam. Has a fairly smooth, yet slightly gritty feel; clods crumble easily. Squeezed when dry, loam forms a cast that can be handled carefully without breaking; squeezed when moist, the cast can be handled freely without breaking.

(4) Silt Loam. Feels soft and floury; clods are easily crumbled. Squeezed when dry or wet, silt loam forms a cast that can be handled freely without breaking. A small ball of moist soil pressed between thumb and finger will not form a ribbon.

(5) Clay Loam. Fine-textured; clods are hard. Moist clay loam is plastic and, when squeezed, forms a cast that can withstand considerable handling without breaking. A small ball of moist clay loam pressed between thumb and finger forms a thin ribbon that barely sustains its own weight.

(6) Clay. Fine-textured; clods are very hard. Wet clay is plastic and usually sticky. A small ball of moist clay pressed between thumb and finger forms a long ribbon.

When the soil at the proposed site has been identified by sight and feel, use Table 1 to determine whether it is suitable for a disposal system.

Table 1. Soil Suitability

Soil Type	Suitability
Sand	No
Sandy Loam	Yes
Loam	Yes
Silt Loam	Yes
Clay Loam	Yes/No*
Clay	No

*Yes, if test is for system other than pit or improved privy and if percolation rate is less than 60 minutes per 25mm; no, if test is for pit or improved privy or if percolation rate is more than 60 minutes per 25mm.

Locating Groundwater and Bedrock Levels

Most disposal systems require a minimum of 1m of pervious soil below the bottom of the system and above the highest groundwater level, bedrock, or impervious layers. The most direct method of locating groundwater levels, bedrock, and impervious layers is to dig a test hole. The hole must be 1m deeper than the bottom of the proposed system.

An auger with extension handles is an ideal tool for digging test holes. If an auger is not available and the hole must be dug with a shovel, be very careful if the hole is deeper than 1.5m. The sides must be shored up to prevent cave-in and possible serious injury.

Bedrock. Bedrock or impervious layers are easily identified in a test hole as it becomes extremely difficult to dig and the soil consists mostly of rocks, shale, or tightly packed, consolidated material.

If bedrock or impervious layers are reached before the test hole reaches the proper depth, the proposed system cannot be constructed as designed. There are three choices: (1) select another site; (2) redesign the proposed system, if possible, to make it shallower but still with its bottom 1m above bedrock or impervious layers; or (3) select and design an alternate system that can be used at this site (see "Simple Methods of Excreta Disposal," SAN.1.M.1, "Simple Methods of Washwater Disposal," SAN.1.M.2, or "Methods of Combined Washwater and Excreta Disposal," SAN.2.M).

Groundwater. The same hole used to test for bedrock can be used to find groundwater levels. Groundwater is easily identified in a test hole. After a few hours, the hole will fill with water to the groundwater level or moist soil will be found at the groundwater level. Since the highest yearly groundwater level must be found, and since groundwater levels fluctuate throughout the year, test for groundwater during the wettest season.

If the highest groundwater level is encountered before the test hole reaches the proper depth, the proposed system cannot be constructed as designed. There remain the three choices noted earlier.

If soil type, bedrock layer, and groundwater level are all acceptable, and the proposed system is a pit or improved privy, the system can be constructed on the site with no further testing. If the proposed system is a soakage pit or trench, cesspool, or absorption field, a percolation test must be conducted at the site to determine, as accurately as possible, the permeability of the soil. The permeability will directly affect the size of the system.

Determining Soil Permeability

Soil permeability refers to the rate at which liquid percolates into the soil. Percolation of water into soil can be measured by digging a hole, pouring in water, and timing the rate at which the water drains out of the hole. This is called a percolation test. The test is fairly simple to conduct, but it must be done carefully in order to yield accurate results.

Conducting a Percolation Test.

1. Two percolation tests must be conducted at the proposed site. If the system is an absorption field or soakage trench, the tests should be conducted about one-third of the distance in from each end of the system, as shown in Figure 1. The test holes for a field or trench are dug to the depth of the system. For example, if the proposed trench is 1m deep, the test hole should also be 1m deep. If the proposed system is a cesspool or soakage pit, the tests are conducted in the center of the system at the proposed site of the cesspool or the soakage pit. The first test should be carried out at half the depth of the cesspool or pit, and the second test at the full depth. For example, if the proposed pit is 2.4m deep, the first percolation test is conducted at a depth of 1.2m, and the second at 2.4m. Generally, the results of the two tests will be about the same. If they differ, use the slower of the two percolation rates to design the system.

2. Dig or bore a hole about 300mm in diameter, or 300mm square, to the proper depth. Do not use the same hole used for locating groundwater and bedrock. That hole is too deep and, if filled in to the proper depth, will yield inaccurate test results. Make the walls of the hole vertical. Scrape the walls to remove any patches of compacted soil. Place about 50mm of clean gravel in the bottom of the hole.

3. Fill the hole with water and let it soak overnight. This will allow ample time for soil swelling and saturation, and provide more accurate test results.

4. Place a board or piece of lumber across the center of the hole and anchor it firmly in place, perhaps by placing a rock on each end. The board must not be moved until the test is complete. Mark a point near the center of the board to be used as a guide for the remainder of the test.

5. Most or all of the water poured in the day before will have drained away. Pour in enough water so that the depth is 200mm.

6. Place a pointed slat or similar measuring stick next to the reference mark on the board and slide it down until it just touches the water surface. Ripples on the water can be observed when the slat touches. Note the exact time and draw a horizontal

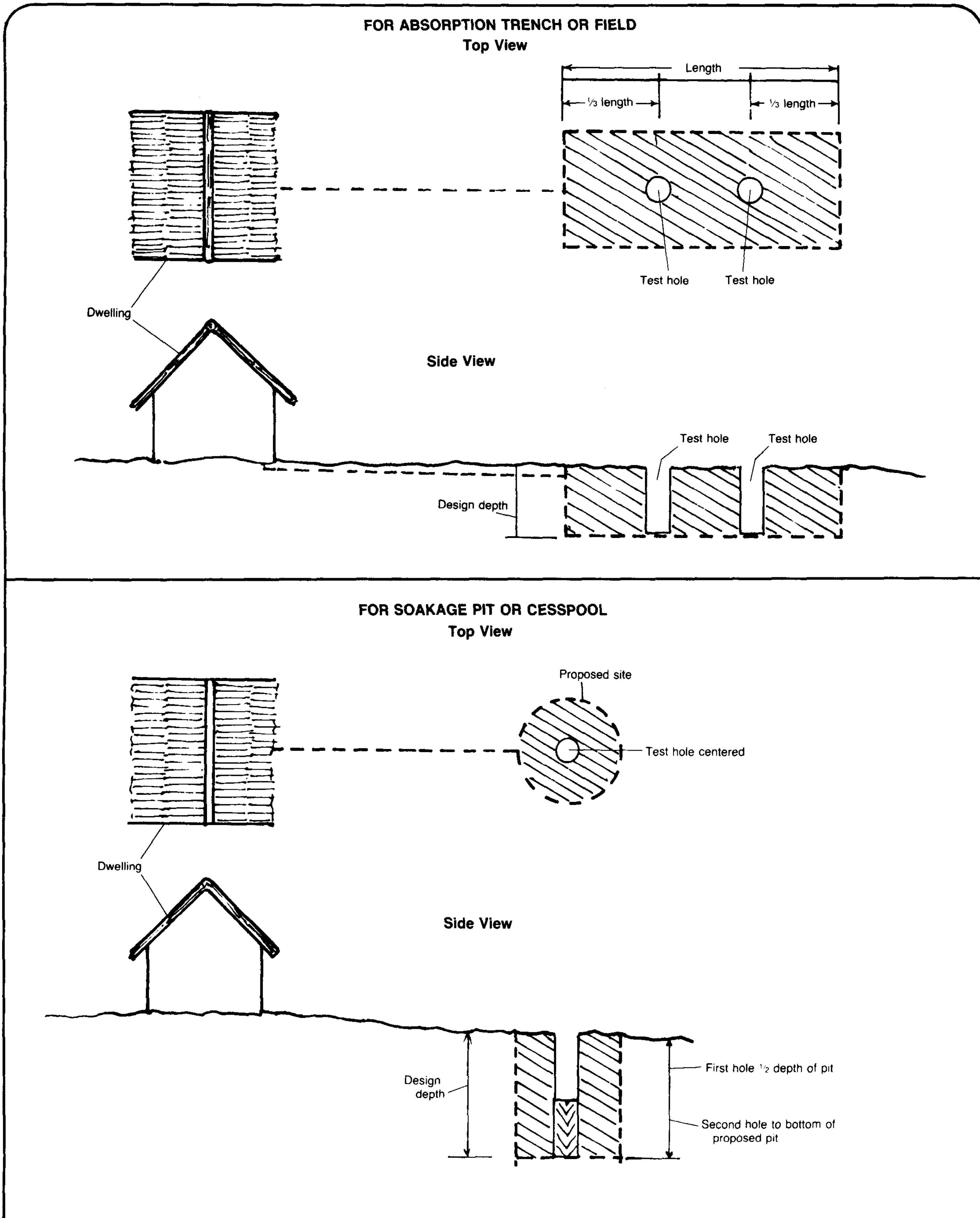

Figure 1. Location and Depth of Percolation Tests

line on the slat, using the edge of the board for a guide, as shown in Figure 2.

7. Repeat step 6 at 10-minute intervals. If the water level drops rapidly, repeat at one-minute intervals. Do not allow the water to drop lower than 100mm. If it does, pour in more water to the 200mm depth and continue the test.

8. Note the spacing between the pencil marks on the slat. When at least three spaces become approximately equal, as shown in Figure 3, the test is completed. This may take as little as one-half hour or as long as several hours.

9. Using the measuring tape or ruler, measure the space between the equal pencil markings and compute how long it took the water level to drop 25mm. This step is necessary because percolation rates are described in terms of "minutes per 25mm." This can be approximated closely with the ruler and a series of equally spaced markings on the slat, as shown in Figure 3, or it can be calculated. Worksheet A shows how to tabulate information and calculate soil suitability.

To find how long it takes for the water level to drop 25mm, divide 25mm by the distance between two equal markings and multiply by the time interval for those two markings.

For example, suppose the markings are made at 10-minute intervals and the distance between the equal markings is 9mm. Then:

$$\frac{25mm}{9mm} \times 10 \text{ minutes} = \text{about } 27 \text{ minutes}$$

The percolation rate is 27 minutes per 25mm.

If the percolation rate for 25mm is between 10 and 60 minutes, the soil is acceptable. The percolation rate can be used to determine the size of the system as described in the next section. If the percolation rate is less than 10 minutes or more than 60 minutes, the proposed system cannot be constructed as designed. There remain two choices: select another site for testing; or select and design an alternate system that can be used at this site.

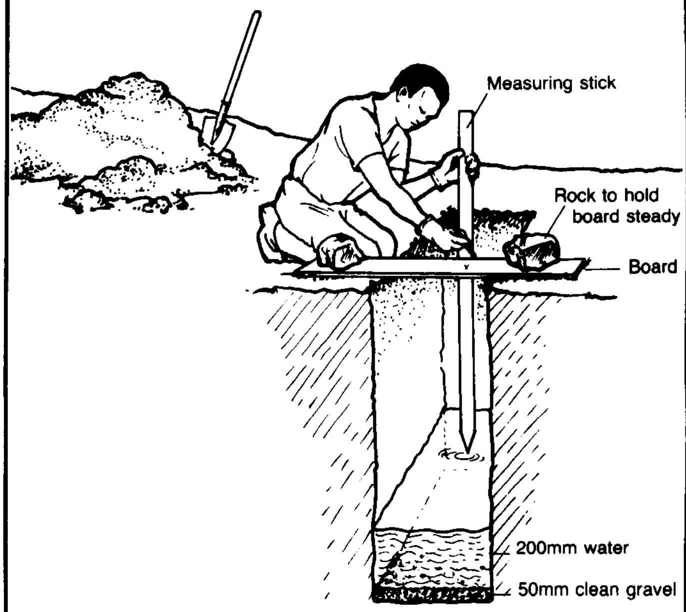

Figure 2. Test Hole with Apparatus

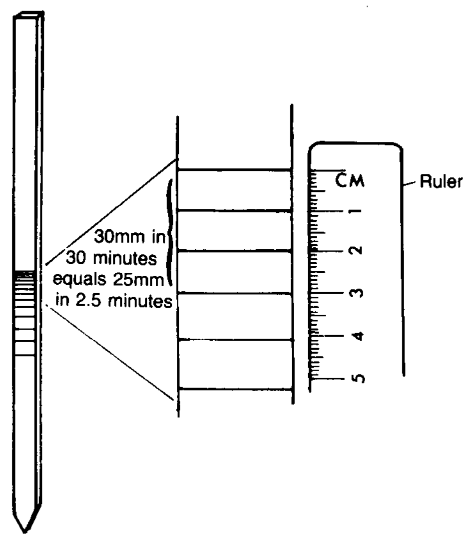

Figure 3. Typical Markings on Measuring Stick at Ten-Minute Intervals

Worksheet A. Determining Soil Suitability

Type of Disposal System (check one):

☐ pit or improved privy ☐ soakage trench ☒ absorption trench (or field)

☐ cesspool ☐ soakage pit ☐ other ______

Depth of system: 1m

1. Evaluating Soil Types.

Soil type found at site:

☐ sand ☐ sandy loam ☒ loam ☐ silt loam ☐ clay loam ☐ clay

Suitability: ☒ Yes ☐ No ☐ Maybe

2. Locating Groundwater, Bedrock or Impervious Layers.

Depth of test hole = depth of system + 1m
= 1m + 1m
= 2m

Was groundwater encountered? ☐ Yes ☒ No

If Yes, at what depth? ______

Do soil colorations indicate higher groundwater levels? ☐ Yes ☒ No

If Yes, at what depth? ______

3. Determining Soil Permeability (Percolation Test).

Depth of percolation test hole: 1m

Time interval for test marks: 10 minutes

Space between equal marks: 9mm

Percolation rate $= \frac{25\text{mm}}{\text{space}} \times$ minutes

$= \frac{25\text{mm}}{9\text{mm}} \times 10$ minutes

= 27 minutes

4. Determining Allowable Rate of Sewage Effluent Application from Table 2.

Rate of application: 37-41 lpd/m²

Determining the Allowable Rate of Sewage Effluent Application

To determine the allowable rate of application, use the results of the percolation test and Table 2. In the first column of Table 2, find the percolation rate as indicated by the field test. The second column shows the allowable rate of application for each percolation rate. The allowable rate of sewage effluent or washwater application is given in liters per day per square meter (lpd/m^2). This information, along with "Estimating Sewage or Washwater Flows," SAN.2.P.2, will be used to determine the size of the soakage pit or trench, cesspool, or absorption field.

Table 2. Allowable Rate of Effluent/Washwater Application

Percolation Rate (minutes per 25mm)	Allowable Rate of Application (lpd/m^2)
less than 10	soil not suitable
10	65
12	57
15	53
20	45
25	41
30	37
35	33
40	33
50	29
60	24
more than 60	soil not suitable