4. Bulk Density Test

The bulk density measurement should be performed at the soil surface and/or in a compacted zone (plow pan, etc.) if one is present . Measure bulk density near (between 1 and 2 feet) the site of the respiration and infiltration tests. To get a more representative bulk density measurement of the area, additional samples may be taken.

Materials needed to measure bulk density:

- **3-inch diameter ring**
- **hand sledge**
- **wood block**
- **garden trowel**
- **flat-bladed knife**
- **sealable bags and marker pen**
- **scale (0.1 g precision)**
- **1/8 cup (30 mL) measuring scoop**
- **paper cups**
- **18-inch metal rod**
- **access to a microwave oven**

Did You Know?

Bulk density is the weight of soil for a given volume. It is used to measure compaction. In general, the greater the density, the less pore space for water movement, root growth and penetration, and seedling germination.

Considerations: For rocky or gravelly soils, use the alternate procedure on page 11.

1 **Drive Ring into Soil**

- Using the hand sledge and block of wood, drive the 3-inch diameter ring, beveled edge down, to a depth of 3 inches **(Figure 4.1)**.

- The exact depth of the ring must be determined for accurate measurement of soil volume. To do this, the height of the ring above the soil should be measured. Take four measurements (evenly spaced) of the height from the soil surface to the top of the ring and calculate the average. Record the average on the Soil Data worksheet.

Figure 4.1

NOTE: Use the metal rod to probe the soil for depth to a compacted zone. If one is found, dig down to the top of this zone and make a level surface. Proceed with Step 1.

2 **Remove 3-inch Ring**

Dig around the ring and **with the trowel underneath it,** carefully lift it out to prevent any loss of soil.

3 Remove Excess Soil

Remove excess soil from the sample with a flat-bladed knife. The bottom of the sample should be flat and even with the edges of the ring **(see Figure 4.2).**

Figure 4.2

4 Place Sample in Bag and Label

Touch the sample as little as possible. Using the flat-bladed knife, push out the sample into a plastic sealable bag. Make sure the entire sample is placed in the plastic bag. Seal and label the bag.

NOTE: Steps 5-7 can be done in a lab or office if a scale is not available in the field. Step 8 requires access to a microwave.

5 Weigh and Record Sample

- Weigh the soil sample in its bag. [If the sample is too heavy for the scale, transfer about half of the sample to another plastic bag. The weights of the two sample bags will need to be added together. Enter the weight (sum of two bags, if applicable) on the Soil Data worksheet.

- Weigh an empty plastic bag to account for the weight of the bag. Enter the weight (sum of two bags, if applicable) on the Soil Data worksheet.

6 Extract Subsample to Determine Water Content and Dry Soil Weight

- Mix sample thoroughly in the bag by kneading it with your fingers.

- Take a 1/8-cup level scoop subsample of loose soil (not packed down) from the plastic bag and place it in a paper cup (a glass or ceramic cup may be used).

7 Weigh and Record Subsample

- Weigh the soil subsample in its paper cup. Enter the weight on the Soil Data worksheet.

- Weigh an empty paper cup to account for its weight. Enter the weight on the Soil Data worksheet.

8 Dry Subsample

Place the paper cup containing the subsample in a microwave and dry for two or more four-minute cycles at full power. Open the microwave door for one minute between cycles to allow venting. Weigh the dry subsample in its paper cup and enter the weight on the Soil Data worksheet.

NOTE: To determine if the soil is dry, weigh the sample and record its weight after each 4-minute cycle. When its weight does not change after a drying cycle, then it is dry.

CALCULATIONS (See page 13)

Bulk Density Test for Gravelly and Rocky Soils

This method is to be used when rocks or gravels prevent sampling bulk density by the core method described in the first part of this Chapter. This excavation method will require the user to sieve out the coarse material greater than 2 mm in size.

Materials needed to measure bulk density:

- **Plastic wrap**
- **140-cc syringe**
- **water**
- **garden trowel**
- **sealable bags and marker pen**
- **2-mm sieve**
- **scale (0.1 g precision)**
- **1/8-cup (30 mL) measuring scoop**
- **paper cup or bowl**
- **access to a microwave oven**

Considerations: Choose a spot that is as level as possible to allow water to fill the hole evenly. If the soil is too wet to sieve, ignore the part in Step 2 about replacing rocks, and proceed to Step 3. Soil will have to be dried and sieved later. The volume of gravel will need to be determined and subtracted from the total volume of the soil sample taken in the field.

1 **Dig Hole**

- Dig a bowl shaped hole three inches deep and approximately five inches in diameter using the trowel (**Figure 4.3)**. Avoid compacting the soil in the hole while digging. Place **all** of the soil and gravel removed from the hole in a plastic bag.

- Using the 2-mm sieve, sieve the soil in the plastic bag to separate the gravel. Collect the soil in a plastic sealable bag. Put the gravel aside to be used in Step 2. Seal and label the plastic bag. **[Note: See Considerations above if soil is wet.]**

Figure 4.3

2 Line the Hole

Line the hole with plastic wrap as shown in **Figure 4.4**. Leave some excess plastic wrap around the edge of the hole. Place the sieved rocks and gravel carefully in the center of the hole on top of the plastic wrap. Assure that the pile of rocks **do not** protrude above the level of the soil surface.

Figure 4.4

3 Add Water to Hole

- Use the 140 cc syringe to keep track of how much water is needed to fill the lined hole. The level of the water should be even with the soil surface.

- The amount of water represents the volume of soil removed. Record the total amount of water in cubic centimeters (1 cc = 1 cm^3) on the Soil Data worksheet.

NOTE: Steps 4-6 can be done in a lab or office if a scale is not available in the field. Step 7 requires access to a microwave.

4 Weigh and Record Sample

- Weigh the soil sample in its bag. [If the sample is too heavy for the scale, transfer about half of the sample to another plastic bag. The weights of the two sample bags will need to be added together. Enter the weight (sum of two bags, if applicable) on the Soil Data worksheet.

- Weigh an empty plastic bag to account for the weight of the bag. Enter the weight (sum of two bags, if applicable) on the Soil Data worksheet.

5 Extract Subsample to Determine Water Content and Dry Soil Weight

- Mix sample thoroughly in the bag by kneading it with your fingers.

- Take a 1/8-cup level scoop subsample of loose soil (not packed down) from the plastic bag and place it in a paper cup (a glass or ceramic cup may be used).

6 Weigh and Record Subsample

- Weigh the soil subsample in its paper cup. Enter the weight on the Soil Data worksheet.

- Weigh an empty paper cup to account for its weight. Enter the weight on the Soil Data worksheet.

7 Dry Subsample

Place the paper cup containing the subsample in a microwave and dry for two or more four-minute cycles at full power. Open the microwave door for one minute between cycles to allow venting. Weigh the dry subsample in its paper cup and enter the weight on the Soil Data worksheet.

NOTE: To determine if the soil is dry, weigh the sample and record its weight after each 4-minute cycle. When its weight does not change after a drying cycle, then it is dry.

CALCULATIONS (for both bulk density methods):

Soil water content (g/g) = $\frac{\text{(weight of moist soil - weight of oven dry soil)}}{\text{weight of oven dry soil}}$

Soil bulk density (g/cm^3) = $\frac{\text{oven dry weight of soil}}{\text{volume of soil}}$

Soil water-filled pore space (%) = $\frac{\text{volumetric water content x 100}}{\text{soil porosity}}$

Volumetric water content (g/cm^3) = soil water content (g/g) x bulk density (g/cm^3)

Soil porosity (%) = $1 - \left(\frac{\text{soil bulk density}}{2.65}\right)$

Volume of Rocks (cm^3) = Fill 1/3 of a graduated cylinder with water, and record the amount. Add the rocks to the cylinder and record the change in the water level. The difference is the volume of rocks (1 mL = 1 cm^3).

Volume of Soil (cm^3) = Total soil volume - volume of rocks