Module 3 Lesson A: Soil Fundamentals – Hands-On Activity A1, A2, A3, A4

Student Instructions Worksheet for Module 3 HOA A

Lesson Overview: In this lesson, you will explore four fundamental soil properties through hands-on activities. Follow the safety guidelines and instructions for each activity, and use the provided NRCS guides and videos (https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/soil-health/soil-health-educators-guide) for detailed reference. Remember to record your observations and data as you go.

Activity A1: Soil Texture by Feel

Safety Considerations

- Wear gloves if you have cuts or concerns about soil cleanliness. The soil and water are generally safe to handle.
- Avoid touching your face or mouth while working with soil. Do not ingest any soil or soil water.
- Clean up spills immediately, as mixing water and soil can make surfaces slippery. Wash your hands thoroughly after the activity.

Materials

- Local soil samples (small container or bag per sample/location)
- Small container or bag
- Water in squeeze bottle or cup
- Disposable gloves (optional for hygiene)
- Small tray, paper plate, or paper towel (work surface)
- Ruler (to measure ribbon length)
- Soil Texture by Feel flow chart or NRCS guide handout
- Pencils and student data worksheet

Objectives & Outcomes

- **Understand soil texture:** Learn that soil texture is determined by the proportions of sand, silt, and clay in a sample bentonswcd.org. Recognize how texture influences properties like water holding capacity and infiltration (e.g., sandy soils drain quickly, while clay soils hold water longer) bentonswcd.org.
- **Skill:** Practice the “texture by feel” method to classify soil by hand. By the end, you should be able to identify your soil’s texture class (such as loam, sand, or clay) and describe how it feels.

- **Outcome:** Connect soil texture to real-world soil function – for example, predicting how a sandy vs. clayey soil might affect plant growth or require different management.

The USDA soil texture triangle illustrates the 12 soil texture classes based on the percentage of sand, silt, and clay. Each corner represents 100% of one particle size; real soils fall in between. For example, a "sandy loam" has a high sand content with some silt and clay, whereas a "clay" soil has a very high clay content. The Texture by Feel method allows you to estimate a soil's class by its feel and behavior, without needing to measure exact percentages.

Procedure Summary (refer to NRCS *Texture by Feel* Guide and YouTube Texture By Feel Procedure video)

- **Prepare the sample:** Take about a tablespoon of **dry** soil and slowly add water while working it in your palm until the soil becomes moldable like putty (not too soupy). Remove any pebbles or debris. (See NRCS guide PDF for detailed steps – *link to be provided*).
- **Feel the soil:** Rub the moistened soil between your fingers. Note if it feels **gritty** (indicates sand) or **smooth** like flour (indicates silt), or **sticky** (indicative of clay). Fingers are very sensitive and can detect differences in particle size by these sensations bentonswcd.org.
- **Ribbon test:** Roll the soil into a ball, then press it out between your thumb and forefinger to form a "ribbon." Try to form the longest ribbon possible without it breaking. Measure the ribbon's length. Soil that forms a long, thin ribbon has higher clay content, whereas soil that won't ribbon at all is likely sand or sandy loam nrcs.usda.gov.
- **Classify texture:** Use the flow chart from the NRCS guide or class handout to determine the texture class based on your ribbon length and feel. For example, a short ribbon that feels gritty might be a sandy loam, while a long, pliable ribbon that feels smooth could be a clay loam. **Cleanup:** Collect any dropped soil onto a tray or paper. Rinse your hands and tools. Leave the area as you found it.

Observation & Data Recording

- **Descriptive notes:** As you work, describe the feel of the soil in words (e.g. "initially powdery, then gritty when wet" or "smooth and very sticky"). These notes will help justify your texture classification.
- **Measurements:** Record the length of the ribbon you made (in cm or inches) and the final texture class you decided on. Use the data worksheet table for Activity A1 to log this information.
- **Reminder:** If testing more than one soil sample (from different locations), repeat the steps for each and note differences. Be sure to label which data belongs to which sample. This will help you compare textures across sites.

Activity A2: Soil pH

Safety Considerations

- Wear safety goggles if using chemical pH test solutions (many classes use pH paper or strips, which are low risk). In all cases, **do not taste** or directly sniff any soil or solutions.
- Handle the pH test strips or probe carefully. Rinse any equipment (like cups or probes) after use. If using a liquid reagent or capsule kit, avoid skin contact and wash hands afterward.
- Clean up any spilled soil or water immediately to keep the workspace safe and tidy.

Materials

- Soil samples (labeled per location)
- Distilled water (very important for accurate pH)
- Cups or test tubes (1 per sample)
- Stir sticks or plastic spoons
- pH test strips **or** handheld pH meter with calibration solution
- Color comparison chart (included with strips)
- Paper towels
- Waste container for slurry disposal
- Pencils and student data worksheet
- Goggles (recommended if using chemical reagent kits)
- Gloves
- Beakers, wash bottle, and rinse water

Objectives & Outcomes

- **Understand pH:** Learn that **soil pH** is a measure of how acidic or basic the soil is, which is a key indicator of soil health nrcs.usda.gov. Soil pH affects plant nutrient availability and micro-organism activity in the soil nrcs.usda.gov. For example, at very low or high pH, plants can't access certain nutrients easily.
- **Skill:** Practice measuring pH using a soil slurry and pH test strips (or a pH meter). You will collect soil samples from different locations and determine how their pH values compare.
- **Outcome:** Be able to classify soils as acidic, neutral, or alkaline. Understand why a farmer or gardener might need to adjust soil pH (e.g., adding lime to raise pH or sulfur to lower pH) to improve crop growth.

Procedure Summary (refer to NRCS *Soil pH* Guide and YouTube Soil pH Overview Video and Soil pH Test Video)

- **Sample collection:** Gather small soil samples from each location to be tested (e.g. different parts of the garden, under different plants, or even compare garden soil to potting soil). Label each sample.

- **Prepare soil slurry:** For each sample, put about 1 part soil (for example, 1 tablespoon) into a clean cup or test tube. Add an equal amount of **distilled water** (1:1 ratio of soil to water). Stir or cap and shake gently. Let it sit for a few minutes so the mixture becomes a slurry.
- **Test the pH:** Dip a pH test strip into the soil-water mixture (or insert the pH probe if using an electronic pH meter). Wait the instructed time (usually ~30 seconds) for the strip to develop its color. Compare the strip's color to the pH color chart to get the pH value. **Tip:** For accuracy, perform multiple trials by testing each soil sample three times, using a fresh strip each time.
- **Record and average:** Write down each pH reading for each trial in your data table. Then calculate the average pH for that sample. For example, if trials gave pH 6.4, 6.6, 6.5, the average is ~6.5. Round to the nearest tenth if needed.
- **Classify the soil:** Determine if each sample is acidic (pH < 7), neutral (pH ~7), or alkaline/basic (pH > 7). You can note this in the data sheet (e.g., "Sample A – pH 5.8 – **acidic**").
- **Clean up:** Discard used pH strips in the trash. Dispose of soil slurry as directed (it's generally safe to pour into garden soil or trash, not down a sink). Rinse any containers or probes.

Observation & Data Recording

- **Data notes:** For each soil sample, record all pH readings and the average. The data worksheet includes a table for Soil pH, where you can enter these values.
- **Observations:** Note any interesting observations. Did one soil sample's mixture fizz or bubble? (This might happen if you accidentally added something like vinegar – not expected if using just water and strips, but worth noting any odd reactions.) Also, observe the color of the soil or water – sometimes organic-rich soils make a darker slurry, but this does not directly affect pH.
- **Reflection reminders:** Consider why the pH might be what it is. For example, if a soil under pine trees is more acidic, write that down as an observation ("Soil from pine area had pH 5, possibly due to acidic pine needles"). These notes will help you answer questions about how pH differences arise and why they matter for plants.

Activity A3: Soil Infiltration

Safety Considerations

- This activity often takes place outdoors. Be cautious of your surroundings. Choose a level area to avoid trip hazards.
- **Using the mallet:** Keep hands clear when pounding the infiltration ring into the soil. One person should hold the ring (using a block of wood on top) while another gently taps – communicate and wear gloves to protect your hands.
- **Water usage:** Pour water carefully to avoid splashing (especially if using a large container). Water on the ground can make things muddy; step carefully to not slip.
- After finishing, remove the metal ring or mark the area so no one accidentally trips on it later.

Materials

- Metal infiltration ring (3–6 inch diameter) — 1 per group
- Rubber mallet
- Small wooden block (to protect ring while tapping)
- Water container (graduated pitcher or bottle)
- Stopwatch or phone timer
- Small plastic sheet (plastic wrap) — used inside ring before pouring water
- Ruler or marked measuring guide on ring (to confirm water volume height)
- Clipboard or notebook for timing
- Pencils and student data worksheet

Objectives & Outcomes

- **Understand infiltration:** Observe how quickly water can enter and move through the soil. *Infiltration* is the process of water soaking into the ground nrcs.usda.gov. It's crucial for recharging groundwater and providing moisture to plants and soil organisms nrcs.usda.gov.
- **Skill:** Learn to measure infiltration rate using a simple field test. You will time how many minutes it takes for a set amount of water (for example, 1 inch worth) to infiltrate into the soil.
- **Outcome:** Identify factors that affect infiltration (soil texture, compaction, ground cover). Recognize problems related to infiltration extremes – if it's too slow, you can get puddling and erosion; if it's too fast, water might not be retained (or could leach nutrients). This ties directly to soil health and land management.

Procedure Summary (refer to NRCS *Soil Infiltration* Guide and and YouTube Soil Infiltration Overview Video and Soil Infiltration Test Video)

- **Setup:** At your test site, clear any surface litter like leaves or mulch from a small area. Place a metal infiltration ring (usually 3 or 6 inches in diameter) on the soil and **gently push** it in a little by hand. Next, put a wooden block or plastic cap on the ring and **drive it straight down** about 3 inches into the soil using a rubber mallet nrcs.usda.gov. The ring should be firmly embedded in the ground, with about 2 inches protruding above the surface.
- **Initial saturation (optional):** If the soil is very dry, it can absorb water erratically. You might be instructed to pre-wet the soil: pour a small amount of water to moisten inside the ring, then wait a few minutes. This mimics a rain shower that moistens the soil and can improve test consistency nrcs.usda.gov. If pre-wetting is done, note that the soil was pre-moistened.
- **Infiltration test:** Line the inside of the ring with a piece of plastic wrap covering the soil surface (this prevents disturbing the soil when pouring water) nrcs.usda.gov. Quickly pour **a known volume** of water onto the plastic (for a 6-inch ring, ~444 mL is 1 inch of water; for a 3-inch ring, ~107 mL is 1 inch) nrcs.usda.govnrcs.usda.gov. Then carefully pull the plastic out, letting the water touch the soil simultaneously, and start soaking in. Immediately start the stopwatch.
- **Time it:** Observe the water as it infiltrates. Stop the timer when **the water is gone and the soil surface just glistens damp** (no standing water) nrcs.usda.gov. Note the time it took for 1 inch of water to infiltrate.
- **Repeat (for steady rate):** If instructed, you may conduct a second round by adding another 1 inch of water and timing again nrcs.usda.gov. In many soils, the second inch infiltrates at a different rate once the soil is wet. This can give a more “steady-state” rate. Record the time for the second round as well.
- **Multiple locations:** If possible, test two different spots for comparison – for example, a **compacted area** (like a footpath or bare ground) versus a **protected area** (like under grass or mulch). Repeat the above procedure for the second location. Ensure you label which data comes from which test site.
- **Cleanup:** After tests, carefully pull out the ring (you can wiggle it or dig around it slightly). *If you are also doing Activity A4 (Bulk Density) using the same soil core, keep the soil intact in the ring!* Otherwise, you can clean the ring for the next group. Dry off and store the equipment.

Observation & Data Recording

- **During the test:** Watch how the water behaves. Does it disappear straight down or spread out? Did you notice water pooling or running off anywhere? (Ideally with the ring, it should only go downward, but if you see any leaking under the ring or sideways, make a note.)
- **Timing:** Write down the infiltration time for each run in your data table. If you did two runs, record both times. If you only did one, that’s fine – just note it.
- **Calculate rate:** You can calculate the infiltration rate in inches per hour. For example, if 1 inch of water infiltrated in 5 minutes, that’s 12 inches per hour (because 60 min/5 min = 12). Write the rate next to your time if you calculate it. This helps compare with other conditions.

- **Comparisons:** If you tested two locations, compare your observations. Perhaps one soil took 2 minutes and another took 10 minutes for the same amount of water. Record any differences in soil conditions (e.g., “Location A had a crust of hard soil on top” or “Location B was covered in grass and stayed intact”).
- **Notes:** Also note the soil’s initial moisture (was it very dry, moist?). If one spot was initially wetter (after rain or irrigation), it might infiltrate a bit faster at first. These notes will be useful when discussing why results came out the way they did.

Activity A4: Soil Bulk Density, Moisture & Aeration

Safety Considerations

- This activity involves tools and heat. **Use caution when handling the mallet and knife:** one student should hold the ring (with a protective block on top) while another gently pounds, just like in the infiltration test. Keep fingers clear and wear gloves if available.
- **Cutting/trimming soil:** Use a flat-bladed knife or spatula to trim the soil core. Always cut away from yourself. Go slowly to avoid slipping.
- **Handling the soil sample:** The soil core can be heavy and messy. Keep it in a bag or on a tray to avoid dropping clumps on the floor.
- **Drying the soil:** If using a microwave or oven to dry the soil, **only an adult or the teacher** should handle that part unless you have explicit permission. No metal should go in a microwave (so you must remove the soil from any metal ring). Use oven mitts or tongs to handle hot containers. Allow the soil to cool before students touch it for weighing.
- **General:** Wash hands after handling soil. Clean any equipment (scale, surfaces) of soil dust after the activity.

Materials

- Soil core ring (same or similar size to infiltration ring)
- Rubber mallet + wooden block (for inserting ring)
- Trowel or flat knife for trimming core
- Labeled plastic bags or containers (1 per sample)
- Scale (grams) — digital preferred
- Microwave-safe container (paper plate or ceramic bowl)
- Cup of water for microwave safety (if using microwave method)
- Oven mitts or tongs (teacher use)
- Ruler or calipers (if volume measurement required)
- Pencils and student data worksheet

Objectives & Outcomes

- **Understand bulk density:** Bulk density is the mass of dry soil in a given volume. It's an indicator of soil compaction nrcs.usda.gov. You will learn that high bulk density means soil particles are packed tightly (less pore space), which can restrict root growth and reduce soil aeration.
- **Understand soil moisture:** By weighing the soil before and after drying, you can determine how much water was in the soil. This teaches how soil holds moisture – an important factor for plants. You'll see the concept of **gravimetric water content** (water weight as a percentage of dry soil weight).
- **Skill:** Practice taking a soil core and doing basic measurements (mass and volume). Calculate bulk density (g/cm^3) and moisture percentage.

- **Outcome:** Recognize a "compacted" soil vs. a well-aggregated soil. For instance, a dense urban soil might have a higher bulk density than a loose garden soil with lots of organic matter. Understand how this affects **aeration** (air space for roots and microbes) – tight soils have poor aeration. This ties back to soil health principles (avoiding compaction, adding organic matter to improve structure).

Procedure Summary (refer to NRCS *Bulk Density* guide and YouTube Soil Bulk Density Overview video and Soil Bulk Density test video

- **Collect the soil core:** You may already have a soil core in a ring from the infiltration test. If so, use that. If not, choose a spot (it could be the same infiltration site or another). Push or gently hammer the 3-inch diameter ring into the soil to a depth of 3 inches nrcs.usda.gov (with 2 inches sticking out above ground). Use the techniques from Activity A3 for inserting the ring.
- **Remove the core:** With the ring now full of soil, carefully excavate it. First, use a knife or trowel to cut around the outside of the ring, freeing it from the surrounding soil nrcs.usda.gov. Then slide a trowel or flat tool under the ring and lift it out with the soil intact inside. **Trim off excess soil** flat at the bottom of the ring so the soil is exactly flush with the ring's edges nrcs.usda.gov. Now you have a known-volume soil sample.
- **Bag and label:** Gently place the soil from the ring into a plastic bag (you can push it out or if it's stable, leave it in the ring and put the whole thing in a bag). Seal the bag and label it (e.g., "Soil sample A – bulk density"). If doing multiple samples, keep them separate.
- **Weigh moist soil:** Using a scale, find the weight of the *moist soil*. If the soil is in a bag, you'll weigh "soil + bag". In that case, also weigh an identical empty bag. Subtract to get the soil's weight alone. Record this as the wet soil weight (in grams).
- **Dry the soil:** Transfer the soil (if not already) to a microwave-safe container (like a paper plate or ceramic bowl). If using a microwave, also place a cup of water inside (this helps absorb excess microwave energy). Heat the soil sample on high in short increments (1-2 minutes at a time) until the soil is completely dry. **Alternatively**, the teacher might dry the soil in a laboratory oven at ~105°C for 24 hours, or even air-dry over several days if time allows. The goal is to remove all water. (**Teacher will advise the drying method – follow their instructions**).
- **Weigh dry soil:** Once the soil is dried and cooled, weigh the dry soil (again subtracting the container or bag weight). This gives the *oven-dry soil weight*.
- **Calculate Bulk Density:** You know the volume of the soil that was in the ring. For a standard 3-inch diameter ring driven 3 inches deep, the volume is about 347 cm^3 (cubic centimeters). Your teacher will confirm the volume or have you calculate it from the ring dimensions. Now calculate bulk density = (dry soil mass in grams) ÷ (soil volume in cm^3). The result will be in g/cm^3. For example, if you had 400 g of dry soil in 347 cm^3, the bulk density is 1.15 g/cm^3.
- **Calculate Moisture Content:** Subtract the dry soil weight from the moist soil weight – this difference is the weight of water that was in the sample. You can express the soil's gravimetric moisture as a percentage: (water weight ÷ dry soil weight) × 100%. For instance, if the moist soil was 500 g and the dry soil was 450 g, the water weight = 50 g. 50/450 = 0.111… so about 11% moisture.

- **Dispose of sample:** Once measurements are done, you can return the dried soil to a garden or designated soil bin. Clean the ring and tools.

Observation & Data Recording

- **During sampling:** Note how hard or easy it was to push the ring in. If it was very difficult (needed a lot of hammering) or if you noticed a hard layer, record that observation (it indicates compaction).
- **Wet vs dry appearance:** Observe the soil sample's appearance when moist vs after drying. Did it change color (darker when wet, lighter when dry is normal)? Did it clump or fall apart? Any visible pores or roots?
- **Data:** Record the weights of the following: wet soil (and bag), empty bag, and dry soil (and bag). The data sheet for Activity A4 has a table to fill these in and space to compute bulk density and moisture.
- **Calculations:** Write down your calculated bulk density and moisture %. If you need to show work (depending on the teacher's instructions), you can note it on scrap or below the table.
- **Interpretation notes:** Is the bulk density number high or low? For reference, most uncultivated topsoils have a bulk density around 1.1 to 1.4 g/cm^3. Values above ~1.6 g/cm^3 may indicate compaction that could hinder root growth. Jot down if you think your soil is "compact" or "loose" compared to these benchmarks. Also note the moisture percentage – was the soil holding a lot of water, or was it quite dry? This can relate back to how recently it rained or the soil texture (clayey soils hold more water). These notes will help you in the analysis and discussion.