SOIL JUDGING

in Virginia

4-H and FFA Member's Guide for Soil Judgers

Authored by John M. Galbraith, Extension Specialist, Crop and Soil Environmental Sciences, Virginia Tech; Andy Seibel, Extension Specialist, Virginia Cooperative Extension, Virginia Tech; and Jinx L. Baney, Extension Agent, Brunswick County, Virginia, retired.

Publication CSES-183P (SPES-660P)

Virginia Cooperative Extension
Virginia Tech • Virginia State University

Acknowledgments:

The authors wish to acknowledge members of the State 4-H Soils/Crops Curriculum Development Committee and other Extension Staff for their assistance. Special thanks to Bob Blanton, retired from the State 4-H Office, for his support, guidance and motivation, and to Mike L. Rogers, agronomist, City of Danville, for his input on a previous version.

VT/0725/ CSES-183P (SPES-660P)

Introduction

Why are soils important?

Soil is one of Virginia's basic natural resources. We are dependent upon the soil as a primary resource of supporting food, fuel, and fiber production. Soils supply nutrients (elements or compounds) necessary for vigorous plant growth for plant growth. Soil moisture affects air pollution and vegetation cover that prevents erosion. Soils are necessary as a base for buildings and roads. Most new houses rely on onsite septic system drain fields to dispose of and treat septic waste through the soil nearby. Soils store carbon and water, clean the water of pollutants and excess nutrients, provide a rooting zone and structural support for plants, and offer habitat to microbes and animals.

What will we learn about soil?

The basic and applied knowledge in this guide will provide a base for understanding soils and how to use them properly. Readers will learn to use soil and site properties to identify suitability for production of food or fiber. They will also learn how to rate the erosion, infiltration and runoff, and natural soil drainage class. Observed soil and site properties are used to rate a soil for agricultural and non-agricultural land uses such as foundations, septic tank drain-field systems, or landscaping (e.g. shrubs and flower gardens). Using this guide provides users an opportunity to better understand soils as an important resource.

Soil Profile and Horizons

Soils are composed of solid mineral particles, organic matter, humus, living roots and organisms, and spaces holding air and water (pores). Soil is a non-living body but it is teeming with life. In fact, there are more microbes in one tablespoon of soil than there are people on the planet. Soil may seem unchanging, but it changes moisture content and it changes volume when it wets and dries and when it freezes and thaws. Soils gain additions of organic matter from dying plants and gain amendments like fertilizer, and they lose particles to erosion and lose soluble elements to groundwater. Some clay and iron oxides move from the surface layer (topsoil) into the subsoil every time it rains.

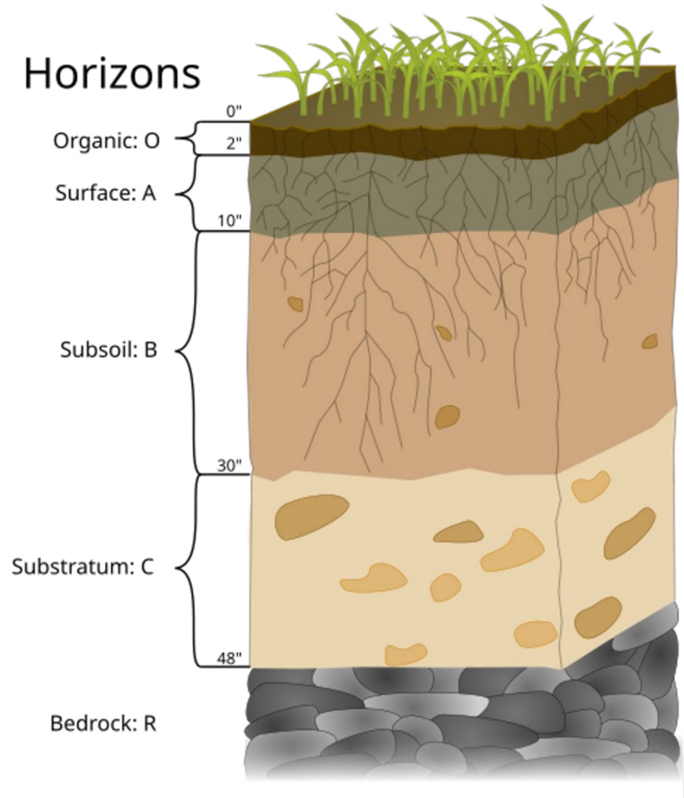

Figure 1. Soil profile showing several common master horizons. Soil horizon. (Reprinted from Wikipedia, https://en.wikipedia.org/wiki/Soil_horizon, modified from work by Hridith Sudev Nambiar at English Wikipedia.)

A soil profile (fig. 1) is a vertical cross-section cutting down through several different soil layers. A profile of the soil can be observed in a freshly dug pit, road bank, or auger borings. The profile can be divided into layers with different appearances and properties. These layers are called soil horizons (table 1). O, A and E horizons are typically the source of materials that move down into the B horizons. Leaching occurs when materials move deeper than the B horizons in the soil.

Table 1: The most common soil horizons in Virginia.

Horizon	Description
O	Composed of leaf litter organic matter and moderately to highly decomposed organic matter called humus. Think "O" for "organic matter."
A	Surface soil, darkened by accumulation of humus to a brown to black color. Most plant roots and microbes occur here. If the surface soil has been plowed, it is identified by the symbol "Ap." Think "A" for "accumulation of humus."
E	The E horizon is found beneath the A horizon. It is a subsurface horizon that is lighter-colored than other horizons because it has little humus. It has lost clay, iron oxides, and soluble elements that have been carried by water deeper into the profile. Not all soils have an E horizon. Think "E" for "bleached horizon."

Horizon	Description
B	The B horizon, or subsoil, is the zone of maximum accumulation of clay, iron oxides, and other elements washed down from A and E horizons. It is usually the brightest colored (red to brown) horizon and has higher clay and iron oxide content and better structure than underlying horizons. The B horizons are where many nutrients are stored. Think "B" for "best developed horizon."
C	The C horizon is the parent material from which soil horizons form. It lacks B horizon structure and color, and frequently shows bedrock structure in soils forming directly from the bedrock beneath. Roots cannot penetrate a "Cr" bedrock horizon, although the bedrock is soft enough that it can be dug through or broken apart by hand. Think of "C" for "crude, undeveloped horizon."
R	Bedrock that cannot be dug through or broken apart by hand is an R horizon. Roots cannot penetrate an R horizon. Think "R" for "rock hard."

Parent material varies across Virginia, depending on the geology and physiographic province (fig. 2). Parent materials (C and R horizons) have been altered by weathering and biological processes to form soil horizons. The uppermost soil horizons which comprise the solum (O, A, E, and B horizons) have different colors, textures, structures, and other properties that are the result of these soil forming processes (Soil Survey Staff 2003-2017).

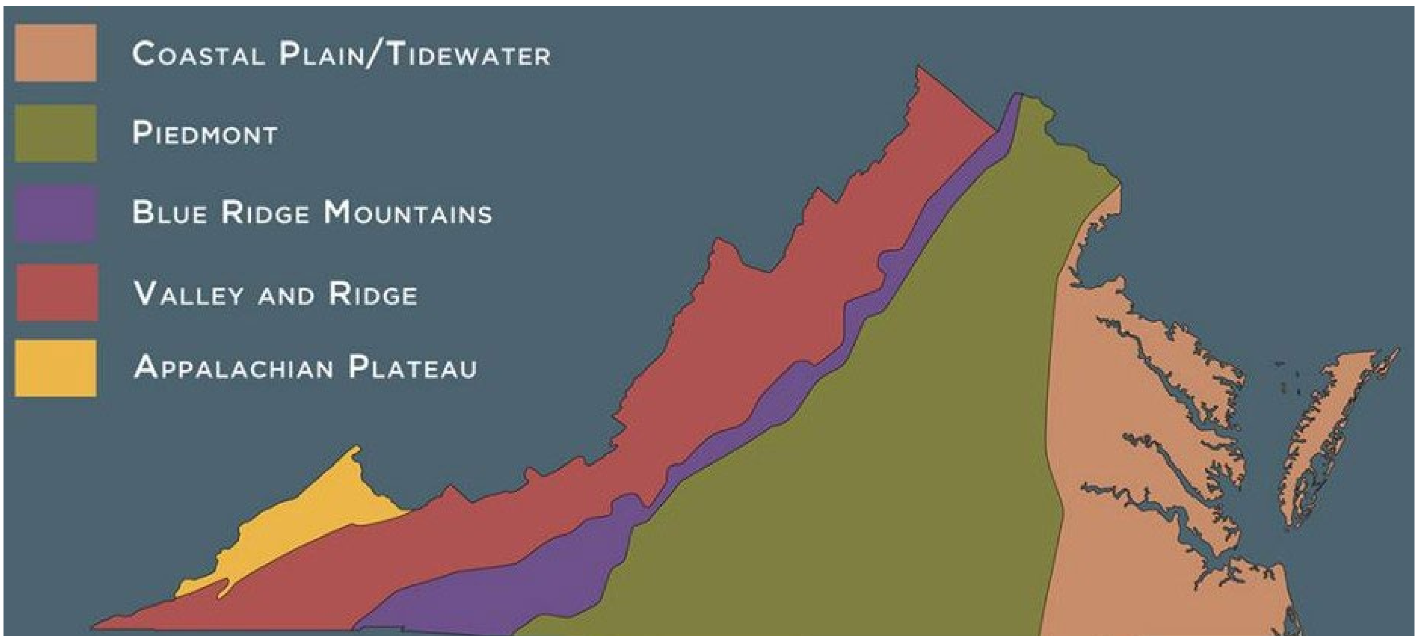

Figure 2. The Regions of Virginia courtesy of the Virginia Museum of History and Culture (https://virginiahistory.org/learn/regions-virginia).

Part 1: Soil Features

A. Surface Thickness

The surface layer (topsoil) thickness is measured from the top of the mineral soil to either the bottom of the A or Ap horizon (fig. 3). The surface is the A horizon darkened by accumulation of humus following breakdown of organic matter. If the land has been plowed, the surface horizon is identified by the symbol "Ap." The base of the surface layer is determined by a sharp cutback in dark coloration, the identification of a plow line (distinct line in the soil at the base of the plow layer), or a significant increase in clay or iron (usually accompanied by a change to yellow, orange or red colors). The structure of the surface is typically granular but may also be blocky if plowed or has high sand content. The surface does not have prismatic structure of a B horizon and does not have the light coloration of an E horizon.

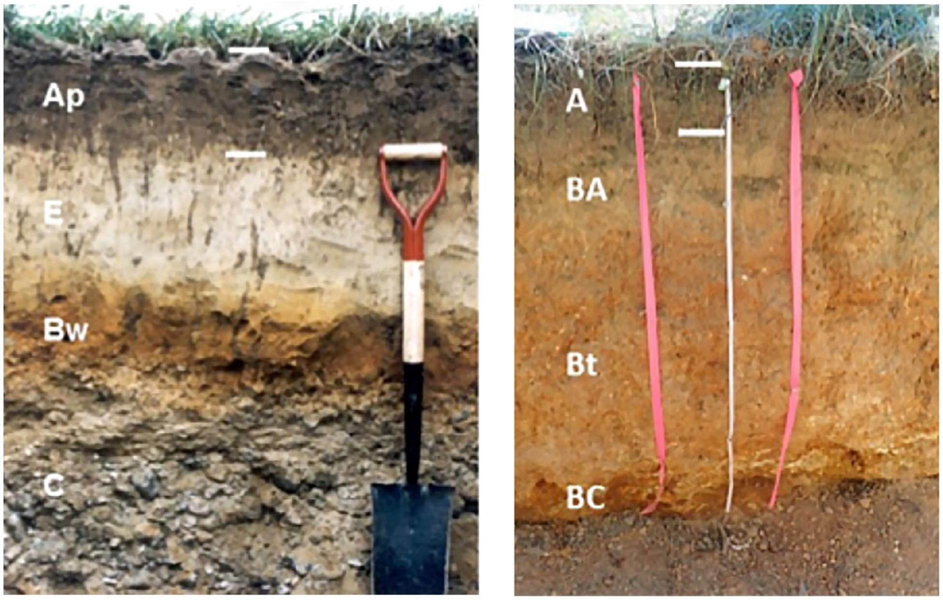

Figure 3: Left: The surface layer (plow layer, Ap horizon) extends from the soil surface to the top of the shovel handle (white line to white line). Photo courtesy Jim Turenne, USDA-NRCS. Right: The surface layer (A horizon) extends from white line to white line. The measuring tape is used to determine thickness and depth to gray wetness mottles. Photo courtesy John Galbraith, Virginia Tech.

B. Surface Texture

Particle size can be measured in the lab or texture can be estimated in the field by feeling the soil in a moist state. For the soil judging contest, texture will be estimated by contestants in the field. Table 2 contains some guidelines.

A surface layer (topsoil) will be placed in a clearly marked container near the soil pit. Students should feel this topsoil sample and record the texture on the scoresheet.

C. Subsoil Texture

The subsoil texture sample will be placed in a second clearly marked container near the soil pit. Students should feel this sample and record the subsoil texture on the scoresheet.

Table 2. Technique for determining soil textural class.

Tips for Texturing Soil
Start with moist, doughy soil about the size of an egg. Squeeze the ball in your hand and push forward horizontally with your thumb to make the soil form a ribbon shape. (Figure 5). Measure ribbon length when it bends or breaks. Surface textures are usually in group 1-3 below, but subsoils can be any texture.
1. If it will not make a ribbon and will not hold together during the process, it is a sand.
2. If it holds together but makes a ribbon < 0.5 inch long, it is a loamy sand.
3. If it makes a ribbon 0.5 to 2.5 inches long, and
a) is gritty, > 50% sand[1], it is a sandy loam.
b) is smooth or flowery, < 30% sand, it is a silt loam.
c) is intermediate between gritty and smooth, it is a loam.
4. If it makes a ribbon 2.5[2] to 4[2] inches long, and
a) is gritty, > 50% sand, it is a sandy clay loam.
b) is smooth and a little shiny, < 20% sand, it is a silty clay loam.
c) is intermediate between gritty and smooth, it is a clay loam.
5. If it makes a ribbon 4[2] or more inches long, and
a) is gritty, > 50% sand, it is a sandy clay.
b) is very smooth and plastic, < 20% sand, it is a silty clay.
c) is intermediate between gritty and smooth, it is a clay.

Modified from Thien. 1979. Sand and clay contents shown here are approximate amounts.

[1] Mica flakes are not gritty but count as sand regardless.

[2] In Blue Ridge and Piedmont subsoils, divide this length in half.

The solid mineral particles are divided into three particle sizes: sand, silt, and clay. Mica flakes feel smooth like silt and clay but are sand because individual particles can be seen. If an average-sized sand particle was the size of a basketball, an average silt particle would be the size of a baseball, and an average clay particle would be smaller than a BB shot. The proportion of each of the three particle sizes in any given soil sample is called soil texture. Soil textural classes, according to the actual percentages of sand, silt, and clay, are shown on the textural triangle (fig. 4).

Textural classes are named according to the particle-size that dominates their behavior. Most names are not single words but are a combination of two or three names: the last word is like a noun, and the first words are like adjectives. An even-acting mix of all three particle sizes is a loam. Those loams with significant clay and a lot of sand are a sandy clay loam. Those with loams with significant clay but also a dominance of silt are silty clay loams. Those with loams with significant clay but no dominance of sand or silt are a clay loam. Clay particles have more control over the properties of a soil than does either sand or silt. Therefore, a soil may be placed in the clay textural class with only 40 percent clay, whereas a minimum of 85 percent sand is required to place a soil in the sand textural class. Table 2 can be used to estimate texture class. Figure 5 shows a ribbon formed from a ball of moistened soil.

D. Subsoil Color

Subsoil colors are determined using a Munsell® soil color book or the Globe Professional® color book (fig. 6). A color book can be borrowed from USDA or purchased online to determine precise soil colors. In this soil judging contest, contestants will either use a book or estimate the color based on the color of common objects. If no color book is available, general soil colors can be estimated using table 3.

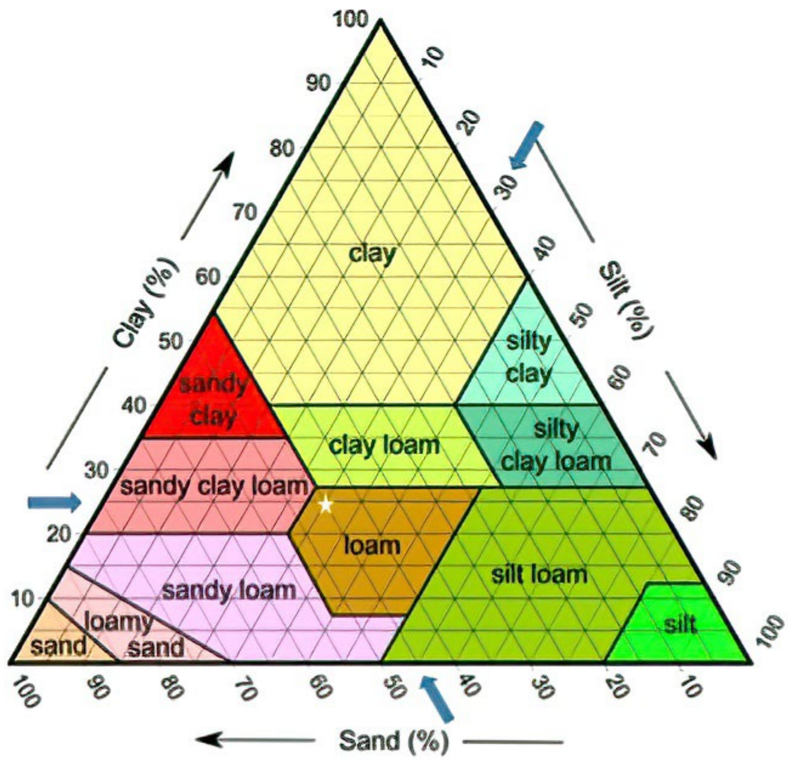

Figure 4: The texture triangle relates the percent sand, silt and clay to one of 12 texture classes. Thick arrows show the direction to read the values. A soil with 25% clay, 45% sand, and 30% silt (white star) would be a “loam” texture. Soil. (Reprinted from https://en.wikipedia.org/wiki/Soil). Drawn by Mike Norton, redrawn from USDA-NRCS Soils web page (https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/ home/).

Figure 5: Guide to estimating one of 12 texture classes by hand from a moist, mixed soil sample about the size of an egg. This sample makes a ribbon over 4 inches long and is not very gritty, and would be would be classified as a clay, or silty clay, depending on how much grit could be felt. Photo courtesy of John Galbraith, Virginia Tech.

Figure 6. Left: An X-Rite soil color book (X-Rite, Grand Rapids, MI). Gray colors are inside the virtual black rectangle on any page. Gray is defined as having value 4 or more and chroma 2 or less on any page in the book. Right: The Globe Professional® book (Visual Color Systems, Kingston, NY). Gray colors are inside the black box on any pages with chroma 1 or 2.

Table 3. General soil colors and common objects that have that color.

Soil Colors	Common Objects for Reference
Red	Stop sign, red apple, red brick.
Brown	Coffee with cream, roasted peanuts, cardboard
Yellow	Spicy mustard, ripe banana.
Reddish Yellow (orange)	Pumpkins, sweet potatoes.
Gray	Fireplace ash, limestone gravel, concrete, cinder block.

Subsoils may have uniform colors or contain color patterns called mottles. Uniform red, brown, orange, and yellow subsoil colors without mottles occur in well-drained (aerated, oxygenated) soils (fig. 7, left). Dominantly brown, orange, and yellow subsoils occur in the Coastal Plain and Ridge & Valley provinces, while dominantly red subsoils occur in the Blue Ridge and Piedmont provinces. Linear shaped mottles (called lithochromic colors) may be left behind when rocks or bedrock layers weather (decompose) into soil (fig. 7, right). Lithochromic mottles, subsoil clods mixed into a plow layer, and earthworm burrows do not indicate wetness problems if no gray wetness mottles or dominant gray colors due to wetness are present.

Gray colors are defined as having value 4 or more and chroma 2 or less on any Munsell® color book page. Irregular-shaped patterns called gray wetness mottles (like gray paint splatters or gray surrounding root channels) occur in subsoils with inadequate drainage (fig 8, left). Dominantly gray subsoils (with or without iron mottles) occur in wet conditions with high groundwater tables and inadequate drainage (fig. 8, right). Gray wetness mottles are usually found around roots or pores or on aggregate surfaces, while yellow, orange, or red iron mottles are found inside pores and next to live roots.

Figure 7. Left: Well-drained red subsoil color without wetness mottles. Right: Well-drained soil with linear lithochromic color mottles but no gray wetness mottles. Photo on left courtesy John Kelley, NRCS retired, and photo on right courtesy John M. Galbraith, Virginia Tech.

Figure 8. Left: gray wetness mottles and iron mottles (redoximorphic features) in a red colored horizon temporarily saturated by rainfall. Right: soil taken below a groundwater table with red iron mottles (redoximorphic features) in a dominantly gray colored horizon. Photo on left courtesy John Kelley, NRCS retired, and photo on right courtesy Ben Smith, Virginia Tech.

E. Depth to Wetness Features

The natural soil drainage class is estimated by measuring the shallowest depth to gray wetness mottles (fig. 8, left) or dominant gray colors (with or without iron mottles) (fig. 8, right). This information is used widely to determine need for agricultural drainage systems (ditches or tile drains) and to determine soil suitability for many non-agricultural uses.

Under wet (saturated) conditions, the iron compounds are chemically altered to a more easily dissolved form and lose their bright colors. Thus, the occurrence of gray subsoil mottles or dominant color indicates that the soil is saturated for a significant period of time (or has a seasonal water table) at the depth at which gray colors start appearing, especially if they are adjacent to red, brown, orange, yellow or black mottles.

F. Surface Structure

Soil structure is the way individual particles (humus, sand, silt, and clay) form compound structural units known as aggregates (fig. 9). The outsides of aggregates are smoothed from shrinking and swelling, or they are coated with organic carbon, silt or clay where water flows repeatedly between the aggregates. The aggregates fit tightly together like pieces of a puzzle. Other irregular shaped masses of soil without such edges are called clods. Soil structure is a very important characteristic that can greatly influence the rate of water movement in soil. For example, a clay textured subsoil with strong blocky structure will allow water to move readily through it, whereas the same clay texture with platy or massive structure would have virtually no water flowing through.

Students should write down the topsoil and dominant subsoil structure on the scorecard, even though they are not graded. Students determine the structure units in the pit by examining the soil horizons that correspond to the samples in the texture containers provided at each pit.

G. Subsoil Structure

Students should write down the dominant topsoil structure on the scorecard after examining the soil horizon that corresponds to the sample in the surface (topsoil) texture container provided at each pit.

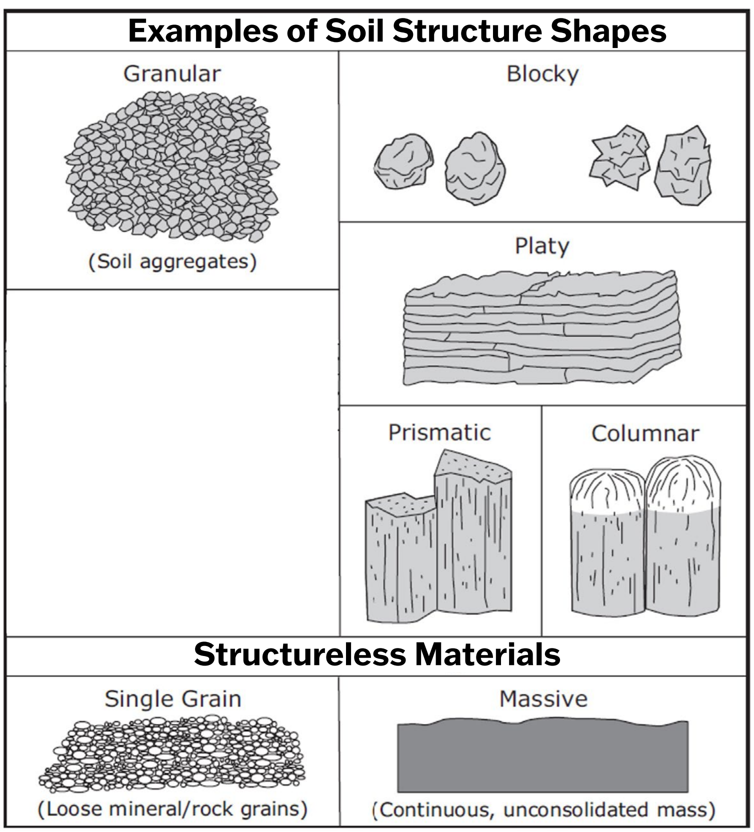

Figure 9. Several shapes of soil structure aggregates and structureless material. From Schoeneberger et al. (2012).

Soil Structure Shapes

The following descriptions are from Schoeneberger et al. (2012).

Granular: The aggregates are approximately spherical or polyhedral and are bounded by curved or very irregular faces that are not casts of adjoining aggregates. Not found in subsoils.

Platy: The aggregates are flat and plate like. They may be as thin as 1 mm or as thick as 2 inches. These may form from mechanical compaction or vehicle traffic.

Blocky: The aggregates are blocks but may have angled edges. The structure is described as angular blocky if the edges are sharp or the flat faces intersect at right angles, and as subangular blocky if the faces are a mixture of shapes and the edges are mostly rounded.

Prismatic: The individual aggregates are bounded by flat or slightly rounded vertical faces. Units are distinctly longer vertically; the tops of the prisms are somewhat indistinct and normally flat.

Columnar: The aggregates are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded and covered with white soil particles. These are not found in Virginia but may occur in sodium-rich soils in drier regions.

Structureless Material (without a defined shape)

Single Grain: Individual sand particles do not bind together to form aggregates. When handled, individual sand grains fall apart easily.

Massive: Individual soil particles hold together in irregular shaped clods that are not bounded by coated or smoothed surfaces on the sides. Broken pieces are irregular (no consistent shape or size) and may result from recent plowing or compaction.

Part 2: Landscape Factors

A. Slope Gradient

The steepness of slope is important in estimating the rate of soil runoff and predicting the hazard of erosion. Since humans cannot lay flat on the ground, we compare elevations at two points that are the same height above the ground to represent the slope (fig. 10a). In a soil judging contest, the contest host places two stakes 50 or 100 feet apart and about 4-5 feet high above the ground. The difference in elevation between them is the rise (in feet), and the distance between them is the run (in feet).

In the contest, students must estimate slope to the nearest half percent, and students should record that number on their scorecard for later use. Using table 4 to find the slope class name.

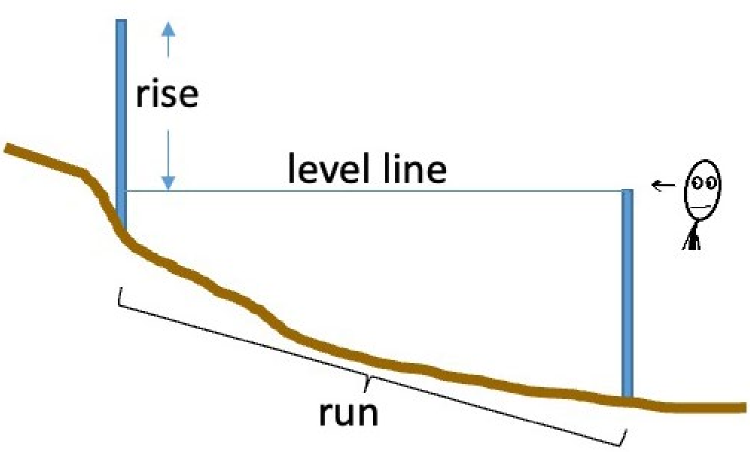

Figure 10a. Slope stakes placed 100 feet apart (run). Project a level line from the downhill to the uphill stake. The difference in height (feet) between where the level line lands on the uphill stake and the top of the uphill stake is the rise. Rise/run x 100 = percent slope. Eyesight image courtesy of clipartfest.com. Drawing by John M. Galbraith, Virginia Tech.

Level Line Method 2:

Same as method 1 but using an extended arm with your hand held at eye height as a pointer for the level line. Students may agree to pair with a student of similar height from a different team. One stands next to the uphill stake while the other student estimates rise, then they switch. However, no talking is allowed during the contest.

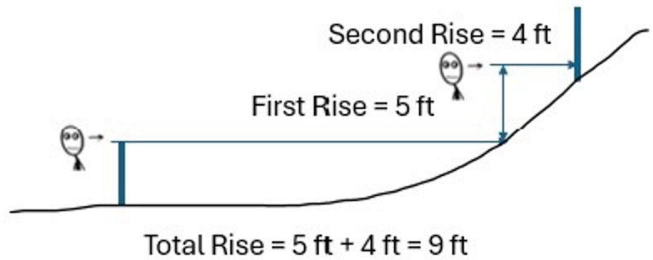

Figure 10b. The stakes are 5 feet tall. The first level line hits the ground in front of the uphill stake, where the student kneels or stands and projects a second level line. The second level line hits 4 feet below the top of the uphill stake. Eyesight image courtesy of clipartfest.com. Drawing by John M. Galbraith, Virginia Tech.

Slope Calculation Example 1:

If your level line lands about 2.5 feet below the top of the uphill stake, the rise is 2.5 feet. If the run is 100 feet, the slope is 2.5/100 x 100 = 2.5%. The slope class from table 4 would be “gently sloping.”. If the run is 50 feet, the slope would be 2.5/50 x 100 = 5%, or “sloping”. Note this is double (2x) the slope calculated at 100 feet with the same rise.

Slope Calculation Example 2:

Your eyes are about 5 feet above the ground. If your level line lands on the ground between the stakes, you walk up to that point and project a second level line. If that second line lands on the uphill stake about4 feet below the top, the rise is your eye height rise is 5 feet plus the 4 feet rise on the stake, for a total rise of 9 feet. Divide by the run distance as in example 1 to get the slope percent.

Table 4. Relationship between slope and slope class.

Slope %	Slope Class
< 2	Nearly Level
2 to < 7	Gently Sloping
7 to < 15	Sloping
15 to < 25	Moderately Steep
>= 25	Steep

B. Erosion

Erosion is the detachment and transport of soil particles by wind or water. Erosion causes the loss of millions of tons of valuable topsoil from Virginia soils each year. Most erosion in Virginia is caused by raindrop splash and running water on bare soil. Cleared fields may also be subject to wind erosion.

Soil scientists estimate past erosion by estimating topsoil loss. To estimate how much erosion has occurred in a soil judging contest, evaluate the original topsoil thickness (given information located on the site card at each pit) and the current topsoil thickness (measured in the soil pit by students) (fig. 3).

Example calculation of erosion class:

(Current topsoil thickness (measured) / Original topsoil thickness remaining = percent lost. Round negative percent lost values up t deposits extra topsoil on footslopes.

Example 1: (2 inches current topsoil thickness / 10 inches original topsoil thickness) x 100 = 20% remaining. 100% – 20% = 80% lost. Erosion class “Severe.”

Example 2: (5 inches current topsoil thickness / 10 inches original topsoil thickness) x 100 = 50.0% remaining. 100% – 50% = 50% lost. Erosion class = “Moderate.”

Example 3: (12 inches current topsoil thickness / 10 inches original topsoil thickness) x 100 = 120% remaining. 100-120% = -20% lost (rounded up to 0%). Erosion class = “None to Slight.”

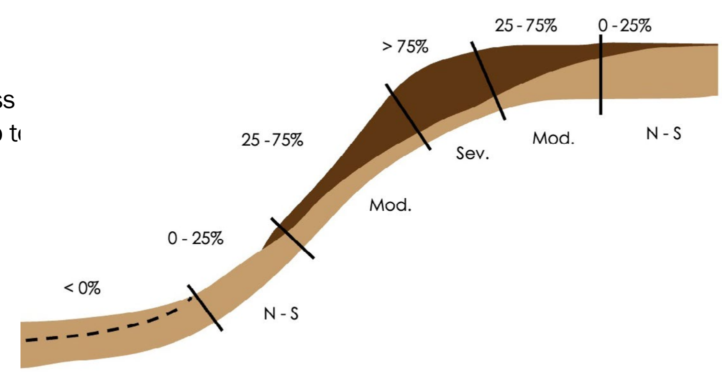

Figure 11. Erosion alters surface layer thickness over time. Dark brown represents the original topsoil now eroded away, and light brown is the current topsoil. Dashed line represents the original surface on a footslope whewre there now is more topsoil than before due to erosion deposition. Erosion category names are shown (N-S: None to Slight; Mod: Moderate; S: Severe). Drawing by John M. Galbraith, Virginia Tech.

Erosion Classes

None to Slight: 25% or less of the original topsoil layer eroded for the soil to be placed in this class. If there is a plow layer, it consists mostly of the original topsoil horizon material.

Moderate: Moderately eroded soils have lost 25-75% of the original topsoil layer. If there is a plow layer, it consists mainly of the original topsoil horizon plus some of the subsoil material. The base of the plow layer rests on or in the subsoil.

Severe: More than 75% of the original topsoil has been lost. If there is a plow layer, it consists mostly of the subsoil material. It has color and texture like those of the subsoil.

C. Landscape Analysis

The landscape is made up of all the landforms that can be seen from a single vantage point. These landforms influence the type of soil there, how the soil is used, and best management practices. Landforms are identified where the soil pit is located.

Upland Landforms

The upland landscape (fig. 12) is used to describe all landforms that are not cut by flowing water or built by water-transported deposits (next section).

Upland Ridge/Summit: Upland ridge/summits are landforms that form the uppermost part of the local landscape hillslope. They are higher than surrounding side slopes.

Side Slopes: Side slopes are sloping ground between the upland summit and lower, flatter footslopes. Side slopes usually are the steepest sloping part of the local hillslope.

Footslopes: Footslopes are slopes at the base of the side slopes that are more gently sloping than steeper side slopes uphill. Soils on the foot slopes are primarily developed in materials carried downhill by gravity (colluvium) from upland ridge summits and side slopes.

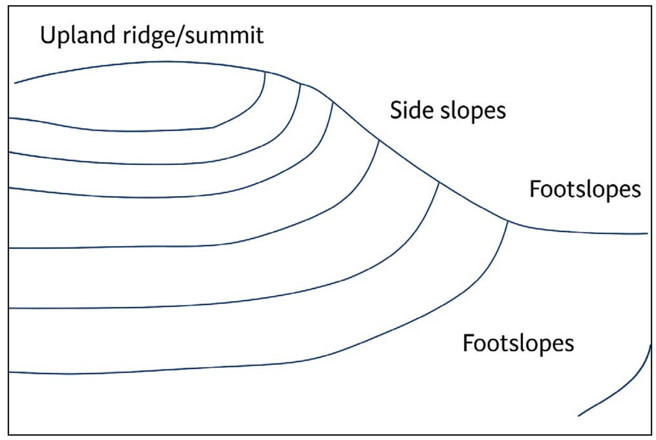

Figure 12. Upland landscapes and associated landforms. Drawing by John M. Galbraith, Virginia Tech.

Landforms Associated with Flowing Water

Alluvial landforms formed from flowing water erosion (drainageways) or in sediment deposited by flowing water (floodplains and terraces) (fig. 13). A water transported deposit may have a buried topsoil horizon, may be sandier, have differing textures with depth, have more gravel, or the gravel is more rounded than the surrounding soils.

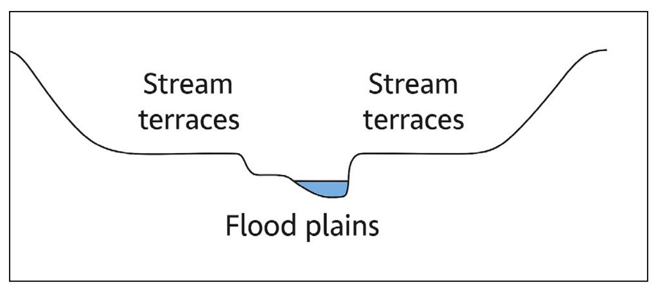

Figure 13. Stream terraces flanking a flood plain landform in alluvial landscapes. Drawing by John M. Galbraith, Virginia Tech.

Floodplains: Floodplains (bottomlands) are the lowest landscapes immediately along streams. On the floodplain, new material is deposited so frequently that the soils are relatively young and not well developed. Many floodplain soils are so young that there is minimal subsoil development, or there may be a buried topsoil horizon present. Floodplains seldom have any buildings on them because of flood damage.

Stream Terraces: Once a stream has cut deeper into the landscape, which creates a new floodplain, it leaves an old floodplain behind. Since the old floodplain is no longer covered by water and sediment, soil formation can occur for a long time and have strongly developed subsoils. These former floodplains that are now above the flood level are called stream terraces and some can be found at considerable distances from modern streams.

Drainageways: Before runoff reaches a perennial stream, it collects in small natural drains in higher landscapes called drainageways (fig. 14). Drainageways slope up from the floodplains and erode into the sloping hillslopes, carrying water only shortly after heavy rains. The upper part of the soil in a drainageway is made up of local sediments washed from nearby uplands or side slopes.

Part 3: Inferred Soil Characteristics

Inferred soil properties are those that cannot be easily measured.

A. Infiltration Rate

The soil infiltration rate is the rate at which rainfall enters the soil surface rather than flowing across it. This rate is mostly affected by surface layer (topsoil) texture and structure (table 5). For example, if the students determine that the topsoil in the sample container is sandy loam, and the soil structure as seen in the pit is blocky, the infiltration rate would be “rapid.” If the soil structure had been platy, the infiltration rate would be “medium” instead.

Figure 14. Drainageways are sloping waterways (blue dashed arrows) that carry water to more level flood plains (solid blue line). Drainageways in cropland may have perennial grass planted to prevent erosion (grassed waterways). Terrain view (Map Data 2017 Google). Annotated by John M. Galbraith, Virginia Tech.

Table 5. Relation between surface texture, structure, and infiltration rate.

Surface Texture	Soil Structure	Infiltration Rate
Sand, Loamy Sand	Any	Rapid
Sandy Loam	Granular or Blocky	Rapid
Sandy Loam	Massive or Platy	Medium
Silt Loam, Loam, Silt	Granular or Blocky	Medium
Silt Loam, Loam, Silt	Massive or Platy	Slow
Silty Clay Loam, Clay Loam, Sandy Clay Loam	Granular	Medium
Silty Clay Loam, Clay Loam, Sandy Clay Loam	Blocky, Massive or Platy	Slow
Silty Clay, Sandy Clay, Clay	Any	Slow

B. Surface Runoff

Surface runoff is the relative rate that water is flows across the soil surface rather than infiltrating into it. Surface runoff is affected by slope, slope length, surface layer (topsoil) texture, vegetative cover, infiltration rate, and the intensity and duration of rainfall. Only slope and infiltration rate are used to estimate surface runoff (table 6).

For the purpose of the contest, we will evaluate runoff as runoff potential as if the soil were bare (so that vegetative cover extent will not have to be considered). For example, if the percent slope is 2% and the infiltration rate is “medium,” the surface runoff would be “slow” according to table 6.

Vegetation on the soil surface greatly decreases runoff. For example, a stable forest with leaf litter has a much slower runoff than a site of pasture grass; grass has slower runoff than bare ground. However, once a soil becomes saturated or the rate of rainfall exceeds the infiltration rate, the surface runoff rate increases regardless of texture, slope, or vegetative cover.

Table 6. Runoff class is based on the relation between slope percent and infiltration rate.

Slope %	Rapid Infiltration	Medium Infiltration	Slow Infiltration
<1	Very Slow	Very Slow	Very Slow
1 to< 2	Very Slow	Slow	Slow
2 to < 7	Slow	Medium	Rapid
7 to < 15	Medium	Rapid	Rapid
≥ 15	Rapid	Rapid	Rapid

Very Slow: Water is removed so slowly or stands so long that the soil remains wet for long periods. Most of the water either passes through the soil or evaporates. Generally, this condition occurs on level to slightly concave slopes. However, deep sandy soils with rapidly permeable subsoils on slopes also have very slow runoff. This is because the infiltration is so high that rainfall produces little or no runoff.

Slow: Water flows away so slowly that free water covers the soil for moderate periods. This increases the moisture supply but may interfere with farming operation.

Medium: Water drains away readily but is slow enough that a large amount of the water enters the soil. This condition causes little erosion hazard and is considered a normal amount of runoff.

Rapid: Water is removed from the surface at a rapid rate. A large amount of rainfall is lost and only a small portion moves into the soil increasing the erosion hazard. This is a result of compaction, clayey textures, poor surface structure, and/or slopes greater than 3% (except when the soils are rapidly permeable).

C. Permeability

Permeability is the rate that water moves or percolates downward through the subsoil following infiltration. Soil texture has a major effect on subsoil permeability (fig. 15), but other properties such as structure, bulk density, pore size and quantity, root channels, and animal or insect burrows affect permeability as well (Easton and Bock 2016). In this soil judging contest, permeability will be determined based on texture and structure (table 7) of the subsoil horizon that matches the sample in the subsoil texture container.

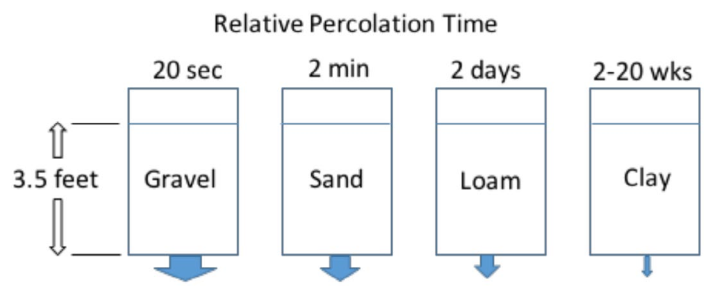

Figure 15. Relation between texture and permeability rate (time/distance) based on subsoil texture alone. Soil structure has a major influence as well. Drawing by John M. Galbraith, Virginia Tech.

Table 7. Relation between texture, structure, and permeability rate.

Subsoil Texture	Structure	Permeability
Sand, Loamy Sand	Any	Rapid
Sandy Loam[1], Loam, Silt Loam,	Any	Moderately Rapid
Sandy Clay Loam, Clay Loam, Silty Clay Loam	Any	Moderate
Clay, Sandy Clay, Silty Clay	Blocky or Prismatic	Moderate
Clay, Sandy Clay, Silty Clay[3]	Platy or Massive	Slow[2]

[1] Sandy loams with significant amounts of gravel (15% or more) have rapid permeability.

[2] Hardpans, claypans, and fragipans (see the Glossary and fig. 16) always produce slow permeability regardless of texture.

[3] High shrink-swell clays (see page 19) are always included in the “Slow” class.

For example, if the subsoil texture sample is clay loam, and the structure of that horizon observed in the pit is blocky, the permeability would be "moderate." Hardpans, claypans, and fragipans limit percolation rates, regardless of their texture. Hardpans are dense horizons with platy structure at the base of a plow layer caused by severe compaction of plowing a wet soil with heavy machinery. Claypans are subsoils that have an E horizon right above a very large increase in clay and change in color. The clay is usually a high shrink-swell type. Fragipans (fig. 16) are naturally occurring loamy subsoils that are dense and hard to dig in and that restrict root growth and water movement. Many are light colored or have white colors just above, and some have vertical gray ribbons.

Figure 16. Fragipans (dense horizon below the white colors) have slow permeability, forming a water perching zone. Some have dominantly white colors. Photograph courtesy of Erik Severson, Virginia Tech.

D. Natural Soil Drainage Classes

Natural soil drainage (drainage class) is the result of the interaction of soil texture and depth to the shallowest of an observed water table, or gray wetness mottles, or a dominantly gray color (with or without iron mottles) seen in the pit (fig. 8). For example, if the subsoil texture is loamy sand and the depth to gray mottles is 20 inches, the drainage class is "moderately well." Table 8 (Soil Survey Staff 2017) is used even if the soil has been artificially drained for growing crops, hay, or pasture. The interpretation of drainage class depends on the intended use. Excessively drained soils do not hold enough water for optimum plant growth and do not have gray wetness mottles or evidence of a water table in the profile. Poorly drained soils (wet near the surface for long periods) are opposite in that they are so wet that crops can only grow if the soils are artificially drained. Moderately well drained soils may be wet late in the spring but are not wet enough to warrant drainage ditches. Well drained soils do not have water tables at depths shallow enough to hinder agricultural use.

Excess water is a wetness problem in moderately well, somewhat poorly, and poorly drained soils. Another equally important problem is retaining sufficient water within the rooting depth to supply plant needs. Water that is held briefly by the soil for plant growth between wilting point and field capacity is called "plant available water." Excessively drained soils usually cannot hold adequate available water for plant growth. Available water for plants in all other drainage classes varies depending on soil texture and structure.

Table 8. Relation between drainage class, subsoil texture, and depth to water or gray mottles.

Drainage Class	Subsoil Texture	Depth to Water or Gray Mottles (inches)
Poorly	Any textures	< 10
Somewhat Poorly	Any textures	10 to 18
Moderately Well	Any textures	18 to 36
Well	Any textures except sand and loamy sand	> 36
Excessively	Sand or loamy sand	> 36

Excessively Drained: Seasonal high water table is not within the rooting zone long enough during the growing season to adversely affect yields, and the texture is sand or loamy sand that drains rapidly.

Well Drained: Seasonal high water table is not within the rooting zone long enough during the growing season to adversely affect yields. The B horizon is usually uniform in color.

Moderately Well Drained: Seasonal high water table is within the rooting zone for a sufficiently long period of time to adversely affect some crops unless the soil is artificially drained.

Somewhat Poorly Drained: Seasonal high water table is near the surface for periods long enough to affect yields unless an artificial drainage system is installed. The horizon immediately below the A horizon is not dominantly gray.

Poorly Drained: Seasonal high water table is at or near the surface during a large part of the year. The A horizons are dark gray to black, and subsurface horizons immediately below the A horizon are dominantly gray. Very poorly drained soils are ponded most of the year or tidally flooded.

Part 4: Agricultural Management

A. Major factors that keep area out of Class 1

Students should record all factors that might keep a site out of Class 1 on their scorecard. See Table 9, Class 1. Stony surface texture is grouped with sands and loamy sands in the "Texture" container.

Table 9. Key to land capability class. Start at Class I and select the first class that qualifies (has none of the unacceptable limitations, and meets one of the listed requirements).

Class	Criteria
I	Unacceptable Limitations: • Sand or loamy sand surface texture • Stony surface texture • Rock outcrops 10 feet or less apart • Rock or a fragipan is less than 20 inches deep • 2% or higher slope • Moderate or severe erosion • Slow or rapid permeability • Very slow or rapid runoff • Wetness problems (poorly drained soils, water table at 18 inches or less; or ponded, cannot be artificially drained) • Any flooding/ponding
II	Unacceptable Limitations: • Sand or loamy sand surface texture • Stony surface texture • Rock or a fragipan is less than 20 inches deep • Rock outcrops 10 feet or less apart • Rapid permeability • >= 7% or higher slopes • Severe erosion • Rapid runoff • Wetness problems (poorly drained soils, water table at 18 in. or less; or ponded, cannot be artificially drained) • Occasional or frequent flooding/ponding
III	Unacceptable Limitations: • Stony surface texture • Rock or a fragipan is less than 20 inches deep • Rock outcrops 10 feet or less apart • >= 15% slopes • Severe erosion • Wetness problems (ponded, cannot be artificially drained) • Frequent flooding/ponding

Class	Criteria
IV	Unacceptable Limitations: • Stony surface texture • Rock or a fragipan is less than 20 inches deep • Rock outcrops 10 feet or less apart • >=25% slopes • Severe erosion • Wetness problems (ponded, cannot be artificially drained) • Frequent flooding/ponding
V	Unacceptable Limitations: • Rock or a fragipan is less than 20 inches deep • Rock outcrops 10 feet or less apart • >=25% slopes • Severe erosion • Requirements (Must have one of the following): • Stony surface texture • Wetness problems (if ponded or cannot be artificially drained)
VI	• Requirements (Must have one of the following): • Rock or fragipan is < 20 inches deep • Rock outcrops are 10 feet or less apart • >= 25% slope (that can be modified by terracing) • Severe erosion (that can be modified to allow pasture or cropland use)
VII	Meet one or more criteria for class VI, but slope and erosion cannot be modified enough to allow any pasture or cropland use. The site may allow grazing native plants or harvesting trees.
VIII	All other soils. Nearly barren areas, only suited to native plants.

B. Land Capability Class:

The land capability classification system groups soils with similar potential for cultivated crops, pasture, range, forestry, and wildlife (Warren 2016; Edmonds et al. 1998). Classes I through IV are capable of producing cultivated crops. Soils in classes V, VI, and VII are not suited to cultivated crops but are suitable for grazing and forestry. Soils in class VIII are suitable only for wildlife and recreation. The intended land use is listed on the site card.

Complete definitions of the eight land capability classes are given below. Contestants use table 9 as a key to identify the class and use table 10 to check the class placement made. Artificial drainage means that ditches and canals have been dug by humans to lower the water table. For all classes: Flooding or ponding frequency (rare, occasional, or frequent) are given for each site in the land-judging contest. If no flooding or ponding frequency is given, assume they do not occur. The duration of flooding is likely to be brief (a few days or less) but the duration of ponding is likely to be long (one week or longer).

Table 10. Land capability class in relation to soil and site criteria. Use this table to check class placement using Table 9.

Soil Factor	Criteria	Best Class
Surface Texture	Sand, Loamy Sand	III
	All other textures	I
Surface Texture (stoniness)	Stony	V
	Not stony	I
Depth to Bedrock or Fragipan	< 20 inches	VI
	>= 20 inches	I
Rock outcrops	Rock outcrops 10 feet or less apart	VI
Permeability	Rapid	III
	Moderate, Moderately Rapid	I
	Slow	II
Slope	Nearly Level (< 2%)	I
	Gently Sloping (2 to < 7%)	II
	Sloping (7 to < 15%)	III
	Moderately Steep (15 to < 25%)	IV
	Steep (>= 25%)	VI
Erosion	None to Slight	I
	Moderate	II
	Severe	VI
Runoff	Rapid	III
	Medium or Slow	I
	Very Slow	II
Wetness	Ponded (cannot be artificially drained)	V
	Water Table at 0 to 18 inches	III
	Water Table > 18 inches	I
Flooding/Ponding	None	I
	Rare	II
	Occasional	III
	Frequent	V

Class I Land: Class I land has few or no conditions that limit its use for most common agriculture crops; it can be safely cultivated without special conservation treatment. Class I land soils may be used safely for cultivated crops, improved pasture, hayland, range, forestry, and wildlife. Because they are nearly level, the water erosion hazard is low. Wind erosion may be high if textures are sandy and the soil is left bare. They are deep, generally well drained, and easily tilled. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to fertilizer. Class I land does not have a wetness problem or other unfavorable soil characteristics in the root zone. These soils are not subject to flooding or ponding.

Class II Land: Class II land has some natural conditions that require some conservation practices when it is cultivated or that limit the kinds of plants it can produce. Class II soils require more careful management than do those of Class I land, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are slight, however, and the practices are easy to apply. May be rarely flooded.

Class III Land: Class III Land has one or more moderate limitations on its use. These soils are more restricted in the crops that can be produced than are those in classes I and II but can easily be used for improved pasture or hayland. When cultivated, conservation practices are more difficult to implement, and/or maintenance is usually required. Class III soils have limitations, as they restrict the amount of clean cultivation; time of planting, tillage or harvesting operations; choice or yield of crops; or a combination of these. The limitations may be natural ones, such as steep slopes or wetness problems, or the limitations may be the result of erosion brought on by the way land has been used.

Class IV Land: Class IV land is suitable for only occasional or limited cultivation. It has one or more severe limitations that restrict its use and the kinds of plants that can grow. Class IV land requires very careful management when cultivated. Conservation practices are more difficult to apply and maintain than on Class I, II and III soils. Class IV land includes areas where flooding or ponding may preclude planting or harvesting crops during unfavorable years. Many sloping, Class IV soils in humid areas are suited to occasional, but not regular, cultivation because of the severe erosion hazard. Some of the poorly drained, nearly level soils are not subject to erosion but are poorly suited to some crops because of wetness problems or low productivity for cultivated crops. Some hilly soils in Class IV are well suited to grow improved or native pasture, hayland, or special crops such as fruits or ornamental trees and shrubs.

Class V Land: Class V land is level but has some conditions that limit its use to improved or native pasture, range, hayland, forestry, recreation, watershed protections, or wildlife habitat. The soils in class V land have limitations other than erosion that restrict the kinds of plants that can be grown and/or that prevent tillage of cultivated crops. Examples of limitations a) stony surface texture; b) subject to frequent flooding or ponding; c) ponded areas where drainage is not feasible.

Class VI Land: Class VI land has soils with very severe limitations that make it unsuitable for cultivations. Class VI soils are best restricted to Improved and native pasture, hayland, range, forestry, recreation, watershed protection, or wildlife habitat. It may be well or poorly suited to forestry, depending on the characteristics of the soil. For these soils, it is practical to apply range or pasture improvement such as seeding, liming, fertilization, or water control by means of contour furrows, drainage ditches, diversions, or water spreaders. Some soils in class VI are well adapted to long-term meadows and sodded orchards that do not require cultivation or to special crops such as blueberries that require soil conditions unlike those demanded by most cultivated crops.

Class VII Land: Class VII land has soils with very severe limitations that make it unsuited for cultivation. Class VII is used for grazing, range, forestry, recreation, watershed protections, or wildlife habitat.

Even these uses in class VII soils require careful management. Soils in the class VII land have restrictions more severe than those in class VI because of one or more limitations that cannot be modified. These conditions make the land unsuited for common cultivated crops, although some special crops can be grown using precision management practices. Physical conditions of the soils make it impractical to apply pasture or range improvements. Forestry operations are possible.

Class VIII Land: Class VIII land has soils with severe limitations that prevent its use for commercial production of anything other than native plants. Soils and landforms in Class VIII cannot be expected to return significant on-site benefits from management for crops, grasses, or trees. Benefits from wildlife use, watershed protection, or recreation may be possible. Bedrock outcrops, sand beaches, river wash, mine tailings, and other nearly barren areas are included in Class VIII.

C. Soil Amendments:

A soil amendment is any substance added to the soil that alters soil properties (Haering and Evanylo 2015). Examples are lime and fertilizers. The pH, Nitrogen (N), Phosphorus (P), and Potassium (K) levels needed are based on soil tests of the surface layer for plant available nutrients (Maguire and Heckendorn 2010). It is assumed that all the plant's nutritional needs can be supplied by fertilizer (or legumes) and lime applications to the surface layer because most of the root system is in that layer.

None Needed: The soil has an adequate amount of lime and fertilizer (or legume) to produce the highest yield that the soil can produce.

Soil pH: Lime is used to correct excess soil acidity and to supply calcium (Ca) or magnesium (Mg) as plant nutrients. Soil pH also affects the availability of most nutrients to plants and their mobility in soil water (fig. 17). For example, Phosphorus becomes less available at pH less than 6.5 and micronutrients such as boron, copper, and zinc become less available at pH 7.0 or above.

Calcitic limestone ($CaCO_3$) and dolomitic limestone ($MgCO_3$) are the most common agricultural liming products. Lime should be added for most agronomic crops if the pH is less than 6.0. Soils with a pH of 8.0 are alkaline and elemental sulfur (S) can be used to lower the pH. Ammonium (NH_4) containing nitrogen fertilizers like ammonium nitrate or ammonium sulfate can also be used to lower soil pH.

Nitrogen (N): Nitrogen should be added to every crop except legumes, which have nodules on their roots containing microbes that fix atmospheric nitrogen. Nitrogen is a major component of chlorophyll and amino acids in plants and microbes. As part of the information given for each site for the soil judging contest you will be told the crop to be grown.

Phosphorus (P): Phosphorus is needed on crops except when the soil test is very high (starter P applied as a band may be beneficial when the soil test is high). Phosphorus is used in photosynthesis, respiration, energy storage, and cell growth in plants. The phosphorus content of a fertilizer is expressed as percent phosphate (P_2O_5).

Potassium (K): Potassium is needed on crops except when the soil test is very high. Potassium regulates stomate opening and closing and production of ATP in plants. The potassium content of a fertilizer is expressed as percent potassium oxide (K_2O) and is often called "potash."

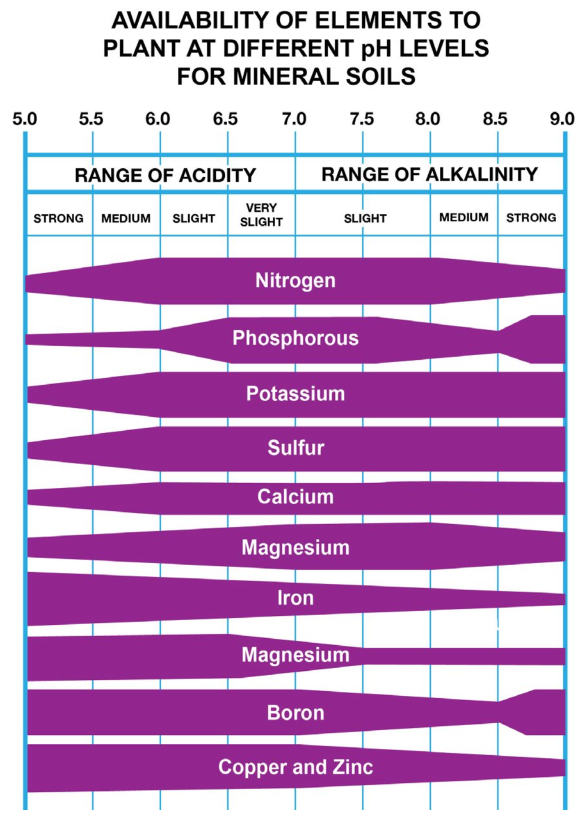

Figure 17. Affect of pH on nutrient availability. Used by permission from Manutec Garden Products (www.soilphtesting.com).

D. Land Management Systems

Land management systems involve both crop rotation and tillage systems. Class I – IV lands may be used for growing row crops or any other purpose, but row crops are not recommended on Class V – VIII Lands. The intended crop and land use will be given on the site card. The following land management options are given by Land Class. Row crops include all traditional crops (corn, wheat, soybeans, etc.) and hay that must be planted annually or replanted frequently, such as sorghum, alfalfa, clover, or vetch.

Recommendations for row crop agriculture:

For Class I Land: Continuous Row Crops may be grown, but crop rotation is recommended to minimize pests and diseases.

For Class II Land: Sod or Legume Crop Every 4th Year.

For Class III Land that does not have sand or loamy sand surface texture: Sod or Legume Crop Every 3rd Year.

For Class III Land with sand or loamy sand surface texture, and all Class IV soils: Sod or Legume Crop Every 2nd Year.

Surface Residue Management, Cover Crops, and Minimum Tillage: Some Surface residue management and minimum tillage operations should be used in all row crops production. Surface residue management involves leaving as much crop residue on or only slightly mixed into the surface layer by using an off-set disk or similar implement to prepare a seedbed with as few tractor trips as possible. Residue adds organic matter, enhances infiltration, and reduces erosion.

Cover crops may be used instead to accomplish the same benefits, and they can use up excess Nitrogen fertilizer following a corn crop. Cover crop mixes with legumes can also be a substantial source of Nitrogen for the following crop.

Minimum tillage should leave the soil surface quite rough, also enhancing infiltration and reducing erosion. No-till is a form of reduced tillage that involves chemical weed control and planting directly into the previous year's stubble and residue to minimize erosion and preserve available water in the soil.

Recommendations for improved pasture and grazing operations on Class I –VI Lands:

Establish Recommended Grasses and Legumes: Native forested areas in Virginia must be cleared and planted to improved grasses.

Control grazing and conduct proper pasture management: Once planted, the improved pastures may used for hay operations or grazed. If grazed, utilize rotational grazing and proper stocking techniques that will maintain or improve the pastures. Control weeds and invasive plants, maintain proper forage height, rotate livestock, provide adequate clean water supply, fence off eroded banks, springs and riparian areas and maintain the proper pH and fertility. If used for hay, the proper pH and fertility must be maintained. Proper cutting height and frequency must be followed.

Recommendations for Grazing Operations on Class VII Lands:

Control grazing and conduct proper pasture management: In native communities, avoid overgrazing, rotate livestock, maintain proper grazing height, control invasive plants, provide adequate clean water supply, fence off eroded banks or trails, springs and riparian areas.

Recommendations for Forestry Operations on Class I –VI and on Class VII Lands:

Plant Recommended Trees and Harvest Trees selectively: For plantations such as Loblolly Pine, plant trees on establishment or after clearcut harvest. On plantations and native forests, remove undesirable tree species and invasive competition and harvest desirable species as they mature. Thinning and pruning may be needed.

Recommendations for Wildlife and Recreation Operations on Class I – VII and on Class VIII Lands:

Use Only for Wildlife or Recreation: The Class I – VII area is not used for crops, hay, permanent pasture, grazing, or forestry by choice of the owner or by regulations. Class VIII cannot be used for anything other than for wildlife or recreation. This might include very steep slopes, rock outcrop areas, beaches, pits and dumps, wetlands, and floodplains that flood frequently for long duration. urban or suburban development.

E. Mechanical Practices

Mechanical practices serve to reduce soil limitations within a given land capability class. This way, the soil can be used more intensively and sustainably without degradation.

Farm on Contour, or Strip Crop: Farming on contour or strip cropping is used on soils to reduce erosion hazard to an acceptable level. Select for Class II, III, and IV lands used for row crop agriculture.

Control Brush or Trees: Select this practice for soils that are capable of growing crops or improved pasture on Class I-IV land where brush or trees are present and too big to be removed by normal tillage operations (greater than 2 inches in diameter and/or 5 feet in height).

Control Gullies: Control in fields where gullies are present near the soil pit or slope stakes by establishing grassed waterways and by filling and grading. Gullies are defined as being at least six inches deep and twelve or more inches wide, and they should be present near the soil pit.

Windbreaks or Cover Crops: Wind erosion must be controlled on soil with sand or loamy sand surface texture. Windbreaks prevent damaging winds from eroding bare soil and cover crops minimize the amount of time that the soil is bare.

No Treatment Needed: Not checked on soil with sand or loamy sand surface texture. This would be checked on (a) Class I land where brush and trees and gullies are not a problem, (b) Class II land where erosion is not severe and gullies are not present near the soil pit, and the site is not ponded and has no wetness at 18 inches or less.

Part 5: Land Use Interpretations

Only a small percentage of our population is actually involved in food, feed, and fiber production. The tremendous productivity of the agricultural sector allows most of us to work in non-agricultural areas. It is critically important that we all understand the need to conserve our soils for agricultural use, but for many of us the impact of non-agricultural land use will directly affect us. For example, in purchasing a house, many critical soil properties should be considered. This section provides an opportunity to learn how to evaluate soil for uses other than food and fiber production.

Scorecard Interpretations

When using soil for non-agricultural purposes, the emphasis shifts from surface to subsurface soil properties. In addition, the impact of infrequent catastrophic events, such as flooding or ponding, are much more important than in most agricultural uses.

In this section, important soil properties are evaluated and identified; then the limitation of that soil property for a specific use is determined (table 11).

Use limitations categories for each soil feature are those used by the National Cooperative Soil Survey (Edmonds et al. 1998). They are defined as follows:

Slight Limitations: Those soils or locations that have properties favorable for the planned use and present few or no problems.

Moderate Limitations: Those soils or locations that have properties only moderately favorable for the planned use. Limitations can be overcome or modified with special planning, design, or maintenance. Special treatment of the site for the desired use may be necessary.

Severe Limitations: Those soils that have one or more properties unfavorable for the planned use. Limitations are difficult and costly to modify or overcome for the use desired.

After limitations on each use, for each soil feature, have been determined, a final evaluation for each use is completed. This determines the overall limitation on the use of the site. The final limitation is based on the most restrictive soil-site property. For example, if a soil is rated slight for homesite foundations (no basement) (table 11) for all features except it is rated severe for frequent flooding or ponding, it receives a final evaluation of “severe” because the most limiting factor will control the use. Everything else may be suitable for a homesite, but if the site floods frequently, it is not a desirable homesite.

Soil Properties to be Evaluated

Most of the properties evaluated in this section are similar to those evaluated in Parts 1, 2, and 3. Limits for classes may be somewhat different in this section since we are more concerned about internal water flow and soil properties at greater depths. Differences between this section and other sections are discussed below.

Texture:

Five general textural classes are used for soil interpretations.

Sands: Sands and loamy sands are combined.

Loams: Sandy loams, silts loams, and loams.

Clay Loams: Sandy clay loams, silty clay loams, and clay loams.

High shrink-swell clays: Subsoils shrink and crack open when dry and cracks swell shut when wet. The horizon samples are “tight” (stiff when texturing) and hard to wet up, and have shiny pressure faces on aggregate edges due to repeated volume change. Shrink-swell clays are plastic and can form very long, very thin ribbons during texturing and can form strong “toothpicks” when rolled. Sandy clays, silty clays, and clays are combined.

Low shrink-swell clays: Most clays in Virginia are not high shrink-swell, and do not meet the description of high shrink-swell clays above. Sandy clays, silty clays, and clays are combined.

Permeability:

The same classes are used as in Part 3. C.

Depth to Bedrock: Class limits are based on impact on land use, but limitation breaks for a specific use do not necessarily correspond with depth class breaks used by NRCS. The importance of depth to bedrock depends on the use.

Slope: Slope breaks are the same as in Part 2.A.

Water Table Depth: Water table depth is the shallowest of these features: 1) the depth to permanent water given on the pit card, 2) observed groundwater table in the pit, 3) a dominantly gray colored horizon (with or without red mottles), or 4) gray wetness mottles.

Flooding/Ponding: Three frequency classes are used, but all three are severely limiting for most land uses. The duration of flooding is likely to be brief (a few days or less) but the duration of ponding is likely to be long (one week or longer). If no flooding or ponding frequency is given on the site card, assume none occurs.

- **Frequent:** 50% likely to occur every year.
- **Occasional:** 5 to 50% likely to occur every year.
- **Rare:** 1 to 5% likely to occur every year.
- **None:** No chance of occurring.

Determination of Use Limitation

A. Foundation (No Basement)

Soil properties evaluated are depth to bedrock, slope, landscape position, texture of the soil at a depth of two to seven feet and depth to a water table. It is assumed that footings will be placed thirty inches below the surface. The footings can be anchored in bedrock, but it is more expensive. Table 11 is used to determine the degree of limitation for small building or house foundations (no basement) based on these soil properties.

Table 11. Soil and site properties associated with limitations for foundations.

Soil Property	Slight	Moderate	Severe
Subsoil Texture	Loams, Clay Loams	Sands, Low shrink-swell Clays	High Shrink-swell Clays
Permeability	Rapid, Moderately Rapid, Moderate	---	Slow
Depth to Bedrock	>= 3 feet	---	< 3 feet
Slope	< 7%	7 to < 15%	>= 15%
Water Table Depth	>= 3 feet	---	< 3 feet
Flooding/Ponding	None	---	Any frequency

High shrink-swell clays could cause the foundation to crack. Slow permeability makes it likely that wetness will be a problem around the foundation.

Removing bedrock is expensive, but if part of the foundation is on hard bedrock and part on clay, the foundation may not be stable. Special designs can reduce this problem but are expensive.

On steep slopes, it becomes more difficult to prepare suitable footings. House sites on steeper slopes may require special designs and are usually more costly. Cut and fill associated with site development on steep slopes is also expensive. Water in the subsoil reduces the soil-bearing capacity, making it susceptible to slippage and foundation cracks. High soil humidity from inadequately drained soils increases the chance for wetness problems in the house. House foundations should not be built on sites subject to any flooding or ponding.

B. Septic Tank Absorption Drainfields

Disposal of human waste is a critical role that the soil must handle. Wastewater entering a conventional drainfield (fig. 18) must then pass through the oxygenated soil at a moderate rate. This will allow microbes to decompose the remaining organic matter, oxygen to kill harmful anaerobic microbes, and clays to absorb excess nutrients. The soil in a drainfield must be able to filter wastewater equivalent to 200 inches of rainfall a year. Therefore, a good drainfield soil must be moderately permeable and deep to water and bedrock (table 12). A certain minimum thickness of soil, depending largely on permeability, is needed for effectively filtering wastewater. A minimum thickness of 18 inches of suitable soil is required between the drainfield trench bottom and either bedrock or water table.

Soil texture that is too sandy allows wastewater to enter the groundwater too rapidly. Clays with high shrink-swell potential swell shut when wet and severely limit permeability. Rapid or slow permeability makes it likely that water will percolate either too rapidly or too slowly for microbial treatment and cleanup of contaminants. Bedrock near the land surface often has open cracks that wastewater can enter and flow directly to the groundwater, especially in areas of limestone or dolomite and cave systems.

Slope that is steep allows wastewater to rise to the soil surface or requires many trenches, raising the cost of installation. Water in the subsoil may intercept wastewater and carry it to groundwater or surface water, and the lack of oxygen in wet soils limits the microbial treatment and cleanup of contaminants. Drainfields should not be built on sites subject to flooding or ponding because in flood events or when the site is ponded the wastewater directly enters the stream or groundwater.

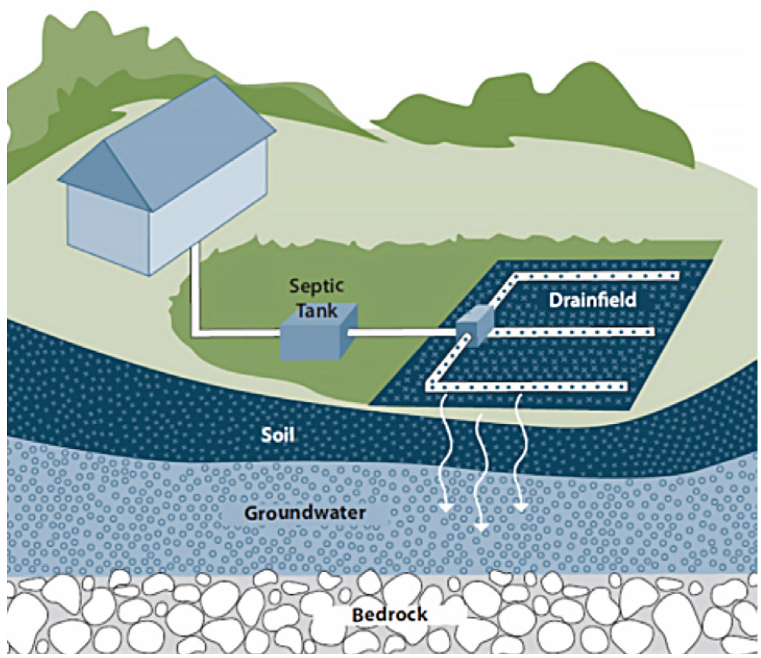

Figure 18. A conventional on-site wastewater dispersal system for a single house is typically made up of a septic tank and a drainfield installed in the soil above the water table. (Reprinted by permission from The Groundwater Foundation. "Potential Threats to Our Groundwater: On-Site Wastewater Treatment Systems." www.groundwater.org/get-informed/ groundwater/ wastewater.html.)

Table 12. Soil and site properties associated with limitations for septic tank absorption fields.

Soil Property	Slight	Moderate	Severe
Subsoil Texture	Loams, Clay Loams	Low shrink-swell Clays	Sands, High shrink-swell Clays
Permeability	Moderately Rapid	Moderate	Rapid and Slow
Depth to Bedrock	>= 5 feet	---	< 5 feet
Slope	< 7%	7 to < 15%	>= 15%
Water Table Depth	>=5 feet	---	< 5 feet
Flooding/Ponding	None	---	Any frequency

C. Shrubs and Trees

Most of the soil around a newly built home has been highly disturbed during construction. Often the topsoil is put back on top of subsoil. Shrubs and trees include those normally used as ornamental plantings around the homesites. Table 13 is used to determine the degree of limitation for trees and shrubs planted near houses.

Table 13. Soil and site properties associated with limitations for shrubs and trees.

Soil Property	Slight	Moderate	Severe
Subsoil Texture	Loams, Clay Loams	Sands, Clays of any type	---
Permeability	Moderate, Moderately Rapid	Rapid	Slow
Depth to Bedrock	>= 3 feet	---	< 3 feet
Slope	< 15%	15 to < 25%	>= 25%
Water Table Depth	>= 3 feet	---	< 3 feet
Flooding/Ponding	None	Rare or Occasional	Frequent

Sands will hold water inadequately. Slowly permeable soils and clays that seal when wet will slowly cause percolating water to perch and soils to lose oxygen. Rapidly permeable soils will not keep water in the root zone. Woody plants need adequate depth to bedrock or water tables for roots to uptake water and nutrients. Excessive slopes increase runoff and erosion and reduce water available for growth. Frequent flooding or ponding can physically damage shrubs and trees or cause the roots to die from lack of oxygen.

D. Road-fill

Soil properties important for road-fill or fill of any kind relate to soil texture, rock content (not estimated in this contest), and thickness of suitable material (table 14). The table below rates the suitability of a source area for materials, not for location of the road.

Table 14. Soil and site properties associated with limitations for roadfill.

Soil Property	Slight	Moderate	Severe
Subsoil Texture	Loams, Clay Loams	Sands	Clays of any type
Permeability	Moderate, Moderately Rapid	Rapid	Slow
Depth to Bedrock	>= 5 feet	---	< 5 feet
Slope	< 15%	15 to < 25%	>= 25%
Water Table Depth	>= 5 feet	---	< 5 feet
Flooding/Ponding	None	---	Any frequency

Soil materials that are too high in clay or sand are less desirable than soil materials with a good mixture of sand-, silt-, and clay- sized particles. Rock content is favorable for road-fill because it withstands heavier weights and has fewer ruts. A sufficient depth of suitable material above bedrock or a water table is needed for economic operation. What is left after the excavation ends must be capable of growing plants with appropriate additions of lime and fertilizer. When removing soil to construct a road the disturbed area must be protected from erosion while soil is being removed and while vegetation is being reestablished. Installing a silt fence should always be recommended when land is disturbed for road-fill. Any flooding or ponding prevents the site from being used for long periods unless specialized equipment is used.

E. Waste Lagoons

Aerobic waste lagoons for holding animal manure and other waste require a very slowly permeable soil or one that can be made impermeable. Most lagoons are a combination of a shallow excavation and a berm. It is most economical to use excavated soil material for the berm and for lining the bottom and sides. The floor and side walls of a lagoon must have very slow permeability rates such that wastewater will not leak into local groundwater or surface water. Table 15 lists those soil properties that must be evaluated for this kind of use.

Table 15. Soil and site properties associated with limitations for waste lagoons.

Soil Property	Slight	Moderate	Severe
Subsoil Texture	Low shrink-swell clays	Loams, Clay Loams, High shrink-swell Clays	Sands
Permeability	Slow	Moderate, Moderately Rapid	Rapid
Depth to Bedrock	>= 3 feet	---	< 3 feet
Slope	< 2%	2 to < 7%	>= 7%
Water Table Depth	> 3 feet	---	< 3 feet
Flooding/Ponding	None	---	Any frequency

The permeability of the side walls and bottom of a lagoon must be slow or the soil must be modified to make it impermeable. Rapidly permeable material is unsuitable because of leakage. Moderate and moderately rapid soils require more expensive modifications such as severe mechanical compaction. In some cases, a costly plastic or rubber liner is needed. Often, local clayey soil material can be used to line ponds and lagoons. High shrink-swell clays may crack after the lagoon if emptied and may leak when the lagoon is refilled. Shallow depth to bedrock or water table reduces the depth of a lagoon pond. Exposed bedrock must be sealed, and animal waste cannot be allowed to contact the water table, where it can enter the groundwater or stream system. Steep slopes make construction difficult and costly. Flooding could lead to a washout of lagoon contents unless the berm is above flood level and ponding could directly cause water contamination.

Part 6: Setting up and Holding a Soil Judging Contest

Selection of Site

The following information is derived from Land Judging in Oklahoma (Warren 2016) and Land Judging and Soil Evaluation (Edmonds et al. 1998).

A site should have only one landscape and slope gradient. The area to be evaluated for landscape is the soil pit, and the slope stakes should be on a similar position if possible. Depending on the land complexity, a site may be small or large in area. When a field with complex slopes is being evaluated, the pit and slope stakes should be located in the least variable part. A team consists of three or four contestants with the three high scores tabulated as the official team score. A club may enter a junior and senior team in the event. Students that have competed in the National Soils Contest are not eligible for state-level competition.

Slope: slope stakes should be the same height above the ground and should be located 50 or 100 feet apart (fig. 19). The slope should be measured with a clinometer or Abney level, and the stakes moved so that they represent the area where the pit is and are not between or on one end of the slope class range.

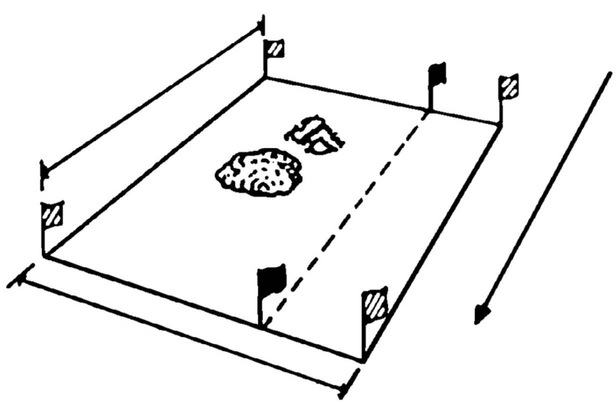

Figure 19. Proper slope measurement location (Warren, 2016).

Soil Profile: A pit should be 4-5 feet deep and 10-15 feet long with a gradual ramp into the pit. The pit should be of sufficient width to allow at least six people to judge simultaneously. Auger holes are not an acceptable way to expose a soil profile. A recent road cut can be used. The contestant can evaluate only what can be observed. So, if soil properties below the depth of the pit are important for interpretations, they must be listed on the information card (appendix A - CSES-202P-A). The width and depth of the soil pit must meet with all pertinent local and state trench safety standards.

The control area (no-pick zone) evaluated by the judges should be marked with a measuring tape. The sides are about 6-12 inches away from the tape and clearly marked to the bottom of the pit. This area should be used for measurements and contestants should not dig in this area. The soil profile exposed in the pit wall is assumed to be representative of the soil in the area being evaluated.

Topsoil and subsoil layer samples must be put into containers so that everyone has equal access to them. The samples in the containers may be used for texture, but the structure is determined in the soil pit in the horizons that match what is in the texture sample container. Depth to gray mottles, water table, or bedrock is measured in the pit from the top of the surface mineral horizon. Do not include the O horizon if one occurs.

An information card at each pit (publication CSES 202P-A) should include:

- Original soil thickness (can be estimated).
- Flooding or ponding information (specify which and give the frequency [rare, occasional, or frequent], or mark “none”).
- pH of surface soil (can be estimated; ex: 5.5, 6.4, etc.).
- Phosphorus and Potassium soil test levels (can be estimated; ex: Very High, High, etc.).

- Crop to be planted (If a legume is to be grown- no nitrogen is needed).
- Intended land use (If not cropland, specify if for grazing, hay, improved pasture, or forestry).
- Depth to bedrock to nearest half-foot, or “measured in the pit” if observable in the soil pit.
- Depth to water table to nearest half-foot, or “measured in the pit” if observable in the soil pit.
- Distance between slope stakes.
- A reminder not to dig in the control area (no-pick zone).

General Rules

Students will be given 20 to 30 minutes per site to complete their score sheets. Additional travel time may be provided if the soil pits are not close to each other.

No talking, texting, or communicating during the contest.

- No electronic searching during the contest.
- No comparing or copying scoresheets.
- No water bottles. Water to moisten soil will be provided at the site.

Contestants can bring the following equipment:

- Pencils, pens, or markers.
- Tape measure or ruler.
- A handheld tool to dig with.
- Towel or rag.
- Clip board.
- Score cards.
- A four function calculator.

Handouts to students: On the morning of the contest, each contestant should be given a packet containing four scorecards (appendix B - CSES-202P). The scorecards should be printed on cardstock and each pit should be evaluated using a different designated color, of paper. It is recommended that the colored scorecard be posted at each site.

Pit Rotation: Each team has four members (numbered A-D). Student A should start at pit 1. Student B should start at pit 2. Student C should start at pit 3. Student D should start at pit 4. Students rotate to the next higher pit after being told to do so. Students at pit 4 rotate to pit 1. They should not rotate ahead of time.

Scoring: Have individuals familiar with the contest procedures verify the answer keys prior to beginning grading and designate a person to as the lead authority for interpreting grading rules. Provide detailed instructions for the graders before scoring begins. Double check scores before turning them over to the tabulation committee. The total score for the pit should be circled on the front of the scorecard. The tabulation committee should set up a spreadsheet that totals the four pit scores. A formula should be utilized that adds the top three scores for each team together for the team score. The fourth contestants score, low team score, can still qualify for individual awards. The data entry person should put bogus data (scores) into the spreadsheet and hand check the spreadsheet formulas before the official scores are entered.

Results: The contest results should be announced by an official as soon as possible after the contest. The top five to ten individuals should be recognized then the top teams are recognized. The announced results will be final. The return of the scorecards to the contestants is left to the discretion of the contest official.

Tie Breakers: In case of an individual or team tie the high score on pit 1, then pit 2, then pit 3, then pit 4 will be used to break the tie. If the teams are still tied after the first tiebreaker, then the forth-individual’s score will be added to the team score to break the tie.

Resource People: In many localities, USDA-NRCS soil scientists, Virginia Tech Soils Extension Specialists or Soils faculty are available to assist with site selection and evaluation of soil profiles. Extension agents, SWCD, and USDA-NRCS conservationists should assist with agricultural and urban interpretations.

Additional Resources: It is recommended that a portable toilet should be provided at the contest site, along with water and first aid supplies. Snacks may be provided while the results are tabulated.

Duties of the Pit Monitors

A few minutes before starting the time:

- Announce the pit number, the color of cardstock to use, and that no digging is allowed in the restricted (no-pick) area.
- Remind the students to be courteous and safe when entering the pit.
- Identify the location of the surface layer (topsoil) container and the subsoil container.
- Identify the location of the provided water bottle.
- Identify where the slope stakes are located.
- Identify the location of the pit information card given by the judges.
- Collect scorecards when the horn sounds.

Additional Resources:

DeMarco, L. W. 2014. It's More Than Just Dirt: Exploring the World of Plants and Soils. Project Book 1. Virginia Cooperative Extension. Publication 380-020. www.pubs.ext.vt.edu/380/380-020/380-020_pdf.pdf.

Easton, Z. M., and E. Bock. 2016. Soil and Soil Water Relationships. Virginia Cooperative Extension. Publication BSE-194P. www.pubs.ext.vt.edu/BSE/BSE-194/BSE-194-PDF.pdf.

Maguire, R., and S. Heckendorn. 2010. Soil Test Note #1 - Explanation of Soil Tests. Virginia Cooperative Extension. Publication 452-701. https://www.pubs.ext.vt.edu/452/452-701/452-701.html.

Haering, K. C., and G. K. Evanylo. 2015. The Mid-Atlantic Nutrient Management Handbook. Virginia Cooperative Extension. Publication CSES-122P. www.pubs.ext.vt.edu/CSES/CSES-122/CSES-122-pdf.pdf.

References

Easton, Z. M., and E. Bock. 2016. Soil and Soil Water Relationships. Virginia Cooperative Extension. Publication BSE-194P. www.pubs.ext.vt.edu/BSE/BSE-194/BSE-194-PDF.pdf.

Edmonds, W. J. Thomas, P. J. Simpson, T. W., and J. C. Baker. 1998. Land Judging and Soil Evaluation. www.vaswcd.org/wp-content/uploads/2011/10/Land-Judging-and-Soil-Evaluation.pdf.

Haering, K. C., and G. K. Evanylo. 2015. The Mid-Atlantic Nutrient Management Handbook. Virginia Cooperative Extension. Publication CSES-122P. www.pubs.ext.vt.edu/CSES/CSES-122/CSES-122-pdf.pdf.

Maguire, R., and S. Heckendorn. 2010. Soil Test Note #1 - Explanation of Soil Tests. Virginia Cooperative Extension. Publication 452-701. https://www.pubs.ext.vt.edu/452/452-701/452-701.html.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field Book for Describing and Sampling Soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054184.

Soil Science Society of America. 2008. Glossary of Soil Science Terms. Soil Science Society of America. www.soils.org/publications/soils-glossary (Accessed 13 Mar. 2017).

Soil Science Division Staff. 2017. Soil Survey Manual. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. Government Printing Office, Washington, D.C. Available online at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054262.

Thien, S.J. (1979). A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55

USDA-NRCS. 2017. National Soil Survey Handbook, Title 430-VI. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242 (accessed 15 March 2017).

Warren, J. 2016. Land Judging in Oklahoma. Oklahoma Cooperative Extension. Publication 4H-HPS-101. www.landjudging. com/2009/land_judging_manual_2009.pdf.

Glossary of Terms

Many of the following definitions were taken from the Glossary of Soil Science Terms (Soil Science Society of America 2008).

Alluvium: Sediment deposited by flowing water.

Available Nutrient: The quantity of a nutrient element or compound in the soil that can be readily absorbed and taken up by growing plants.

Available Water: The portion of water in a soil that is available to be absorbed by plant roots (the amount of water held between wilting point and field capacity).

Bedrock: The solid (consolidated) rock layers underlying soils. Cementation ranges from very weak to strong.

Clay: As a soil-separate: individual particles less than 0.002 mm in diameter. As a textual class: a soil that is 40% or more clay, less than 45% sand, and less than 40% silt.

Clayey: Containing large amounts of clay.

Claypan: A layer in the subsoil having a much higher clay content and density than the overlying horizons, from which it is separated by a sharply defined boundary. Most underlie an E horizon and have high shrink-swell clay. Claypans are usually hard when dry and plastic and sticky when wet. They usually impede the movement of water and air and limit the growth of plant roots.

Coastal Plain Sediments: Unconsolidated sediment deposited by rivers and oceans.

Colluvium: A deposit of rock fragments and soil material accumulated on footslopes at the base of steep slopes as a result of gravity driven movement. May also be found on lower sideslopes, particularly in the Piedmont and Blue Ridge. Drainage: The act of creating open ditches or installing drainage tile, so that excess water can be removed by surface or by internal flow.

Erode: To wear away or remove the land surface by wind, water, or other transportation agents.

Erosion: 1) The wearing away of the land surface by running water, wind, ice, and other geological agents, including such processes as gravitational creep. 2) Detachment and movement of soil or rock by water, wind, ice, or gravity.

Fertilizer: An amendment that supplies one or more of the nutrients essential to plant growth.

Field Capacity: The content of water remaining in a soil 2 or 3 days after having been wetted with water and after drainage due to gravity is negligible.

Fragipan: A natural subsurface horizon with high density relative to horizons above. Fragipans are seemingly cemented when dry, but when moist they rupture when squeezed and break in a sudden manner of failure called brittleness in about three-fourths or more of the volume of the horizon. The layer is low in organic matter and may be light-colored or mottled with gray wetness mottles and iron concentrations. They are slowly or very slowly permeable to water, and usually show bleached cracks between large polygons with prismatic shape.

Gullies: Channel resulting from erosion and caused by the concentrated but flow of water usually during and immediately following heavy rain. Large enough (6 inches or more and 12 or more inches wide) that they are not obliterated by normal tillage operations. May also occur on grazed lands as eroded cattle trails.

Hardpan: A soil layer in the lower part of the plow layer or in the upper B horizon caused by compaction from plowing a wet soil with heavy machinery. Also called plowpan.

Landforms: Portions of the landscape that describe the shape of the land and its position relative to other land segments.

Landscape: All the natural features that the eye can comprehend in a single view, such as landforms, fields, hills, forests, water, etc., which distinguish one part of the earth's surface from another part.

Leaching: The complete removal of materials in solution from the soil by deep percolation.

Lime: An amendment that raises the soil pH. The most common form of lime is $CaCO3$ (ground limestone).

Lithochromic colors: Regular shaped color patterns or mottles left behind when bedrock is weathered. The pattern resembles the color pattern of the original bedrock layer or surrounds a weathering rock fragment.

Mottled: Contains spots or blotches (patterns) of different colors.

Mottle: A color pattern interspersed with the dominant horizon color. Mottles formed due to prolonged saturation and reduction and subsequent oxidation of iron (Fe) and manganese (Mn) are called redoximorphic features. Mottles associated with mineral or rock decomposition and weathering are called lithochromic colors.

Oxidation: Exposure of reduced elements to gas oxygen causes precipitation of iron oxides that have yellow to red colors or manganese oxides that are black. This process follows reduction in long term saturated soils.

Parent Material: The mineral or organic matter from which soil horizons are developed by soil forming processes. Bedrock forms the residual parent material of most soils west of the Fall Line, while unconsolidated (uncemented) sediments form most of the parent materials east of the Fall Line.

Particle Size: The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

Percolation: The downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil.

Permeability, soil: The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil. Soil horizons vary in permeability, and the most limiting rate of any horizon in the profile is considered.

pH (reaction): The degree of acidity (or alkalinity) of a soil sample determined by a lab instrument or field indicator kit and expressed in terms of the pH scale (1 to 14).

Plastic: A soil sample capable of being molded or deformed continuously and permanently, by relatively moderate pressure, into various shapes that hold together.

Plow Layer: The plowed or formerly plowed and mechanically mixed part of the soil (Ap horizon).

Profile: A vertical view of the soil through all its horizons and layers.

Redoximorphic Features: Concentrations of iron and/or manganese and depletions of iron and manganese formed from long-term saturation and reduction followed by oxidation of the soil.

Reduction: Reduction occurs when soil stays wet for long enough that iron and manganese are reduced and become soluble. Removal of both iron and manganese causes gray colors to develop. Depth to gray wetness mottles (redoximorphic features) or a dominantly gray horizon indicates the depth to a long-term water table.

Residuum: Soil material; formed by disintegration of bedrock in place.

Rock: An individual, detached fragment of a bedrock layer.

Sand: (particle) A soil particle from 0.05 mm to 2.0 mm in diameter. (texture class) A texture class with 85% or more sand and not more than 10% clay.

Sandy: Containing large amounts of sand or having properties to those of sand. Includes sand and loamy sand texture classes.

Soil Forming Processes: Processes that help soil develop horizons and characteristics, as influenced by soil forming factors: parent material, organisms (humans, other animals, and plants), relief (landforms, aspect, slope, etc.), climate, and time.

Solum: The O, A, E, and B horizons of a soil profile.

Surface Runoff: Surface runoff is the relative rate water is removed by flowing over the soil surface.

Sustainably: Managing soil and crop cultural practices so as not to degrade or impair environmental quality on- or off-site, and without eventually reducing yield potential as a result of the chosen practice through exhaustion of either on-site resources or non-renewable inputs.

Terrace: A step-like surface, bordering a stream or shoreline, that represents the former position of a floodplain, lake, or seashore.

Texture: The relative proportions of the sand, silt, and clay soil particles as described by the classes of soil texture shown in the texture triangle.

Tillage: The mechanical manipulation of the soil profile for any purpose; but in agriculture it is usually restricted to modifying soil conditions and/or managing crop residues and/or weeds and/or incorporating chemicals for crop production.

Topsoil: The fertile A horizon that formed at the land surface and darkened by humus. If trees have been cleared for cropping or pasture it is an Ap horizon.

Weathering: The breakdown and changes in rocks and sediments into soil at or near the Earth's surface due to biological, chemical, and physical processes or combinations of them.

Wilting point: Water content of a soil when indicator plants growing in that soil wilt and fail to recover when placed in a humid chamber.

Appendix A

Virginia Cooperative Extension
Virginia Tech • Virginia State University

CSES-202-A

Soils Contest Site # ____

Original Topsoil Depth ________________

Flooding/Ponding Frequency ________________

pH Level ________________

Nitrogen (N) Level ________________

Phosphorus (P) Level ________________

Potassium (K) Level ________________

Crop to be Grown ________________

Intended Land Use ________________

Depth to Bed Rock ________________

Depth to Permanent Water ________________

Slope Stakes are ______ Feet Apart.

Please don't dig in the no-pick zone.

Visit our website: www.ext.vt.edu
Produced by Virginia Cooperative Extension, Virginia Tech, 2025

VT/0725/CSES-202P (SPES-660P-A)

Appendix B

Virginia Cooperative Extension
Virginia Tech • Virginia State University

CSES-202-B

Virginia Soil Judging Scorecard

Name: ________________

County: ________________ Pit # ____

Part 1: SOIL FEATURES

A. Measure Thickness (in inches) of the Surface Layer or the A Horizon (5)

B. Surface Layer Textural Class (5)

Sand	
Loamy Sand	
Sandy Loam	
Loam	
Silt Loam	
Silty Clay Loam	
Clay Loam	
Sandy Clay Loam	
Clay	
Silty Clay	
Sandy Clay	

C. Subsoil Textural Class (5)

Sand	
Loamy Sand	
Sandy Loam	
Loam	
Silt Loam	
Silty Clay Loam	
Clay Loam	
Sandy Clay Loam	
Clay	
Silty Clay	
Sandy Clay	

D. Subsoil Color (5)

Red, Brown or Yellow	
Mottled (No Gray Mottles)	
Mottled (With Gray Mottles)	
Gray (With or Without Red, Yellow, or Brown Mottles)	

E. Depth to Saturation (5)

Shallowest Gray Mottles or Water	

F. Topsoil Structure (not graded)

G. Subsoil Structure (not graded)

Part 2: LANDSCAPE FACTORS

A. Slope Gradient (5)

Nearly Level	0-2%	
Gently Sloping	3-7%	
Sloping	8-15%	
Moderately Steep	16-25%	
Steep	>25%	

B. Erosion (5)

None or Slight	
Moderate	
Severe	

C. Landscape Analysis (5)

Upland Ridge	
Slideslope	
Footslope	
Floodplain, Terrace, Drainageways	

Part 3: INFERRED FEATURES

A. Infiltration Rate (5)

Rapid	
Medium	
Slow	

B. Surface Runoff (5)

Rapid	
Medium	
Slow	
Very Slow	

C. Permeability (Slowest rate) (5)

Rapid	
Moderately Rapid	
Moderate	
Slow	

D. Agricultural Drainage Class (5)

Excessive	
Well	
Moderately Well	
Somewhat Poorly	
Poorly	

Part 4: AGRICULTURAL MANAGEMENT

A. Major factors that keep area out of Class I (3 pts each)

None		Permeability	
Slope		Runoff	
Erosion		Wetness	
Depth		Flooding	
Texture			

B. Land Capability Class (5)

Class I		Class V	
Class II		Class VI	
Class III		Class VII	
Class IV		Class VIII	

C. Soil Amendments (3 pts each)

None Needed		Soil Test Data Surface	
Lime/ sulfur		pH	
Nitrogen		N	
Phosphorous		P	
Potassium		K	

D. Land Management (3 pts each)

Continuous row crops	
Sod or legume crop every 4th year	
Sod or legume crop every 3rd year	
Sod or legume crop every 2nd year	
Residue management or cover crops along with minimum tillage	

Establish recommended grasses and legumes	
Control grazing and conduct proper pasture management	

Plant recommended trees and harvest trees selectively	

Use only for wildlife or recreation	

E. Mechanical Practices (3 pts each)

No treatment needed	
Farm on contour or strip crop	
Control brush, trees	
Control gullies	
Windbreaks or cover crops	

TOTALS

Part 1 _________ *Part 4*__________ *Pit Total* __________

Part 2 _________ *Part 5*__________

Part 3 _________

Part 5: LAND USE INTERPRETATIONS

Rate each soil site property in column 1 for each land use below. (1 point per answer)

Circle the correct answer.	Degree of Limitations	Foundations (no basement)	Septic Tank Drainfields	Shrubs and Trees	Roadfill	Waste Lagoons
A. GENERAL SUBSOIL TEXTURE 1. Sands 2. Loams & Clay Loams 3. Clay – low shrink-swell 4. Clay – high shrink-swell	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
B. PERMEABILITY 1. Slow <0.6 "/hr. 2. Moderate 0.61-8.0 "/hr. 3. Moderately Rapid 0.81-2.0"/hr. 4. Rapid > 2.1 "/hr.4.	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
C. DEPTH TO ROCK 1. Shallow 0 - 20" 2. Mod. Deep 21 - 40" 3. Deep 41 - 72" 4. Very Deep over 72"	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
D. SLOPE NEARLY LEVEL 1. Nearly level 0-2% 2. Gentle 2.1 - 7% 3. Moderate 7.1 - 15% 4. Strong 15.1 - 25% 5. Steep > 25%	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
E. WATER TABLE (permanent or temporary) 1. Shallow < 30" 2. Mod. Deep 30 > 72" 3. Deep > 72"	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
F. FLOODING 1. None 2. Occasional 3. Frequent	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
FINAL EVALUATION Circle the correct answer. 1. All factors none to slight 2. One or more factors moderate, none, severe 3. One or more factors severe	Slight Moderate Severe	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐

Visit our website: www.ext.vt.edu

Produced by Virginia Cooperative Extension, Virginia Tech, 2025

VT/0725/CSES-202P (SPES-660P-B)