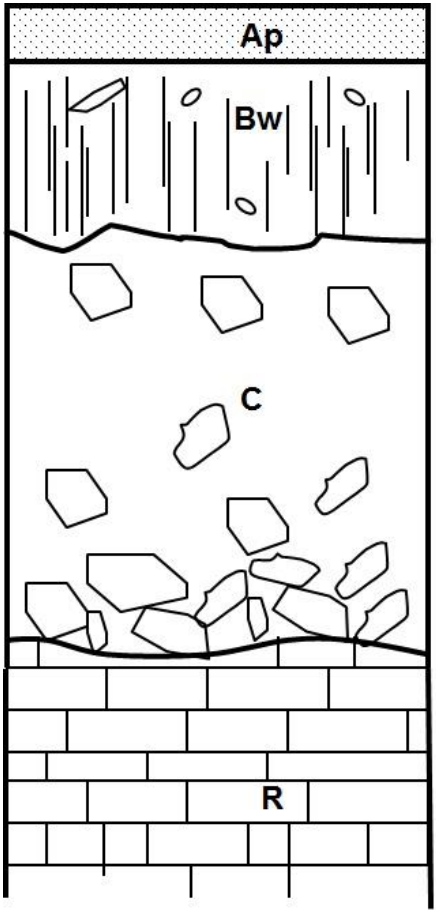


# *Describing and Documenting Soil Conditions for Soil Evaluators*

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# Contents

# Geologic Deposits

There are seven broad groupings of unconsolidated geologic sediments (soil parent materials) occurring within New England. Knowing the geology of a site is crucial to understanding how a site will impact adjacent areas and will help to narrow the focus of an on-site investigation to key issues.

**Glacial Till**

Definition: Dominantly unsorted and unstratified debris deposited directly by a glacier; consisting of a heterogeneous mixture of clay, silt, sand, gravel, cobbles, stones, and boulders.

**Kinds:** ***Two broad groupings of till:***

1. **Compact till (referred to as basal till or lodgement till)**
2. **Loose, sandy till (referred to as ablation till or meltout till)**

***Compact till***

**Characteristics:**

1. **Wide particle size distribution: clay, silt, sand, gravel, cobbles, stones and boulders**
2. **Unsorted, heterogeneous mixture**
3. **Angular shaped rock fragments**
4. **Substratum, firm and compact (locally referred to as hardpan)**
5. **Relatively high percent clay (7 - 25%)**
6. **Rock fragments are held firmly in soil matrix**

**Associated Landforms:**

- **Drumlin**
- **Till ridge**
- **Ground moraine**

**Focus of on-site Investigation:**

1. **Verify presence of compact substratum. Observe the ease or difficulty of excavation; may indicate the presence of compact till.**
2. **Check for presence of a perched water table**
3. **Vertical fractures filled with loose soil material may occur in the substratum of compact tills**

***Sandy, loose till (Ablation)***

**Characteristics:**

1. **Coarse-textured, sandy, gravelly and stony**
2. **Typically, loose, permeable material**
3. **Typically, unsorted, heterogeneous mixture**
4. ***Variable,* often has lenses or pockets of silty material**
5. **Many stones and boulder**
6. **Small but significant amount of silt and clay**

**Associated Landforms:**

- **Moraines: terminal and recessional**
- **Ground moraine**
- **May blanket compact till**

**Focus of On-Site Investigations:**

1. **Determine variability and extent of soil conditions**
2. **Check for impermeable strata**

**Shallow to Bedrock Areas**

**Characteristics:**

1. **Variable, complex soil conditions, typically pockets of deep soil and areas of shallow to bedrock soils**
2. **Depth to bedrock often varies over short distances**
3. **Weathered or fractured bedrock: is it soil or bedrock?**
4. **Rippable or non-rippable with an excavator**

**Associated Landforms:**

- **Bedrock areas are not associated with any particular landform other than outcroppings of ledge**

- **Typically, bedrock areas are associated with irregular terrain, steep ridges, abrupt knobs - however, some areas are smooth and nearly level**

**Glacial Outwash**

Definition: Stratified deposits of sands and gravel produced by glaciers and carried, sorted, and deposited by melt-water streams.

**Kinds: Two broad groupings of outwash:**

1. **Proglacial outwash - stratified outwash deposited in front of or just beyond the outer limits of a glacier**
2. **Ice-contact outwash - sands and gravel, originally deposited immediately adjacent to glacial ice, that collapsed with subsequent melting, leaving an irregular surface**

***Proglacial outwash***

**Characteristics:**

1. **Stratified, well sorted material**
2. **Clean sands and gravel, typically with very little silt and clay**
3. **Generally, lacks stones and boulders**
4. **Loose material, walls of pit slough in**
5. **If present, gravel- and cobble-sized rock fragments are rounded or sub-rounded**

**Associated Landforms:**

- **Outwash plain**

**Focus of On-Site Investigation:**

**If extensive and thick, these deposits are often groundwater recharge areas and are underlain by aquifers.**

***Ice-Contact outwash***

**Characteristics:**

1. **Variable - conditions change over short distances, very difficult to predict**
2. **Collapsed or slumped bedding**
3. **Well sorted to poorly sorted debris**
4. **Typically, loose, sandy material but may include pockets or lenses of fine-textured material**
5. **Dirty feel, often contains significant amounts of silt and clay**
6. **May have areas of stones and boulders**

**Associated Landforms:**

- **Kames**
- **Eskers**
- **Kame deltas**
- **Kame plains**
- **Kame terraces**
- **Kettles**

**Focus of On-Site Investigation:**

1. **Variable within short distances, both laterally and vertically**
2. **Check for impermeable strata**

**Lakebed (Lacustrine) Sediments**

Definition: Well sorted, fine textured sediments deposited originally at the bottom of a glacial lake that has since drained.

**Characteristics:**

1. **Well sorted, fine textured sediments**
2. **Generally high content of silt and/or clay**
3. **Coarse rock fragments are typically absent**

**Associated Landforms:**

- **Typically, an undulating to rolling terrain and may have steep erosionary escarpments adjacent to water courses**
- **Positioned above the present-day floodplain and bordered by highlands**

**Focus of On-Site Investigation:**

**Poor internal drainage often causes these areas to be wet**

**Marine Silts and Clays**

Definition: Areas of silts and clays deposited within a marine environment that have since been uplifted above present sea levels.

**Characteristics:**

1. **Limited extent in southern New England only occurring in the Boston area and north, and only in those towns close to the coastline**
2. ***Variable* - typically well sorted soils high in silts and clays**
3. **Locally referred to as blue clay**

**Associated Landforms:**

**Typically undulating to rolling terrain, locally associated with land areas below certain elevations**

**Focus of On-Site Investigation:**

1. **Poor internal drainage causes these areas to be wet and have high seasonal water tables**
2. **Variable within some areas**

**Dune Deposits**

Definition: Natural hill, mound, or ridge of sediment, often landward of a coastal beach that was deposited by wind action or storm overwash.

**Characteristics:**

1. **Fine to coarse sands**
2. **Well sorted, often finely stratified**
3. **Little or no silt and clay, typically no gravel size or coarser rock fragments; shell fragments may be found in some coastal situations**

**Associated Landforms:**

- **Ridges that often parallel shoreline landward of beach**
- **Hills or mounds**
- **There are often unvegetated areas of loose, windblown sand**

**Focus of On-Site Investigation:**

1. **Ever-changing landscape, susceptible to coastal erosion by wave action and strong winds**
2. **A protected resource area; check reference materials to determine extent of area**

**Floodplain (Alluvial) Deposits**

Definition: Material transported and deposited by running water.

**Characteristics:**

1. **Susceptible to flooding**
2. **Well sorted, generally stratified**
3. **Fine textured, but varies depending upon stream velocity**
4. **Typically, nearly level areas adjacent to large streams and rivers**
5. **May have buried soil profiles**

**Associated Landforms:**

- **Floodplain**
- **Stream terrace**
- **Oxbow**
- **Meander scar**

**Focus of On-Site Investigation:**
**Susceptible to seasonal flooding and erosion**

## Soil Profile Descriptions

**SOIL PROFILE: A vertical section of the soil extending through all its horizons and into the parent material.**

**SOIL HORIZON: A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes.**

**SOIL LAYER: A layer in the soil deposited by geologic forces (e.g., wind, water, ice) and not related to a soil-forming process.**

## Soil Horizon and Layer Designations

**Three kinds of symbols are used in various combinations to designate soil horizons and layers: *capital letters, lower-case letters, and Arabic numerals.***

**Master Horizons and Layers: O, A, E, B, C, and R - are symbols that designate major breaks in the soil and are base symbols to which other characters may be added to describe the soil in more detail.**

**Subordinate Distinctions: Lower-case letters are used as suffixes to designate specific kinds of master horizons and layers (e.g. Ap, Bw, Bs, Cd).**

***Vertical Subdivision*: Two or more horizons or layers designated by a single combination of letters which needs to be subdivided. Arabic numerals are used, and generally follow all letters. Within a C Layer, for example, successive C layers should be designated as C1, C2, C3, etc.**

***When lithological discontinuities occur* in a profile, Arabic numerals are placed in front of all letters starting at the first discontinuity. For example, sequence Bw, 2BC indicates that the BC horizon has formed in a parent material different from the Bw.**

**O-Horizon**

Definition: O-horizons are layers dominated by organic matter.

**Field Criteria:**

1. **Greater than 20-30% organic matter by weight**
2. **Dark color, nearly black or black, (*note:* colors can be misleading and should only be used when other field criteria are observed)**
3. **Weak strength, greasy feel, light weight when dry, high fiber content**
4. **Typically, a surface horizon; if buried, often indicates disturbance**

**A-Horizon**

Definition: The A-horizon is commonly referred to as the topsoil, and typically ranges from 3 to 10 inches in thickness. It is a mineral horizon that formed at the surface or below an O-horizon, and is characterized by an accumulation of humified organic matter intimately mixed with the mineral fraction.

**A-Horizon Field Criteria:**

1. **Mineral soil material**
2. **Mixture of well decomposed organic matter and mineral material**
3. **Surface mineral horizon**
4. **Typically dark in color - characteristically darker than underlying horizons due to a relatively high organic matter content**

**Subordinate Distinctions of A-horizon:**

**Ap* Plowing or other disturbance.**

***** This symbol is used to indicate disturbance of the surface layer by cultivation, pasturing, or similar uses. *Ap horizons may be > 10 inches thick*.

**E-Horizon**

Definition: The E-horizon is a mineral horizon in the upper part of the soil, typically underlying an O or an A-horizon. It is a light-colored, leached horizon often associated with woodland areas. E-horizons range from not being present in the soil to thicknesses of about 4 to 8 inches.

**E-Horizon Field Criteria:**

1. **Commonly near the surface, below an O or A-horizon and above a B-horizon**
2. **Generally lighter in color than overlying organic and/or A-horizons and underlying B horizon**

**Formation: Weak organic acids strip coatings from sand grains, and material is leached down into the subsoil. Light color is due to natural color of the dominant quartz sand grains.**

**B-Horizon**

Definition: The B-horizon is commonly referred to as the subsoil. It is a zone of accumulation within the soil. Well-drained soils typically have bright orange-brown colors.
B-horizons generally extend about 1.5 to 3.0 feet below the surface.

**B-Horizon Field Criteria:**

1. **Subsurface horizon formed below an O-, A- and/or E-horizon and above the C-layer**
2. **Formed as a result of soil-forming processes**
3. **In well-drained soils, typically have orange-brown colors which fade with depth**
4. **Illuvial concentration - zone of accumulation**

**Subordinate Distinctions of B-Horizon:**

**Bw** **Development of color and/or structure. Because many of the soils in New England are considered to be geologically young, this symbol is used frequently**

**Bhs or Bs** **Illuvial accumulation of sesquioxides and organic matter**

**Bt** **Illuvial accumulation of silicate clay, often forming coatings on ped faces, in pores, or on bridges between sand sized grains**

**C-Layer**

Definition: C-Layers are commonly referred to as the substratum. They are layers, excluding bedrock, that are little affected by soil-forming processes (i.e., are unweathered geologic material).

**Field Criteria:**

1. **Little affected by soil-forming processes**
2. **Lack color development; color is that of the unweathered geologic material**
3. **Geologic layering often present**

**Subordinate Distinctions of the C-Layer:**

**Cd** **Dense, unconsolidated sediment; used to designate compact till**

**Cr** **Weathered or soft bedrock**

**Cg** **Strong gleying, indicating prolonged periods of saturation**

**R-Layers**

Definition: R-layers are hard bedrock (ledge).

**Field criteria:**

1. **Typically cannot be excavated using a backhoe unless fractured, and blasting is often needed to remove this material**
2. **When highly fractured and/or weathered, it is often difficult to differentiate from the overlying soil material**
3. **May be difficult to differentiate between large boulders and depth to bedrock**

# Soil Texture

Definition: The physical composition of soil defined in terms of the relative proportion by weight of the different particle size groups. Particle size and distribution are key factors in determining the rate of water movement through a soil.

**Soil Particle Sizes**

| | |
|---|---|
| ***Clay:*** | **< 0.002 mm** |
| ***Silt:*** | **0.002 - 0.05 mm** |
| ***Sand:*** | **0.05 - 2 mm** |
| ***Gravel:*** | **2 mm - 8 cm (3")** |

**Sand Size Particles Classes**

| | |
|---|---|
| ***very coarse sand:*** | **2.0 - 1.0 mm** |
| ***coarse sand:*** | **1.0 - 0.5 mm** |
| ***medium sand:*** | **0.5 - 0.25 mm** |
| ***fine sand:*** | **0.25 - 0.10 mm** |
| ***very fine sand:*** | **0.10 - 0.05 mm** |

**Coarse Fragments**

| | |
|---|---|
| **Gravel** | **2 mm to 3 inches** |
| **Cobbles** | **3 to 10 inches** |
| **Stones** | **10 inches to 2 feet** |
| **Boulders** | **greater than 2 feet** |

**USDA Soil Textural Classes**

Textural classes are defined in terms of particle size distribution of material finer than 2 mm (i.e., sand, silt, and clay size particles). There are six groupings of soil textural classes that soil evaluators should be able to readily identify in the field.

**Textural Classes**

| | |
|---|---|
| ***Sand (s)*** | ***Loams (l)*** |
| ***Loamy sands (ls)*** | ***Silt loams (sil)*** |
| ***Sandy loams (sl)*** | ***Silty clay loams (sicl)*** |

**Textural Class Modifiers**

| | |
|---|---|
| ***Less than 15% by volume:*** | **no modifier** |
| ***15-35% by volume:*** | **gravelly, cobbly, stony, bouldery** |
| ***35-60% by volume:*** | **very gravelly** |
| ***> 60% by volume:*** | **extremely gravelly** |

Stickiness is measured by squeezing a wet sample between the thumb and index finger and then pulling them apart. Clay soil material will adhere to both the thumb and finger.

Plasticity is measured by how well a soil will ribbon. A sample is rolled between both hands creating a thin wire. A wire that can be rolled to less than 1/8 inch in diameter before breaking has a significant amount of clay (typically greater than 25%). It is rare to find soils in Massachusetts that have greater than 40% clay.

**Moist Sample Does Not Ribbon or Ribbons Weakly**

**A1. Moist**
* **will not form a cast, or**
* **forms a weak cast which crumbles or falls apart when touched**
* **does not stain your fingers**

→ **SAND**

**A2. Moist**
* **soil will form weak cast that crumbles when transferred from one hand to another**
* **will stain fingers slightly**
* **very gritty feel**

→ **LOAMY SAND**

**A3. Moist**
* **forms stable cast that withstands moderate handling**
* **strongly stains fingers**
* **gritty feel**

→ **SANDY LOAM**

**A4. Moist**
* **forms stable cast that withstands moderate to strong handling**
* **loams with >20% clay may form a weak ribbon <1"and may feel slightly sticky**
* **may feel either creamy or slightly gritty.**

→ **LOAM**

## of Soil Textural Class

**Moist Sample forms Ribbon > 1"**

**B1. Moist**
- *** forms stable cast**
- *** feels smooth, sometimes somewhat greasy, when rubbed between fingers**
- *** forms ribbon < 1.5" that has a broken or rippled appearance**
- *** non sticky**

→ **SILT LOAM**

**B2. Moist**
- *** very stable cast**
- *** forms ribbons ≥ 1.5" that feel sticky**
- *** soil is plastic and sticky**
- *** forms wire ≥ 2" long that is < 1/8 " in diameter**

→ **SILTY CLAY LOAM**

**B3. Moist**
- *** soil feels somewhat gritty when rubbed between fingers**
- *** forms ribbons ≥ 1.5" that feel sticky**
- *** soil is plastic and sticky**
- *** forms wire ≥ 2" long that is < 1/8 " in diameter**

→ **CLAY LOAM**

**B4. Moist**
- *** cast is very durable**
- *** forms wire ≥ 3" long**
- *** forms long flexible ribbon**
- *** soil is very plastic and very sticky**

→ **CLAY**

**Textural Triangle**

Directions: The textural triangle is to be used when laboratory data are available. Plot the percent sand using the bottom of the triangle, percent silt using the right side, and percent clay using the left side. Plot the particle size percentages along the lines paralleling the numerical designations. Point where the three lines converge denotes textural class.

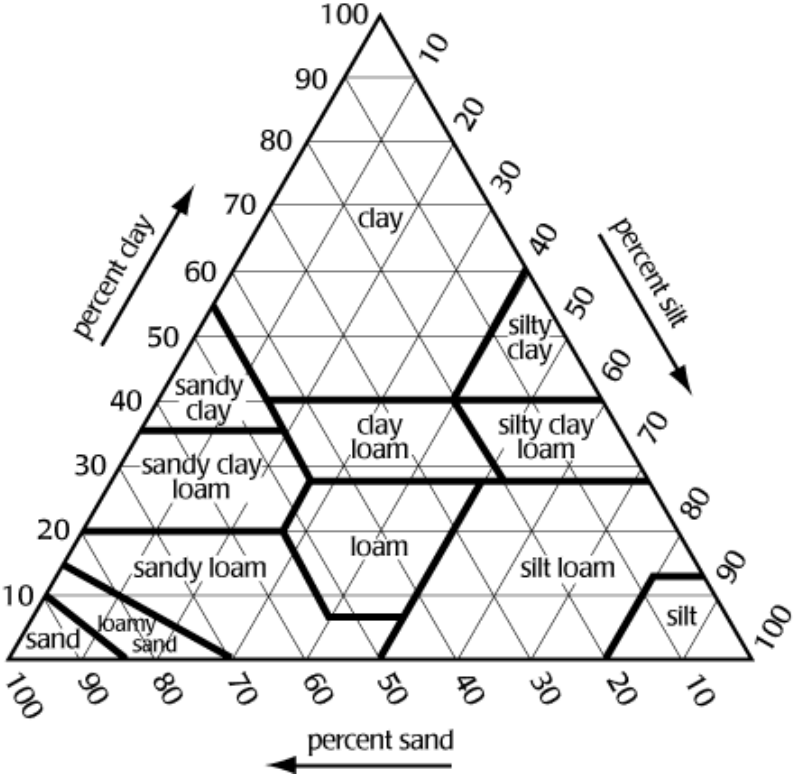



**Chart showing the percentages of clay, silt and sand in the basic textural classes**

# Soil Color

**Soil color is the most obvious and easily determined soil characteristic. Although it has little known direct influence on the functioning of the soil, color is one of the most useful properties for soil identification and interpretation. Other, more important, characteristics that are not as easily observed can be inferred from soil color.**

**Well-drained soils have bright colors in the subsoil.**

**Soils with a fluctuating seasonal high water table typically have a blotchy color pattern of gray, yellow, and orange.**

**Coloring Agents in the Soil**

**Organic matter darkens the soil and is typically associated with the surface layers. Organic matter will mask all other coloring agents. Buried A-horizons generally indicate floodplains or disturbed soil areas.**

**Iron is the primary coloring agent in the subsoil. Iron minerals are nearly universal in all New England soils. The bright orange-brown color associated with well drained soils is the result of iron oxide coating individual soil particles.**

**Manganese is common in some New England soils and is a very dark black or purplish-black color.**

***Note:*** **In the absence of any coatings, soils reflect the color of the mineral grains.**

## Munsell Color System

Soil colors are most conveniently measured by comparison with a color chart. Munsell color books consist of different colored chips, systematically arranged according to their Munsell notations.

***Hue:*** **Refers to the dominant spectral wavelength of light (red, yellow, green, blue, etc.). The symbol for hue is the letter abbreviation of the color preceded by a number from 0 to 10. Within the YR (yellow-red) range, the hue becomes more yellow and less red as the number increases. The notation for hue in the Munsell Color Book is located at the top corner of the chart page. One hue is represented on each page.**

***Value:*** **Refers to the degree of lightness and darkness of a color in relation to a neutral gray scale. The notation for value consists of numbers from 0 (black) to 10 (white). Value is located along the vertical scale to the left of the page.**

***Chroma:*** **Is the relative purity or strength of the color (hue). The notation for chroma consists of numbers beginning at 0 for neutral grays and increasing at equal intervals to 8 (bright color). Chroma varies along the horizontal scale.**

## Soil Color Notation

Once a determination of soil color is made, the proper notation of the color is the hue (e.g., 10YR) followed by the value/chroma. An example of a soil color notation would be 10YR 5/6 (value of 5, chroma of 6).

**Recording Soil Color**

**Colors for Title 5 purposes should be described in the moist condition. It is typically the moisture condition of the soil when it is first removed from the pit.**

***Note:*** **There is a natural variability between evaluators, as people's perceptions of color vary. It is not unusual for color readings to vary one color chip in any direction, and in most cases this is not critical to the site assessment.**

**Color Patterns in the Soil**

***Matrix Color*****: If more than one soil color is present, note both the dominant color (matrix, > 50% of the horizon) and the lesser color or colors.**

***Redox Concentrations and Depletions*****: Spots or blotches of different color or shades of color interspersed with the dominant color (matrix). These color patterns often relate to intermittent periods of saturation by a fluctuating water table, and may indicate poor aeration and impeded drainage. Concentrations have gained material (often iron oxide); depletions have lost material and often have low chroma colors.**

***Depleted Matrix*****: Matrix depletions with or without concentrations, are the result of long periods of saturation. A depleted matrix is caused by the reduction of iron and its subsequent removal by groundwater flow. The dominant gray color is the natural color of uncoated quartz sand grains.**

**Gleyed: Gleization is the reduction of iron due to extended periods of saturation and the formation of reduced iron-sulfate compounds. The dominant blue-gray or green-gray color is caused by the presence of these compounds.**

**Describing Redoximorphic Features**

**A description of redoximorphic features requires a notation of the colors and of the color pattern(s). Colors should be noted by Munsell symbols for the matrix and mottles. Color patterns may be described with the following terms:**

**Abundance**

***Few (f):*** **< 2% of surface**
***Common (c):*** **2 - 20% of surface***
***Many (m):*** **> 20% of surface**

* Remark: When preparing soil logs note the actual percentage of redoximorphic features within the exposed soil

**Variegated Colors: Streaks of orange and red colors associated with textural changes in the soil. These are not the result of a seasonal high water table, and are caused by momentary pauses as a wetting front moves through the soil.**

**Potential Problems When Interpreting Redoximorphic Features**

***Sandy Soils*: Redox concentrations and depletions are often faint and difficult to observe.**

***Relic Mottles*: Redoximorphoric features that formed in a wet soil that has since been drained, persist for years and do not represent the present hydrology.**

***Stratified Deposits:* Soil texture changes or discontinuities, which momentarily interrupt wetting fronts as they move downward through the soil. This brief pause is not considered a perched water table, but may produce bright**

**streaks or blotches at the interface. These are often seen within gravel pits, high above the water table, and are referred to as variegated colors.**

***Parent Material*: Some soils have developed in dark sediments with dark mineralogy, and may mask redoximorphic features development.**

***Soil Chemistry*: Some soils have unique chemical properties that inhibit the development of redoximorphic features. Soils developed within Triassic Red Sandstone sediments and soils that are immediately adjacent to salt or brackish water are examples of soils which do not display easily recognizable redoximorphic features.**

***Recently Deposited Material*: Redoximorphic features typically develop slowly over time, often taking decades to develop. (For example, aluvial soils or fills)**

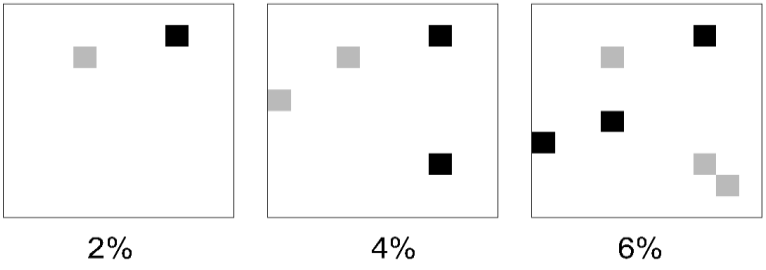
***Light conditions*: Soil colors are recorded outdoors in indirect sunlight, typically sunlight coming from over the shoulder. When the sun is at a low angle, colors become difficult to read.**

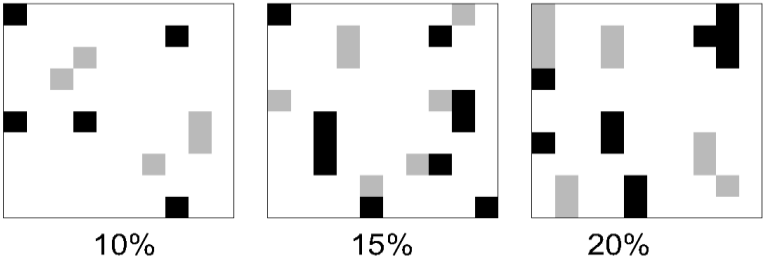
***Note:* always remove sunglasses.**

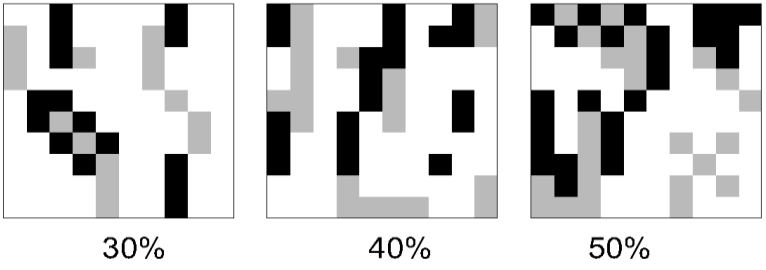
***Location in soil*: Colors are typically recorded from the surface of a freshly broken clod of soil.**

***Number of colors*: If more than one color is present, note both the dominant color (matrix) and the lesser colors.**

***Note:* record weather conditions, as dark, overcast days do affect color readings.**




**Charts for Estimating Proportions of Redoximorphic Features and Coarse Fragments**

# Soil Structure

Soil structure is the arrangement of individual soil particles into compound particles or aggregates. Structureless soil has no observable aggregation, or no orderly arrangement of natural lines of weakness.

**Shape** The following terms are used to describe shape:

***Structurless:*** **No aggregation of fine particles when dry**

***Granular:*** **Small aggregates held together**
***(gr)*** **primarily by organic matter**

***Single Grain:*** **No aggregation of coarse particles**
***(sg)*** **when dry**

***Subangular blocky*** **Cube-like, with flattened surfaces and**
***(sabk):*** **rounded corners**

***Blocky:*** **Cube –like with flattened surfaces and**
***(abk)*** **sharp corners**

***Prismatic:*** **Rectangular with a long vertical**
***(pr)*** **dimension and a flattened top**

***Columnar:*** **Rectangular with a long vertical**
***(cpr)*** **dimension and a rounded top**

***Platy:*** **Rectangular with a long horizontal dimension**

**Grade**

***Weak:*** **Poorly formed, indistinct peds, barely observable in place**

***Moderate:*** **Well-formed, distinct peds, moderately durable and evident, but not distinct in undisturbed soil**

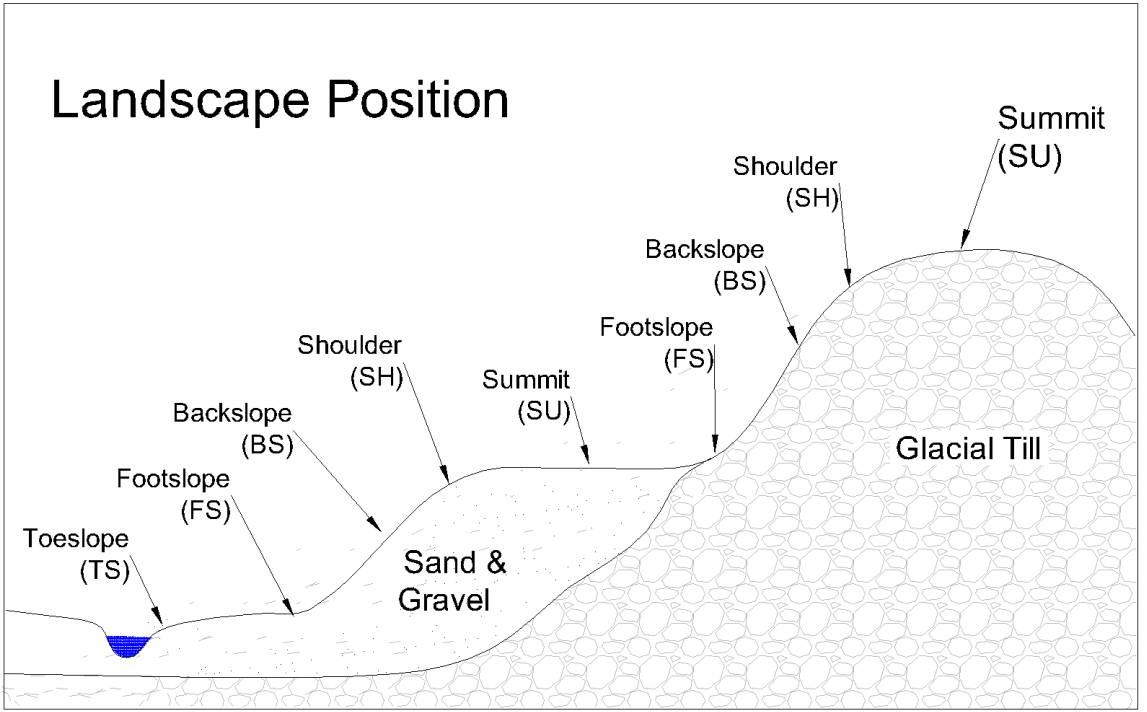
***Strong:*** **Durable peds that are quite evident in undisplaced soil, adhere weakly to one another, withstand displacement, and become separated when soil is disturbed**

# Soil Consistence

**Soil consistence is the feel of the soil and the ease with which a lump can be crushed by the fingers.**

**CONSISTENCE**

| | |
|---|---|
| ***Loose:*** | **Noncoherent – refers to sands and loamy sands.** |
| ***Very Friable:*** | **Soil material crushes under very gentle pressure, but coheres when pressed together** |
| ***Friable:*** | **Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together** |
| ***Firm:*** | **Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinct** |
| ***Very Firm:*** | **Soil material crushes under strong pressure, and is barely crushable between thumb and forefinger** |
| ***Extremely Firm:*** | **Soil material crushes only under very strong pressure, cannot be crushed between thumb and forefinger, and must be broken apart bit by bit.** |
| ***Rigid:*** | **Very strongly cemented. Cannot be crushed under full body weight.** |


Landscape Position
Summit
(SU)
Shoulder
(SH)
Backslope
(BS)
Footslope
(FS)
Shoulder
(SH)
Summit
(SU)
Backslope
(BS)
Footslope
(FS)
Toeslope
(TS)
Sand &
Gravel
Glacial Till