Field Book for Describing and Sampling Soils

Version 4.0

U.S. Department of Agriculture
Natural Resources Conservation Service

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Proper citation for this document is:

> Soil Survey Staff. (2024). *Field book for describing and sampling soils, version 4.0.* USDA, Natural Resources Conservation Service. U.S. Government Printing Office.

Foreword

Purpose: The “Field Book for Describing and Sampling Soils,” often called the “Field Book,” is a National Cooperative Soil Survey (NCSS) standard. It lists instructions, definitions, concepts, and codes for making or reading soil descriptions and sampling soils.

Background: Soil description methodology was developed by soil scientists throughout the entire course of the soil survey program. The USDA published small instruction booklets for field parties, including soil descriptions, in 1902–1904, 1906, and 1914. The first USDA guide for soil horizon identification and description was released in 1937 (Bureau of Chemistry and Soils, 1937). Dr. Roy Simonson and others later summarized and revised this information (Soil Survey Staff, 1951; Soil Survey Staff, 1962). Brief “color-book” inserts with shorthand notation were released by the Soil Conservation Service (Spartanburg, SC, 1961; Western Technical Center, Portland, OR, 1974). Previous versions of the “Field Book” were released in 1998 (Schoeneberger et al.), 2002 (Schoeneberger et al.), and 2012 (Schoeneberger et al.).

Standards: The “Field Book” summarizes current NCSS standard conventions to consistently describe soils. It works complementarily with the “Soil Survey Manual,” “National Soil Survey Handbook,” “Keys to Soil Taxonomy,” and other NCSS standards.

NCSS standard procedures and terms for describing soils are used in the National Soil Information System (NASIS) database, which stores soil descriptions and associated information. Differences and linkages between soil science conventions, NASIS, and older systems are shown, where reasonable, as an aid for interpreting and converting archived data.

Sources: The “Field Book” draws from several primary sources: the “Soil Survey Manual” (Soil Survey Division Staff, 2017), the “National Soil Survey Handbook” (Soil Survey Staff, 2024), and National Soil Survey Information System (NASIS) metadata. Other important sources are footnoted throughout to give appropriate credit and encourage in-depth information review. Other material is unique to this book.

Brevity: In a field book, brevity is efficiency. Despite this book’s apparent length, the criteria, definitions, and concepts are condensed. We urge users to review the comprehensive information in original sources to avoid errors.

Measurement Units: For soil description, metric units are the scientific standard.

Format: The “Site Description” and “Profile Description” sections generally follow conventional profile description format and sequence (e.g., “Pedon Description” form, p. 2-93). Some descriptors are arranged in a sequence more compatible with field description than data entry (e.g., “Horizon Boundary” is next to “Horizon Depth” rather than at the end). The sequence followed differs somewhat from and does not supersede convention for writing formal soil descriptions in soil survey reports or official soil series descriptions (e.g., “National Soil Survey Handbook,” Part 614, Soil Survey Staff, 2024).

Codes: Shorthand notation is listed in the “Code” column for some descriptors. Long-standing conventional codes are retained because of widespread recognition. Some recent codes have been changed to make them more logical. Some data elements have different codes in various systems (e.g., conventional [Conv.] vs. NASIS vs. Pedon PC), and several columns may be shown to facilitate conversions. If only one code column is shown, it can be assumed that the conventional, NASIS, and Pedon PC codes are all the same.

Standard Terms Versus Creativity: *Describe and record what you observe*. Choice lists in this document are a minimal set of descriptors. Use additional descriptors, notes, and sketches to record pertinent information and features if no data element or choice list entry exists. Record such information as free-hand notes under “Miscellaneous Field Notes / Sketch.”

Changes: Soil science is an evolving field. Changes to the “Field Book” should and will occur. Please send comments or suggestions to the Soil and Plant Science Division, national leader for standards.

Table of Contents

Site Description

Describer(s)

Describer(s)—Record the name or initials of the person, or people, making the description (e.g., Erling E. Gamble or EEG*)*.

Date

Month/Day/Year—Record the observation date. Use numeric notation (MM/DD/YYYY) (e.g., 05/21/2024 for May 21, 2024).

Climate

Document the prevailing weather conditions at time of observation (a site condition that affects some field methods [e.g., Ksat]). Record the major **Weather Conditions** and **Air Temperature** (e.g., rain, 27 °C).

Weather Conditions	Code
sunny/clear	SU
partly cloudy	PC
overcast	OV
rain	RA
sleet	SL
snow	SN

Air Temperature—Ambient air temperature at chest height in Celsius (e.g., 27 °C).

Soil Temperature—Record the ambient **Soil Temperature** and **Depth** at which it is determined (e.g., 22 °C, 50 cm). (***Note***: Soil taxonomy generally requires a 50 cm depth.) Soil temperature should only be determined from a freshly excavated surface that reflects the ambient soil conditions. Avoid surfaces equilibrated with air temperatures.

> **Soil Temperature**—Record soil temperature in Celsius.
>
> **Soil Temperature Depth**—Record depth at which the ambient soil temperature is measured (e.g., 50 cm).

Location

Record precisely the point or site location (e.g., coordinates). Latitude and longitude as measured with a Global Positioning System (GPS) is the preferred descriptor. Report lat. and long. as decimal degrees. For example:

Latitude— 39.9673321

Longitude— -74.0866363

Geodetic Datum (**Horizontal_datum_name** in NASIS)—A geodetic datum must accompany latitude and longitude. A geodetic datum is a model that defines the Earth's shape and size and serves as a latitude, longitude reference. Geodetic datum is a selectable GPS parameter. The preferred datum is the "World Geodetic System 1984" (WGS-84). See the "Location" section for the complete geodetic datum list (p. 6–1).

Topographic maps display latitude and longitude and the geodetic datum employed (e.g., NAD 27, NAD 83). ***Note:*** NASIS requires latitude and longitude in decimal degrees but allows other coordinate or location descriptors (e.g., UTM, State Plane Coordinates, Public Land Survey, Metes and Bounds). See the "Location" section for details.

Waypoint (Number)—Record the GPS waypoint number.

Topographic Quadrangle

Record the topographic map name (USGS quadrangle) that covers the observation site. Include scale (or series) and year printed. An example is *Pollard Creek-NW; TX; 1:24,000; 1972*.

Soil Survey Site Identification Number (Site ID)

An identification number must be assigned if samples are collected (called **User_pedon_ID** in NASIS). For the Kellogg Soil Survey Laboratory (Soil Survey Staff, 2011), this identifier consists of five required and one optional item.

Example: S2024WA27009

1) "S" indicates a sampled pedon. ("S" is omitted for pedons described but *not* sampled.)

2) "2024" indicates the calendar year sampled. Use 4-digit format (e.g., 2024).

3) “WA” indicates the two-character United States Postal Service State postal abbreviation for the State where sampled. For non-U.S. sites, use ISO-3166-1, the International Standard for country codes from the International Organization for Standards, 2020a.

4) “027” indicates the 3-digit (numeric) Federal Information Processing Standards, or FIPS, code for county where sampled. For non-U.S. sites, use the appropriate two- or three-letter Administrative Subdivision code from ISO 3166-2 (International Organization for Standards, 2020b) preceded by a 0 (zero) for two-letter codes (e.g., 0SK for Saskatchewan).

5) “009” indicates the consecutive pedon number for calendar year for county. This should be a 3-digit number. Use 0s (zeros) as placeholders when necessary (e.g., 9 becomes 009).

6) (Optional) A one-character “satellite” code can be used, if needed, to indicate a relationship between a primary pedon and satellite sample points (e.g., A in S2024WA027009A).

Note: Do not use spaces, dashes, or hyphens (for database reasons). Use uppercase letters. A complete example is *S2024OK061005A*, which indicates a sampled soil characterization pedon collected in 2024 (*2024*) from Oklahoma (*OK*), Haskell County (*061*); this is a satellite pedon (*A*) of the fifth pedon (*005*) sampled in that county during 2024.

MLRA

This 1- to 3-digit number, often including one alpha character, identifies the major land resource area (MLRA) (USDA NRCS, 2022) (e.g., 58C, or Northern Rolling High Plains, Northeastern Part).

Transects

If a soil description is one of multiple transect points, record transect information (e.g., **Transect ID**, **Stop Number**, **Interval, GPS Coordinates**). NASIS also accommodates **Transect Kind** (random point [–*R*], regular interval [–*I*]), **Transect Section Method** (biased [–*B*], random [–*R*]), **Delineation Size** (acres), and **Transect Direction** (azimuth heading [e.g., 180°]).

Transect ID—A 4- or 5-digit number that identifies the transect (e.g., 0010, or the tenth transect within the survey area).

Stop Number—If the sample/pedon is part of a transect, enter the 2-digit stop number along the transect (e.g., 07). ***Note:*** NASIS allows up to 13 characters.

Interval—Record distance between observation points, compass bearing, and GPS coordinates, or draw a route map under "Miscellaneous Field Notes / Sketch**."**

Soil Series or Map Unit Component Name

Assign the appropriate **Soil Series** or **Map Unit Componen**t name at time of description (e.g., Cecil). If unknown, enter *SND* for "Series Not Designated." (In NASIS, "SND" is not used; assign an appropriate soil taxonomy class [e.g., Udorthents].) ***Note:*** A field-assigned series name may change after additional data collection and lab analyses.

Map Unit Symbol—Record the soil map unit symbol (if known) for the sample site.

Photo #—If aerial imagery is used, record the photograph number that covers the sample site.

Geomorphic Information

See the "National Soil Survey Handbook," Part 629 (Soil Survey Staff, 2024) and the "Geomorphic Description System" (Schoeneberger and Wysocki, 2017). Codes follow each listed choice. Conventionally, the entire name (e.g., mountains) is recorded.

Part 1: Physiographic Location

Physiographic Divisions—e.g., Interior Plains or IN
Physiographic Provinces—e.g., Central Lowland or CL
Physiographic Sections—e.g., Wisconsin Driftless ection or WDS
State Physiographic Areas (Optional)—e.g., Wisconsin Dells
Local Physiographic/Geographic Names (Optional.)—e.g., Bob's Ridge

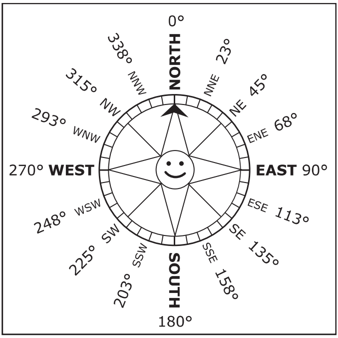
Part 2: Geomorphic Description

Landscapes—e.g., Foothills or FH
Landforms—e.g., Ridge or RI
Microfeatures—e.g., Mound or MO
Anthroscapes—e.g., Urban anthroscape or UAT
Anthropogenic Landforms—e.g., Sanitary landfill or SL
Anthropogenic Microfeatures—e.g., Drainage ditch or DD

Part 3: Surface Morphometry

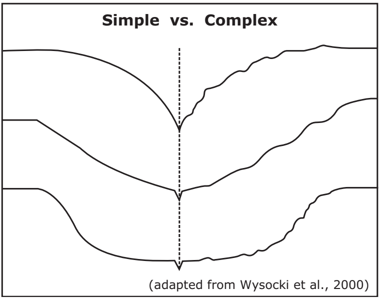
Elevation—The height of a point on the Earth's surface relative to mean sea level (MSL). Record units (e.g., 106 m). Recommended methods: interpolation from topographic map contours; altimeter reading tied to a known elevation datum. ***Note:*** An elevation value from a GPS receiver can be recorded. Since the GPS elevation value typically is less certain than the latitude and longitude values, a correction for quantifiable errors is important (e.g., WAAS, or averaging many elevation values at a point by collecting a track log at the point and averaging the elevation values).The latitude and longitude coordinates can be used to extract an elevation value from a DEM, if available. All parts of a DEM cell return the same elevation value, so a higher resolution DEM is important for accuracy, especially if the point is on a steep slope.

Slope Aspect—The compass direction (in degrees and accounting for declination) that a slope faces, viewed downslope (e.g., 225°).



Slope Gradient (commonly called "slope")—The ground surface inclination with respect to the horizontal plane. Make observations downslope to avoid errors from clinometer types (e.g., 18%).

Slope Complexity—Describe the relative ground surface uniformity (smooth linear or curvilinear is *simple* or *S*) or irregularity (*complex* or *C*) downslope through the site (e.g., simple or S).

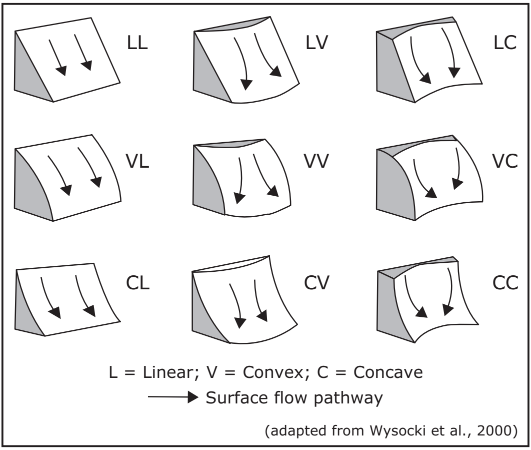


(adapted from Wysocki et al., 2000)

Relative Slope Segment Position (called **Geomorph_slope_segment** in NASIS)—If useful to subdivide long slopes, describe relative slope location of the area or point of interest.

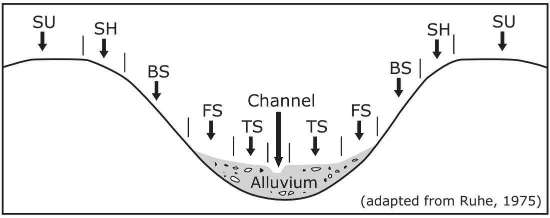
Relative Slope Segment Position	Code	Criteria
lower third	LT	on lower third of slope
middle third	MT	on middle third of slope
upper third	UT	on upper third of slope

Slope Shape—Slope shape is described in two directions: up and down slope (perpendicular to the elevation contour) and across slope (along the elevation contour) (e.g., linear, convex or LV).



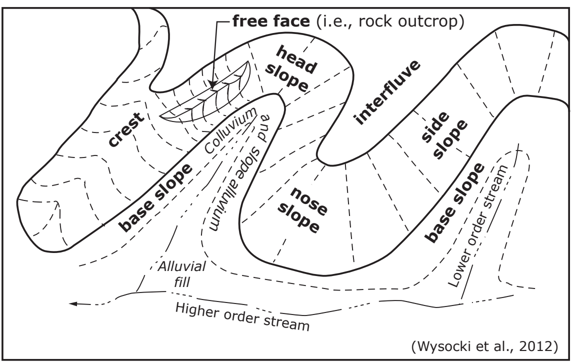
Hillslope Profile Position (commonly called "hillslope position")—Two-dimensional geomorphic descriptors that are segments (i.e., slope position) along a line that runs up and down slope (e.g., backslope or BS). This is best applied to points, not areas (e.g., map units).

Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS

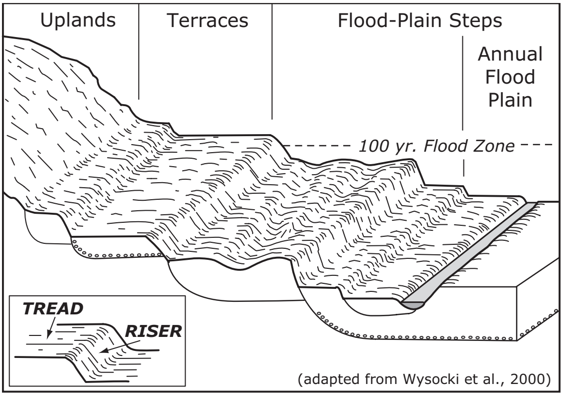


Geomorphic Component—Three-dimensional geomorphic descriptors for landforms, landform portions, or microfeatures that are applied to areas. Unique 3D descriptors are defined for hills, terraces and stepped landforms, mountains, and flat plains.

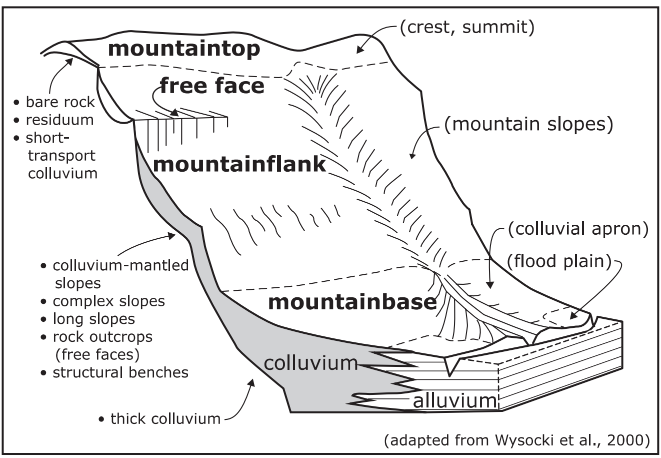
Hills	NASIS Code
interfluve	IF
crest	CT
head slope	HS
nose slope	NS
side slope	SS
free face	FF
base slope	BS



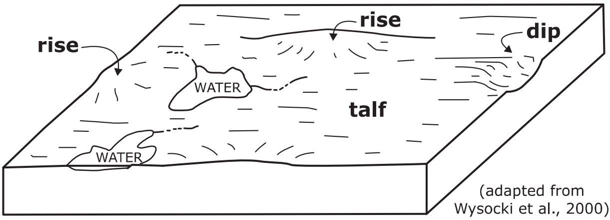
Terraces and Stepped Landforms	Code
riser	RI
tread	TR



Mountains	Code
mountaintop	MT
mountainflank	MF
upper third—mountainflank	UT
center third—mountainflank	CT
lower third—mountainflank	LT
free face	FF
mountainbase	MB



Flat Plains	Code
dip	DP
rise	RI
talf	TF



- very low gradients (e.g., slope 0-1%)
- deranged, nonintegrated, or incipient drainage network
- “high areas” are broad and low (e.g., slope 1-3%)
- sediments, commonly lacustrine, alluvial, eolian, or till

Microrelief—Small, relative elevation differences between adjacent areas on the Earth’s surface (e.g., microhigh, or MH; or microlow, or ML).

Microrelief	Code
microhigh	MH
microlow	ML
microslope	MS

Drainage Pattern—The interconnected system of drainage channels on the land surface; also called “drainage network.” (See graphics, p. 3–43.) This can be recorded under “Miscellaneous Field Notes / Sketch.”

Drainage Pattern	Code
annular	AN
artificial	AR
centripetal	CE
dendritic	DN
deranged	DR
karst	KA
parallel	PA
pinnate	PI

Drainage Pattern	Code
radial	RA
rectangular	RE
thermokarst	TH
trellis	TR

Water Status

Drainage—An estimate of the natural drainage class (i.e., the prevailing wetness conditions) of a soil (e.g., somewhat poorly drained or SP).

Drainage Class	Conv. Code
subaqueous	SA
very poorly drained	VP
poorly drained	PD
somewhat poorly drained	SP
moderately well drained	MW
well drained	WD
somewhat excessively drained	SE
excessively drained	ED

The following definitions are from the traditional, national criteria for natural soil drainage classes (Soil Science Division Staff, 2017). Specific regional definitions and criteria exist. (Contact an NRCS State office for specific local criteria.)

Subaqueous—Free water is above the soil surface. The occurrence of internal free water is permanent, and there is a positive water potential at the soil surface for more than 21 hours each day. The soils have a peraquic soil moisture regime.

Very poorly drained—Water is at or near the soil surface during much of the growing season. Internal free water is *very shallow* and *persistent* or *permanent*. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Commonly, the soil occupies a depression or is level. If rainfall is persistent or high, the soil can be sloping.

Poorly drained—The soil is wet at shallow depths periodically during the growing season or remains wet for long periods. Internal free water is *shallow* or *very shallow* and *common* or *persistent*. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soil, however, is not continuously wet directly below plow depth. The water table is commonly the result of a *low* or *very low* saturated hydraulic conductivity class or persistent rainfall or a combination of these factors.

Somewhat poorly drained—The soil is wet at a shallow depth for significant periods during the growing season. Internal free water is commonly *shallow* or *moderately deep* and *transitory* or *permanent*. Unless the soil is artificially drained, the growth of most mesophytic plants is markedly restricted. The soil commonly has a *low* or *very low* saturated hydraulic conductivity class or a high water table, receives water from lateral flow or persistent rainfall, or is affected by some combination of these factors.

Moderately well drained—Water is removed from the soil somewhat slowly during some periods of the year. Internal free water commonly is *moderately deep* and may be *transitory* or *permanent*. The soil is wet for only a short time within the rooting depth during the growing season but is wet long enough that most mesophytic crops are affected. The soil commonly has a *moderately low* or lower saturated hydraulic conductivity class within 1 meter of the surface, periodically receives high rainfall, or both.

Well drained—Water is removed from the soil readily but *not* rapidly. Internal free water commonly is *deep* or *very deep*; annual duration is not specified. Water is available to plants in humid regions during much of the growing season. Wetness does not inhibit growth of roots for significant periods during most growing seasons.

Somewhat excessively drained—Water is removed from the soil rapidly. Internal free water commonly is *very deep* or *very rare*. The soils are commonly coarse textured and have *high* saturated hydraulic conductivity or are *very shallow*.

Excessively drained—Water is removed from the soil very rapidly. Internal free water commonly is *very deep* or *very rare*. The soils are commonly coarse textured and have *very high* saturated hydraulic conductivity or are *very shallow*.

Flooding—Estimate the **Frequency**, **Duration**, and **Months** that flooding is expected (e.g., rare, brief, Jan.–March).

Frequency—Estimate how often, typically, flooding occurs.

Frequency Class	Code	Criteria: Estimated Average Number of Flood Events per Time Span [1]
none	NO	no reasonable chance (e.g., < 1 time in 500 years)
very rare	VR	≥ 1 time in 500 years, but < 1 time in 100 years
rare	RA	1 to 5 times in 100 years
occasional [2]	OC	> 5 to 50 times in 100 years
frequent [2, 3]	FR	> 50 times in 100 years
very frequent [3, 4]	VF	> 50% of all months in year

[1] Flooding frequency is an estimate of the **current condition**, whether natural or human influenced, such as by dams or artificial levees.

[2] Historically, *occasional* and *frequent* classes could be combined and called *common*; this is *not* recommended.

[3] *Very frequent* class takes precedence over *frequent*, if applicable.

[4] The *very frequent* class is intended for tidal flooding.

Duration—Estimate how long an area typically is flooded during a single flood event.

Duration Class	Conv. Code	NASIS Code	Criteria: Estimated Average Duration per Flood Event
extremely brief	EB	EB	0.1 to < 4 hours
very brief	VB	VB	4 to < 48 hours
brief	BR	B	2 to < 7 days
long	LO	L	7 to < 30 days
very long	VL	VL	≥ 30 days

Months—Estimate the beginning and ending month(s) in a year that flooding generally occurs (e.g., Dec.–Feb).

Ponding—Estimate or monitor the **Frequency**, **Depth**, and **Duration** of standing water. A complete example is: *occasional, 50 cm, brief, Feb.–Apr.*

Frequency—Estimate how often, typically, ponding occurs.

Frequency Class	Code	Criteria: Estimated, Average # of Ponding Events per Time Span
none	NO	< 1 time in 100 years
rare	RA	1 to 5 times in 100 years
occasional	OC	> 5 to 50 times in 100 years
frequent	FR	> 50 times in 100 years

Depth—Estimate the average, representative depth of ponded water at the observation site and specify units (e.g., 1 ft or 30 cm).

Duration—Estimate how long, typically, the ponding lasts.

Duration Class	Conv. Code	NASIS Code	Criteria: Estimated, Average Time per Ponding Event
very brief	VB	VB	< 2 days
brief	BR	B	2 to < 7 days
long	LO	L	7 to < 30 days
very long	VL	VL	≥ 30 days

(Soil) Water State (called **Observed_soil_moisture_status** in NASIS.)—Estimate the water state of the soil at the time of observation (e.g., wet, nonsatiated). Soil temperature must be above 0 °C. (Does not apply to frozen soil.)

Water State Class	Conv. Code	NASIS Code	Criteria: tension	Traditional Criteria: tension and field
dry [1]	D	D	>1500 kPa	> 15 bars of tension [2] *(=1500 kPa)*
moist [1]	M	M [4]	≤ 1500 kPa to > 1.0 kPa (*or* > 0.5 kPa) [3]	former usage: > 1/3 to 15 bars of tension *(33 to 1500 kPa)* (field capacity to wilting point)
wet	W	M [4]	≤ 1.0 kPa (*or* < 0.5 kPa) [3]	0–1/3 bar tension *(< 33 kPa)* (field capacity or wetter)
wet: non-satiated [5]	WN	M [4]	> 0.00 *and* ≤ 1.0 kPa (*or* < 0.5 kPa) [3]	no free water: water films are visible; sand grains and peds glisten, but no free water is present
wet: satiated [5]	WS	W	≤ 0.00 kPa	free water: free water easily visible

[1] Additional subclasses of water state can be recognized for dry and moist classes, if desired (Soil Science Division Staff, 2017, p. 209).

[2] Convention assumes 15 bars of tension as the wilting point for most annual agricultural row crops. ***Caution***: Various perennials, shrubs, trees, and other native vegetation have a wilting point of as much as 66 bars tension (=6600 kPa) or more.

[3] Use the 1 kPa limit for all textures, *except* those coarser than loamy fine sand (which use 0.5 kPa limit; Soil Science Division Staff, 2017, p. 209).

[4] NASIS uses the same three class names (dry, moist, wet) but lumps the “wet: nonsatiated” subclass with the moist class.

[5] **Satiation vs. Saturation:** Satiation implies minor amounts of entrapped air in the smallest pores. True saturation implies no entrapped air. In “Soil Taxonomy,” “Saturation is ... zero or positive pressure in the soil ...” (Soil Survey Staff, 2022). Satiation, for practical purposes, is approximately equal to saturation. Temporal monitoring of a water table by piezometer or other accepted methods may be needed to verify saturation. Related terms used for classifying soils (i.e., soil taxonomy): *endosaturation* is saturation in all layers to > 200 cm (80 inches); *episaturation* requires saturated layers that overlie unsaturated layers within the upper 2 m (80 inches); and *anthric saturation*, a variant of episaturation, is saturation due to management-induced flooding (e.g., for rice or cranberry production).

Cover

Cover – Kind (called **Cover Kind One** and **Cover Kind Two** in NASIS)—Record the dominant kind of cover at the site (e.g., intermixed hardwoods and conifers). (Previously called “Earth Cover Kind One” and “Earth Kind Cover Two” in NASIS to reference 1992 NRI data.)

Kind [1]	Code	Kind [1]	Code
Artificial Cover (A) — nonvegetative cover; due to human activity			
rural transportation — roads, railroads	RU	urban and built-up — cities, farmsteads, industry	UR
Barren Land (B) — < 5% vegetative cover naturally or from construction			
culturally induced — saline seeps, mines, quarries, and oil-waste areas	CI	other barren — salt flats, mudflats, slickspots, badlands	OB
permanent snow or ice	PS	rock	RK
		sand or gravel	SG
Crop Cover (C) — includes entire cropping cycle (land prep, crop, or crop residue) for annual or perennial herbaceous plants			
close-grown crop — wheat, rice, oats, and rye; small grains	CG	row crop — corn, cotton, soybeans, tomatoes, and other truck crops, tulips	RC
Grass/Herbaceous Cover (G) — > 50% grass, grasslike (sedges/rushes), or forb cover, mosses, lichens, ferns; nonwoody			
hayland — alfalfa, fescue, bromegrass, timothy	HL	rangeland, savanna — 10 to 20% tree cover	RS
marshland — grasses and grasslike plants	ML	rangeland, shrubby — 20 to 50% shrub cover	RH
pastureland, tame — fescues, bromegrass, timothy, lespedeza	PL	rangeland, tundra	RT

Kind [1]	Code	Kind [1]	Code
rangeland, grassland; < 10% trees, < 20% shrubs; rangeland used for hayland	RG	other grass and herbaceous cover	OH
Shrub Cover (S) — > 50% shrub or vine canopy cover.			
crop shrubs — filberts, blueberry, ornamental nursery stock	CS	native shrubs — shrub live oak, mesquite, sagebrush, creosote bush; rangeland > 50% shrub cover	NS
crop vines — grapes, blackberries, raspberries	CV	other shrub cover	OS
Tree Cover (T) — > 25% canopy cover by woody plants, natural or planted.			
conifers — spruce, pine, fir	CO	swamp — trees, shrubs	SW
crop, trees — nuts, fruit, nursery, Christmas trees	CR	tropical — mangrove and royal palms	TR
hardwoods — oak, hickory, elm, aspen	HW	other tree cover	OC
intermixed hardwoods and conifers — oak-pine mix	IM		
Water (W) — water at the soil surface; includes seasonally frozen water.			

[1] "Cover – Kind[s]" are presented at two levels of detail: bolded table subheadings are the NASIS "Cover Kind One" (level 1) choices ("National Soil Survey Handbook," Part 622.13; Soil Survey Staff, 2024b). Individual choices under the subheadings are the NASIS "Cover Kind Two" (level 2) choices.

Vegetation

Plant Symbol—Record the codes (scientific plant name abbreviations) for the major plant species found at the site (USDA NRCS, 2024) (e.g., ANGE; *Andropogon gerardii* or big bluestem). ***Note:*** The combination of plant symbol and common name is the primary plant data element in NASIS.)

Plant Common Name—Record the common names of the major plant species found at the site (USDA NRCS, 2024) (e.g., cottonwood and big bluestem). This item may be recorded as a secondary data element to augment the **Plant Symbol**. ***Caution:*** Multiple common names exist for some plants; not all common names for a given plant are in the national PLANTS database.

Plant Scientific Name—Record the scientific plant name along with or in lieu of common names; (e.g., *Acer rubrum* or red maple). ***Note:*** NASIS codes for common plant names are derived from the scientific names.

Vegetation Cover—Estimate the percent of the ground covered by each plant species recorded at the site.

Parent Material

Describe the nature of the unconsolidated material (regolith) in which the soil is formed. If the soil is derived directly from the underlying bedrock (e.g., granite), identify the **Parent Material** as either grus, saprolite, or residuum and then record the appropriate **Bedrock – Kind** choice. ***Note:*** NASIS uses "Component Parent Material Origin" to convey the source from which a parent material is derived, predominantly **Bedrock – Kind**. Multiple parent materials, if present, should be denoted (e.g., loess, over colluvium, over residuum). Use numerical prefixes in the **Horizon** designations to denote different parent materials (lithologic discontinuities) (e.g., A, BE, 2Bt, 2BC, 3C; Peoria Loess, or Calvert Formation).

Kind—Record the kind (e.g., saprolite, loess, colluvium).

Kind [1]	Code	Kind [1]	Code
Eolian Deposits (Nonvolcanic)			
eolian deposit	EOD	loess, calcareous	CLO
eolian sands	EOS	loess, noncalcareous	NLO
loess	LOE	parna	PAR
Glacial and Periglacial Deposits			
cryoturbate	CRY	till, ablation	ATI
drift	GDR	till, basal	BTI
glaciofluvial deposit	GFD	till, flow	FTI
glaciolacustrine deposit	GLD	till, lodgment	LTI
glaciomarine deposit	GMD	till, melt-out	MTI

Kind [1]	Code	Kind [1]	Code
outwash	OTW	till, subglacial	GTI
solifluction deposit	SOD	till, supraglacial	UTI
supraglacial debris-flow	SGF	till, supraglacial meltout	PTI
till	TIL		
In-Place Deposits (Nontransported)			
bauxite	BAU	residuum [2]	RES
grus [2]	GRU	saprolite [2]	SAP
Mass Movement Deposits [3] *(See "Mass Movement Types" table)*			
Miscellaneous Mass Movement Deposits			
colluvium	COL	slump block	SLB
scree	SCR	talus	TAL
Mass Movement Deposit (Unspecified Landslide)			MMD
Complex Landslide Deposits			CLD
Fall Deposits			FAD
debris fall deposit	DLD	soil fall deposit (=earth fall)	SFD
rock fall deposit	RFD		
Flow Deposits			FLD
earthflow deposit	EFD	debris avalanche deposit	DAD
creep deposit	CRP	debris flow deposit	DFD
mudflow deposit	MFD	debris slide deposit	DSD
sand flow deposit	SAD	lahar	LAH
solifluction deposit	SOD	rockfall avalanche deposit	RAD
Slide Deposits			SD
debris slide deposit [4]			OSD
rotational side deposit	RLD	translational slide deposit	TSD
rotational debris slide deposit	RDD	translational debris slide deposits	TDD
rotational earth slide deposit	RED	translational earth slide deposit	TED

Kind [1]	Code	Kind [1]	Code
rotational rock slide deposit	RRD	translational rock slide deposit	TRD
		block glide deposit	BGD
Spread Deposits (=lateral spread)			LSD
debris spread deposit	DPD	rock spread deposit	RSD
earth spread deposit	EPD		
Topple Deposits			TOD
debris topple deposit	DTD	rock topple deposit	RTD
earth topple (=soil topple)	ETD		
Miscellaneous Deposits			
diamicton	DIM	limonite	LIM
gypsite	GYP		
Organic Deposits [5]			
coprogenic materials	COM	organic materials	ORM
diatomaceous earth	DIE	organic, grassy materials	OGM
marl	MAR	organic, herbaceous materials	OHM
marl, coastal	CMA	organic, mossy materials	OMM
marl, freshwater	FWM	organic, woody materials	OWM
Volcanic Deposits (Unconsolidated; Eolian and Mass Movement)			
ash, volcanic (< 2 mm)	ASH	lahar deposit (volcaniclastic mudflow)	LAH
ash, acidic	ASA	lapilli (2-64 mm, > 2.0 sg) [6]	LAP
ash, andesitic	ASN	pumice (< 1.0 sg) [6]	PUM
ash, basaltic	ASB	pyroclastic flow	PYF
ash, basic	ASC	pyroclastic surge	PYS
ash flow (pyroclastic)	ASF	scoria (> 2.0 sg) [6]	SCO
bombs, volcanic (> 64 mm)	BOM	tephra (all ejecta)	TEP
cinders (2-64 mm)	CIN		

Kind [1]	Code	Kind [1]	Code
Waterlaid (or Transported) Deposits			
alluvium	ALL	lagoonal deposits	LGD
backswamp deposit	BSD	marine deposit	MAD
beach sand	BES	marl	MAR
coprogenic materials	COM	marl, coastal	CMA
diatomaceous earth	DIE	marl, freshwater	FWM
estuarine deposit	ESD	overbank deposit	OBD
fluviomarine deposit	FMD	pedisediment	PED
greensands	GRS	slope alluvium	SAL
lacustrine deposit	LAD	valley side alluvium	VSA
Anthropogenic Deposits			
coal extraction mine spoil	CES	metal ore extraction mine spoil	MES
dredge spoils	DGD	mine spoil or earthy fill	MSE
human-transported materials	HTM	human-altered materials	HAM

[1] Parent material definitions are found in the “Glossary of Landform and Geologic Terms,” “National Soil Survey Handbook,” Part 629 (Soil Survey Staff, 2024), or the “Glossary of Geology” (Neuendorf et al., 2005).

[2] Use the most precise term for the in situ material. Residuum is the most generic term.

[3] Cruden and Varnes, 1996.

[4] Debris slide is a more general, encompassing term that may be further subdivided into rotational debris slide or translational debris slide.

[5] These generic terms refer to the dominant origin of the organic materials or deposits from which the organic soil has formed (i.e., parent material) (Soil Science Division Staff, 2017). These terms partially overlap with those recognized in soil taxonomy (terms that refer primarily to what the organic material presently is); see the “Diagnostic Horizons or Characteristics” table.

[6] sg=specific gravity=the ratio of a material’s density to that of water (weight in air/[weight in air – weight in water]).

Bedrock

Describe the nature of the continuous hard rock underlying the soil. Specify the **Kind**, **Fracture Interval**, **Hardness**, and **Weathering Class**.

Bedrock – Kind—Record the kind of bedrock found (e.g., limestone).

Kind [1]	Code	Kind [1]	Code
Igneous—Intrusive			
anorthosite	ANO	pyroxenite	PYX
diabase	DIA	quartzite	QZT
diorite	DIO	quartz-diorite	QZD
gabbro	GAB	quartz-monzonite	QZM
granite	GRA	syenite	SYE
granitoid [2]	GRT	syenodiorite	SYD
granodiorite	GRD	tonalite	TON
monzonite	MON	ultramafic rock [2]	UMU
peridotite	PER		
Igneous—Extrusive			
aa lava	AAL	pahoehoe lava	PAH
andesite	AND	pillow lava	PIL
basalt	BAS	pumice (flow, coherent)	PUM
block lava	BLL	rhyolite	RHY
dacite	DAC	scoria (coherent mass)	SCO
latite	LAT	tachylite	TAC
obsidian	OBS	trachyte	TRA
Igneous—Pyroclastic			
ignimbrite	IGN	tuff, welded	TFW
pyroclastics (consolidated)	PYR	tuff breccia	TBR
pyroclastic flow	PYF	volcanic breccia	VBR
pyroclastic surge	PYS	volcanic breccia, acidic	AVB
tuff	TUF	volcanic breccia, basic	BVB
tuff, acidic	ATU	volcanic sandstone	VST
tuff, basic	BTU		

Kind [1]	Code	Kind [1]	Code
Metamorphic			
amphibolite	AMP	metavolcanics	MVO
gneiss	GNE	mica	MIC
gneiss, biotite	BTG	mica schist	MSH
gneiss, granodiorite	GDG	migmatite	MIG
gneiss, hornblende	HBG	mylonite	MYL
gneiss, migmatitic	MMG	phyllite	PHY
gneiss, muscovite-biotite	MBG	schist	SCH
granofels	GRF	schist, biotite	BTS
granulite	GRL	schist, graphitic	GRS
greenstone	GRE	schist, muscovite	MVS
hornfels	HOR	schist, sericite	SCS
marble	MAR	serpentinite	SER
meta-conglomerate	MCN	siltite	SIT
metaquartzite	MQT	slate	SLA
metasedimentary rocks [2]	MSR	slate, sulfidic	SFS
metasiltstone	MSI	soapstone (talc)	SPS
Sedimentary—Clastics			
arenite	ARE	mudstone	MUD
argillite	ARG	ortho-quartzite	OQT
arkose	ARK	porcellanite	POR
breccia, nonvolcanic (angular fragments)	NBR	sandstone	SST
breccia, nonvolcanic, acidic	ANB	sandstone, calcareous	CSS
breccia, nonvolcanic, basic	BNB	shale	SHA
claystone	CST	shale, acid	ASH
conglomerate (rounded fragments)	CON	shale, calcareous	CSH
conglomerate, calcareous	CCN	shale, clayey	YSH
fanglomerate	FCN	siltstone	SIS
glauconitic sandstone	GLS	siltstone, calcareous	CSI
graywacke	GRY		

Kind [1]	Code	Kind [1]	Code
Sedimentary—Evaporites, Organics, and Precipitates			
bauxite	BAU	limestone, coral	COR
chalk	CHA	limestone, phosphatic	PLS
lignite	LIG	limonite	LIM
chert	CHE	novaculite	NOV
coal	COA	rock anhydrite	RAN
diatomite	DIA	rock gypsum	GYP
dolomite (dolostone)	DOL	rock halite	RHL
limestone	LST	travertine	TRV
limestone, arenaceous	ALS	tripoli	TRP
limestone, argillaceous	RLS	tufa	TUA
limestone, cherty	CLS		
Interbedded (alternating layers of different sedimentary lithologies)			
limestone-sandstone-shale	LSS	sandstone-shale	SSH
limestone-sandstone	LSA	sandstone-siltstone	SSI
limestone-shale	LSH	shale-siltstone	SHS
limestone-siltstone	LSI		

[1] Definitions for kinds of bedrock are found in the "Glossary of Landform and Geologic Terms," "National Soil Survey Handbook," Part 629 (Soil Survey Staff, 2024), or in the "Glossary of Geology" (Neuendorf et al., 2005).

[2] Generic term; use only with regional or reconnaissance surveys (order 3, 4).

Bedrock – Fracture Interval Class (called **Bedrock_fracture_interval** in NASIS)—Describe the dominant (average) horizontal spacing between vertical joints (geogenic cracks or seams) in the bedrock layer.

Average Distance Between Fractures	Code
< 10 cm	1
10 to < 45 cm	2
45 to < 100 cm	3
100 to < 200 cm	4
≥ 200 cm	5

Bedrock – Weathering Class (called **Bedrock_weathering** in NASIS)—The subjective extent to which bedrock has weathered as compared to its presumed nonweathered state. Record under "Miscellaneous Field Notes / Sketch," if used.

Class	Code
slight	SL
moderate	MO
strong	ST

Depth (to Bedrock)—Record the depth (cm) from the ground surface to the contact with coherent (continuous) bedrock.

Lithostratigraphic Unit(s)

Record the lithostratigraphic unit(s) of the unconsolidated material (regolith) and the bedrock in which the soil is formed or from which it is derived. (This is a text field in NASIS.) For example, *Peoria Loess* over *pre-Illinoian till* over *Dakota Formation*. (See discussion, p. 5–12)

Erosion

Estimate the dominant kind and magnitude of accelerated erosion at the site. Specify the **Kind** and **Degree**.

Kind (called **Erosion_accelerated_kind** in NASIS)—Record the kind of erosion.

Kind	Code	Criteria
wind	I	deflation by wind
water:	—	removal by running water
sheet	S	even soil loss, no channels
rill	R	small channels [1]
gully	G	big channels [2]
tunnel	T	subsurface voids within soil that enlarge by running water (i.e., piping)

[1] Small runoff channels that can be obliterated by conventional tillage.

[2] Large runoff channels that cannot be obliterated by conventional tillage.

Degree Class (called **Erosion_class** in NASIS)—Record the degree of erosion.

Class [1]	Code	**Criteria:** Estimated % loss of the original, combined A + E horizons or the estimated loss of the upper 20 cm (if original, combined A + E horizons were < 20 cm thick). [2]
None	0	0
1	1	> 0 up to 25%
2	2	25 up to 75%
3	3	75 up to 100%
4	4	> 75 % and total removal of A

[1] In NASIS, the choices include the preceding word “Class” (e.g., Class 1).

[2] Soil Survey Division Staff, 2017, p. 76.

Surface Fragments

Record the amount of surface fragment cover as a numerical percent, as determined by either a “point count” or “line-intercept” method. In NASIS, additional details can be recorded: **Surface Fragment Kind** (called **Surface_frag_kind** in NASIS), **Surface Fragment Class** (relative quantity), **Mean Distance Between Fragments** (edge to edge), **Shape** (FL-flat or NF-nonflat), **Size**, **Roundness** (use classes and criteria found in “Rock Fragment – Roundness Table”), and **Rock Fragment – Rupture Resistance**.

Kind—Document the types of coarse fragments present (same options as “Rock and Other Fragments – Kind”).

Kind	Code	Kind	Code
Includes all choices in **Bedrock—Kind** (except *Interbedded*), plus:			
calcrete (caliche) [1]	CA	metamorphic rocks [2]	MMR
carbonate concretions	CAC	mixed rocks [3]	MXR
carbonate nodules	CAN	ortstein fragments	ORF
carbonate rocks [2]	CAR	petrocalcic fragments	PEF
charcoal	CH	petroferric fragments	TCF
cinders	CI	petrogypsic fragments	PGF
durinodes	DNN	plinthite nodules	PLN
duripan fragments	DUF	quartz	QUA
foliated metamorphic rocks [2]	FMR	quartzite	QZT

Kind	Code	Kind	Code
gibbsite concretions	GBC	scoria	SCO
gibbsite nodules	GBN	sedimentary rocks [2]	SED
igneous rocks [2]	IGR	shell fragments	SHF
iron-manganese concretions	FMC	silica concretions	SIC
iron-manganese nodules	FMN	volcanic bombs	VB
ironstone nodules	FSN	volcanic rocks [2]	VOL
lapilli	LA	wood	WO

[1] Fragments strongly cemented by carbonate; may include fragments derived from petrocalcic horizons.

[2] Generic rock names may be appropriate for identifying fragments (e.g., a cobble) but are too general and should *not* be used to name **Bedrock – Kind**.

[3] Numerous unspecified fragment lithologies are present, as in till or alluvium; not for use with residuum.

Surface Fragment Class—

Surface Fragment Class	Conv. Code[2]	NASIS Code	Criteria: Percentage of Surface Covered
stony or bouldery	Class 1	%	0.01 to < 0.1
very stony or very bouldery	Class 2	%	0.1 to < 3
extremely stony or extremely bouldery	Class 3	%	3 to < 15
rubbly	Class 4	%	15 to < 50
very rubbly	Class 5	%	≥ 50 [3]

[1] This is also used to record large wood fragments (e.g., tree trunks) on organic soils if the fragments are a management concern and appear to be relatively permanent.

[2] Historically called “Surface Stoniness” classes (now “Surface Fragment” classes). Use as a map unit phase modifier is restricted to stone-sized fragments or larger (> 250 mm; Soil Survey Staff, 1951).

[3] If the percentage of surface fragments is > 80%, the fragments are considered to be a distinct, separate horizon.

Diagnostic Horizons and Characteristics

Identify the **Kind** and **Upper** and **Lower Depths** of occurrence of soil taxonomic diagnostic horizons and characteristics (Soil Survey Staff, 2022) (e.g., mollic epipedon; 0-45 cm*)*. Multiple features per horizon can be recorded. (Called **Pedon_diagnostic_features** in NASIS.) Record **Kind**, **Thickness**, **Representative Value** (RV). **High Value** and **Low Value** can also be recorded.

Kind—(see definitions in current "Keys to Soil Taxonomy")

Kind	Code	Kind	Code
Mineral Soils			
Epipedons (Diagnostic Surface Horizons)			
anthropic	AN	mollic	MO
folistic	FO	ochric	OC
histic	HI	plaggen	PL
melanic	ME	umbric	UM
Subsurface Horizons			
agric	AG	kandic	KA
albic	AL	natric	NA
anhydritic	AN	orstein	OR
argillic	AR	oxic	OX
calcic	CA	petrocalcic	PE
cambic	CM	petrogypsic	PG
duripan	DU	placic	PA
fragipan	FR	salic	SA
glossic	GL	sombric	SO
gypsic	GY	spodic	SP
Soil Characteristics			
abrupt textural change	AC	lamella/lamellae	LA
albic materials	AM	linear extensibility	LE
albic materials, interfingering of	AI	lithologic discontinuity	LD
andic soil properties	AP	*n* value	NV
anhydrous conditions	AH	petroferric contact	TC

Kind	Code	Kind	Code
coefficient of linear extensibility	CL	plinthite	PL
durinodes	DN	resistant minerals	RM
fragic soil properties	FP	slickensides	SS
free carbonates	FC	spodic materials	SPM
gypsum accumulations	GA	volcanic ash	VA
identifiable secondary carbonates	SC	weatherable minerals	WM
Organic Soils			
Kinds of Soil Material			
fibric soil materials	FM	humilluvic material	UM
hemic soil materials	HM	sapric soil materials	RM
Both Mineral and Organic Soils			
Soil Characteristics or Horizons			
aquic conditions	AQ	lithic contact	LA
cryoturbation	CR	paralithic contact	PC
densic contact	DC	paralithic materials	PM
densic materials	DM	permafrost	PF
gelic materials	GM	soil moisture regime	SMR
glacic layer	GL	soil temperature regime	STR
limnic materials:	LM	sulfidic materials	SM
coprogenous earth	CO	sulfuric horizon	SU
diatomaceous earth	DI		
marl	MA		
Human-Altered and Human-Transported Materials or Layers			
Diagnostic Characteristics—Anthropogenic Materials or Layers			
artifacts	ART	manufactured layer	ML
human-altered materials	HAM	manufactured layer contact	MC
human-transported materials	HTM		

Kind	Code	Kind	Code
Miscellaneous Horizon Features or Conditions			
anthric saturation [1]	AS	redox depletions with chroma 2 or less [1]	RD
endosaturation [1]	EN	reduced matrix [1]	RX
episaturation [1]	ED	salt accumulations	ST
fibers	FI	strongly contrasting particle-size class	SR
redox concentrations	RC	volcanic glass	VG

Depth—Document the zone of occurrence for a diagnostic horizon or property, as observed, by recording the **Top Depth** and **Bottom Depth** and specifying units (e.g., 22–39 cm).

Soil Taxonomy Classification—After completely describing the soil, classify the pedon as thoroughly as possible (to the lowest level). See most recent version of “Soil Taxonomy” and “Keys to Soil Taxonomy” for complete choice lists (e.g., fine, mixed, active, mesic Typic Haplohumults).

Particle-Size Control Section—Record the **Upper** and **Lower Depth** of the zone used as the basis for identifying the particle-size control section (e.g., *30–80 cm);* used to classify in soil taxonomy.

Restriction

Restriction – Kind—Identify any root-limiting/restrictive layers within the soil profile. Also record the **Upper** and **Lower Depth** of occurrence.

Kind	Code	Kind	Code
abrupt textural change	AC	paralithic bedrock	BPL
cemented horizon	CH	permafrost	PF
densic material	DM	petrocalcic	PE
densic bedrock	BD	petroferric	TC
duripan	DU	petrogypsic	PG
fragipan	FR	placic	PA
manufactured layer	ML	plinthite	PI
lithic bedrock	BL	salic	SA

Kind	Code	Kind	Code
natric	NA	strongly contrasting textural stratification	SR
ortstein	OR	sulfuric	SU

Restriction – Hardness—Estimate the hardness of a root-restrictive layer. (Use *Rupture Resistance – Cementation Classes*.)

References

American National Standards Institute (ANSI) Codes for the States. 2009. INCITS 38:2009.

Bureau of Chemistry and Soils. 1937. Soil survey manual. USDA Misc. Publ. 274. Washington, DC.

Cruden, D.M., and D.J. Varnes. 1996. Landslide types and processes. *In* A.K. Turner and R.L. Schuster (ed.) Landslides: Investigation and mitigation. Spec. Rep. 247, Transportation Research Board, National Research Council. National Academy Press, Washington, DC.

International Organization for Standardization. 2020a. Codes for the representation of names of countries and their subdivisions- Part 1: Country code (ISO Standard No. 3166-1:2020(en)).

International Organization for Standardization. 2020b. Codes for the representation of names of countries and their subdivisions – Part 2: Country subdivision codes (ISO Standard No. 3166-2:2020(en)).

National Institute of Standards and Technology. 1990. Counties and equivalent entities of the United States, its possessions and associated areas. U.S. Dep. Commerce, Federal Information Processing Standards Publ. (FIPS PUB 6–4).

Neuendorf, K., J.P. Mehl, and J.A. Jackson. 2005. Glossary of geology, 5th ed. Am. Geol. Inst., Alexandria, VA.

Ruhe, R.V. 1975. Climatic geomorphology and fully developed slopes. Catena 2:309–320. doi:10.1016/S0341-8162(75)80019-1.

Schoeneberger, P.J., and D.A. Wysocki. 2017. Geomorphic description system, ver. 5.0. USDA Natural Resources Conservation Service.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and W.D. Broderson. 1998. Field book for describing and sampling soils, ver. 1.1. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and W.D. Broderson (ed.) 2002. Field book for describing and sampling soils, ver. 2.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, ver. 3.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Conservation Service. 1981. Land resource regions and major land resource areas of the United States. USDA, Agriculture Handbook No. 296.

Soil Survey Division Staff. 1993. Soil survey manual. USDA, Agriculture Handbook No. 18.

Soil Survey Staff. 1962. Identification and nomenclature of soil horizons. Supplement to Agriculture Handbook No. 18, Soil Survey Manual (replacing pages 173–188). USDA Soil Conservation Service.

Soil Survey Staff. 2022. Keys to Soil Taxonomy, 13th ed. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2024. National soil survey handbook (NSSH). USDA Natural Resources Conservation Service.

Soil Survey Staff. 2011. Soil survey laboratory information manual. Soil Survey Investigations Report No. 45, ver. 2.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Survey Staff. 1951. Soil survey manual. USDA, Agriculture Handbook No. 18.

USDA Natural Resources Conservation Service. 2022. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. USDA, Agriculture Handbook 296.

USDA Natural Resources Conservation Service. 2024. The PLANTS Database. National Plant Data Team, Greensboro, NC USA.

Wysocki, D.A., P.J. Schoeneberger, D. Hirmas, and H.E. LaGarry. 2012. Geomorphology of soil landscapes. *In* P.M. Huang et al. (ed.) Handbook of soil science: Properties and processes, 2nd ed. CRC Press, Taylor and Francis Group, LLC, Boca Raton, FL. ISBN: 978-1-4398-0305-9.

Wysocki, D.A., P.J. Schoeneberger, and H.E. LaGarry. 2000. Geomorphology of soil landscapes. *In* M.E. Sumner (ed.) Handbook of soil science. CRC Press, LLC, Boca Raton, FL. ISBN: 0–8493–3136–6.

Observation Method

For each layer, record the observation method by which the primary observations are made. (Common sampling devices are included in the "Soil Sampling" section.) Describe **Kind** and **Relative Size** (e.g., bucket auger, 3 inch; trench, 2 x 4 m).

Kind (called **Observation_method** in NASIS)—Record the kind of observation method.

Kind [1]	Code	Criteria
Disturbed Samples		
bucket auger	BA	open, closed, sand, mud buckets (5–12 cm diam.)
dutch or mud auger	DA	an open, strap-sided bucket (5–10 cm diam.) with a sharpened outer edge and a screw tip with a partial twist
screw auger	SA	external thread hand augers, power (flight) auger (2–30 cm diam.)
Undisturbed Samples		
Macaulay sampler	MC	a half-cylinder, "gouge" sampler with a hinged door that's pushed in and partially rotated to obtain a sample of soft sediments (e.g., organics)
push tube	PT	handheld or hydraulic, hollow stem (2–10 cm diam.)
shovel slice [2]	SS	undisturbed block extracted with a shovel (sharpshooter: 20 x 40 cm)
vibracore tube	VT	a hollow tube (4-8 cm diam.) vibrated into wet sand, silt, or organics
Wall/Floor—Undisturbed Area or Exposure		
small pit	SP	hand or machine dug (< 1 m x 2 m)
trench	TR	hand or machine dug (> 1 m x 2 m)
beveled cut	BC	roadcuts graded to < 60% slope
cut	CU	roadcut, streambank, medium borrow pit wall > 60% slope (> 4 m, < 33 m)
large open pit or quarry	LP	large borrow pit or quarry with large or irregular banks (> 33 m)

Kind [1]	Code	Criteria
Other Observations		
dive	DV	a visual onsite assessment performed underwater
video	VO	electronically recorded photo or sequential digital images of a subaqueous setting/site

[1] Refer to **Examples of Common Soil-Sampling Equipment** (p. 8–5) and **Bucket Auger Types** (p. 8–6) for examples of field equipment.

[2] Field method used for hydric soil investigations.

Relative Size (of exposure) (called **Relative_Exposure_UOM** in NASIS)—Record the approximate size (scale) of the exposure observed. Use cm for “Drill Cores” and m for “Wall/Floor” observations; e.g., bucket auger, 3 cm; trench wall, 3 m. (***Note:*** Common size range for each method is indicated in the “Criteria” column of the “Observation Method – Kind” table. These dimensions are approximate and are not intended to be precise.)

Relative Size of Exposure Observed	Code
centimeters	cm
meters	m

Horizon and Layer Designations

Use capital letters to identify master horizons (e.g., A, B). Use suffixes (lowercase letters) to denote additional horizon characteristics or features (e.g., Ap, Btk). (For more detailed criteria, see the “Soil Taxonomy” section [p. 4–1]; for complete definitions, see “Keys to Soil Taxonomy” [Soil Survey Staff, 2022].) Label a horizon (assign horizon designation) only after all morphology is recorded.

Master and Transitional Horizons and Layers[1]—Identify the master horizons of the soil profile.

Horizon	**Criteria** (expanded details listed in “Soil Taxonomy” section)
O	organic soil materials (not limnic)
A	mineral; organic matter (humus) accumulation, loss of Fe, Al, clay

Horizon	Criteria (expanded details listed in “Soil Taxonomy” section)
AB or **AE** or **AC**	dominantly A horizon characteristics but also contains some B, E, or C horizon attributes
A/B or **A/E** or **A/C**	discrete, intermingled bodies of A and B, E, or C material; majority is A material
E	mineral; some loss of Fe, Al, clay, or organic matter
EA or **EB** or **EC**	dominantly E horizon characteristics but also contains some A, B, or C horizon attributes
E/A or **E/B**	discrete, intermingled bodies of E and A or B horizon material; majority of horizon is E material
E and Bt or **B and E**	thin, heavier textured lamellae (Bt) within a dominantly E horizon (or thin E within dominantly B horizon)
BA or **BE** or **BC**	dominantly B characteristics but contains A, E, or C horizon attributes
B/A or **B/E** or **B/C**	discrete, intermingled bodies of B and A, E, or C material; majority of horizon is B material
B	subsurface accumulation of clay, Fe, Al, Si, humus, $CaCO_3$, $CaSO_4$; or loss of $CaCO_3$; or accumulation of sesquioxides; or subsurface soil structure
CB or **CA**	dominantly C horizon characteristics but also contains attributes of the B or A horizon
C/B or **C/A**	discrete, intermingled bodies of C and B or A material; majority of horizon is C material
C	little or no pedogenic alteration, unconsolidated earthy material, soft bedrock
L	limnic soil materials
W	a layer of liquid water (W) or permanently frozen water (Wf) within or beneath the soil (excludes water/ice above soil)
M	root-limiting subsoil layers of human-manufactured materials
R	bedrock, strongly cemented to indurated

[1] See “Soil Taxonomy” for older horizon nomenclature.

[2] Soil Survey Staff, 2022.

Horizon Suffixes—Historically referred to as “Horizon Subscripts,” “Subordinate Distinctions,” [1] “Horizon_designation_suffix” in NASIS, and as “Suffix Symbols” in soil taxonomy. (Historical designations and conversions are shown in the “Soil Taxonomy” section.)

Horizon Suffix	Criteria (expanded details listed in “Soil Taxonomy” section)
a	highly decomposed organic matter (used only with O); sapric materials
b	buried genetic horizon (not used with C horizons)
c	concretions or nodules
co	coprogenous earth (used only with L)
d	densic layer (physically root restrictive)
di	diatomaceous earth (used only with L)
e	moderately decomposed organic matter (used only with O); hemic materials
f	permanently frozen soil or ice (permafrost); continuous subsurface ice; not seasonal ice
ff	permanently frozen soil (“dry” permafrost); no continuous ice; not seasonal ice
g	strong gley
h	illuvial organic matter accumulation
i	slightly decomposed organic matter (used only with O); fibric materials
j	jarosite accumulation
jj	evidence of cryoturbation
k	pedogenic $CaCO_3$ accumulation (< 50% by vol.)
kk	major pedogenic $CaCO_3$ accumulation (> 50% by vol.)
m	continuous cementation (pedogenic)
ma	marl (used only with L)
n	pedogenic, exchangeable sodium accumulation
o	residual sesquioxide accumulation (pedogenic)
p	plow layer or other artificial disturbance
q	secondary (pedogenic) silica accumulation
r	weathered or soft bedrock
s	illuvial sesquioxide and organic matter accumulation

Horizon Suffix	Criteria (expanded details listed in "Soil Taxonomy" section)
se	presence of sulfides (in mineral or organic horizons)
ss	slickensides
t	illuvial accumulation of silicate clay
u	presence of human-manufactured materials (artifacts)
v	plinthite
w	weak color or structure within B (used only with B)
x	fragipan characteristics
y	accumulation of gypsum
yy	dominance of gypsum (≈≥ 50% by vol.)
z	pedogenic accumulation of salt more soluble than gypsum

[1] Soil Science Division Staff, 2017.

Other Horizon Modifiers:

Numerical Prefixes (2, 3, etc.)—Used to denote lithologic discontinuities. By convention, 1 is understood but is *not* shown (e.g., A, E, Bt1, **2**Bt2, **2**BC, **3**C1, **3**C2). ***Note:*** Discontinuities have important implications for site history, internal water flow, and soil interpretations (see additional discussion under "Subaqueous Soils," p. 2–107).

Numerical Suffixes—Used to denote subdivisions within a master horizon (e.g., A**1**, A**2**, E, Bt**1**, Bt**2**, Bt**3**, Bs**1**, Bs**2**).

The Prime (´) (Called **Horz_desgn_master_prime** in NASIS)—Used to indicate the recurrence of identical horizon descriptor(s) in a profile or pedon (e.g., A, **E,** Bt, **E´** Btx, C*)*. The prime does not indicate either buried horizons (which are denoted by a lowercase "b" [e.g., Btb]) or lithologic discontinuities (denoted by numerical prefixes). In NASIS, up to five primes can be used to denote subsequent occurrences of horizon descriptors in a pedon (e.g., A, E, Bt, **E´**, Btx, **E˝**, Cd).

The Caret (^)—Used as a prefix to master horizons to indicate mineral or organic horizons formed in human-transported materials (e.g., **^**A, **^**Bw, 2**^**C).

Horizon Depth—Record the depths of both the upper and lower boundary for each horizon; specify units (centimeters preferred); e.g., 15–24 cm. Begin (zero datum) at the ground surface [1], which is not necessarily the mineral surface. ***Note:*** Prior to 1993, the zero datum was at the top of the mineral surface, except for thick organic layers, such as peat or muck. Organic horizons were recorded as above and mineral horizons recorded as below, relative to the mineral surface.

Example: Zero Datum for the same horizons

At Present: Oe 0 – 5 cm, A 5 – 15 cm, E 15 – 24 cm
Before 1993: Oe 5 – 0 cm, A 0 – 10 cm, E 10 – 19 cm

[1] Conventionally, the "soil surface" is considered to be the top boundary of the first layer that can support plant and root growth. This equates to:

a) (for bare mineral soil) the air and fine-earth interface;
b) (for vegetated mineral soil) the upper boundary of the first layer that can support root growth;
c) (for organic mantles) the same as "b" but *excludes* freshly fallen plant litter and includes litter that has compacted and begun to decompose (e.g., Oi horizon);
d) (for submerged soil) the same as "b" but refers to the water and soil contact that extends out from shore to the limit of emergent rooted plants;
e) (for rock mulches [e.g., desert pavement, scree]) the same as "a" unless the areal percentage of surface rock coverage is greater than 80%, the top of the soil is the mean height of the top of the rocks.

Horizon Thickness—Record the average thickness and range in thickness of horizon (e.g., 15 cm [12–21 cm]). ***Note:*** Used primarily for irregular soil horizons/layers.

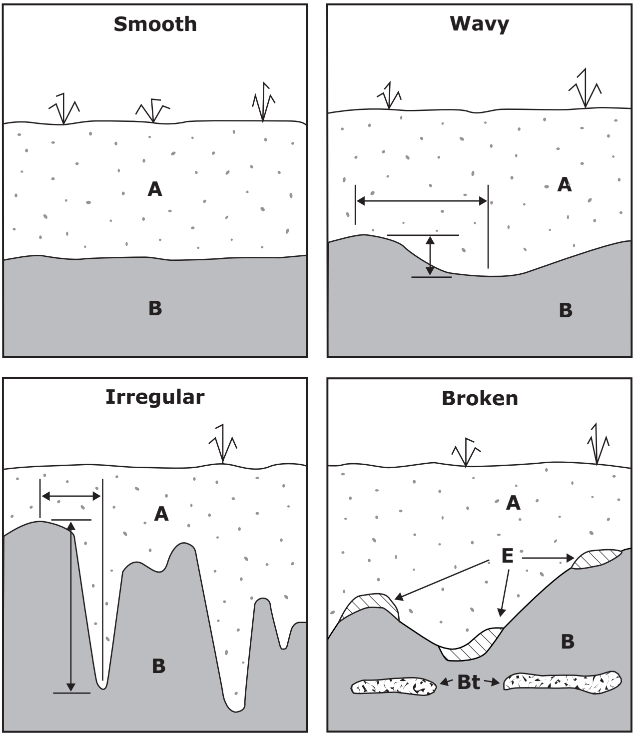
Horizon Boundary—Record **Distinctness** and **Topography** of horizon boundaries. (In NASIS, Distinctness is called "Boundary Distinctness"). Distinctness is the vertical distance through which the bottom of one horizon grades (transitions) into another. Topography is the lateral undulation and continuity of the boundary between horizons. A complete example is *clear, wavy*, or *C,W*.

Distinctness—The vertical distance (thickness) over which a horizon transitions to the top of the next.

Distinctness Class	Code	Criteria: Transitional Zone Thickness
very abrupt	V	< 0.5 cm
abrupt	A	0.5 to < 2 cm
clear	C	2 to < 5 cm
gradual	G	5 to < 15 cm
diffuse	D	≥ 15 cm

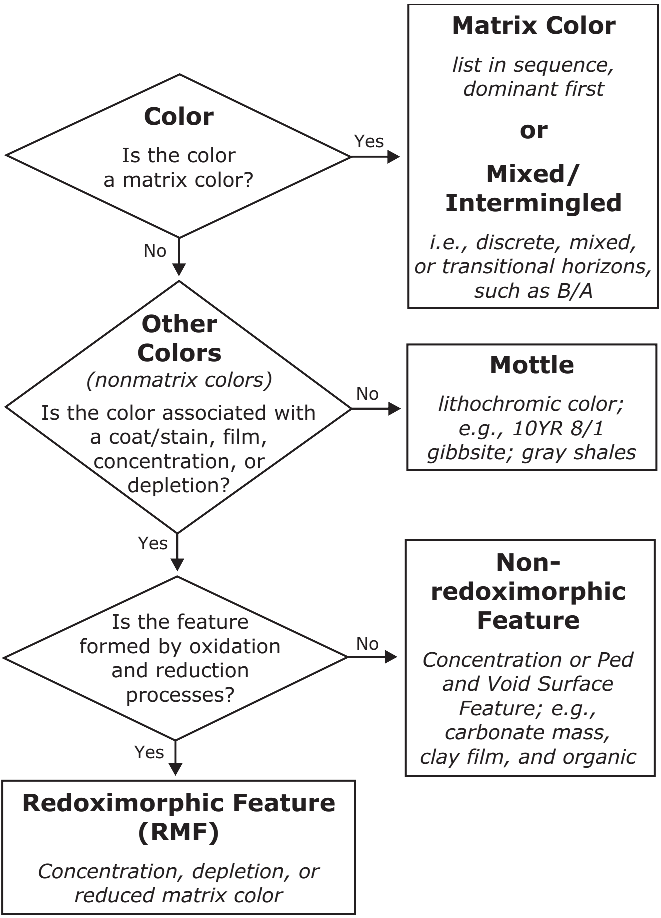
Topography—Cross-sectional shape of the contact between horizons.

Topography	Code	Criteria
smooth	S	planar with few or no irregularities
wavy	W	width of undulation is greater than depth
irregular	I	depth of undulation is greater than width
broken	B	discontinuous horizons; discrete but intermingled, or irregular, pockets



Soil Color

Decision Flowchart for Describing Soil Colors—Use the following chart to decide how and with which data elements the color patterns of a soil or soil feature should be described.



Note: *Reduced matrix* color is described as a *matrix color* and with the terms in the“(Soil Color) – Location or Condition Described Table.”

(Soil) Matrix Color—Record the **Color(s)**, **Moisture State**, and **Location or Condition**.

(Soil) Matrix Color – (Soil) Color—Identify the soil matrix color(s) with Munsell notation (**Hue, Value, Chroma**) (e.g., 10YR 3/2). For neutral colors, chroma is zero but not shown (e.g., N 4/). For other gley colors, use appropriate notation (see Munsell gley pages [e.g., 5GY 6/1]). For narrative descriptions (e.g., soil survey reports, Official Soil Series Descriptions), both the verbal name and the Munsell notation are given (e.g., dark brown, 10YR 3/3).

(Soil) Matrix Color – Moisture State—Record the general moisture condition of the soil described (e.g., moist). (Not to be confused with “Soil Water State.”)

Moisture State	Code
dry	D
moist	M

(Soil) Matrix Color – Location or Condition—Record pertinent circumstances of the color described (called **Color_physical_state** in NASIS) under “Miscellaneous Field Notes / Sketch.”

Color Location or Condition	Code
Color Location	
interior (*within ped*)	IN
exterior (*ped surface*)	EX
Color, Mechanical Condition	
broken face	BF
crushed	CR
rubbed (*used only with organic matter*)	RU
Color, Redoximorphic Condition	
oxidized [1]	OX
reduced [2]	RE
Color, Intricate Multicolored Pattern	
variegated [3]	VA

[1] Soil that is reduced *in situ* but has been extracted and exposed to the atmosphere (air) and has oxidized (changed color). A mineral example is vivianite. ***Note:*** Not used for soil that is normally oxidized in place. For indicators of reduction, see “Redoximorphic Features.”

[2] Color determined immediately after extraction from a reduced environment and prior to oxidation (e.g., FeS). Also used to record **Reduced Matrix**.

[3] Color pattern is too intricate (banded or patchy) with numerous diverse colors to credibly identify dominant matrix colors (e.g., foliated felsic crystalline saprolite).

Redoximorphic Features—RMFs (Discussion)

Redoximorphic features (RMFs) are color patterns in a soil caused by loss (depletion) or gain (concentration) of pigment compared to the matrix color, formed by oxidation/reduction of Fe and/or Mn coupled with their removal, translocation, or accrual; or a soil matrix color controlled by the presence of Fe^{+2}. The composition and process of formation for a soil color or color pattern must be known or inferred before it can be described as an RMF. Because of this inference, RMFs are described separately from mottles, other concentrations (e.g., salts), or compositional features (e.g., clay films). RMFs generally occur in one or more of these settings:

1. In the soil matrix, unrelated to surfaces of peds or pores.
2. On or beneath the surfaces of peds.
3. As filled pores, as linings of pores, or beneath the surfaces of pores.

RMFs include the following:

1. **Redox Concentrations**—Localized zones of enhanced pigmentation due to an accrual of, or a phase change in, the Fe-Mn minerals; or physical accumulations of Fe-Mn minerals. ***Note:*** Iron concentrations may be either Fe^{+3} or Fe^{+2}. Types of redox concentrations are:
    a. **Masses**—Noncemented bodies of enhanced pigmentation that have a redder or blacker color than the adjacent matrix.
    b. **Nodules or Concretions**—Cemented bodies of Fe-Mn oxides.
2. **Redox Depletions**—Localized zones of “decreased” pigmentation that are grayer, lighter, or less red than the adjacent matrix. Redox depletions include, but are not limited to, what were previously called “low-chroma mottles” (chroma ≤ 2). Redox depletions of chroma ≤ 2 formed through reduction and oxidation processes are strong field indicators of saturation. Types of redox depletions are:
    a. **Iron Depletions**—Localized zones that have one or more of the following: a yellower, greener, or bluer hue; a higher value; or a lower chroma than the matrix color. Color value is normally ≥ 4. Loss of pigmentation results from the loss of Fe and/or Mn. Clay content equals that in the matrix.
    b. **Clay Depletions**—Localized zones that have either a yellower, greener, or bluer hue, a higher value, or a lower chroma than the matrix color. Color value is normally ≥ 4. Loss of pigmentation results from a loss of Fe and/or Mn and clay. Silt coats or skeletans commonly form as depletions but

can be nonredox concentrations if deposited as flow material in pores or along faces of peds.

3. **Reduced Matrix**—A soil horizon that has an in situ matrix chroma ≤ 2 due to the presence of Fe^{+2}. Color becomes redder or brighter (oxidizes) when the sample is exposed to air. The color change usually occurs within 30 minutes. A 0.2% solution of α,α'-dipyridyl dissolved in 1N ammonium acetate (NH_4OAc) pH 7 can verify the presence of Fe^{+2} in the field (Childs, 1981).

Note: RMF alters the traditional sequence for describing soil color (see the "Decision Flowchart for Describing Colors for Soil Matrix and Soil Features"). RMFs are described separately from other color variations or concentrations. Mottles (color variations *not* due to loss or accrual of Fe-Mn oxides; e.g., variegated weathered rock) are still described under **Soil Color**. A reduced matrix is recorded as an RMF and as "reduced" in **Soil Color – Location** or **Condition Described**.

Redoximorphic Features

Record **Kind**, **Quantity** (percent of area covered), **Size**, **Contrast**, **Color**, **Moisture State**, **Shape**, **Location**, **Hardness**, and **Boundary**. At present, relict RMFs, as supported by geomorphic setting, water table data, etc., are recorded as "relict RMFs" (include horizons and depths) under "Miscellaneous Field Notes / Sketch."

Redoximorphic Features – Kind—Record the kind of redoximorhpic features.

Kind	Code	Kind	Code
Reduced Matrix (chroma ≤ 2 primarily from Fe^{+2})			
reduced matrix	RMX		
Redox Depletions (loss of pigment or material)			
clay depletions	CLD	iron depletions	FED
Redox Concentrations (accumulated pigment, material)			
Masses [1] ***(noncemented)***			
iron (Fe^{+2}) [2]	F2M	jarosite	JAM
iron (Fe^{+3}) [3, 4, 5]	F3M	manganese [4, 5]	MNM
iron-manganese [3, 4, 5]	FMM		
Nodules [1] ***(cemented; no layers, crystals not visible at 10x)***			
ironstone	FSN	jarosite	JAN
iron-manganese [4]	FMN	plinthite	PLN
Concretions [1] ***(cemented; distinct layers, crystals not visible)***			
iron-manganese [4]			FMC

Kind	Code	Kind	Code
Surface Coats/Films or Hypocoats			
manganese (mangans: flat black, very thin, exterior films)			MNF
ferriargillans (Fe^{+3} stained clay film)			FEF

[1] See discussion under **Concentrations** for definitions.

[2] A concentration of reduced iron Fe^{+2} (e.g., FeS).

[3] A concentration of oxidized iron Fe^{+3} (e.g., hematite [formerly described as reddish mottles]).

[4] Fe and Mn commonly occur in combination, and field identification of distinct phases is difficult. Use “Mn masses” only for those that are at least *slightly effervescent* with H_2O_2. Describe nodules and concretions as *“iron-manganese”* unless colors are unambiguous.

[5] Suggested color guidelines for field description of Fe vs. Mn masses.

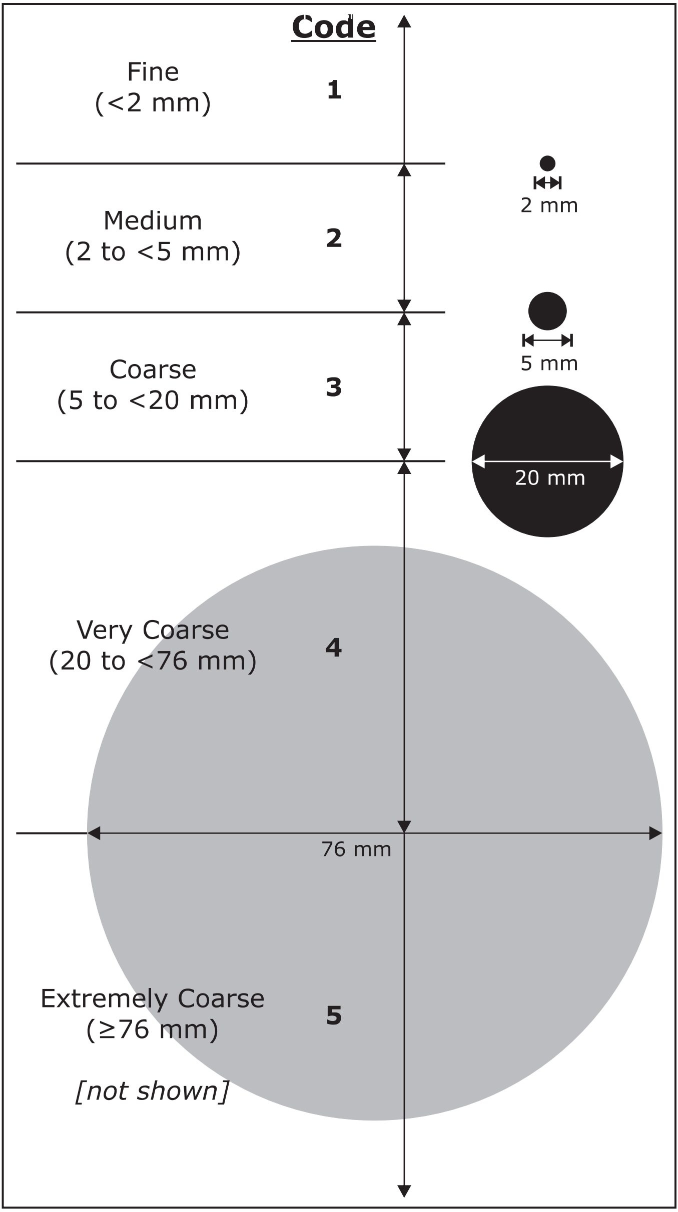
Redoximorphic Features – Color of RMF or Concentration—

Value	Chroma	Dominant Composition
≤ 2	≤ 2	Mn
> 2 and ≤ 4	> 2 and ≤ 4	Fe and Mn
> 4	> 4	Fe

Redoximorphic Features – Quantity (Percent of Area Covered)—See graphics for **Percent of Area Covered (2 to 20%)** beginning on p. 7–1.

Class	Conv. Code	NASIS Code	Criteria: Percent of Surface Area Covered
few	f	%	< 2
common	c	%	2 to < 20
many	m	%	≥ 20

Redoximorphic Features – Size—See size class graphic on next page.


Code
Fine
(<2 mm)
1
Medium
(2 to <5 mm)
2
Coarse
(5 to <20 mm)
3
Very Coarse
(20 to <76 mm)
4
Extremely Coarse
(≥76 mm)
5
[not shown]
2 mm
5 mm
20 mm
76 mm

Size Class	Code	Criteria
fine	1	< 2 mm
medium	2	2 to < 5 mm
coarse	3	5 to < 20 mm
very coarse	4	20 to < 76 mm
extremely coarse	5	≥ 76 mm

Redoximorphic Features – Contrast—Record the color difference between the RMF and the dominant matrix color (e.g., prominent or p). Use this table or the following chart to express the difference. (Also used for **Concentrations** and **Mottles**.)

Contrast Class	**Code**	**Difference in Color Between Matrix and RMF (Δ means "difference between")**				
		Hue (h)		**Value (v)**		***Chroma (c)***
faint [1]	F	Δh = 0;		Δv ≤ 2	and	Δc ≤ 1
		Δh = 1;		Δv ≤ 1	and	Δc ≤ 1
		Δh = 2;		Δv = 0	and	Δc = 0
distinct [1]	D	Δh = 0;		Δv ≤ 2	and	Δc > 1 to < 4
			or	Δv > 2 to < 4	and	Δc < 4
		Δh = 1;		Δv ≤1	and	Δc > 1 to < 3
			or	Δv > 1 to < 3	and	Δc < 3
		Δh = 2;		Δv = 0	and	Δc > 0 to < 2
			or	Δv > 0 to < 2	and	Δc < 2
prominent [1]	P	Δh = 0;		Δv ≥ 4	or	Δc ≥ 4
		Δh = 1;		Δv ≥ 3	or	Δc ≥ 3
		Δh = 2;		Δv ≥ 2	or	Δc ≥ 2
		Δh ≥ 3;				

[1] If compared colors have both a value ≤ 3 and a chroma of ≤ 2, the contrast is *faint*, regardless of hue differences.

Tabular List for Determination of Color Contrast

Hues are the same (Δ h = 0) [1]

Δ Value	Δ Chroma	Contrast
0	≤ 1	faint
0	2	distinct
0	3	distinct
0	≥ 4	prominent
1	≤ 1	faint
1	2	distinct
1	3	distinct
1	≥ 4	prominent
≤ 2	≤ 1	faint
≤ 2	2	distinct
≤ 2	3	distinct
≤ 2	≥ 4	prominent
3	≤ 1	distinct
3	2	distinct
3	3	distinct
3	≥ 4	prominent
≥ 4	—	prominent

Hues differ by 1 (Δ h = 1) [1]

Δ Value	Δ Chroma	Contrast
0	≤ 1	faint
0	2	distinct
0	≥ 3	prominent
1	≤ 1	faint
1	2	distinct
1	≥ 3	prominent
2	≤ 1	distinct
2	2	distinct
2	≥ 3	prominent
≥ 3	—	prominent

Hues differ by 2 (Δ h = 2) [1]

Δ Value	Δ Chroma	Contrast
0	0	faint
0	1	distinct
0	≥ 2	prominent
1	≤ 1	distinct
1	≥ 2	prominent
≥ 2	—	prominent

Hues differ by 3 or more (Δ h ≥ 3) [1]

Δ Value	Δ Chroma	Contrast
color contrast is *prominent*, except for low chroma and value [1]		prominent

[1] Exception: If both colors have a value ≤ 3 and a chroma ≤ 2, the color contrast is *faint*, regardless of hue differences.

Redoximorphic Features – Color—Use standard Munsell notation from the “Soil Color” section (e.g., light brownish gray or 2.5Y 6/2).

Redoximorphic Features – Moisture State—Describe the moisture condition of the redoximorphic feature (use “Soil Color – Moisture State” table) (e.g., moist [M]).

Moisture State	Code
dry	D
moist	M

Redoximorphic Features – Shape—Describe the shape of the redoximorphic feature (use “Concentrations – Shape” table) (e.g., spherical [S]).

Redoximorphic Features – Location—Describe the location(s) of the redoximorphic feature within the horizon (use “Concentrations – Location” table) (e.g., In the matrix around depletions [MAD]).

Redoximorphic Features – Hardness—Describe the relative force required to crush the redoximorphic feature (use the same classes and criteria as the “Rupture Resistance for Blocks/Peds/Clods-Cementation” column) (e.g., strongly cemented [ST]).

Redoximorphic Features – Boundary—The gradation between the redoximorphic feature and the adjacent matrix (use “Concentrations – Boundary” table) (e.g., sharp [S]).

Mottles

Describe mottles (areas that differ from the matrix color). Mottles commonly have a lithomorphic or lithochromic (e.g., gray shale) geologic origin rather than pedogenic. Mottles do not indicate existing redox conditions. Describe redoximorphic features and ped and void surface features (e.g., clay films) separately from mottles. Record **Quantity Class** (in NASIS, estimate **Percent of Horizon Area Covered**), **Size**, **Contrast**, **Color**, and **Moisture State** (D or M). **Shape** is an optional descriptor. A complete example is: *15%, medium, distinct, 7.5YR 7/8, moist, irregular mottles*.

Mottles – Quantity (Percent of Area Covered)—See graphics for "Percent of Area Covered (2 to 20%)" beginning on p. 7–1

Quantity Class	Conv. Code	NASIS Code	Criteria: Percent of Surface Area Covered
few	f	%	< 2%
common	c	%	2 to < 20%
many	m	%	≥ 20%

Mottles – Size—Size refers to dimensions as seen on a plane. If mottle length is less than 3 times the mottle width, record the greater of the two. If length is greater than 3 times width, record the smaller dimension. (See graphic on p. 2–13.)

Size Class	Code	Criteria
fine	1	0.25 to < 2 mm
medium	2	2 to < 5 mm
coarse	3	5 to < 20 mm
very coarse	4	20 to < 76 mm
extremely coarse	5	≥ 76 mm

Mottles – Contrast—Use "Redoximorphic Features – Contrast" criteria and table (p. 2–14).

Mottles – Color—Use standard Munsell notation of hue, value, and chroma (e.g., 5YR 4/4 [for reddish brown]).

Mottles – Moisture State—Record moisture condition of mottle (don't confuse with soil water state) (e.g., moist [M] or dry [D]).

Mottles – Shape (optional)—Use "Concentrations – Shape" table (e.g., irregular).

Mottles – Location (optional)—Use "(Soil) Matrix Color – Location or Condition" table (e.g., interior).

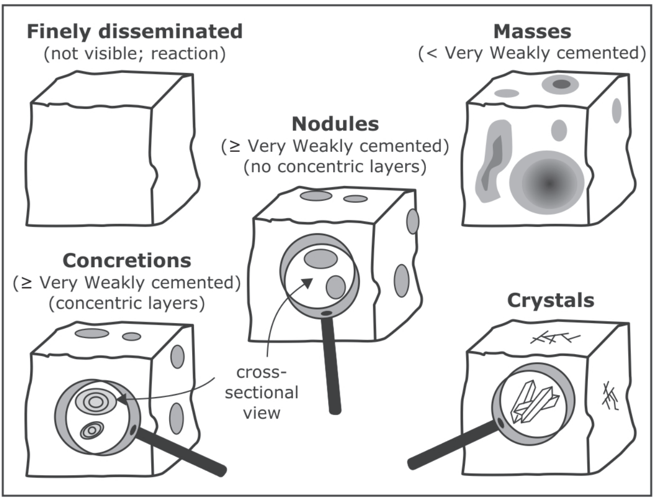
Concentrations (Discussion)

Concentrations are soil features that form by accumulation of material during pedogenesis. Dominant processes involved are chemical dissolution/precipitation; oxidation and reduction; and physical and/or biological removal, transport, and accrual. Types of concentrations (modified from Soil Science Division Staff, 2017) include the following:

1. **Finely disseminated materials** are physically small precipitates (e.g., salts, carbonates) dispersed throughout the matrix of a horizon. The materials cannot be readily seen (10x lens) but can be detected by a chemical reaction (e.g., effervescence of $CaCO_3$ by HCl) or other proxy indicators.
2. **Masses** are noncemented ("Rupture Resistance-Cementation Class" of *extremely weakly cemented* or less) bodies of accumulation of various shapes that cannot be removed as discrete units and do not have a crystal structure that is readily discernible in the field (10x hand lens). These include finely crystalline salts and redox concentrations that do not qualify as nodules or concretions.
3. **Nodules** are cemented (*very weakly cemented* or greater) bodies of various shapes (commonly spherical or tubular) that can be removed as discrete units from soil and don't slake. Crystal structure is not discernible with a 10x hand lens.
4. **Concretions** are cemented bodies (*very weakly cemented* or greater) that don't slake and are similar to nodules except for the presence of visible concentric layers of material around a point, line, or plane. The terms "nodule" and "concretion" are not interchangeable.
5. **Crystals** are macro-crystalline forms of relatively soluble salts (e.g., halite, gypsum, carbonates) that form *in situ* by precipitation from soil solution. The crystalline shape and structure are readily discernible in the field with a 10x hand lens.
6. **Biological concentrations** are discrete bodies accumulated by a biological process (e.g., fecal pellets) or pseudomorphs of biota or biological processes (e.g., insect casts) formed or deposited in soil.
7. **Inherited minerals** are field-observable particles (e.g., mica flakes) or aggregates (e.g., glauconite pellets) that impart distinctive soil characteristics and formed by geologic processes in the original parent material and subsequently inherited by the soil rather than formed or concentrated by pedogenic processes. Included here due to historical conventions; not all concentrations descriptors may apply (e.g., shape, color).

General conventions for documenting various types of concentrations:

Type of Distribution	Documentation	Examples
finely disseminated (discrete bodies not visible)	horizon suffix, concentrations (finely disseminated)	carbonates (none); salts (Bz, Bn)
masses, nodules, concretions, crystals, biological features	redoximorphic features, or concentrations	Mn nodules; Fe concretions; insect casts
continuous cementation	terms in lieu of texture	duripan petrocalcic



Concentrations

Record **Kind**, **Quantity** (percent of area covered), **Size**, **Contrast**, **Color**, **Moisture State**, **Shape**, **Location**, **Hardness**, and **Boundary**.

Concentrations – Kind—Identify the composition and the physical state of the concentration in the soil. ***Note:*** Table subheadings (e.g., masses) are a guide to various physical states of materials. Materials with similar or identical chemical composition may occur in multiple physical states (under several subheadings) (e.g., salt masses and salt crystals).

Concentrations (Nonredox) *(accumulations of material)*			
Kind	**Code**	**Kind**	**Code**
Finely Disseminated *(bodies not visible by unaided eye; detectable by chemical tests; e.g., effervescence)*			
finely disseminated carbonates	FDC	finely disseminated salts	FDS
finely disseminated gypsum	FDG		
Masses *(noncemented; crystals not visible with 10x hand lens)*			
barite masses *($BaSO_4$)*	BAM	gypsum masses *($CaSO_4 \cdot 2H_2O$);* crystals not visible	GYM
carbonate masses *(Ca, Mg, $NaCO_3$)*	CAM	salt masses *(NaCl, Na-Mg sulfates)*	SAM
clay bodies	CBM	silica masses	SIM
gypsum crystal clusters *(nests); very fine crystals*	GNM		
Nodules *(cemented; noncrystalline at 10x, no layers)*			
carbonate nodules [1]	CAN	opal	OPN
durinodes *(SiO_2)*	DNN	ortstein nodules	ORT
gibbsite nodules *(Al_2O_3)*	GBN		
Concretions *(cemented; noncrystalline at 10x, distinct layers)*			
carbonate concretions [1]	CAC	silica concretions	SIC
gibbsite concretions	GBC	titanium oxide concretions	TIC
Crystals *(crystals visible with 10x hand lens or larger)*			
barite crystals *($BaSO_4$)*	BAX	salt crystals *(NaCl, Na-Mg sulfates)*	SAX
calcite crystals *($CaCO_3$)*	CAX	satin spar crystals *($CaSO_4 \cdot 2H_2O$)*	SSC
gypsum crystals *(unspecified; $CaSO_4 \cdot 2H_20$)*	GYX	selenite crystals *($CaSO_4 \cdot 2H_2O$)*	SEC

Concentrations (Nonredox) *(accumulations of material)*			
Kind	**Code**	**Kind**	**Code**
Biological Concentrations *(entities, byproducts, or pseudomorphs)*			
diatoms [2]	DIB	root sheaths	RSB
fecal pellets	FPB	shell fragments *(terrestrial or aquatic)*	SFB
insect casts [3] *(e.g., cicada mold)*	ICB	sponge spicules [2]	SSB
plant phytoliths [2] *(plant opal)*	PPB	worm casts [3]	WCB
Inherited Minerals *(geogenic)* [4]			
glauconite pellets	GLI	volcanic glass	VOG
mica flakes	MIC		
Miscellaneous [5]			
carbonate bands	CBA	carbonate ooliths	CAO
carbonate beds	CBE	carbonate pisoliths	CAP
carbonate laminae	CAL	carbonate root casts	CRC

[1] For example: loess doll (aka “loess kindchen,” “loess puppies,” etc.).

[2] Commonly requires magnification greater than 10x to be observed.

[3] Worm casts are ovoid, fecal pellets excreted by earthworms. Insect casts are cemented (e.g., $CaCO_3$) molds of insect bodies or burrows.

[4] Minerals inherited from parent material rather than formed in soil.

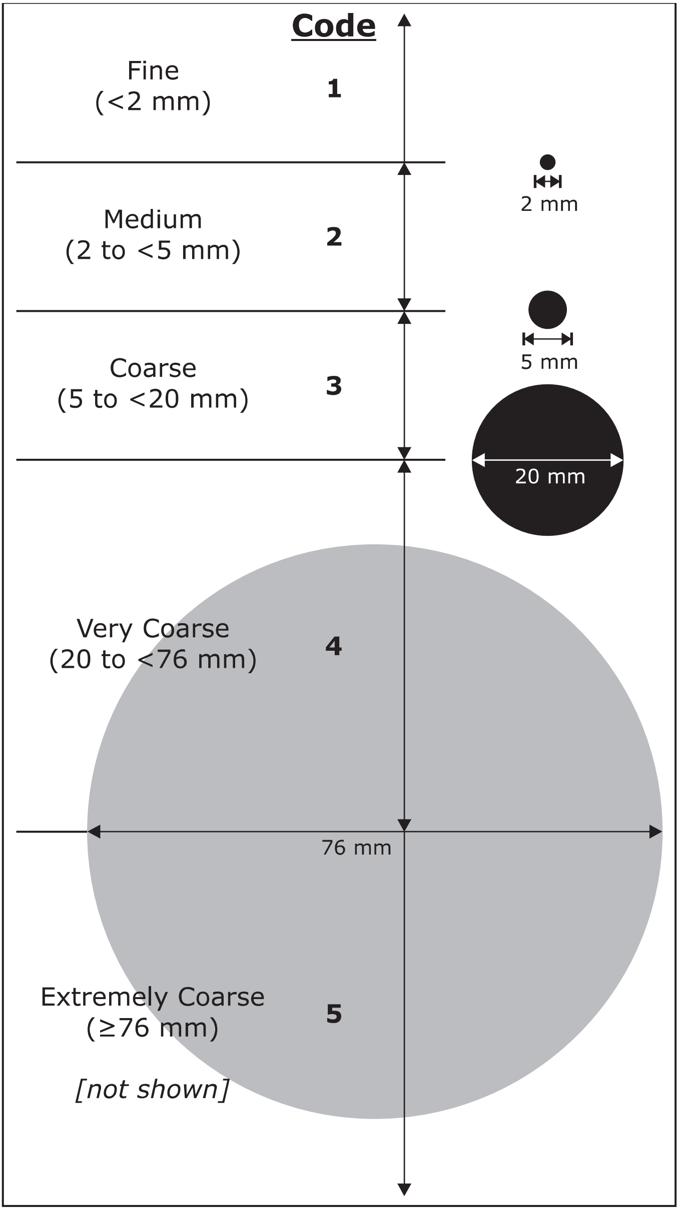
[5] See discussion on carbonate stages (p. 2–27).

Concentrations – Quantity (Percent of Area Covered)—See graphics for **Percent of Area Covered** (2 to 20%) beginning on p. 7–1.

Class	Conv. Code	NASIS Code	Criteria: Percent of Surface Area Covered
few	f	#	< 2
common	c	#	2 to < 20
many	m	#	≥ 20

Concentrations – Size (Same as "RMFs" and "Mottle Size Classes")—See graphic on the next page .

Size Class	Code	Criteria
fine	1	0.25 to < 2 mm
medium	2	2 to < 5 mm
coarse	3	5 to < 20 mm
very coarse	4	20 to < 76 mm
extremely coarse	5	≥ 76 mm


Code
Fine
(<2 mm)
1
Medium
(2 to <5 mm)
2
Coarse
(5 to <20 mm)
3
Very Coarse
(20 to <76 mm)
4
Extremely Coarse
(≥76 mm)
5
[not shown]
2 mm
5 mm
20 mm
76 mm

Concentrations – Contrast—Use “RMF – Contrast” table or chart (e.g., distinct).

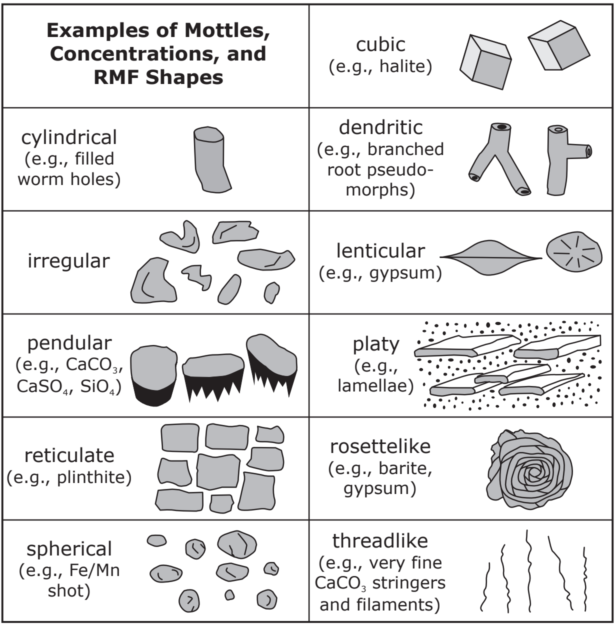
Concentrations – Color—Use standard Munsell notation (e.g., 7.5YR 8/1).

Concentrations – Moisture State—Use “Soil Color – Moisture State” table (i.e., moist [M] or dry [D]).

Concentrations – Shape [1] (also used for **Mottles** and **Redoximorphic Features**)

Shape [1]	Code	Criteria
cubic	CU	crudely equidimensional blocklike units
cylindrical	C	tubular and elongated bodies (e.g., filled wormholes and insect burrows)
dendritic	D	tubular, elongated, and branched bodies (e.g., pipestems [root pseudomorphs])
irregular	I	bodies of nonrepeating spacing or shape
lenticular	L	disk-shaped forms with thicker centers and thinning towards outer edge (e.g., double-convex lens)
pendular	PE	irregular drapes, coatings, or nodules suspended from underside of coarse fragments (e.g., pendular gypsum masses)
platy	P	relatively thin, tabular sheets, lenses (e.g., lamellae)
reticulate	R	crudely interlocking bodies with similar spacing (e.g., plinthite)
rosettelike	RO	interlocking blades radiating out from a central point forming petal-like clusters (e.g., barite)
spherical	S	well-rounded to crudely spherical bodies (e.g., Fe/Mn “shot”)
threadlike	T	thin (e.g., < 1 mm diam.) elongated filaments; generally not dendritic (e.g., very fine $CaCO_3$ stringers)

[1] Shape terms are presented as adjectives due to the typical data string output (e.g., dendritic carbonate concretions).



Concentrations – Location—Describe the location(s) of the concentration (or depletion for RMFs) within the horizon. Historically called "Concentrations – Distribution."

Location	Code
Matrix (in soil matrix; not associated with ped faces or pores)	
in the matrix (not associated with peds/pores)	MAT
in matrix surrounding redox depletions	MAD
in matrix surrounding redox concentrations	MAC
throughout (e.g., finely disseminated carbonates)	TOT
Peds (on or associated with faces of peds)	
between peds	BPF
infused into the matrix along faces of peds (hypocoats)	MPF
on faces of peds (all orientations)	APF
on horizontal faces of peds	HPF
on vertical faces of peds	VPF

Location	Code
Pores (in pores or associated with surfaces along pores)	
infused into the matrix adjacent to pores (hypocoats; see graphic p. 2–33)	MPO
lining pores (see graphic p. 2–33)	LPO
on surfaces along pores	SPO
on surfaces along root channels	RPO
Other	
in cracks	CRK
at top of horizon	TOH
around rock fragments	ARF
on bottom of rock fragments (e.g., pendants)	BRF
on slickensides	SSS
along lamina or strata surfaces	ALS

Concentrations – Hardness—Describe the relative force required to crush the concentration body (use the same criteria and classes as in the **"**Rupture Resistance for Blocks, Peds, and Clods – Cementation**"** column (exclude the *noncemented* class)

Concentrations – Boundary—The gradation between feature and matrix. (Also used to describe **Redoximorphic Features – Boundary**.)

Class	Code	Criteria
sharp	S	color changes in < 0.1 mm between the feature and the soil matrix; change is abrupt even under a 10x hand lens
clear	C	color changes within 0.1 to < 2 mm between the feature and the soil matrix; gradation is visible without 10x lens
diffuse	D	color changes in ≥ 2 mm between the feature and the soil matrix; gradation is easily visible without 10x hand lens

Pedogenic Carbonate Development: In arid, semiarid, and subhumid environments, pedogenic carbonate accumulation is of overarching and unifying importance. The present morphological concepts and intellectual basis for soil-carbonate horizons and stages that follow originate from the seminal contributions of Leland Gile (Gile, 1961, 1970, 1975, 1993; Gile and Grossman, 1968; Gile and Grossman, 1979; Gile et al., 1966; Gile et al., 2007).

Calcium carbonate ($CaCO_3$) mediates or controls key chemical and physical soil properties (e.g., pH, nutrient availability, dispersion-flocculation, organic matter stabilization). Calcium carbonate in soil may be inherited from parent material and/or may accumulate via pedogenic processes. Climate (precipitation, temperature, evapotranspiration), carbonate solubility, and microbial biomineralization control and constrain the rate and quantity of pedogenic carbonate accumulation. Major carbonate accumulation occurs mainly in subhumid to arid regions (precipitation ~< 750mm/annum). Pedogenic carbonate formation requires a Ca source, such as mineral weathering, concentration by soil or ground water evaporation, and/or input via dust and/or precipitation. The carbonate (CO_3^{-2}) source is plant and microbial respiration (CO_2) via the CO_2-HCO_3^{-1}-CO_3^{-2} equilibria. Beyond the major climatic control, pedogenic carbonate accumulation depends on a balance among geomorphic age or landscape stability, soil water movement (at both profile and landscape scales), soil texture, and vegetation type and quantity.

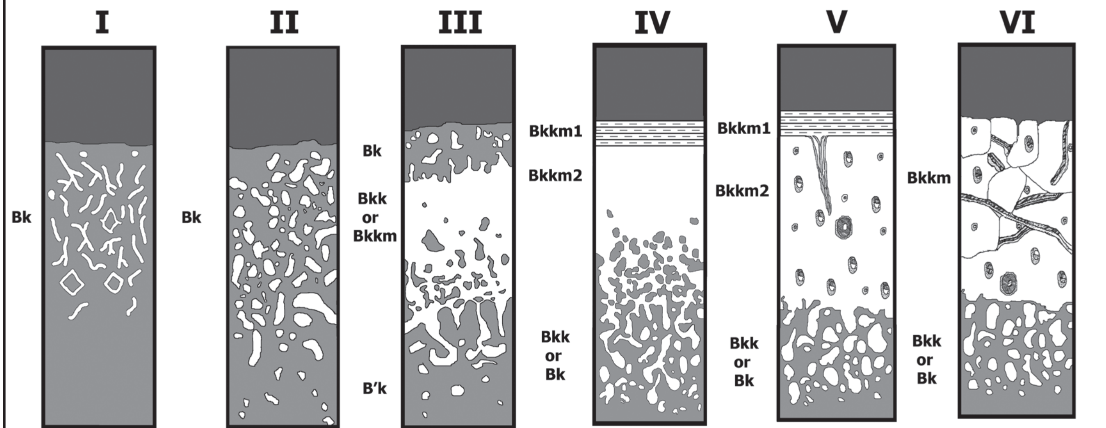
Pedogenic carbonate accumulation follows a morphogenetic development sequence starting as horizon features, such as carbonate coatings, masses, and fine nodules. If carbonate continues to accumulate, it may entirely engulf, plug, and cement soil horizons. Carbonate-cemented soil horizons are generically termed caliche or calcrete and are recognized in soil taxonomy as petrocalcic horizons. Pedogenic carbonate accumulation is closely linked to soil age (Gile et al., 1981; Machette, 1985). Soils on progressively older geomorphic surfaces contain sequentially more pedogenic carbonate. The progression of carbonate development and morphology has been defined as Stages I through VI (see figures A and B) (Gile et al., 1966; Gile et al., 1981; Brock, 2007; Machete, 1985; Bachman and Machette, 1977).

Pedogenic carbonate stage morphology and expression are initially different for a fine-earth matrix (fig. A; e.g., lacustrine, distal fan deposits, eolian deposits) than for a coarse fragment matrix (fig. B; e.g., proximal alluvial fan deposits, channel deposits) (Gile et al., 1966; Flach et al., 1969; Gile et al., 1981). The time required for carbonate stage development depends on soil texture and its control on porosity. A fine-grained soil has greater surface area and total porosity that requires a correspondingly greater carbonate quantity to fill voids and form equivalent carbonate stages compared to a coarse-textured soil (Gile, 1993; Gile et al., 1981). Thus, it takes more time for a fine-grained soil to reach the same carbonate stage as a coarse-textured soil under the same conditions.

Multiple Carbonate Stages: Pedogenic carbonates (especially Stages IV through VI) are durable and persistent in arid environments. If different sedimentation events and subsequent pedogenesis (separated by time) occur to produce a stacked soil sequence (paleosols), a pedon may contain multiple carbonate stages. Each soil sequence (sediment package) is evaluated independently, and a carbonate stage is attached to horizons in that sequence. For example, Stage II carbonate may occur in a soil overlying a buried soil with Stage IV carbonate (e.g., A, 0–12 cm; Bt, 12–22 cm; Bk [Stage II $CaCO_3$ nodules], 22–65cm; 2Bkkm1 [Stage IV [$CaCO_3$], 65–150 cm; 2Bkkm2 [Stage IV $CaCO_3$], 150–260 cm). Moreover, on stable geomorphic surfaces, climatic shifts may superpose younger carbonate forms into preexisting, more advanced stages within the same soil. For example, carbonate nodules may occur above and into a stage IV Bkkm (e.g., A, 0–11 cm; Bt, 11–22 cm; Bk [$CaCO_3$ nodules], 22–65 cm; Bkkm [Stage IV $CaCO_3$], 65–150 cm; 2Bkkm [Stage IV $CaCO_3$], 150–260 cm). Despite the more recent nodules, this soil is Stage IV in the morphogenetic sequence.

Pedogenic Carbonate Stage Description: Evaluate and record the **Pedogenic Carbonate Stage** by pedon. More than one $CaCO_3$ stage may exist in a pedon as a result of multiple sediment layers or shifting climate conditions (see discussion). Pedogenic carbonates are described under both “Concentrations” and “Ped and Void Surface Features.” In arid and semiarid regions, a pedogenic carbonate stage is commonly based upon the overall carbonate morphology in relation to texture and coarse fragment content (see figures A and B). The “stage” is recorded as an interpretive text note following the conventional carbonate concentration description (e.g., 100–165 cm, 2Bkkm [massive indurated $CaCO_3$], Stage IV). Assigning a $CaCO_3$ stage is an interpretive complement to, but not a replacement for, conventional soil horizonation.

Figure A - Pedogenic Carbonate Development Stages - Fine Earth Matrix



I: Carbonate occurs as few to common fine masses, threads, and/or patchy coatings in B horizon. Carbonate may also exist in A C horizons.

II: Carbonate occurs as common or many, fine to very coarse nodules, concretions, masses, and/or discontinuous coatings in B horizon.

III: Carbonate engulfs and plugs majority of the B horizon. (≥ 50% vol. K-fabric). B horizon may be cemented. Many concretions, nodules, and masses below plugged horizon.

IV: Fine carbonate laminae at top of cemented and plugged horizon. Common to many masses, nodules and concretions may occur below plugged horizon.

V: Carbonate plugs and cements the B horizon. Top of cemented horizon has > 1 cm thick laminae. Some vertical fractures may be laminae lined. Pisoliths commonly occur.

VI: Carbonate plugs and cements the B horizon. Multiple generations of recemented breccia and laminae are present. Pisoliths commonly occur.

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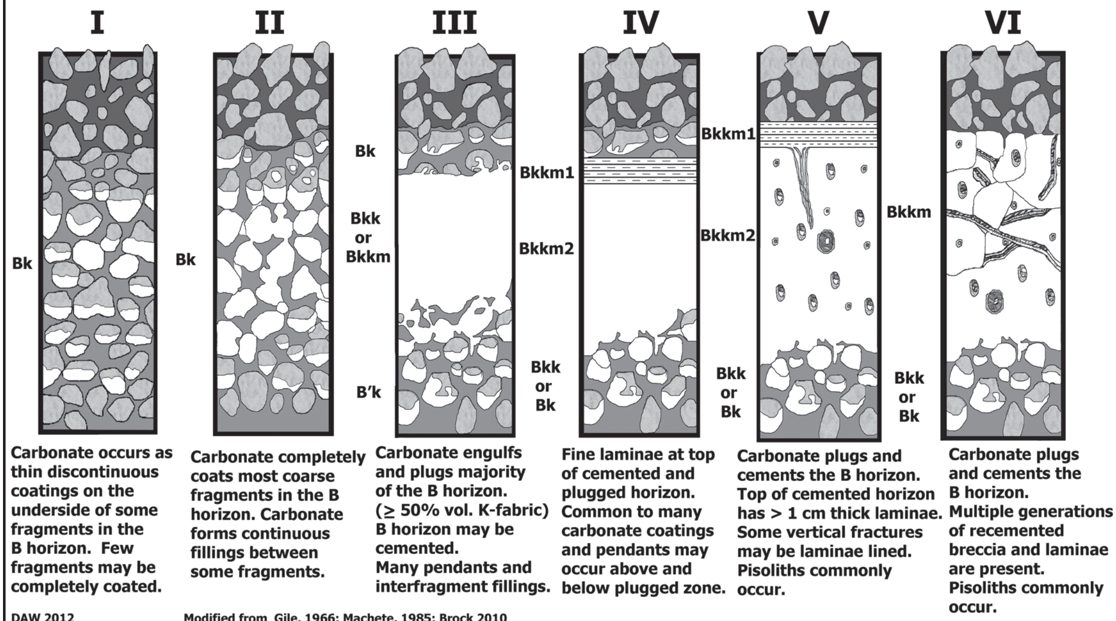
Modified from Gile, 1966; Machete, 1985; Brock 2010

Figure B - Pedogenic Carbonate Development Stages - Coarse Fragment Matrix



Ped and Void Surface Features

These features are coats and films, hypocoats, or stress features formed by translocation and deposition or by shrink-swell processes on or along surfaces. Describe **Kind**, **Amount Class** (percent in NASIS), **Distinctness**, **Location**, and **Color** (dry or moist).

Ped and Void Surface Features – Kind (nonredoximorphic)

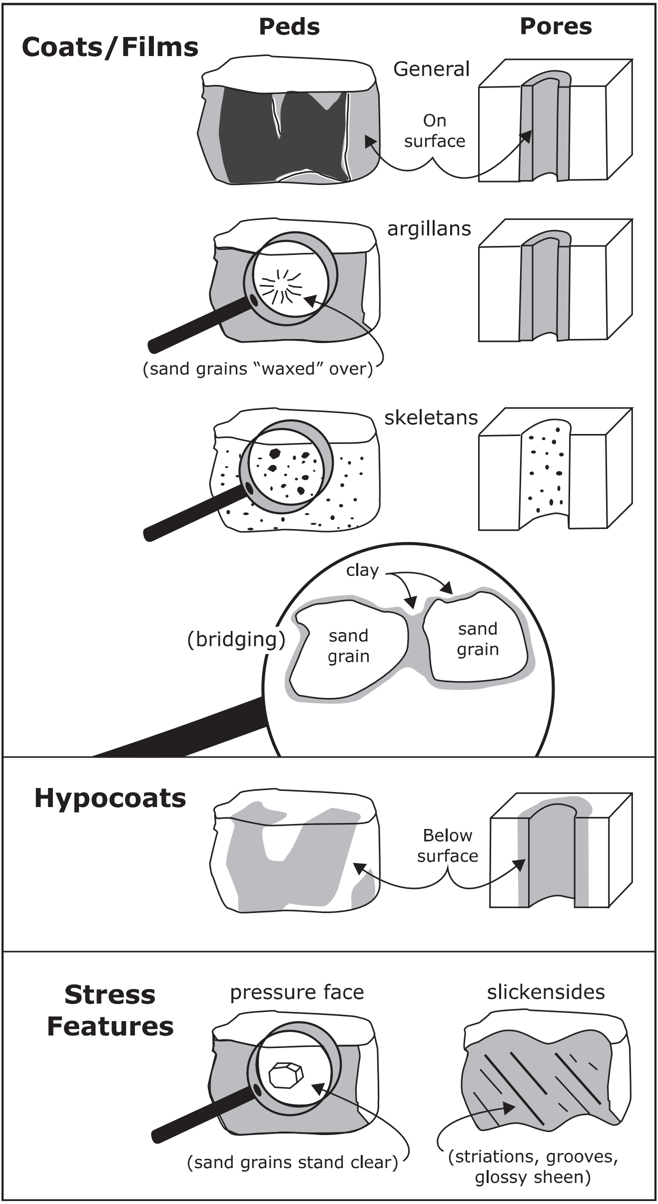
Kind	Code	Field Criteria
Coats, Films (exterior, adhered to surface)		
carbonate coats	CAF	off-white, effervescent with HCl
silica *(silans, opal)*	SIF	off-white, noneffervesent with HCl
clay films *(argillans)*	CLF	waxy, exterior coats
clay bridges	BRF	“wax” between sand grains
ferriargillans *described as RMF-Kind*	*see RMFs*	Fe^{+3} stained clay film
gibbsite coats *(sesquan)*	GBF	$AlOH_3$, off-white, noneffervescent with HCl
gypsum coats	GYF	$CaSO_4 \cdot 2H_2O$
manganese *(mangans) described as RMF-Kind*	*see RMFs*	black, thin films effervescent with H_2O_2
organic stains	OSF	dark organic films
organoargillans	OAF	dark, organic stained clay films
sand coats	SNF	separate grains visible with 10x
silt coats [1]	SLF	separate grains not visible at 10x
skeletans [2] (sand or silt)	SKF	clean sand or silt grains as coats

Kind	Code	Field Criteria
Hypocoats [3] (a stain infused beneath a surface)		
Stress Features (a smeared exterior face)		
pressure faces (i.e., stress cutans)	PRF	look like clay films; sand grains uncoated
slickensides (pedogenic)	SS	shrink-swell shear features (e.g., grooves, striations, glossy surface) on pedo-structure surfaces (e.g., wedges, bowls); can be horizontal
slickensides (geogenic)	SSG	vertical/oblique, roughly planar shear face from external stress (e.g., faults; mass movement); striations, grooves

[1] Individual silt grains are not discernible with a 10x lens. Silt coats occur as a fine, off-white, noneffervescent, “grainy” coat on ped surfaces.

[2] Skeletans are (pigment) stripped grains >2 µm and <2 mm (Brewer, 1976). Preferably describe either *silt coats* (grains not discernible with 10x lens) or *sand coats* (grains discernible with 10x lens).

[3] Hypocoats, as used here, are field-scale features commonly expressed only as redoximorphic features. Micromorphological hypocoats include nonredoximorphic features (Bullock et al., 1985).


Coats/Films
Peds
Pores
General
On surface
argillans
(sand grains "waxed" over)
skeletans
clay
(bridging)
sand grain
sand grain
Hypocoats
Below surface
Stress Features
pressure face
slickensides
(sand grains stand clear)
(striations, grooves, glossy sheen)

Ped and Void Surface Features – Amount—Estimate the relative percent of the visible surface area that a ped surface feature occupies in a horizon. (See graphics for **Percent of Area Covered** [5, 25, 50, 90%] beginning on page 7–1.) In NASIS, record the estimate as a numeric percent (e.g., 20%).

Amount Class	Conv. Code	NASIS Code	Criteria: Percent of Surface Area Covered
very few	vf	%	< 5
few	f	%	5 to < 25
common	c	%	25 to < 50
many	m	%	50 to < 90
very many	vm	%	≥ 90

Ped and Void Surface Features – Distinctness—The relative extent to which a ped surface feature visually stands out from adjacent material.

Distinctness Class	Code	Criteria
faint	F	visible only with magnification (10x hand lens); little contrast between materials
distinct	D	visible without magnification; significant contrast between materials
prominent	P	markedly visible without magnification; sharp visual contrast between materials

Ped and Void Surface Features – Location—Specify where ped surface features occur within a horizon (e.g., between sand grains).

Location	Code
Peds	
on all faces of peds (vertical and horizontal)	PF
on bottom faces of peds	BF
on top faces of peds	TF
on tops of soil columns	TC
on vertical faces of peds	VF

Location	Code
Other (Nonped)	
between sand grains (bridging)	BG
on bedrock	BK
on bottom surfaces of rock fragments	BR
on concretions	CC
on nodules	NO
on rock fragments	RF
on slickensides	SS
on surfaces along pores	SP
on surfaces along root channels	SC
on top surfaces of rock fragments	TR

Ped and Void Surface Features – Color—Use standard Munsell notation (hue, value, chroma) to record feature color. Indicate whether the color is moist (M) or dry (D) (e.g., 7.5R 5/8 M).

Soil Texture

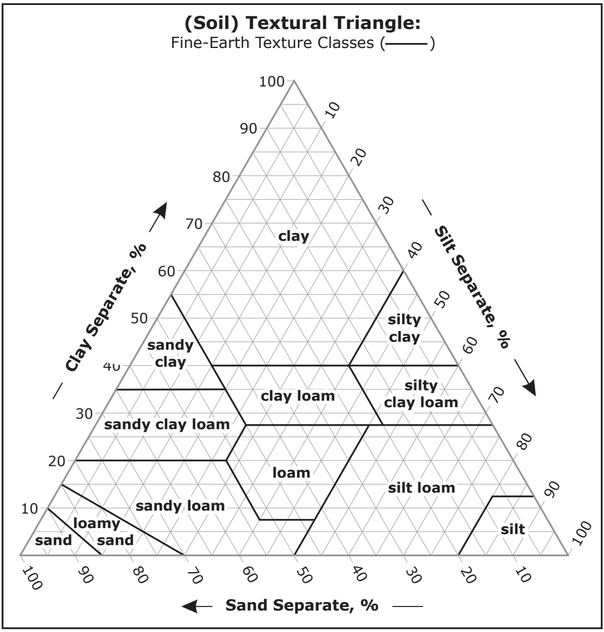
Soil texture is the numerical proportion (weight percentage) of the sand, silt, and clay separates in the fine-earth fraction (< 2 mm). Soil texture is field estimated by hand or lab measured by hydrometer or pipette and placed within the textural triangle to obtain **Texture Class**.

Record the **Texture Class** (e.g., loam) or **Subclass** (e.g., fine sandy loam), or choose a **Term in Lieu of Texture** (e.g., gravel). If appropriate, use a **Texture Class Modifier** (e.g., gravelly loam).

Note: **Soil Texture** includes only the fine-earth fraction (< 2 mm). “Whole-soil Particle-Size Distribution” includes the fine-earth fraction (< 2 mm, wt %) *and* coarse fragments (≥ 2 mm). For fragment 76 mm or more in diameter, visually estimate the volume percent, which is then converted to a weight basis using the estimated particle density (Dp) and bulk density (Db).

Texture Class—

Texture Class or Subclass	Conv Code.	NASIS Code
coarse sand	cos	COS
sand	s	S
fine sand	fs	FS
very fine sand	vfs	VFS
loamy coarse sand	lcos	LCOS
loamy sand	ls	LS
loamy fine sand	lfs	LFS
loamy very fine sand	lvfs	LVFS
coarse sandy loam	cosl	COSL
sandy loam	sl	SL
fine sandy loam	fsl	FSL
very fine sandy loam	vfsl	VFSL
loam	l	L
silt loam	sil	SIL
silt	si	SI
sandy clay loam	scl	SCL
clay loam	cl	CL
silty clay loam	sicl	SICL
sandy clay	sc	SC
silty clay	sic	SIC
clay	c	C



Texture Modifiers—Conventions for using "Rock Fragment Texture Modifiers" and for using textural adjectives that convey the "Percent Volume" ranges for **Rock Fragments – Quantity and Size**.

Frag. Content Vol. %	Rock Fragment Modifier Usage
< 15	No texture class modifier (noun only; e.g., loam).
15 to < 35	Use fragment-size adjective with texture class (e.g., gravelly loam).
35 to < 60	Use "very" with fragment-size adjective with texture class (e.g., very gravelly loam).
60 to < 90	Use "extremely" with fragment-size adjective with texture class (e.g., extremely gravelly loam).
≥ 90	No adjective or modifier. If ≤ 10% fine earth, use the appropriate fragment-size class name for the dominant size class (e.g., gravel). Use "Terms Used in Lieu of Texture" (see table on p. 2–41).

Texture Modifiers – Quantity and Size (adjectives)—

Rock Fragments: Quantity and Size [1]	Conv. Code	NASIS Code	Criteria: Total (Rock) Fragment Volume % Dominated By (*Name Size*) [1]
Rock Fragments (> 2 mm; ≥ Strongly Cemented)			
gravelly	GR	GR	≥ 15% but < 35% gravel
fine gravelly	FGR	GRF	≥ 15% but < 35% fine gravel
medium gravelly	MGR	GRM	≥ 15% but < 35% med. gravel
coarse gravelly	CGR	GRC	≥ 15% but < 35% coarse gravel
very gravelly	VGR	GRV	≥ 35% but < 60% gravel
extremely gravelly	XGR	GRX	≥ 60% but < 90% gravel
cobbly	CB	CB	≥15% but < 35% cobbles
very cobbly	VCB	CBV	≥ 35% but < 60% cobbles
extremely cobbly	XCB	CBX	≥ 60% but < 90% cobbles
stony	ST	ST	≥ 15% but < 35% stones
very stony	VST	STV	≥ 35% but < 60% stones
extremely stony	XST	STX	≥ 60% but < 90% stones
bouldery	BY	BY	≥ 15% but < 35% boulders
extremely bouldery	XBY	BYX	≥ 35% but < 60% boulders
channery	CN	CN	≥ 15% but < 35% channers
very channery	VCN	CNV	≥ 35% but < 60% channers
extremely channery	XCN	CNX	≥ 60% but < 90% channers
flaggy	FL	FL	≥ 15% but < 35% flagstones
very flaggy	VFL	FLV	≥ 35% but < 60% flagstones
extremely flaggy	XFL	FLX	≥ 60% but < 90% flagstones
Pararock Fragments (> 2 mm; < Strongly Cemented) [2, 3]			
paragravelly	PGR	PGR	(same criteria as for gravelly)
very paragravelly	VPGR	PGRV	(same criteria as for very gravelly)
extr. paragravelly	XPGR	PGRX	(same criteria as for extr. gravelly)
etc.	etc.	etc.	(same criteria as for nonpara)
Dual Rock Fragment – Artifact Modifiers (Cohesive and Persistent Artifacts) [4]			
gravelly – artifactual	GRART	GRART	(same criteria as for gravelly)
very gravelly – artifactual	VGRART	GRVART	(same criteria as for very gravelly)
extremely gravelly – artifactual	XGRART	GRXART	(same criteria as for extr. gravelly)
etc.	etc.	etc.	(same criteria as for noncomposite)

[1] The “Quantity” modifier (e.g., very) is the volume percent whole soil of the total rock fragment content. The “Size” modifier (e.g., cobbly) is independently based on the largest, dominant fragment size. (See “Comparison of Particle Size Classes” table; p. 2–45, first row.) For a size mixture (e.g., gravel and stones), a smaller size class is named if its quantity (percent) sufficiently exceeds that of a larger size class. For field texture determination, a smaller rock fragment size class must exceed either 1.5 or 2 times the quantity (volume %) of a larger size class before it is named (e.g., 30% gravel and 14% stones is very gravelly, but 20% gravel and 14% stones is stony). For detailed naming criteria, see the “National Soil Survey Handbook,” Part 618, Subpart B, Exhibits, “Rock Fragment Modifier of Texture” (Soil Survey Staff, 2024).

[2] Use “para” prefix if the rock fragments are soft (i.e., meet criteria for “para”). (“Rupture Resistance – Cementation Class” is < strongly coherent, and fragments do not slake [slake test: ≈3 cm (1 inch) diam. block, air dried, then submerged in water for 1 hour or more; collapse/disaggregation=“slaking”].)

[3] For “para” codes, add “P” to “Size” and “Quantity” code terms. Precedes noun codes and follows quantity adjectives (e.g., paragravelly if PGR; very paragravelly is PGRV).

[4] Used if a horizon contains both rock fragments and cohesive and persistent artifacts 2 mm or more whose combined percent by volume is 15% or more; use appropriate “Quantity Class” (the dominant size fraction is named) (e.g., CBART for cobbly-artifactual; VSTART for very stony-artifactual).

Texture Modifiers – Soils with Artifacts [1]—Artifact Quantity adjectives (e.g., artifactual loam).

Artifacts: Quantity	Code	Criteria
Anthropogenic Materials		
artifactual	ART	≥ 15% but < 35% (vol.) artifacts
very artifactual	ARTV	≥ 35% but < 60% (vol.) artifacts
extremely artifactual[2]	ARTX	≥ 60% but < 90% (vol.) artifacts

[1] If a combination of artifacts and fragments are present and the combined volume of artifacts that are both cohesive and persistent and any rock fragments present is less than 15 percent

[2] If artifact fragments are more than 90% (by vol.), no texture is described and a “Term Used in Lieu of Texture” is applied (i.e., artifacts).

Texture Modifiers – Compositional[1]—Compositional adjectives.

Types	Code	Criteria
Volcanic		
ashy	ASHY	andic soil properties, and is neither hydrous nor medial, or ≥ 30% of the < 2 mm fraction is 0.02 to 2.00 mm in size, ≥ 5% is volcanic glass, and the [Al + 1/2 Fe, % by ammonium oxalate) x 60] + % volc glass is ≥ 30
hydrous	HYDR	andic soil properties, and with field moist 15 bar water content ≥ 100% of the dry weight
medial	MEDL	andic soil properties, and with field moist 15 bar water content ≥ 30% to < 100% of the dry weight, or ≥ 12% water content for air-dried samples
Organic Soil Materials		
grassy [2]	GS	OM > 15% (vol.) grassy fibers
herbaceous [2]	HB	OM > 15% (vol.) herbaceous fibers
mossy [2]	MS	OM > 15% (vol.) moss fibers
woody [2]	WD	OM ≥ 15% (vol.) wood pieces or fibers
Highly Organic Mineral Materials		
highly organic [3]	HO	organic carbon (wt %) is 5 to < 12%
mucky [4]	MK	mineral soil > 10% OM and < 17% fibers
peaty [4]	PT	mineral soil > 10% OM and > 17% fibers
Limnic Materials (used only with Histosols)		
coprogenous	COP	limnic layer with many very small fecal pellets
diatomaceous	DIA	limnic layer composed of diatoms
marly	MR	light-colored limnic layer composed of $CaCO_3$ mud
Other		
cemented	CEM	material is “cemented” by ≥ 1 cementing agents; does not slake
gypsiferous	GYP	≥ 15 to < 40% (by weight) gypsum
permanently frozen	PF	e.g., permafrost

[1] “Texture Modifiers – Compositional” can be used with the “Soil Texture Name” (e.g., gravelly ashy loam) or with “Texture Modifiers – Terms Used in Lieu of Texture” (e.g., mossy peat). For complete definitions and usage of compositional texture modifiers,” see the “National Soil Survey Handbook,” Part 618.72 (Soil Survey Staff, 2024).

[2] Used to modify muck, mucky peat, or peat terms in histic epipedons and organic horizons (of any thickness) that are saturated with water for 30 or more consecutive days in normal years (or are artificially drained), including those in Histels and Histosols (except Folists).

[3] Used only with near-surface horizons of mineral soils saturated < 30 cumulative days in normal years (and *not* artificially drained).

[4] Designed for near-surface horizons saturated 30 or more cumulative days annually.

Texture Modifiers – Terms Used in Lieu of Texture—Nouns (used only if fragments or artifacts are more than 90% by volume). Bedrock, organic terms, gypsum materials, and permanent water have different criteria.

Terms Used in Lieu of Texture	Code
Size (Rock Fragments) ≥ Strongly Cemented	
gravel	GR
cobbles	CB
stones	ST
boulders	BY
channers	CN
flagstones	FL
Size (Pararock Fragments) < Strongly Cemented	
paragravel	PG
paracobbles	PCB
parastones	PST
paraboulders	PBY
parachanners	PCN
paraflagstones	PFL
Composition	
Cemented/Consolidated:	
bedrock	BR
Organic Soil Materials:	
highly decomposed plant material (Oa) [1]	HPM
moderately decomposed plant material (Oe) [1]	MPM
slightly decomposed plant material (Oi) [1]	SPM

Terms Used in Lieu of Texture	Code
muck [2] (≈Oa)	MUCK
mucky peat [2] (≈Oe; saturated, moderately decomposed organic matter)	MPT
peat [2] (≈Oi)	PEAT
Other:	
artifacts [3] (human-manufactured materials)	ART
coarse gypsum material	CGM
fine gypsum material	FGM
ice [4, 5] (permanent, subsurface)	ICE
water [5] (permanent, subsurface)	W

[1] Use only with organic horizons of mineral and organic soils that are saturated < 30 cumulative days in normal years (and are *not* artificially drained).

[2] Use only with organic horizons (of any thickness) of mineral and organic soils that are saturated ≥ 30 cumulative days in normal years or are artificially drained.

[3] "Artifacts" is used only to denote the presence of manufactured materials associated with human activities (e.g., bitumen, bricks, construction debris, garbage, etc.).

[4] Use only for layers found below the soil surface (e.g., a floating bog).

[5] Used for permanent (nonseasonal), massive, subsurface ice (e.g., a glacic layer).

Von Post Humification Scale—The Von Post Humification Scale is a field test to determine the degree of decomposition of organic soil materials in O horizons. The scale can be utilized in conjunction with the rubbed / unrubbed fiber field test to determine the appropriate field determination of suffix symbols (e.g., Oa, Oe, or Oi). The table below is from the "Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region" (U.S. Army Corps of Engineers, 2012).

Degree of Humification	Nature of Material Extruded upon Squeezing	Nature of Plant Structure in Residue	Horizon Descriptor	Soil Texture
H1	clear, colorless water; no organic solids squeezed out	unaltered, fibrous, undecomposed	fibric	peat
H2	yellowish water; no organic solids squeezed out	almost unaltered, fibrous		
H3	brown, turbid water; no organic solids squeezed out	easily identifiable		
H4	dark brown, turbid water; no organic solids squeezed out	visibly altered but identifiable	hemic	mucky peat
H5	turbid water; some organic solids squeezed out	recognizable but vague; difficult to identify		
H6	turbid water; 1/3 of sample squeezed out	indistinct, pasty		

Degree of Humification	Nature of Material Extruded upon Squeezing	Nature of Plant Structure in Residue	Horizon Descriptor	Soil Texture
H7	very turbid water; 1/2 of sample squeezed out	faintly recognizable; few remains identifiable, mostly amorphous	sapric	muck
H8	thick and pasty; 2/3 of sample squeezed out	very indistinct		
H9	no free water; nearly all of sample squeezed out	no identifiable remains		
H10	no free water; all of sample squeezed out	completely amorphous		

Comparison of Particle Size Classes in Different Systems

	FINE EARTH										ROCK FRAGMENTS					
											channers			flagst	stones	boulders
USDA[1]	Clay[2]		Silt		Sand					Gravel			Cob-bles	Stones	Boulders
	fine	co.	fine	co.	v.fi.	fi.	med.	co.	v. co.	fine	medium	coarse			

Rock fragments limits: 6" 150; 15" 380; 24" 600 mm

millimeters: 0.0002 .002 mm .02 .05 .1 .25 .5 1 2 mm 5 20 76 250 mm 600 mm

U.S. Standard Sieve No. *(opening)*: 300 [3] 140 60 35 18 10 4 *(3/4")* *(3")* *(10")* *(25")*

Inter-national[4]	Clay	Silt	Sand		Gravel	Stones
			fine	coarse		

millimeters: .002 mm .02 .20 2 mm 20 mm

U.S. Standard Sieve No. *(opening)*: 10 *(3/4")*

Unified[5]	Silt or Clay	Sand			Gravel		Cobbles	Boulders
		fine	medium	co.	fine	coarse		

millimeters: .074 .42 2 mm 4.8 19 76 300 mm

U.S. Standard Sieve No. *(opening)*: 200 40 10 4 *(3/4")* *(3")*

AASHTO[6, 7]	Clay	Silt	Sand		Gravel or Stones			Broken Rock (angular), or Boulders (rounded)
			fine	coarse	fine	med.	co.	

millimeters: .005 mm .074 .42 2 mm 9.5 25 75 mm

U.S. Standard Sieve No. *(opening)*: 200 40 10 *(3/8")* *(1")* *(3")*

phi #: 12 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -12

Modified Wentworth[8]: clay | silt | sand | pebbles | cobbles | boulders

millimeters: .00025 .002 .004 .008 .016 .031 .062 .125 .25 .5 1 2 4 8 16 32 64 128 256 4092 mm

U.S. Standard Sieve No.: 230 120 60 35 18 10 5

[1] Soil Survey Staff, 2011; p. 489.

[2] Soil Survey Staff, 2011; p. 33. Note: Mineralogy studies may subdivide clay into three size ranges: fine (< 0.08 μm), medium (0.08–0.2 μm), and coarse (0.2–2 μm) (Jackson, 1969).

[3] The Kellogg Soil Survey Laboratory (Lincoln, NE) uses a no. 300 sieve (0.047-mm opening) for the USDA sand/silt measurement. A no. 270 sieve (0.053-mm opening) is more readily available and widely used.

[4] Soil Survey Staff, 1951; p. 207.

[5] ASTM, 2011; ASTM designation D2487–92.

[6] AASHTO, 1997a.

[7] AASHTO, 1997b.

[8] Ingram, 1982.

Rock and Other Fragments

These are discrete, water-stable particles ≥ 2 mm. Hard fragments (e.g., rock) have a "Rupture Resistance – Cementation Class" ≥ *strongly cemented*. Softer fragments (e.g., pararock) are less strongly cemented. ***Note:*** Artifacts are addressed separately following this section (p. 2–50). Describe **Kind**, **Volume Percent** (classes given below), **Roundness or Shape**, **Size** (mm), and **Hardness**; e.g., granite, 17%, subangular, gravel, indurated; or GRA, 17%, SA, GR, I.

Rock and Other Fragments – Kind (called **Fragments** in NASIS)—Use the choice list given for "Bedrock – Kind" and the additional choices in the table below. ***Note:*** Interbedded rocks from the "Bedrock – Kind" table are not appropriate choices or terminology for rock fragments.

Kind	Code	Kind	Code
Includes all choices in "Bedrock – Kind" (except interbedded), plus:			
calcrete (caliche) fragments [1]	CA	metamorphic rock fragments, unspecified [2]	MMR
carbonate concretions	CAC	mixed rock fragments [3]	MXR
carbonate nodules	CAN	ortstein fragments	ORF
carbonate rocks [2]	CAR	petrocalcic fragments	PEF
charcoal fragments	CH	petroferric fragments	TCF

Kind	Code	Kind	Code
cinders	CI	petrogypsic fragments	PGF
durinodes	DNN	plinthite nodules	PLN
duripan fragments	DUF	quartz fragments	QUA
foliated metamorphic rocks [2]	FMR	quartzite fragments	QZT
gibbsite concretions	GBC	scoria fragments	SCO
gibbsite nodules	GBN	sedimentary rock fragments, unspecified [2]	SED
igneous rock fragments, unspecified [2]	IGR	shell fragments	SHF
iron-manganese concretions	FMC	silica concretions	SIC
iron-manganese nodules	FMN	volcanic bombs	VB
ironstone nodules	FSN	volcanic rock fragments, unspecified [2]	VOL
lapilli	LA	wood fragments	WO

[1] Fragments strongly cemented by carbonate; may include fragments derived from petrocalcic horizons.

[2] Generic rock names may be appropriate for identifying fragments (e.g., a cobble) but are too general and should *not* be used to name "Bedrock – Kind."

[3] Numerous unspecified fragment lithologies are present, as in till or alluvium; not for use with residuum.

Rock and Other Fragments – Volume Percent (Quantity)—Estimate the quantity (volume percent) of rock and other fragments present. ***Note:*** Refer to the "Total (rock) fragment volume percent" column found under the "Texture Modifiers – Quantity and Size" table (p. 2–38).

Rock and Other Fragments – Size Classes and Descriptive Terms

Size [1]	Noun	Adjective [2]
Shape—Spherical or Cubelike (discoidal, subdiscoidal, or spherical)		
2 – 75 mm diam.	gravel	gravelly
2 – 5 mm diam.	fine gravel	fine gravelly
> 5 – 20 mm diam.	medium gravel	medium gravelly
> 20 – 75 mm diam.	coarse gravel	coarse gravelly
> 75 – 250 mm diam.	cobbles	cobbly
> 250 – 600 mm diam.	stones	stony
> 600 mm diam.	boulders	bouldery
Shape—Flat (prismoidal or subprismoidal)		
2 – 150 mm long	channers	channery
> 150 – 380 mm long	flagstones	flaggy
> 380 – 600 mm long	stones	stony
> 600 mm long	boulders	bouldery

[1] Fragment sizes measured by sieves; rotate particles by hand, if necessary, to determine whether they will pass through a particular opening; however, do not force particles to pass through an opening. Class limits have a greater lower limit.

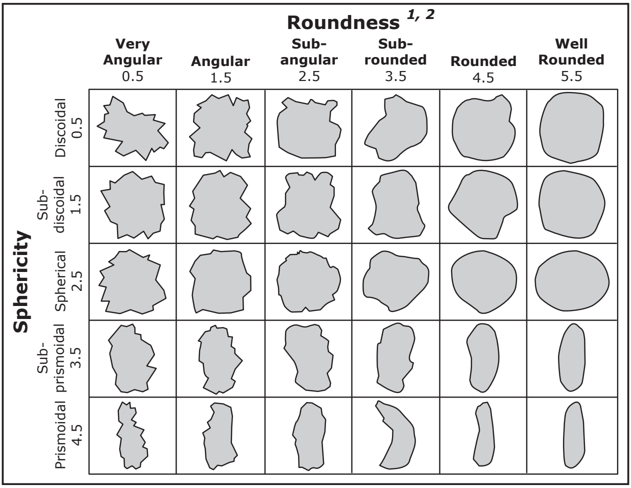
[2] For a mixture of sizes (e.g., both gravel and stones present), the largest size class (most mechanically restrictive) is named. A smaller size class is named only if its quantity (%) sufficiently exceeds that of a larger size class. For field texture determination, a smaller size class must exceed 2 times the quantity (volume %) of a larger size class before it is named (e.g., 30% gravel and 14% stones is *very gravelly*; but 20% gravel and 14% stones is *stony*). For more explicit naming criteria, see the “National Soil Survey Handbook,” Part 618, Subpart B, Exhibits, “Rock Fragment Modifier of Texture” (Soil Survey Staff, 2024).

Rock and Other Fragments – Roundness—Estimate the relative roundness of rock fragments; use the following classes.

Roundness Class	Code	Criteria: Visual Estimate [1]
very angular	VA	(Use “Roundness” graphic below)
angular	AN	
subangular	SA	
subrounded	SR	
rounded	RO	
well rounded	WR	

[1] The criteria consist of a visual estimation; use the following graphic.

Estimate the relative roundness of rock fragments. (Ideally, use the average roundness of 50 or more fragments.) The conventional geologic and engineering approach is presented in the following graphic. ***Note:*** NRCS does *not* quantify “Sphericity.” It is included here for completeness and to show the fragment **“**Roundness” range.



[1] After Powers, 1953.

[2] Numerical values below “Roundness” and “Sphericity” headings are class midpoints (median rho values; Folk, 1955) used in statistical analysis.

Rock and Other Fragments – Hardness (called **Fragment_hardness** in NASIS)—Describe the relative force required to crush the fragment. Use the same criteria and classes as the “Rupture Resistance for Blocks, Peds, and Clods – Coherence” column (p. 2–64) (e.g., moderately coherent).

Artifacts (Human-Derived)

These are discrete, water-stable fragments of human origin (cultural byproducts) (called **Human_artifacts** in NASIS). They are described separately from “Rock and Other Fragments” due to their unique properties and nongeologic origins and due to unique historical and cultural implications.

Describe **Kind**, **Quantity** (vol. percentage), **Roundness**, **Shape**, **Cohesion**, **Penetrability**, **Persistence**, and **Safety**.

Artifacts – Kind—Record the dominant types of human artifacts present by horizon/layer. (Used in NASIS primarily for percent passing sieve calculation.) All fragments are 2 mm or more.

Kind	
bitumen *(asphalt)*	fly ash
boiler slag	glass
bottom ash	metal
brick	paper
cardboard	plasterboard
carpet	plastic
cloth	potsherd
coal combustion byproducts	rubber (*tires, etc.*)
concrete *(fragments)*	treated wood
crushed rock	untreated wood
debitage *(stone tool flakes)*	

Artifacts – Quantity—Estimate the relative amount (volume %) of artifacts by horizon/layer. In NASIS, estimate a Representative Value (RV).

Quantity	Criteria
#	(volume percent)

Artifacts – Size—Describe the cross-sectional diameter of artifacts by horizon/layer.

Size Class	Size
fine	2 to < 20 mm
medium	20 to < 75 mm
coarse	75 to < 250 mm
very coarse	≥ 250 mm

Artifacts – Roundness—Estimate the dominant extent of roundness of the artifacts by horizon/layer. (Refer to "Rock and Other Fragments – Roundness" graphic on p. 2–49)

Roundness Class	Code
angular	AN
rounded	RO
subangular	SA
subrounded	SR
very angular	VA
well rounded	WR

Artifacts – Shape—Describe the dominant form (shape) of the artifacts by horizon/layer.

Shape Class	Code	Criteria
elongated	E	one dimension (length, width, or height) is 3x longer than either of the others
equidimensional	Q	length, width, height are approximately the same
flat	F	one dimension is < 1/3 that of either of the others, and one dimension is < 3x that of the intermediate
irregular	I	branching or convoluted form

Artifacts – Cohesion—Describe the dominant relative fragment integrity.

Cohesion Class	Code	Criteria
cohesive	C	cannot be readily broken to < 2 mm pieces
noncohesive	N	easily broken to < 2 mm pieces by hand or simple crushing

Artifacts – Penetrability—Describe the prevalent relative ease of penetration of artifacts by external mechanical force by horizon/layer.

Penetrability Class	Code	Criteria
nonpenetrable	N	roots cannot penetrate through or between artifacts
penetrable	P	roots can penetrate through or between artifacts

Artifacts – Persistence—Describe the dominant relative extent.

Persistence Class	Code	Criteria
nonpersistent	N	susceptible to relatively rapid weathering or decay (expected loss in < 10 years)
persistent	P	expected to remain intact in soil for > 10 years

Artifacts – Safety—Describe the dominant relative level of chemical safety of artifacts present.

Safety Class	Code	Criteria
innocuous artifacts	IA	harmless to living beings (e.g., brick, wood, glass, etc.)
noxious artifacts	NA	potentially harmful or destructive to living beings (e.g., batteries, garbage, bitumen [asphalt], treated wood with arsenic)

(Soil) Structure

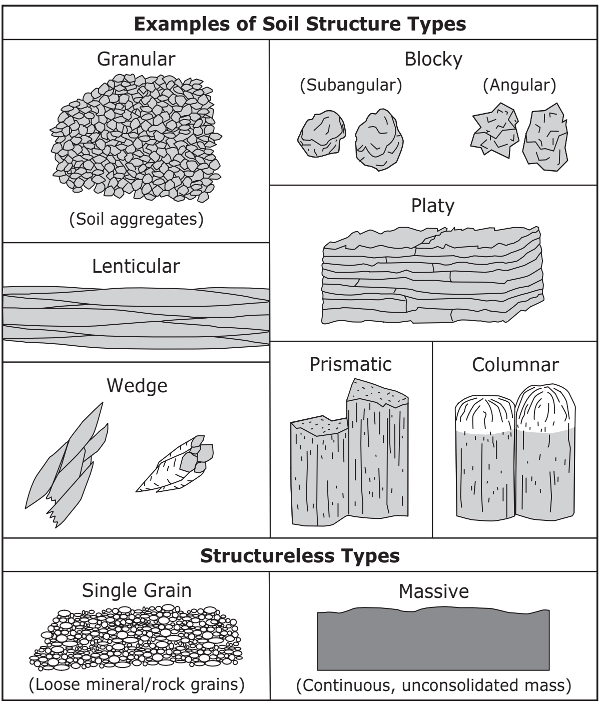
(Soil) structure is the naturally occurring arrangement of soil particles into aggregates that results from pedogenic processes. Record **Grade**, **Size**, and **Type**. For compound structure, list each size and type (e.g., medium and coarse SBK parting to fine GR). Lack of structure (structureless) has two end members: massive (MA) or single grain (SG). A complete example is: *weak, fine, subangular blocky or 1, f, sbk*.

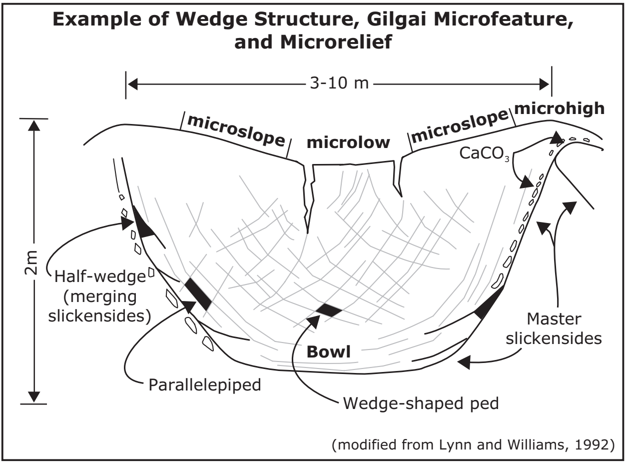
(Soil) Structure – Type (formerly **Shape**)—Record the dominant type of ped, by layer (e.g., granular or gr). If a prevailing large shape readily breaks into smaller units, record as "[larger type] parting to [smaller type]" (e.g., prismatic parting to subangular blocky).

Type	Conv. Code	NASIS Code	Criteria: Definition
Natural Soil Structural Units (pedogenic structure)			
granular	gr	GR	small polyhedrals with curved or very irregular faces
angular blocky	abk	ABK	polyhedrals with faces that intersect at sharp angles (planes)
subangular blocky	sbk	SBK	polyhedrals with subrounded and planar faces lacking sharp angles
lenticular	lp	LP	overlapping, lens-shaped peds generally parallel to the soil surface that are thick at the center and taper toward the edges; formed by active or relict periglacial frost processes; most common in soils with moderate to high water-holding capacity in moist conditions
platy	pl	PL	flat and platelike units
wedge	wg	WEG	elliptical, interlocking lenses that terminate in acute angles, bounded by slickensides; not limited to vertic materials
prismatic	pr	PR	vertically elongated units; flat tops
columnar	cpr	COL	vertically elongated units with rounded tops that commonly are "bleached."

Type	Conv. Code	NASIS Code	Criteria: Definition
Structureless			
single grain	sg	SGR	no structural units; entirely noncoherent; e.g., loose sand
massive	m	MA	no structural units; material is a coherent mass (not necessarily cemented)
Artificial Earthy Fragments or Clods[1] (nonpedogenic structure)			
cloddy [1]	—	CDY	irregular blocks created by artificial disturbance; e.g., tillage or compaction

[1] Used only to describe oversized, "artificial" earthy units that are not pedogenically derived soil structural units (e.g., the direct result of mechanical manipulation); use "Blocky Structure Size" criteria.





(Soil) Structure – Grade—

Grade	Code	Criteria
structureless	0	no discrete units observable in place or in a hand sample
weak	1	units are barely observable in place or in a hand sample
moderate	2	units well formed and evident in place or in a hand sample
strong	3	units are distinct in place (undisturbed soil) and separate cleanly when disturbed

(Soil) Structure – Size—

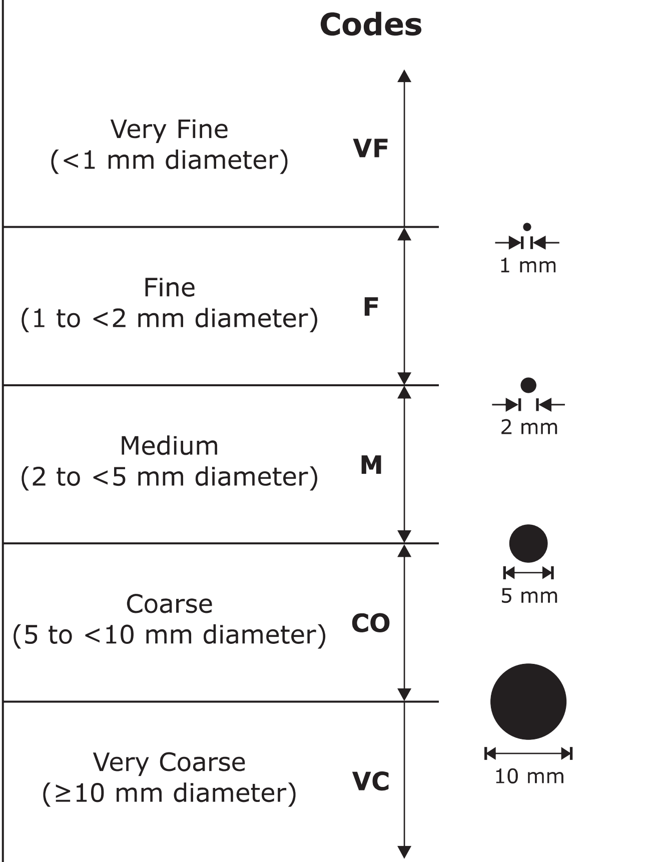
Size Class	Conv. Code	NASIS Code	Criteria: Structural Unit Size [1] (mm)—Granular, Platy [2], (Thickness)	Criteria: Structural Unit Size [1] (mm)—Columnar, Prismatic, Wedge [3] (Diameter)	Criteria: Structural Unit Size [1] (mm)—Angular and Subangular Blocky and Lenticular (Diameter)
very fine (very thin) [2]	vf (vn)	VF (VN)	< 1	< 10	< 5
fine (thin) [2]	f (tn)	F (TN)	1 to < 2	10 to < 20	5 to < 10
medium (medium)	m (m)	M (M)	2 to < 5	20 to < 50	10 to < 20
coarse (thick) [2]	co (tk)	CO (TK)	5 to < 10	50 to < 100	20 to < 50
very coarse (very thick) [2]	vc (vk)	VC (VK)	≥ 10	100 to < 500	≥ 50
extremely coarse	ec (—)	EC (—)	—	≥ 500	—

[1] Size limits always denote the *smallest* dimension of the structural units.

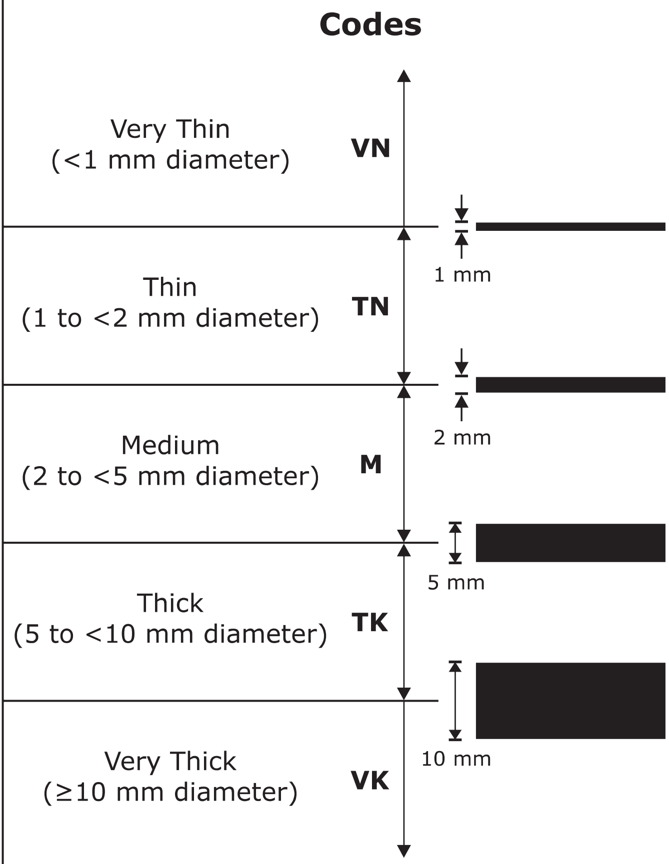
[2] For platy structures only, substitute *thin* for *fine* and *thick* for *coarse* in the "Size Class" names.

[3] Wedge structure is generally associated with Vertisols, which is a requirement, or related soils (e.g., "Vertic" subgroups) with high amounts of smectitic clays.

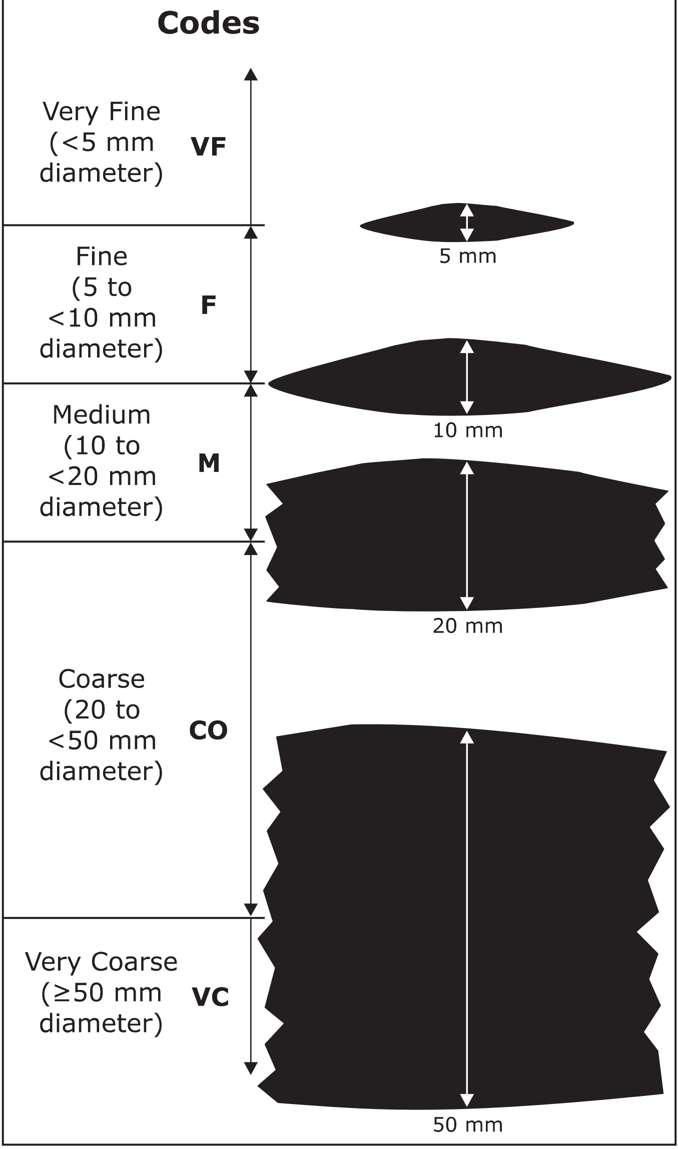
Granular


Codes
Very Fine
(<1 mm diameter)
VF
Fine
(1 to <2 mm diameter)
F
1 mm
Medium
(2 to <5 mm diameter)
M
2 mm
Coarse
(5 to <10 mm diameter)
CO
5 mm
Very Coarse
(≥10 mm diameter)
VC
10 mm

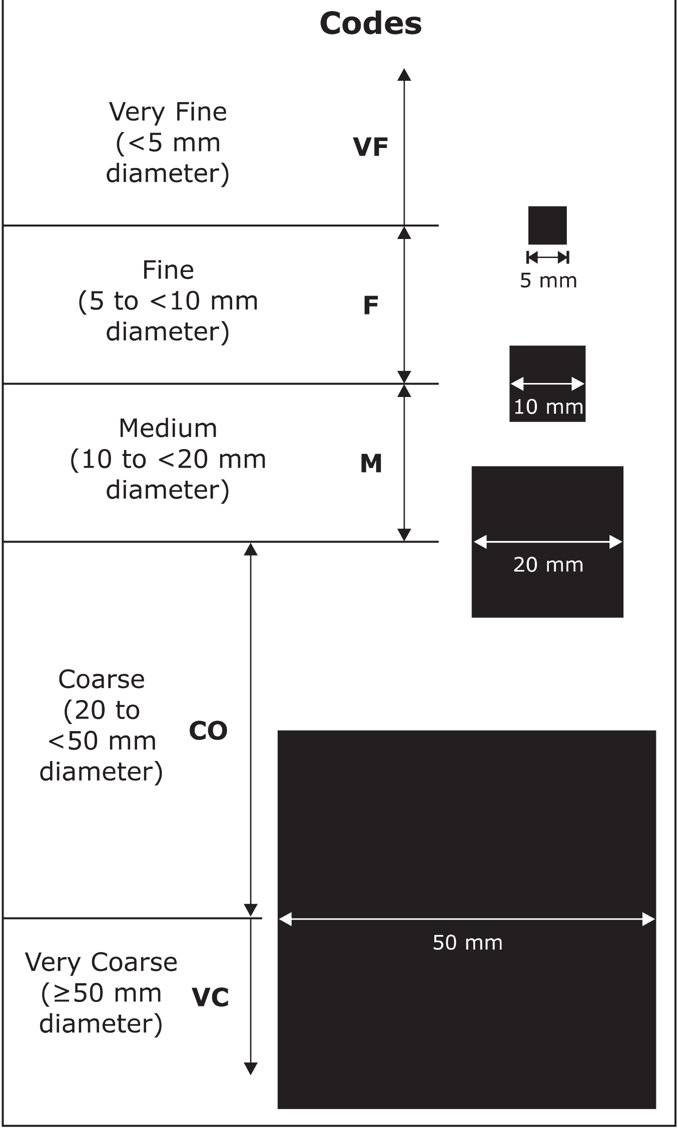
Platy


Codes
Very Thin
(<1 mm diameter)
VN
1 mm
Thin
(1 to <2 mm diameter)
TN
2 mm
Medium
(2 to <5 mm diameter)
M
5 mm
Thick
(5 to <10 mm diameter)
TK
10 mm
Very Thick
(≥10 mm diameter)
VK

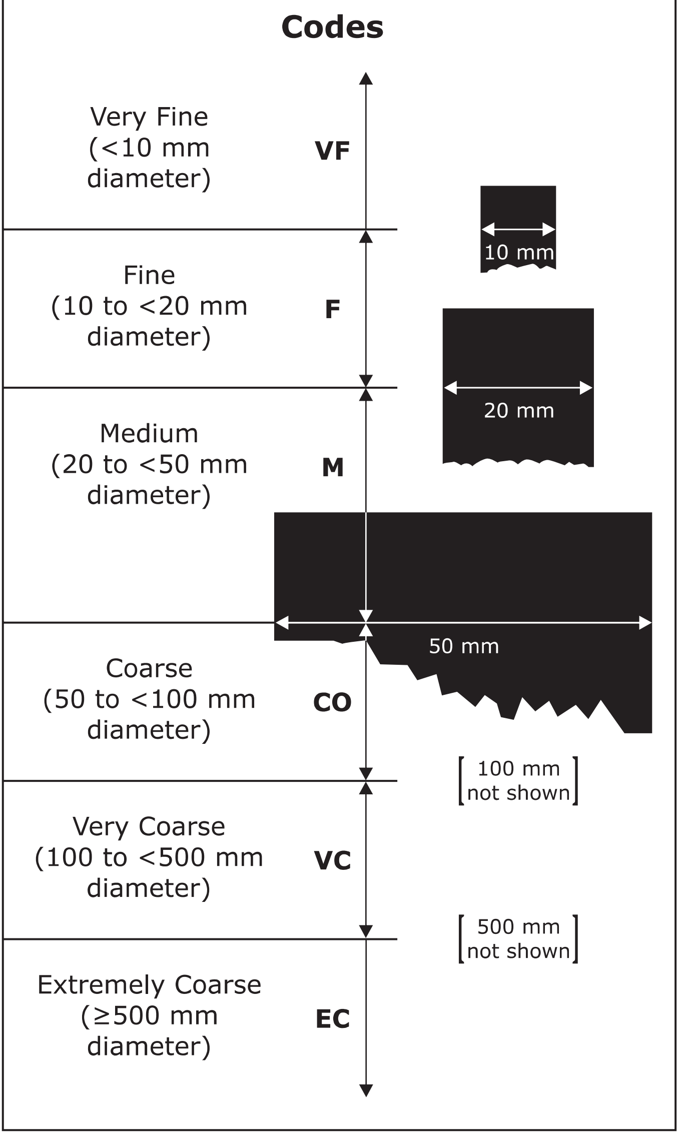
Lenticular


Codes
Very Fine (<5 mm diameter)
VF
Fine (5 to <10 mm diameter)
F
Medium (10 to <20 mm diameter)
M
Coarse (20 to <50 mm diameter)
CO
Very Coarse (≥50 mm diameter)
VC
5 mm
10 mm
20 mm
50 mm

Angular and Subangular Blocky

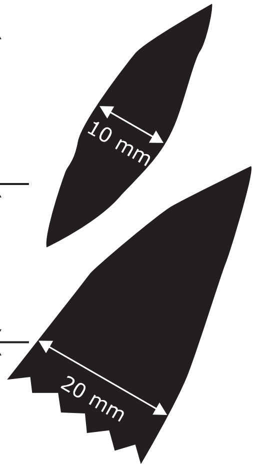


Prismatic and Columnar



Wedge

	Codes
Very Fine (<10 mm thick)	**VF**
Fine (10 to <20 mm thick)	**F**
Medium (20 to <50 mm thick)	**M**
Coarse (50 to <100 mm thick)	**CO**
Very Coarse (100 to <500 mm thick)	**VC**
Extremely Coarse (≥500 mm thick)	**EC**



[50 mm not shown]

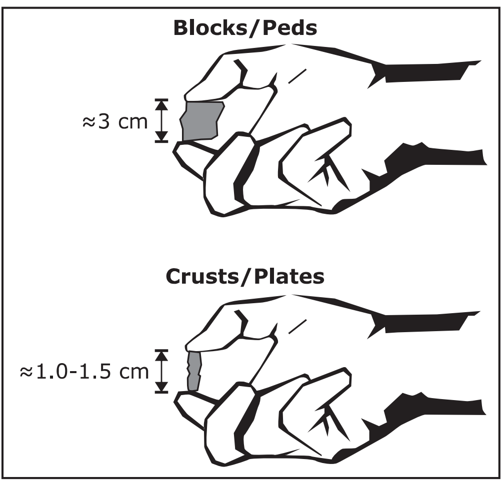
[100 mm not shown]

[500 mm not shown]

Consistence

Consistence is the degree and kind of cohesion and adhesion that soil exhibits and/or the resistance of soil to deformation or rupture under an applied stress. Soil-water state strongly influences consistence. Field evaluations of consistence include: **Rupture Resistance** (blocks, peds, and clods; or surface crusts and plates), **Manner of Failure** (brittleness, fluidity, smeariness), **Stickiness**, **Plasticity**, and **Penetration Resistance**. Historically, consistence is applied to dry, moist, or wet soil as observed in the field. Wet consistence evaluated stickiness and plasticity. **Rupture Resistance** now applies to dry soils and to soils in a water state from moist through wet. **Stickiness** and **Plasticity** of soil are independent evaluations.

Rupture Resistance—A measure of the strength of soil to withstand an applied stress. Separate estimates of **Rupture Resistance** are made for **Blocks/Peds/Clods** and for **Surface Crusts and Plates** of soil. Block-shaped specimens should be approximately 2.8 cm across. If 2.8-cm cubes (e.g., ≈ 2.5–3.1 cm, or 1 inch) are not obtainable, use the following equation and the table below to calculate the stress at failure: *(2.8 cm/cube length cm)*^{2} *x estimated stress (N) at failure*; e.g., for a 5.6-cm cube, *(2.8/5.6)*^{2} *x 20 N = 5 N* ⇒ *Soft Class*. Plate-shaped specimens (surface crusts or platy structure) should be approximately 1.0–1.5 cm long by 0.5 cm thick (or the thickness of occurrence, if less than 0.5 cm thick).



Rupture Resistance for:

Blocks, Peds, and Clods—Estimate the class by the force required to rupture (break) a soil unit. Select the column for the appropriate soil water state ("dry" vs. "moist") and/or the "Coherence" column, if applicable.

Dry [1] Class	**Dry [1] Code [3]**	**Moist[1] Class**	**Moist[1] Code [3]**	**Coherence Class**	**Coherence Code [3]**	**Specimen Fails Under**
loose	L d(lo)	loose	L m(lo)	(not applicable)		*(intact specimen not obtainable)*
soft	S d(so)	very friable	VFR m(vfr)	(not applicable)		very slight force between fingers; < 8 N
slightly hard	SH d(sh)	friable	FR m(fr)	extremely weakly coherent	EW	slight force between fingers; 8 to < 20 N
mod. hard	MH d(h)	firm	FI m(fi)	very weakly coherent	VW	moderate force between fingers; 20 to < 40 N
hard	HA d(vh)	very firm	VFI m(vfi)	weakly coherent	W c(w)	strong force between fingers; 40 to < 80 N
very hard	VH d(vh)	extr. firm	EF m(efi)	moderately coherent	M	moderate force between hands; 80 to < 160 N
extr. hard	EH d(eh)	slightly rigid	SR m(efi)	strongly coherent	ST c(s)	foot pressure by full body weight; 160 to < 800 N
rigid	R d(eh)	rigid	R m(efi)	very strongly coherent	VS	blow of < 3 J but not body weight; 800 N to < 3 J
very rigid	VR d(eh)	very rigid	VR m(efi)	indurated	I c(I)	blow of ≥ 3 J (3 J = 2 kg weight dropped 15 cm)

[1] "Dry" rupture resistance column applies to soils that are moderately dry or drier (*moderately dry* and *very dry* "Soil Water State" subclasses).

Moist column applies to soils that are slightly dry or wetter (*slightly dry* through *satiated* "Soil Water State" subclasses) (Soil Science Division Staff, 2017, p. 208).

[2] This is not an immediate field test; specimen must first be air dried and then submerged in water for a minimum of 1 hour prior to test; collapse and disaggregation is "slaking" (Soil Science Division Staff, 2017, p. 181).

[3] Codes in parentheses (e.g., d(lo); Soil Survey Staff, 1951) are obsolete.

Surface Crust and Plates—

Class (air dried)	Code	Force [1] (Newtons)
extremely weak	EW	not obtainable
very weak	VW	removable, < 1N
weak	W	1 to < 3N
moderate	M	3 to < 8N
moderately strong	MS	8 to < 20N
strong	S	20 to < 40N
very strong	VS	40 to < 80N
extremely strong	ES	≥ 80N

[1] For operational criteria (field estimates of force [N]), use the "Fails Under" column in the "Rupture Resistance for Blocks, Peds, Clods" table.

Cementing Agents (called **Rupture_resist_cem_agent** in NASIS)—Record kind of cementing agent, if present.

Kind	Code [1]
carbonates	K
gypsum [2]	G
humus	H
iron	I
silica (SiO_2)	S

[1] Conventional codes traditionally consist of the entire material name or its chemical symbols (e.g., silica or SiO_2). Consequently, the "Conv. Code" column would be redundant and is not shown in this table.

[2] Gypsum is not a true cement but functionally behaves as such.

Manner of Failure—The rate of change and the physical condition soil attains when subjected to compression. Samples are moist or wetter.

Failure Class	Code	Criteria: Related Field Operation
Brittleness		***Use a 3-cm Block (press between thumb and forefinger)***
brittle	BR	ruptures abruptly ("pops" or shatters)
semi-deformable	SD	rupture occurs before compression to < 1/2 original thickness
deformable	DF	rupture occurs after compression to ≥ 1/2 original thickness
Fluidity [1]		***Use a palmful of soil (squeeze in hand)***
nonfluid	NF	after full compression, no soil flows through the fingers
slightly fluid	SF	after full compression is exerted, some soil flows through fingers but most remains in the palm of the hand
mod. fluid	MF	after full pressure is exerted, most soil flows through fingers; a small residue remains in the palm of the hand
very fluid	VF	under very gentle pressure, most soil flows through the fingers as a slightly viscous fluid and very little or no residue remains in the palm of the hand
Smeariness		***Use a 3-cm block (press between thumb and forefinger)***
nonsmeary [2]	NS	at failure, the sample does not change abruptly to fluid; fingers do not skid and no smearing occurs
weakly smeary [2]	WS	at failure, the sample changes abruptly to fluid; fingers skid, soil smears, and little or no water remains on fingers
moderately smeary [2]	MS	at failure, the sample changes abruptly to fluid; fingers skid, soil smears, and some water remains on fingers
strongly smeary [2]	SM	at failure, the sample abruptly changes to fluid; fingers skid, soil smears and is slippery, and water is easily seen on fingers

[1] See additional comments on fluidity under “Subaqueous Soil” (p. 2–110).

[2] *Smeariness* failure classes are used dominantly with materials displaying andic soil properties (and some spodic materials).

Stickiness—The capacity of soil to adhere to other objects. Stickiness is estimated at the moisture content that displays the greatest adherence when pressed between thumb and forefinger.

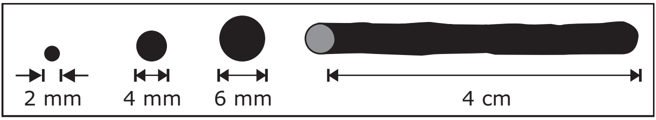
Stickiness Class	Conv. Code	NASIS Code	Criteria: Work Moistened Soil between Thumb and Forefinger
nonsticky	(w) so	SO	little or no soil adheres to fingers after release of pressure
slightly sticky	(w) ss	SS	soil adheres to both fingers after release of pressure; soil stretches little on separation of fingers
moderately sticky [1]	(w) s	MS	soil adheres to both fingers after release of pressure; soil stretches some on separation of fingers
very sticky	(w) vs	VS	soil adheres firmly to both fingers after release of pressure; soil stretches greatly upon separation of fingers

[1] Historically, the “moderately sticky” class was simply called “sticky.”

Plasticity—The degree to which “puddled” or reworked soil can be permanently deformed without rupturing. The evaluation is made by forming a roll (wire) of soil at a water content where the maximum plasticity is expressed.

Plasticity Class	Conv. Code	NASIS Code	Criteria: Make a Roll of Soil 4 cm Long
nonplastic	(w) po	PO	will not form a roll 6 mm in diameter, or if a roll is formed, it can’t support itself if held on end
slightly plastic	(w) ps	SP	6 mm diameter roll supports itself; 4 mm diameter roll does not
moderately plastic [1]	(w) p	MP	4 mm diameter roll supports itself; 2 mm diameter roll does not
very plastic	(w) vp	VP	2 mm diameter roll supports its weight

[1] Historically, the ”moderately plastic” class was simply called “plastic.”



Penetration Resistance—The ability of soil in a confined (field) state to resist penetration by a rigid object of specified size. A pocket penetrometer (Soil-Test Model CL-700) with a rod diameter of 6.4 mm (area 20.10 mm^2) and insertion distance of 6.4 mm (note line on rod) is used for the determination. An average of five or more measurements should be used to obtain a value for penetration resistance.

Note: The pocket penetrometer has a scale of 0.25 to 4.5 $tons/ft^2$ ($tons/ft^2 \approx kg/cm^2$). The penetrometer does *not* directly measure penetration resistance. The penetrometer scale is correlated to and gives a field estimate of *unconfined compressive strength* of soil as measured with a Tri-Axial Shear device. The table below converts the scale reading on the pocket penetrometer to penetration resistance in MPa. Penetrometer readings are dependent on the spring type used. Springs of varying strength are needed to span the range of penetration resistance found in soil.

Penetrometer Scale Reading **$tons/ft^2$**	**Spring Type:**[1, 2, 3] Original MPa	**Spring Type:**[1, 2, 3] Lee MPa	**Spring Type:**[1, 2, 3] Jones 11 MPa	**Spring Type:**[1, 2, 3] Jones 323 MPa
0.25	**0.32 L**	**0.06 VL**	**1.00 M**	**3.15 H**
0.75	0.60	**0.13 L**	1.76	4.20
1.00	0.74	0.17	**2.14 H**	4.73
1.50	**1.02 M**	0.24	2.90	5.78
2.75	1.72	0.42	4.80	**8.40 EH**
3.50	**2.14 H**	0.53	—	—

[1] On wet or “soft” soils, a larger “foot” may be needed (Soil Sciece Division Staff, 2017).

[2] Each bolded value highlights the force associated with a rounded value on the penetrometer scale that is closest to a *Penetration Resistance Class* boundary. The bolded letter represents the *Penetration Resistance Class* from the following table (e.g., **M** indicates the *moderate* class).

[3] Each spring type spans only a part of the range of penetration resistance possible in soils; various springs are needed to span all *Penetration Resistance Classes*.

Penetration Resistance Class (called **Penetration_resistance** in NASIS)—Record the appropriate class, by horizon or layer, based on the average value of five or more measurements with a pocket penetrometer.

Penetration Resistance Class	Code	Criteria: Penetration Resistance (MPa)
extremely low	EL	< 0.01
very low	VL	0.01 to < 0.1
low	L	0.1 to < 1
moderate	M	1 to < 2
high	H	2 to < 4
very high	VH	4 to < 8
extremely high	EH	≥ 8

Penetration Orientation—Record the orientation of the pocket penetrometer used to determine the **Penetration Resistance Class**.

Orientation	Code	Criteria
horizontal	H	oriented perpendicular to a vertical pit face
vertical [1]	V	oriented perpendicular to the ground surface

[1] The conventional (preferred) orientation.

Excavation Difficulty—The relative force or energy required to dig soil out of place. Describe the **Excavation Difficulty Class** and the moisture condition (*moist* or *dry*, but not wet); use the "(Soil) Water State" table (e.g., moderate, moist or M, M). Estimates can be made for either the most limiting layer or for each horizon.

Class	Code	Criteria
low	L	excavation by tile spade requires arm pressure only; impact energy or foot pressure is not needed
moderate	M	excavation by tile spade requires impact energy or foot pressure; arm pressure is insufficient
high	H	excavation by tile spade is difficult but easily done by pick with over-the-head swing

Class	Code	Criteria
very high	VH	excavation by pick with over-the-head swing is moderately to markedly difficult; backhoe excavation by a 50- to 80-hp tractor can be made in a moderate amount of time
extremely high	EH	excavation with pick is nearly impossible; backhoe excavation by a 50- to 80-hp tractor cannot be made in a reasonable amount of time

Roots

Record the **Quantity**, **Size**, and **Location** of roots in each horizon. ***Note:*** Describe **Pores** using the same “Quantity” and “Size” classes and criteria as those for “Roots;” use the combined tables.

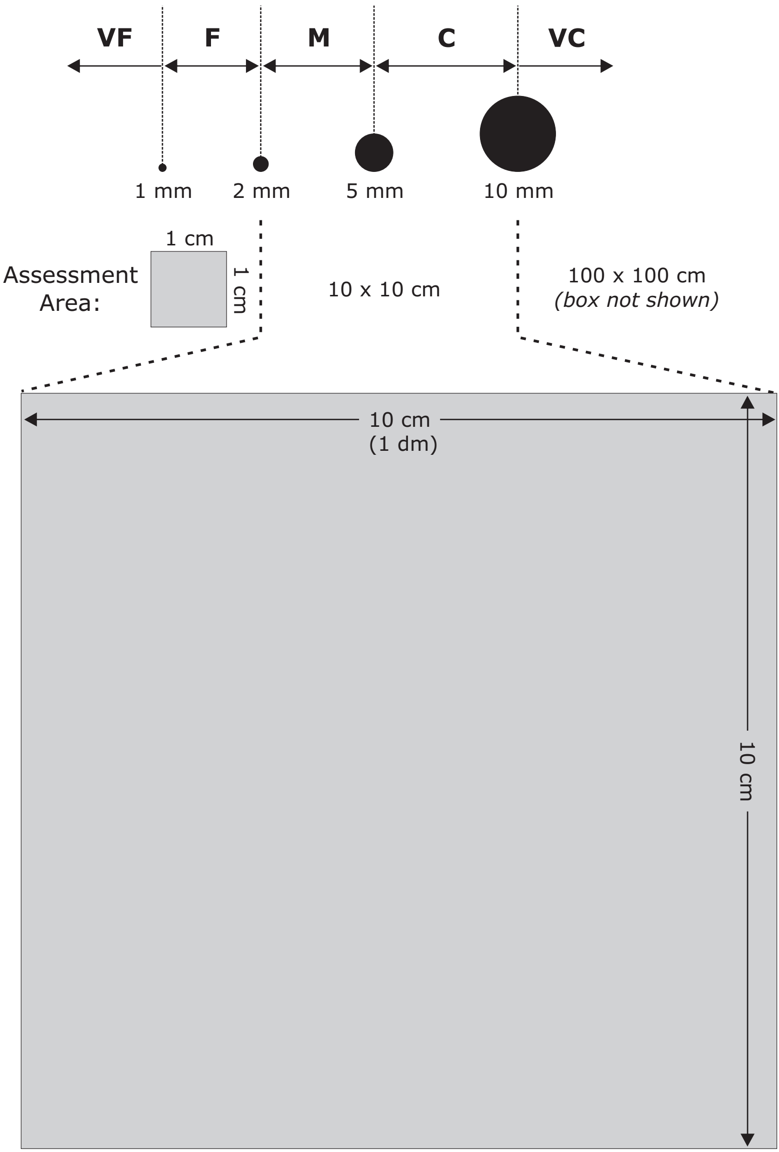
Roots (and Pores) – Quantity—Describe the quantity (number) of roots for each size class in a horizontal plane. ***Note:*** Typically, this is done across a vertical plane, such as a pit face. Record the average quantity from three to five representative unit areas. ***Caution:*** The unit area that is evaluated varies with the “Size Class” of the roots being considered. Use the appropriate unit area stated in the “Soil Area Assessed” column of the “Size (Roots and Pores)” table (also see following graphic). In NASIS, record the actual number (#) of roots per unit area (NASIS then assigns the appropriate class). Use class names in narrative description.

Quantity Class [1]	Conv. Code	NASIS Code	Average Count [2] (per assessed area)
few	1	#	< 1 per area
very few [1]	—	#	< 0.2 per area
moderately few [1]	—	#	0.2 to < 1 per area
common	2	#	1 to < 5 per area
many	3	#	≥ 5 per area

[1] The *very few* and *moderately few* subclasses can be used for roots (optional) but do not apply to pores.

[2] The applicable area for appraisal varies with the size of roots or pores. Use the appropriate area stated in the “Soil Area Assessed” column of the “Size (Roots and Pores)” table or use the following graphic.

Roots (and Pores) – Quantity (graphic)—Soil area to be assessed.



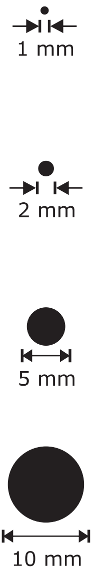
Roots (and Pores) – Size—(See the following graphic for size.)

Size Class	Conv. Code	NASIS Code	Diameter	Soil Area Assessed [1]
very fine	vf	VF	< 1 mm	1 cm^2
fine	f	F	1 to < 2 mm	1 cm^2
medium	m	M	2 to < 5 mm	1 dm^2
coarse	co	C	5 to < 10 mm	1 dm^2
very coarse	vc	VC	≥ 10 mm	1 m^2

[1] One dm^2=a square that is 10 cm on a side, or 100 cm^2.

Root and Pore Size Classes

	Codes
Very Fine (<1 mm)	**VF**
Fine (1 to <2 mm)	**F**
Medium (2 to <5 mm)	**M**
Coarse (5 to <10 mm)	**CO**
Very Coarse (≥10 mm)	**VC**



Roots – Location (Roots Only)—Identify where roots occur.

Location	Code
between peds	P
in cracks	C
in mat at top of horizon [1]	M
matted around rock fragments	R
throughout	T

[1] Describing a root mat at the top of a horizon rather than at the bottom or within the horizon flags the horizon that restricts root growth.

Pores (Discussion)

Pores are the air- or water-filled voids in soil. Historically, description of soil pores, called “nonmatrix” pores in the “Soil Survey Manual” (Soil Science Division Staff, 2017), excluded interstructural voids, cracks, and, in some schemes, interstitial pores. *Interstructural voids* (i.e., the subplanar fractures between peds; also called interpedal or structural faces/planes), which can be inferred from soil structure descriptions, are not recorded directly. *Cracks* can be assessed independently (Soil Science Division Staff, 2017). *Interstitial pores* (i.e., visible, primary packing voids) may be visually estimated, especially for fragmental soils, or can be inferred from soil porosity, bulk density, and particle-size distribution. Clearly, one cannot assess the smallest interstitial pores (e.g., < 0.05 mm) in the field. Field observations are limited to those that can be seen through a 10x hand lens or larger. Field estimates of interstitial pores are considered to be somewhat tenuous but still useful.

Pores

Describe the **Quantity** and **Size** of pores for each size class, by horizon, in a horizontal plane. (***Note:*** Typically, this is actually assessed on a vertical face.) Description of soil pore **Shape** and **Vertical Continuity** is optional.

Pores – Quantity—See and use **Quantity (Roots and Pores)**.

Pores – Size—See and use **Size (Roots and Pores)**.

Pores – Shape (or Type)—Record the dominant form (or "type") of pores discernible with a 10x hand lens and by the unaided eye. (See graphic on p. 2–76.)

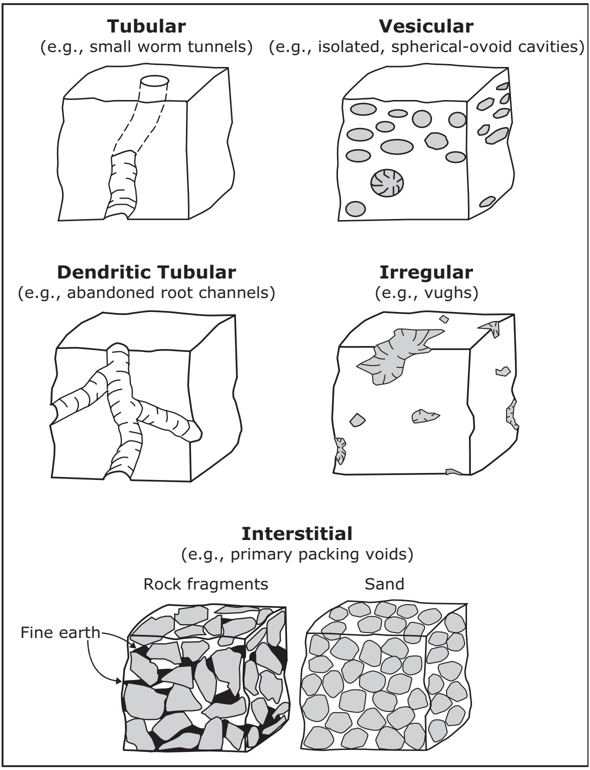
Description	Code	Criteria
Soil Pores [1]		
dendritic tubular	DT	cylindrical, elongated, branching voids (e.g., empty root channels)
irregular	IG	nonconnected cavities and chambers (e.g., vughs; various shapes)
tubular	TU	cylindrical and elongated voids (e.g., worm tunnels)
vesicular	VE	ovoid to spherical voids (e.g., solidified pseudomorphs of entrapped gas bubbles concentrated below a crust); most common in arid and semiarid environments
Primary Packing Voids [2]		
interstitial	IR	voids between sand grains or rock fragments

[1] Also called "nonmatrix pores" (Soil Science Division Staff, 2017).

[2] "Primary packing voids" include a continuum of sizes. As used here, they have a minimum size that is defined as pores that are visible with a 10x hand lens. "Primary packing voids" are also called "matrix pores" (Soil Science Division Staff, 2017).

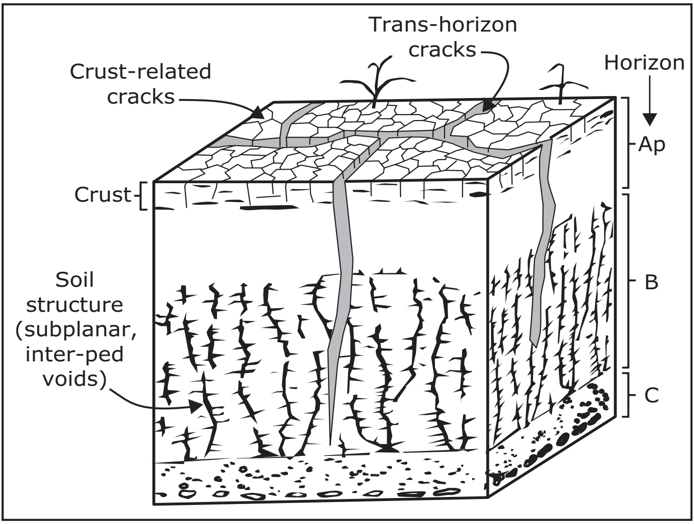
Pores – Vertical Continuity—The average vertical distance the minimum pore diameter exceeds 0.5 mm. Soil must be moist or wetter.

Class	Conv. Code	NASIS Code	Criteria: Vertical Distance
low	—	L	< 1 cm
moderate	—	M	1 to < 10 cm
high	—	H	≥ 10 cm


Tubular
(e.g., small worm tunnels)
Vesicular
(e.g., isolated, spherical-ovoid cavities)
Dendritic Tubular
(e.g., abandoned root channels)
Irregular
(e.g., vughs)
Interstitial
(e.g., primary packing voids)
Rock fragments
Sand
Fine earth

Cracks

Cracks (also called "Extra-Structural Cracks"; Soil Science Division Staff, 2017) are fissures other than those attributed to soil structure. Cracks are commonly vertical, subplanar, and polygonal and are the result of desiccation, dewatering, or consolidation of earthy material. Cracks are much longer and can be much wider than planes that surround soil structural units, such as prisms and columns. Cracks are key to preferential flow, also called "bypass flow" (Bouma et al., 1982), and are a primary cause of temporal (transient) changes in ponded infiltration and hydraulic conductivity in soils (Soil Science Division Staff, 2017). Cracks are primarily associated with, but not restricted to, clayey soils and are most pronounced in high shrink-swell soils (high COLE value). Record the **Relative Frequency** (estimated average number per m^2), **Depth** (average), and **Kind**. A complete example is: *3, 25 cm deep, reversible trans-horizon cracks*.



Cracks – Kind—Identify the dominant types of fissures.

Kind	Code [1]	General Description
Crust-Related Cracks [2] *(shallow, vertical cracks related to crusts; derived from raindrop-splash and soil puddling followed by dewatering/ consolidation and desiccation)*		
reversible crust-related cracks [3]	RCR	very shallow (e.g., 0.1-0.5 cm); very transient (generally persist less than a few weeks); formed by drying from surface down; minimal seasonal influence on ponded infiltration (e.g., raindrop crust cracks).
irreversible crust-related cracks [4]	ICR	shallow (e.g., 0.5-2 cm); seasonally transient (not present year-round nor every year); minor influence on ponded infiltration (e.g., freeze-thaw crust and associated cracks).
Trans-Horizon Cracks [5] *(deep, vertical cracks that commonly extend across more than one horizon and may extend to the surface; derived from wetting and drying or original dewatering and consolidation of parent material)*		
reversible trans-horizon cracks [6]	RTH	transient (commonly seasonal; close when rewetted); large influence on ponded infiltration and K_{sat}; formed by wetting and drying of soil (e.g., Vertisols, vertic subgroups).
irreversible trans-horizon cracks [7]	ITH	permanent (persist year-round; see “Soil Taxonomy”), large influence on ponded infiltration and K_{sat} (e.g., extremely coarse subsurface fissures within glacial till; drained polder cracks).

[1] No conventional codes; use entire term. NASIS codes are shown.

[2] Called “surface-initiated cracks” (Soil Science Division Staff, 2017).

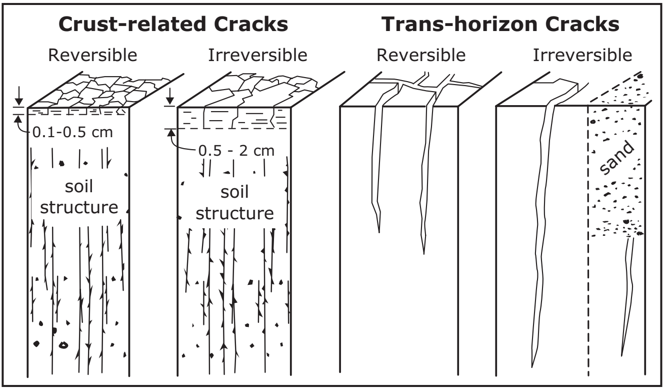
[3] Called “surface-initiated reversible cracks” (Soil Science Division Staff, 2017).

[4] Called “surface-initiated irreversible cracks” (Soil Science Division Staff, 2017).

[5] Also called “subsurface-initiated cracks” (Soil Science Division Staff, 2017).

[6] Called “subsurface-initiated reversible cracks” (Soil Science Division Staff, 2017).

[7] Called “subsurface-initiated irreversible cracks” (Soil Science Division Staff, 2017).



Cracks – Depth—Record the **Average Apparent Depth** (also called a "depth index value" in the "Soil Survey Manual" [Soil Science Division Staff, 2017]), measured from the surface as determined by the wire-insertion method (≈2 mm diameter wire). ***Note:*** This method commonly gives a standard but conservative measure of the actual fracture depth. Do not record this data element for cracks that are not open to the surface. Depth (and apparent vertical length) of subsurface cracks can be inferred from the "Horizon Depth" column of layers exhibiting subsurface cracks.

Cracks – Relative Frequency—Record the **Average Number of Cracks**, per meter, across the surface or **Lateral Frequency** across a soil profile as determined with a line-intercept method. This data element cannot be assessed from cores or push-tube samples.

Soil Crusts (Discussion)

A soil crust is a thin (i.e., < 1 cm up to 10 cm thick) surface layer of soil particles bound together by living organisms and/or by minerals into a horizontal "mat" or small polygonal plates. Soil crusts form at the soil surface and have different physical and/or chemical characteristics than the underlying soil material. Typically, soil crusts change the infiltration rate of the mineral soil and stabilize loose soil particles and aggregates. There are two general categories of soil crusts: biological crusts and mineral crusts.

1. **Biological Crust** (also called *biotic*, *cryptogamic, microbiotic*, or *microphytic* crust): a thin, biotically dominated surface layer or mat formed most commonly by cyanobacteria (blue green algae), green and brown algae, mosses, and/or lichens (USDA NRCS, 1997; USDA NRCS, 2001) that forms in or on the soil surface.

Various types of microbiotic crusts have been recognized based on the biological communities of which they are composed (no prevailing consensus on types of biological crusts, at present).

2. **Mineral Crust** (also called *abiotic*, *nonbiotic,* or *nonmicrobiotic* crust): a thin surface layer composed of reversibly bonded soil particles or secondary mineral crystals, sometimes laminated, that is not physically dominated by a microbiotic "mat."

    a. **Chemical Crust** (e.g., salt incrustations): a thin surface layer that is dominated by macro- or microcrystalline evaporites of halite (NaCl), $MgSO_4$, mirabilite ($Na_2SO_4 \cdot 10H_2O$), thenardite (Na_2SO_4), epsomite ($MgSO_4 \cdot 7H_2O$), hexahydrite ($MgSO_4 \cdot 6H_2O$), bloedite ($Na_2Mg(SO_4)_2 \cdot 4H_2O$), konyaite ($Na_2Mg(SO_4)_2 \cdot 5H_2O$), loeweite ($Na_{12}Mg_7 (SO_4)_{13} \cdot 15H_2O$), gypsum ($CaSO_4 \cdot 2H_2O$) (Singer and Warrington, 1992; Doner and Lynn, 1989), or other minerals. Other surficial mineral incrustations (e.g., from acid mine drainage or other sources) are included within this group.

    b. **Physical Crust**: a physically reconstituted, reaggregated, or reorganized surface layer composed predominantly of primary mineral particles.

        1) **Raindrop Impact Crust** (also called a *structural* crust): a thin layer that forms as a result of *raindrop impact*, which causes the clay in the soil to disperse, and subsequently hardens into a massive structureless or platy surface layer when it dries (Singer and Warrington, 1992).

        2) **Depositional Crust** (also called a *fluventic zone*; Soil Science Division Staff, 2017): a surface layer, commonly laminated and of variable thickness, consisting of small aggregates or primary mineral grains deposited by short-range runoff and subsequently dried (Singer and Warrington, 1992).

        3) **Freeze-Thaw Crust** (Soil Science Division Staff, 2017): a seasonal surface sediment layer 1 to 5 cm thick occurring on bare ground that has been disaggregated or puddled by radiant heating and cooling to produce freeze/thaw cycles while *very moist* or *wet*. Commonly, the layer is composed of interlocking polygonal plates 5 to 20 cm in diameter, separated by cracks 1 to 2 cm wide that extend to the base of the crust and do not completely close upon wetting; dry rupture resistance is ≤ *moderately hard*.

        4) **Vesicular Crust**: a surface soil layer or zone characterized by spherical or ovoid, discontinuous pores 0.5 to 2 mm in diameter that are visible to the naked eye and make up a substantial portion of the matrix volume

(i.e., ≥ 20% cross-sectional area). These vesicles are believed to form when the pores between clay particles in platy soil structure are subjected to repeated wetting and drying. If soil aggregates become particularly unstable when they become saturated, air pressure may form small round voids (e.g., “bubbles”) that remain when the soil dries (Blackburn et al., 1975). Vesicular crusts occur primarily in arid and semiarid areas.

Soil Crusts

Soil Crusts—Record the presence of any surface crust. No entry implies that no crust is present. (In NASIS, crusts are included under **Pedoderm**.)

Description—Soil crusts can be identified and recorded by **Kind**. Additional suggested descriptors may include: **Rupture Resistance** (**Surface Crusts and Plates**), **Porosity (Kind)**, **Size**, **Diameter**, **Thickness**, **Amount** (cross-sectional ground coverage), and **Color**.

Soil Crusts – Kind—

Kind	Code	Criteria
biological crusts	MC	biotically dominated surface “mat” of algae, lichens, mosses, etc.; also called biotic, cryptogamic, microbiotic, or microphytic crusts; slightly flexible when moist
mineral crusts	MI	reversibly bonded primary, secondary mineral grains; not biotically dominated; stiff or rigid when moist or dry
chemical crusts	CC	evaporites (e.g., NaCl) or precipitates (e.g., $CaCO_3$)
physical crusts	—	reorganized, reconstituted
raindrop impact crust	RC	dispersed, puddled, dried
depositional crust	DC	sediments of variable thickness
freeze-thaw crust	FC	bare ground, small polygons
vesicular crust/ zone	VC	substantial discontinuous, spherical or ovoid pores (e.g., 0.5 to 4 mm diameter)

Special Features

Record the **Kind** and **Area (Percent) Occupied**. Describe the special soil feature by kind and estimate the cross-sectional area (percent) of the horizon that the feature occupies (e.g., lamellae, 15%).

Special Features – Kind (Called **Horizon_feature_kind** in NASIS)—Identify the kind of special soil feature.

Kind	Code [1]	Criteria
desert pavement [2]	DP	a natural concentration of closely packed and polished stones at the soil surface in a desert (may or may not be an erosional lag)
water repellent layer	HL	either a surface or subsurface layer that repels water (e.g., dry organic materials; scorch layers in chaparral); see p. 7–14
ice wedge cast	IC	a vertical, often trans-horizon, wedge-shaped or irregular form caused by infilling of a cavity as an ice wedge melts; commonly stratified
krotovinas	KR	filled faunal burrows
lamellae [3]	LA	thin (e.g., > 0.5 cm), pedogenically formed plates or intermittent layers
lamina	LN	thin (e.g., < 1 cm), geogenically deposited strata or layers of alternating texture (e.g., silt and fine sand or silt and clay)
stone line	SL	a natural concentration of rock fragments caused by water erosion or transport erosional lag (i.e., carpedolith)
tongues of albic material	E	small areas or lobes of albic material that dip down (interfinger) more than 5 cm into nonalbic material
tongues of argillic material	B	small areas or lobes of argillic material that dip down (interfinger) more than 5 cm into nonargillic material

[1] Conventional codes consist of the entire name (e.g., tongues of albic material). Consequently, no "Conv. code" is shown.

[2] In NASIS, moved to new descriptor (data element) called **Pedoderm**.

[3] In NASIS, described under **Diagnostic_horizon_or_property – kind**.

Special Features – Area (%) Occupied—Estimate the cross-sectional area (%) of the horizon that the feature occupies (see graphics, p. 7–1).

Saturated Hydraulic Conductivity and Permeability (Discussion)

Saturated hydraulic conductivity (Ksat) is the single most scientifically valuable parameter for phenomena related to soil-water flow and transport. Ksat quantitatively defines a soil's capacity to transmit water. Traditionally, NRCS (formerly SCS) used the term "permeability" for water-flow phenomena and used "permeability classes" (PC), which have prescribed percolation rate ranges (originally inches/hr). The PC and associated percolation rates are commonly mistaken to be Ksat. The confusion between Ksat, the term "permeability," and the permeability classes arises for several reasons (Wysocki et al., 2002). A primary reason is that the term "permeability" has three meanings in soil science.

1. Permeability in a qualitative sense describes a soil's capacity to transmit fluids, including water or gases. No quantitative measure is implied. For example, sandy soils are more "permeable" than clayey soils.
2. Permeability (k) (Richards, 1952) (also known as intrinsic permeability) is an exclusive, quantitative porous material parameter controlled by pore geometry. In a stable porous material, (k) is independent of the fluid. Permeability (k) is the hydraulic conductivity (K) times the fluid viscosity (n) divided by the fluid density (ρ) and the gravitational constant (g) (**Eq. 1**). Permeability (k) has area units (e.g., m^2).
3. Permeability is short for permeability coefficient, which is hydraulic conductivity (K), or in saturated soil (Ksat). The Darcy equation quantitatively defines (**Eq. 2**) hydraulic conductivity (K) as the factor that relates flux (q) to the hydraulic gradient (∆h/l). Ksat depends upon both soil and fluid attributes. Measurement units for Ksat depend on the input units. With flux expressed as volume (cm^3), head change (∆h) as cm (cm H_2O/cm), and length as cm, the Ksat units are length/time (cm/s). Note that both variables q and K have units of length/time (cm/s), but they are distinctly different entities. Flux (q), when expressed as length/time, is an apparent rate that varies with ∆h/l. Ksat is a proportionality factor that relates q to ∆h/l. Ksat remains constant when the hydraulic gradient (∆h/l) varies. It is a physical parameter, not a rate.

Eq. 1 **$k = Kn/\rho g$**

k = permeability (cm^2)
K = hydraulic conductivity (cm/sec)
n = fluid (water) viscosity (dyne-sec/cm)
ρ = fluid (water) density (gm/cm^3)
g = gravitation acceleration (cm/sec^2)

Eq. 2 $q = V/At = -K(\Delta h/l)$

Darcy's Equation (one dimensional flow)

q = fluid flux (cm/s)
V = fluid volume (cm^3)
A = cross-sectional area (cm^2)
t = time (s)
K = hydraulic conductivity (cm/s)
Δh = change in hydraulic head (cm)
l = length (cm)

The different permeability meanings have important distinctions that are not scientifically interchangeable. Most importantly, the intended meaning of permeability is *not* specifically discernible from written or verbal context alone. Meaning #1 carries no quantitative implications; meanings #2 and #3 have defined scientific applications. Uhland and O'Neal (1951) developed seven permeability classes (PC) from measurements on about 10,000 3-inch cores collected from 900 sites. They chose the original PC ranges so that each class represented an equal number of measured values from the sample population (Mason et al., 1957). Uhland and O'Neal (1951) measured discharge volume and calculated flux (q) as follows.

Eq. 3 $q = V/At$

V = fluid volume (in^3)
A = cross-sectional area (in^2)
t = time (hr)

Uhland and O'Neal (1951) specifically noted that the calculated value was a percolation rate with units of inches hr^{-1}. These percolation rates defined the permeability class ranges. The Uhland and O'Neal study did not calculate Ksat from Darcy's equation (Eq. 2). The study method employed both a falling and constant head phase during measurement; the hydraulic gradient ($\Delta h/l$) varied and was undefined. Darcy's equation requires a defined hydraulic gradient to solve for Ksat. The PC, therefore, are a set of soil permeability (meaning #1) classes arrayed by a method-specific percolation rate. To obtain an approximation of Ksat for the Uhland and O'Neal (1951) study, one can use the constant head hydraulic gradient (0.857 in) and the flux (V/At) as a general solution of Darcy's equation, which yields V/At times 0.857=Ksat. This solution shows that PC percolation rates, at a minimum, exceed Ksat by about 15 percent. Two errors result if percolation rates are used as a proxy for Ksat. One is added uncertainty when estimating a soil Ksat. Do you decrease the estimate by 15 percent? Secondly, measured Ksat values would not be equivalent to the PC percolation rates. Ksat is the scientific standard for soil-water flow calculations (Hillel, 1980), and there is great scientific merit in using Ksat over PC for soil-water flow interpretations.

Uhland and O'Neal (1951) also developed a set of field-observable properties to link the large number of unmeasured soils to a permeability class. The field properties included structure size and type, aggregate overlap, texture, pores, compaction, and clay mineralogy (O'Neal, 1952). NRCS soil scientists assigned soils to the permeability classes based on this characteristic set, or extrapolation from soils measured in the initial study. The original percolation rate ranges for the PC were altered (Soil Survey Staff, 1971) and an eighth class added. The PC have historic merit and are retained for selected uses.

To avoid the confounding difficulties inherent in the PC and the term "permeability," the Soil Science Division Staff (2017) developed Ksat classes. To summarize:

1. Ksat and the percolation rates (that defined the permeability classes) are different physical parameters. Both Ksat and percolation rates are commonly expressed in units length/time, which presents a false equivalency.
2. Darcy's equation relates Ksat to PC percolation rates. Core percolation rates used in permeability class development exceed Ksat by a minimum 15 percent. Ksat is not a rate.
3. No simple transformation exists to reliably convert PC percolation rates to Ksat. Soils with slower percolation rates have a greater difference between Ksat than those with more rapid percolation rates.
4. To prevent confusion and avoid scientific inaccuracies, NRCS now emphasizes Ksat rather than the term "permeability" and Ksat classes rather than permeability classes.

Saturated Hydraulic Conductivity (Ksat)

Saturated hydraulic conductivity (Ksat) is the ease with which a saturated soil can transmit water through the pore space. Ksat is formally defined as the proportionality factor that relates water flow rate to the hydraulic gradient in Darcy's equation (see Discussion). Ksat is a measurable soil property, or it may be estimated from other properties (texture, structure, bulk density, etc.). Direct field Ksat measurement is possible with various devices (Amoozemeter, Guelph Permeameter, double-ring infiltrometer). Multiple (e.g., ≥ 5) measurement replications are needed on a horizon or layer to capture the natural variation.

Record an estimated **Ksat class** or a measured Ksat value for each horizon/layer. If measured, record the **Average Ksat**, **Standard Deviation**, **Replication Number (n)**, and **Method**. See the "National Soil Survey Handbook," Exhibit 618.88 (Soil Survey Staff, 2024b) for guidelines for Ksat class estimation using texture and bulk density.

Ksat Class	NASIS Code [1]	Criteria [2] µm/s	Criteria [2] cm/hr	Criteria [2] in/hr
very low	#	< 0.01	< 0.0036	< 0.001417
low	#	0.01 to < 0.1	0.00360 to < 0.036	0.001417 to < 0.01417
mod. low	#	0.1 to < 1.0	0.0360 to < 0.360	0.01417 to < 0.1417
mod. high	#	1.0 to < 10	0.360 to < 3.60	0.1417 to < 1.417
high	#	10 to < 100	3.60 to < 36.0	1.417 to < 14.17
very high	#	≥ 100	≥ 36.0	≥ 14.17

[1] For alternative units commonly used for these class boundaries (e.g., Standard International Units [Kg s/ m^3]), see the “Soil Survey Manual” (Soil Science Division Staff, 2017, p. 221).

[2] To convert µm/sec to in/hr, multiply µm/sec by 0.1417; e.g., (100 µm/sec) x (0.1417)=14.17 in/hr. To convert in/hr to µm/sec, multiply by 7.0572.

Permeability Classes

NRCS deemphasizes the use of permeability classes. Use Ksat. The permeability classes are listed here because of historic usage and because they are needed for selected soil interpretations.

Permeability Class	Code	Criteria: Estimated in/hr [1]
impermeable	IM	< 0.0015
very slow	VS	0.0015 to < 0.06
slow	SL	0.06 to < 0.2
moderately slow	MS	0.2 to < 0.6
moderate	MO	0.6 to < 2.0
moderately rapid	MR	2.0 to < 6.0
rapid	RA	6.0 to < 20
very rapid	VR	≥ 20

[1] These class breaks were originally defined in English units and are retained here as no convenient metric equivalents are available.

Chemical Response

Chemical response is the reaction of a soil sample to an applied chemical solution or a measured chemical value. Responses are used to identify the presence or absence of certain materials, to obtain a rough assessment of the amount present, to measure the intensity of a chemical parameter (e.g., pH), or to identify the presence of chemical species (e.g., Fe^{+2}) in the soil.

Reaction (pH) – (Called **Field_pH** in NASIS)—Record **pH** and **Method**; record the pH value to the precision limit of the method (e.g., to the nearest tenth). The preferred method is pH meter for 1:1 (water:soil). In NASIS, record the pH numerical value and the method used (e.g., pH 6.5; 1:1 water:soil).

Descriptive Term	Code [1]	Criteria: pH Range
ultra acid	#	< 3.5
extremely acid	#	3.5 to 4.4
very strongly acid	#	4.5 to 5.0
strongly acid	#	5.1 to 5.5
moderately acid	#	5.6 to 6.0
slightly acid	#	6.1 to 6.5

Descriptive Term	Code [1]	Criteria: pH Range
neutral	#	6.6 to 7.3
slightly alkaline	#	7.4 to 7.8
moderately alkaline	#	7.9 to 8.4
strongly alkaline	#	8.5 to 9.0
very strongly alkaline	#	> 9.0

[1] No codes; enter the measured value.

pH Method (called **ph_determination_method** in NASIS)—Record the method used to measure pH.

pH Method [1]		Code
Indicator Solution [2]	*(pH range)* [1]	
bromocresol green	*3.8 – 5.4*	BG
bromocresol purple	*5.2 – 6.8*	BP
bromophenol blue	*3.0 – 4.6*	BL
bromothymol blue	*6.0 – 7.6*	BB
chlorophenol red	*5.2 – 6.8*	CHR
cresol red	*7.0 – 8.8*	CR
methyl red	*4.8 – 6.0*	MR
phenol red	*6.8 – 8.4*	PR
phenolphthalein	*8.2 – 10.0*	PT
thymol blue	*8.0 – 9.6*	TB
Commercial Colorimetric Kits		
Hellige-Truog (kit)		HT
Lamotte-Morgan (kit)		LM
Soil Test (kit)		ST
pH Meter [2]		
pH meter 1:1 water [3]		M11
pH meter 1:2 water *(0.01 M $CaCl_2$)* [3]		C12
pH meter 1N KCl		M12
pH meter, saturated paste		MSD
Indicator Strips [2]		
indicator paper strip 1N NaF [1]		NF
pH indicator strip (unspecified) [2]		STR
(H)ydrion (unspecified; = hydrogen ion paper strip)		YD
pH unspecified [2, 3]		PHU

[1] Soil Survey Staff, 2014.

[2] The pH method options in NASIS.
[3] Preferred method.

Effervescence—The gaseous response (seen as bubbles) of soil to applied HCl (carbonate test), H_2O_2 (MnO_2 test), or other chemicals. Commonly, ≈1 N HCl is used for carbonate test. Apply the chemical to the soil matrix (for HCl, effervescence class refers only to the matrix; do not include carbonate masses, which are described separately as "Concentrations"). Record the observed response (**Effervescence Class**) and the **Chemical Agent** used. A complete example is: *strongly effervescent with 1N HCl*; or *ST, H2*. ***Note:*** In NASIS, manganese effervescence (by H_2O_2) is handled in separate tables; called "MN_ Effervescence_Agent" and "Mn_Effervescence" classes; class codes and criteria are the same as those for effervescence class."

Effervescence – Class—

Effervescence Class	Code	Criteria
noneffervescent	NE	no bubbles form
very slightly effervescent	VS	few bubbles form
slightly effervescent	SL	numerous bubbles form
strongly effervescent	ST	bubbles form a low foam
violently effervescent	VE	bubbles rapidly form a thick foam

Effervescence – Location (obsolete in NASIS)—Use locations and codes from **(Ped and Void) Surface Features – Location**. ***Note:*** The requirement to apply chemical agents (e.g., HCl) to the soil matrix makes many location choices invalid.

Effervescence – Chemical Agent (In NASIS, the manganese chemical test agent [H_2O_2] is recorded in a separate table [**Mn_effervescence_ agent**].)—

Effervescence Agent	Code	Criteria
HCl (unspecified) [1]	H1	hydrochloric acid: concentration unknown
HCl (1N) [1, 2]	H2	hydrochloric acid: concentration=1 normal
HCl (3N) [1, 3]	H3	hydrochloric acid: concentration=3 normal
HCl (6N) [1, 4]	H4	hydrochloric acid: concentration=6 normal

Effervescence Agent	Code	Criteria
H_2O_2 (unspecified) [5, 6]	P1	hydrogen peroxide: concentration unknown
H_2O_2 [5, 6]	P2	hydrogen peroxide: concentration 3-4%

[1] Positive reaction indicates presence of carbonates (e.g., $CaCO_3$).

[2] The only HCl concentration used for the effervescence field test. ***Note:*** A (1N HCl) solution is made by combining 1 part concentrated (37%) HCl (which is widely available) with 11 parts distilled H_2O.

[3] Use 3N HCl to determine the calcium carbonate equivalent test. It is not used for effervescence class. An approximately 3N HCl solution (10% HCl or 2.87N) is made by combining 6 parts 37% HCl (which is widely available) with 19 parts distilled H_2O.

[4] A 6N HCl solution is used to distinguish between calcium and dolomitic carbonates. Dolomite reaction is slower and less robust than $CaCO_3$ effervescence. A 6N HCl solution is made by combining 1 part concentrated (37%) HCl (which is widely available) with 1 part distilled H_2O. Soil sample should be saturated in a spot plate and allowed to react for 1 to 2 minutes; froth is a positive response.

[5] Rapid reaction indicates presence of manganese oxides (e.g., MnO_2). Not used to determine effervescence class.

[6] Under ambient conditions, Mn-oxides react rapidly whereas most organic matter reacts slowly with (3-4%) H_2O_2.

Reduced Conditions (called **Reaction_to_alpha-dipyridyl** in NASIS)—Record under “Miscellaneous Field Notes / Sketch” if evaluated.

Chemical Agent	Code	Criteria
α,α-dipyridyl [1] (0.2% conc. [3])	P	positive reaction [2]: red or pink color develops
	N	negative reaction: no color develops

[1] Commonly stated as “alpha-alpha dipyridyl.”

[2] Positive reaction indicates presence of Fe^{+2} (i.e., reduced conditions).

[3] Childs, 1981.

Dipyridyl – Location—Describe the location(s) where the chemical test was conducted (use "Concentrations – Location" table); e.g., in the matrix (MAT).

Salinity Class (Discussion)—Soil salinity classes are based on electrical conductivity from a saturation paste extract. Gypsum ($CaSO_4 \cdot 2H_2O$) and salts more soluble than gypsum (e.g., Na, Mg, and Ca chlorides and sulfates) are the sole or major contributors to the saturated paste extract EC.

Note: Electrical conductivity may be measured at various soil solution extract ratios (e.g., 1:1, 1:2, 1:5). The resultant EC values are not directly comparable because of the dilution effect. The salinity standard is the saturated paste extract EC. To avoid confusion, saturated paste EC is commonly denoted as ECe and other extracts denoted by the dilution ratio (e.g., $EC_{1:1}$).

In addition to solution extracts, field measures of EC exist (e.g., electromagnetic induction [EMI], salinity probes). These measurements obtain an EC value that depends on salinity, moisture content, mineralogy, and texture. Such EC measurements are *not* directly comparable to ECe or EC of any extract ratio. For example, the electromagnetic induction (EMI) EC is known as apparent EC, which is denoted as ECa.

Salinity Class—Estimate the **Salinity Class**. If the electrical conductivity is measured, record the **EC Value** (under "Miscellaneous Field Notes / Sketch"). Salinity class is based on saturated paste extract EC.

Salinity Class	Code	Saturated Paste – ECe dS/m
nonsaline	0	< 2
very slightly saline	1	2 to < 4
slightly saline	2	4 to < 8
moderately saline	3	8 to < 16
strongly saline	4	≥ 16

Sodium Adsorption Ratio (SAR)—A measure of ion equilibrium between sodium (Na) in solution and exchangeable Na adsorbed on the soil (Soil Survey Staff, 2011). It is applied to soil solution extracts and irrigation waters. $SAR=(Na^{+})/([(Ca^{+2}) + (Mg^{+2})]/2)^{0.5}$, where the cation concentration is in milliequivalents per liter. As a field method, it is commonly determined with soil paste and an electronic wand.

Odor

Odor – Kind—Record the **Kind** and relative **Intensity of odor (by horizon)** immediately after soil is exposed to air. The presence of an intense hydrogen sulfide odor (H_2S; rotten egg) is commonly associated with a strongly anaerobic horizon where sulfate is reduced to sulfide (Fanning and Fanning, 1989).

Odor – Kind	Code	Criteria
none	N	no odor detected
petrochemical	P	presence of gaseous or liquid gasoline, oil, creosote, etc.
sulfurous	S	presence of H_2S (hydrogen sulfide); “rotten egg” smell; commonly associated with strongly reduced soil containing sulfides

Odor – Intensity *(proposed)*—Estimate and record the relative intensity of any odor present.

Odor Intensity	Code	Criteria: Relative Intensity of Odor
slight	SL	odor is faint (e.g., only detected when sample is brought close to nose)
moderate	MD	odor is readily noticeable at arm’s length as one handles the material (e.g., intermediate intensity); only detected as one starts to dig into the material
strong	ST	odor is quite intense and readily detected before or immediately after the sample is exposed to air

Miscellaneous Field Notes / Sketch

Use additional descriptors and sketches to capture and convey information and features with no existing data element. Record as freehand notes under **Miscellaneous Field Notes / Sketch**.

Minimum Data Set (for a Soil Description)

Purpose, field logistics, habits, and soil materials all influence the specific properties necessary to adequately describe a given soil. However, some soil properties or features are so universally essential for interpretations or behavior prediction that they should always be recorded. These include: **Location**, **Horizon**, **Horizon Depth**, **Horizon Boundary**, **Color**, **Redoximorphic Features**, **Texture**, **Structure**, and **Consistence**.

Pedon Description Data Sheet

Over the years, field data for soils have been documented in various ways. For many years, soil descriptions were made on small blue cards (form SCS-SOI-232, USDA SCS, various versions, dates, and locations of issuance). In past years, data was entered into multi-page PEDON (PDP) data sheets (form SCS-SOI-232, USDA SCS, 1987). MLRA Soil Survey Regions generated informal, locally tailored data sheets. The included “Pedon Description” form (p. 2-95) and the “Subaqueous Pedon Description” form (p. 2-113) are national in scope.

The following (blank) data sheet is provided to record basic soil description information. This data sheet contains the most widely used soil descriptors (e.g., depth, color). Other descriptors (called “data elements” in NASIS) should be added as needed in blank boxes or under “Miscellaneous Field Notes / Sketch.”

Pedon Description Example

A completed profile description data sheet is included to demonstrate recording soil information in the field.

Most field descriptions will likely be entered into an electronic database by the describer or must be deciphered by other scientists. Therefore, descriptions should use reasonably mnemonic abbreviations, standard codes, or a combination of these or be written in “longhand” (using complete words). The following profile description contains examples of all of these conventions.

Soil descriptions in soil survey reports, Official Soil Series Descriptions (OSDs), or other NRCS products should follow prescribed formats and descriptor sequences (i.e., “National Soil Survey Handbook,” Part 614; Soil Survey Staff, 2024).

Pedon Description

Transcect ID #: | **Pedon ID #** | **Waypoint:** | **July 2024**

Series sampled as	Series correlated to	Map Unit Sym	Classification	Soil Moist. Regime

Describer(s)	Date	Weather	Temp. *Air:* *Soil:* *Depth:*	Latitude " N / Longitude " W	Datum:	Soil Temperature Regime

Site ID *Yr:* *State:* *County:* *Pedon #:*	Soil Survey Area	MLRA	Transect Interval / Transect Stop #	Aspect (deg)	Slope (%)	Slope Complexity

Landscape	Landform 1	Landform 2	Microfeature/Microrelief	Elevation (m)	Elevation (ft)	Slope Shape *(Up & Dn)*	Slope Shape *(Across)*

2-D Hillslope Profile Position	3-D Geom. Component	Physio. Division	Physio. Province	Physio. Section	Cover Kind One	Cracks *Depth* *Freq* *Kind*

Drainage	Flooding	Ponding	Soil Moisture Status	Permeability / Ksat	Cover Kind Two

Parent Material	Bedrock *Kind:* *Fract.:* *Hard.:* *Depth:*	Lithostrat. Units *Group* *Formation* *Member*

Erosion *Kind* *Degree*	Surface Fragments *Kind:* *Total %:*	*CB %* *76-250 mm*	*ST%* *>25-60 cm*	*BD %* *> 60 cm*		Soil Crust *Kind* *Thickness*

PS Control Section	Tdepth	Bdepth	Avg Clay%	Avg Frag %

Vegetation

Symbol	Common Name	%GD Cover

Miscellaneous Field Notes / Sketch

Diagnostic Horizons

Kind	Tdepth	Bdepth

Sampled as		Date	
Correlated to		Map Unit Symbol	

	Obs Method	Depth (cm)		Horizon	Boundary		Matrix Color					Texture class	Clay	Sand	Fragments						Structure			Consistence			
		top	bot		dist	top	mst	%	hue	val	chr		%	%	kind	vol %	rnd	shp	size	hard	grd	size	type	type	value	type	value
1																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											

	Redoximorphic Features									Concentrations or Mottles									Ped / Void Surf. Features					Roots	Pores	pH	Eff
	%	size	cntrst	hard	shp	kind	loc	bnd	color	%	sz	cntrst	hard	shp	kind	loc	bnd	color	%	kind	dist	loc	color	qty sz loc	qty sz cont shp	meth	agent
1																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											

Pedon Description

Transect ID #:		Pedon ID #		Waypoint:		July 2024

Series sampled as	Series correlated to	Map Unit Sym	Classification	Soil Moist. Regime
Dormont	Dormont	DoD	Fine-loamy, mixed, superactive, mesic Oxyaquic Hapludalfs	udic

Describer(s)	Date	Weather	Temp.	Latitude / Longitude	Datum:	Soil Temperature Regime
AWD-WRK	08/02/2024	sunny	Air: 65 F; Soil: ; Depth:	Latitude 40.17389 " N; Longitude -79.79333 " W	NAD83	mesic

Site ID (Yr: State: County: Pedon #:)	Soil Survey Area	MLRA	Transect Interval / Transect Stop #	Aspect (deg)	Slope (%)	Slope Complexity
04PA129001	PA129	126		300	20	simple

Landscape	Landform 1	Landform 2	Microfeature/Microrelief	Elevation (m)	Elevation (ft)	Slope Shape (Up & Dn)	Slope Shape (Across)
hills	hill			308		linear	

2-D Hillslope Profile Position	3-D Geom. Component	Physio. Division	Physio. Province	Physio. Section	Cover Kind One	Cracks (Depth, Freq, Kind)
backslope	side slope		Appalachian plateau	Kanahwa	grass	none

Drainage	Flooding	Ponding	Soil Moisture Status	Permeability / Ksat	Cover Kind Two
moderately well	none	none	moist throughout	Permeability: slow; Ksat: moderately low	pasture

Parent Material	Bedrock Kind:	Fract.:	Hard.:	Depth:	Lithostrat. Units (Group, Formation, Member)
siltstone residuum	shale	5	ST	225	Formation: Monongahela fm.

Erosion (Kind, Degree)	Surface Fragments	CB % 76-250 mm	ST% >25-60 cm	BD % > 60 cm	Soil Crust (Kind, Thickness)
none	Kind: ; Total %: 0				none

P.S. Control Section	Tdepth	Bdepth	Avg Clay%	Avg Frag %
	28	78	29	6

Vegetation

Symbol	Common Name	%GD Cover
PHPR3	Timothy	40
DAGL	Orchardgrass	30
ROMU	multiflora rose	20
POPR	Kentucky bluegrass	10

Miscellaneous Field Notes / Sketch

Diagnostic Horizons

Kind	Tdepth	Bdepth
ochric	0	28
argillic	28	157

Sampled as	Dormont	Date	08/02/2024
Correlated to	Dormont	Map Unit Symbol	DoD

	Obs Method	Depth (cm) top	Depth (cm) bot	Horizon	Boundary dist	Boundary top	Matrix Color mst	%	hue	val	chr	Texture class	Clay %	Sand %	Fragments kind	vol %	rnd	shp	size	hard	Structure grd	size	type	Consistence type	value	type	value
1							d		10YR	6	3				SIS	3	SR	FL	5-50	IN				rupt	FR	plast	SP
		0	28	Ap	A	W	m		10YR	4	3	SIL	20	22	SH	2	SA	FL	10-40	IN	2	F	GR	stick	SS		
2															SIS	4	SA	FL	5-50	IN				rupt	FI	plast	SP
		28	53	Bt1	C	W			7.5YR	5	6	SIL	24	20	SH	1	SA	FL	10-40	IN	3	M	SBK	stick	SS		
3																								rupt	FI	plast	MP
		53	79	Bt2	C	W			7.5YR	6	6	SICL	32	18	SIS	10	AN	FL	5-80	IN	2	M	SBK	stick	MS		
4																								rupt	FI	plast	MP
		79	117	Bt3	G	W			10YR	6	3	CN-SICL	32	15	SIS	20	AN	FL	15-100	IN	3	MC	SBK	stick	MS		
5																		FL						rupt	FI	plast	SP
		117	157	Bt4	G	W			10YR	6	4	CNV-SICL	32	15	SIS	40	AN	FL	10-140	IN	3	MC	SBK	stick	SS		
6																								rupt	FI	plast	SP
		157	191	BC	C	W			10YR	6	4	CNX-SICL	30	15	SIS	75	AN	FL	15-125	IN	1	C	SBK	stick	SS		
7															SIS	5	AN	FL	150-300	IN				rupt	VFI	plast	SP
		191	210	C	A	W			10YR	6	3	CNX-SICL	30	18	SIS	75	AN	FL	15-150	IN	0		MA	stick	SS		
8																								coh	IN		
		210	215	R								BR			SIS												

	Redoximorphic Features %	size	cntrst	hard	shp	kind	loc	bnd	color	Concentrations or Mottles %	sz	cntrst	hard	shp	kind	loc	bnd	color	Ped / Void Surf. Features %	kind	dist	loc	color	Roots qty	sz	loc	Pores qty	sz	cont	shp	pH meth	Eff agent
1																								2	F	T					6.4	
																								2	VF	T	1	F	M	DT	BB	
2																			10	CLF	F	APF	10YR 5/4	.1	VF	P					5.6	
																															CHR	
3																			30	CLF	D	APF	10YR 5/6	.1	VF	P					5.6	
																															CHR	
4	15	1	D	S	i	F3M	MAT	D	10YR 6/6										40	CLF	D	APF	10YR 6/3								5.8	
	15	1	D	S	i	FED	MAT	D	10YR 6/6																						CHR	
5	25	2	D	S	I	F3M	MAT	D	10YR 5/6										20	CLF	D	APF	10YR 6/4								6.0	
	20	2	D	S	I	FED	MAT	D	10YR 6/1																						CHR	
6	25	3	D	S	I	F3M	MAT	D	7.5YR 5/6																						6.0	
	20	3	D	S	I	FED	MAT	D	10YR 7/1																						CHR	
7	10	2	P	2	I	MNF	APF	D	10YR 2/1																						6.2	
																															CHR	
8																																

Subaqueous Soil (SAS) Description

Discussion—Permanently submerged mineral or organic substrates covered by relatively shallow water display recognizable soil morphology and meet Simonson's soil formation (1959) model in that chemical and physical additions, losses, transformations, and translocations created the morphology. Such soils are informally known as subaqueous soils. Kubiena (1953) proposed a comprehensive classification that included subaqueous soils. More recently, Demas (1993, 1998) and Demas et al. (1996) reintroduced subaqueous soil concepts in the U.S. Recent reviews (Stolt and Rabenhorst, 2012; Soil Survey Staff, 2024) provide comprehensive treatment of subaqueous soil settings and processes. Payne (2010) presents operational methods for subaqueous soil inventory. The 13th edition of "Keys to Soil Taxonomy" (Soil Survey Staff, 2022) recognized subaqueous soils as suborders of Entisols and Histosols (Wassents and Wassists) that meet the criterion of "a field observable water table 2 cm or more above the soil surface for more than 21 hours of each day in all years."

The description of subaqueous soils is similar to that of terrestrial soils but differs in several important ways. Many subaqueous soil parameters (color, texture, RMF, etc.) fit traditional descriptive conventions outlined in this field book. The unique setting and morphology of subaqueous soil coupled with its recent scientific import warrant a separate section that presents all descriptors in one place. This section includes description forms and subaqueous soil description examples. ***Note:*** The most prevalent subaqueous settings are coastal marine or brackish estuarine. The descriptive conventions presented here reflect this. Freshwater subaqueous settings may require additional descriptors.

Subaqueous Soil Description—Record subaqueous soil profile information using the following parameters. ***Note:*** "Field Book" soil descriptors presented elsewhere (e.g., horizon) have page number references. Please refer to the cited page for complete choice lists.

Bathymetry

Bathymetry is the measurement of sea- or lake-floor or river bottom relief. Because of nautical importance, bathymetric data are commonly expressed as a depth from the water surface at mean lower low water (MLLW) tidal datum to the bottom. The water surface reference in a coastal setting is commonly mean low water (MLW) or mean tide level (MTL) (see graphic on p. 2–101). Lack of bathymetric data often requires field collection of such data during subaqueous soil survey. Protocols for bathymetric data collection are addressed elsewhere (Payne, 2010; Bradley and Payne, 2010).

The inverse of water depth is the subaqueous soil survey relief, which is useful for interpretation of subaqueous geoforms (landforms) and geomorphic description. Geomorphic description for subaqueous soils follows the same convention as those for terrestrial soils (p. 1–4). A compendium of subaqueous geoforms exists in the “Geomorphic Description System (GDS)” (Schoeneberger and Wysocki, 2017).

Site Description

Site/Pedon ID—Record the site/pedon identification number, such as the “Soil Survey Site Identification Number” (see p. 1–2). A complete example is *S2024RI009014A*. (Translation: This is a pedon sampled [*S*] for soil characterization during 2024 [*2024*], from Rhode Island [*RI*], in Washington County [*009*]; it is the fourteenth pedon [*014*] sampled in that county during 2024; and it is a satellite sample [*A*] related to the primary pedon.)

Date—Record the date the sample was collected (e.g., MM/DD/YYYY).

Time: Start/End—Record the time that the pedon was opened (start time) and exposed to aerobic conditions for description and the time that the description was finished (end time). ***Note:*** First describe soil color and other soil properties that can change as a result of oxidation.

Describer(s)—Record the name or initials of the person, or people, describing the core (e.g., Herman Munster or HM).

Waypoint (Number)—Record the GPS waypoint number.

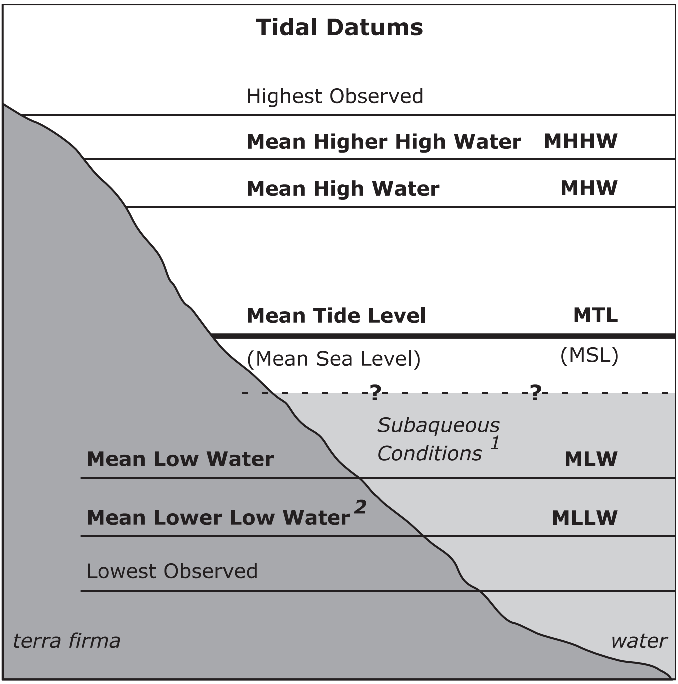
GPS (Model)—Record the GPS model used. (In NASIS, this is a text field.)

Coordinates—Record the sample site GPS coordinates. Use standard latitude and longitude (decimal degrees). ***Note:*** For subaqueous soils, location is always obtained as a GPS coordinate.

Geodetic Datum—Record the Geodetic Datum (called **GPS Datum** in NASIS) used (e.g., WGS84).

Elevation—Elevation should be normalized relative to an appropriate vertical or tidal datum. In the U.S., use the North American Vertical Datum, 1988 (NAVD88). This elevation datum is the standard shown on recent USGS topographic maps. ***Note:*** For elevations below mean tide level (MTL), a minus sign precedes the numerical value (e.g., -1.2 m). For terrestrial anthropogenic water bodies (e.g., reservoir), the elevational reference (datum) is the design pool level.

Tidal Datum (Discussion)—In a tidal system, a tidal datum is the elevation of the contact between open water and the land at a specified mean tidal level. A variety of tidal datums are commonly used (see "Tidal Datums" graphic). Mean tide level (MTL) is the average of all tidal fluctuation in a given area and represents the land-water interface on conventional topographic maps. It is also the datum to which terrestrial elevations are normalized. Mean high water (MHW) and mean low water (MLW) represent typical 24-hour tidal cycles. Mean higher high water (MHHW) and mean lower low water (MLLW) are based on lunar cycles that increase the amplitude of tides. Nautical charts used for boating are based on mean lower low water in an attempt to represent minimum water depths for navigation. Highest and lowest observed water depths are often related to severe storm events (e.g., storm surge) that exaggerate the typical tidal water depth. Specific vegetative communities are associated with the various tidal datums.



[1] Stylized SAS upper limit: ≥ 21 hours submerged/day (Soil Survey Staff, 2024).

[2] Tidal datum widely used on nautical maps for navigational context.

Map Unit Symbol—Record the map symbol in which the sample site occurs.

Location Description—Record relevant geographic information (e.g., Greenwich Bay, Warwick, RI–southeastern shoreline, 1300 m SE of Sally Rock Point).

Water Depth—Record water depth at observation time (e.g., 120 cm).

Bottom Type—Record the dominant bottom type (used in combination with subaqueous vegetation type) at the sample site (e.g., sand).

Bottom Type [1]	Criteria
algal substrate	substrate composed of algae in various states of decomposition or growth (e.g., macroalgae and attached sponges)[1]
anthropogenic substrate	substrate primarily composed of mineral or manufactured materials that were purposefully or accidentally deposited by humans (e.g., artificial reefs, dredge deposits, stone, breakwater materials, etc.)[1]
coarse unconsolidated mineral substrate — gravelly or cobbly	< 5% surface cover with fragments 2 to 250 mm in size[1]
coarse unconsolidated mineral substrate — very gravelly or cobbly	5 to < 50% surface cover with fragments 2 to 250 mm in size[1]
coarse unconsolidated mineral substrate — extremely gravelly or cobbly	≥ 50% surface cover with fragments 2 to 250 mm in size[1]
coral substrate	nonliving coral reefs (or coral particles) constitute this benthic substrate; the substrate may or may not be inhabited by live corals[1]
mud (obsolete)	silty, clayey, or organic bottom matrix
fine unconsolidated mineral substrate — fine	soil surface layer with textures of coarse sandy loam or finer; these areas are very fluid muds or thin oxidized surface muds (former bottom-type mud); < 5 percent cover of rock fragments[1]

Bottom Type [1]	Criteria
fine unconsolidated mineral substrate — sand	soil surface layer with textures of loamy very fine sand and coarser; these areas are bare sands, thin oxidized surfaces of sands, or ripple sand bedforms; < 5% cover of rock fragments[1]
organic substrate	substrate is primarily composed of nonliving organic material, likely a former tidal marsh platform[1]
sand (obsolete)	sandy bottom matrix
shell substrate	bottom dominated by shells or shell fragments; a biogenic substrate that is primarily composed of shells or shell particles (e.g., clams, mussels, oysters, and scallops); the shells could also consist of nonliving mollusks; this substrate could consist of attached oysters, mussels, clam beds, or scallop beds[1]
subaquatic vegetated substrate	vegetated substrate composed of subaquatic species; the vegetated coverage should be estimated and the species identified (*Zostera*, *Ruppia*, *Halodule*, *Halophila*, *Thalassia*, etc.)[1]
worm substrate	biogenic substrate that is primarily composed of the cemented or conglomerated (fine or sandy) tubes of polychaetes or other worm-like fauna[1]
stony or bouldery	bottom sparsely covered by stones or boulders (0.01 to < 0.1%)
very stony or very bouldery	bottom partially covered by stones or boulders (0.1 to < 3%)
extremely stony or extremely bouldery	bottom dominated by stones or boulders (3 to < 15%)
gravelly or cobbly	bottom sparsely covered by gravel or cobbles (0.01 to < 0.1%)
very gravelly or very cobbly	bottom partially covered by gravel or cobbles (0.1 to < 3%)
extremely gravelly or extremely cobbly	bottom dominated by gravel or cobbles (3 to < 15%)
rubbly	bottom substantially covered by large rock fragments > 250 mm (15 to < 50%)

Bottom Type [1]	Criteria
very rubbly	bottom extensively covered by large rock fragments > 250 mm (≥ 50%) [2]
bedrock	substrate with mostly continuous formations of bedrock that cover 50% or more of the substrate surface

[1] These bottom types have been used in coastal SAS mapping. Other types exist and should be added as necessary. A formal ecologically based substrate array is found in the "Coastal and Marine Ecological Classification Standard" (Federal Geographic Data Committee, 2012).

[2] If the surface rock fragments are more than 80 percent, the fragments are described as a distinct horizon and should be described as such.

Submerged Aquatic Vegetation (SAV) (In NASIS, called **Vegetation_ plot** table) (e.g., ZOSTE [*Zostera L.*], eelgrass).—Record the **Plant Symbol**, **Plant Scientific Name,** and **Plant Common Name** of aquatic plants observed at the site (see p. 1–16). It is helpful to record the estimated percent cover for each major plant.

Observation Method—For each layer, describe the **Kind** of sampling device or procedure used to make observations of the site. Methods and tools for SAS are listed in the following table.

Kind (called **Observation Method** in NASIS)—

Kind	Code	Criteria: Tools and Methods
bucket auger	BA	open, closed, sand, or mud buckets (5-12 cm diam.)
dutch or mud auger	DA	an open, strap-sided bucket auger (5-10 cm diam.) with a sharpened outer edge and a screw tip with a partial twist
dive observation	DV	a visual, onsite assessment performed under water
Macaulay sampler	MS	a half-cylinder "gouge" sampler with a hinged door that's pushed in and partially rotated to obtain a sample of soft sediments (e.g., organics)
vibracore tube	VT	a hollow tube (e.g., 4-8 cm diam.) vibrated into wet sands, silts, or organics
video	VO	electronically recorded photo or sequential digital images of a subaqueous setting or site

(Soil) Drainage Class—Subaqueous soils have, by definition, a *subaqueous* (soil) drainage class (p. 1–10). There is a positive water potential at the soil surface for more than 21 hours of each day. The soils have a *peraquic* soil moisture regime.

Water Column Measurements

Water quality measurements are not required but are recommended to provide supplemental information on the specific aquatic environment in which the soil occurs. Lenses of differing water qualities can occur within subaqueous environments; this is the reason for two water depth measurements (e.g., halocline and / or thermocline).

pH—Measure the pH (see p. 2–88) at two depths within the water column above the soil.

pH (#)	Criteria
pH top	within 10 cm of the water surface
pH bottom	within 10 cm of the bottom

pH Method—Record the pH method used, as there can be considerable difference between methods (see p. 2–88).

Dissolved Oxygen or DO (mg/l)—Measure the dissolved oxygen (DO) at two depths within the water column above the soil.

Dissolved Oxygen (DO) (#)	Criteria (mg/l)
DO top	within 10 cm of the water surface
DO bottom	within 10 cm of the bottom

Salinity (ppt)—Measure the salinity; record in parts per thousand (ppt) at two depths within the water column above the soil. Measurement methods include handheld salinity meters and refractometers (e.g., YSI salinity meter, and Vee Gee refractometer).

Salinity (#)	Criteria
salinity top	within 10 cm of the water surface
salinity bottom	within 10 cm of the bottom

Water Temperature—Record the water temperature at two depths within the water column above the soil.

Water Temperature (#)	Criteria: Degrees (Celsius [°C])
water temperature top	within 10 cm of the water surface
water temperature bottom	within 10 cm of the bottom

Soil Profile Measurements and Description

Horizon and Layer Designations—See p. 2–2.

Horizon Suffixes for Subaqueous Soils (*Discussion*)—Among the conventional list of horizon subscripts (see "Horizon Subscripts," p. 2–4), several suffixes are used extensively for subaqueous soils and warrant brief clarification:

g: Strong gleying—The suffix *g* is used for soil horizons (including subaqueous soils) where Fe has been reduced and pedogenically removed, resulting in a color of chroma 2 or less. ***Note:*** Subaqueous soils are permanently submerged, and most are dominated by reduced conditions and subsequent gray colors, indicated by the use of the g suffix. The *g* is not applied to soil materials with gray colors attributed to the natural color of the geologic material from which they are derived (geogenic colors; e.g., gray shales).

se: Presence of sulfides—This symbol indicates the presence of sulfides in mineral or organic horizons. Horizons with sulfides typically have dark colors (e.g., value ≤ 4, chroma ≤ 2).

Discussion: An *se* horizon typically forms in coastal soil environments that are permanently saturated or submerged (e.g., low tidal marshes, lagoons, and some freshwater marshes or swamps). Soil materials in which sulfur reduction actively occurs release hydrogen sulfide gas (H_2S), which is detectable by its distinctive odor (Fanning and Fanning, 1989; Fanning et al., 2002). ***Note:*** Not all sulfide-bearing soil materials produce hydrogen sulfide gas. Sulfides may also occur in drier (oxidized) upland environments that have a geologic sulfide source. Examples include soils formed in parent materials derived from coal deposits (e.g., lignite) or soils that formed in coastal plain deposits (e.g., marcasite or pyrite) that have not been oxidized because of thick layers of overburden.

Lithologic Discontinuities *(Discussion)*—Describe the presence of any lithologic discontinuities (see p. 2–5: “Numerical Prefixes;” “The Prime”). Contrasting changes in parent material are indicated in soil horizon nomenclature by a sequential numeric prefix (e.g., *A–Bw–**2**Bw–**3**C*). ***Note:*** The prefix “1” is implied and not shown by convention. Discontinuities in subaqueous soils are described when there is a significant change in particle size or mineralogy that indicates the material was deposited by a different process. Important examples are a discontinuity at the change from material deposited in a marine environment to older material deposited on land and later inundated, or sand deposited over marsh organics. In contrast, deposits of similar particle size from multiple washover events on a washover-fan flat behind a barrier island (different washover depositions from significant events) would ***not*** be described as discontinuities (analogous to finely stratified alluvium).

Use of Primes – (called **Horz_desgn_master_prime** in NASIS)—A prime (′) is used for horizons with identical characters that are separated by a horizon with different designations (see p. 2–5). The prime symbol (′), where appropriate, is placed after the master horizon designation and before the lowercase suffix letter symbols that follow it (e.g., B′t). In cases where three to five horizons have identical letter symbols, three to five prime symbols can be used for the other horizons (e.g., A, Cg, Aseb, Cseg1, Cseg2, A**′**seb, Cseb, A**″**seb, C**′**seb).

Horizon Thickness—See p. 2–6.

Horizon Boundary—Record **Horizon Boundary Distinctness** when possible (see p. 2–6). ***Note:*** The **Horizon Boundary Topography** cannot be adequately determined from small auger, push tube, or vibracore samples.

Rocks and Other Fragments (Coarse Fragments)—Describe the **Kind**, **Size**, and **Quantity** (percent vol.), **Roundness**, etc., of rock and other coarse fragments in each horizon (see p. 2–46). Shell fragments 2 mm or more are considered to be coarse fragments and are often flat like a channer.

Field Texture Class—Estimate the **Field Texture Class** by hand for each horizon (see p. 2–35).

Soil Color—Record the Munsell color of the soil matrix (see p. 2–8). Include **Color Condition** as needed (e.g., *reduced*).

Reaction to H_2O_2– (*Peroxide 3% and 30%)*—see “Subaqueous Soil Profile Description” form**)** (In NASIS, called H_2O_2 3% and 30% Reaction)

Peroxide 3%—Record the soil color response, as either **yes (Y)** or **no (N)** (check box in NASIS Pedon Horizon row), to the application of 3% H_2O_2 solution immediately after exposure to air (e.g., a freshly broken ped or core interior). A positive reaction (color change) indicates the presence of monosulfides (FeS), which quickly oxidize and change color upon application of hydrogen peroxide. Peroxide color change is an immediate (within 10 seconds), discernible color change upon addition of H_2O_2. ***Note:*** This method is for monosulfide detection only and is *not* applicable to other sulfides (e.g., pyrite, marcasite, FeS_2).

Monosulfides, often in the form of Fe(II) monosulfides (FeS), are visible in reduced soil as a black color (e.g., 10YR 2/1 or N 2.5/0). When a sulfidic soil is oxidized, either in place due to oxidized water conditions or when the soil is drained or excavated and thus exposed to air (oxidized), Fe(II) converts to Fe(III) and the typical black color is lost, leaving a gray or brown color (Lyle, 1983). An example of a common monosulfide oxidation reaction is: $4FeS + 9O_2 + 10H_2O = 4Fe(OH)_3 + 8H^+ + 4SO_4$.

Peroxide 30%—Record the soil effervescence class response to the application of 30% H_2O_2 solution to a freshly broken ped or vibracore interior. Listed below are the 30% peroxide effervescence classes (choice list in NASIS):

30% H_2O_2	**Effervescene Reaction Criteria**	**Audible Reaction Criteria**
none	no visible effervescence	no audible reaction
slight	few (fine or very fine) effervescence bubbles to none	slightly audible reaction (slight fiz / sizzle)
moderate	effervescence visible with bubbles forming	audible reaction (snap, crackle, and pop)
strong	effervescence visible with a low foam and some gas release	audible reaction (snap, crackle, and pop)
violent	effervescence visible with a thick foam and gas forming	audible reaction with gas bubbles released

Acid Volatile Sulfides (AVS) Presence Test—A positive odor for acid volatile sulfides (AVS) indicates the presence of meta stable iron sulfide compounds, a rapid field test for the presence of monosulfides. If hydrogen sulfide odor is detected, check the **AVS Presence Test** box in NASIS in the “Pedon Horizon” row.

The Acid Volatile Sulfides (AVS) Test is a rapid field/lab test to identify the presence of monosulfides in the subaqueous and subaerial soils in the estuarine environment. It is an indication of metastable iron sulfur compounds such as mackinawite (Wessel and Rabenhorst, 2017). This test is especially important when soils fail to test positive using the standard sulfide "whiff test" or the hydrogen peroxide color change or effervescence tests.

> **Procedure**: Place a pinch of soil, from a freshly exposed sample, in a sealable plastic bag, add a few drops of 10% HCL, close the bag, and allow several seconds for a reaction. Open the bag and apply the "whiff test", H_2S gas smell is positive for monosulfides (Wessel and Rabenhorst, 2017).

> ***Caution***: Hydrogen sulfide is a toxic gas and care should be taken with this test — a broad sweep of the hand to the nose in the open air while approaching a small sample of the material is commonly used (Australian Soil Taxonomy System, reviewed 2016).

Odor—Record the **Kind** and **Intensity** of odor (by horizon) immediately after soil is exposed to air. The presence of an intense hydrogen sulfide odor (H_2S; "rotten egg" smell) is commonly associated with a strongly anaerobic horizon where sulfate is reduced to sulfide (Fanning and Fanning, 1989). See p. 2–92

> **Soil Odor Kind** is **Sulfurous** with odor intensities of none, slight, moderate, or strong.

Reaction by Oxidized pH (Discussion) (Not a field test)—Oxidation of sulfides creates sulfuric acid as a byproduct that lowers pH. Monosulfidic materials are typically identified in the laboratory using an "oxidized pH" measurement (pH 1:1 water by pH meter), in which a soil undergoes aerobic incubation for at least 16 weeks and the change in pH measurements are compared over time (especially initial vs. final). Sulfidic materials are indicated when 1) the initial pH > 3.5 and 2) after oxidation, the pH decreases by ≥ 0.5 unit to a value ≤ 4.0 within 16 weeks (or longer if the pH is still dropping after 16 weeks) until the pH reaches a nearly constant value. Exposure and oxidation of sulfidic materials (acid sulfate weathering) result in a sulfuric horizon via the formation of sulfuric acid. Field pH is initially measured either immediately after sampling or after thawing a frozen sample. Care should be taken to prevent oxidation of the sample prior to starting the aerobic incubation period and measurements. Hydrogen peroxide has also been used to determine the presence of reduced sulfides in soil samples with pH measurements made after complete oxidation with H_2O_2 (Finkelman and Giffin, 1986; Jennings et al., 1999). Hydrogen peroxide speeds up the natural oxidation reaction and can be represented in the following

reaction as:
$2FeS + 9H_2O_2 = 2Fe(OH)_3 + 2SO_4^{2-} + 4H^+ + 4H_2O$.

Reaction by Oxidized pH (Laboratory Test)—Measure the pH over time; report the initial and final pH (after 16 weeks) and compare results for evidence of pH reduction over time.

Fluidity Class—See p. 2–66, under “Manner of Failure.” Record the Fluidity class of each horizon/layer. (***Note:*** Fluidity is estimated by squeezing a moist to wet palmful of soil and observing the extent to which the soil flows out between clenched fingers. Fluidity classes are based on the degree of “flow.” Soil bearing capacity decreases as fluidity increases.)

Fluidity Class	Code	Criteria
nonfluid	NF	after full compression, no soil flows through the fingers; *n* value < 0.7
slightly fluid	SF	after full compression is exerted, some soil flows through fingers; most remains in the palm of the hand; *n* value is 0.7 to 1.0
moderately fluid	MF	after full pressure is exerted, most soil flows through fingers; a small residue remains in the palm of the hand; *n* value is > 1.0 to < 2.0
very fluid	VF	under very gentle pressure, most soil flows through the fingers as a slightly viscous fluid; very little or no residue remains in the palm of the hand; *n* value is ≥ 2.0

Origin—Record the source of parent material from which the soil is derived (e.g., estuarine deposit).

Site Notes and **Notes**—Describe supplemental information in the **Site Notes** area or the **Notes** column on the description form. For example, describe the dominant plant fragment type and percent (e.g., black needlerush fragments, 25%).

Salinity (of Subaqueous Soils)

Electrical Conductivity of Subaqueous Soils (*Discussion)*—Salinity in terrestrial soils is evaluated by electrical conductivity (ds/m) of a saturated paste extract (Saturated Paste method, SSIR 51; Soil Survey Staff, 2014) or a given soil to water (by weight) ratio (e.g., 1:2, 1:5). The saturated paste EC is the standard salinity measure for terrestrial soils and is placed into *salinity classes* (see p. 2–91). Salinity is a crucial property of subaqueous soils and is also evaluated via EC measurement. The EC measurement, however, is conducted on a 1:5 by *volume* soil to solution mixture (1:5 vol. method, SSIR 51; Soil Survey Staff, 2014). The resultant EC is ***not*** placed into the conventional (terrestrially focused) *salinity classes*.

Electrical conductivity of subaqueous soils is measured on samples that typically have been stored in a refrigerator or freezer immediately after sampling to prevent sulfide oxidation, which can influence the EC value. Terrestrial soil samples are dried prior to preparing a saturated paste extract. Subaqueous soils cannot be dried because of the sulfide oxidation potential. Hence, a 1:5 volume method is used as follows: Measure 10 ml of moist sample; add 50 ml distilled water (5 times the soil volume). Stir the mixture briefly (10 seconds) and let settle (15 to 60 minutes). Electrical conductivity of the unfiltered supernatant is measured using a hand-held conductivity meter.

Electrical Conductivity of SAS (1:5 vol method)—Measure and record the **Electrical Conductivity** (EC) in dS/m and record the **Measurement Method** used (e.g., 11.2 dS/m by hand-held electrical conductivity meter).

Sulfides *(Discussion)*—Identifying the presence of sulfate is important to both pH and salinity (see “Reaction by Oxidized pH”). Oxidation of sulfides may generate salts that can alter salinity.

Bulk Density Satiated *(Discussion)*—(These are variations of the *Soil Core Method*. See section 3.3.1.4 in SSIR 51, Soil Survey Staff, 2014) It is generally not possible to collect subaqueous soil samples using the clod method for bulk density determination. Recommended alternative methods are:

1. Collect a known volume at the field moisture state (satiated). Bulk density is then calculated based on the dried weight of a known volume of soil at the field moisture status.
   Calculations (Soil Survey Staff, 2014)
   Db = (ODW – RF – CW)/[CV – (RF/PD)], where:
   Db = Bulk density of <2-mm fabric at sampled, field water state (g cm^{-3})
   ODW = Oven-dry weight
   RF = Weight of rock fragments
   CW = Empty core weight
   CV = Core volume
   PD = Density of rock fragments

2. For vibracore samples (opened by cutting the sampling tube rather than by compressive extrusion), a 50-ml syringe with the end removed and shaped to fit the curved core is used as a mini-corer to extract a 10- to 30-ml volume sample. The cylinder

is removed, extracting a sample of known volume. The sample is then analyzed following method 1 (above).

3. Samples collected in a peat sampler (e.g., Macaulay sampler) can be analyzed for bulk density following method 2 if a known volume (e.g., a core segment) is collected and dried.

Subaqueous Soil Description

Site/Pedon ID		Series or Component Name		Map Unit Symbol		
Date		Location Description		Water Column Measurements		
Start Time					Top	Bottom
End Time		Water Depth *(cm)*		pH		
Describer(s)		Bottom Type		DO (mg/l)		
Waypoint *(#)*		Submerged Aq. Veg.		Salinity (ppt)		
GPS *(unit#)*		Observation Method		Temp (°C)		
Coordinates 1		Site Notes				
Coordinates 2						
Geodetic Datum						

Depth (cm)	Horizon	Horizon Boundary Distinctness	Soil Color *(matrix)*	Field Texture Class (M) von Post (O)	Coarse Frags *(%)*	Fluidity Class / Plasticity / Stickiness / Fibers (UR / R)	RMFs	Peroxide *(3% / 30%)*	Oxidized pH		Electrical Conductivity (1:5) dS/M	Odor *(Intensity, Kind)*	Origin	Notes
									init.	16 wks.				

Subaqueous Soil Description

Site/Pedon ID	S2011RI009014A	**Series or Component Name**	Frankensoil Series	**Map Unit Symbol**	1313	
Date	08/02/2024	**Location Description**	Ninigret Pond; 1000 m. E. of intersection of Route 1 and Route 1A at Ninigret Park, RI	**Water Column Measurements**		
Start Time	8:30AM				**Top**	**Bottom**
End Time	11:45AM	**Water Depth *(cm)***	120 cm	**pH**	7.7	7.7
Describer(s)	Herman Munster	**Bottom Type**	mud	**DO (mg/l)**	6	5
Waypoint *(#)*	4	**Submerged Aq. Veg.**	thick macroalgae	**Salinity (ppt)**	27	29
GPS *(unit#)*	Trimble Geo XH	**Observation Method**	Vibracore tube	**Temp (°C)**	20 °C	18 °C
Coordinates 1	N 41° 22' 13.0" Lat	**Site Notes**				
Coordinates 2	W 71° 39' 4.0" Lon					
Geodetic Datum	WGS84					

Depth (cm)	Horizon	Horizon Boundary Distinctness	Soil Color *(matrix)*	Field Texture Class (M) von Post (O)	Coarse Frags *(%)*	Fluidity Class / Plasticity / Stickiness / Fibers (UR / R)	RMFs	Peroxide *(3% / 30%)*	Oxidized pH		Electrical Conductivity (1:5) dS/M	Odor *(Intensity, Kind)*	Origin	Notes
									init.	16 wks.				
0-12	A	abrupt	5Y6/1	mucky silt loam	0	very fluid		Y / violent	7.8	4.7		strong sulfurous	marine silt	pH by pH meter
Dec-53	C1	clear	5Y2.5/1	mucky silt loam	0	moderately fluid		Y / strong	7.7	4.9		strong sulfurous	marine silt	
53-88	C2	abrupt	5Y3/1	mucky silt loam	0	moderately fluid		Y / slight	8	2.6		strong sulfurous	marine silt	
88-98	2Oa1	abrupt	N 2.5/	muck / H7	14%gr			N / slight	7.8	6.6		slight sulfurous	organics, fresh	
98-130	2Oa2	abrupt	10YR 2/1	muck / H8	1 % wood frags			N / none	7.7	6.5		none	organics, fresh	
130-191	2Oa3		10YR 2/2	muck / H9	1 % wood frags			N / none	7.7	6.5		none	organics, fresh	

Vibracore Sampling for Subaqueous Soil

Discussion—Subaqueous soils are challenging to observe and sample because of the positive pore pressure of free water in the soil and the water above the soil. Vibracore sampling is particularly well suited to obtain minimally disturbed samples from sandy, silty, or organic subaqueous materials lacking large or substantial coarse fragments. The principal concern is accounting for sample compression (compaction, repacking, or "core rot"), especially in material with *moderately fluid or very fluid* fluidity classes. ***Note:*** A "Vibracore Log Sheet" (p. 2–117) must be paired with a "Subaqueous Soil Description" (p. 2–113) or a conventional "Soil Profile Description" (p. 2–93).

Site Description—Record subaqueous soil site information much the same as you record subaerial soil site information (see p. 1–1). Additional items to evaluate and describe include the following:

> **Water Depth (Unit)**—Record the depth of water (and the units used) above the soil surface at the time the core is collected. (This information is used to develop/verify the map unit name; e.g., Billington silt loam, 0–1 m water depth.)
>
> **Tidal Period**—Record the tidal period (incoming, high, outgoing, low, none) at the time of sample extraction. ***Note***: Most freshwater lakes do not exhibit appreciable tidal fluctuations.

Core Descriptions—Record subaqueous core descriptions. Evaluate and describe the following:

> **Total Pipe Length**—Describe the total length of the collection pipe prior to coring. (This information is used as a check for depth of sample collection. The information may also be used to track how much pipe is consumed during a field season.)
>
> **Riser Length**—After insertion of the pipe tube, record the external length (cm) from the top of the collection pipe to the soil surface outside the pipe.
>
> **Inside Length**—After insertion of the pipe tube, record the length (cm) from the top of the collection pipe to the soil surface inside the pipe. ***Note:*** A sinker tied to a string and lowered to the soil surface inside the pipe facilitates measurement.
>
> **Core Settlement**—Calculate the sample settlement/compaction (also called "rot") by subtracting the *riser length* from the *inside length*. ***Note:*** Settlement of the soil sample inside the pipe is common and difficult to precisely account for; therefore, vibracore samples only provide reasonable estimates of horizon depths.

Final Core Length—Record the calculated length of the soil profile collected. (See graphic on “Vibracore Log Sheet,” p. 2–117.)

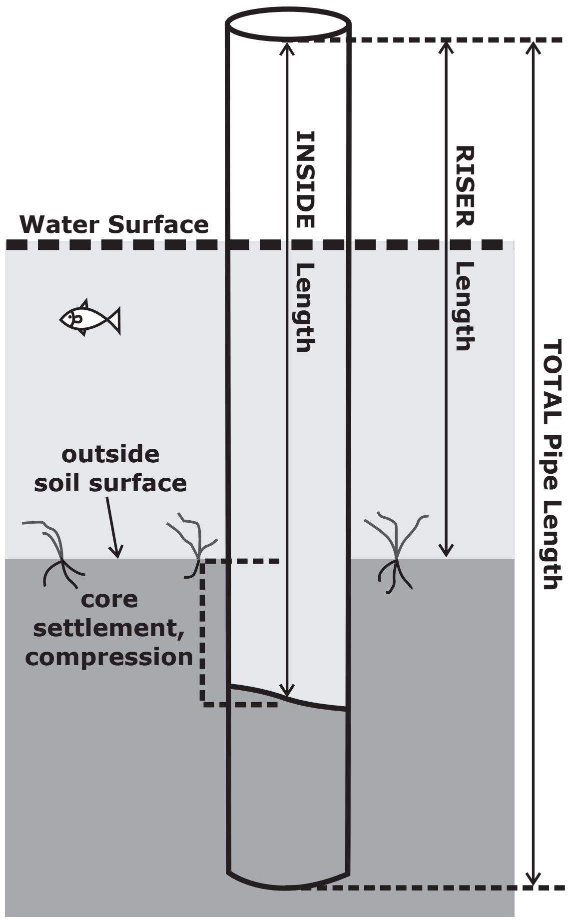
Where Core Is Stored—Describe where the core is stored for future retrieval, description, and analysis (e.g., shed 2, core # 2011-25). ***Note***: Subaqueous soils should be kept in refrigerated storage to slow chemical reactions, such as conversion of sulfides to sulfates, which influence pH or other soil properties.

VIBRACORE LOG SHEET

SITE

Site/Pedon ID *(YYYYSTFIPS###)*	
Date/Time Sampled	
Soil Type	
Map Unit	
Location *(geographic)*	
Waypoint *(#)*	
GPS *(model/unit #)*	
Lat.	
Lon.	
UTM Easting	
UTM Northing	
UTM Zone	
Elevation *(NAVD 88)*	
Water Depth *(cm)*	
Tidal Period	

Core Sketch



CORE LOG

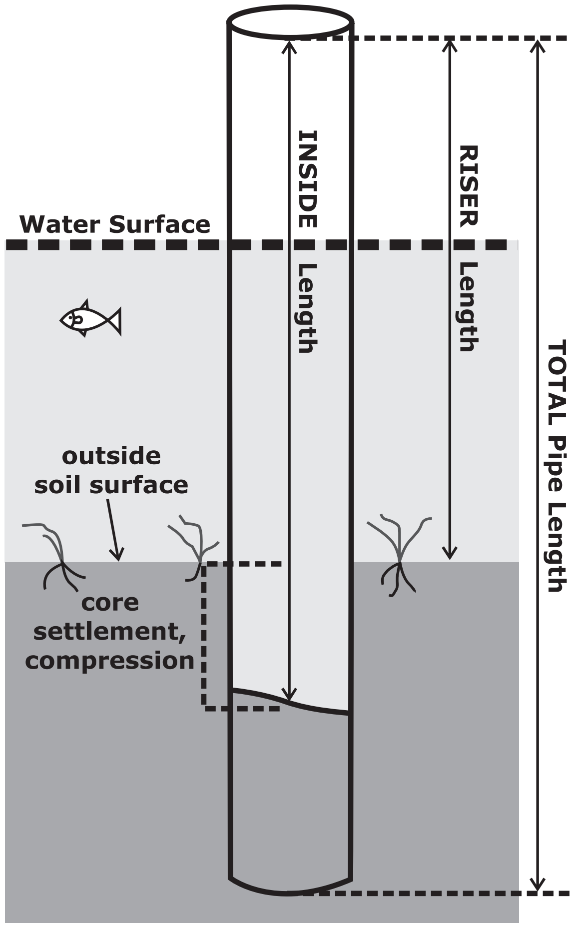
a) TOTAL Pipe Length *(before coring)*	
b) RISER Length *(after coring)*	
c) INSIDE Length *(sinker length: surface to bottom)*	
d) Core Settlement *(= c - b)*	
Final Core Length *(after core completed: = a - c)*	
Where Is Core Stored?	
Date Described	

VIBRACORE LOG SHEET *EXAMPLE*

SITE

Site/Pedon ID *(YYYYSTFIPS###)*	S2011RI009014A
Date/Time Sampled	8/16/2011 8:30 AM
Soil Type	Frankensoil
Map Unit	Frankensoil mucky silt loam
Location *(geographic)*	Ninigret Pond: 1000 m E. of intersection of Route 1 and Route 1A at Ninigret Park, RI
Waypoint *(#)*	4
GPS *(model/unit #)*	Trimble Geo XH
Lat.	41° 22' 13.0"
Lon.	W 71° 39' 4.0"
UTM Easting	721720 m
UTM Northing	4583254 m
UTM Zone	19
Elevation *(NAVD 88)*	- 1.2 m
Water Depth *(cm)*	120 cm
Tidal Period	Outgoing

Core Sketch



CORE LOG

a) TOTAL Pipe Length *(before coring)*	390 cm
b) RISER Length *(after coring)*	260 cm
c) INSIDE Length *(sinker length: surface to bottom)*	264 cm
d) Core Settlement *(= c - b)*	4 cm
Final Core Length *(after core completed: = a - c)*	126 cm
Where Is Core Stored?	URI Bay Campus cold storage
Date Described	8/17/2011

References

AASHTO. 1997a. The classification of soils and soil-aggregate mixtures for highway construction purposes. AASHTO designation M145–91. In Standard specifications for transportation materials and methods of sampling and testing, Part 1: Specifications (18th ed.). American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 1997b. Terms relating to subgrade, soilaggregate, and fill materials. AASHTO designation M146–91 (1995). In Standard specifications for transportation materials and methods of sampling and testing, Part 1: Specifications (18th ed.). American Association of State Highway and Transportation Officials, Washington, DC.

American National Standards Institute (ANSI) Codes for the States. 2009. INCITS 38:2009.

ASTM. 2011. Standard practice for classification of soils for engineering purposes (Unified Soil Classification System). ASTM designation D2487–92. In Soil and rock; dimension stone; geosynthetics. Annual book of ASTM standards.

Australian Soil Classification System (as online interactive key) CSIRO. [Accessed 11 February 2016]

Bachman, G.O., and M.W. Machette. 1977. Calcic soils and calcretes in the southwestern U.S. U.S. Geol. Soc. Open-File Rep. 77–794.

Blackburn, W.H., R.E. Eckert, Jr., M.K. Wood, and F.F. Peterson. 1975. Influence of vesicular horizons on watershed management. p. 494–515. In Proc. ASCE Watershed Management Symposium. Logan, UT, 11–13 Aug. 1975. ASAE, New York.

Bouma, J., R.F. Paetzold, and R.B. Grossman. 1982. Measuring hydraulic conductivity for use in soil survey. Soil Surv. Invest. Rep. 38. USDA Soil Conservation Service. U.S. Gov. Print. Office, Washington, DC.

Bradley, M.P., and M. Payne. 2010. Bathymetric mapping and landscape units in shallow subtidal coastal environments: Integrating fathometry, GPS, and GIS. In 2nd National Workshop on Subaqueous Soils. Rhode Island, 9–12 Aug. 2010.

Brewer, R. 1976. Fabric and mineral analysis of soils. Krieger Publ. Co., Huntington, NY.

Brock, A.L. 2007. Characterization of stage VI petrocalcic horizons—S. Nevada and N.W. Arizona. Ph.D. diss. Univ. of Nevada Las Vegas, Department of Geoscience.

Brock, A.L. 2010. Personal communication (carbonate stages source graphic).

Bullock, P., N. Fedoroff, A. Jongerius, G. Stoops, and T. Tursina. 1985. Handbook for soil thin section description. Waine Res. Publ., Wolverhampton, England.

Childs, C.W. 1981. Field tests for ferrous iron and ferric-organic complexes (on exchange sites or in water-soluble forms) in soils. Aust. J. Soil Res. 19:175–180.

Demas, G.P. 1993. Submerged soils: A new frontier in soil survey. Soil Surv. Horiz. 34:44–46.

Demas, G.P. 1998. Subaqueous soils of Sinepuxent Bay, MD. Ph.D. diss. Univ. of Maryland, College Park.

Demas, G.P., R.B. Rabenhorst, and J.C. Stevenson. 1996. Subaqueous soils: A pedological approach to the study of shallow-water habitats. Estuaries 19:229–237.

Doner, H.E., and W.C. Lynn. 1989. Carbonate, halide, sulfate, and sulfide minerals. In J.B. Dixon and S.B. Weed (ed.) Minerals in the soil environment, 2nd ed. SSSA Book Ser. 1. SSSA, Madison, WI.

Fanning, D.S., and M.C.B. Fanning. 1989. Soil: Morphology, genesis, and classification. John Wiley & Sons, New York.

Fanning, D.S., M.C. Rabenhorst, S.N. Burch, K.R. Islam, and S.A. Tangren. 2002. Sulfides and sulfates. In J.B. Dixon et al. (ed.) Soil mineralogy with environmental applications. SSSA, Madison, WI.

Federal Geographic Data Committee. 2012. Coastal and marine ecological classification standard, ver. 4.0. Federal Geographic Data Committee Secretariat, U.S. Geol. Surv., Reston, VA.

Finkelman, R.B., and D.E. Giffin. 1986. Hydrogen peroxide oxidation: An improved method for rapidly assessing acid-generation potential of sediments and sedimentary rocks. Recl. Reveg. Res. 5:521–534.

Flach, K.W., W.D. Nettleton, L.H. Gile, and J.G. Cady. 1969. Pedocementation: Induration by silica, carbonates, and sesquioxides in the Quaternary. Soil Sci. 107:442–453.

Folk, R.L. 1955. Student operator error in determination of roundness, sphericity and grain size. J. Sediment. Petrol. 25:297–301.

Gile, L.H. 1961. A classification of Ca horizons in soils of a desert region, Doña Ana County, New Mexico. Soil Sci. Soc. Am. Proc. 25(1):52–61.

Gile, L.H. 1970. Soils of the Rio Grande valley border in southern New Mexico. Soil Sci. Soc. Am. Proc. 34(3):465–472.

Gile, L.H. 1975. Causes of soil boundaries in an arid region, I. Age and parent materials. Soil Sci. Soc. Am. Proc. 39:316–323.

Gile, L.H. 1993. Carbonate stages in sandy soils of the Leasburg surface, southern New Mexico. Soil Sci. 156:101–110.

Gile, L.H., and R.B. Grossman. 1968. Morphology of the argillic horizon in desert soils of southern New Mexico. Soil Sci. 106(1):6–15.

Gile, L.H., and R.B. Grossman. 1979. The desert project soil monograph. USDA, Natl. Tech. Inf. Serv. Doc. PB80–13534. Springfield, VA.

Gile, L.H., J.W. Hawley, and R.B. Grossman. 1981. Soils and geomorphology in the Basin and Range area of southern New Mexico—Guidebook to the desert project. New Mexico Bureau of Mines and Mineral Resources, Memoir 39.

Gile, L.H., H.C. Monger, R.B. Grossman, R.J. Ahrens, J.W. Hawley, F.F. Peterson, R.P. Gibbens, J.M. Lenz, B.T. Bestelmeyer, and B.A. Nolen. 2007. A 50th anniversary guidebook for the desert project. USDA Natural Resources Conservation Service.

Gile, L.H., F.F. Peterson, and R.B. Grossman. 1966. Morphological and genetic sequences of carbonate accumulation in desert soils. Soil Sci. 101:347–360.

Hillel, D. 1980. Fundamentals of soil physics. Academic Press, New York, NY.

Ingram, R.L. 1982 (updated by M. Johnson, 2007). Modified Wentworth scale. In Grain-size scales. AGI data sheet 8.2. J.D. Walker and H.A. Cohen (ed.) 2005 (reprinted 2007). The geoscience handbook. AGI data sheets, 4th ed. Am. Geol. Inst., Alexandria, VA.

Jackson, M.L. 1969. Soil chemical analysis—Advanced course. Madison, WI.

Jennings, S.R., D.J. Dollhopf, and W.P. Inskeep. 1999. Acid production from sulfide minerals using hydrogen peroxide weathering. Appl. Geochem. 15:235–243.

Kubiena, W.M. 1953. The soils of Europe. T. Murby, London.

Lyle, M. 1983. The brown-green color transition in marine sediments: A marker of the Fe(III)-Fe(II) redox boundary. Limnol. Oceanogr. 28:1026–1033.

Lynn, W., and D. Williams. 1992. The making of a Vertisol. Soil Surv. Horiz. 33:23–52.

Machette, M.N. 1985. Calcic soils of the southwestern United States. In D.L. Weide (ed.) Soils and Quaternary geomorphology of the southwestern United States. Geol. Soc. Am. Spec. Pap. 203.

Mason, D.D., J.F. Lutz, and R.G. Petersen. 1957. Hydraulic conductivity as related to certain soil properties in a number of great soil groups—Sampling errors involved. Soil Sci. Soc. Am. Proc. 21:554–561.

Neuendorf, K., J.P. Mehl, and J.A. Jackson. 2005. Glossary of geology, 5th ed. Am. Geol. Inst., Alexandria, VA.

O'Neal, A.M. 1952. A key for evaluating soil permeability by means of certain field clues. Soil Sci. Soc. Am. Proc. 16:312–315.

Payne, M. 2010. Bathymetry data collection for subaqueous soil mapping. In 2nd National Workshop on Subaqueous Soils. Rhode Island, 9–12 Aug.

Powers, M.C. 1953. A new roundness scale for sedimentary particles. J. Sediment. Petrol. 23:117–119.

Richards, L.A. (chairman) 1952. Report of the subcommittee on permeability and infiltration, committee on terminology, Soil Science Society of America. Soil Sci. Soc. Am. Proc. 16:85–88.

Schoeneberger, P.J., and D.A. Wysocki. 2017. Geomorphic description system, ver. 5.0. USDA Natural Resources Conservation Service.

Simonson, R.W. 1959. Outline of a generalized theory of soil genesis. Soil Sci. Soc. Am. Proc. 23:152–156.

Singer, M.J., and D.N. Warrington. 1992. Crusting in the western United States. In M.E. Sumner and B.A. Stewart (ed.) Advances in soil science: Soil crusting—Chemical and physical processes. Lewis Publishers, Boca Raton, FL.

Soil Science Division Staff. 2017. Soil Survey Manual. USDA, Agriculture Handbook No. 18.

Soil Survey Staff. 1971. Guide for interpreting engineering uses of soils. USDA, Handbook NB–1.

Soil Survey Staff. 2022. Keys to soil taxonomy, 13th ed. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2024. National soil survey handbook (NSSH). USDA Natural Resources Conservation Service.

Soil Survey Staff. 2014. Soil survey field and laboratory methods manual. soil survey investigations report, no. 51, version 2.0. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2011. Soil survey laboratory information manual. Soil Surv. Invest. Rep. 45, ver. 2.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Survey Staff. 1951. Soil survey manual. USDA, Agriculture Handbook No. 18.

Stolt, M.H., and M.C. Rabenhorst. 2012. Introduction and historical development of subaqueous soil concepts. In P.M. Huang et al. (ed.) Handbook of soil science. CRC Press, LLC, Boca Raton, FL. ISBN: 978–1–4398–0305–9.

Sumner, M.E., and B.A. Stewart (ed.) 1992. Soil crusting: chemical and physical processes. Advances in soil science. Lewis Publishers, Boca Raton, FL.

Uhland, R.E., and A.M. O'Neal. 1951. Soil permeability determinations for use in soil and water conservation. SCS–TP–101. Washington, DC.

U.S. Army Corps of Engineers. 2012. Regional supplement to the Corps of Engineers wetland delineation manual: Northcentral and Northeast Region, version 2.0. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

USDA Natural Resources Conservation Service. 1997. Introduction to microbiotic crusts. Soil Quality Institute and Grazing Lands Technology Institute, Fort Worth, TX.

USDA Natural Resources Conservation Service. 2001. Physical and biological soil crusts. Soil Quality Information Sheet—Rangeland Information Sheet 7. Soil Quality Institute.

USDA Natural Resources Conservation Service. 2022. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. USDA, Agriculture Handbook 296.

USDA Natural Resources Conservation Service. 2024. The PLANTS database. National Plant Data Team, Greensboro, NC.

Wessel, B.M. and Rabenhorst. 2017. Geoderma. Volume 308. pages 215-225.

Wysocki, D.A., P.J. Schoeneberger, B. Lowery, and R. Paetzold. 2002. Hydraulic conductivity vs. soil permeability classes: Facts, fiction, and the future. ASA, Indianapolis, IN.

Geomorphic Description

Part I: Physiographic Location

A) Physiographic Divisions

B) Physiographic Provinces

C) Physiographic Sections

D) State Physiographic Areas

E) Local Physiographic/Geographic Names

Part II: Geomorphic Description

A) Landscapes

B) Landforms

C) Microfeatures

D) Anthroscapes

E) Anthropogenic Landforms

F) Anthropogenic Microfeatures

Part III: Surface Morphometry

A) Elevation

B) Slope Aspect

C) Slope Gradient

D) Slope Complexity

E) Relative Slope Segment Position

F) Slope Shape

G) Hillslope Profile Position

H) Geomorphic Component
   1. Hills
   2. Terraces and Stepped Landforms
   3. Mountains
   4. Flat Plains

I) Microrelief

J) Drainage Pattern

Note: Italicized NASIS shorthand codes, if available, follow each choice. Conventionally, the entire term is recorded.

Part I: Physiographic Location

References for items **A**, **B**, and **C**: *Physical Divisions of the United States* (Fenneman, 1946); *Physiographic Divisions of Alaska* (Wahrhaftig, 1965).

Physiographic Divisions (A)		Physiographic Provinces (B) Physiographic Sections (C)	
Laurentian Upland	*LU*	1. Superior Upland	*SU*
Atlantic Plain	*AP*	2. Continental Shelf	*CS*
		3. Coastal Plain	*CP*
		a. Embayed section	*EMS*
		b. Sea Island section	*SIS*
		c. Floridian section	*FLS*
		d. East Gulf Coastal plain	*EGC*
		e. Mississippi alluvial valley	*MAV*
		f. West Gulf Coastal plain	*WGC*
Appalachian Highlands	*AH*	4. Piedmont Province	*PP*
		a. Piedmont upland	*PIU*
		b. Piedmont lowlands	*PIL*
		5. Blue Ridge Province	*BR*
		a. Northern section	*NOS*
		b. Southern section	*SOS*
		6. Valley and Ridge Province	*VR*
		a. Tennessee section	*TNS*
		b. Middle section	*MIS*
		c. Hudson Valley	*HUV*
		7. St. Lawrence Valley	*SL*
		a. Champlain section	*CHS*
		b. St. Lawrence Valley, Northern section	*NRS*
		8. Appalachian Plateau	*AP*
		a. Mohawk section	*MOS*
		b. Catskill section	*CAS*
		c. Southern New York sect.	*SNY*
		d. Allegheny Mountain sect.	*AMS*
		e. Kanawaha section	*KAS*
		f. Cumberland Plateau sect.	*CPS*
		g. Cumberland Mtn. sect.	*CMS*

Physiographic Divisions (A)		Physiographic Provinces (B) / Physiographic Sections (C)	
		9. New England Province	*NE*
		a. Seaboard lowland sect.	*SLS*
		b. New England upland sect.	*NEU*
		c. White Mountain section	*WMS*
		d. Green Mountain section	*GMS*
		e. Taconic section	*TAS*
		10. Adirondack Province	*AD*
Interior Plains	*IN*	11. Interior Low Plateaus	*IL*
		a. Highland rim section	*HRS*
		b. Lexington lowland	*LEL*
		c. Nashville basin	*NAB*
		d. Possible western section (not delimited on map)	*WES*
		12. Central Lowland Province	*CL*
		a. Eastern lake section	*ELS*
		b. Western lake section	*WLS*
		c. Wisconsin driftless section	*WDS*
		d. Till plains	*TIP*
		e. Dissected till plains	*DTP*
		f. Osage plain	*OSP*
		13. Great Plains Province	*GP*
		a. Missouri plateau, glaciated	*MPG*
		b. Missouri plateau, unglaciated	*MPU*
		c. Black Hills	*BLH*
		d. High Plains	*HIP*
		e. Plains Border	*PLB*
		f. Colorado Piedmont	*COP*
		g. Raton section	*RAS*
		h. Pecos valley	*PEV*
		i. Edwards Plateau	*EDP*
		k. Central Texas section	*CTS*

This division includes portions of Alaska
(see “Alaskan Physiographic Areas” section).

Interior Highlands	*IH*	14. Ozark Plateau	*OP*
		a. Springfield-Salem plateaus	*SSP*
		b. Boston “Mountains”	*BOM*

Physiographic Divisions (A)		Physiographic Provinces (B) / Physiographic Sections (C)	
		15. Ouachita Province	*OU*
		a. Arkansas Valley	*ARV*
		b. Ouachita Mountains	*OUM*
Rocky Mountain System	*RM*	16. Southern Rocky Mountains	*SR*
		17. Wyoming Basin	*WB*
		18. Middle Rocky Mountains	*MR*
		19. Northern Rocky Mountains	*NR*

This division includes portions of Alaska (see “Alaskan Physiographic Areas” section).

Intermontane Plateaus	*IP*	20. Columbia Plateau	*CR*
		a. Walla Walla Plateau	*WWP*
		b. Blue Mountain section	*BMS*
		c. Payette section	*PAS*
		d. Snake River Plain	*SRP*
		e. Harney section	*HAS*
		21. Colorado Plateau	*CO*
		a. High Plateaus of Utah	*HPU*
		b. Uinta Basin	*UIB*
		c. Canyon Lands	*CAL*
		d. Navajo section	*NAS*
		e. Grand Canyon section	*GCS*
		f. Datil section	*DAS*
		22. Basin and Range Province	*BP*
		a. Great Basin	*GRB*
		b. Sonoran Desert	*SOD*
		c. Salton Trough	*SAT*
		d. Mexican Highland	*MEH*
		e. Sacramento section	*SAS*

This division includes portions of Alaska (see “Alaskan Physiographic Areas” section).

Pacific Mountain	*PM*	23. Cascade-Sierra Mountains	*CM*
		a. Northern Cascade Mtns.	*NCM*
		b. Middle Cascade Mtns.	*MCM*
		c. Southern Cascade Mtns.	*SCM*
		d. Sierra Nevada	*SIN*

		24. Pacific Border Province	*B*
		a. Puget Trough	*PUT*
		b. Olympic Mountains	*OLM*
		c. Oregon Coast Range	*OCR*
		d. Klamath Mountains	*KLM*
		e. California Trough	*CAT*
		f. California Coast Ranges	*CCR*
		g. Los Angeles Ranges	*LAR*
		25. Lower California Province	*LC*

This division includes portions of Alaska
(see "Alaskan Physiographic Areas" section).

Alaskan Physiographic Areas (Warhaftig, 1965)

The following Alaskan-Peninsula physiographic areas are extensions of the preceding North American Physiographic Divisions (e.g., Rocky Mountain System). These Alaskan extensions are presented separately rather than intermingled with the previous Division I Province lists because: a) they constitute a geographically coherent package (Wahrhaftig, 1965); b) these extensions were not contained within Fennman's original work, which dealt only with the conterminous U.S. (Fenneman, 1931, 1938, 1946); and c) Wahrhaftig's map unit numbers are independent of, and inconsistent with, Fenneman's. Wahrhaftig's original map unit scheme and numbers are retained here for simplicity in using his map of the Alaskan peninsula. ***Caution:*** Wahrhaftig's map unit numbers should not be confused with similar map unit numbers from Fenneman's map for the conterminous U.S.

Interior Plains	*IN*	1. Arctic Coastal Plain Province	—
		a. Teshekpuk Hills section	—
		b. White Hills section	—
		2. Arctic Foothills Province	*AF*
		a. Northern Section	—
		b. Southern Section	—
Rocky Mountains System	*RM*	Arctic Mountains Province	*AM*
		3. Delong Mountains section	—
		4. Noatak Lowlands section	—
		5. Baird Mountains section	—
		6. Central & E. Brooks Range sect.	—

Physiographic Divisions (A)		Physiographic Provinces (B) Physiographic Sections (C)	
		7. Ambler-Chandalar Ridge & Lowland sect.	—

Note: The map unit numbering sequence shown here is from Wahrhaftig (1965) and is independent of, and not consistent with, that of Fenneman.

Intermontane Plateaus	*IP*	Northern Plateaus Province	—
		8. Porcupine Plateau section	—
		a. Thazzik Mountain	
		9. Old Crow Plain section (noted but not described)	—
		10. Olgivie Mountains section	—
		11. Tintina Valley (Eagle Trough) sect.	—
		12. Yukon-Tanana Upland section	—
		a. Western Part	
		b. Eastern Part	
		13. Northway-Tanacross Lowland sect.	—
		14. Yukon Flats section	—
		15. Rampart Trough section	—
		16. Kokrine-Hodzana Highlands sect.	—
		a. Ray Mountains	
		b. Kokrine Mountains	
		Western Alaska Province	—
		17. Kanuti Flats section	—
		18. Tozitna-Melozitna Lowland sect.	—
		19. Indian River Upland section	—
		20. Pah River Section	—
		a. Lockwood Hills	
		b. Pah River Flats	
		c. Zane Hills	
		d. Purcell Mountains	
		21. Koyukuk Flats section	—
		22. Kobuk-Selawik Lowland sect.	—
		a. Waring Mountains	
		23. Selawik Hills section	—
		24. Buckland River Lowland sect.	—
		25. Nulato Hills section	—
		26. Tanana-Kuskowin Lowland sect.	—
		27. Nowitna Lowland section	—

Physiographic Divisions (A)		Physiographic Provinces (B) Physiographic Sections (C)	
		28. Kuskokwim Mountains section	—
		29. Innoko Lowlands section	—
		30. Nushagak-Big River Hills sect.	—
		31. Holitna Lowland section	—
		32. Nushagak-Bristol Bay Lowland sect.	—
		33. Seward Peninsula Province	*SEP*
		a. Bendeleben Mountains	
		b. Kigluaik Mountains	
		c. York Mountains	
		Bering Shelf Province	*BES*
		34. Yukon-Kuskokwim Coastal Lowland sect.	—
		a. Norton Bay Lowland	
		35. Bering Platform section	—
		a. St. Lawrence Island	
		b. Pribilof Island	
		c. St. Matthew Island	
		d. Nunivak Island	
		36. Ahklun Mountains Province	—

Note: The map unit numbering sequence shown here is from Wahrhaftig (1965) and is independent of, and not consistent with, that of Fenneman.

Pacific Mountain System	*PM*	Alaska-Aleutian Province	*AAC*
		37. Aleutian Islands section	—
		38. Aleutian Range section	—
		39. Alaska Range (Southern Part) sect.	—
		40. Alaska Range (Central & Eastern Parts) section	—
		a. Mentasta-Nutzotin Mtn. segment	
		41. Northern Foothills of the Alaska Range section	—
		Coastal Trough Province	—
		42. Cook Inlet-Susitna Lowland sect.	—
		43. Broad Pass Depression section	—
		44. Talkeetna Mountains section	—
		a. Chulitna Mountains	
		b. Fog Lakes Upland	

Physiographic Divisions (A)		Physiographic Provinces (B) Physiographic Sections (C)	
		c. Central Talkeetna Mountains	
		d. Clarence Lake Upland	
		e. Southeastern Talkeetna Mountains	
		45. Upper Matanuska Valley sect.	—
		46. Clearwater Mountains section	—
		47. Gulkana Upland section	—
		48. Copper River Lowland section	—
		a. Eastern Part	
		b. Western Part: Lake Louis Plateau	
		49. Wrangell Mountains section	—
		50. Duke Depression (not described)	
		51. Chatham Trough section	—
		52. Kupreanof Lowland section	—
		Pacific Border Ranges Province	*PBS*
		53. Kodiak Mountains section	—
		54. Kenai-Chugach Mtns. sect.	—
		55. St Elias Mountains section	—
		a. Fairweather Range subsection	
		56. Gulf of Alaska Coastal section	—
		57. Chilkat-Baranof Mtns. section	—
		a. Alsek Ranges subsection	
		b. Glacier Bay subsection	
		c. Chichagof Highland subsection	
		d. Baranof Mountains subsection	
		58. Prince of Wales Mtns. sect.	—
		Coast Mountains Province	*COM*
		59. Boundary Pass section	—
		60. Coastal Foothills section	—

Other Physiographic Areas

(not addressed by Fenneman, 1946, or Wahrhaftig, 1965)

Pacific Rim	*PR*	Pacific Islands Province	*PI*
		a. Hawaiian Islands	*HAI*
		b. Guam	*GUM*

Physiographic Divisions (A)		Physiographic Provinces (B) / Physiographic Sections (C)	
		c. Trust Territories * (e.g., Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Palau, Republic of Marshall Islands, American Samoa, etc.)	*TRT*
		d. Other	

* Most of the former U.S. Trust Territories of the Pacific are now independent nations. This designation is used here solely for brevity and to aid in accessing archived historical data.

Caribbean Basin	*CB*	Caribbean Islands Province	*CI*
		a. Greater Antilles (Puerto Rico, Cuba, Hispaniola, Jamaica)	*GRA*
		b. Lesser Antilles (U.S. Virgin Islands, Barbados, Grenada, Martinique, etc.)	*LEA*
		c. Other	
Undesignated	*UN*	Other	*OT*

(reserved for temporary or international designations)

State Physiographic Areas (D)

e.g., *Des Moines Lobe* (IA)

(Optional) — (Entries presently undefined; to be developed in conjunction with each State Geological Survey; target scale is approximately 1:100,000.)

Local Physiographic/Geographic Names (E)

e.g., *Pilot's Knob* (IA)

(Optional) — (Entries presently undefined; to be developed in conjunction with each State Geological Survey; may include area names found on USGS 7.5- and 15-minute topographic maps; target scale is approximately 1:24,000.)

Part II: Geomorphic Description (Outline)

I) **Comprehensive Lists:** Alphabetical rosters of all terms currently recognized in a given category.

   A) **Landscapes**

   B) **Landforms**

   C) **Microfeatures**

   D) **Anthroscapes**

   E) **Anthropogenic Landforms**

   F) **Anthropogenic Microfeatures**

II) **Geomorphic Environments and Other Groupings:**

Landscape, landform, and microfeature terms grouped by geomorphic process (e.g., fluvial) or by common settings (e.g., water bodies). These lists are *not* mutually exclusive; some features occur in more than one environment or setting (e.g., hill).

Geomorphic Environments

1. Coastal Marine and Estuarine
2. Lacustrine
3. Fluvial
4. Solution
5. Eolian
6. Glacial
7. Periglacial
8. Mass Movement
9. Volcanic and Hydrothermal
10. Tectonic and Structural

Other Groupings

11. Slope
12. Erosional
13. Depressional
14. Wetlands
15. Water Bodies
16. Subaqueous Features

Codes: Conventionally, the entire land-feature term is used (e.g., dune field). Some data storage programs (e.g., NASIS) may have shorthand codes developed for some terms. If available, an italicized code follows each term (e.g., meander belt MB); these are shown for historical purposes. (“LS” is landscape; “LF” is landform; “Micro” is microfeature; “Anthro” is anthropogenic; “w” is water body).

I) Comprehensive Lists:

A) **Landscapes** (broad or unique regional groups of spatially associated landforms)

alluvial plain	*AP*	fold-thrust hills	*FTH*
alluvial plain remnant	*AR*	foothills	*FH*
badlands	*BA*	glaciokarst	*GK*
bajada (also LF)	*BJ*	gulf (w; also LF)	*GU*
barrier island (also LF)	*BI*	hills (singular is LF)	*HI*
basin	*BS*	ice-margin complex	*IC*
basin floor (also LF)	*BC*	intermontane basin (also LF)	*IB*
batholith	*BL*	island (also LF)	*IS*
bay [coast] (w; also LF)	*BY*	karst	*KR*
bolson	*BO*	kegel karst	*KK*
breached anticline (also LF)	*BD*	lagoon (w; also LF)	*LG*
breaklands	*BR*	lake plain (also LF)	*LP*
breaks (also LF)	*BK*	lava field (also LF)	*LF*
caldera (also LF)	*CD*	lava plain (also LF)	*LV*
canyonlands	*CL*	lava plateau (also LF)	*LL*
coastal plain (also LF)	*CP*	lowland	*LW*
cockpit karst	*CPK*	marine terrace (also LF)	*MT*
cone karst	*CK*	meander belt	*MB*
continental glacier	*CG*	mountain range	*MR*
coppice dune field	*CDF*	mountain system	*MS*
delta plain (also LF)	*DP*	mountains (singular is LF)	*MO*
dissected breaklands	*DB*	ocean (w)	*OC*
dissected plateau	*DI*	outwash plain (also LF)	*OP*
drumlin field	*DF*	peninsula	*PE*
dune field (also LF)	*DU*	piedmont	*PI*
estuary (w; also LF)	*ES*	piedmont slope	*PS*
everglades	*EG*	plains (singular is LF)	*PL*
fan piedmont (also LF)	*FP*	plateau (also LF)	*PT*
fault-block mountains	*FM*	rift valley	*RF*
fluviokarst	*FK*	river valley (also LF)	*RV*
fluviomarine terrace (also LF)	*FT*	sand plain	*SP*

sandhills	*SH*
scabland	*SC*
sea (w; also LF)	*SEA*
semi-bolson	*SB*
shield volcano (also LF)	*SV*
shore complex (also LF)	*SX*
sinkhole karst	*SK*
sound (w; also LF)	*SO*
strait (w; also LF)	*ST*
tableland	*TB*
thermokarst	*TK*
till plain (also LF)	*TP*
tower karst	*TW*
upland	*UP*
valley (also LF)	*VA*
volcanic field (also LF)	*VF*

B) **Landforms** (natural, individual earth-surface features mappable at soil survey scales)

aa lava flow	*ALF*
alas	*AA*
alluvial cone	*AC*
alluvial fan	*AF*
alluvial flat	*AP*
alpine glacier	*AG*
anticline	*AN*
arete	*AR*
arroyo	*AY*
ash field	*AQ*
ash flow	*AS*
atoll	*AT*
avalanche chute	*AL*
axial stream	*AX*
back-barrier beach	*BBB*
back-barrier flat	*BBF*
backshore	*AZ*
backswamp	*BS*
bajada (also LS)	*BJ*
ballena	*BL*
ballon	*BV*
bar	*BR*
barchan dune	*BQ*
barrier beach	*BB*
barrier beach [relict]	*BBR*
barrier cove	*BAC*
barrier flat	*BF*
barrier island (also LS)	*BI*
basin floor (also LS)	*BC*
basin-floor remnant	*BD*
bay [coast] (w; also LS)	*BAY*
bay [geom.]	*BYG*
bay bottom	*BOT*
bayou (w)	*WC*
beach	*BE*
beach plain	*BP*
beach ridge	*BG*
beach terrace	*BT*
berm	*BM*
beveled base	*BVB*
blind valley	*VB*
block field	*BW*
block glide	*BLG*
block lava flow	*BLF*
block stream	*BX*
blowout	*BY*
bluff	*BN*
bog	*BO*
box canyon	*BOX*
braided stream	*BZ*
breached anticline (also LS)	*BRL*
breaks (also LS)	*BK*
broad interstream divide	*BID*
butte	*BU*
caldera (also LS)	*CD*
canyon	*CA*
canyon bench	*CYB*
canyon wall	*CW*
Carolina Bay	*CB*
channel (also Micro)	*CC*
chenier	*CG*
chenier plain	*CH*
cinder cone	*CI*
cirque	*CQ*

cirque floor	*CFL*	divide	*DN*
cirque headwall	*CHW*	dome	*DO*
cirque platform	*CPF*	drainageway	*DQ*
cliff	*CJ*	drainhead complex	*DRC*
climbing dune	*CDU*	draw	*DW*
closed depression (also Micro)	*CLD*	drumlin	*DR*
coastal plain (also LS)	*CP*	drumlinoid ridge	*DRR*
cockpit	*COC*	dune	*DU*
col	*CL*	dune field (also LS)	*DUF*
collapse sinkhole	*CSH*	dune lake (w)	*DUL*
collapsed ice-floored lakebed	*CK*	dune slack (also Micro)	*DUS*
collapsed ice-walled lakebed	*CN*	earth spread	*ESP*
collapsed lake plain	*CS*	earth topple	*ETO*
collapsed outwash plain	*CT*	earthflow	*EF*
colluvial apron	*COA*	end moraine	*EM*
complex landslide	*CLS*	ephemeral stream (also Micro)	*EPS*
coral island	*COR*	eroded fan remnant	*EFR*
coulee	*CE*	eroded fan-remnant side slope	*EFS*
cove	*CO*	erosion remnant	*ER*
cove [water] (w)	*COW*	escarpment	*ES*
crag and tail	*CAT*	esker	*EK*
creep	*CRE*	estuary (w; also LS)	*WD*
crevasse filling	*CF*	faceted spur	*FS*
cuesta	*CU*	fall	*FB*
cuesta valley	*CUV*	falling dune	*FDU*
cutoff	*CV*	fan	*FC*
debris avalanche	*DA*	fan apron	*FA*
debris fall	*DEF*	fan collar	*FCO*
debris flow	*DF*	fan piedmont (also LS)	*FG*
debris slide	*DS*	fan remnant	*FH*
debris spread	*DES*	fan skirt	*FI*
debris topple	*DET*	fanhead trench	*FF*
deflation basin	*DB*	fault block	*FAB*
deflation flat	*DFL*	fault zone	*FAZ*
delta	*DE*	fault-line scarp	*FK*
delta plain (also LS)	*DC*	fen	*FN*
depression	*DP*	fissure vent	*FIV*
diapir	*DD*	fjord (w)	*FJ*
diatreme	*DT*	flat	*FL*
dike	*DK*	flatwoods	*FLW*
dip slope	*DL*	flood plain	*FP*
disintegration moraine	*DM*	flood-plain playa	*FY*
distributary	*DIS*	flood-plain splay	*FM*

flood-plain step	*FO*
flood-tidal delta	*FTD*
flood-tidal delta flat	*FTF*
flood-tidal delta slope	*FTS*
flow	*FLO*
flute (also Micro)	*FU*
fluviomarine bottom	*FMB*
fluviomarine terrace (also LS)	*FMT*
fold	*FQ*
foredune	*FD*
fosse	*FV*
free face *(also Geom. Component—Hills, Mountains)*	*FW*
fringe-tidal marsh	*FTM*
gap	*GA*
geyser	*GE*
geyser basin	*GEB*
geyser cone	*GEC*
giant ripple	*GC*
glacial drainage channel	*GD*
glacial lake (w)	*WE*
glacial lake [relict]	*GL*
glacial-valley floor	*GVF*
glacial-valley wall	*GVW*
glacier	*GLA*
gorge	*GO*
graben	*GR*
ground moraine	*GM*
gulch	*GT*
gulf (w; also LS)	*GU*
gut [channel]; (w; also Micro)	*WH*
gut [valley]	*GV*
half graben	*HG*
hanging valley	*HV*
headland	*HE*
head-of-outwash	*HD*
headwall	*HW*
high hill	*HH*
highmoor bog	*HB*
hill (plural is LS)	*HI*
hillslope	*HS*
hogback	*HO*
homoclinal ridge	*HCR*
homocline	*HC*
horn	*HR*
horst	*HT*
hot spring	*HP*
ice pressure ridge	*IPR*
ice-contact slope	*ICS*
ice-marginal stream	*IMS*
ice-pushed ridge	*IPU*
inlet	*IL*
inselberg	*IN*
inset fan	*IF*
interdrumlin	*IDR*
interdune (also Micro)	*ID*
interfluve *(also Geom. Component—Hills)*	*IV*
interior valley	*INV*
intermittent stream (also Micro)	*INT*
intermontane basin (also LS)	*IB*
island (also LS)	*IS*
kame	*KA*
kame moraine	*KM*
kame terrace	*KT*
karst cone	*KC*
karst lake	*KAL*
karst tower	*KTO*
karst valley	*KVA*
karstic marine terrace	*KMT*
kettle	*KE*
kipuka	*KIP*
knob	*KN*
knoll	*KL*
lagoon (w; also LS)	*WI*
lagoon bottom	*LBO*
lagoon channel	*LCH*
lagoon [relict]	*LAR*
lahar	*LA*
lake (w)	*WJ*
lake plain (also LS)	*LP*
lake terrace	*LT*
lakebed (w)	*LB*
lakebed [relict]	*LBR*

lakeshore	*LF*	mountain slope	*MN*
landslide	*LK*	mountain valley	*MV*
lateral moraine	*LM*	mud pot	*MP*
lateral spread	*LS*	mudflow	*MW*
lava dome	*LD*	muskeg	*MX*
lava field (also LS)	*LFI*	natural levee	*NL*
lava flow	*LC*	nearshore zone	*NZ*
lava flow unit (also Micro)	*LFU*	nearshore zone [relict]	*NZR*
lava plain (also LS)	*LN*	notch	*NO*
lava plateau (also LS)	*LL*	nunatak	*NU*
lava trench (also Micro)	*LTR*	open depression (also Micro)	*ODE*
lava tube	*LTU*	outwash delta	*OD*
ledge	*LE*	outwash fan	*OF*
levee	*LV*	outwash plain (also LS)	*OP*
loess bluff	*LO*	outwash terrace	*OT*
loess hill	*LQ*	overflow stream channel	*OSC*
longitudinal dune	*LDU*	oxbow	*OX*
longshore bar	*LON*	oxbow lake (w)	*WK*
longshore bar [relict]	*LR*	paha	*PA*
louderback	*LU*	pahoehoe lava flow	*PAF*
low hill	*LH*	paleoterrace	*PTR*
lowmoor bog	*LX*	parabolic dune	*PB*
maar	*MAA*	parna dune	*PD*
main scarp (also Micro)	*MAS*	partial ballena	*PF*
mainland cove	*MAC*	patterned ground	*PG*
mangrove swamp	*MAN*	pavement karst	*PAV*
marine lake (w)	*ML*	peak	*PK*
marine terrace (also LS)	*MT*	peat plateau	*PJ*
marsh	*MA*	pediment	*PE*
mawae	*MAW*	perennial stream (w; also Micro)	*PS*
meander	*MB*	pillow lava flow	*PIF*
meandering channel	*MC*	pingo	*PI*
meander scar	*MS*	pinnacle (also Micro)	*PIN*
meander scroll	*MG*	pitted outwash plain	*PM*
medial moraine	*MH*	pitted outwash terrace	*POT*
mesa	*ME*	plain (plural is LS)	*PN*
meteorite crater	*MEC*	plateau (also LS)	*PT*
mogote	*MOG*	playa	*PL*
monadnock	*MD*	playa dune (also Micro)	*PDU*
monocline	*MJ*	playa floor (also Micro)	*PFL*
moraine	*MU*	playa lake (w)	*WL*
mountain (plural is LS)	*MM*	playa rim (also Micro)	*PRI*

playa slope (also Micro)	*PSL*
playa step (also Micro)	*PST*
plug dome	*PP*
pluvial lake (w)	*PLL*
pluvial lake [relict]	*PQ*
pocosin	*PO*
point bar	*PR*
point bar [coastal]	*PRC*
pothole (also Micro)	*PH*
pothole lake (w)	*WN*
proglacial lake (w)	*WO*
proglacial lake [relict]	*PGL*
pyroclastic flow	*PCF*
pyroclastic surge	*PCS*
raised beach	*RA*
raised bog	*RB*
ravine	*RV*
recessional moraine	*RM*
reef	*RF*
ribbed fen	*RG*
ridge	*RI*
rim	*RJ*
rise (also Micro); (also Geom. Component—Flat Plains)	*RIS*
river (w)	*RIV*
river valley (also LS)	*RVV*
roche moutonnée (also Micro)	*RN*
rock glacier	*RO*
rock pediment	*ROP*
rock spread	*ROS*
rock topple	*ROT*
rockfall (also Micro)	*ROF*
rockfall avalanche	*RFA*
rotational debris slide	*RDS*
rotational earth slide	*RES*
rotational rock slide	*RRS*
rotational slide	*RTS*
sabkha	*SAB*
saddle	*SA*
sag (also Micro)	*SAG*
sag pond (w; also Micro)	*SGP*
salt marsh	*SM*
salt pond (w; also Micro)	*WQ*
sand flow (also Micro)	*RW*
sand ramp	*SAR*
sand sheet	*RX*
scarp	*RY*
scarp slope	*RS*
scree slope	*SCS*
sea (w; also LS)	*SEA*
sea cliff	*RZ*
seep (also Micro)	*SEE*
seif dune	*SD*
semi-open depression	*SOD*
shield volcano (also LS)	*SHV*
shoal (w)	*WR*
shoal [relict]	*SE*
shore	*SHO*
shore complex (also LS)	*SHC*
sill	*RT*
sinkhole	*SH*
slackwater (w)	*WS*
slickrock (also Micro)	*SLK*
slide	*SJ*
slot canyon	*SLC*
slough (w)	*SL*
slump block	*SN*
snowfield	*SNF*
soil fall	*SOF*
solution platform	*SOP*
solution sinkhole	*SOS*
sound (w; also LS)	*SO*
spit	*SP*
spur	*SQ*
stack [coast]	*SRC*
stack [geom.]	*SR*
star dune	*SDU*
steptoe	*ST*
stock	*STK*
stoss and lee	*SAL*

strait (w; also LS)	*STT*
strand plain	*SS*
strath terrace	*SU*
stratovolcano	*SV*
stream (w)	*STR*
stream terrace	*SX*
strike valley	*STV*
string bog	*SY*
structural bench	*SB*
submerged back-barrier beach	*SBB*
submerged mainland beach	*SMB*
submerged point bar [coast]	*SPB*
submerged wave-built terrace	*SWT*
submerged wave-cut platform	*SWP*
submerged–upland tidal marsh	*STM*
swale (also Micro)	*SC*
swallow hole	*TB*
swamp	*SW*
syncline	*SZ*
talus cone	*TC*
talus slope	*TAS*
tarn (w; also Micro)	*TAR*
terminal moraine	*TA*
terrace	*TE*
terrace remnant	*TER*
thermokarst depression (also Micro)	*TK*
thermokarst lake (w)	*WV*
tidal flat	*TF*
tidal inlet	*TI*
tidal inlet [relict] (w)	*TIR*
tidal marsh	*TM*
till plain (also LS)	*TP*
till-floored lake plain	*TLP*
toe (also Micro)	*TOE*
tombolo	*TO*
topple	*TOP*
tor	*TQ*
Toreva block	*TOR*
translational debris slide	*TDS*
translational earth slide	*TES*
translational rock slide	*TRS*
translational slide	*TS*
transverse dune	*TD*
trough	*TR*
tunnel valley	*TV*
tunnel-valley lake (w)	*TVL*
underfit stream	*US*
U-shaped valley	*UV*
valley (also LS)	*VA*
valley flat	*VF*
valley floor	*VL*
valley side	*VS*
valley train	*VT*
valley-border surfaces	*VBS*
valley-floor remnant	*VFR*
volcanic cone	*VC*
volcanic crater	*CR*
volcanic dome	*VD*
volcanic field (also LS)	*VOF*
volcanic neck	*VON*
volcanic pressure ridge (also Micro)	*PU*
volcano	*VO*
V-shaped valley	*VV*
wash	*WA*
washover fan	*WF*
washover-fan flat	*WFF*
washover-fan slope	*WFS*
water-lain moraine	*WM*
wave-built terrace	*WT*
wave-cut platform	*WP*
wave-worked till plain	*WW*
wind gap	*WG*
window	*WIN*
wind-tidal flat	*WTF*
yardang (also Micro)	*YD*
yardang trough (also Micro)	*YDT*

C) **Microfeatures** (discrete, natural, earth-surface features too small to delineate at common survey scales)

1) **Common Microfeatures** (not used in association with the landform "patterned ground")

bar	*BA*
channel (also LF)	*CH*
closed depression (also LF)	*CD*
corda	*CO*
cutter	*CU*
dune slack (also LF)	*DS*
dune traces	*DT*
earth pillar	*EP*
ephemeral stream (also LF)	*ES*
estuarine tidal stream (also Micro)	*ETS*
finger ridge	*FR*
flute (also LF)	*FL*
frost boil	*FB*
glacial groove	*GG*
groove	*GR*
gully	*GU*
gut [channel]; (w; also LF)	*WH*
hillock	*HI*
hoodoo	*HO*
ice wedge	*IWD*
ice wedge cast	*IWC*
interdune (also LF)	*ID*
intermittent stream (w; also LF)	*INT*
karren	*KA*
lava flow unit (also LF)	*LFU*
lava trench (also LF)	*LT*
main scarp (also LF)	*MAS*
minor scarp	*MIS*
mound	*MO*
nivation hollow	*NH*
open depression (also LF)	*OP*
perennial stream (w; also LF)	*PS*
pinnacle (also LF)	*PI*
playa dune (also LF)	*PD*
playa floor (also LF)	*PF*
playa rim (also LF)	*PR*
playa slope (also LF)	*PSL*
playa step (also LF)	*PST*
playette	*PL*
pond (w)	*PON*
pool (w)	*POO*
pothole (also LF)	*PH*
rib	*RB*
rill	*RL*
ripple mark	*RM*
rise (also LF); (also Geom. Component—Flat Plains)	*RIS*
roche moutonnée (also LF)	*POC*
rockfall (also LF)	*ROF*
sag (also LF)	*SAG*
sag pond (w; also LF)	*SP*
salt pond (w; also LF)	*WQ*
sand boil	*SB*
sand flow (also LF)	*RW*
seep (also LF)	*SE*
shoreline	*SH*
shrub-coppice dune	*SCD*
slickrock (also LF)	*SLK*
slip face	*SF*
solifluction lobe	*SOL*
solifluction sheet	*SS*
solifluction terrace	*ST*
solution chimney	*SCH*
solution corridor	*SCO*
solution fissure	*SOF*
solution pipe	*SOP*
spatter cone	*SPC*
spiracle	*SPI*
strandline	*SL*
swale (also LF)	*SW*
swash zone	*SZ*
tank (w)	*TA*
tarn (w; also LF)	*TN*
terracettes	*TER*

thermokarst depression (also LF)	*TK*	vernal pool (seasonal water)	*VP*
toe [mass mvt.]; (also LF)	*TOE*	volcanic pressure ridge (also LF)	*VPR*
tree-tip mound	*TTM*	yardang (also LF)	*YD*
tree-tip pit	*TTP*	yardang trough (also LF)	*YDT*
tumulus (pl.: tumuli)	*TU*	zibar	*ZB*

2) **Periglacial “Patterned Ground” Microfeatures** (singular forms [e.g., *circle*] used for a single feature [pedon scale], whereas plural forms [e.g., circles] used for map unit components)

circle	*CI*	palsa (is peat hummock)	*PA*
earth hummock	*EH*	polygon	*PYG*
high-center polygon	*HCP*	sorted circle	*SCI*
ice wedge polygon	*IWP*	stripe	*STR*
low-center polygon	*LCP*	turf hummock	*TH*
nonsorted circle	*NSC*		

3) **Other “Patterned Ground” Microfeatures** (Singular forms [e.g., hummock] used for a single feature [pedon scale], whereas plural forms [e.g., hummocks] used for map unit components)

bar and channel	*BC*	linear gilgai	*LG*
circular gilgai	*CG*	mima mound	*MM*
elliptical gilgai	*EG*	pimple mound	*PM*
gilgai	*GI*	puff	*PU*
hummock	*HU*		

D) Anthroscapes (large, discrete, artificial [human-made or extensively modified] landscapes)

anthroscape	*ANT*	resource extraction anthroscape	*RXT*
agricultural anthroscape	*AGT*	suburban anthroscape	*SAT*
hillslope terrace anthroscape	*HAT*	urban anthroscape	*UAT*
reclaimed mineland anthroscape	*RCT*		

E) Anthropogenic Landforms (discrete, artificial [human-made or extensively modified] earth-surface features)

artificial collapsed depression	*ACD*	burial mound (also Anthro Micro)	*BM*
artificial levee (also Anthro Micro)	*AL*	conservation terrace [modern]	*CT*
bioswale (also Anthro Micro)	*BS*	cut (e.g., railroad); (also Anthro Micro)	*CUT*
borrow pit (also Anthro Micro)	*BP*		

cutbank (also Anthro Micro)	*CB*	polder	*POL*
dredge spoil bank	*DSB*	pond [human-made]; (also Anthro Micro)	*PO*
dredge-deposit shoal	*DDS*	quarry	*QU*
dredged channel (also Anthro Micro)	*DC*	railroad bed (also Anthro Micro)	*RRB*
dump	*DU*	reclaimed land (also Anthro Micro)	*RL*
fill (also Anthro Micro)	*FI*	rice paddy (also Anthro Micro)	*RP*
filled marshland (also Anthro Micro)	*FM*	road cut (also Anthro Micro)	*RC*
floodway (also Anthro Micro)	*FW*	sand pit (also Anthro Micro)	*SP*
gravel pit (also Anthro Micro)	*GP*	sanitary landfill	*SL*
headwall [anthro]; (also Anthro Micro)	*HW*	scalped area (also Anthro Micro)	*SA*
hillslope terrace [ancient]; (also Anthro Micro)	*HT*	sewage lagoon (also Anthro Micro)	*SWL*
landfill [see “sanitary landfill”]	—	spoil bank (also Anthro Micro)	*SB*
leveled land	*LVL*	spoil pile (also Anthro Micro)	*SPP*
midden (also Anthro Micro)	*MI*	surface mine	*SM*
openpit mine	*OM*	truncated soil (also Anthro Micro)	*TS*

F) Anthropogenic Microfeatures (discrete, artificial [human-made or extensively modified] earth-surface features too small to delineate at normal mapping scales)

artificial levee (also Anthro LF)	*AL*	furrow	*FR*
beveled cut	*BC*	gravel pit (also Anthro LF)	*GP*
bioswale (also Anthro LF)	*BS*	headwall [anthro] (also Anthro LF)	*HW*
borrow pit (also Anthro LF)	*BP*	hillslope terrace [ancient] (also Anthro LF)	*HT*
burial mound (also Anthro LF)	*BM*	impact crater	*IC*
conservation terrace [modern] (also Anthro LF)	*CT*	interfurrow	*IF*
cut (e.g., railroad) (also Anthro LF)	*CUT*	log landing	*LL*
cutbank (also Anthro LF)	*CB*	midden (also Anthro LF)	*MI*
ditch	*DI*	pond [human-made] (also Anthro LF)	*PO*
double-bedding mound (i.e., bedding mound used for timber; lower Coastal Plain)	*DBM*	railroad bed (also Anthro LF)	*RRB*
drainage ditch	*DD*	reclaimed land (also Anthro LF)	*RL*
dredged channel (also Anthro LF)	*DC*	rice paddy (also Anthro LF)	*RP*
fill (also Anthro LF)	*FI*	road bed	*RB*
filled marshland (also Anthro LF)	*FM*	road cut (also Anthro LF)	*RC*
floodway (also Anthro LF)	*FW*	sand pit (also Anthro LF)	*SP*
		scalped area (also Anthro LF)	*SA*
		sewage lagoon (also Anthro LF)	*SWL*

skid trail	*ST*	tillage mound	*TM*
spoil bank (also Anthro LF)	*SB*	truncated soil (also Anthro LF)	*TS*
spoil pile (also Anthro LF)	*SPP*		

II) Geomorphic Environments and Other Groupings: Landscape, landform, and microfeature terms grouped by geomorphic process (e.g., fluvial) or by common setting (e.g., water body); (LS is landscape; LF is landform; Micro is microfeature. Lists are not mutually exclusive.)

1. Coastal Marine and Estuarine (wave or tidal control or near-shore/shallow marine)

Landscapes:

barrier island (also LF)	*BI*	lowland	*LW*
bay [coast] (w; also LF)	*BY*	marine terrace (also LF)	*MT*
coastal plain (also LF)	*CP*	ocean (w)	*OC*
delta plain (also LF)	*DP*	peninsula	*PE*
estuary (w; also LF)	*ES*	sea (w; also LF)	*SEA*
fluviomarine terrace (also LF)	*FT*	shore complex	*SX*
gulf (w; also LF)	*GU*	sound (w; also LF)	*SO*
island (also LF)	*IS*	strait (w; also LF)	*ST*
lagoon (w; also LF)	*LG*		

Landforms:

atoll	*AT*	bluff	*BN*
back-barrier beach	*BBB*	chenier	*CG*
back-barrier flat	*BBF*	chenier plain	*CH*
backshore	*AZ*	coastal plain (also LS)	*CP*
bar	*BR*	coral island	*COR*
barrier beach	*BB*	cove [water] (w)	*COW*
barrier cove	*BAC*	delta	*DE*
barrier flat	*BF*	delta plain (also LS)	*DC*
barrier island (also LS)	*BI*	drainhead complex	*DRC*
bay [coast] (w; also LS)	*BAY*	estuary (also LS)	*WD*
bay bottom	*BOT*	flat	*FL*
beach	*BE*	flatwoods	*FLW*
beach plain	*BP*	fluviomarine terrace (also LS)	*FMT*
beach ridge	*BG*	foredune	*FD*
beach terrace	*BT*	fringe-tidal marsh	*FTM*
berm	*BM*	gulf (w; also LS)	*GU*

gut [channel] (w, also Micro)	*WH*	semi-open depression	*SOD*
headland	*HE*	shoal [relict]	*SE*
island (also LS)	*IS*	shore	*SHO*
lagoon (w; also LS)	*WI*	shore complex (also LS)	*SHC*
lagoon [relict]	*LAR*	sound (w; also LS)	*SO*
longshore bar	*LON*	spit	*SP*
longshore bar [relict]	*LR*	stack [coast]	*SRC*
mangrove swamp	*MAN*	strait (w; also LS)	*STT*
marine lake (w)	*ML*	strand plain	*SS*
marine terrace (also LS)	*MT*	submerged–upland tidal marsh	*STM*
nearshore	*NZ*	tidal flat	*TF*
nearshore zone [relict]	*NZR*	tidal inlet	*TI*
point bar [coastal]	*PRC*	tidal inlet [relict]	*TIR*
raised beach	*RA*	tidal marsh	*TM*
reef	*RF*	tombolo	*TO*
sabkha	*SAB*	washover fan	*WF*
salt marsh	*SM*	wave-built terrace	*WT*
sea (w; also LS)	*SEA*	wave-cut platform	*WP*
sea cliff	*RZ*	wind-tidal flat	*WTF*

Microfeatures:

gut [channel] (w; also LF)	*WH*	shoreline	*SH*
ripple mark	*RM*	swash zone	*SZ*

2. **Lacustrine** (related to inland water bodies)

Landscapes:

bay [coast] (w; also LF)	*BY*	lake plain (also LF)	*LP*
delta plain (also LF)	*DP*	peninsula	*PE*
island (also LF)	*IS*	shore complex (also LF)	*SX*

Landforms:

backshore	*AZ*	delta	*DE*
bar (also Micro)	*BR*	delta plain (also LS)	*DC*
barrier beach	*BB*	flat	*FL*
barrier flat	*BF*	flood-plain playa	*FY*
barrier island	*BI*	foredune	*FD*
bay [coast] (w; also LS)	*BAY*	headland	*HE*
beach	*BE*	island (also LS)	*IS*
beach plain	*BP*	karst lake	*KAL*
beach ridge	*BG*	lagoon	*WI*
beach terrace	*BT*	lagoon [relict]	*LAR*
berm	*BM*	lake (w)	*WJ*
bluff	*BN*	lakebed [relict]	*LBR*

lake plain (also LS)	*LP*	raised beach	*RA*
lakeshore	*LF*	sabkha	*SAB*
lake terrace	*LT*	salt marsh	*SM*
longshore bar	*LON*	shoal [relict]	*SE*
longshore bar [relict]	*LR*	shore	*SHO*
nearshore zone	*NZ*	shore complex (also LS)	*SHC*
nearshore zone [relict]	*NZR*	spit	*SP*
oxbow lake	*WK*	stack [coast]	*SRC*
playa	*PL*	strand plain	*SS*
playa floor (also Micro)	*PFL*	till-floored lake plain	*TLP*
playa lake (w)	*WL*	tombolo	*TO*
playa rim (also Micro)	*PRI*	water-lain moraine	*WM*
playa slope (also Micro)	*PSL*	wave-built terrace	*WT*
playa step (also Micro)	*PST*	wave-cut platform	*WP*
pluvial lake (w)	*PLL*	wave-worked till plain	*WW*
pluvial lake [relict]	*PQ*		

Microfeatures:

bar (also LF)	*BA*	ripple mark	*RM*
playa floor (also LF)	*PF*	shoreline	*SH*
playa rim (also LF)	*PR*	strandline	*SL*
playa slope (also LF)	*PSL*	swash zone	*SZ*
playa step (also LF)	*PST*	vernal pool	*VP*
playette	*PL*		

3. **Fluvial** (dominantly related to concentrated water flow [channel flow]; includes both erosional and depositional features with the exceptions of glaciofluvial landforms [see “Glacial”] and permanent water features [see “Water Bodies”])

Landscapes:

alluvial plain	*AP*	delta plain (also LF)	*DP*
alluvial plain remnant	*AR*	dissected breaklands	*DB*
badlands	*BA*	fan piedmont	*FP*
bajada (also LF)	*BJ*	meander belt	*MB*
breaklands	*BR*	river valley (also LF)	*RV*
breaks	*BK*	scabland	*SC*
canyonlands	*CL*		

Landforms:

alluvial cone	*AC*	arroyo	*AY*
alluvial fan	*AF*	axial stream (w)	*AX*
alluvial flat	*AP*	backswamp	*BS*

bajada (also LS)	*BJ*	gorge	*GO*
bar (also Micro)	*BR*	gulch	*GT*
basin-floor remnant	*BD*	gut [valley]	*GV*
block stream	*BX*	inset fan	*IF*
box canyon	*BOX*	intermittent stream (also Micro)	*INT*
braided stream	*BZ*	levee	*LV*
canyon	*CA*	meandering channel	*MC*
channel	*CC*	meander scar	*MS*
coulee	*CE*	meander scroll	*MG*
cutoff	*CV*	natural levee	*NL*
delta	*DE*	overflow stream channel	*OSC*
delta plain (also LS)	*DC*	oxbow	*OX*
drainageway	*DQ*	paleoterrace	*PTR*
drainhead complex	*DRC*	point bar	*PR*
draw	*DW*	ravine	*RV*
ephemeral stream (also Micro)	*EPS*	river valley (also LS)	*RVV*
fan apron	*FA*	semi-open depression	*SOD*
fan collar	*FCO*	slot canyon	*SLC*
fanhead trench	*FF*	strath terrace	*SU*
fan remnant	*FH*	stream terrace	*SX*
fan skirt	*FI*	terrace remnant	*TER*
flood plain	*FP*	valley flat	*VF*
flood-plain playa	*FY*	valley-border surfaces	*VBS*
flood-plain splay	*FM*	valley-floor remnant	*VFR*
flood-plain step	*FO*	wash	*WA*
giant ripple	*GC*	wind gap	*WG*

Microfeatures:

bar (also LF)	*BA*	groove	*GR*
bar and channel *(patterned ground)*	*BC*	gully	*GU*
		intermittent stream (also LF)	*INT*
channel	*CH*	ripple mark	*RM*
ephemeral stream (also LF)	*ES*	swash zone	*SZ*

4. **Solution** (dominated by dissolution and, commonly, subsurface drainage)

Landscapes:

cockpit karst	*CPK*	glaciokarst	*GK*
cone karst	*CK*	karst	*KR*
fluviokarst	*FK*	kegel karst	*KK*

sinkhole karst	*SK*	tower karst	*TW*
thermokarst	*TK*		

Landforms:

blind valley	*VB*	pavement karst	*PAV*
cockpit	*COC*	pinnacle	*PIN*
collapse sinkhole	*CSH*	sinkhole	*SH*
interior valley	*INV*	solution platform	*SOP*
karst cone	*KC*	solution sinkhole	*SOS*
karstic marine terrace	*KMT*	swallow hole	*TB*
karst lake (w)	*KAL*	thermokarst depression (also Micro)	*TK*
karst tower	*KTO*	yardang (also Micro)	*YD*
karst valley	*KVA*	yardang trough (also Micro)	*YDT*
mogote	*MOG*		

Microfeatures:

cutter	*CU*	solution pipe	*SOP*
karren	*KA*	thermokarst depression (also LF)	*TK*
solution chimney	*SCH*	yardang (also LF)	*YD*
solution corridor	*SCO*	yardang trough (also LF)	*YDT*
solution fissure	*SOF*		

5. **Eolian** (dominantly wind related; erosion or deposition)

Landscapes:

dune field (also LF)	*DU*	sand plain	*SP*
sandhills	*SH*		

Landforms:

barchan dune	*BQ*	interdune (also Micro)	*ID*
blowout	*BY*	loess bluff	*LO*
climbing dune	*CDU*	loess hill	*LQ*
deflation basin	*DB*	longitudinal dune	*LDU*
deflation flat	*DFL*	paha	*PA*
dune	*DU*	parabolic dune	*PB*
dune field (also LS)	*DUF*	parna dune	*PD*
dune lake (w)	*DUL*	playa dune (also Micro)	*PDU*
dune slack (also Micro)	*DUS*	sabkha	*SAB*
falling dune	*FDU*	sand ramp	*SAR*
foredune	*FD*	sand sheet	*RX*

seif dune	*SD*	transverse dune	*TD*
slickrock (also Micro)	*SLK*	yardang (also Micro)	*YD*
star dune	*SDU*	yardang trough (also Micro)	*YDT*

Microfeatures:

dune slack (also LF)	*DS*	slickrock (also LF)	*SLK*
dune traces	*DT*	slip face	*SF*
interdune (also LF)	*ID*	yardang (also LF)	*YD*
playa dune (also LF)	*PD*	yardang trough (also LF)	*YDT*
playette	*PL*	zibar	*ZB*
shrub-coppice dune	*SCD*		

6. **Glacial** (directly related to glaciers; includes glaciofluvial, glaciolacustrine, glaciomarine, and outwash features)

Landscapes:

continental glacier	*CG*	ice-margin complex	*IC*
drumlin field	*DF*	outwash plain (also LF)	*OP*
glaciokarst	*GK*	till plain (also LF)	*TP*
hills	*HI*		

Landforms:

alpine glacier	*AG*	flute (also Micro)	*FU*
arete	*AR*	fosse	*FV*
cirque	*CQ*	giant ripple	*GC*
cirque floor	*CFL*	glacial drainage channel	*GD*
cirque headwall	*CHW*	glacial lake (w)	*WE*
cirque platform	*CPF*	glacial lake [relict]	*GL*
col	*CL*	glacial-valley floor	*GVF*
collapsed ice-floored lakebed	*CK*	glacial-valley wall	*GVW*
collapsed ice-walled lakebed	*CN*	glacier	*GLA*
collapsed lake plain	*CS*	ground moraine	*GM*
collapsed outwash plain	*CT*	hanging valley	*HV*
crag and tail	*CAT*	head-of-outwash	*HD*
crevasse filling	*CF*	ice-contact slope	*ICS*
disintegration moraine	*DM*	ice-marginal stream	*IMS*
drumlin	*DR*	ice pressure ridge	*IPR*
drumlinoid ridge	*DRR*	ice-pushed ridge	*IPU*
end moraine	*EM*	interdrumlin	*IDR*
esker	*EK*	kame	*KA*
fjord (w)	*FJ*	kame moraine	*KM*

kame terrace	*KT*	proglacial lake [relict]	*PGL*
kettle	*KE*	recessional moraine	*RM*
lateral moraine	*LM*	roche moutonnée (also Micro)	*RN*
medial moraine	*MH*	rock glacier	*RO*
moraine	*MU*	snowfield	*SNF*
nearshore zone	*NZ*	stoss and lee	*SAL*
nearshore zone [relict]	*NZR*	swale (also Micro)	*SC*
nunatak	*NU*	tarn (w; also Micro)	*TAR*
outwash delta	*OD*	terminal moraine	*TA*
outwash fan	*OF*	till-floored lake plain	*TLP*
outwash plain (also LS)	*OP*	till plain (also LS)	*TP*
outwash terrace	*OT*	tunnel valley	*TV*
paha	*PA*	tunnel-valley lake (w)	*TVL*
pitted outwash plain	*PM*	underfit stream	*US*
pitted outwash terrace	*POT*	U-shaped valley	*UV*
pothole (also Micro)	*PH*	valley train	*VT*
pothole lake (intermittent water)	*WN*	water-lain moraine	*WM*
proglacial lake (w)	*WO*	wave-worked till plain	*WW*

Microfeatures:

flute (also LF)	*FL*	pothole (also LF)	*PH*
glacial groove	*GG*	roche moutonnée (also LF)	*POC*
ice wedge	*IWD*	swale (also LF)	*SW*
ice wedge cast	*IWC*	tarn (w; also LF)	*TN*
nivation hollow	*NH*		

7. **Periglacial** (related to nonglacial, cold climate [modern or relict], including periglacial forms of patterned ground); (***Note:*** Consider “patterned ground” as a landform, but treat specific types of patterned ground [singular or plural] as microfeatures.)

Landscapes:

coastal plain	*CP*	plains	*PL*
hills	*HI*	thermokarst	*TK*

Landforms:

alas	*AA*	pingo	*PI*
block field	*BW*	rock glacier	*RO*
muskeg	*MX*	string bog	*SY*
patterned ground *(see Microfeatures below for types)*	*PG*	thermokarst depression (also Micro)	*TK*
peat plateau	*PJ*	thermokarst lake (w)	*WV*

Microfeatures:

circle	*CI*	palsa (is peat hummock)	*PA*
earth hummock	*EH*	polygon	*PYG*
frost boil	*FB*	solifluction lobe	*SOL*
high-center polygon	*HCP*	solifluction sheet	*SS*
ice wedge	*IWD*	solifluction terrace	*ST*
ice wedge cast	*IWC*	sorted circle	*SCI*
ice-wedge polygon	*IWP*	stripe	*STR*
low-center polygon	*LCP*	thermokarst depression (also LF)	*TK*
nivation hollow	*NH*	turf hummock	*TH*
nonsorted circle	*NSC*		

8. **Mass Movement (=Mass Wasting)** (dominated by gravity, including creep forms; also see “Mass Movement Types” table, p. 5–8)

Landscapes: (These generic landscapes are not mass movement features per se but are commonly modified by and include localized areas of mass movement.)

breaklands	*BR*	hills	*HI*
dissected breaklands	*DB*	mountain range	*MR*
foothills	*FH*	mountains	*MO*

Landforms:

ash flow	*AS*	lateral spread	*LS*
avalanche chute	*AL*	main scarp (also Micro)	*MAS*
block glide	*BLG*	mudflow	*MW*
block stream	*BX*	rockfall (also Micro)	*ROF*
colluvial apron	*COA*	rockfall avalanche	*RFA*
complex landslide	*CLS*	rock glacier	*RO*
creep	*CRE*	rock spread	*ROS*
debris avalanche	*DA*	rock topple	*ROT*
debris fall	*DEF*	rotational debris slide	*RDS*
debris flow	*DF*	rotational earth slide	*RES*
debris slide	*DS*	rotational rock slide	*RRS*
debris spread	*DES*	rotational slide	*RTS*
debris topple	*DET*	sag (also Micro)	*SAG*
earthflow	*EF*	sag pond (w; also Micro)	*SGP*
earth spread	*ESP*	sand flow	*RW*
earth topple	*ETO*	scree slope	*SCS*
fall	*FB*	slide	*SJ*
flow	*FLO*	slump block	*SN*
lahar	*LA*	soil fall	*SOF*
landslide	*LK*	talus cone	*TC*

talus slope	*TAS*	translational debris slide	*TDS*
toe (also Micro)	*TOE*	translational earth slide	*TES*
topple	*TOP*	translational rock slide	*TRS*
Toreva block	*TOR*	translational slide	*TS*

Microfeatures:

main scarp (also LF)	*MAS*	solifluction lobe	*SOL*
minor scarp	*MIS*	solifluction sheet	*SS*
rockfall (also LF)	*ROF*	solifluction terrace	*ST*
sag (also LF)	*SAG*	terracettes	*TER*
sag pond (w; also LF)	*SP*	toe (also LF)	*TOE*
sand boil	*SB*		

9. Volcanic and Hydrothermal

Landscapes:

caldera (also LF)	*CD*	lava plateau (also LF)	*LL*
foothills	*FH*	mountains	*MO*
hills	*HI*	shield volcano (also LF)	*SV*
lava field (also LF)	*LF*	volcanic field (also LF)	*VF*
lava plain (also LF)	*LV*		

Landforms:

aa lava flow	*ALF*	lava plain (also LS)	*LN*
ash field	*AQ*	lava plateau (also LS)	*LL*
ash flow	*AS*	lava trench (also Micro)	*LTR*
block lava flow	*BLF*	lava tube	*LTU*
caldera (also LS)	*CD*	louderback	*LU*
cinder cone	*CI*	maar	*MAA*
diatreme	*DT*	mawae	*MAW*
dike	*DK*	mud pot	*MP*
fissure vent	*FIV*	pahoehoe lava flow	*PAF*
geyser	*GE*	pillow lava flow	*PIF*
geyser basin	*GEB*	plug dome	*PP*
geyser cone	*GEC*	pyroclastic flow	*PCF*
hot spring	*HP*	pyroclastic surge	*PCS*
kipuka	*KIP*	shield volcano (also LS)	*SHV*
lahar	*LA*	steptoe	*ST*
lava dome	*LD*	stratovolcano	*SV*
lava field (also LS)	*LFI*	volcanic cone	*VC*
lava flow	*LC*	volcanic crater	*CR*
lava flow unit (also Micro)	*LFU*	volcanic dome	*VD*

volcanic field (also LS)	*VOF*	volcanic pressure ridge (also Micro)	*PU*
volcanic neck	*VON*	volcano	*VO*

Microfeatures:

corda	*CO*	spiracle	*SPI*
lava flow unit (also LF)	*LFU*	tumulus (pl.: tumuli)	*TU*
lava trench (also LF)	*LT*	volcanic pressure ridge (also LF)	*VPR*
spatter cone	*SPC*		

10. **Tectonic and Structural** (related to regional or local bedrock structures or crustal movement; recognized only if expressed at or near the land surface)

Landscapes:

basin floor	*BC*	mountain range	*MR*
batholith	*BL*	mountains	*MO*
bolson	*BO*	mountain system	*MS*
breached anticline (also LF)	*BD*	piedmont slope	*PS*
dissected plateau	*DP*	plateau	*PT*
fault-block mountains	*FM*	rift valley	*RF*
fold-thrust hills	*FTH*	semi-bolson	*SB*
foothills	*FH*	tableland	*TB*
hills	*HI*	valley	*VA*
intermontane basin	*IB*		

Landforms:

anticline	*AN*	homoclinal ridge	*HCR*
breached anticline (also LS)	*BRL*	homocline	*HC*
canyon bench	*CYB*	horst	*HT*
cuesta	*CU*	louderback	*LU*
cuesta valley	*CUV*	meteorite crater	*MEC*
diapir	*DD*	monocline	*MJ*
dike	*DK*	rock pediment	*ROP*
dip slope	*DL*	scarp slope	*RS*
dome	*DO*	sill	*RT*
fault block	*FAB*	stock	*STK*
fault-line scarp	*FK*	strike valley	*STV*
fault zone	*FAZ*	structural bench	*SB*
fold	*FQ*	syncline	*SZ*
graben	*GR*	window	*WIN*
half graben	*HG*		
hogback	*HO*		

Microfeatures:

sand boil	*SB*

11. Slope (generic terms [e.g., hill] or those that describe slope form, geometry, or arrangement of land features rather than any particular genesis or process)

Landscapes:

badlands	*BA*
breached anticline (also LF)	*BD*
breaklands	*BR*
breaks	*BK*
canyonlands	*CL*
dissected breaklands	*DB*
dissected plateau	*DI*
fault-block mountains	*FM*
foothills	*FH*
hills (singular is LF)	*HI*
mountain range	*MR*
mountains	*MO*
mountain system	*MS*
piedmont	*PI*
piedmont slope	*PS*
plains (singular is LF)	*PL*
plateau (also LF)	*PT*
tableland	*TB*
upland	*UP*

Landforms:

beveled base	*BVB*
block stream	*BX*
bluff	*BN*
breached anticline (also LS)	*BRL*
broad interstream divide	*BID*
butte	*BU*
canyon bench	*CYB*
canyon wall	*CW*
cliff	*CJ*
colluvial apron	*COA*
cuesta	*CU*
dip slope	*DL*
dome	*DO*
escarpment	*ES*
faceted spur	*FS*
fault block	*FAB*
fault-line scarp	*FK*
free face *(also Geom. Component—Hills, Mountains)*	*FW*
gap	*GA*
headwall	*HW*
high hill	*HH*
hill (plural is LS)	*HI*
hillslope	*HS*
hogback	*HO*
interfluve *(also Geom. Component—Hills)*	*IV*
knob	*KN*
knoll	*KL*
ledge	*LE*
low hill	*LH*
mesa	*ME*
mountain (plural is LS)	*MM*
mountain slope	*MN*
mountain valley	*MV*
notch	*NO*
paha	*PA*
peak	*PK*
pediment	*PE*
plain (plural is LS)	*PN*
plateau (also LS)	*PT*
ridge	*RI*
rim	*RJ*
rise (also Micro) *(also Geom. Component—Flat Plains)*	*RIS*
rock pediment	*ROP*

scarp	*RY*	talus cone	*TC*
scarp slope	*RS*	talus slope	*TAS*
scree slope	*SCS*	tor	*TQ*
slickrock (also Micro)	*SLK*	valley	*VA*
spur	*SQ*	valley-floor remnant	*VFR*
stack [geom.]	*SR*	wind gap	*WG*
structural bench	*SB*		

Microfeatures:

finger ridge	*FR*	rill	*RL*
mound	*MO*	rise (also LF) *(also Geom. Component—Flat Plains)*	*RIS*
rib	*RB*	slickrock (also LF)	*SLK*

12. **Erosional** (related dominantly to water erosion but excludes perennial, concentrated channel flow [i.e., fluvial, glaciofluvial], or eolian erosion)

Landscapes:

badlands	*BA*	hills	*HI*
breached anticline (also LF)	*BD*	mountain range	*MR*
breaklands	*BR*	mountains	*MO*
breaks	*BK*	piedmont	*PI*
canyonlands	*CL*	piedmont slope	*PS*
dissected breaklands	*DB*	plateau (also LF)	*PT*
dissected plateau	*DI*	tableland	*TB*
foothills	*FH*		

Landforms:

ballena	*BL*	free face *(also Geom. Component—Hills, Mountains)*	*FW*
ballon	*BV*	gap	*GA*
basin floor remnant	*BD*	hogback	*HO*
beveled base	*BVB*	inselberg	*IN*
breached anticline (also LS)	*BRL*	monadnock	*MD*
canyon bench	*CYB*	notch	*NO*
canyon wall	*CW*	paha	*PA*
col	*CL*	partial ballena	*PF*
colluvial apron	*COA*	peak	*PK*
cuesta	*CU*	pediment	*PE*
cuesta valley	*CUV*	plateau (also LS)	*PT*
eroded fan remnant	*EFR*	rock pediment	*ROP*
eroded fan-remnant side slope	*EFS*	sabkha	*SAB*
erosion remnant	*ER*		

saddle	*SA*	terrace remnant	*TER*
scarp slope	*RS*	tor	*TQ*
slickrock (also Micro)	*SLK*	valley-border surfaces	*VBS*
stack [geom.]	*SR*	valley-floor remnant	*VFR*
strike valley	*STV*	wind gap	*WG*
structural bench	*SB*	window	*WIN*

Microfeatures:

earth pillar	*EP*	pinnacle	*PI*
finger ridge	*FR*	rib	*RB*
groove	*GR*	rill	*RL*
gully	*GU*	slickrock (also LF)	*SLK*
hoodoo	*HO*	swale	*SW*

13. **Depressional** (low areas or declivity features, excluding permanent water bodies)

Landscapes:

basin	*BS*	breaklands	*BR*
basin floor (also LF)	*BC*	dissected breaklands	*DB*
bolson	*BO*	semi-bolson	*SB*
breached anticline (also LF)	*BD*	valley	*VA*

Landforms:

alluvial flat	*AP*	gut [valley]	*GV*
basin floor (also LS)	*BC*	intermontane basin	*IB*
basin floor remnant	*BD*	kettle	*KE*
box canyon	*BOX*	mountain valley	*MV*
breached anticline (also LS)	*BRL*	open depression (also Micro)	*ODE*
canyon	*CA*	playa	*PL*
canyon wall	*CW*	playa floor (also Micro)	*PFL*
Carolina Bay	*CB*	playa rim (also Micro)	*PRI*
closed depression (also Micro)	*CLD*	playa slope (also Micro)	*PSL*
col	*CL*	playa step (also Micro)	*PST*
coulee	*CE*	pothole (also Micro)	*PH*
cove	*CO*	pothole lake (intermittent water)	*WN*
cuesta valley	*CUV*	ravine	*RV*
depression	*DP*	sabkha	*SAB*
drainageway	*DQ*	saddle	*SA*
drainhead complex	*DRC*	sag (also Micro)	*SAG*
gap	*GA*	semi-open depression	*SOD*
gorge	*GO*	slot canyon	*SLC*
gulch	*GT*	strike valley	*STV*

swale (also Micro)	*SC*	valley	*VA*
trough	*TR*	valley floor	*VL*
U-shaped valley	*UV*	V-shaped valley	*VV*

Microfeatures:

closed depression (also LF)	*CD*	playette	*PL*
open depression (also LF)	*OP*	pothole (also LF)	*PH*
playa floor (also LF)	*PF*	sag (also LF)	*SAG*
playa rim (also LF)	*PR*	semi-open depression	*SOD*
playa slope (also LF)	*PSL*	swale (also LF)	*SW*
playa step (also LF)	*PST*	tree-tip pit	*TTP*

14. **Wetlands** (related to vegetated and/or shallow water areas and wet soils); (provisional list: conventional, geologic definitions; not legalistic or regulatory usage)

Landscapes:

estuary (also LF)	*ES*	everglades	*EG*

Landforms:

alas	*AA*	peat plateau	*PJ*
backswamp	*BS*	playa (intermittent water)	*PL*
bog	*BO*	pocosin	*PO*
Carolina Bay	*CB*	pothole (also Micro)	*PH*
dune slack (also Micro)	*DUS*	pothole lake (w)	*WN*
ephemeral stream (also Micro)	*EPS*	raised bog	*RB*
estuary (also LS)	*WD*	ribbed fen	*RG*
fen	*FN*	sabkha	*SAB*
flood-plain playa	*FY*	salt marsh	*SM*
fringe-tidal marsh	*FTM*	seep (also Micro)	*SEE*
highmoor bog	*HB*	semi-open depression	*SOD*
intermittent stream (also Micro)	*INT*	slough (intermittent water)	*SL*
lowmoor bog	*LX*	string bog	*SY*
mangrove swamp	*MAN*	swamp	*SW*
marsh	*MA*	tidal flat	*TF*
muskeg	*MX*	tidal marsh	*TM*
oxbow lake (ephemeral water)	*WK*		

Microfeatures:

dune slack (also LF)	*DS*	playette	*PL*
ephemeral stream (also LF)	*ES*	pothole (also LF)	*PH*
intermittent stream (also LF)	*INT*	vernal pool (seasonal water)	*VP*

15. **Water Bodies** (discrete “surface water” features; primarily permanent open water, which in soil survey reports is commonly treated as the generic map unit “water” [e.g., lake] or as a spot/line symbol [e.g., perennial stream])

Landscapes:

bay [coast] (also LF)	*BY*	ocean	*OC*
estuary (also LF)	*ES*	sea (also LF)	*SEA*
gulf (also LF)	*GU*	sound (also LF)	*SO*
lagoon (also LF)	*LG*	strait (also LF)	*ST*

Landforms:

axial stream	*AX*	playa lake	*WL*
bay [coast] (also LS)	*BAY*	pluvial lake	*PLL*
bayou	*WC*	pothole lake	*WN*
cove [water]	*COW*	proglacial lake	*WO*
dune lake	*DUL*	river	*RIV*
estuary (also LS)	*WD*	sag pond (also Micro)	*SGP*
fjord	*FJ*	salt pond (also Micro)	*WQ*
glacial lake	*WE*	sea (also LS)	*SEA*
gulf (also LS)	*GU*	shoal	*WR*
gut [channel] (also Micro)	*WH*	slackwater	*WS*
ice-marginal stream	*IMS*	slough	*SL*
inlet	*IL*	sound (also LS)	*SO*
lagoon (also LS)	*WI*	strait (also LS)	*STT*
lagoon channel	*LCH*	stream (permanent water)	*STR*
lake	*WJ*	tarn (also Micro)	*TAR*
marine lake	*ML*	thermokarst lake	*WV*
nearshore zone	*NZ*	tidal inlet	*TI*
oxbow lake	*WK*	tidal inlet [relict]	*TIR*
perennial stream (also Micro)	*PS*	tunnel-valley lake	*TVL*

Microfeatures:

channel (permanent water)	*CH*	sag pond (also LF)	*SP*
gut [channel] (also LF)	*WH*	salt pond (also LF)	*WQ*
perennial stream (also LF)	*PS*	tank	*TA*
pond	*PON*	tarn (also LF)	*TN*
pool	*POO*		

16. **Subaqueous Features** (discrete underwater features [that commonly can support rooted plants] and adjacent features ordinarily found below permanent open water—*historically, these underwater features included in the generic map unit "water" in soil survey reports;* subaqueous "landscape" terms obviously not terrestrial but earth-surface features)

Landscapes:

bay [coast] (w; also LF)	*BY*	ocean (w)	*OC*
estuary (w; also LF)	*ES*	sea (w; also LF)	*SEA*
gulf (w; also LF)	*GU*	sound (w; also LF)	*SO*
lagoon (w; also LF)	*LA*	strait (w; also LF)	*ST*

Landforms:

barrier cove	*BAC*	mainland cove	*MAC*
bay [coast] (w; also LS)	*BAY*	marine lake	*ML*
bay bottom	*BOT*	nearshore zone	*NZ*
cove [water] (w)	*CO*	reef	*RF*
estuary (also LS)	*WD*	sea (w; also LS)	*SEA*
flood-tidal delta	*FTD*	shoal	*WR*
flood-tidal delta flat	*FTF*	sound (w; also LS)	*SO*
flood-tidal delta slope	*FTS*	strait (w; also LS)	*STT*
fluviomarine bottom	*FMB*	submerged back-barrier beach	*SBB*
gulf (w; also LS)	*GU*	submerged mainland beach	*SMB*
inlet	*IL*	submerged point bar [coast]	*SPB*
lagoon (also LS)	*WI*	submerged wave-built terrace	*SWT*
lagoon bottom	*LBO*	submerged wave-cut platform	*SWP*
lagoon channel	*LCH*	tidal inlet	*TI*
lake	*WJ*	tidal inlet [relict]	*TIR*
lakebed (w)	*LB*	washover-fan flat	*WFF*
longshore bar	*LON*	washover-fan slope	*WFS*

Microfeatures:

channel (permanent water)	*CH*	gut [channel] (w)	*WH*

Anthropogenic Features:

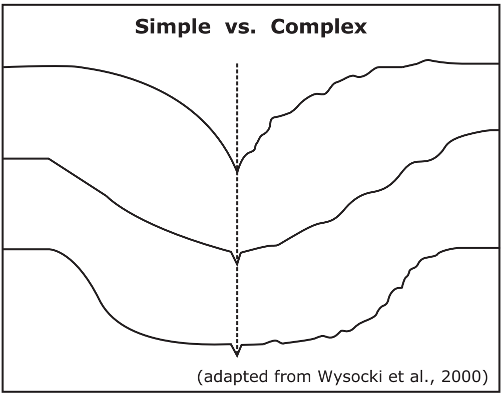
dredge-deposit shoal	*DDS*	dredged channel	*DC*

A) **Elevation:** The height of a point on the Earth's surface relative to mean sea level (msl); indicate units; e.g., 106 m or 348 ft.

B) **Slope Aspect:** The compass bearing (in degrees, corrected for declination) that a slope faces, viewed downslope; e.g., 287°.

C) **Slope Gradient:** The angle of the ground surface (in percent) through the site and in the direction that overland water would flow (commonly referred to as slope); e.g., 18%.

D) **Slope Complexity:** Describe the relative uniformity (smooth linear or curvilinear=*simple* or *S*) or irregularity (*complex* or *C*) of the ground surface leading downslope through the point of interest; e.g., simple or S.

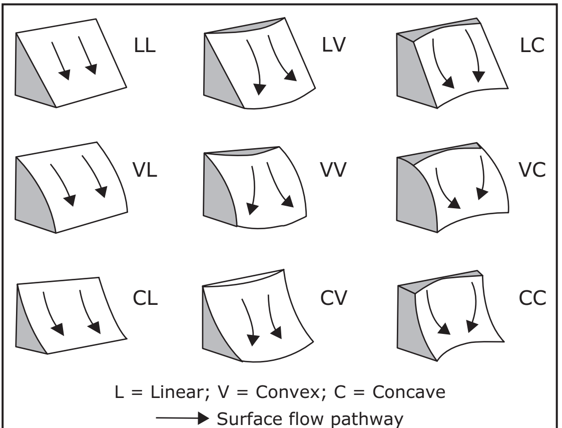


E) **Relative Slope Segment Position** (called **geomorph_slope_ segment** in NASIS)**:** If useful to subdivide long slopes, describe the relative slope location of the area of interest.

Relative Slope Segment Position	Code	Criteria
lower third	LT	on lower third
middle third	MT	on middle third
upper third	UT	on upper third

F) **Slope Shape:** Slope shape is described in two directions: 1) up and down slope (perpendicular or "normal" to the contour; called **slope_down** in NASIS); and 2) across slope (along the horizontal contour; called **slope_across** in NASIS). These two descriptors are commonly reported as a pair. The first term refers to up and down slope (or vertical), and the second term refers to across slope; e.g., linear, convex or LV.

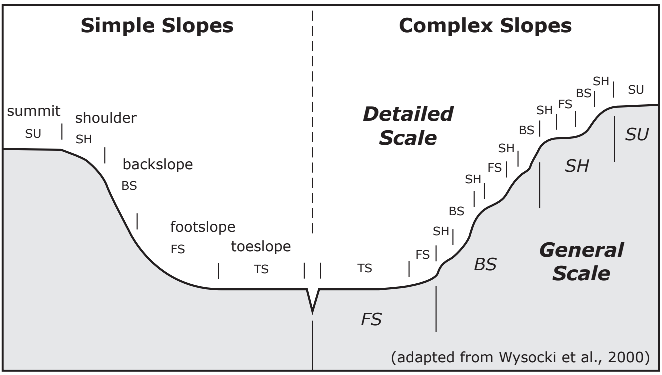
Down Slope (Vertical)	Across Slope (Horizontal)	Code
concave	concave	CC
concave	convex	CV
concave	linear	CL
convex	concave	VC
convex	convex	VV
convex	linear	VL
linear	concave	LC
linear	convex	LV
linear	linear	LL



(adapted from Wysocki et al., 2000)

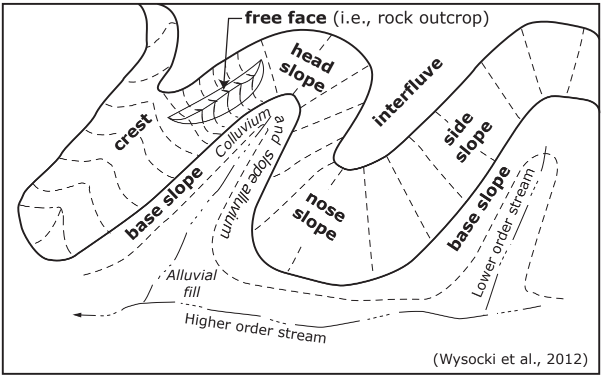
G) **Hillslope Profile Position** (commonly called “hillslope position”)**:** Two-dimensional descriptors of parts of line segments (i.e., slope position) along a transect that runs up and down the slope; e.g., backslope or BS. This set of terms is best applied to transects or points, not areas.

Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS

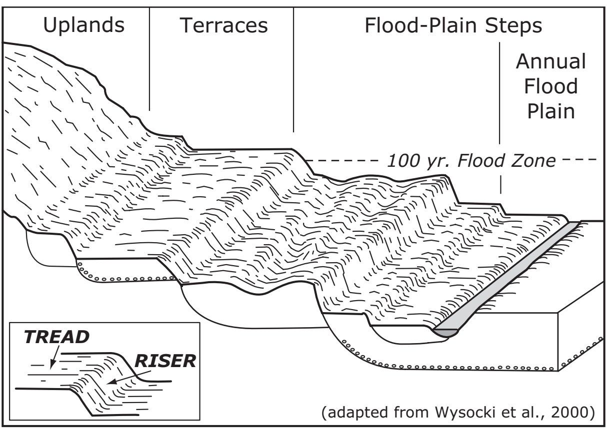


H) **Geomorphic Component** (Geomorphic Position in PDP)**:** Three-dimensional descriptors of parts of landforms or microfeatures that are best applied to areas. Other unique descriptors are available for hills, terraces and stepped landforms, mountains, and flat plains; e.g. (for hills), nose slope or NS.

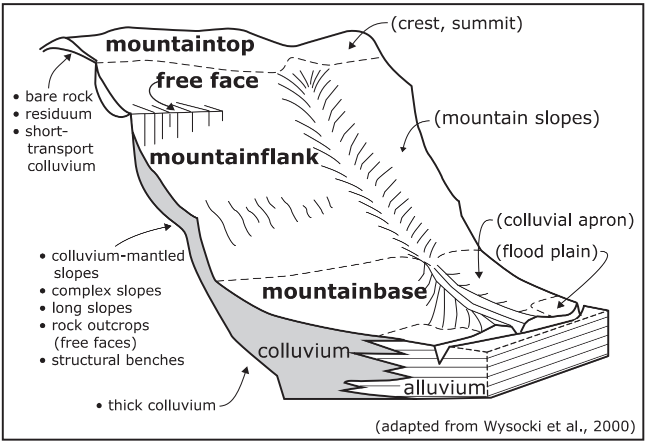
1) Hills	Code
interfluve	IF
crest	CT
head slope	HS
nose slope	NS
side slope	SS
free face	FF
base slope	BS



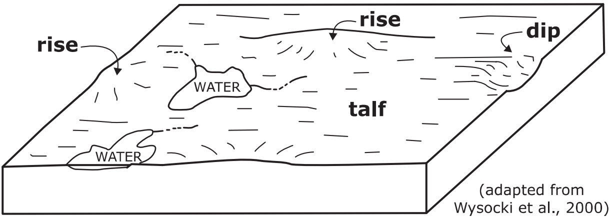
2) Terraces and Stepped Landforms	Code
riser	RI
tread	TR



3) Mountains	Code
mountaintop	MT
mountainflank	MF
upper third – mountainflank	UT
center third – mountainflank	CT
lower third – mountainflank	LT
free face	FF
mountainbase	MB



4) Flat Plains	Code
dip	DP
rise	RI
talf	TF



- very low gradients (e.g., slope 0-1%)
- deranged, nonintegrated, or incipient drainage network
- "high areas" are broad and low (e.g., slope 1-3%)
- sediments, commonly lacustrine, alluvial, eolian, or till

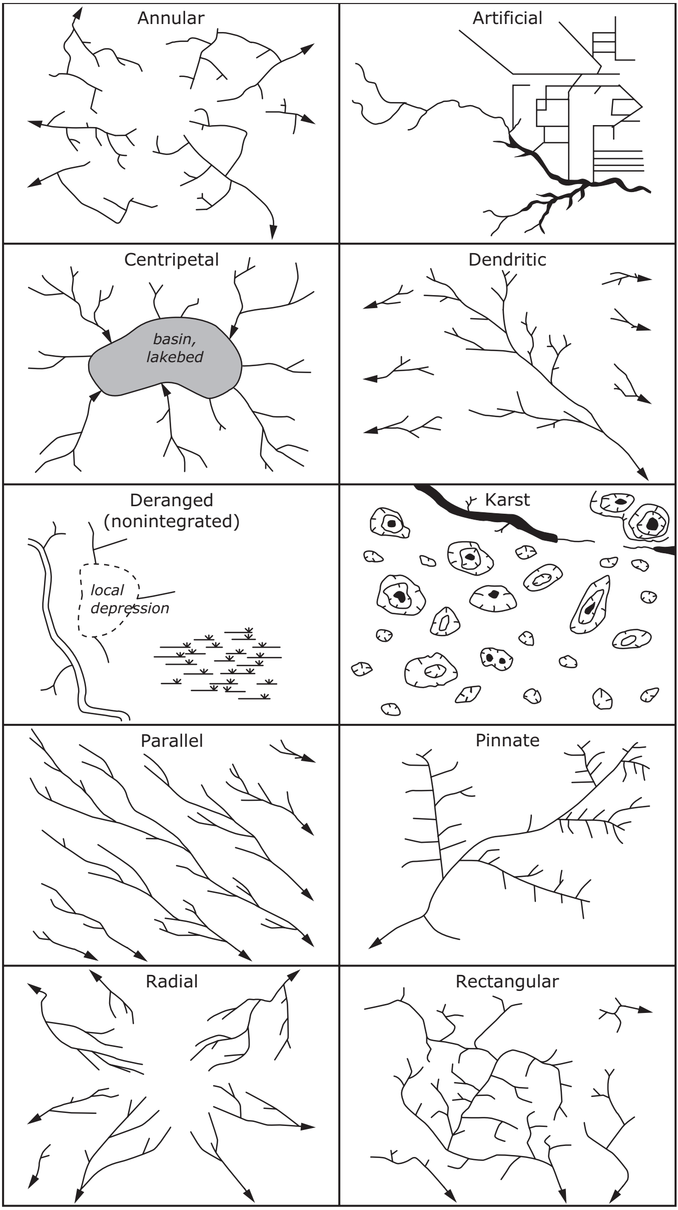
I) **Microrelief:** Small, relative differences in elevation between adjacent areas on the Earth's surface; e.g., microhigh or MH.

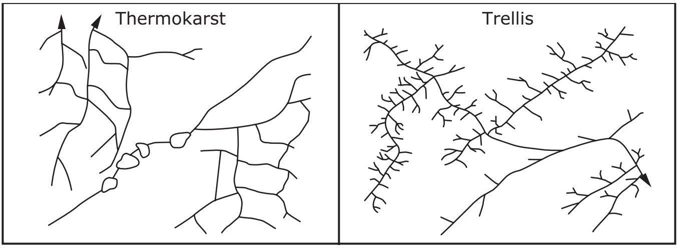
Microrelief	Code
microhigh	MH
microlow	ML
microslope	MS

Note: See graphic on p. 2–55.

J) **Drainage Pattern:** The arrangement of drainage channels on the land surface; also called drainage network.

Drainage Pattern	Code
annular	AN
artificial	AR
centripetal	CE
dendritic	DN
deranged	DR
karst	KA
parallel	PA
pinnate	PI
radial	RA
rectangular	RE
thermokarst	TH
trellis	TR


Annular
Artificial
Centripetal
basin,
lakebed
Dendritic
Deranged
(nonintegrated)
local
depression
Karst
Parallel
Pinnate
Radial
Rectangular



References

Fenneman, N.M. 1931. Physiography of the western United States. McGraw-Hill Co., New York, NY.

Fenneman, N.M. 1938. Physiography of the eastern United States. McGraw-Hill Co., New York, NY.

Fenneman, N.M. 1946 (reprinted 1957). Physical divisions of the United States. U.S. Geological Survey. U.S. Gov. Print. Office, Washington, DC. 1 sheet; 1:7,000,000.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geol. Surv. Prof. Pap. 482.

Wysocki, D.A., P.J. Schoeneberger, D. Hirmas, and H.E. LaGarry. 2012. Geomorphology of soil landscapes. *In* P.M. Huang et al. (ed.) Handbook of soil science: Properties and processes, 2nd ed. CRC Press, Taylor and Francis Group, LLC, Boca Raton, FL. ISBN: 978–1–4398–0305–9.

Wysocki, D.A., P.J. Schoeneberger, and H.E. LaGarry. 2000. Geomorphology of soil landscapes. *In* M.E. Sumner (ed.) Handbook of soil science. CRC Press, LLC, Boca Raton, FL. ISBN: 0–8493–3136–6.

Soil Taxonomy

Introduction

The purpose of this section is to expand upon and augment the abbreviated soil taxonomic contents of the “Pedon Description” section. Complete definitions are found in “Keys to Soil Taxonomy” (Soil Survey Staff, 2022).

Horizon and Layer Designations

Note: Horizons are considered to be layers of pedogenically derived or modified material. Layers are deemed to be zones of nonpedogenically derived/modified material (e.g., geologic strata).

Master and Transitional Horizons or Layers—

Horizon	Criteria [1]
O	Organic soil materials other than limnic materials. The mineral fraction is a small percent by volume and is < 80% by weight.
A	Mineral soil, formed at the surface or below an O horizon, little remnant rock structure, and one or more: 1) accumulation of humified organic matter but dominated by mineral matter, and not dominated by E or B horizon properties; 2) properties resulting from cultivation, pasturing, or similar disturbance; or 3) morphology resulting from surficial processes different from the underlying B or C. Excludes recent eolian or alluvial deposits that retain stratification.
AB or **AE** or **AC**	Dominantly A horizon characteristics but also contains some B, E, or C horizon attributes.
A/B or **A/E** or **A/C**	Discrete, intermingled bodies of two horizons: A material dominates with lesser but discrete bodies of B, E, or C material.
E	Mineral soil with some loss of silicate clay, iron, aluminum, and/or organic matter leaving a net concentration of sand and silt; little or no remnant rock structure; typically lighter color (higher value, chroma) and coarser texture than A.

Horizon	Criteria [1]
EA or **EB** or **EC**	Dominantly E horizon characteristics but also contains some A, B, or C horizon attributes.
E/A or **E/B**	Discrete, intermingled bodies of two horizons: E material dominates with lesser but discrete bodies of A or B material.
E and Bt **B and E**	Thin, heavier textured lamellae (Bt) within a predominantly E horizon with less clay (or thin E layers within a predominantly B horizon).
BA or **BE** or **BC**	Dominantly B characteristics but also contains some A, E, or C horizon attributes.
B/A or **B/E** or **B/C**	Discrete, intermingled bodies of two horizons: B material dominates with lesser but discrete bodies of A, E, or C material.
B	Mineral soil, typically formed below O, A, or E; little or no rock structure; and with one or more of the following: 1) illuvial accumulation of silicate clay, Fe, Al, humus, carbonate, gypsum, silica, or salt more soluble than gypsum (one or more); 2) removal, addition, or transformation of carbonates, gypsum, or more soluble salts; 3) residual concentration of oxides, sesquioxides, and silicate clays (one or more); 4) sesquioxide coatings; 5) alterations that form silicate clays or liberate oxides and form pedogenic structure; 6) brittleness; 7) strong gleying in the presence of aquic conditions (or artificial drainage); layers with gleying but no other pedogenic change are not B horizons. (Most B horizons are or were subsurface horizons. Some formed at the surface by accumulation of evaporites. Cemented and brittle layers that have other evidence of pedogenesis are included as B horizons.)

Horizon	Criteria [1]
CB or **CA**	Dominantly C horizon characteristics but also contains some B or A horizon attributes.
C/B or **C/A**	Discrete, intermingled bodies of two horizons: C material dominates, with lesser but discrete bodies of A or B material.
C	Mineral soil, soft bedrock (excluding *strongly cemented* to *indurated* bedrock unless highly cracked); layer little affected by pedogenesis and lacks properties of O, A, E, or B horizons. May or may not be parent material of the solum.
V	Mineral soil, formed at the soil surface or below a layer of rock fragments (e.g., desert pavement), a physical or biological crust, or recently deposited eolian material. Characterized by the predominance of vesicular pores and a platy, prismatic, or columnar structure.
L	Limnic soil materials. Sediments deposited in a body of water (subaqueous) and dominated by organic materials (aquatic plant and animal fragments and fecal material) and lesser amounts of clay.
W	A layer of liquid water (W) or permanently frozen ice (Wf), within or beneath the soil (excludes *water / ice above soil*).
M	Root-limiting subsoil layers of human-manufactured materials (e.g., geotextile liner).
R	Hard bedrock (continuous, coherent *strongly cemented* to *indurated* cementation classes).

[1] Soil Survey Staff, 2023.

Horizon Suffixes—Historically referred to as "Horizon Subscripts," "Subordinate Distinctions," [1] "Horizon_Designation_Suffix" in NASIS, and "Suffix Symbols" in "Keys to Soil Taxonomy." [2] (Historical nomenclature and conversions are shown in the tables on p. 4–6.)

Horizon Suffixes	Criteria [2]
a	Highly decomposed organic matter (OM); rubbed fiber content < 17% (by vol.) (sapric materials); used only with O (see "e," "i").
b	Buried genetic horizon (not used with organic materials or to separate organic from mineral materials).

Horizon Suffixes	Criteria [2]
c	Concretions or nodules; significant accumulation of *cemented* bodies enriched with Fe, Al, Mn, Ti (cement not specified except *excludes* a predominance of silica [see “q”]); not used for carbonates or soluble salts (see “z”).
co	Coprogenous earth (used only with L); organic materials deposited under water and dominated by fecal material from aquatic animals.
d	*Physical* root restriction due to high bulk density (natural or human-induced conditions; e.g., lodgment till, plow pans.
di	Diatomaceous earth (used only with L); materials deposited under water and dominated by the siliceous diatom remains.
e	Moderately (intermediately) decomposed organic matter; rubbed fiber content 17 to < 40% (by vol.) (hemic materials); used only with O (see “a,” “i”).
f	Permafrost (permanently frozen subsurface soil or ice); excludes seasonally frozen ice and surface ice.
ff	Dry permafrost (permanently frozen soil; not used for seasonally frozen soil; no continuous ice bodies [see “f”]).
g	Strong gley (Fe reduced and pedogenically removed); typically ≤ 2 chroma; may have other redoximorphic features (RMF); not used for geogenic gray colors.
h	Illuvial organic matter (OM) accumulation (with B: accumulation of illuvial, amorphous OM-sesquioxide complexes); coats sand and silt particles and may fill pores; use *Bhs* if significant accumulation of sesquioxides and moist chroma *and* value ≤ 3.
i	Slightly decomposed organic matter; rubbed fiber content ≥ 40% (by vol.) (fibric materials); used only with O (see “a,” “e”).
j	Jarosite accumulation (e.g., acid sulfate soils).
jj	Evidence of cryoturbation (e.g., irregular or broken horizon boundaries, sorted rock fragments (patterned ground), or OM in lower boundary between active layer and permafrost layer).
k	Pedogenic carbonate accumulation (e.g., $CaCO_3$; < 50% by vol.).
kk	Major pedogenic carbonate accumulation; soil fabric is plugged ≈ continuous (≥ 50% by vol. estimated).

Horizon Suffixes	Criteria [2]
m	Continuous pedogenic cementation or induration (> 90% cemented, even if fractured); physically root restrictive. Dominant cement type can be indicated by additional letters (e.g., km or kkm—carbonates; qm—silica; kqm—carbonates and silica; sm—iron; yym—gypsum; zm—salts more soluble than gypsum).
ma	Marl (used only with L); materials deposited under water and dominated by a mixture of clay and $CaCO_3$; typically gray or beige.
n	Pedogenic exchangeable sodium accumulation.
o	Residual accumulation of sesquioxides.
p	Tillage or other disturbance of surface layer (pasture, plow, etc.). Designate *Op* for disturbed organic surface, *Ap* for mineral surface even if the layer clearly was originally an E, B, C, etc.
q	Accumulation of secondary (pedogenic) silica.
r	Used with C to indicate weathered or soft bedrock (root-restrictive saprolite or soft bedrock), such as weathered or partially consolidated sandstone, siltstone, or shale; materials are sufficiently incoherent to allow hand digging with a spade (excavation difficulty classes are low to high). Roots only penetrate along joint planes.
s	Significant illuvial accumulation of amorphous, dispersible sesquioxides and organic matter complexes and moist color value or chroma ≥ 4. Used with B horizon; used with h as *Bhs* if moist color value and chroma are ≤ 3.
se	Presence of sulfides (in mineral or organic horizons). Typically dark colors (e.g., value ≤ 4, chroma ≤ 2); may have a sulfurous odor.
ss	Slickensides (e.g., oblique shear faces 20-60 degrees off horizontal); caused by shrink-swell clay action; wedge-shaped peds and seasonal surface cracks also are commonly present.
t	Accumulation (by translocation or illuviation) of silicate clays (clay films, lamellae, or clay bridging in some part of the horizon).
u	Presence of human-manufactured materials (artifacts) (e.g., bitumen [asphalt], bricks, plastic, glass, metals, construction debris, garbage).

Horizon Suffixes	Criteria [2]
v	Plinthite (high Fe, low OM, reddish contents; firm or very firm moist consistence; irreversible hardening with repeated wetting and drying).
w	Incipient color or pedogenic structure development, minimal illuvial accumulations; used only with B horizons, excluded from use with transition horizons.
x	Fragipan or fragic characteristics (pedogenetically developed brittleness, firmness, bleached prisms, high bulk density, root restrictive).
y	Accumulation of gypsum ($CaSO_4 \cdot 2H_2O$); < 50% by volume (estimated).
yy	Dominance of gypsum (≈ ≥ 50% by vol. estimated); light colored (e.g., value ≥ 7, chroma ≤ 4); may be pedogenically derived or inherited transformation of primary gypsum from parent material.
z	Pedogenic accumulation of salts more soluble than gypsum (e.g., NaCl).

[1] Soil Science Division Staff, 2017.

[2] Soil Survey Staff, 2023.

Horizon and Layer Designations Conversion Charts—***Note:*** Gray boxes indicate the year the convention was first adopted.

Master Horizons, Layers, or Combinations				
1951 [1]	**1962** [2], **1975** [3]	**1982** [4]	**1998** [5]	**2006** [6], **2010** [7]
Aoo or Ao	O	O	O	O
Aoo	O1	Oi and/or Oe	Oi and/or Oe	Oi and/or Oe
Ao	O2	Oe and/or Oa	Oe and/or Oa	Oe and/or Oa
—	—	Oi	Oi	Oi
—	—	Oe	Oe	Oe
—	—	Oa	Oa	Oa
A	A	A	A	A
A1	A1	A	A	A
A2	A2	E	E	E
A3	A3	AB or EB	AB or EB	AB or EB

Master Horizons, Layers, or Combinations				
1951 [1]	**1962** [2], **1975** [3]	**1982** [4]	**1998** [5]	**2006** [6], **2010** [7]
AB	AB	—	—	—
A&B	A&B	A/B or E/B	A/B or E/B	A/B or E/B
AC	AC	AC	AC	AC
—	—	E and Bt	E and Bt	E and Bt
B	B	B	B	B
B1	B1	BA or BE	BA or BE	BA or BE
B&A	B&A	B/A or B/E	B/A or B/E	B/A or B/E
B2	B2	B or Bw	B or Bw	B or Bw
G	g [8]	Ag, Bg, Cg	Ag, Bg, Cg	Ag, Bg, Cg
B3	B3	BC or CB	BC or CB	BC or CB
—	—	B/C, C/B, C/A	B/C, C/B, C/A	B/C, C/B, C/A
C	C	C	C	C
Cca	Cca	*Bk*	*Bk*	*Bk, Bkk* [6]
Ccs	Ccs	*By, Cy*	*By, Cy*	*By* or *Byy*, *Cy* or *Cyy* [7]
D	—	—	—	—
Dr	R	R	R	R
—	—	—	L [3, 6]	L
—	—	—	—	M [6]
—	—	—	W	W

[1] Soil Survey Staff, 1951.

[2] Soil Survey Staff, 1962; same content used in *Soil Taxonomy* (Soil Survey Staff, 1975), except for addition of Limnic (L) horizon. [3]

[3] Soil Survey Staff, 1975. Limnic materials and limnic layer were recognized in 1975, formally dropped in 1985 (National Soil Taxonomy Handbook 615.30); master L horizon was formally adopted in 2006. [6]

[4] Guthrie and Witty, 1982.

[5] Soil Survey Staff, 1998.

[6] Soil Survey Staff, 2006.

[7] Soil Survey Staff, 2010.

[8] Master horizon G (1951) was changed to a horizon suffix (g) that can be used with master horizon A, B, or C; e.g., Bg.

Horizon Suffixes (Conventions)—***Note:*** Gray boxes indicate the year the convention was first adopted.

Horizon Suffixes (Coventions) (Also called "Horizon Subscripts" and "Subordinate Distinctions")				
1951 [1]	**1962** [2], **1975** [2]	**1982** [3]	**1998** [4]	**2010** [5]
—	—	a	a	a
b	b	b	b	b
ca	ca	*k*	*k*	*k*
cn	cn	c	c	c
—	—	—	co [6]	co
cs	cs	*y*	*y*	*y*
—	—	—	d (1988) [7]	d
—	—	—	di [6]	di
—	—	e	e	e
f	f	f	f	f
—	—	—	ff	ff
g	g	g	g	g
h	h	h	h	h
ir	ir	*s*	*s*	*s*
—	—	i	i	i
—	—	—	j	j
—	—	—	jj	jj
ca	*ca*	k	k	k
—	—	—	—	kk [8] (2006)
m	m [9]	m	m	m
—	—	—	ma [6]	ma
—	—	n	n	n
—	—	o	o	o
p	p	p	p	p
si	*si*	q	q	q
r [10]	—	r	r	r
ir	*ir*	s	s	s
sa	sa	*n*	*n*	*n*
—	—	—	—	se [9] (2011)
—	si	*q*	*q*	*q*

Horizon Suffixes (Coventions) (Also called "Horizon Subscripts" and "Subordinate Distinctions")				
1951 [1]	**1962** [2], **1975** [2]	**1982** [3]	**1998** [4]	**2010** [5]
—	—	—	ss (1991)	ss
t	t	t	t	t
u	—	—	—	u [8] (2006)
—	—	v	v	v
—	—	w	w	w
—	x	x	x	x
cs	*cs*	y	y	y
—	—	—	—	yy [5]
sa	sa	z	z	z

[1] Soil Survey Staff, 1951.

[2] Soil Survey Staff, 1962; same content also used in *Soil Taxonomy* (Soil Survey Staff, 1975).

[3] Guthrie and Witty, 1982.

[4] Soil Survey Staff, 1998.

[5] Soil Survey Staff, 2010a.

[6] Soil Survey Staff, 1999.

[7] Soil Survey Staff, 1988.

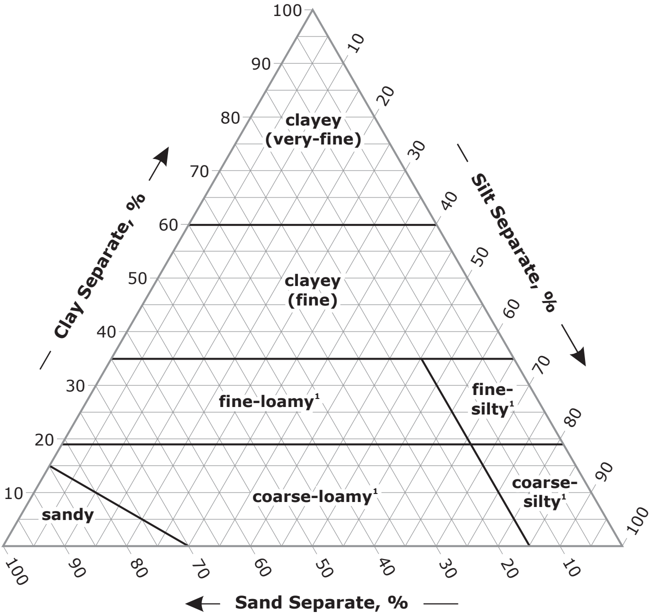
[8] Soil Survey Staff, 2006.

[9] The definition is changed to no longer include fragipans (which become "x").

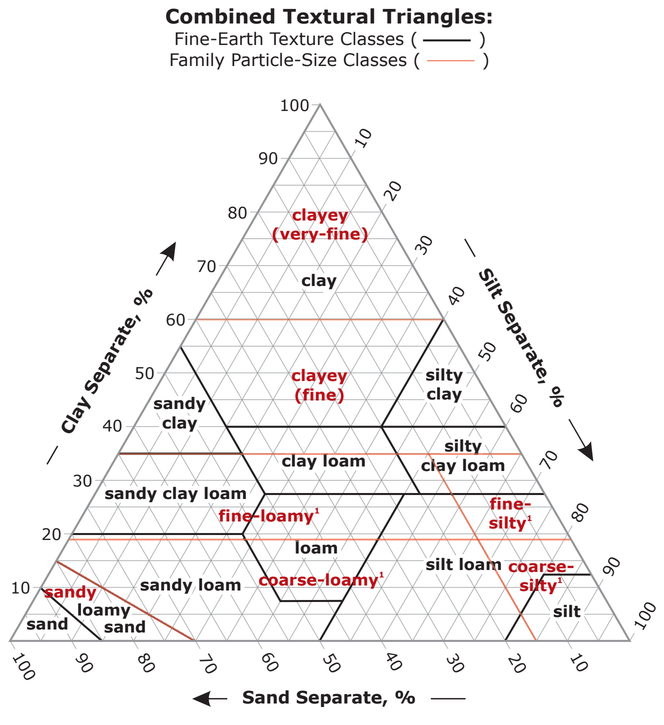
[10] Definition of r (1951; dropped 1962 [2]) is *not* the same as used since 1981. [3]

(Soil) Textural Triangle:

Family Particle-Size Classes (——)



[1] Very fine sand fraction (0.05 - 0.1 mm) is treated as silt for Soil Taxonomy family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between silty and loamy classes.



[1] Very fine sand fraction (0.05 - 0.1 mm) is treated as silt for Soil Taxonomy family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between silty and loamy classes.

Soil Moisture Regimes—Refers to soil moisture or ground water presence in or on soil at tensions > 0 and ≤ 1500 kPa (≈ ≤ 15 bar).

Soil moisture conditions of a pedon (i.e., soil water state) can be estimated or measured at the time of observation and subsequently assigned to a water state class (or subclass; see p. 1–14). In a broader context, the prevailing soil moisture condition of a site can be estimated or measured for “normal years” (i.e., most typical or dominant climatic conditions). Class assignment takes into account: 1) the extent of ground water influence (usually via “depth to”) and 2) the seasonal status of water held at tensions < 1500 kPa (≈ < 15 bar) in the moisture control section. [1] In soil taxonomy [1], soil moisture regimes are assigned as classes (e.g., ustic soil moisture regime) and are used at the higher categories of the system (i.e., from order down through subgroup).

Soil Moisture Regime	Criteria [1] (generalized, abbreviated)
aquic	A reducing regime for soils that are free of dissolved oxygen and saturated (seasonal ground water fluctuations typical). Unlike other regimes, the aquic regime may occur temporarily for only a few days.
peraquic	A reducing regime for soils that are free of dissolved oxygen and permanently saturated (ground water is almost always above, at, or very close to the surface).
aridic (torric) [2]	The predominantly dry regime for soils of arid and semiarid climates that are unsuitable for cultivation without irrigation. Soil is dry (in all parts of soil moisture control section) > 50% of all days annually when soil is > 5 °C at 50 cm and moist in some part for < 90 consecutive days when soil is > 8 °C at 50 cm in normal years.
udic	The predominantly moist regime for soils of humid climates with well distributed rainfall. Soil is dry (in any part of soil moisture control section) for < 90 cumulative days in normal years.
perudic	An extremely wet regime for soils of climates where precipitation exceeds evapotranspiration in all months in normal years. Soil is almost always moist; soil tension is rarely > 100 kPa (≈ > 1 bar).
ustic	The temporarily dry regime for soils of climates that are intermediate between dry (aridic) and moist (udic). Soil is intermittently moist and dry; moisture limited but usually available when climate is suitable for plant growth. Soil is moist > 180 cumulative days or > 90 consecutive days.
xeric	The seasonally dry regime for soils of Mediterranean climates with cool, moist winters and warm, dry summers. Soil is moist in all parts for ≥ 45 consecutive days in the 4 months following the winter solstice and dry in all parts for ≥ 45 consecutive days in the 4 months following the summer solstice. Soil is also moist in some part > 50% of all days when soil is > 5 °C at depth of 50 cm or moist in some part for ≥ 90 consecutive days when soil is > 8 °C at depth of 50 cm in normal years.

[1] Complete criteria available in “Keys to Soil Taxonomy,” (Soil Survey Staff, 2022).

[2] Aridic and torric are terms for the same soil moisture regime, but they are used in different categories in soil taxonomy. Limits set for soil temperature exclude from this regime soils in very cold and dry polar regions and in areas at high elevations. Such soils are considered to have *anhydrous conditions*.

Soil Temperature Regimes and Classes (per "Keys to Soil Taxonomy" [1, 2])—

Soil Temperature Regimes [1]	Soil Temperature Classes [2]	Criteria: MAST [3] measured at 50 cm or at the upper boundary of a root-limiting layer if shallower
gelic	(see below)	≤ 0 °C in Gelic suborders and Gelic great groups *or* < 1 °C in Gelisols (permafrost expected)
	hypergelic	≤ -10 °C
	pergelic	-10 to -4 °C
	subgelic	-4 to 1 °C
cryic	(no family temperature class)	≥ 0 to < 8 °C, but no permafrost, and 1. In mineral soils: the MSST [4] is: a. If soil is not saturated ring summer and (1) If no O horizon: ≥ 0 to 15 °C; or (2) If there is an O horizon: ≥ 0 to 8 °C; or b. If soil is saturated during summer and (1) If no O horizon: ≥ 0 to 13 °C; or (2) If there is an O horizon or a histic epipedon: ≥ 0 to 6 °C. 2. In organic soils: ≥ 0 to 6 °C.
For soils with a difference between mean summer and mean winter soil temperature of ≥ 6 °C:		
frigid	frigid	≥ 0 to < 8 °C (but warmer than cryic in summer)
mesic	mesic	8 to < 15 °C

Soil Temperature Regimes [1]	Soil Temperature Classes [2]	Criteria: MAST [3] measured at 50 cm or at the upper boundary of a root-limiting layer if shallower
thermic	thermic	15 to < 22 °C
hyperthermic	hyperthermic	≥ 22 °C
For soils with a difference between mean summer and mean winter soil temperature of < 6 °C:		
isofrigid	isofrigid	< 8 °C
isomesic	isomesic	8 to < 15 °C
isothermic	isothermic	15 to < 22 °C
isohyperthermic	isohyperthermic	≥ 22 °C

[1] Soil temperature regimes are used as criteria in the suborder, great group, and subgroup categories of soil taxonomy (Soil Survey Staff, 2023).

[2] Soil temperature classes are used as differentiae in the family category of soil taxonomy, excluding Cryic soils (Soil Survey Staff, 2023).

[3] MAST=Mean annual soil temperature (Soil Survey Staff, 1999).

[4] MSST=Mean summer soil temperature (see Soil Survey Staff, 1999, p. 108).

References

Guthrie, R.L., and J.E. Witty. 1982. New designations for soil horizons and layers and the new Soil Survey Manual. Soil Sci. Soc. Am. J. 46:443–444.

Soil Science Division Staff. 2017. Soil survey manual. USDA, Agriculture Handbook No. 18.

Soil Survey Staff. 1951. Soil survey manual. USDA, Agriculture Handbook No. 18.

Soil Survey Staff. 1962. Identification and nomenclature of soil horizons. Supplement to Agriculture Handbook No.18, Soil Survey Manual (replacing pages 173–188). USDA Soil Conservation Service.

Soil Survey Staff. 1988. Keys to soil taxonomy, 4th ed. SMSS Tech. Monogr. 6, Cornell Univ., Ithaca, NY.

Soil Survey Staff. 1998. Keys to soil taxonomy, 8th ed. USDA Soil Conservation Service.

Soil Survey Staff. 2006. Keys to soil taxonomy, 10th ed. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2010. Keys to soil taxonomy, 11th ed. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2023. Keys to soil taxonomy, 13th ed. USDA Natural Resources Conservation Service.

Soil Survey Staff. 1975. Soil taxonomy. USDA, Agriculture Handbook No. 436.

Soil Survey Staff. 2024. National soil survey handbook (NSSH). USDA Natural Resources Conservation Service.

Soil Survey Staff. 1999. Soil taxonomy, 2nd ed. USDA, Agriculture Handbook No. 436.

Geology

Introduction

The purpose of this section is to expand and augment the geologic information found or needed in the “Site Description” and “Profile/Pedon Description” sections.

Bedrock – Kind—

This table is repeated here from the “Site Selection” section for convenience in using the following rock charts.

Kind [1]	Code	Kind [1]	Code
Igneous—Intrusive			
anorthosite	ANO	pyroxenite	PYX
diabase	DIA	quartzite	QZT
diorite	DIO	quartz-diorite	QZD
gabbro	GAB	quartz-monzonite	QZM
granite	GRA	syenite	SYE
granitoid [2]	GRT	syenodiorite	SYD
granodiorite	GRD	tonalite	TON
monzonite	MON	ultramafic rock [2]	UMU
peridotite	PER		
Igneous—Extrusive			
a’a lava	AAL	pahoehoe lava	PAH
andesite	AND	pillow lava	PIL
basalt	BAS	pumice (flow, coherent)	PUM
block lava	BLL	rhyolite	RHY
dacite	DAC	scoria (coherent mass)	SCO
latite	LAT	tachylite	TAC
obsidian	OBS	trachyte	TRA
Igneous—Pyroclastic			
ignimbrite	IGN	tuff, welded	TFW
pyroclastics (consolidated)	PYR	tuff breccia	TBR
pyroclastic flow	PYF	volcanic breccia	VBR

Kind [1]	Code	Kind [1]	Code
pyroclastic surge	PYS	volcanic breccia, acidic	AVB
tuff	TUF	volcanic breccia, basic	BVB
tuff, acidic	ATU	volcanic sandstone	VST
tuff, basic	BTU		
Metamorphic			
amphibolite	AMP	metavolcanics	MVO
gneiss	GNE	mica schist	MSH
gneiss, biotite	BTG	migmatite	MIG
gneiss, granodiorite	GDG	mylonite	MYL
gneiss, hornblende	HBG	phyllite	PHY
gneiss, migmatitic	MMG	schist	SCH
gneiss, muscovite-biotite	MGB	schist, biotite	BTS
granofels	GRF	schist, graphitic	GRS
granulite	GRL	schist, muscovite	MVS
greenstone	GRE	schist, sericite	SCS
hornfels	HOR	serpentinite	SER
marble	MAR	siltite	SIT
meta-conglomerate	MCN	slate	SLA
metaquartzite	MQT	slate, sulfidic	SFS
metasedimentary rocks [2]	MSR	soapstone (talc)	SPS
metasiltstone	MSI		
Sedimentary—Clastics			
arenite	ARE	mudstone	MUD
argillite	ARG	ortho-quartzite	OQT
arkose	ARK	porcellanite	POR
breccia, nonvolcanic (angular fragments)	NBR	sandstone	SST
breccia, nonvolcanic, acidic	ANB	sandstone, calcareous	CSS

Kind [1]	Code	Kind [1]	Code
breccia, nonvolcanic, basic	BNB	shale	SHA
claystone	CST	shale, acid	ASH
conglomerate (rounded fragments)	CON	shale, calcareous	CSH
conglomerate, calcareous	CCN	shale, clayey	YSH
fanglomerate	FCN	siltstone	SIS
glauconitic sandstone	GLS	siltstone, calcareous	CSI
graywacke	GRY		
Evaporites, Organics, and Precipitates			
bauxite	BAU	limestone, argillaceous	RLS
chalk	CHA	limestone, cherty	CLS
chert	CHE	limestone, coral	COR
coal	COA	limestone, phosphatic	PLS
diatomite	DIA	limonite	LIM
dolomite (dolostone)	DOL	novaculite	NOV
gypsum	GYP	travertine	TRV
limestone	LST	tripoli	TRP
limestone, arenaceous	ALS	tufa	TUA
Interbedded (alternating layers of different sedimentary lithologies)			
limestone-sandstone-shale	LSS	sandstone-shale	SSH
limestone-sandstone	LSA	sandstone-siltstone	SSI
limestone-shale	LSH	shale-siltstone	SHS
limestone-siltstone	LSI		

[1] Definitions for kinds of bedrock are found in the "Glossary of Landform and Geologic Terms," NSSH, Part 629 (Soil Survey Staff, 2024), or in the *Glossary of Geology* (Neuendorf et al., 2005).

[2] Generic term; use only with regional or reconnaissance surveys (Order 3, 4, 5; see Guide to Map Scales and Minimum-Size Delineations, p. 7–21).

Rock Charts

The following rock charts (**Igneous**, **Metamorphic**, and **Sedimentary** and **Volcaniclastic**) summarize grain size, composition, or genetic differences between related rock types. ***Note:*** 1) Most, but not all, of the rocks in these tables are found in the NASIS choice lists. Those not in NASIS are uncommon in the pedosphere but are included in the charts for completeness and to aid in the use of geologic literature. 2) Most, but not all, of the rocks presented in these tables can be definitively identified in the field; some may require additional laboratory analyses (e.g., grain counts, thin section analyses).

Igneous Rocks Chart

Crystalline Texture	Key Mineral Composition							
	Acidic (felsic)		Intermediate				Basic (mafic)	Ultrabasic (ultramafic)
	Potassium (K) Feldspar > 2/3 of Total Feldspar Content		Potassium (K) Feldspar and Plagioclase (Na, Ca) Feldspar in about Equal Proportions		Plagioclase (Na, Ca) Feldspar > 2/3 of Total Feldspar Content			Pyroxene and Olivine
					Sodic (Na) Plagioclase		Calcic (Ca) Plagioclase	
	Quartz	*No Quartz*	*Quartz*	*No Quartz*	*Quartz*	*No Quartz*		
Pegmatitic [1]	granite pegmatite	syenite pegmatite	← monzonite pegmatite →			diorite pegmatite	gabbro pegmatite	peridotite (mostly olivine)
Phaneritic [2]	granite	syenite	quartz monzonite	monzonite	quartz-diorite granodiorite	diorite	gabbro	pyroxenite (mostly pyroxene)
Porphyritic [3]	granite porphyry	syenite porphyry	quartz-monzonite porphyry	monzonite porphyry	quartz-diorite porphyry	diorite porphyry	diabase	
	rhyolite porphyry	trachyte porphyry	quartz-latite porphyry	latite porphyry	dacite porphyry	andesite porphyry	basalt porphyry	
Alphanitic [4] micro [5] crypto [6]	rhyolite	trachyte	quartz latite	latite	dacite	andesite	basalt	} lava [7]
Glassy [8]	Obsidian (and its varieties: perlite, pitchstone, pumice, scoria). Pyroclastics are shown on the "Sedimentary and Volcaniclastic Rocks" chart.							

[1] Pegmatitic: Very course, uneven-sized crystal grains; 5 to > 20 mm
[2] Phaneritic: Crystals discernable by eye or 10x lens; 1–5 mm
[3] Porphyritic: Larger crystals embedded within a fine-grained matrix
[4] Aphanitic: Crystals not visible by eye or 10x lens; < 1 mm
[5] Microcrystalline crystals resolvable by optical microscope
[6] Cryptocrystalline crystals resolvable by electron microscope
[7] Lava: Generic name for extrusive flows of non-clastic aphanitic rocks (rhyolite, andesite, basalt)
[8] Glassy: Noncrystalline or weakly crystalline

Metamorphic Rocks Chart

Not all rock types listed here can be definitively identified in the field (e.g., may require grain counts). Not all rock types shown here are available on Bedrock - Kind choice list. They are included here for completeness and as aids to using geologic literature.

<table>
<tr><th colspan="3">Nonfoliated Structure</th><th>Crude Alignment</th><th colspan="4">Foliated Structure (e.g., banded)</th></tr>
<tr><th colspan="3">Contact Metamorphism</th><th>Fault Zone Metamorphism</th><th colspan="2">Regional Metamorphism</th><th colspan="2">Plutonic Metamorphism</th></tr>
<tr><td>Low Grade</td><td>Medium Grade</td><td>High Grade</td><td>Low Grade</td><td>Low Grade</td><td>Medium Grade</td><td colspan="2">High Grade</td></tr>
<tr><td colspan="3">granofels
hornfels
marble
metaquartzite
serpentinite
soapstone (talc)</td><td>crush breccia
mylonite</td><td>slate
phyllite
greenstone</td><td>schist
amphibolite</td><td>gneiss
granulite</td><td>migmatite</td></tr>
<tr><td colspan="3"></td><td></td><td colspan="3"><------------------------Metaconglomerate----------------------->
<---------------------------Metavolcanics-------------------------->
<-------------------------Metasedimentary------------------------></td><td></td></tr>
</table>

Sedimentary and Volcaniclastic Rocks

Clastic				Nonclastic			
Dominant Grain Size				***Chemical***		***Biochemical***	***Organic***
Very Fine <----- *(Argillaceous)* -----> < 0.002 mm	*Fine* 0.002 – 0.06 mm	*Medium* *(Arenaceous)* 0.06 - 2.0 mm	*Coarse* *(Rudaceous)* >2.0 mm	**Evaporates, Precipitates**		**Accretionates**	**Reduzates**
<-------- argillite --------> *(more indurated, less laminated and fissile)* <---------- shale ---------> *(laminated, fissile)* <------- mudstone -------> *(nonlaminated, nonfissile)* *(» equal clay and silt)* claystone *(nonlaminated, nonfissile)*	siltstone *nonlaminated, nonfissile)*	Sandstones (ss): arenite arkose *(mainly feldspar)* glauconitic ss *("greensand")* graywacke *(dark, "dirty" ss)* orthoquartzite *(mainly quartz)*	breccia *(nonvolcanic, angular frags)* conglomerate *(nonvolcanic, rounded frags)*	anhydrite *($CaSO_4$)* *gypsum* *($CaSO_4 \cdot 2H_2O$)* halite *(NaCl)*	**Carbonate Rocks** Limestones (ls) (> 50% calcite) chemical types caliche travertine tufa dolomite *(> 50% calcite + dolomite)* phosphatic limestone	accretionary types biostromal ls organic reef pelagic ls (chalk) bio-clastic types coquina oolithic ls lithographic ls	black shale *(organics and fine sediments)* bituminous ls bog iron ores coal
Volcaniclastics *(includes Pyroclastics)*							
<----------------- ignimbrite -----------------> (mainly pumice frags; consolidated pyroclastic flows) <-------------------- tuff --------------------> (consolidated volcanic ash, tephra)			agglomerate *(rounded frags)* volcanic breccia *(angular frags)*				
<------------ pumice *(specific gravity <1.0; highly vesicular)*------------->				**Other Nonclastic Rocks**			
<----- scoria *(specific gravity >2.0; slightly or moderately vesicular)* ------>				Siliceous rocks (Silica dominated): chert (jasper, chalcedony, opal); diatomite Rock phosphate Iron-bearing rocks (Fe-SiO2 dominated): jaspilite, specular hematite, magnetite			

Mass Movement (Mass Wasting) Types for Soil Survey

(landforms , processes, and sediments)

	Movement Types:	Landslide						
		Fall *Free fall, bouncing, or rolling*	***Topple*** *Forward rotation over a point*	***Slide**** *Net lateral displacement along a slip face* ***Rotational Slide*** *Lateral displacement along a concave slip face with backward rotation*	***Translational Slide*** *Lateral displacement along a planar slip face; no rotation*	***Spread*** *A wet layer becomes "plastic," squeezes up and out and drags along intact blocks or beds (e.g., extrusion, liquefaction)* (=Lateral Spread)	***Flow*** *The entire mass, wet or dry, moves as a viscous liquid*	***Complex Landslide*** *Combination of multiple (2 or more) types of movement*
				<------ Compound Slide ------> Intermediate between rotational and translational (e.g., a compound rock slide)				
Dominant Material	***Consolidated: (Bedrock)*** *Bedrock masses dominant*	rockfall	rock topple	rotational rock slide (e.g., Toreva block)	translational rock slide (=planar slide) (e.g., block glide)	rock spread block spread	rock fragment flow (e.g., rockfall avalanche =sturzstrom)	No unique subtypes are recognized here; many possible
	Unconsolidated: Coarser *Coarse fragments dominant*	debris fall	debris topple	rotational debris slide <------------ debris slide ------------>	translational debris slide	debris spread	debris avalanche (drier, steep slope) debris flow (wetter) (e.g., lahar)	Option: name the main movement types (e.g., a Complex Rock Spread-Debris Flow Landslide)
	Finer *Fine-earth particles dominant*	earth fall (=soil fall)	earth topple (=soil topple)	rotational earth slide	translational earth slide	earth spread (e.g., sand boil)	earth flow (e.g., creep, loess flow, mudflow, sandflow, solifluction)	

* Slides, especially rotational slides, are commonly and imprecisely called "slumps."

(Developed from Cruden and Varnes, 1996)

North American Geologic Time Scale [1, 2]

Era	Geologic Period		Geologic Epoch	Subdivision	Oxygen Isotope Stage	Years (BP)
Cenozoic	*Quaternary*		**Holocene**		(1)	0 to 10-12 ka*
			Late Pleistocene	Late Wisconsin	(2)	10-12 to 28 ka
				Middle Wisconsin	(3, 4)	28 to 71 ka
				Early Wisconsin Late Sangamon	(5a - 5d)	71 to 115 ka
				Sangamon	(5e)	115 to128 ka
			Pleistocene *Middle Pleistocene*	Late Middle Pleistocene (Illinoian)	(6 - 8)	128 to 300 ka
				Middle Pleistocene	(9 - 15)	300 to 620 ka
				Early Middle Pleistocene	(16 - 19)	620 to 770 ka
			Early Pleistocene			770 ka to 2.6 Ma**
	Tertiary	**Neo-gene**	**Pliocene**			2.6 to 5.3 Ma
			Miocene			5.3 to 23.0 Ma
		Paleo-gene	**Oligocene**			23.0 to 33.9 Ma
			Eocene			33.9 to 55.8 Ma
			Paleocene			55.8 to 65.5 Ma
Mesozoic	*Cretaceous*		*Late Cretaceous*			65.5 to 99.6 Ma
			Early Cretaceous			99.6 to 145.5 Ma
	Jurassic					145.5 to 201.6 Ma
	Triassic					201.6 to 251.0 Ma
Paleozoic	*Permian*					251.0 to 299.0 Ma
	Pennsylvanian					299.0 to 318.0 Ma
	Mississippian					318.0 to 359.0 Ma
	Devonian					359.0 to 416.0 Ma
	Silurian					416.0 to 444.0 Ma
	Ordovician					444.0 to 488.0 Ma
	CambriaN					488.0 to ≈ 542.0 Ma
	Precambrian Era					> 542.0 Ma

*ka = x 1,000   ** Ma = x 1,000,000 (≈ = approximately)

[1] Modified from Morrison, 1991; Sibrava et al., 1986; and Harland et al., 1990.

[2] Modified from Walker and Geissman, 2009.

Till Terms

Genetic classification and relationships of till terms commonly used in soil survey (adapted from Goldthwaite and Matsch, 1988).

Location (Facies of tills grouped by position at time of deposition)	**Till Type Terrestrial**	**Till Type Waterlaid**
proglacial till (at the front of or in front of glacier)	proglacial **flow till**	waterlaid **flow till**
supraglacial till (on top of or within upper part of glacier)	supraglacial **flow till** [1, 3] supraglacial **melt-out till** [1] (ablation till—NP) [1] (lowered till—NP) [2] (sublimation till—NP) [2]	—
subglacial till (within the lower part of or beneath glacier)	**lodgment till** [1] subglacial **melt-out till** subglacial **flow till** (= "squeeze till" [2, 3]) (basal till—NP) [1] (deformation till—NP) [2] (gravity flow till—NP) [2]	waterlaid **melt-out till** waterlaid **flow till** iceberg till (= "ice-rafted")

[1] *Ablation till* and *basal till* are generic terms that only describe "relative position" of deposition and have been widely replaced by more specific terms that convey both relative position and process. *Ablation till* (any comparatively permeable debris deposited within or above stagnant ice) is replaced by *supraglacial melt-out till*, *supraglacial flow till*, etc. *Basal till* (any dense, nonsorted subglacial till) is replaced by *lodgment till*, *subglacial melt-out till*, *subglacial flow till*, etc.

[2] Additional (proposed) till terms that are outdated or have not gained wide acceptance and are considered to be *not preferred* and should *not* be used.

[3] Also called *gravity flow till* (not preferred).

Pyroclastic Terms

<table>
<tr><th colspan="4">Pyroclasts and Pyroclastic Deposits (Unconsolidated)</th></tr>
<tr><td colspan="4">Size Scale:
0.062 mm[1]   2 mm   64 mm[1]</td></tr>
<tr><td colspan="4"><---------------------------------- tephra ---------------------------------->
(all ejecta)</td></tr>
<tr><td colspan="2"><------------ ash[1] ------------></td><td rowspan="2"><--- cinders[2] --->
(specific gravity >1.0 and <2.0)</td><td rowspan="2"><--- bombs[1] --->
(fluid-shaped coarse fragments)</td></tr>
<tr><td><---------->
fine ash[1]</td><td><-------------->
coarse ash[1]</td></tr>
<tr><td></td><td></td><td><---- lapilli[1] ---->
(specific gravity >2.0)</td><td><--- blocks[1] --->
(angular-shaped coarse fragments)</td></tr>
<tr><td></td><td></td><td colspan="2"><-------------- scoria[2] --------------->
(slightly or moderately vesicular; specific gravity >2.0)</td></tr>
<tr><td></td><td><-------------->
pumiceous ash[3]</td><td colspan="2"><---------------- pumice --------------->
(highly vesicular; specific gravity <1.0)</td></tr>
<tr><th colspan="4">Associated Lithified (Consolidated) Rock Types</th></tr>
<tr><td><---------->
fine tuff[1]</td><td><-------------->
coarse tuff[1]</td><td><- lapillistone[1] ->
(sp. gravity >2.0)</td><td><----------------->
pyroclastic breccia</td></tr>
<tr><td colspan="2"><------- welded tuff[1] -------></td><td colspan="2"><------------ agglomerate[1] ----------->
(<i>rounded</i>, volcanic coarse fragments)</td></tr>
<tr><td colspan="2"><-------- ignimbrite -------->
(consolidated ash flows and nuee ardentes)</td><td colspan="2"><--------- volcanic breccia[1] ---------->
(<i>angular</i>, volcanic coarse fragments)</td></tr>
</table>

[1] These size breaks are taken from geologic literature (Fisher, 2005) and based on the modified Wentworth scale. The 0.062-mm break is very close to the USDA's 0.05-mm break between *coarse silt* and *very fine sand* (Soil Science Division Staff, 2017). The 64-mm break is relatively close to the USDA's 76-mm break between *coarse gravel* and *cobbles*. (See "Comparison of Particle Size Classes in Different Systems" in the "Profile/Pedon Description" on p. 2–45.)

[2] A lower size limit of 2 mm is required in soil taxonomy (Soil Survey Staff, 2022) but is *not* required in geologic usage (Fisher, 2005).

[3] The descriptor for pumice particles < 2 mm, as used in soil taxonomy (Soil Survey Staff, 2022). Geologic usage does *not* recognize any size restrictions for pumice.

Hierarchical Rank of Lithostratigraphic Units [1, 2, 3]

Supergroup—The broadest lithostratigraphic unit. A supergroup is an assemblage of related, superposed groups, or groups and formations. Supergroups are most useful in regional or broad scale synthesis.

Group—The lithostratigraphic unit next in rank below a supergroup. A group is a named assemblage of related superposed formations, which may include unnamed formations. Groups are useful for small-scale (broad) mapping and regional stratigraphic analysis.

Formation (called **Geologic Formation** in NASIS)—The basic lithostratigraphic unit used to describe, delimit, and interpret sedimentary, extrusive igneous, metavolcanic, and metasedimentary rock bodies (excludes metamorphic and intrusive igneous rocks) based on lithic characteristics and stratigraphic position. A formation is commonly, but not necessarily, tabular and stratified and is of sufficient extent to be mappable at the Earth's surface or traceable in the subsurface at conventional map scales.

(Formations can be, but are not necessarily, combined to form higher rank units [groups and supergroups] or subdivided into lower rank units [members or beds].)

Member—The formal lithostratigraphic unit next in rank below a formation and always part of a formation. A formation need not be divided selectively or entirely into members. A member may extend laterally from one formation to another.

Specifically defined types of members:

Lens (or Lentil)—A geographically restricted member that terminates on all sides within a formation.

Tongue—A wedge-shaped member that extends beyond the main formation boundary or that wedges or pinches out within another formation.

Bed—The smallest formal lithostratigraphic unit of sedimentary rock. A bed is a subdivision of a member based upon distinctive characteristics and/or economic value (e.g., coal bed). Members need not be divided selectively or entirely into beds.

Flow—The smallest formal lithostratigraphic unit of volcanic rock. A flow is a discrete, extrusive, volcanic body distinguishable by texture, composition, superposition, and other criteria.

[1] Lithostratigraphic units are mappable rock or sediment bodies that conform to the Law of Superposition (Article 2, Section A).

[2] Separate data element (text field) in NASIS.

[3] Adapted from "North American Stratigraphic Code" (North American Commission on Stratigraphic Nomenclature, 1983).

References

Cruden, D.M., and D.J. Varnes. 1996. Landslide types and processes. *In* A.K. Turner and R.L. Schuster (ed.) Landslides: Investigation and mitigation. Spec. Rep. 247, Transportation Research Board, National Research Council. National Academy Press, Washington, DC.

Fisher, R.V. (updated by T. Frost) 2005. Pyroclastic sediments and rocks. AGI data sheet 6.3. *In* J.D. Walker and H.A. Cohen (ed). The geoscience handbook. AGI data sheets, 4th ed. Am. Geol. Inst., Alexandria, VA.

Goldthwaite, R.P., and C.L. Matsch (ed.) 1988. Genetic classification of glacigenic deposits: Final report of the commission on genesis and lithology of glacial Quaternary deposits of the International Union for Quaternary Research (INQUA). A.A. Balkema, Rotterdam.

Harland, W.B., R.L. Armstrong, L.E. Craig, A.G. Smith, and D.G. Smith. 1990. A geologic time scale. Press Syndicate of University of Cambridge, Cambridge, UK. 1 sheet.

Morrison, R.B. (ed.) 1991. Quaternary nonglacial geology: Conterminous United States. Geol. Soc. Am., Decade of North American Geology, Geology of North America, vol. K–2.

Neuendorf, K., J.P. Mehl, and J.A. Jackson. 2005. Glossary of geology, 5th ed. Am. Geol. Inst., Alexandria, VA.

North American Commission on Stratigraphic Nomenclature. 1983. North American stratigraphic code. Am. Assoc. Petrol. Geol. Bull. 67:841–875.

Sibrava, V., D.Q. Bowen, and D.Q. Richmond (ed.) 1986. Quaternary glaciations in the Northern Hemisphere: Final report of the International Geological Correlation Programme, Project 24. Quaternary Sci. Rev., Vol. 5. Pergamon Press, Oxford.

Soil Survey Staff. 2023. Keys to soil taxonomy, 13th ed. USDA Natural Resources Conservation Service.

Walker, J.D., and J.W. Geissman. 2009. Geologic time scale. Geol. Soc. Am.

Location

GPS Location

Geodetic Datum (**Horizontal_datum_name** in NASIS)—A geodetic datum must accompany latitude and longitude. A geodetic datum is a model that defines the Earth's shape and size and serves as a latitude, longitude reference. Geodetic datum is a selectable GPS parameter. The preferred datum is the World Geodetic System 1984 (WGS-84).

Datum Name	Code
American Samoa 1962	
Astro Beacon "E" 1945	
Astro Tern Island (FRIG)	
Astronomical Station 1952	
Bellevue (IGN)	
Canton Astro 1966	
Chatham Island Astro 1971	
DOS 1968	
Easter Island 1967	
Geodetic Datum 1949	
Guam 1963	
Gux 1 Astro	
Johnston Island 1961	
Kusaie Astro 1961	
Luzon	
Midway Astro 1961	
North American Datum of 1927	NAD27
North American Datum of 1983 [1]	NAD83
Old Hawaiian	
Pitcairn Astro 1967	
Santo (DOS) 1965	
Viti Levu 1916	
Wake Island Astro 1952	
Wake-Eniwetok 1960	
World Geodetic System 1984 [1]	**WGS84**

[1] Preferred datum method for continental U.S.

Public Land Survey

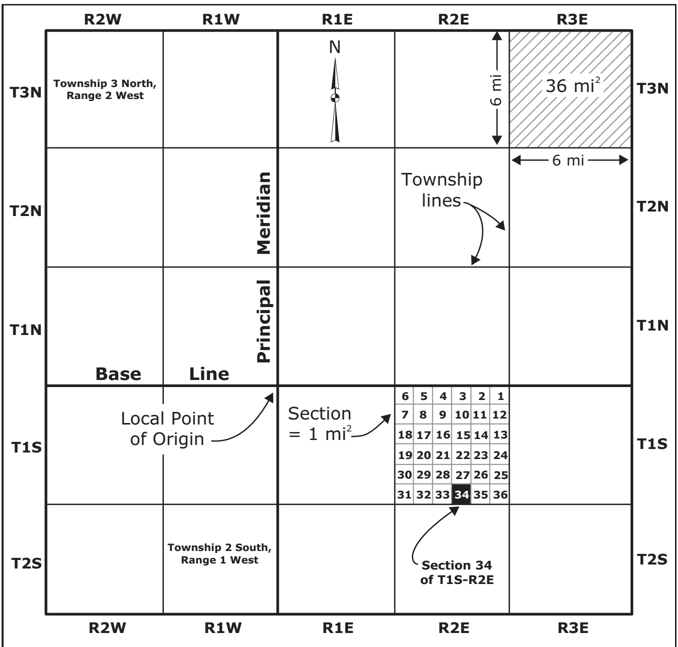
The Public Land Survey System (PLSS) is a rectangular method for describing and subdividing land in the U.S. The PLSS process first establishes two controlling survey lines for a large tract: an east-west base line and a north-south principal meridian, which intersect at an initial point. Thompson (1987; p. 82–83) shows base lines and principal meridians for the conterminous U.S. Lines parallel (standard parallels) to the base line are established at 24- or 30-mile intervals. The meridian, baseline, and standard parallels form a lattice for further subdivision. Subsequent survey divides land into townships of 36 square miles (6 miles on a side). Each township is subdivided into 36 sections 1 mile square (640 acres). Each section is further subdivided into quarter-sections (160 acres).

PLSS Principal Meridians	
Black Hills	New Mexico Principal
Boise	Ohio Company Purchase
Chickasaw	Ohio River
Choctaw	Principal
Cimarron	Salt Lake
Connecticut Western Reserve	San Bernardino
Copper River	Second Principal
Fairbanks	Second Scioto River
Fifth Principal	Seward
First Principal	Sixth Principal
First Scioto River	St. Helena
Fourth Principal	St. Stephens
Fourth Principal Extended	Tallahassee
Gila and Salt River	Third Principal
Great Miami River	Third Scioto River
Humboldt	Twelve-Mile Square
Huntsville	U.S. Military
Indian	Uintah
Kateel River	Umiat
Louisiana	Ute
Michigan	Washington
Mount Diablo	West of the Great Miami
Muskingum River	Willamette
Navajo	Wind River

Prior to the GPS, soil descriptions predominantly used the PLSS for location. Land survey in certain States predates the PLSS and commonly employs the State Plane Coordinate System for location description. These States include Connecticut, Delaware, Georgia, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio (parts), Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, and West Virginia (see State Plane Coordinate System, p. 6–7).

In soil survey, the base line and principal meridian are generally not recorded. Instead, the name of the appropriate USGS topographic 7.5-minute or 15-minute quadrangle is recorded (e.g., Pleasant Dale, NE, 7.5 min. Quad).

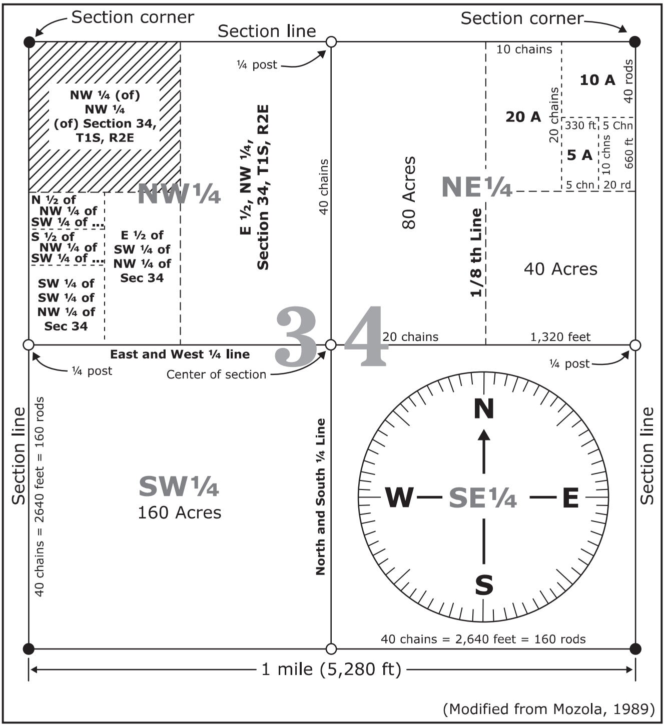
Townships and Ranges—Each township is identified using two indexes: 1) **Township or Tier** (north-south number relative to the base line), and 2) **Range** (east-west number relative to the Principal Meridian). For example, a township is described as T2N, R4E for second township row north of the base line and fourth range row east of the prime meridian.



(Modified from Mozola, 1989)

Sections—Each 1-square-mile **section** is numbered sequentially starting with 1 in the northeast corner of a township proceeding in east-west rows, wrapping back and forth to fill in the township; e.g., *Section 34, T1S, R2E* (Section 34 of Township 1 South, Range 2 East).

Note: Due to the Earth's curvature, survey error, or joins to other survey systems (e.g., Metes and Bounds), occasional irregularities occur in grid areas. Survey adjustments can result in nonstandard size sections and/or breaks in the usual section number sequence.



Section Subdivisions—The PLSS subdivides sections into half- and quarter-sections. The section area fraction (1/2, 1/4) is combined with the compass quadrant that the area occupies in a section; e.g., *SW 1/4, Section 34, T1S, R2E* (southwest quarter of section 34, township 1 south, range 2 east). Additional subdivisions, by halves and quarters, describe progressively smaller areas. The land description is presented consecutively beginning with the smallest subdivision; e.g., a 20-acre parcel described as *N 1/2, NW 1/4, SW 1/4, NW 1/4 of Section 34, T1S,* *R2E* (north half of the northwest quarter of the southwest quarter of the northwest quarter of section 34, township 1 south, range 2 east).

Note: **Point locations** (e.g., soil pits) using the PLSS were traditionally measured in English units with reference to a specified section corner or quarter-corner (1/4 post); e.g., 660 feet east and 1320 feet north of the southwest corner post, Section 34, T1S, R2E.

Universal Transverse Mercator (UTM) Rectangular Coordinate System

The Universal Transverse Mercator coordinate system (UTM) is an international reference (military and civilian) that depicts the Earth's three-dimensional surface in a relatively accurate, two-dimensional, flat plane and uses Cartesian coordinates (meters) for location. The U.S. Army began use of the UTM projection and grid system in 1947. GPS units can display UTM coordinates, which are simpler for map distance plotting and measurement than latitude and longitude.

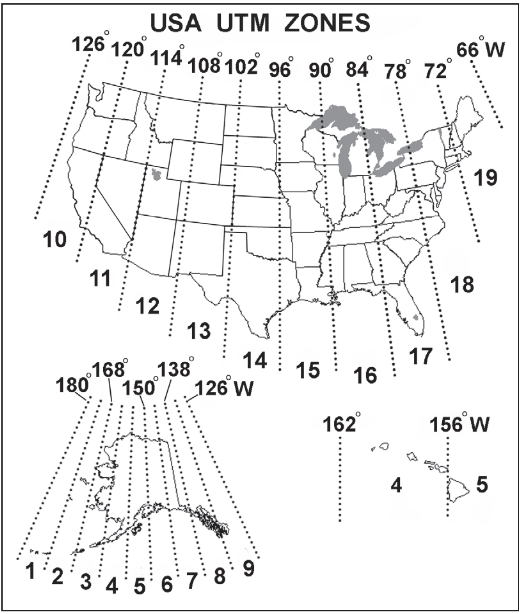
The UTM grid spans from 80˚S through 84˚N latitude (the Universal Polar Stereographic [UPS] system covers polar areas). The UTM system divides the Earth into 60 equally spaced, vertically arranged planes known as zones, or world zones; each zone spans 6 degrees of longitude. The zones are sequentially numbered 1 through 60 west to east. Zone numbering begins at 180 degrees longitude, the International Date Line. UTM zone 1 encompasses 180–174 degrees W longitude, zone 2 spans 174–168 W longitude, and so forth through zone 60.

The UTM grid system also divides the Earth into 20 equally spaced east-west rows. Each row circles the globe and spans exactly 8 latitude degrees, except for the 12-degree-wide row between 72 and 84 degrees north latitude. The 20 UTM rows are lettered C through X from south to north beginning at 80 degrees south latitude; I and O are omitted to avoid confusion with numbers. Row C spans 80–72 degrees south latitude, row D encompasses 72–64 degrees south latitude, and so forth. The southern hemisphere contains rows C, D, E, F, G, H, J, K, L, and M, whereas the northern hemisphere contains rows N, P, Q, R, S, T, U, V, W, and X.

The central meridian of each zone is the east-west control for UTM coordinates, and other N-S grid lines are parallel to the central meridian. UTM coordinates are expressed as a distance in meters east of a zone's central meridian. This value is called an "**easting**." The central meridian by convention is given a value of 500,000 m east; this eliminates negative distance values. A location west of the central meridian has a value < 500,000 m. Easting values can range from 166,000 to 834,000 m. Some protocols give the easting value a leading zero (e.g., 0166000).

The initial north-south grid line for the northern hemisphere is the Equator, which has a value of 0 m. A UTM value called a "**northing**" is expressed as distance in meters north of the Equator. For the northern hemisphere, northings range from 0 to 9,328,000 m (84 N Lat). In the southern hemisphere, the 0 m reference is the South Pole; the northing is expressed as distance in meters north of it. The range in northings is 1,118,000 (80 S Lat) to 10,000,000 m (Equator). Points on the Equator can be described by either the north or south reference.

A complete UTM location gives in order the zone number, row letter, easting value, and northing value; for example, *16 T, 0313702 m E, 4922401 m N*. The row letters designate the hemisphere location (northern or southern).



All quadrangle maps prepared by the USGS show the UTM coordinates (Snyder, 1987). On 7.5-minute quadrangle maps (1:24,000 and 1:25,000 scale) and 15-minute quadrangle maps (1:50,000, 1:62,500, and standard edition 1:63,360 scales), the UTM grid lines are indicated at 1,000-meter intervals, either by blue ticks in the map margin or with full grid lines. The maps display shortened 1,000-meter values at the tick or grid lines. The full meter values are shown only at ticks nearest the southeast and northwest map corners.

To obtain a UTM grid location from a USGS map, use the grid lines, draw lines connecting corresponding ticks on opposite map edges, or place a transparent grid overlay on the map. Measure distance between any map point and the nearest grid line in cm. If the map scale is 1:24000, multiply the measured cm distance by 240 to obtain meters on the ground. The northing of a point is the value of the nearest grid line south plus its distance north of that line; the easting is the value of the nearest grid line west of it plus its distance east of that line. On maps at 1:100,000 and 1:250,000 scale, a full UTM grid is shown at intervals of 10,000 meters and is numbered and used in the same way. Various overlay UTM templates that facilitate distance and coordinate measurement from topographic maps are commercially available.

State Plane Coordinate System

The State Plane Coordinate System (SPCS) is designed for mapping and surveying in the U.S. It was developed in the 1930s by the U.S. Coast and Geodetic Survey. Historically, soil description locations sometimes used the SPCS system where the PLSS is nonexistent. The States that have used this system are Connecticut, Delaware, Georgia, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio (parts), Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, and West Virginia.

The SPCS divides all 50 states of the United States, Puerto Rico, and the U.S. Virgin Islands into 120 numbered zones. The zones correspond to political boundaries (States and most counties). The SPCS establishes a separate coordinate system and two principal lines in each State: a north-south line and an east-west line. USGS 7.5-minute topographic maps indicate SPCS grids by tick marks along the neatlines (outer border). ***Note:*** Older topo maps based on NAD27 have grid units in feet. After adoption of NAD83, meters become the grid unit.

Specific location coordinates are described by distance and primary compass direction (north [northing], south [southing], east [easting], or west [westing]) relative to the principal lines; e.g., *10,240 m easting and 1,234 m northing*.

Contact the NRCS State office or the Regional Soil Survey Office for State-specific details.

References

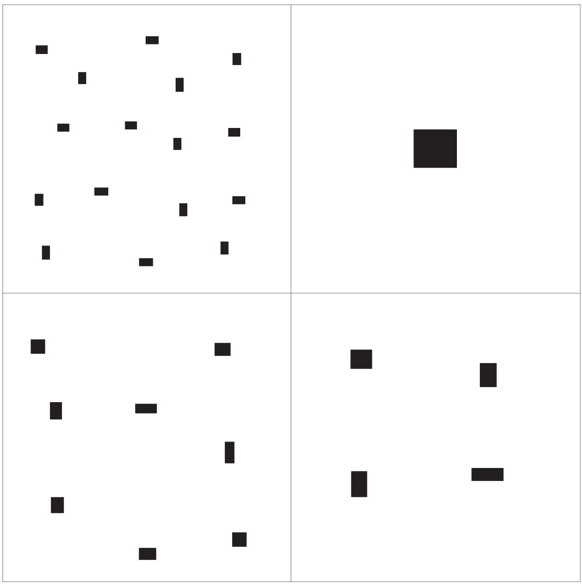
Mozola, A.J. 1989. U.S. public land survey. *In* J.T. Dutro et al., AGI data sheets, 3rd ed. Am. Geol. Inst., United Book Press, Inc.

Snyder, J.P. 1987. Map projections—A working manual. U.S. Geol. Surv. Prof. Pap. 1395.

Thompson, M.M. 1987. Maps for America, 3rd ed. U.S. Geol. Surv., U.S. Dep. Interior.

Percent of Area Covered

The following graphics of **Percent of Area Covered** are used to describe "Amount" or "Quantity." (***Note:*** Within each large box [e.g., 2%], a quadrant contains the same total area covered but contains different object sizes and numbers.)



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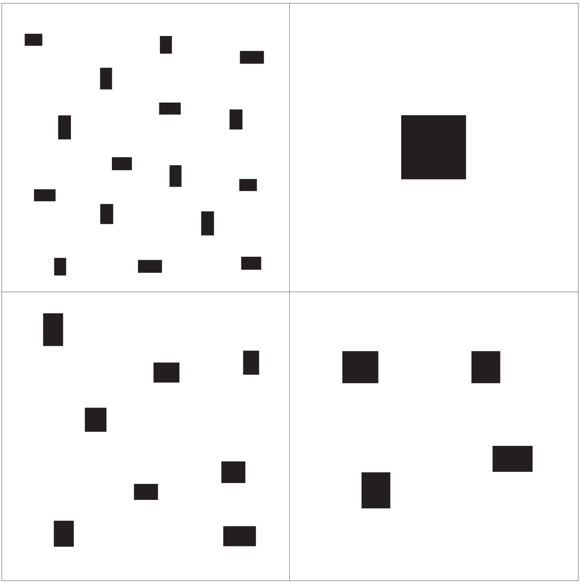

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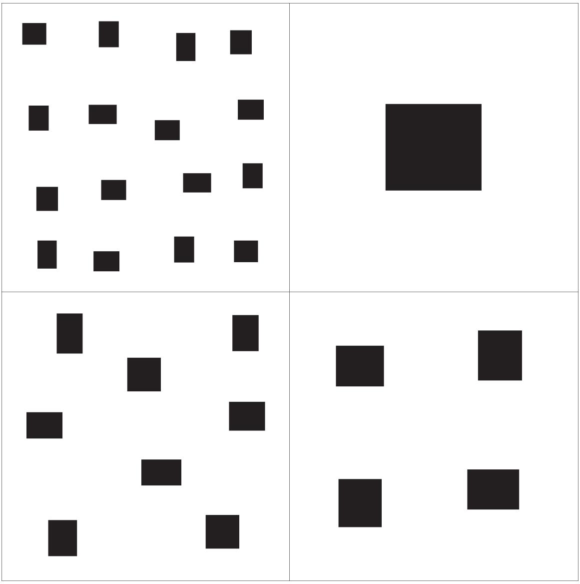

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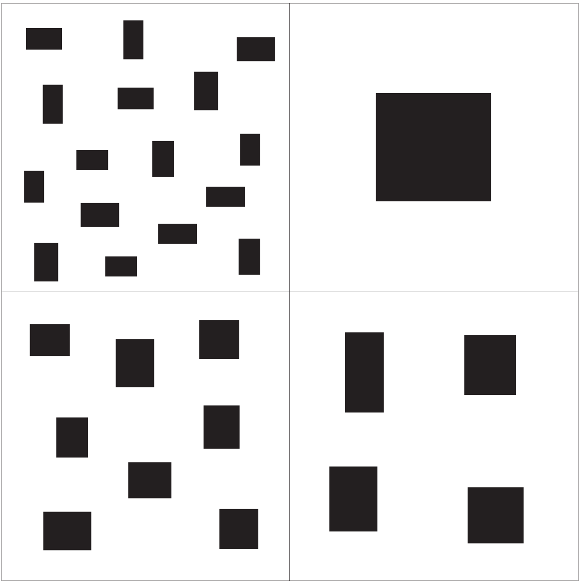

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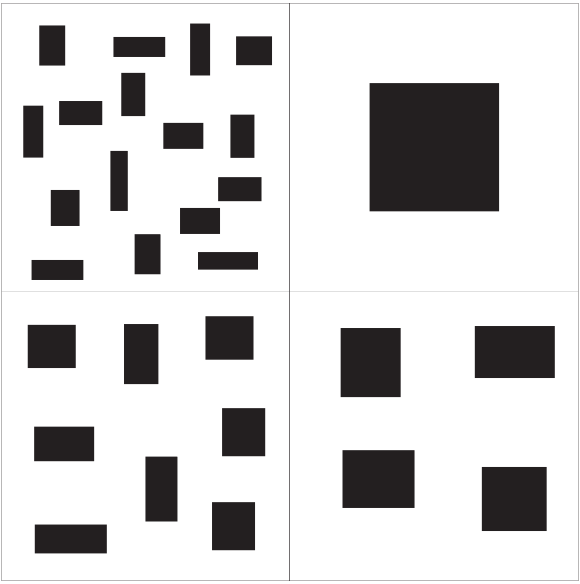

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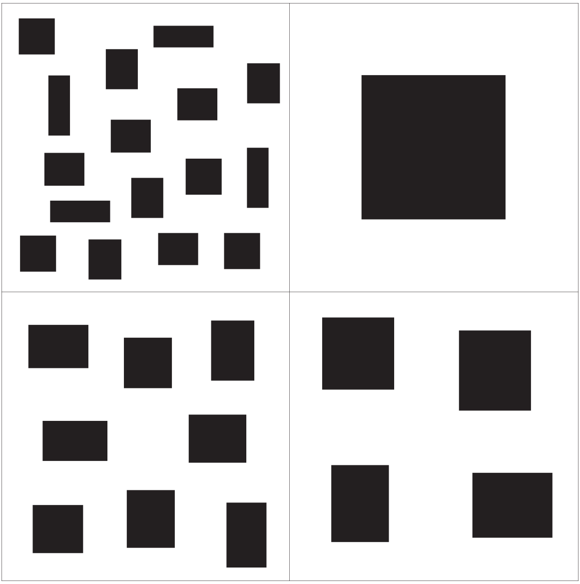

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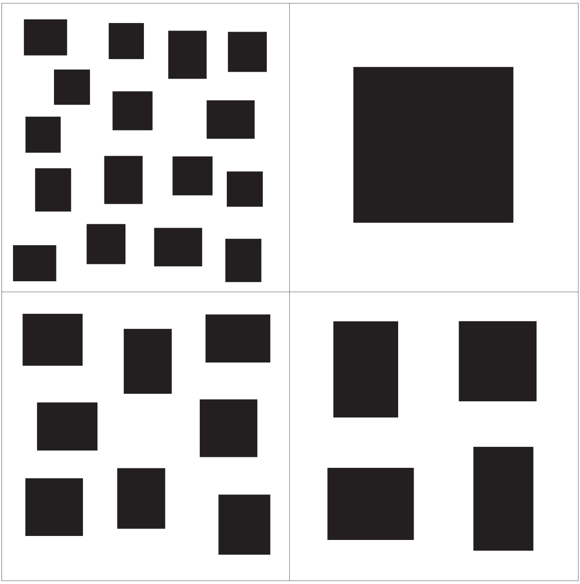

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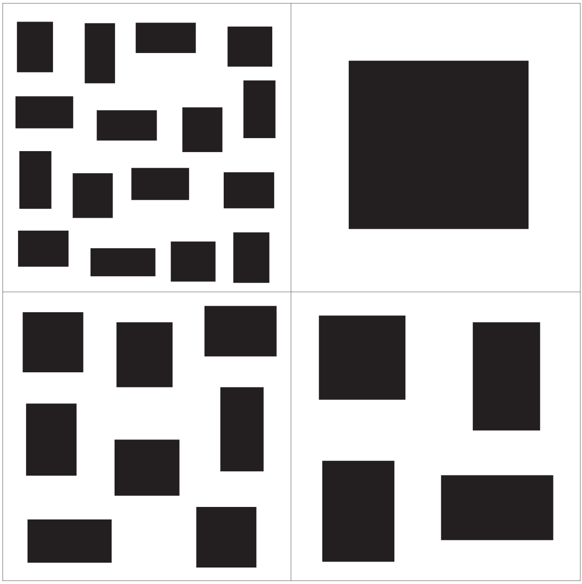

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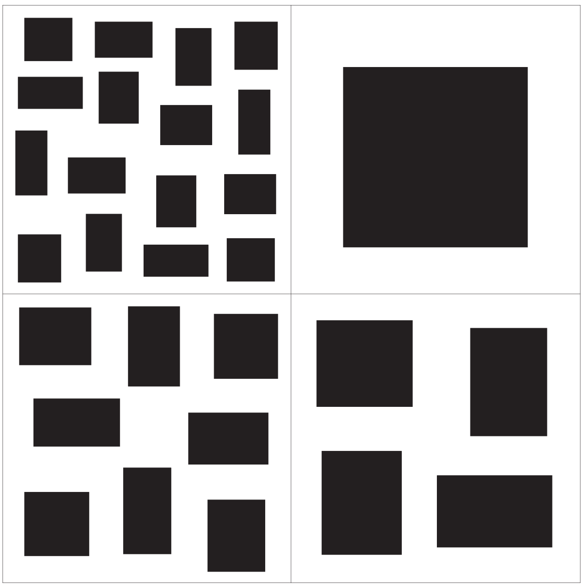

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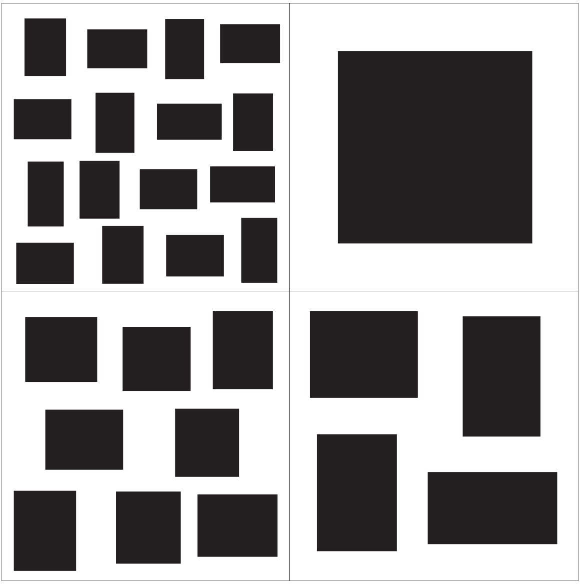

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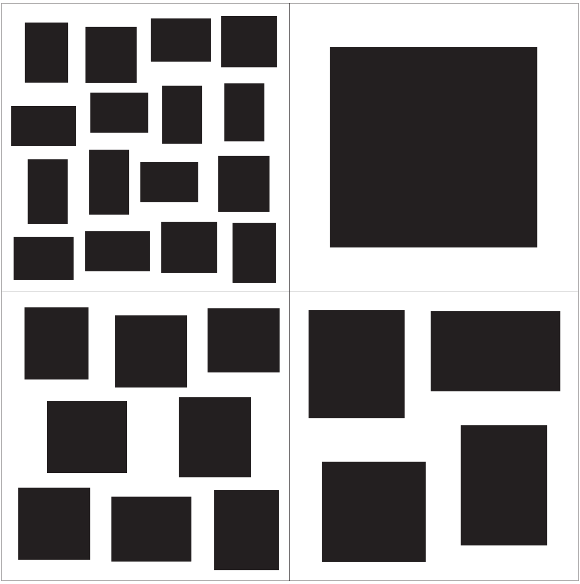

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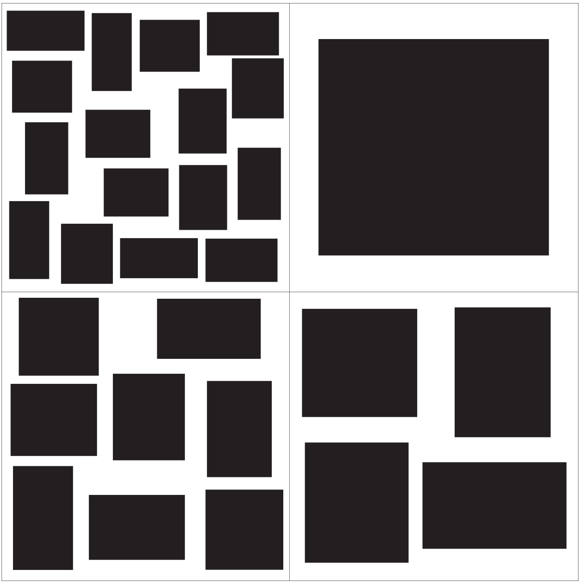

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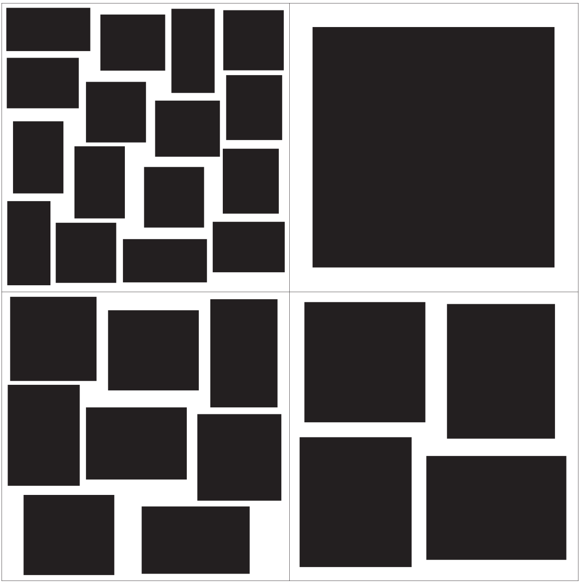

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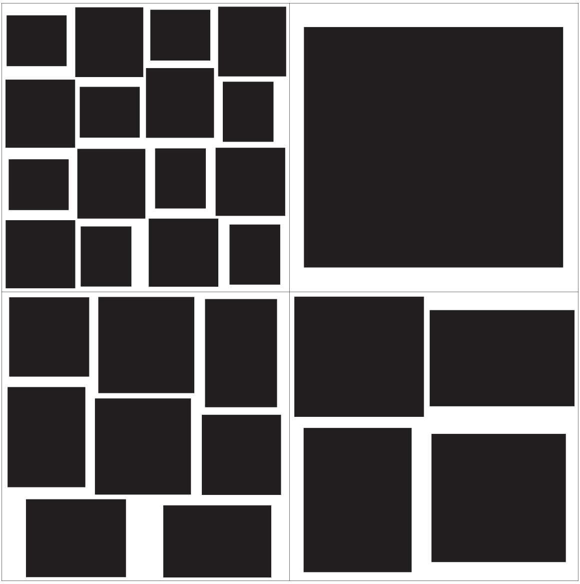

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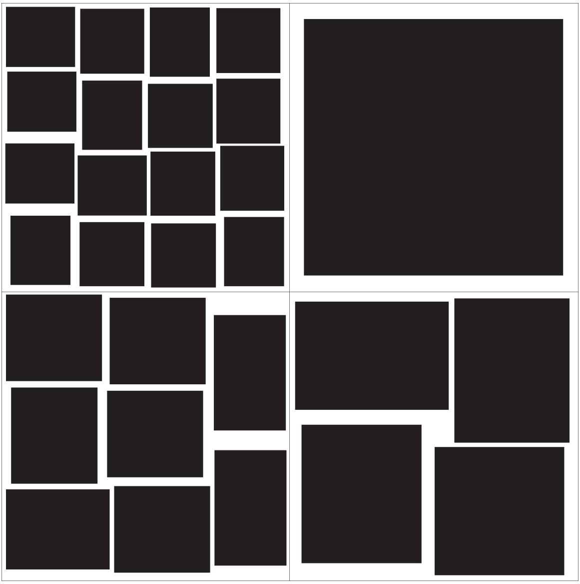

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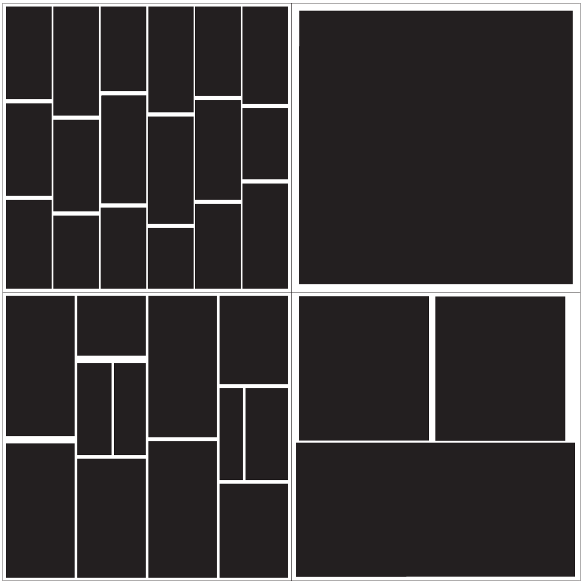


90%

Ksat Class Estimate

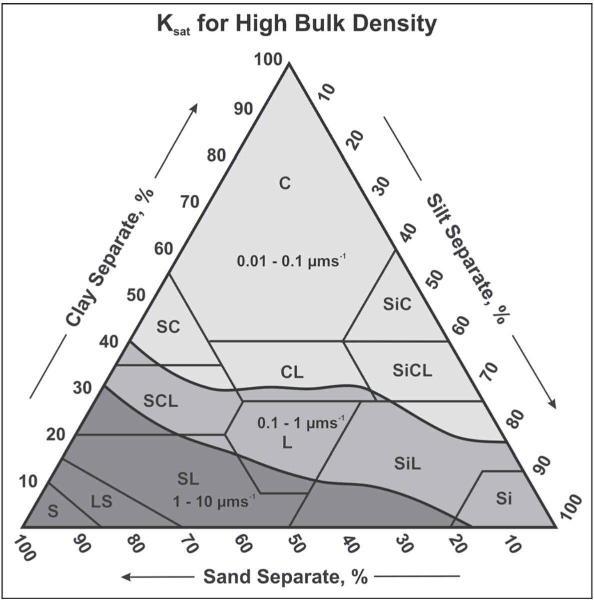
Field Ksat is an important soil property and its measurement is greatly preferred over laboratory determined or mathematically predicted Ksat values. Field Ksat reflects horizon, pedon, and larger-scale macropore networks that strongly influence water flow in soilscapes. Various methods exist for field Ksat measurement (Soil Survey Staff, 1982; Bouma et al., 1982; Amoozegar and Warrick, 1986; Soil Survey Staff, 2009).

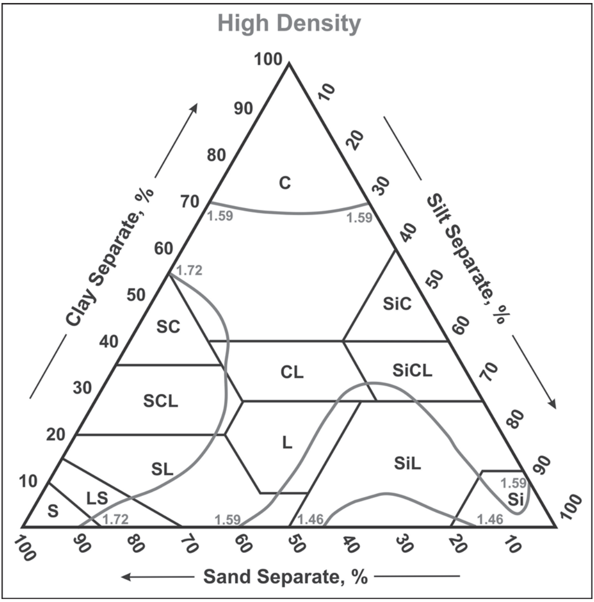
Where measured Ksat values are unavailable, mathematical models or predictions can provide approximate estimates. Such Ksat estimates rely on other estimated or measured soil physical properties (e.g., texture, bulk density, porosity). Estimated Ksat values are assigned as a class range to compare soils and are not used as a Ksat value for a specific site (Soil Science Division Staff, 2017).

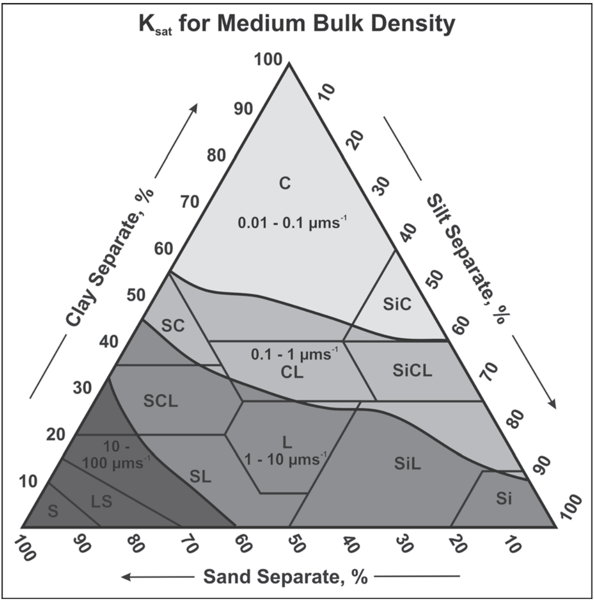
A general guide for estimating Ksat classes (Soil Survey Staff 2024; Rawls and Brakensiek, 1983) involves a set of textural triangles that group soils by relative bulk density (low, medium, or high) and soil texture. Use the following charts and steps to predict Ksat by class range.

Step 1 - Use an estimated or known bulk density and texture to select the appropriate bulk density triangle for the layer. (e.g., A clay loam [35% sand and 35% clay] with a 1.4 g cm^{-3} bulk density fits the “Medium Bulk Density” triangle).

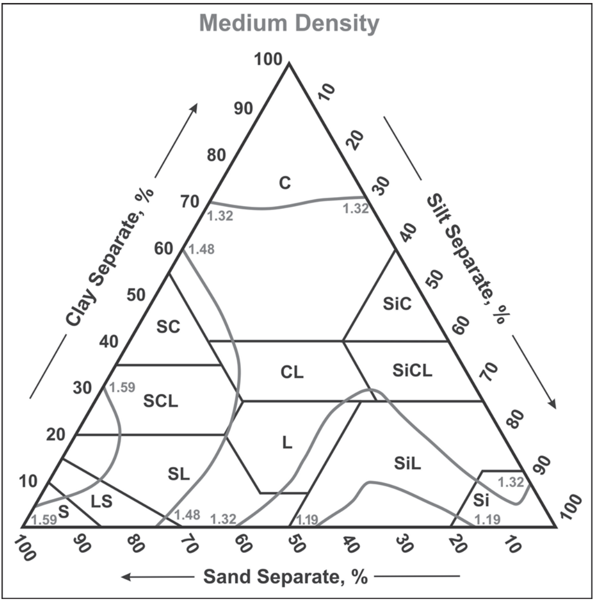
Step 2 - Use the appropriate “Bulk Density / Ksat Class Triangle” to assign a Ksat class. (e.g., A clay loam texture [35% clay and 35% sand] with medium bulk density assigns an estimated *moderately low* [0.1 – 1.0 μm/sec] Ksat Class).


Ksat for High Bulk Density
C
0.01 - 0.1 µms-1
SiC
SC
CL
SiCL
SCL
0.1 - 1 µms-1
L
SiL
SL
1 - 10 µms-1
Si
LS
S
Clay Separate, %
Silt Separate, %
Sand Separate, %
100
90
80
70
60
50
40
30
20
10

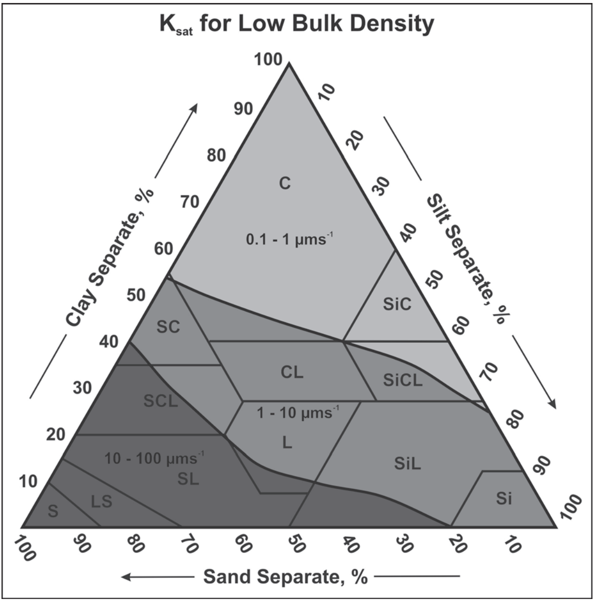

High Density
C
1.59
1.59
1.72
SiC
SC
CL
SiCL
SCL
L
SiL
SL
LS
S
Si
1.59
1.72
1.59
1.46
1.46
Clay Separate, %
Silt Separate, %
Sand Separate, %
100
90
80
70
60
50
40
30
20
10



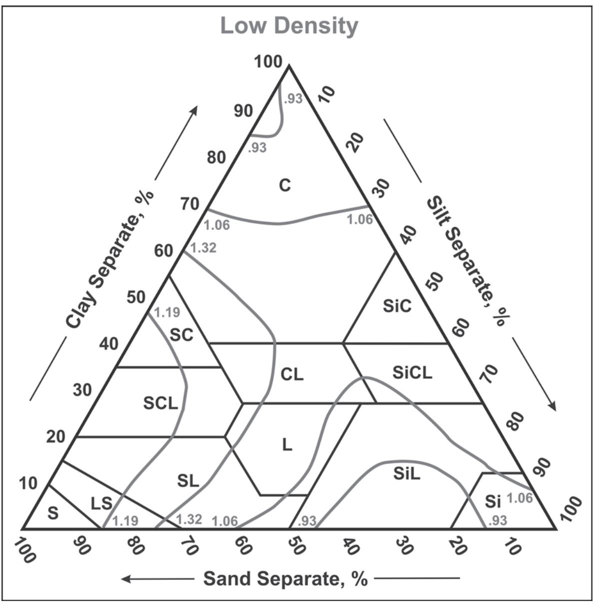
K_sat for Medium Bulk Density
C
0.01 - 0.1 μms-1
SiC
SC
0.1 - 1 μms-1
CL
SiCL
SCL
L
1 - 10 μms-1
10 -
100 μms-1
SL
SiL
Si
S
LS
Clay Separate, %
Silt Separate, %
Sand Separate, %



Medium Density
C
1.32
1.32
1.48
SiC
SC
CL
SiCL
1.59
SCL
L
SL
SiL
1.32
LS
S
Si
1.59
1.48
1.32
1.19
1.19
Clay Separate, %
Silt Separate, %
Sand Separate, %



K_{sat} for Low Bulk Density
C
0.1 - 1 µms-1
SiC
SC
CL
SiCL
SCL
1 - 10 µms-1
L
10 - 100 µms-1
SL
SiL
LS
S
Si
Clay Separate, %
Silt Separate, %
Sand Separate, %



Low Density
.93
.93
C
1.06
1.06
1.32
SiC
1.19
SC
CL
SiCL
SCL
L
SL
SiL
LS
S
Si
1.06
1.19
1.32
1.06
.93
.93
Clay Separate, %
Silt Separate, %
Sand Separate, %

Soil Water Repellency (Discussion)

Water repellency is a soil's ability to resist spontaneous wetting when water is placed on a soil surface. Water-repellent compounds arise from organic matter decomposition, including plant root exudates, fungal processes, and surface waxes from plant leaves (Mainwaring et al., 2004). Initial, irreversible drying of organic materials (Hallett et al., 2003) causes hydrophilic functional groups to strongly bond with each other and soil particles. This process results in an exposed water-repellent surface (Dekker et al., 1998). Soil water repellency is a dynamic property that varies with climate, plant community, and microbial decomposition pathways. Fire is also an important factor; heat volatilizes water-repellent organic substances that move and condense where soil is cooler (Savage, 1974). Fire may have a 3- to 5-year influence on water repellency (DeBano and Krammes, 1966). Water repellency decreases water infiltration and increases surface runoff and soil erodibility.

Organic compounds, particularly fats, waxes, and resins, form repellent coatings on mineral grains. The repellency degree depends on the quantity of particles covered (Doerr et al., 2006). Sandy soils (with low surface area) are more prone to water repellency than are loamy or clayey soils. Soil water repellency is spatially variable both laterally and with depth (Robichand and Miller, 1999; Hubbert et al., 2006). Soil moisture content strongly influences water repellency. Soils that are more than about 10 percent moisture wet more readily than dry soils (Hubbert and Oriol, 2005; MacDonald and Huffman, 2004).

A common technique to assess water repellency is the Water Drop Penetration Test (WDPT). A water drop is placed on a clean soil surface and the absorption time recorded (Letey, 1969). The WDPT test measures repellency persistence (Doerr et al., 2000). Water may penetrate instantly or take hours. Various time classifications relate water repellency to absorption time (Robichand et al., 2008). Such classifications have convenient intervals that allow relative comparison, but the times do not have intrinsic physical meaning.

Soil Water Repellency

Evaluate and record the relative soil water repellency determined from a Water Drop Penetration Time (WDPT) measurement. (***Note:*** Soil should be in a dry state.)

WDPT Procedure

1. Prepare a clean, level horizontal 15 x 15 cm area of soil at a desired depth with a knife or trowel.

2. Use an eyedropper or plastic squeeze bottle to randomly place 5 drops of distilled water (approximately 5 mm in diameter) from a 1-cm height onto the prepared surface.

3. Record the average time (in seconds) that the drops remain on the surface before absorption.

Determine the relative water repellency class according to the following table.

Relative Water Repellency Class	Code	Absorption Time (seconds)
non-water repellent	NWR	0 to 5
slightly water repellent	SWR	> 5 to 60
moderately water repellent	MWR	> 60 to 180
strongly water repellent	TWR	> 180

Modified from Robichand, 2008.

Measurement Equivalents and Conversions

Metric to English

Known	Symbol	Multiplier	Product	Symbol
Length				
micrometers (microns)	*μm*	3.9370	inches	*in or "*
(=10,000 Angstrom units)		x 10^{-5}		
millimeters	*mm*	0.03937	inches	*in or "*
centimeters	*cm*	0.0328	feet	*ft or '*
centimeters	*cm*	0.3937	inches	*in or "*
meters	*m*	3.2808	feet	*ft or '*
meters	*m*	1.0936	yards	*yd*
kilometers	*km*	0.6214	miles (statute)	*mi*
Area				
square centimeters	cm^2	0.1550	square inches	in^2
square meters	m^2	10.7639	square feet	ft^2
square meters	m^2	1.1960	square yards	yd^2
square kilometers	km^2	0.3861	square miles	mi^2
hectares	*ha*	2.471	acres	*ac*
Volume				
cubic centimeters	cm^3	0.06102	cubic inches	in^3
cubic meters	m^3	35.3146	cubic feet	ft^3
cubic meters	m^3	1.3079	cubic yards	yd^3
cubic meters	m^3	0.0008107	acre-feet (=43,560 ft^3)	*acre-ft*
cubic kilometers	km^3	0.2399	cubic miles	mi^3
liters (=1000 cm)	*l*	1.0567	quarts (U.S.)	*qt*
liters	*l*	0.2642	gallons (U.S.)	*gal*
milliliter	*ml*	0.0338	fluid ounces	*oz*
1 milliliter=1 cm^3=1 gm (H_20, at 25 °C)				
Mass				
grams	*g*	0.03527	ounces (avdp.)	*oz*
kilograms	*kg*	2.2046	pounds (avdp.)	*lb*
megagrams (= metric tons)	*Mg*	1.1023	short tons (2000 lb)	
megagrams	*Mg*	0.9842	long tons (2240 lb)	

English to Metric

Known	Symbol	Multiplier	Product	Symbol
Length				
inches	*in or "*	2.54×10^4	micrometers (microns)	*µm*
			[=10,000 Angstrom units (A)]	
inches	*in or "*	2.54	centimeters	*cm*
feet	*ft or '*	30.48	centimeters	*cm*
feet	*ft or '*	0.3048	meters	*m*
yards	*yd*	0.9144	meters	*m*
miles (statute)	*mi*	1.6093	kilometers	*km*
Area				
square inches	in^2	6.4516	square centimeters	cm^2
square feet	ft^2	0.0929	square meters	m^2
square yards	yd^2	0.8361	square meters	m^2
square miles	mi^2	2.59	square kilometers	km^2
acres	*ac*	0.405	hectares	*ha*
Volume				
acre-feet	*acre-ft*	1233.5519	cubic meters	m^3
acre-furrow-slice	*afs*	=6-in.-thick layer that's 1 acre in area		
≈ 2,000,000 lbs	*(assumes b.d.=1.3 g/cm^3)*			
cubic inches	in^3	16.3871	cubic centimeters	cm^3
cubic feet	ft^3	0.02832	cubic meters	m^3
cubic yards	yd^3	0.7646	cubic meters	m^3
cubic miles	mi^3	4.1684	cubic kilometers	km^3
gallons (U.S.)	*gal*	3.7854	liters	*l*
(=0.8327 Imperial gal)				
quarts (U.S.)	*qt*	0.9463	liters (=1000 cm^3)	*l*
ounces	*oz*	29.57	milliliters	*ml*
1 milliliter=1 cm^3=1 gm (H_2O, at 25 °C)				
Mass				
ounces (avdp.)	*oz*	28.3495	grams	*g*
ounces (avdp.)	*(1 troy oz.=0.083 lb)*			
pounds (avdp.)	*lb*	0.4536	kilograms	*km*
short tons (2000 lb)		0.9072	megagrams (= metric tons)	*Mg*
long tons (2240 lb)		1.0160	megagrams	*Mg*

Common Conversion Factors

Known	Symbol	Multiplier	Product	Symbol
acres	*ac*	0.405	hectares	*ha*
acre-feet	*acre-ft*	1233.5019	cubic meters	*m^3*
acre-furrow-slice	*afs*	=6-in.-thick layer that's 1 acre square		
≈ 2,000,000 lbs	*(assumes b.d.=1.3 g/cm^3)*			
Angstrom units	*A*	1x 10^{-8}	centimeters	*cm*
Angstrom units	*A*	1x 10^{-4}	micrometers	*um*
Atmospheres	*atm*	1.0133 x 10^6	dynes/cm^2	
Atmospheres	*atm*	760	mm of mercury (Hg)	
BTU (mean)	*BTU*	777.98	foot-pounds	
centimeters	*cm*	0.0328	feet	*ft or '*
centimeters	*cm*	0.3937	inches	*in or "*
centimeters/hour	*cm/hr*	0.3937	inches/hour	*in/hr*
centimeters/second	*cm/s*	1.9685	feet/minute	*ft/min*
centimeters/second	*cm/s*	0.0224	miles/hour	*mph*
chain (U.S.)		66	feet	*ft*
chain (U.S.)		4	rods	
cubic centimeters	*cm^3*	0.06102	cubic inches	*in^3*
cubic centimeters	*cm^3*	2.6417 x 10^{-4}	gallons (U.S.)	*gal*
cubic centimeters	*cm^3*	0.999972	milliliters	*ml*
cubic centimeters	*cm^3*	0.0338	ounces (U.S.)	*oz*
cubic feet	*ft^3*	0.02832	cubic meters	*m^3*
cubic feet (H_2O, 60 °F)	*ft^3*	62.37	pounds	*lbs*
cubic feet	*ft^3*	0.03704	cubic yards	*yd^3*
cubic inches	*in^3*	16.3871	cubic centimeters	*cm^3*
cubic kilometers	*km^3*	0.2399	cubic miles	*mi^3*
cubic meters	*m^3*	35.3146	cubic feet	*ft^3*
cubic meters	*m^3*	1.3079	cubic yards	*yd^3*
cubic meters	*m^3*	0.0008107	acre-feet (=43,560 ft^3)	*acre-ft*
cubic miles	*mi^3*	4.1684	cubic kilometers	*km^3*
cubic yards	*yd^3*	0.7646	cubic meters	*m^3*
degrees (angle)	°	0.0028	circumfrences	
Faradays		96500	coulombs (abs)	
fathoms		6	feet	*ft*

Known	Symbol	Multiplier	Product	Symbol
feet	*ft or '*	30.4801	centimeters	*cm*
feet	*ft or '*	0.3048	meters	*m*
feet	*ft or '*	0.0152	chains (U.S.)	
feet	*ft or '*	0.0606	rods (U.S.)	
foot pounds		0.0012854	BTU (mean)	*BTU*
gallons (U.S.)	*gal*	3.7854	liters	*l*
gallons (U.S.)	*gal*	0.8327	Imperial gallons	
gallons (U.S.)	*gal*	0.1337	cubic feet	ft^3
gallons (U.S.)	*gal*	128	ounces (U.S.)	*oz*
grams	*g*	0.03527	ounces (avdp.)	*oz*
hectares	*ha*	2.471	acres	*ac*
horsepower		2545.08	BTU (mean)/hour	
inches	*in or "*	2.54×10^4	micrometers (micron) (=10,000 Angstrom units [A])	*µm*
inches	*in or "*	2.5400	centimeters	*cm*
inches/hour	*in/hr*	2.5400	centimeters/hour	*cm/hr*
inches/hour	*in/hr*	7.0572	micrometers/sec	*µm/sec*
kilograms	*kg*	2.2046	pounds (avdp.)	*lb*
kilometers	*km*	0.6214	miles (statute)	*mi*
joules	*J*	1×10^7	ergs	
liters	*l*	0.2642	gallons (U.S.)	*gal*
liters	*l*	33.8143	ounces	*oz*
liters (=1000 cm^3)	*l*	1.0567	quarts (U.S.)	*qt*
long tons (2240 lb)		1.0160	megagrams	*Mg*
megagrams (= metric tons)	*Mg*	1.1023	short tons (2000 lb)	
megagrams	*Mg*	0.9842	long tons (2240 lb)	
meters	*m*	3.2808	feet	*ft or '*
meters	*m*	39.37	inches	*in*
micrometers (microns)	*µm*	1.000	microns	*µ*
micrometers/second	*µm/sec*	0.1417	inches/hour	*in/hr*
micron	*µ*	1×10^{-4}	centimeters	*cm*
microns	*µ*	3.9370	inches	*in or "*

Known	Symbol	Multiplier	Product	Symbol
(=10,000 Angstrom units)		x 10^{-5}		
micron	*μ*	1.000	micrometer	*μm*
miles (statute)	*mi*	1.6093	kilometers	*km*
miles/hour	*mph*	44.7041	cent./second	*cm/s*
miles/hour	*mph*	1.4667	feet/second	*ft/s*
milliliter	*ml*	0.0338	fluid ounces	*oz*
1 milliliter ≈ 1 cm^3=1 gm (H_2O, at 25°C)				
milliliter	*ml*	1.000028	cubic centimeters	*cm^3*
millimeters	*mm*	0.03937	inches	*in or "*
ounces	*oz*	29.5729	milliliters	*ml*
1 milliliter ≈ 1 cm^3=1 gm (H_2O, at 25 °C)				
ounces (avdp.)	*oz*	28.3495	grams	*g*
ounces (avdp.) 1 troy oz.=0.083 lb				
pints (U.S.)	*pt*	473.179	cubic centimeters	*cm^3 or cc*
pints (U.S.)	*pt*	0.4732	liters	*l*
pounds (avdp.)	*lb*	0.4536	kilograms	*kg*
quarts (US liquid)	*qt*	0.9463	liters (=1000 cm^3)	*l*
rods (U.S.)		0.25	chains (U.S.)	*ft*
rods (U.S.)		16.5	feet (U.S.)	*ft*
short tons (2000 lb)		0.9072	megagrams (= metric tons)	*Mg*
square centimeters	*cm^2*	0.1550	square inches	*in^2*
square feet	*ft^2*	0.0929	square meters	*m^2*
square inches	*in^2*	6.4516	sq. centimeters	*cm^2*
square kilometers	*km^2*	0.3861	square miles	*mi^2*
square meters	*m^2*	10.7639	square feet	*ft^2*
square meters	*m^2*	1.1960	square yards	*yd^2*
square miles	*mi^2*	2.5900	square kilometers	*km^2*
square yards	*yd^2*	0.8361	square meters	*m^2*
yards	*yd*	0.9144	meters	*m*

Guide to Map Scales and Minimum Size Delineations [1]

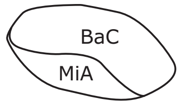
Order of Soil Survey	Minimum Size of Map Units (ha)[2]	Appropriate Scales for Field Mapping Publications
Order 1	1 or less	1:15,840 or larger
Order 2	0.6 to 4	1:12,000 to 1:31,680
Order 3	1.6 to 16	1:20,000 to 1:63,360
Order 4	16 to 252	1:63,360 to 1:250,000
Order 5	252 to 4,000	1:250,000 to 1:1,000,00 or smaller

[1] Soil Science Division Staff. 2017.

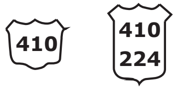
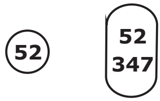
[2] This is about the smallest delineation allowable for readable soil maps. In practice, the minimum size of delineation is generally larger than that shown in the table.

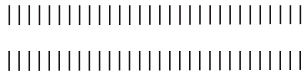
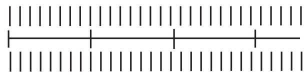
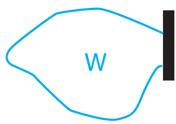
Common Soil Map Symbols (Traditional)

(From Soil Survey Staff, 1990.) The following symbols are common on field sheets (original aerial photograph–based soil maps) and in many soil surveys published prior to 1997. Current guidelines for map compilation symbols are in NSSH, Section 627.14, Feature and Symbol Legend for Soil Survey (Soil Survey Staff, 2024).

FEATURE	SYMBOL
LANDFORM FEATURES	
SOIL DELINEATIONS	
ESCARPMENTS	
Bedrock	 (Points down slope)
Other than bedrock	 (Points down slope)
SHORT STEEP SLOPE	
GULLY	
DEPRESSION, closed	
SINKHOLE	
Prominent hill or peak	
EXCAVATIONS	
Soil sample site (Type location, etc.)	
Borrow pit	
Gravel pit	
Mine or quarry	
LANDFILL	

FEATURE	SYMBOL
MISCELLANEOUS SURFACE FEATURES	
Blowout	
Clay spot	
Gravelly spot	
Lava flow	
Marsh or swamp	
Rock outcrop (includes sandstone and shale)	
Saline spot	
Sandy spot	
Severely eroded spot	
Slide or slip (tips point upslope)	
Sodic spot	
Spoil area	
Stony spot	
Very stony spot	
Wet spot	

FEATURE	SYMBOL
ROAD EMBLEMS	
Interstate	
Federal	
State	
County, farm, or ranch	
CULTURAL FEATURES	
RAILROAD	
POWER TRANSMISSION LINE (normally not shown)	
PIPELINE (normally not shown)	
FENCE (normally not shown)	

FEATURE	SYMBOL
CULTURAL FEATURES (continued)	
LEVEES	
Without road	
With road	
With railroad	
Single side slope (showing actual feature location)	
DAMS	
Medium or small	
Large	

FEATURE	SYMBOL
HYDROGRAPHIC FEATURES	
STREAMS	
Perennial, double line (large)	
Perennial, single line (small)	
Intermittent	
Drainage end or flow direction	
SMALL LAKES, PONDS, AND RESERVOIRS	
Perennial water	
Miscellaneous water	
Flood pool line	
Lake or pond (perennial)	
MISCELLANEOUS WATER FEATURES	
Spring	
Well, artesian	
Well, irrigation	

FEATURE	SYMBOL
MISCELLANEOUS CULTURAL FEATURES	
Airport	
Cemetery	
Farmstead, house (omit in urban areas)	
Church	
School	
Other religion (label)	 Mt. Carmel
Located object (label)	 Ranger Station
Tank (label)	 Petroleum
Lookout tower	
Oil and/or natural gas wells	
Windmill	
Lighthouse	

References

Amoozegar, F. and A.W. Warrick. 1986. Hydraulic conductivity of saturated soils: Field methods. *In* A. Klute (ed). 1986. Methods of soil analysis part 1. Physical and mineralogical methods, 2nd ed. ASA, Agron. Mono. 9, Madison, WI, pp. 735-770.

DeBano, L.F., and J.S. Krammes. 1966. Water repellent soils and their relation to wildfire temperatures. Int. Assoc. Sci. Hydrol. Bull., XI Annals 2, pp. 14-19.

Dekker, L.W., C.J. Ritsema, K. Oostindie, and O.H. Boersma. 1998. Effect of drying temperature on the severity of soil water repellency. Soil Sci. 163:780-796.

Doerr, S.H., R.A. Shakesby, L.W. Dekker, and C.J. Ritsema. 2006. Occurrence prediction and hydrological effects of water repellency amongst major soil and land-use types in a humid temperate climate. Eur. J. Soil Sci. 57:741-754.

Hallett, P.D., D.C. Gordon, and A.G. Bengough. 2003. Plant influence on rhizosphere hydraulic properties: Direct measurements using a miniaturised infiltrometer. New Phytologist 157:597-603.

Hubbert, K.R., and V. Oriol. 2005. Temporal fluctuations in soil water repellency following wildfire in chaparral steeplands, southern California. Intern. J. Wildland Fire 14:439-447.

Hubbert, K.R., H.K. Preisler, P.M. Wohlgemuth, R.C. Graham, and M.G. Narog. 2006. Prescribed burning effects on soil physical properties and soil water repellency in a steep chaparral watershed, southern California. U.S.A. Geoderma. 130:284-298.

Letey, J. 1969. Measurement of contact angle, water drop penetration time, and critical surface tension. Proceed. of the Symp. on Water-Repellent Soils, 6-10 May 1968, UC, Riverside, pp. 43-47.

Mainwaring, K.A., C.P. Morley, S.H. Doerr, P. Douglas, C.T. Llewellyn, G. Llewellyn, I. Matthews, and B.K. Stein. 2004. Role of heavy polar organic compounds for water repellency of sandy soils. Env. Chem. Letters 2:35-39.

Peterson, F.F. 1981. Landforms of the Basin and Range Province defined for soil survey. Nevada Agric. Exp. Stn. Tech. Bull. 28. Reno, NV.

Rawls, W.J., and D.L. Brakensiek. 1983. A procedure to predict Green and Ampt infiltration parameters. *In* Advances in infiltration. Proc. of the National Conf. on Advances in Infiltration, Dec. 12-13. Chicago, IL.

Robichaud, P.R., S.A. Lewis, and L.E. Ashmun. 2008. New procedure for sampling infiltration to assess post-fire soil water repellency. USDA, Forest Service, Rocky Mountain Research Station, Research Note RMRS-RN-33.

Robichaud, P.R., and S.M. Miller. 1999. Spatial interpolation and simulation of post-burn duff thickness after prescribed fire. Intern. J. Wildland Fire 9:137-143.

Savage, S.M. 1974. Mechanism of fire-induced water repellency in soil. Soil Sci. Soc. Amer. Proc. 38:652-657.

Soil Science Division Staff. 2017. Soil survey manual. USDA, Agriculture Handbook No. 18.

Soil Survey Staff. 1982. Measuring hydraulic conductivity for use in soil surveys. Soil Survey Investigations Report No. 38, USDA Soil Conservation Service.

Soil Survey Staff. 1990. National soil survey handbook (NSSH), Title 170, Part 601. USDA Natural Resources Conservation Service.

Soil Survey Staff. 2024. National soil survey handbook (NSSH). USDA Natural Resources Conservation Service.

Soil Survey Staff. 2014. Soil survey field and laboratory methods manual. soil survey investigations report, No. 51, version 2.0. USDA Natural Resources Conservation Service.

Soil Sampling

Introduction

Laboratory measurement of soil properties (e.g., particle size, organic carbon, etc.) requires sample collection. Two fundamental sampling requirements are: 1) appropriate site selection, and 2) a detailed soil description. Soils are landscape entities that reflect geomorphic, pedologic, and hydrologic processes and parent material distribution (Wysocki et al., 2011). Thus, site selection, regardless of purpose, must consider soilscape relationships. A soil profile description identifies the horizons and their thickness and provides context for data collection and interpretation. Soil property data by itself has little value without context; soil data requires an accompanying georeferenced description. Sampling needs and strategies vary by project objectives. Various reviews and summaries (Buol et al., 2003; Soil Survey Staff, 2004; Soil Survey Staff, 2009; Robertson et al., 1999; Carter, 1993) outline sampling strategies and techniques.

Statistical design and analysis (e.g., random, randomized block, grid, transect, traverse, geostatistical) are important aspects of sample collection (Buol et al., 2003). Discussion of statistical methods and design is beyond the scope of this publication. Summary information is available in Webster and Oliver (2007) and Webster and Oliver (1990). Note, however, that statistical blocking by geomorphic context stratifies soil areas by similar geologic and pedogenic processes. Random sampling within a geomorphically stratified area allows determination of both random soil variation and systematic landscape variation (Hall and Olson, 1991).

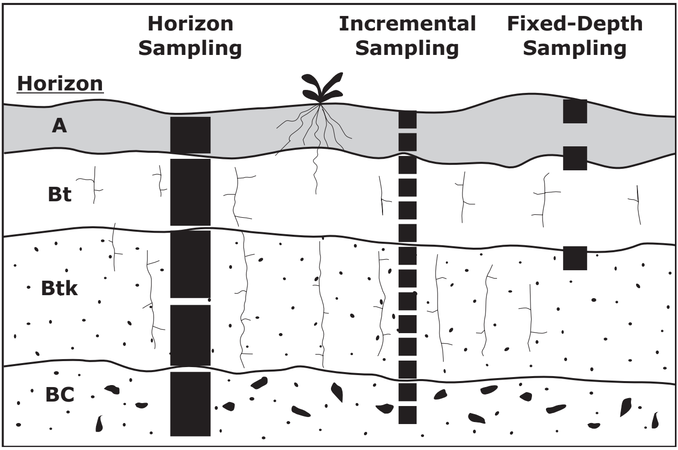
Soil Landscape Sequences—Soil sampling commonly considers pedons as distinct points separate from adjoining soils. Soil water flow is generally interpreted as predominantly vertical; lateral flow receives considerably less emphasis. In many landscapes, however, vertical flow is important but lateral flow is more influential. A slight difference in elevation (15 cm) in nearly level landscapes produces substantial hydrologic and morphological differences (Knuteson et al., 1989). Soil landscape sampling and characterization is an important strategy for increasing and organizing both spatial and soil property data (Wysocki et al., 2011). This approach evaluates landscape-scale processes that relate ecosystem dynamics to soil distribution.

Types of Sampling

Horizon Sampling—Cost and time limit the number of sample collections. The most effective and efficient strategy for sampling is by horizon. Soil horizons develop from natural processes acting over time. Variations in soil properties may occur within a horizon, but distinct differences generally occur between horizons. Consequently, soil horizons are a meaningful and comparable schema for sample collection (see graphic). Soil horizons vary in thickness and boundary (e.g., wavy, irregular, broken) within a pedon and across landscapes. Soil profile descriptions and horizon sampling techniques incorporate depth and boundary variability and can produce homogeneous samples. It is advisable to subsample soil horizons about 50 cm thick. Fixed-depth sampling alone does not capture such variation and may lead to the erroneous interpretation of data.

Incremental Sampling—Project objectives (e.g., soil genesis or archeological) may require within-horizon detail. Property variation or trends within horizons require samples at specified increments (e.g., every 10 cm). Increment samples should be taken within horizons; sample depths should not cross horizon boundaries. Increment sampling provides more detail than horizon sampling but adds time and expense. This approach is generally limited to special projects.

Fixed-Depth Sampling—Specified objectives (e.g., surface compaction studies) may address properties by fixed depths (e.g., 0–5 cm or 5–10 cm) instead of by soil horizons. This approach, while appropriate for certain purposes, precludes data comparison by horizon. Data collected by depth is comparable within a study and to other studies employing the same depths. Fixed-depth samples may straddle horizons that contain contrasting materials (e.g., sandy over clayey strata). The resultant data represents neither horizon and is difficult to interpret. Use this approach with caution.



Sampling Techniques

Excavate a fresh soil pit for sample collection. Avoid road cuts as sample sites because dust and exposure can alter soil properties. If excavation is not possible, collect samples from intact cores (e.g., Giddings tube). If an auger is the only means for sample collection, place the collected soil onto a tarp to identify and sample by horizon. For soil characterization, collect 3- to 4-kg samples. Soils with fragments up to 20 mm in size require a minimum 1 kg (dry weight) sample for a representative quantity (ASTM, 2004). If fragment size exceeds 20 mm, larger sample sizes are needed.

During sample collection:

1) Collect samples in a soil pit from the bottom up. This minimizes contamination by falling debris.

2) Collect the sample across a horizon's full depth and breadth. Avoid atypical pockets or lenses, or subsample these separately.

Soil Sample Kinds

Characterization Samples—Samples collected from a fully described soil chosen to be representative of a given soil series or soil landscape area. All horizons are bulk sampled to a depth of 200 cm or more. In addition, three fist-sized clods are collected from each horizon for bulk density measurement. Bulk samples undergo a suite of analyses (e.g., particle size, 1500 kPa water content, CEC, pH, extractable cations, organic carbon, clay mineralogy, etc.).The specified analyses vary with soil composition. A Mollisol needs a different set of analyses for characterization than does an Andisol or Spodosol. Characterization sampling provides a complete set of measured values for soil comparison or extrapolation.

Reference Samples (grab samples)—Samples collected for a single or limited set of analyses (e.g., OC, PSA, pH) to answer a specific question. For example, there may be a question of whether or not the A horizon has sufficient organic carbon for mollic epipedon criteria (OC ≥ 0.6 %). References samples are generally targeted to specific horizons or layers (e.g., A horizon, Bt horizon, control section) in a profile. Sample intent is to answer a question quickly with little expense.

Field Equipment Checklist

Digging Tools (commonly choose 1 or 2): see graphic

- Bucket auger
- Sharp shooter
- Montana sharp shooter (for rocky soils)
- Tile spade (only for well cultivated or loose material)
- Spade (standard shovel)
- Push probe (e.g., Backsaver, Oakfield)—include a clean-out tool
- Pulaski

Soil Description

- Knife
- Hand lens (10x or combination lenses)
- Acid bottle (1N HCl)
  Water bottle
- Color book (e.g., Munsell, EarthColors)
- Picture tapes ("pit tape"—metric preferred)
- Tape measure (metric or English and metric)
- (3) Ultra-fine point permanent marker pens
- Pocket pH kit or electronic "wand"
- Pocket soil thermometer
- Camera
- Sample bags (for grab samples)
- Soil description sheet ("Pedon Description" form)

Site Description

- Field notebook
- GPS unit
- Abney level
- Clinometer
- Compass
- Altimeter (pocket-sized)

Field References

- "Field Book for Describing and Sampling Soils"
- Aerial photographs
- Topographic maps (1:24,000, 7.5 min; 1:100,000)
- Geology maps
- Soil surveys (county or area)
- AGI field sheets

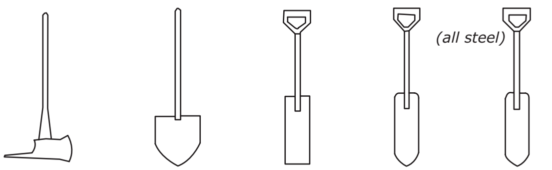
Personal Protective Gear

- Small first aid kit
- Leather gloves
- Sunglasses
- Insect repellent
- Sunscreen
- Hat
- Drinking water

Examples of Common Soil-Sampling Equipment

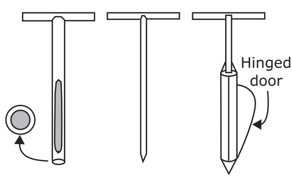
Use of trade or company names is for informational purposes only and does not constitute an endorsement.

Digging Tools/Shovel Types



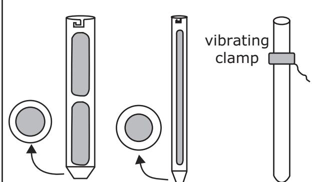
	Pulaski	Standard shovel	Tile spade	Sharp-shooter	Montana sharp-shooter
Primary use:		*most materials*	*loose material*	*most materials*	*rocky soil*

Soil Probes

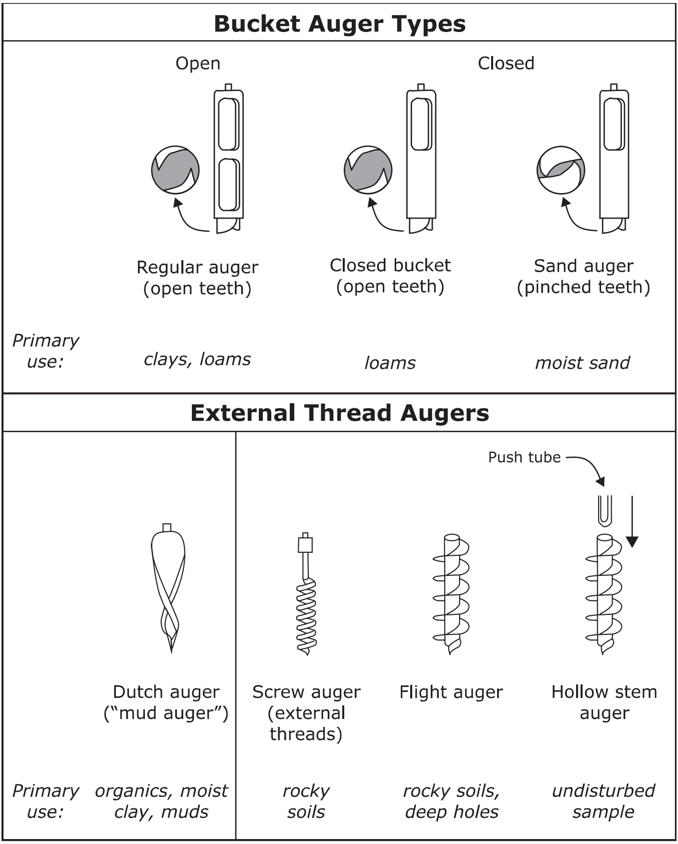


	Regular push-tube	Tile probe (solid steel rod)	Peat sampler (Macaulay)
Primary use:	*fine earth*	*locating hard contact*	*organic soils*

Hydraulic Probes



Giddings tube	Bull probe	Vibracore
(not effective in rocky materials)		*wet sands, organics (no co. frags)*



References

American Society for Testing and Materials (ASTM). 2004. Standard practice for description and identification of soils. D2488 Annual Book of ASTM Standards. Construction. Section 4, Soil and Rock; Dimension Stone. Vol. 04.08. Philadelphia, PA.

Buol, S.W., R.J. Southard, R.C. Graham, and P.A. McDaniel. 2003. Soil genesis and classification. 5th edition. Iowa State Press, Ames, IA. ISBN: 0-8138-2873-2.

Carter, M. (editor). 1993. Soil sampling and methods of analysis. Lewis Publishers, CRC Press, Inc., Boca Raton, FL. ISBN: 0-87371-861-5.

Hall, G.F., and C.G. Olson. 1991. Predicting variability of soils from landscape models. *In* M.J. Mausbach and L.P. Wilding (eds.) Spatial variability of soils and landforms. Soil Sci. Soc. Am. Spec. Pub. #28, SSSA, Inc., Madison, WI. ISBN: 0-89118-198-7.

Knuteson, J.A., J.L. Richardson, D.D. Patterson, and L.D. Prunty. 1989. Pedogenic carbonates in a Calciaquoll associated recharge wetland. Soil Sci. Soc. Am. J. 53:495-499.

Robertson, G.P., D.C. Coleman, C.S. Bledsoe, and P. Sollins (editors). 1999. Standard soil methods for long-term ecological research. Oxford University Press, Inc., New York, NY. ISBN: 0-19-512083-3.

Soil Survey Staff. 2009. Soil survey field and laboratory methods manual. Soil survey investigations report, no. 51, ver. 1.0. R. USDA Natural Resources Conservation Service.

Webster R., and M.A. Oliver. 1990. Statistical methods in soil and land resource survey. Oxford University Press. Oxford, England.

Webster R., and M.A. Oliver. 2007 Geostatistics for environmental scientists. 2nd edition. John Wiley and Sons, Inc. West Sussex, England.

Wysocki, D.A., P.J. Schoeneberger, D.R. Hirmas, and H.E. LaGarry. 2011. Geomorphology of soil landscapes. *In* P.M. Huang, Y. Li, and M.E. Sumner (eds.) Handbook of Soil Sciences: Properties and Processes, 2nd ed, pp. 29-1−29-26. CRC Press, Boca Raton, FL.

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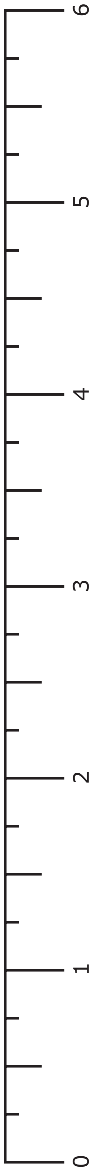

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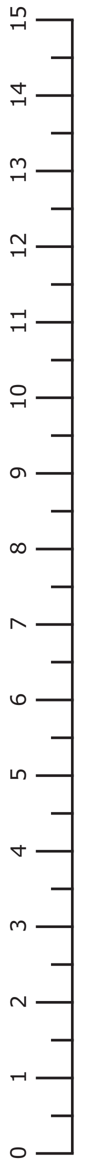

Centimeters