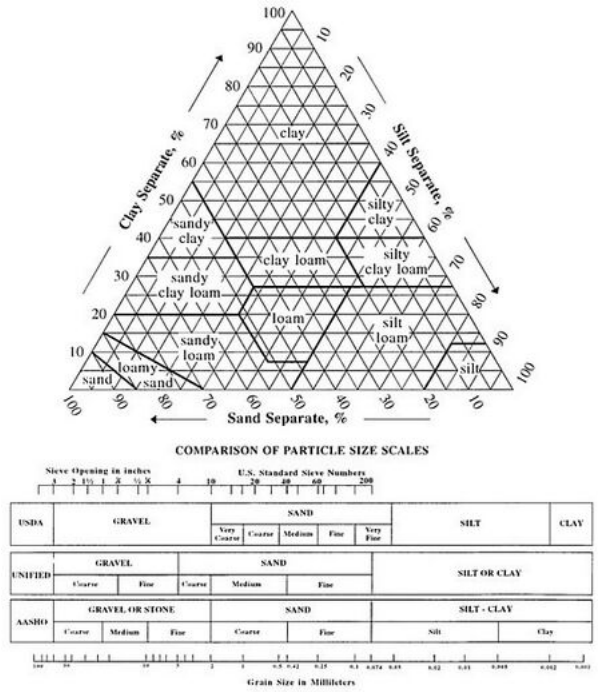
Soil classification

This page provides general information

Soils are typically classified based on a specific property, such as infiltration or **texture**. This page provides a summary of the more commonly used classification systems.

Contents



Soil texture triangle showing the USDA (https://en.wikipedia.org/wiki/United_States_Department_of_Agriculture) classification system based on grain size. Click on image to enlarge.

USDA classification based on soil textures

The United States Department of Agriculture defines twelve major soil texture classifications (**sand**, loamy sand, sandy loam, **loam**, **silt** loam, silt, sandy **clay** loam, clay loam, silty clay loam, sandy clay, silty clay, and clay). Soil textures are classified by the fractions of sand, silt, and clay in a soil. Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes (e.g. sandy clay, silty clay). Loams are soils having roughly equal proportions of sand, silt, and/or clay in a soil sample.

Texture affects many soil properties, such as infiltration, **structure**, **porosity**, **water holding capacity**, and chemistry. For more information on the role and importance of soil texture, link here (https://www.senecahs.org/pages/uploaded_files/Soil%20Texture%20and%20Structure%20E%20Unit.pdf).

The soil texture triangle is based on grain size, that is the distribution of sand, silt, and clay in a soil. The texture triangle is shown in the adjacent image. The relationship to **hydrologic soil group (https://stormwater.pca.state.mn.us/index.php?title=Design_infiltration_rates)**, which is used in stormwater applications, is illustrated in this image.

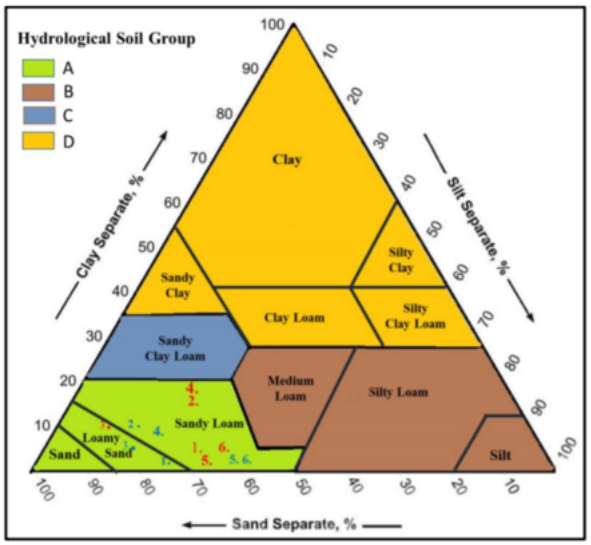


Image showing relationship between hydrologic soil groups and soil texture. Image from Sayl et al., 2017 (https://hess.copernicus.org/preprints/hess-2017-13/hess-2017-13.pdf). CC-BY 3.0 License. Click on image to enlarge.

Natural Resource Conservation Service Hydrologic Soil Groups

Reference: Urban Hydrology for Small Watersheds - TR-55 (USDA) (https://nationalstormwater.com/urban-hydrology-for-small-watersheds-tr-55/#:~:text=Technical%20Release%2055%20(TR%2D55,volumes%20required%20for%20floodwater%20reservoirs.)

Soils are classified by the Natural Resource Conservation Service (https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/) into four Hydrologic Soil Groups (HSG) based on the soil's **runoff** potential. The four Hydrologic Soils Groups are A, B, C and D. Where A's generally have the smallest runoff potential and Ds the greatest.

AASHTO soil classification system (From Wisconsin Department of Transportation (https://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/geotechmanual/gt-03-03.pdf). Click on image to enlarge.

- Group A: sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
- Group B: silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately **coarse textures**.
- Group C: sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- Group D: clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table (https://stormwater.pca.state.mn.us/index.php?title=Shallow_groundwater), soils with a **claypan** or clay layer at or near the surface and shallow soils over nearly impervious material.

This classification system is the most widely used system in the Minnesota Stormwater Manual and in most stormwater applications in the U.S. **Best management practice** (BMP) selection and design are typically based on soils at a site. For example, infiltration bmps are preferred on HSG A and B soils when there are no other site restrictions (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration) (e.g. contamination (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration_and_contaminated_soils_and_groundwater), presence of active karst (https://stormwater.pca.state.mn.us/index.php?title=Karst)).

Link to infiltration rates based on hydrologic soil group

Unified Soil Classification System (USCS)

The Unified Soil Classification System (USCS) (see ASTM (https://www.astm.org/) D-2487) is used in engineering and geology to describe the texture and grain size of a soil. Unconsolidated materials are represented by a two-letter symbol based on type of material (gravel (G), sand (S), silt (M), clay (C), organic (O)) and grading or plasticity (well-graded (W), poorly-graded (P), high plasticity (H), low plasticity (L)). For example, CH materials consist of clay with high plasticity, and SP materials consist of poorly-graded sands. Specific properties of these soils can be found here (https://en.wikipedia.org/wiki/Unified_Soil_Classification_System). This classification is used for engineering applications, where factors such as soil strength and uniformity are important for structural applications.

The adjacent image shows the relationship between the USCS, AASHTO and USDA classifications.

American Association of State Highway and Transportation Officials (AASHTO) Soil Classification System

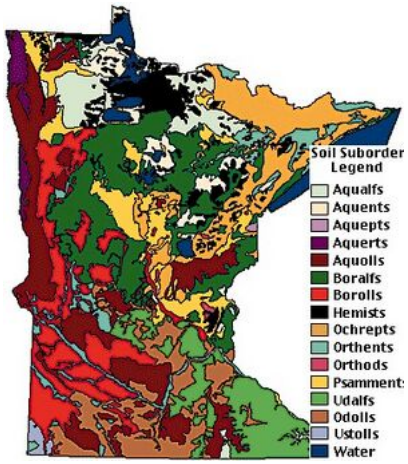
The AASHTO Soil Classification System was developed by the American Association of State Highway and Transportation Officials, and is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes. It roughly divides soils into two groups, granular and silt-clay materials, based on sieve analysis. Granular materials are considered good as a subgrade, while silt-clay materials are less satisfactory.

The adjacent image shows the relationship between the USCS, AASHTO and USDA classifications.

USDA Soil Taxonomy

USDA soil taxonomy provides a classification of soil types according to several parameters (most commonly their properties) and in several levels: Order, Suborder, Great Group, Subgroup, Family, and Series. There are currently twelve soil orders. Suborders are based on a specific property, such as temperature or moisture (e.g. aquic for wet) regime. The following soil orders occur in Minnesota.

- Mollisols: Soils with a dark, humus-rich surface layer containing high concentrations of calcium and magnesium, typical of prairies.
- Alfisols: Leached basic or slightly acid soils with a clay-enriched B horizon (subsoil), typical of deciduous forests.
- Entisols: Mineral soils that have not yet differentiated into distinct horizons, such as soils found on glacial sand plains.
- Histosols: Peaty soils, with a deep surface layer of purely organic material, such as soils found in north central Minnesota.
- Inceptisols: Freely draining soils in which the formation of distinct horizons is not far advanced, such as some soils found in northeastern Minnesota.
- Vertisols: Clayey soils with little organic matter which occurs in regions having distinct wet and dry seasons, such as some soils found in the Red River Valley Basin.
- Spodosols: Acid soils characterized by a subsurface accumulation of humus that is complexed with aluminum and iron, such as some soils



Minnesota soil suborders. Image University of Minnesota. (https://extension.umn.edu/soil-management-and-health/soil-orders-and-suborders-minnesota)

found in northeatern Minnesota.

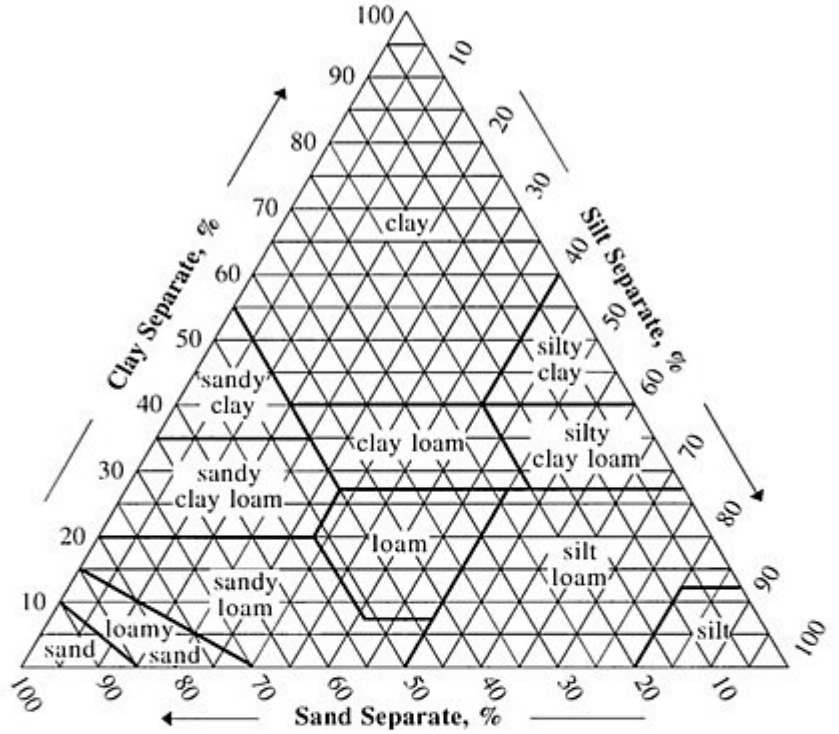
For more information, link here (https://en.wikipedia.org/wiki/USDA_soil_taxonomy).

Other classification systems

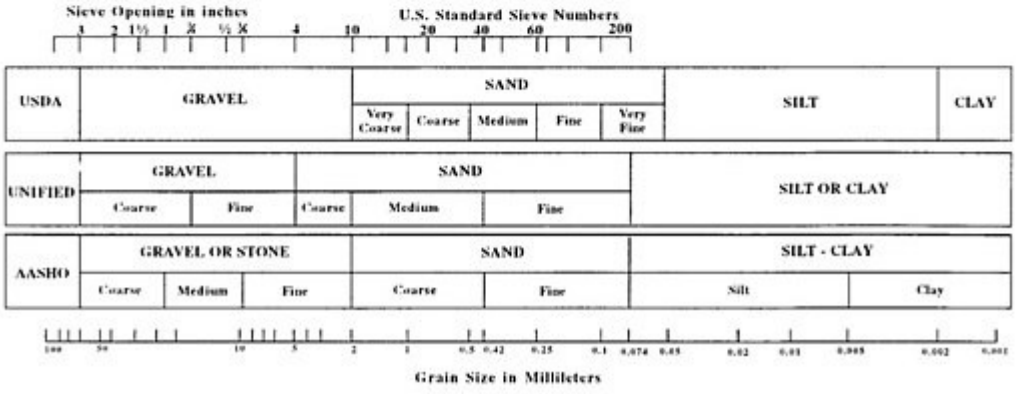
- Australia classification system (https://en.wikipedia.org/wiki/Australian_Soil_Classification)
- Canadian classification system (https://en.wikipedia.org/wiki/Canadian_system_of_soil_classification)
- Food and Agricultural Organization of the United Nations (https://en.wikipedia.org/wiki/FAO_soil_classification)

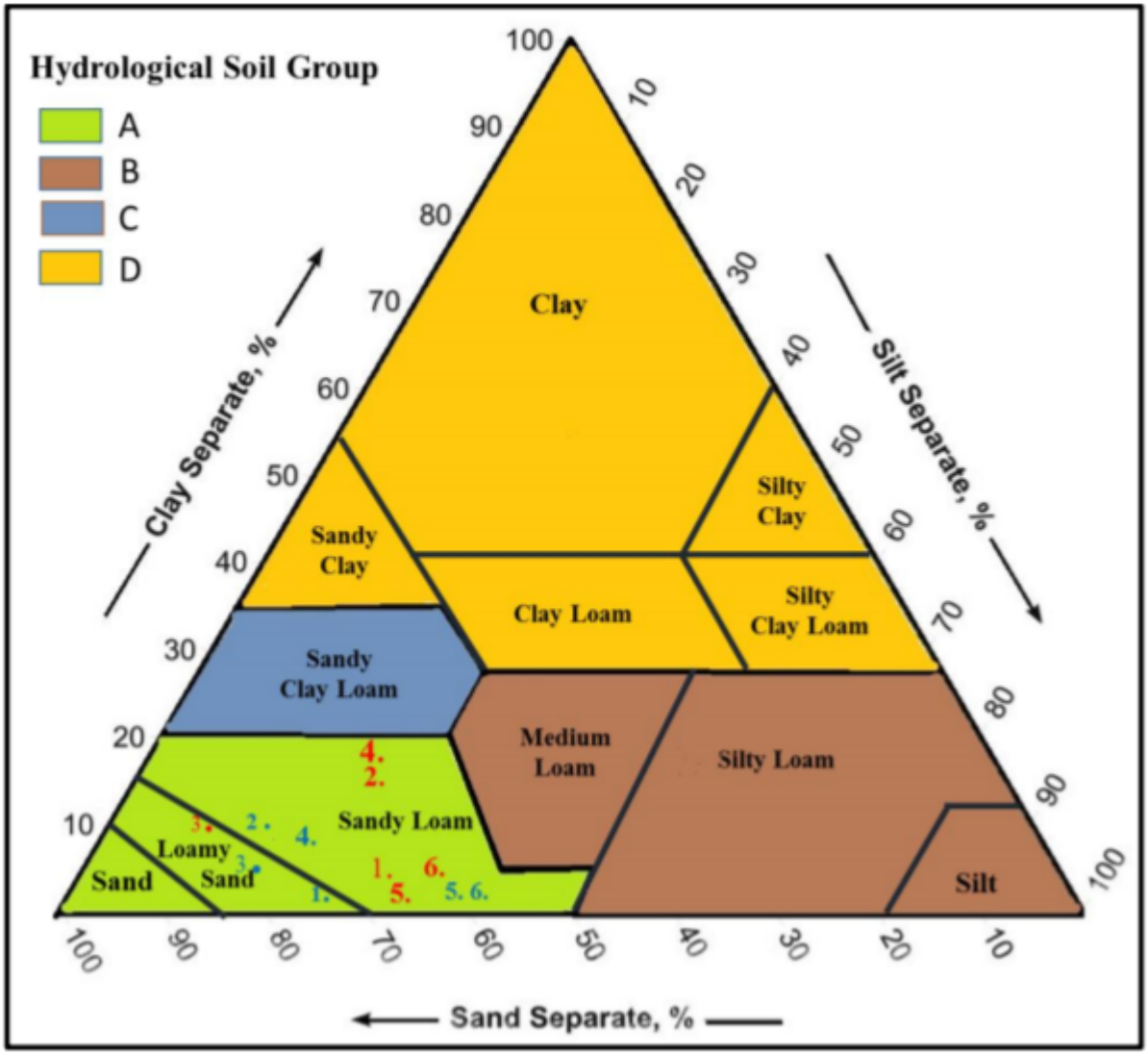
Related links

- Soil Classification Systems (https://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/geotechmanual/gt-03-03.pdf) - Wisconsin Department of Transportation
- World Reference Base for Soil Resources (https://en.wikipedia.org/wiki/World_Reference_Base_for_Soil_Resources)
- Soil Taxonomy (https://www.nrcs.usda.gov/resources/guides-and-instructions/soil-taxonomy) - USDA



COMPARISON OF PARTICLE SIZE SCALES




Hydrological Soil Group
A
B
C
D
Clay
Sandy Clay
Silty Clay
Clay Loam
Silty Clay Loam
Sandy Clay Loam
Medium Loam
Silty Loam
Sandy Loam
Loamy Sand
Sand
Silt
Clay Separate, %
Silt Separate, %
Sand Separate, %
100
90
80
70
60
50
40
30
20
10

General Classification	Granular Materials								Silt-Clay Materials						
	35 percent or less of total sample passing No. 200 (75 µm)								More than 35 percent of total sample passing No. 200 (75 µm)						
Group Classification	A-1		A-3 [1]		A-2				A-4		A-5	A-6		A-7	
	A-1-a	A-1-b	A-3	A-3a	A-2-4	A-2-5	A-2-6	A-2-7	A-4a	A-4b		A-6a	A-6b	A-7-5	A-7-6
Sieve analysis, percent passing:						*				**	*			*	
No. 10 (2 mm)	50 max														
No. 40 (425 µm)	30 max	50 max	51 min	[2]					[3]	[4]					
No. 200 (75 µm)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	35 max	36 min	50 min	36 min	36 min		36 min	
Characteristics of fraction passing No. 40															
Liquid limit	—	—	Non-	—	40 max	41 min	40 max	41 min	40 max		41 min	40 max		41 min	
Plasticity index	6 max	6 max	Plastic	6 max	10 max	10 max	11 min	11 min	10 max		10 max	11 – 15	16 min	≤LL-30	>LL-30
Group Index	0						4 max		8 max		12 max	10 max	16 max	20 max	
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Sand	Silty or clayey gravel and sand				Silty soils			Clayey soils			
General rating as subgrade	Excellent to good								Good to fair						

Notes

With the test data available, the classification of a soil is found by proceeding from left to right on the chart. The first classification that the test data fits is the correct classification.

* A-2-5 is not allowed under 703.16.B. A-5 and A-7-5 is not allowed under 703.16.A. See "Natural Soil and Natural Granular Soils" (203.02.H) in this manual

** A-4b is not allowed in the top 3 feet (1.0 m) of the embankment under 203.03.A.

[1] The placing of A-3 before A-2 is necessary in the "left to right" process, and does not indicate superiority of A-3 over A-2.

[2] A-3a must contain a minimum 50 percent combined coarse and find sand sizes (passing No. 10 but retained on No. 200, between 2 mm and 75 µm).

[3] A-4a must contain less than 50 percent silt size material (between 75 µm and 5 µm).

[4] A-4b must contain 50 percent or more silt size material (between 75 µm and 5 µm).