
MISSOULA CITY-COUNTY HEALTH DEPARTMENT

SITE EVALUATION MANUAL

2001

PURPOSE

This manual is a field reference for persons who conduct site evaluations for subsurface sewage disposal systems. It's also a study guide for preparing to become certified by the Department to perform site evaluations. Certification allows evaluators to determine drainfield size by using soil texture rather than percolation tests for soils no finer than silt loam.

BASIC KNOWLEDGE FOR SITE EVALUATORS

Site evaluators must have a basic knowledge of soils and hydrogeology and be familiar with local and state sewage disposal rules. Missoula City-County Health Code Regulation #1 allows Professional Engineers specializing in civil, environmental, sanitary or agricultural engineering; geologists, hydrogeologists, soil scientists, and sanitarians to perform site evaluations. Others may also be approved upon exhibiting sufficient knowledge in soils so that the Department is satisfied that the necessary criteria can be satisfactorily and consistently evaluated. Site evaluators may become certified by completing an exam based on this manual and Regulation #1.

SUBSURFACE WASTEWATER DISPOSAL DESIGN

In Missoula County site evaluators must be familiar with Missoula City-County Health Code Regulation #1 and State Department of Environmental Quality Circulars 4, 5 & 6 relating to sewage disposal. When a site evaluation is conducted for the purpose of a certificate of survey or subdivision, the evaluator must submit information in conformance with state subdivision rules and complete the subdivision application (*Sub 2 form*). Percolation tests conducted in accordance with **Appendix 1** are required for submittals to the State and are required under regulation # 1 when soils are finer than silt loam.

The specifications in Regulation #1 are for domestic wastewater. If the system is being designed for a use that would produce wastes of a higher BOD or of a more toxic nature than general household waste, then it should be so noted on the evaluation as different rules may apply to the system.

SITE EVALUATION

The site evaluation must include all of the physical characteristics of a specific lot and also include information from adjoining lots when necessary to avoid conflicting development of parcels. Proximity to any item specified in **Table I** below, must be noted to ensure the site meets all minimum separation requirements.

TABLE I **Minimum Allowed Distances in Feet**

FROM:	TO:		
	Sealed components (a)	Other components (b)	ABSORPTION SYSTEMS(c)
1. Public or multi-user wells/springs	100	100	100
2. Other wells	50	50	100
3. Property Boundaries	10	10	10
4. Foundation Walls	10	10	10
5. Suction lines	50	50	100
6. Cisterns	25	25	50
7. Stream, lake, or irrigation ditch, springs	50	50	100
8. Roadcuts, escarpments	10 (d)	10	25 (f)
9. Floodplain or flood prone area	10	100	100
10. Slopes > 25% (e)	10 (d)	10(d)	25
11. Subsurface drains	10	10	10
12. Water Lines	10	10	10
13. Drainfields/sand mounds (c)		10	10
14. Surface water, springs	50	50	100

(a) Sealed components include sewer lines, sewer mains, septic tanks, grease traps, dosing tanks, pumping chambers, holding tanks and sealed pit privies. Holding tanks and sealed pit privies must be located at least 10 feet outside the floodplain or any openings must be at least two feet above the floodplain elevation.

(b) Other components include intermittent and recirculating sand filters, package plants and evapotranspiration systems.

(c) Absorption systems include absorption trenches, absorption beds, sand mounds, and other drainfield type systems that are not lined or sealed. This term also includes seepage pits and unsealed pit privies.

(d) Sewer lines and sewer mains may be located in roadways and on steep slopes if the lines and mains are safeguarded against damage.

(e) Down-gradient of the sealed component, other component or drainfield/sand mound.

(f) The minimum horizontal setback from an escarpment applies in both the upgradient and downgradient direction from the escarpment.

Location of Parcel

A complete legal description, an address when available and directions on how to locate the property must be included with a site evaluation. Where incomplete legal descriptions exist, a USGS map should be used for recording the site's location. The test site must be identified accurately enough on a map so that it can be located by the sanitarian and the installer.

Size and Shape of Lot

A proposed plot plan must be submitted showing the location of test sites and proposed sewer and water systems. The size of the lot and drainfield site must be adequate for the development proposed. For sites with limited room, a more detailed plan must be submitted showing buildings and driveways as well as water and sewer system locations. The site evaluator must make sure that the site is large enough for its intended use based on the proposed wastewater quantity and site soil characteristics.

Slope of Disposal Site

The slope of the site over the entire drainfield area must be determined as well as slopes within 50' of the drainfield area that are in excess of 25%. A 50 foot separation is required between drainfields and escarpments. The maximum slope in the area of the drainfield is 25%. The landscape position of the site should also be noted (*sideslope, swale, depression, bench, ridge, etc.*).

Depth to Groundwater

Site evaluators should look for evidence of groundwater both in the soil profile hole and on the surface. Sites subject to high groundwater will often have rust colored spots (*mottling*) in the soil profile or have hydrophilic plants on the surface such as aspen trees or cat tails. An applicant may be required to have groundwater testing conducted by the Department when there is reason to suspect that the groundwater comes to within 10' of the ground surface. If groundwater testing is required, a 4 inch diameter 10 foot perforated pipe must be installed vertically to a depth of 9 feet.

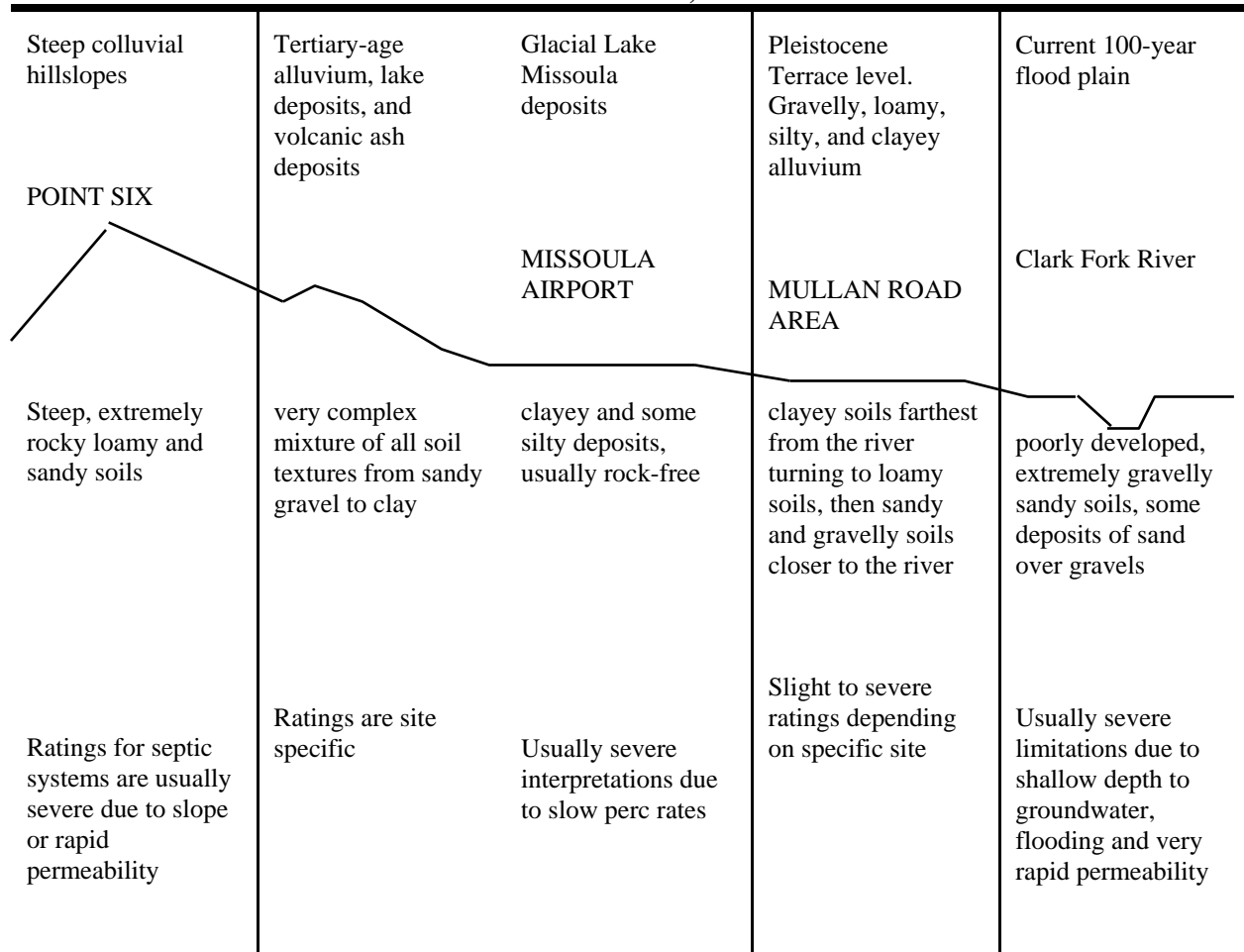
Conventional drainfields are not allowed on sites which have less than 6' separation to groundwater. Some alternative systems, however, are permitted in this County. The site evaluator should be familiar with all alternative systems allowed. **MISSOULA CITY-COUNTY HEALTH DEPARTMENT ALTERNATIVE SYSTEMS CIRCULAR** describes the alternative systems and the conditions under which they are allowed.

Soils Evaluation

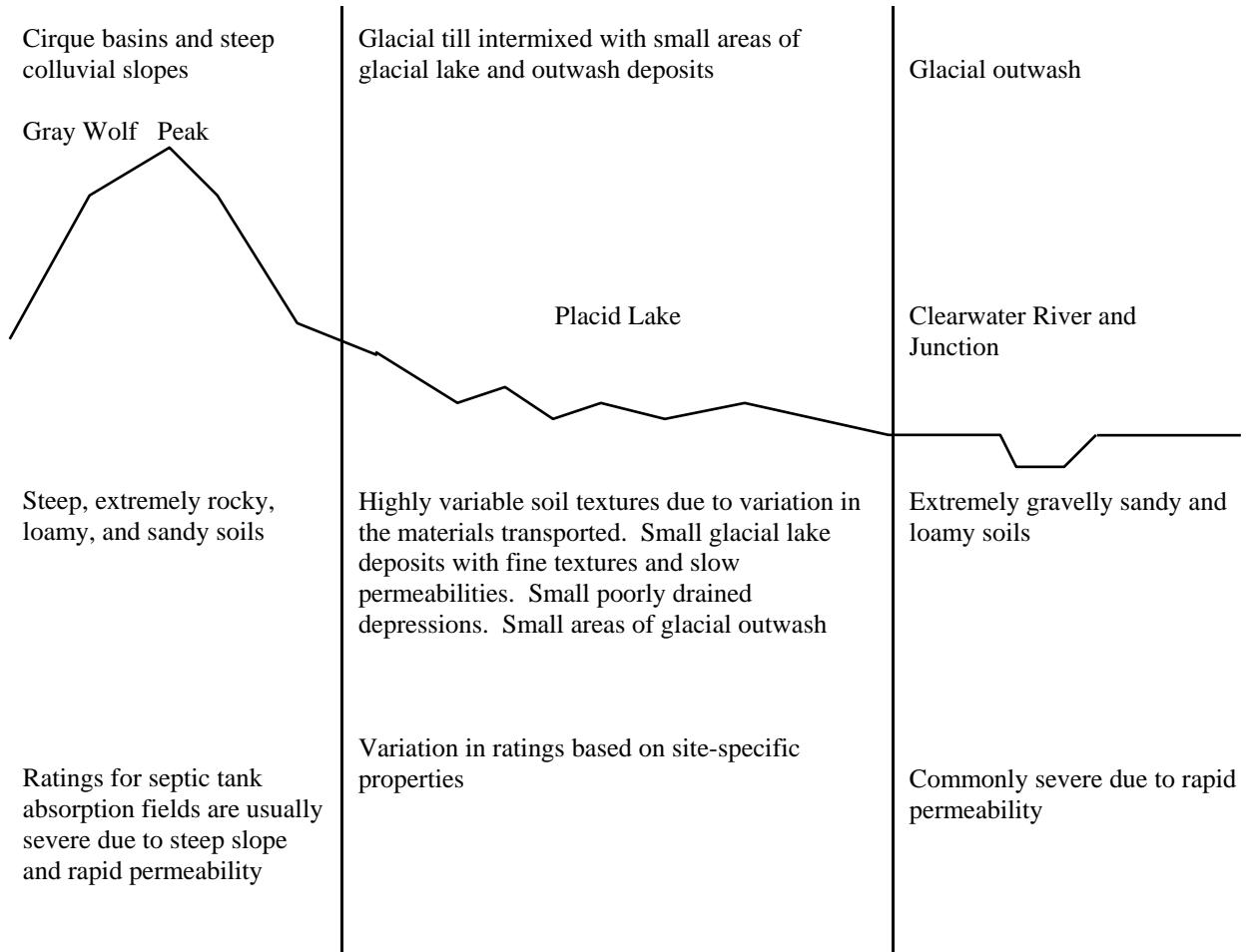
Soil characteristics determine a site's effectiveness at treating and disposing of septic effluent. Soil color can be used to determine potential high groundwater problems. Soils are sometimes quite variable, and the evaluator may need to assess more than one test pit in the area of the proposed disposal site. An evaluator's knowledge of local geology and soils will help in determining when a site should have more than one test hole evaluated.

General soils information can be obtained from the local USDA Conservation District. Soils and groundwater information on specific sites may exist in the health department's groundwater, site evaluation and subdivision files. Existing information from these sources will help limit field-work and make site visits more productive. Knowing general geological sequences can also help in interpreting and planning site evaluations. Figures 1 and 2 adapted from **Soil Interpretations for Urban Related Developments in Western Montana**, illustrate a common sequence of geologic materials and soils along the Clark Fork River and in glacial valleys of Missoula County.

**FIGURE 1.
COMMON SOIL SEQUENCE ALONG THE CLARK FORK RIVER IN
MISSOULA COUNTY, MONTANA**



**FIGURE 2.
COMMON SOIL SEQUENCE IN GLACIATED AREAS**

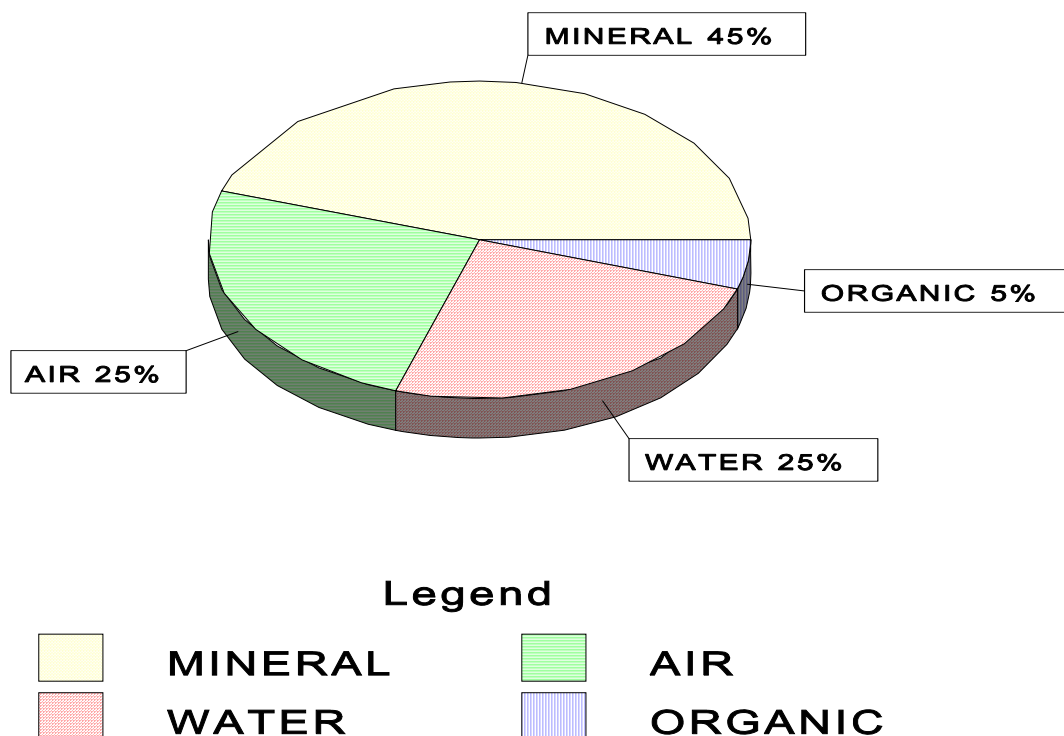


SOIL

Soil is the upper layer of the earth that has been weathered and biologically and chemically altered from the parent material (i.e., bedrock). An average mineral soil is made up of four major components. The percentage by volume of each component is (1) minerals, 45% (2) organic matter, 5%; (3) water, 20-30%; and (4) air, 20-30%. Figure [3] shows the approximate volume composition of an average silt loam surface soil.

Figure 3

SOIL CONSTITUENTS



The solid portion of the soil consists of particles of various sizes which range from the lower limits of the colloidal state to the coarsest fractions of sand and gravel. The individual particles of a soil solid are referred to as textural separates. The clods or aggregates that are formed, called peds, are referred to as structural units. The textural units determine the texture of a soil and the size, shape and strength of the structural units determine the soil structure. **Appendix [2]** shows the major soils textural classification systems in use today and **Appendix [3]** gives a general relationship of these classification systems. The USDA soils classification system must be used in site evaluations for subsurface sewage disposal systems.

When the site evaluator finds a potential site based on distance limitations, slope and building site, he must then determine the suitability of the soils by examining a soil profile hole dug to approximately ten feet. The following criteria are to be included in any soils evaluation:

- a. Thickness of layers or horizons of soil profile;
- b. Texture (USDA Soils Classification System) and structure of horizons;
- c. General color, and color variation (mottling);
- d. Depth to water (if observed) - estimated depth to groundwater if water is not observed. Monitoring pipes may be required.
- e. Depth to bedrock (if observed).
- f. Other prominent features that would have a bearing on a site's compatibility for use as a sewage treatment site. (i.e. compaction)

Site evaluators must determine soil texture and structure and other features that influence the site's suitability for a subsurface disposal system. Evaluators must be familiar with the USDA Soils Classification System and its terminology. Appendix IV defines the 12 USDA soils textural classifications based on particle size and Appendix VI describes the soil textural classifications based on how it feels.

The soil profile will consist of different horizons (layers) that are differentiated by a variation in soil characteristics (i.e., texture, structure, color, etc.) Horizons in the USDA soil taxonomy system are classified using the capital letters O, A, E, B, C, and R. These horizons are shown in their most common order of occurrence below.

Master Horizons

O Horizon: A layer of organic matter. Soils found in a forest or bog environment commonly have a surface layer consisting of leaves, twigs, humus or other organic material.

A Horizon: A surface soil mineral horizon characterized by a highly humified organic matter content intimately mixed with the mineral fraction. The A Horizon may have properties resulting from cultivation, pasturing or similar kinds of disturbance.

E Horizon: A layer of maximum leaching (eluviation) of iron, aluminum, and organic matter. The E Horizon is usually lighter in color than the overlying or underlying horizons. An E Horizon is commonly near the surface below an O or A Horizon and above a B Horizon.

B Horizon: The B Horizon is usually below the E Horizon, and is generally the horizon of maximum accumulation (illuviation) of iron, clays, aluminum, or organic matter. A dark reddish brown to a yellowish brown color may be evident in well developed horizons.

C Horizon: The C Horizon consists of material that has been only slightly altered by the process of soil formation, but it may have been slightly modified by weathering.

R This symbolizes solid and fractured bedrock.

In describing soils for subsurface sewage disposal, it is not as necessary to differentiate and define each horizon as it is to determine and describe the entire profile as to its texture, structure and color variation and record the depths at which changes in the characteristics take place. Texture, structure and color will be discussed in detail.

Soil Texture

Soil texture is determined by the relative proportions of the various size particles in a mass of soil. Specifically it refers to the proportions of clay, silt and sand which are the fine earth material less than 2 millimeters in diameter. These individual mineral particles (i.e., clay, silt and sand) are referred to as soil separates. Rarely does soil consist completely of one separate, but is made up of a combination of separates. Specific combinations are referred to as a *textural class* of soil. There are 12 *textural classes*; they are, in order of increasingly finer texture: sand, loamy sand, sandy loam, silt loam, silt, sandy clay loam, silty clay loam, sandy clay, silty clay, and clay. (See Appendix IV). The soils textural triangle, Appendix V depicts each soil class based on the percentage of sand, silt and clay in the soil. Table 1 below, lists the soil separates and their diameter ranges. It breaks sand into subcategories which are sometimes used in conjunction with a soil textural class name (ie. Very course sandy loam).

Table 1

<u>Name of separate (mm)</u>	<u>Diameter Range</u>
Very course sand	1.0 - 1.0
Course sand	1.0 - 0.5
Medium sand	0.5 - 0.25
Fine Sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	less than 0.002

Soil texture is a nearly permanent feature and greatly influences infiltration, permeability, aeration, drainage, cation exchange capacity, fertility and many other factors. Because of this influence, soil texture is the primary characteristic considered when designing disposal systems.

Soil textural class is determined in the field during an on-site investigation by feeling and observing the soil. This requires knowledge and experience in a technique called *hand texturing*. **Appendix 6** describes the various feelings and appearance of various soil textural classes, and figure on page 11 is a flow chart describing the technique of *hand texturing*.

Rock Fragments

Significant proportions of rock fragments coarser than very coarse sand (>2 mm.) are recognized by an appropriate adjective in the textural soil-class name. Such fragments are regarded as part of the soil mass. They influence moisture storage, infiltration, and runoff. These coarse fragments may increase permeability in sandy soils, but may decrease permeability in finer soils. A large percentage of coarse fragments in very fine soils can reduce the total area available for treating wastewater.

Rock fragments are described in terms that characterize their sizes and shapes, and for some fragments, the kind of rock. The accepted adjective to include in textural soil class names and the size limits of classes of rock fragments are set forth in outline form in **Table 2**.

TABLE 2

Terms for Rock Fragments

Shape and size	Noun	Adjective
Spherical, cubelike, or equiaxial:		
2-75 mm diameter	Pebbles	Gravelly
2-5 mm diameter	Fine	Fine gravelly
5-20 mm diameter	Medium	Medium gravelly
20-75 mm diameter	Coarse	Coarse gravelly
75-250 mm diameter	Cobbles	Cobbly
250-600 mm diameter	Stones	Stony
> 600 mm diameter	Boulders	Bouldery
<u>Flat:</u>		
2-150 mm long	Channers	Channery
150-380 mm long	Flagstones	Flaggy
380-600 mm long	Stones	Stones
> 600 mm long	Boulders	Bouldery

¹*Bouldry is sometimes used where stones are larger than 24 inches*

When soil contains 15 to 35% by volume of coarse fragments, the coarse fragment adjective is incorporated with the textural name (i.e., gravelly sandy loam, cobbly sandy loam, etc.). When the coarse fragments make up 35 to 60%, the word “very” is used as a modifier along with the coarse fragment and textural adjective terms (very gravelly sandy loam, very cobbly loamy sand,

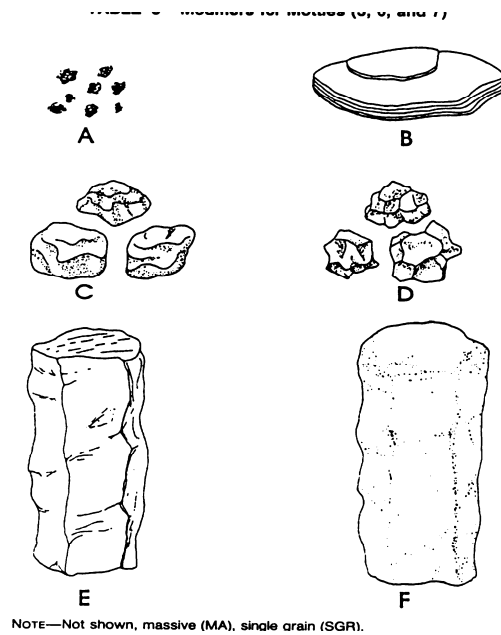
etc.). When soil contains 60 to 96% by volume of coarse fragments, the word “extremely” is used as a modifier of the textural term. When the volume of coarse fragments is about 95% or more, and there is too little fine earth to determine the textural class, the terms gravel, cobbles or stones are used in place of fine earth texture.

Soil Structure

The USDA defines soil structure as “the aggregation of primary soil particles which are separated from adjoining aggregates by surfaces of weakness.” The aggregates formed are referred to as peds. Soil structure is described based on the shape (type), size (class), and strength of the ped or aggregate. Structural shapes are depicted below in **Figure 5**. Structural shapes are further defined on page 12.

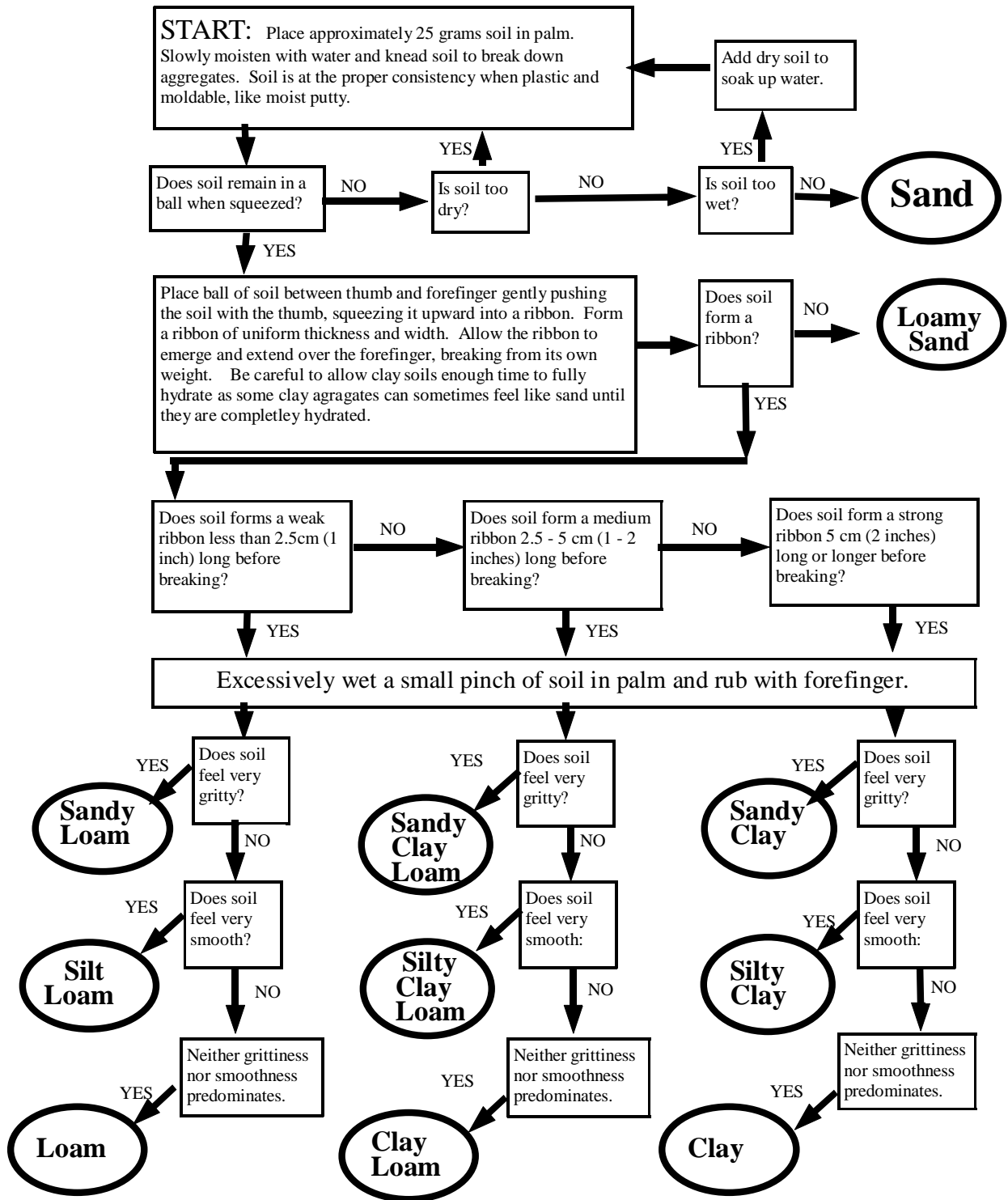
Figure 5
Soil Structure Classification

Figure 5. Examples of ~~different soil structure shapes and sizes~~



A - Granular; B - Platy; C - Subangular blocky; D - Angular blocky; E - Prismatic; F - Columnar (Soil Survey Manual, 1951)

FIGURE 4 SOILS TEXTURING



(1) **Granular and crumb** (spheroidal) - crumb-like particles which are common in surface soils especially those high in organic matter.

(2) **Platy** - aggregates or groups are arranged in relatively thin horizontal plates or lenses. Common in the lower part of the horizon which is usually the upper layer of soil but may be in subsoil horizons as well.

(3) **Blocky** - Block-like aggregates, irregularly six-faced. Their three dimensions are more or less equal in size. The peds range from a fraction of an inch to 3 or 4 inches in thickness and may have sharp (angular blocky) or rounded edges (subangular blocky). Blocky structure is usually associated with subsoils or B horizons which lie beneath the A horizon.

(4) **Columnar or prismatic** - Aggregates are longer in the vertical dimension than the horizontal. These aggregates may reach a diameter of 6 or more inches. Their side surfaces are relatively flat. Peds are generally large in size and associated with subsoils high in clay content. They often break down into blocky structure. This structure commonly occurs in arid and semiarid regions.

(5) **Massive** - This term applies to soil horizons having no definable structure and are identified by particles in the strata being cemented into one large aggregate. Massive soils usually lie below the A and B horizons. Examples may be a glacial till or a hard pan.

(6) **Structureless** - No observable aggregation. This would include the single grain sands or soils that occur in massive formations.

Sizes of structure are described using the following words that define a specific size of the ped: Very fine or very thin, medium, coarse or thick, very coarse or very thick. The structure size descriptions are defined in **Appendix 7**.

The terms weak, moderate and strong are used to define the strength of the structural units or peds. These terms are defined below:

(1) **Strong** - aggregates are visually distinct in undisturbed soil. Moderately durable when handled.

(2) **Moderate** - Aggregates are evident but not distinct in undisturbed soil. Moderately durable when handled.

(3) **Weak** - Aggregates are poorly formed and difficult to see. Will not retain shape when handled. Many loamy sands, sandy loams and loams have a weak structure.

Soil structure of a site should be defined and used in interpreting other physical characteristics. Moderate to strong structure is advantageous to some sites that depend on the structure for increasing the soils absorption capacity. Percolation tests must be carefully interpreted in soils with strong structure. The rates will be based upon initial testing but the structure may not last or it may change resulting in usually slower rates. The soil structure should be used to help interpret percolation test results, especially in finer soils.

General comments regarding the interpretation of soil structure:

- (1) Moderate to strong structure is desirable because it is more durable than weak structure and helps the soil maintain its absorption capacity.
- (2) Granular, blocky or prismatic, structures are more desirable than platy structured or massive soils.
- (3) Platy structure restricts the vertical percolation of water due to their horizontal orientation.
- (4) In finer textured soils the effect of soil structure plays a more important role both in interpreting the prolonged percolation rate and in providing better absorption capabilities for the disposal field as long as the structure is maintained. Construction should only be done when such soils are dry to prevent compaction, smearing of drainfield sidewalls and loss of structure.
- (5) Fine textured soils having no structure (massive) will have slow percolation rates.
- (6) If layering of soil is noted and it represents distinct structural changes, the downward movement of water may be restricted.

Soil Color

Soil color is dependant on the primary soil particle color, coatings of iron and manganese oxides, the amount of organic matter in the soil, and the oxygenation of the soil. Soil color can indicate the drainage characteristics or degree of aeration of the soil. Well drained soils are usually uniformly red, yellow, or brown in color. Soils that are saturated for much of the year will have a blue or green color. Blue, green and grey colors indicate that the soil is in a reduced oxidation state. Reduced soils are called “gley” soils.

A condition called mottling will often exist when the soil is intermittently saturated. Mottles result from a chemical and biochemical reaction which can occur under conditions where soil is saturated for periods but then dry out. Iron and manganese which are normally found throughout the profile are “dissolved”. When the soil drains and dries out, the iron and manganese accumulate in larger soil voids. When they are subsequently reoxydized, they turn rust colored and form red spots or streaks referred to as mottles. When mottlis are encountered,

drainage problems and/or high groundwater should be suspected.

Mottles are only one indicator of groundwater problems and the site evaluator must remember to consider topography, plant species, nearness to water and other criteria that may suggest groundwater problems. Also the site evaluator should be aware that mottling can exist in parent materials of soil where there is no groundwater problems.

Theory of Wastewater Treatment

The two primary objectives in evaluating a site are:

- 1) to ensure that the soil is permeable and will accept wastewater effluent for long periods of time without causing sewage to backup or surface onto the ground, and,
- 2) to ensure that the wastewater effluent is adequately treated by the soil to limit the potential detrimental effects such as bacterial or nutrient contamination of groundwater, surface water or drinking water supplies.

For a soil to meet both objectives it should be permeable (coarse) enough to allow effluent to flow down through the soil horizons yet fine enough to filter or treat the effluent before reaching groundwater.

To adequately treat the sewage effluent the soil should be in an unsaturated condition. If the groundwater is too near (closer than 4') the bottom of the disposal trench, contaminants can reach the groundwater without adequate treatment. Saturated soils will also cause anaerobic conditions and the formation of ferrous sulfides that can inhibit infiltration of effluent causing a system to surface or back up.

The soil should be fine enough that it can effectively treat the effluent. Clay soils are the most effective for treating effluent because of their smaller pore size and much greater surface area available for treating or reacting with the sewage effluent. Too much clay however, will result in an impermeable condition that causes sewage to pond on the ground and/or back-up into the residence or structure. A sandy loam is usually considered ideal for subsurface sewage disposal because it has enough fine soil to react with and treat the effluent and is coarse enough to provide permeability rates very compatible with subsurface sewage disposal systems.

Bibliography

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*²Brady, Nyles, C.; The Nature & Property of Soils 8th Edition, 1974

*³Interim Soil Evaluation Guidelines” Washington State Department of Social and Health Services, Office of Environmental Health Programs, November, 1978.

*⁴Frick, Albert, “Site Evaluation for Subsurface Wastewater Disposal Design in Maine. Maine Department of Human Health Services, Division of Health Engineering, 1983.

*⁵Dutton, Barry L., Soils Conservation Service. U.S. Department of Agriculture; Soil Interpretations for Urban-related Developments in Western Montana August, 1981.

*⁶United States E.P.A. Offices of Research & Development Cincinnati, Ohio 45258, Onsite Wastewater Treatment and Disposal Systems, Design Manual, 1980

*⁷ American Society for Testing and Materials, ASTM Standards, D5921-96, 1996

APPENDIX I
PERCOLATION TEST PROCEDURE

General

Properly conducted percolation tests are needed to determine drainfield site suitability and to size the drainfield.

Test Hole Preparation

1. Dig or bore holes approximately six inches in diameter with vertical sides. Depth of holes shall be equal to the depth of the proposed drainfield trenches.
2. Roughen or scratch the bottoms and sides of the holes to provide natural unsmeared surfaces. Remove loose material. Place about two inches of 1/2 to 3/4 inch washed gravel in the bottom of holes to prevent scouring during water addition.
3. Establish a reference point for measurements in each hole.

Soaking

1. Fill holes with clear water to a level of at least 12 inches above the gravel.
2. In sandy soils, add 12 inches of water a second time. If the second filling seeps away in 60 minutes or less, proceed with test.
3. In other soils, maintain at least 12 inches of water in the hole for at least four hours to presoak soil. Do not remove water remaining after four hours. Permit soil to swell at least 12 hours.

Test

1. Sandy Soils
 - a. Add water to provide a depth of six inches above gravel. Measure water level drops every 10 minutes for one hour.
 - b. Use a shorter time interval if first six inches seeps away in ten minutes or less. Refill when necessary. Do not exceed six inch depth of water. Use final water level drop to calculate rate.

2. Other Soils

- a. Remove loose material on top of gravel.
- b. Adjust water level to six inches above gravel. Measure water level drops every 30 minutes for four hours or until two successive drops do not vary by more than 1/16 inch (stabilized rate achieved)
- c. If first six inches of water seeps away in less than 30 minutes, use a 10 minute interval and run for one hour.
- d. Refill with water only when necessary. Do not exceed six inch depth of water. Adjust water depth for the last three measurement periods such that they start with the same depth. Use final water level drop to calculate rate.

Records

Record the following information:

1. Date(s) of test(s),
2. Location and depth of each test hole,
3. Time of day that each soak period began and ended,
4. Time of day for beginning and end of each water level drop interval,
5. Each water level drop measurement,
6. Name of person performing test,
7. Name of owner or project name.

Rate Calculation

$$\text{Percolation Rate} = \frac{\text{Time Interval in Minutes}}{\text{Water Level Drop in Inches}}$$

**APPENDIX II
TEXTURAL CLASSIFICATION IN CURRENT USE**

American Association of State Highway Officials Soil Classification	Colloids*	Clay	Silt		Fine sand		Coarse sand*		Fine gravel	Medium gravel	Coarse gravel	Boulders																						
U. S. Department of Agriculture Soil Textural Classification	Clay	Silt		Very fine sand	Fine sand	Medium sand	Coarse sand	Very coarse sand	Fine gravel	Coarse gravel		Cobbles																						
Unified Soil Classification	Fines (silt or clay)**				Fine sand		Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles																							
	Sieve sizes																																	
	.001	.002	.003	.004	.006	.008	.01	.02	.03	.04	.06	.075	.085	.1	.149	.2	.3	.4	.6	.8	1.0	2.0	3.0	4.0	6.0	8.0	10	1/8"	3/16"	20	30	40	60	80
	Particle size - m.m.																																	

Modified from PCA Soil Primer

gravelly = 15 - 35%

very gravelly = 35 - 60%

extremely gravelly = over 60%

APPENDIX III
COMPARISON OF SEVERAL MATERIAL CLASSIFICATION SYSTEMS

USDA TEXTURE CLASS AND SYMBOL	UNIFIED SYMBOL	AASHO SYMBOL	SOIL PROPERTIES RELATED TO CLASSIFICATIONS
clay; silty clay "c"; "sic"	CH MH CL	A-7 A-7 A-7	High shrink-swell clays. Mica, iron oxide, kaolinitic clays. Low LL. Generally (45 pct clay).
Silty clay loam "scl"	CL ML-CL CH MH	A-7 A-7 A-7 A-7	Low L.L. Plastic. (A-6 if clay <30 pct). Low LL. Mod. Plastic. (A-6 if clay <30 pct). High LL. High shrink-swell clays. High LL. Mica, iron oxide, kaolinitic.
Clay loam "cl"	CL ML-CL CH MH	A-6 or A-7 A-6 A-7 A-7	Low LL. Plastic Low LL. Moderately plastic High LL. High shrink-swell clays. High LL> Mica, iron oxide, kaolinitic.
Loam "l"	ML-CL CL ML	A-4 A-6 A-4	Moderately plastic (A-6 if clay > 21 pct). Plastic (A-4 if clay <22 pct.) Low plasticity (A-7 if clay >21 pct).
Silt Loam "sil"	ML-CL ML CL	A-4 A-4 A-6	Moderately plastic (A-6 if clay >21 pct). Low plasticity (A-7 if clay >21 pct). Plastic
Silt - "si"	ML	A-4	Low plasticity.
Sandy Clay "sc"	CL SC	A-7 A-7	Fines > 50 pct. Fines 50 pct or less.
Sandy clay loam "scl"	SC SC CL	A-6 A-2-6 A-6	Plastic. Fines 36-50 pct. Plastic. Fines 35 pct or less. Plastic. Fines >50 pct.
Sandy loam "sl"	SM SC SM-SC	A-2-4 or A-4 A-2-4 A-2-4	Low plasticity. Plastic Moderately plastic
Fine sandy loam "fsl"	SM ML ML-CL ML-CL SM-SC	A-4 A-4 A-4 A-4 A-4	Nonplastic. Fines 50 pct or less. Nonplastic. Fines >50 pct. Moderately plastic. Fines > 50 pct. Moderately plastic. Fines > 50 pct. Moderately plastic. Fines 50 pct or less
Very fine sandy loam "vfsl"	ML-CL ML	A-4 A-4	Moderately Plastic. Low plasticity.
Loamy sands "ls"; "lfs" "lvfsf"	SM SM-SC SM ML	A-2-4 A-2-4 A-4 A-4	Nonplastic. Fines 35 pct or less. Modertely plastic. Fines 35 pct or less. Low plasticity. Fines > 35 pct. Little or no plasticity.
Sand: fine sand "s"; "fs"	SP-SM SM SP	A-3 A-2-4 A-3	Fines approx. 5-10 pct. Fines approx. > 10 pct. Fines < 5 pct.
Very fine sand "vfs"	SM ML	A-4 A-4	Low plasticity. Little or no plasticity.
Coarse sand "cs"	SP;GW SP-SM SM SM	A-1 A-1 A-1 A-2-4	Fines <5pct. Fines 5-12 pct. Fines 13-25 pct. Fines < 25 pct.
Gravel, "g" 50% passes no.200 50% of coarse passes #4 sieve	GP;GW CM or GC GM or GC GM GC	A-1 A-1 A-2 A-4 A-6	Fines < 5 pct. Fines 5-25 pct. Fines 26-35 pct. Fines > 35 pct. Fines > 35 pct.

APPENDIX IV

GUIDE FOR TEXTURAL CLASSIFICATION

Verbal definitions of the soil textural classes, defined according to size distribution of mineral particles less than 2 millimeters in diameter are as follows:

Sand: Soil that contains 85% or more of sand; and the percentage of silt, plus one and one-half times the percentage of clay, does not exceed 15%.

Loamy sands: Soil that contains at the upper limit 85% to 90% sand: the percentage of silt, plus one and one-half times the percentage of clay, is not less than 15%. At the lower limit it contains not less than 70% to 85% sand: the percentage of silt, plus twice the percentage of clay does not exceed 30%.

Sandy loam: Soil that contains 20% clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30%, and 52% or more sand; (or) less than 7% clay, less than 50% silt and less than 52% sand.

Loam: Soil that contains 7% to 27% clay, 28 to 50% silt and less than 52% sand.

Silt loam: Soil that contains 50% or more silt and 12% to 27% clay; (or) 50% to 80% silt and less than 12% clay.

Silt: Soil that contains 80% or more silt and less than 12% clay.

Sandy Clay loam: Soil that contains 20% to 35% clay, less than 28% silt and 45% or more sand.

Clay loam: Soil that contains 27% to 40% clay and less than 20% to 45% sand.

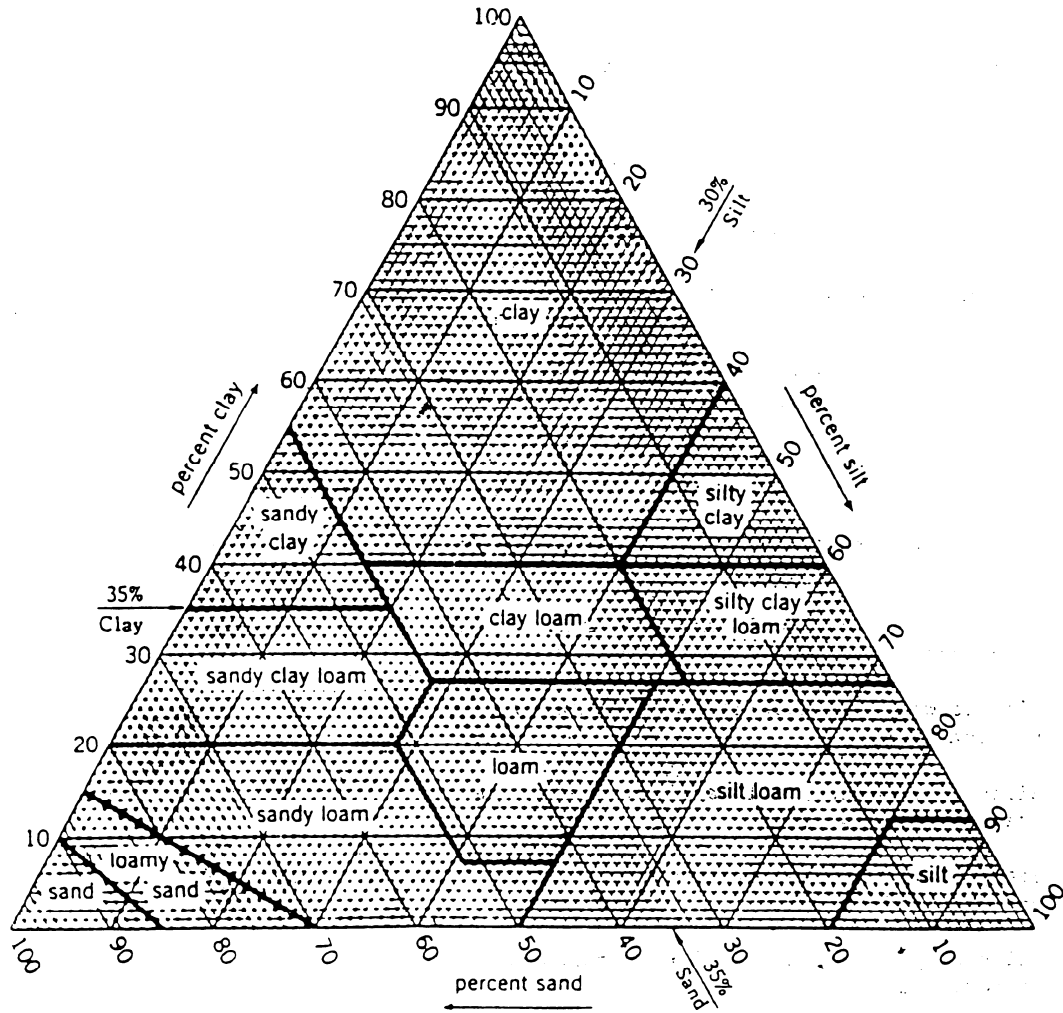
Silty clay loam: Soil that contains 27% to 40% clay and less than 20% sand.

Sandy clay: Soil that contains 35% or more clay and 45% or more sand.

Silty clay: Soil that contains 40% or more clay and 40% or more silt.

Clay: Soil that contains 40% or more clay, less than 45% sand and less than 40% silt.

**APPENDIX V
SOIL CLASSIFICATION TRIANGLE**



APPENDIX VI

TEXTURAL PROPERTIES OF MINERAL SOILS

SAND: As a textural class, sand is quite “clean” and will leave your hand relatively clean after handling a moist sample. When dry sand is loose single grains that can easily be seen and felt and when moist it will not form a ball that can withstand any handling.

SILT: Silt does not ribbon well and does not have a gritty feel to it at all. It feels like flour when wet or dry and shows dilatency.

CLAY: Clay forms very hard clumps when dry. One should be sure that the soil sample is completely moistened before texturing because small dry clumps will sometimes give a clay soil a gritty feel. Clay forms a strong ribbon (5 cm), is plastic and sticky when wet and lacks any grittiness. The amount of plasticity and stickiness in a clay soil will differ depending on its’ mineralogy. Montmorillonitic clays will show more stickiness, are more plastic and have a higher shrink-swell potential than illitic clays found in Missoula County.

LOAMY SAND: “Sand with few fines” or “dirty sand” are names that have been used for this textural class. It will form weak easily broken clods upon drying and when moistened will form a weak ball that can withstand very careful handling but will not form a ribbon when squeezed between the thumb and forefinger. As opposed to a sand, the fines that are found in a loamy sand will leave a clean hand looking dirty after handling the moistened sample.

SANDY LOAM: When moistened, a Sandy loam soil will form a ball that can be handled without breaking and the sample will often begin to ribbon but readily breaks. Sandy loam is distinguished from Loam and Silt loam by its’ dominant sandy or gritty feel. Dry samples are usually easily crushed and will feel gritty when rubbed.

LOAM: Loam will form a weak ribbon (2.5 cm) when moist and when saturated and rubbed between the fingers it will not feel excessively gritty or smooth. Dry soil will form clods that are firm.

SILT LOAM: This soil forms a weak ribbon (2.5 cm) when moist and has a very smooth feeling when rubbed between the fingers. When pulverized, the smooth flour-like feeling of silt predominates. Dry soil forms clods that are firm to hard. Soil aggregates are firm but can be crushed with the hand.

SANDY CLAY LOAM: This soil will form a medium ribbon (2.5 to 5.0 cm) when moist, and does not have excessive smoothness or grittiness when rubbed between the fingers.

SANDY CLAY: This soil type is very uncommon because the geomorphic processes that lead to the formation of sands and clays are quite different. The soil forms a strong ribbon (5.0 cm or longer) and because it has a high percentage of sand it will feel quite gritty when rubbed between the fingers.

SILTY CLAY: Silty clay will form a strong ribbon (5 cm or longer) when moist and forms very hard clods when dry. When moistened and rubbed between the fingers the soil will feel very smooth.

APPENDIX VII

TYPES AND CLASSES OF SOIL STRUCTURE

Class	TYPE (shape and arrangement of peds)						
	Platelike with one dimension (vertical) limited and greatly less than the other two, arranged around a horizontal plane faces mostly horizontal.	Prismlike, with two dimensions (the horizontal) limited and considerably less than the other two, arranged around a vertical line, vertical faces well defined, vertices angular	Blocklike polyhedronlike, or spheroids, or with three dimensions of the same order of arranged around a point				Spheroids or polyhedrons having plane or curved surfaces which have slight or no accommodations to the faces of surrounding ped
		Without rounded caps	With rounded caps	Faces flattened most vertices sharply angular	Mixed rounded and flattened faces with many rounded vertices	Nonporous peds	Porous peds
	Platy	Prismatic	Columnar	(Angular) Blocky**	(Subangular) Blocky	Granular	Crumb
Very fine or very thin	Very thin platy. 1 mm	Very fine prismatic 10 mm	Fine columnar 10 mm	Very fine angular blocky 5mm	Very fine subangular blocky 5mm	Very fine angular 1mm	Very fine crumb 1mm
Fine or thin	Thin platy 2-5mm	Fine prismatic 10-20mm	Very fine columnar 10mm	Fine angular blocky 5-10mm	Fine sub angular blocky 5-10mm	Fine granular 1-2mm	Fine Crumb 1-2mm
Medium	Medium platy 1 to 2 mm	Medium prismatic 20-50mm	Medium columnar 20-50mm	Medium angular blocky 10-20mm	Medium sub-angular blocky 10-20mm	Medium granular 2-5mm	Medium crumb 2-5mm
Coarse or thick	Thick platy 5-10mm	Coarse prismatic 50-100mm	Coarse columnar 50-100mm	Coarse angular blocky 20-50 mm	Coarse sub-angular 20-50mm	Coarse granular 5-10mm	Coarse granular 5-10mm
Very coarse or very	Very thick platy 10mm	Very coarse prismatic 100mm	Very coarse columnar 100mm	Very coarse angular blocky 50mm	Very coarse subangular blocky 50mm	Very coarse granular 10mm	