SECTION B: SOILS & SITE EVALUATIONS

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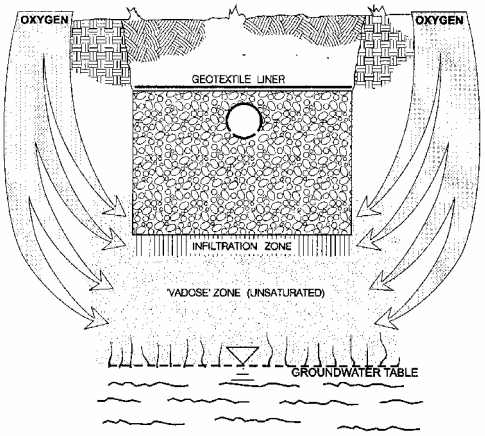
PART I:
SOIL TREATMENT OF SEWAGE

The health of individuals living where public sewers are not available is of major concern in the state of Iowa. Domestic wastewaters contain many substances that are undesirable and potentially harmful such as pathogenic bacteria, infectious viruses, organic matter, toxic chemicals and excess nutrients. To protect the public as well as the environment, wastewater must be treated in a safe and effective manner. The first component in an individual sewage treatment system is usually a septic tank, which removes some organic material (BOD) and some suspended solids (TSS). TSS and BOD removal is very important because it prevents excessive clogging of the soil absorption/dispersal unit. Figure A-5 shows the levels of BOD, TSS, fecal coliform bacteria and nutrients in septic tank effluent.

Suitable soil is an effective treatment medium for sewage tank effluent. Soil contains a complex biological community. One tablespoon of soil contains over one million microscopic organisms, including bacteria, protozoa, fungi, molds and other creatures. The bacteria and other microorganisms in the soil treat the wastewater and purify it before it reaches groundwater. But the wastewater must pass through the soil slowly enough to provide adequate contact time with soil particles and microorganisms.

Soil microorganisms need the same things to live and grow as animals: a place to live, food and water to eat, oxygen to breathe, and time to grow. Soil bacteria attach themselves to soil particles using microbial slimes. The larger soil pores are filled with air containing oxygen. To provide adequate time for treatment of wastewater, it is necessary to have **at least three feet of aerated (unsaturated) soil between the point where wastewater enters the soil and the limiting layer**.



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Upon leaving the septic tank, the effluent usually moves to a secondary treatment unit where it is treated using soil. Soil renovates wastewater physically, chemically and biologically before it reaches the ground water. Under some soil conditions, subsurface absorption systems may not accept the wastewater or may fail to properly treat the wastewater unless special modifications are utilized.

To do its part in wastewater disposal, suitably-textured soil must be deep enough to allow adequate filtration and treatment of the effluent before it is released into the natural environment. Usually this release is into groundwater. **The effective treatment zone needed in the soil before release into the natural environment is three feet**. Therefore, a three-foot separation distance is required from the bottom of sewage treatment trenches or beds to a limiting soil condition such as groundwater or bedrock. This three-foot treatment zone provides sufficient detention time for final bacteria breakdown and sufficient distance for filtration. Both are essential for the safe treatment of effluent. In Figure B-1, the levels of BOD, TSS, bacteria and nutrients remaining after treatment by one foot and three feet of soil are shown.

Figure B-1: Treatment Performance of Soil

parameter	raw waste	septic tank effluent	one foot below trench bottom	three feet below trench bottom
BOD_5 (mg/L)	270 – 400	140 – 220	0	0
TSS (mg/L)	300 – 400	45 – 65	0	0
fecal coliform (MPN/100ml)	1,000,000 – 100,000,000	100,000 – 100,000,000	0 – 100	0
viruses (PFU/ml)	unknown	1,000 – 1,000,000,000	0 – 1,000	0
nitrogen (mg/L)				
total	100 – 150	50 – 60	----	----
NH_4	60 – 120	30 – 60	*B – 60	*B
NO_3	<1	<1	*B – 40	*B – 40
total phosphorus (mg/L)	10 – 40	10 –30	*B – 10	*B –1

*B = background level of naturally occurring parameter in soil

Impacts of Effluent on Groundwater

We commonly think a system is failing when effluent either ponds on the soil surface causing a wet seepy area, or when effluent backs up into the house. However, it is also important to prevent a third, less commonly thought-of failure—contamination of groundwater and surface water. Approximately 30

percent of North American households use septic systems for wastewater disposal, with these same households utilizing groundwater for drinking and other domestic uses.

Groundwater represents the largest volume of fresh water on earth. Only three percent of the earth's fresh water resides in surface streams, lakes, and other surface water bodies. The other 97 percent is beneath the surface, flowing toward points of discharge such as streams, lakes, springs, and swamps. Groundwater becomes surface water at these discharge points.

As water percolates through the soil, it is purified and in most cases requires no treatment before being consumed. However, when the soil is overloaded with a treatable contaminant, or when the contaminant cannot be treated by the soil, the quality of the underlying groundwater may change significantly.
Pollution of groundwater is usually very difficult to correct, since the only access to the water table is through wells, trenches (if the water table is high enough), or natural discharge points such as springs. An incident of groundwater pollution often becomes a problem which persists for many years.

Soil Treatment Processes

The soil treatment unit provides the final treatment and dispersal of septic tank effluent, and to varying degrees treats the wastewater by acting as a filter, exchanger, or absorber by providing a surface area on which many chemical and biochemical processes may occur. The combination of these processes, acting on the wastewater as it passes through the soil, produces clean water.

Biomat

In a series system as sewage tank effluent flows into a drainfield trench, it moves down through the trench rock to the soil where treatment begins. A biological layer or **biomat** is formed by anaerobic bacteria in the trench, which secrete a gluey substance to anchor themselves to the soil or rock particles. This biomat forms first along the trench bottom. As liquid begins to pond in the trench, the biomat forms along the soil surfaces on the sidewalls. When fully developed, the gray-to-black slimy biomat layer is about one inch thick.

Flow through a biomat is considerably slower than flow through natural soil, so unsaturated conditions exist in the soil beneath the drainfield trench. Only the smaller soil pores contain water, while larger pores are filled with air. Unsaturated flow increases travel time of effluent through the soil, ensuring that it contacts the surfaces of soil particles. (See Figure B-2 and B-3)

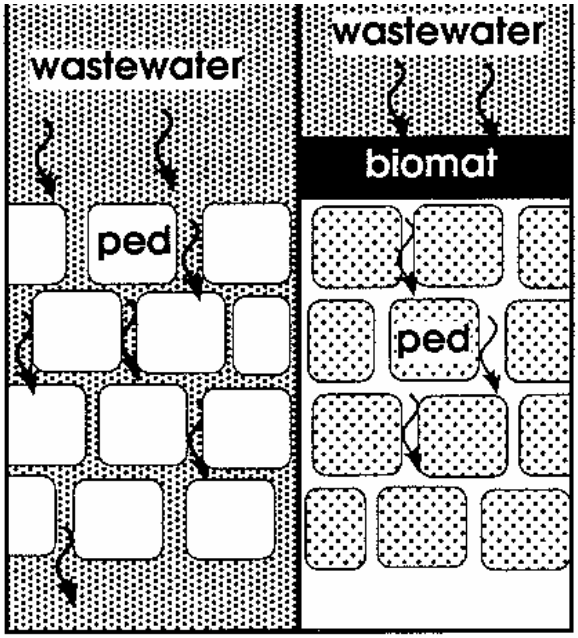


Figure B-2

Unsaturated soil has pores containing both air and water so that aerobic microorganisms living in the soil can effectively treat the wastewater through the soil system.

A developed biomat reaches equilibrium over time, in that it remains at about the same thickness and the same permeability if effluent quality is maintained. The biomat and the effluent ponded within the trench are anaerobic and the organic materials in the wastewater are food for the anaerobic microorganisms, which grow and multiply, increasing the thickness and decreasing the permeability of the biomat. On the soil side of the biomat beneath the drainfield, oxygen is present so that conditions are allowing aerobic soil bacteria to feed on and continuously break down the biomat. These two processes go on at about the same rate so that the thickness and permeability of the biomat remain the same.

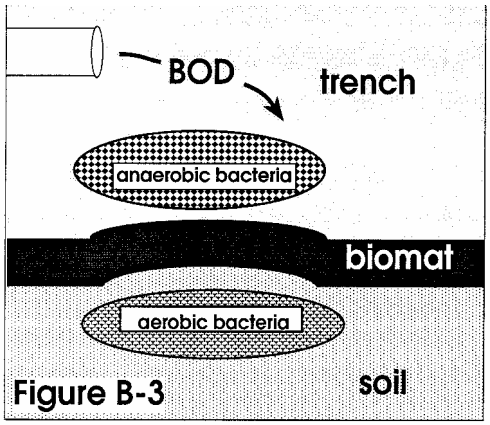


Figure B-3

If the concentration of the wastewater leaving the septic tank increases because of failure to regularly pump the septic tank, more food will be present for the anaerobic bacteria, which will increase the thickness of the biomat and decrease its permeability. If seasonally saturated conditions occur in the soil outside the trench, aerobic conditions will no longer exist. Since aerobic bacteria break down the biomat, these conditions will also cause the biomat to thicken, reducing its permeability and the effectiveness of treatment.

In the unsaturated soil under a biomat, water movement is restricted. In order for the wastewater to move through the soil, it must be pulled or “sucked” through the fine pores by capillary action. This creates a thin film of wastewater around soil particles, and water movement through the finer pores.

Soil Treatment

Once the effluent passes through the biomat, it enters the soil for final treatment. Soil particles, the presence of electrical charges, and the soil microbiological organisms provide treatment.

Soil particles provide the surface area wastewater passes over to be purified. This purification is provided by filtering of the larger particles and by adsorption (attachment or binding). Soil particles are negatively charged, so they can attract and hold positively-charged pollutants. Soils also contain minerals that bind with some pollutants and immobilize them (see Figure B-4).

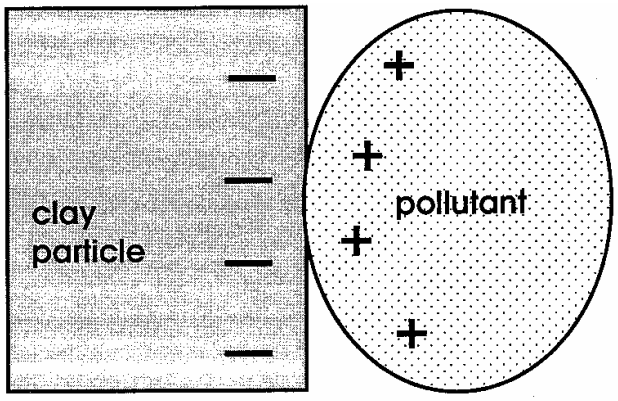


Figure B-4: Negatively-charged soil particles can attract and hold positively-charged impurities in wastewater

Soil contains bacteria, fungi, actinomycetes, and protozoa, all of which feed on organic material in the wastewater. Aerobic bacteria provide treatment and function only in aerated soil. If the soil is saturated and no oxygen is present, anaerobic bacteria function, but they provide insufficient treatment.

BOD is broken down by bacteria in the biomat and filtered out in the first foot below the system. Total suspended solids are also filtered out by the soil within a foot of the trench bottom.

Pathogen Removal

Bacteria in the effluent are large enough that they are usually filtered out like BOD. In general, soil is a hostile environment to the bacteria found in sewage, due to temperature, moisture and soil predators.

Viruses are much smaller than bacteria, and are not filtered. However, some contain a positive ionic charge, and soil particles are negatively-charged, allowing them to attract and hold the positively-charged viruses. In sandy soils with limited negative charges, the main means of viral attachment to soil particles is by microbial slimes laid down by soil bacteria.

Once bacteria and viruses are caught in the soil, they eventually die because of soil conditions such as temperature or moisture levels. Some bacteria are killed by antibiotics given off naturally by soil fungi and other organisms. Others are preyed upon by soil bacteria. Studies have shown that if sandy soils are loaded at no greater than 1.2 gallons per day per square foot (gpd/sqft), virus removal will occur within two feet. The soil sizing factor for sandy soils reflects this loading rate.

Nutrient Removal

The two principle nutrients of concern in wastewater treatment are nitrogen and phosphorus.

Nitrogen is a concern because it can contaminate drinking water. Nitrogen undergoes many changes as it travels through a septic system. Septic tank effluent contains both organic nitrogen and ammonium NH_4^+. The predominant form entering the soil is ammonium. The transport and fate of nitrogen underneath a soil treatment system is dependent upon the forms entering and the biological conversions that take place. Figure B-5 shows the forms and fate of nitrogen in the subsurface environment.

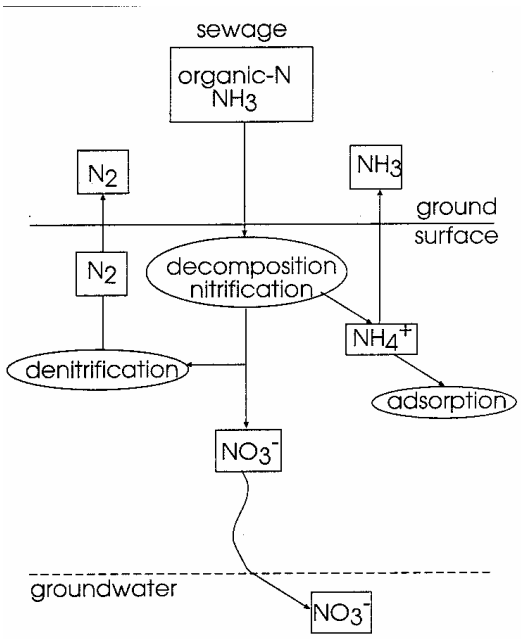


Figure B-5: Form and Fate of Nitrogen in the Subsurface Environment

Nitrates (NO_3^-) can be formed by nitrification. Nitrification ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$) is an aerobic reaction, so it is dependent upon the aeration of the soil.

Denitrification is another important nitrogen transformation in the soil environment below onsite systems. It is the only mechanism by which the NO_3^- concentration in the effluent can be reduced. Denitrification ($NO_3^- \rightarrow N_2O \rightarrow N_2$) occurs in the absence of oxygen. For denitrification to take place, the nitrogen must usually be in the form of NO_3^-, so nitrification must happen before denitrification. Mound systems facilitate this process and typically reduce nitrogen concentrations by 40 to 70 percent.

The transport of nitrate ions may involve movement with the water phase, uptake in plants or crops, or denitrification. Since nitrate ions (NO_3^-) have a negative charge, they are not attracted to soils, and are very mobile.

In a study by Converse et al., 31 at-grade systems were monitored for nitrogen levels. Levels coming out of the septic tank were:

Parameter	Average value
Organic nitrogen	11 mg N/L
Ammonium	48 mg N/L

Nitrogen levels below a pressure dosed at-grade system are shown below.

	Ammonium	nitrate
Depth (in)	(mg N/kg dry soil)	(mg N/kg dry soil)
0-6	29	28
12-18	17	16
24-30	17	13
36-42	15	10

Treatment of nitrates occurs to a limited extent by the following mechanisms.

- **Uptake by Plants:** If trenches are shallow to the ground surface, some of the nitrate will be taken up by surface vegetation during the growing season.

- **Denitrification:** If the ammonium NH_4^+ is nitrified to nitrates NO_3^- and then encounters a saturated zone, which lacks oxygen, the nitrate is converted to nitrogen gas (N_2) and is lost to the atmosphere. Mound systems provide these nitrifying and subsequent denitrifying conditions.

Once nitrates reach the ground water, the only mitigative effect to this contamination is by dilution with the native groundwater. The effectiveness of this dilution is dependent upon the amount of nitrate entering from other sources in the area, including agricultural practices and other onsite systems, along with the hydrogeologic conditions of the groundwater system.

Lakes receiving **phosphorus** will experience an increase in aquatic vegetation. The limiting nutrient in most Iowa lakes is phosphorus, so small additions bring about a great increase in growth. Algae blooms and heavy growth of weeds not only make surface water bodies unappealing for recreation, they threaten the health of fish and other aquatic creatures.

Since groundwater flows until it is ultimately discharged as surface water, the quality of Iowa's surface water is highly dependent upon the quality of its groundwater. Measures should be taken to reduce the risk that phosphorus from onsite systems will not enter lakes and rivers through the groundwater.

Phosphorus is removed from wastewater by being chemically bound by minerals and held on exchange sites on soil particles. Minerals that bind with phosphates are iron, manganese and aluminum. When the adsorption sites are filled, newly added phosphorus must travel deeper in the soil to find fresh sites. Soils higher in clay content have more of these minerals and binding sites than soils high in sand, so phosphorus movement is generally less in finer-textured soils. Laboratory studies on sands indicate that the rate of phosphorus movement is approximately eight inches per year; in clay soils it's about three inches per year. If the treatment system is functioning properly, and proper setbacks are maintained from surface waters, problems from phosphorus movement to surface water or groundwater should be minimal.

Residence Times

The longer contaminants remain in unsaturated soil, the greater the opportunity for treatment. One way to enhance residence times is to have less water percolating through the soil to carry contaminants into groundwater before treatment is achieved. The following methods can be used to limit the amount of water to be treated.

- Water conservation: Using less water in the home will increase contaminate residence times in the soil. Reduced flows also allow increased quiet times in septic tanks which allows the settling of solids and containment of contaminates in the tank which do no reach the soil treatment system.
- Long, narrow, and shallow trenches: Trenches constructed close to the ground surface will allow the upward removal of water by evaporation and transpiration through growing plants. Shallow trenches also provide good oxygen exchange with the atmosphere for the aerobic soil bacteria to provide good treatment.
- Flow-restricting water fixtures.
- Composting, incinerating, chemical, and low-flow toilets.

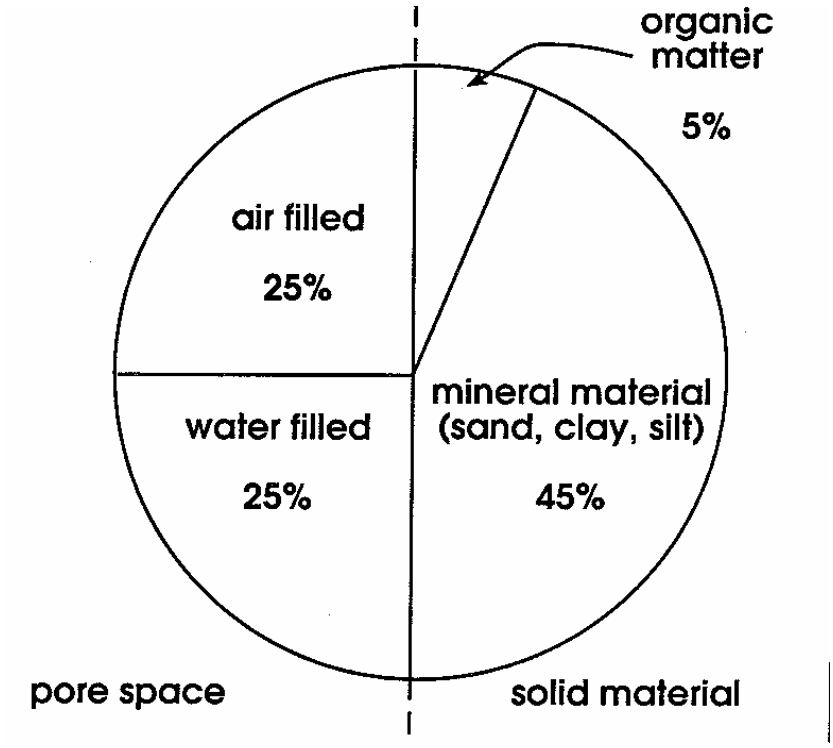
PART II: SOIL DEVELOPMENT

It's important to understand the characteristics of soil in order to understand soil treatment of wastewater and the proper siting of onsite systems.

Components of Soil

Soil contains about 50 percent solid material and 50 percent pore space. The solid portion typically contains five percent organic matter and 45 percent mineral material. The pore space typically contains an equal amount of water and air (See Figure B-6).

Figure B-6 Components of soil by volume



The following was taken from

"Principal Soils of Iowa, Special Report No. 42"

The Factors of Soil Formation

The properties which characterize a soil profile are due to the influence of a particular combination of several soil forming factors. These are (1) soil parent material, (2) climate, (3) living organisms, (4) topography or relief and (5) time.

These factors work interdependently in producing a particular soil. Differences or similarities between soils are due to differences or similarities in the influence of the interrelated soil forming factors. *Each factor modifies and is modified by the other soil-forming factors*. Topography, for example, modifies the effects of rainfall—a climatic factor. The release of plant nutrients from soil minerals which originate in the soil parent material depends upon climate and time. Thus, the effect of living organisms such as growing plants is influenced by time, climate and soil parent materials. Variations in soil properties can be interpreted and explained only through consideration of the interrelated influences of the factors of soil formation.

Parent Material

The initial step in the development of a soil profile is the formation of soil parent material. The parent material provides a soil with a mineral skeleton, consisting of unconsolidated and partly decayed rocks. Some soils are formed from the weathering of bedrock in place. However, most Iowa soils formed from material that was transported from the site of the parent rock and redeposited at a new location through a transporting agency. Ice, water, wind and gravity are transporting agencies. These agencies may act independently or in combination with two or more agencies. Ice—in the form of glaciers—was particularly important in transporting and redepositing the parent materials from which Iowa soils developed.

During the Pleistocene or Ice Age, snow and ice accumulated to great depths. As pressure increased with increased depth of ice and snow, the ice sheet flowed as a plastic mass. Like a giant bulldozer it moved across the landscape. Rocks were ground into smaller particles. Hills were leveled and valleys were filled. Rocks imbedded in the bottom of the ice provided scouring action as the glacier moved.

Four glacial advances have been recognized in Iowa. The glacial periods were separated by interglacial periods with warmer climates. The first glacial period, the Nebraskan, occurred approximately 750,000 years ago. It was followed by the Aftonian interglacial period, which was followed by the Kansas glacial period,

which is thought to have started about 500,000 years ago. The Yarmouth interglacial period followed the Kansan glaciation. The third glacial period, the Illinoian, occurred about 150,000 years ago and was followed by the Sangamon interglacial period. The last period of glaciation was the Wisconsin, which started about 35,000 years ago. It consisted of several substages and an important interglacial substage. The last substage was the Cary, which deposited the till in north central Iowa about 11,000 to 14,000 years ago. The Tazewell left extensive till deposits in northern Iowa. During and following the Tazewell substage (approximately 14,000 to 25,000 years ago), loess was widely deposited over Iowa.

The principal parent materials of Iowa soils are (1) glacial drift, (2) loess and (3) alluvium. Approximately 95 percent of Iowa soils formed from one of these three parent materials. The remaining 5 percent formed from colluvium; limestone, sandstone and shale residuum; and organic deposits. The distribution of the major parent materials is shown in fig. B-7.

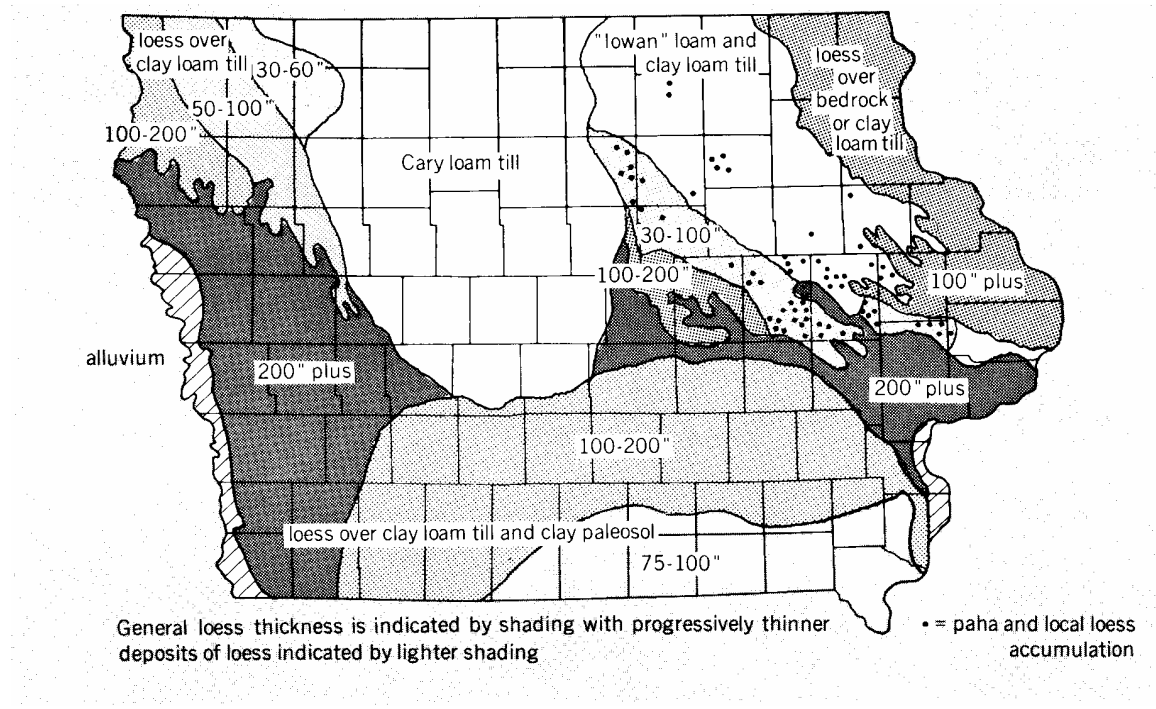


Figure B-7

Glacial drift consists of the unconsolidated mixture of gravel and partly weathered rock fragments left by glaciers. Glacial drift may consist of materials deposited directly by the ice sheet or material which has been reworked by water or other agencies as the glacier melted. Glacial drift provided parent materials for approximately 40 percent of Iowa's soils. Glacial till is the unsorted mixture of clay, silt, sand, gravel and boulders which was deposited by the ice sheet. The glacial tills from which Iowa soils were formed were generally medium to

moderately fine loam and clay loam textures. Small stones, pebbles, gravel and sand are present in most glacial tills of Iowa.

Iowa soils have developed in fresh or unweathered till and also in highly weathered till. The interglacial periods between the earlier glacial periods were long enough to permit the formation of soils with well-developed profiles. These were covered by later deposition. Geologic erosion has dissected the till plain and has re-exposed the buried soils (relict soils or paleosols) through truncation or beveling. Modern soils have developed from the re-exposed material. These soils are common in southern and southeastern Iowa.

In addition to glacial till, glacial drift also includes *glacial outwash*. As the ice melted during warm seasons, melt water flowed from the margins of the ice sheet and redeposited a partly sorted mixture of gravel, sand and silt. Stratification of gravel, sand and silt layers is common, although one of the materials usually predominates. Glacial outwash occurs as pockets and fans associated with old melt-water channels. Many of these channels are now streams. They are most common in the glacial till areas of north central and northeastern Iowa.

Loess (pronounced “luss”) is a silty, wind-deposited material. Major loess deposits in Iowa are of the Wisconsin age. Loess consists almost entirely of silt but may include small amounts of very fine sand or clay. Coarse sand, gravel and boulders are not found in typical loess since these materials were too large to be moved by wind. The high percentage of silt-sized particles gives loess-derived soils a smooth, grit-free floury feel.

Loess deposits originated from materials carried away from the melting ice sheet during warm seasons. During cool seasons, the water flow ceased and the materials were deposited in broad, flat areas such as bottomlands. After drying, they were picked up by wind action and redeposited many miles from the source. For example, the loess of Wayne County is thought to come from near Onawa, a distance of almost 200 miles. Areas near the source received thicker and coarser textured deposits. The deposits thinned in the direction of the then prevailing northwesterly winds.

The major sources of loess in Iowa were (a) the Missouri River bottomlands, (b) a Wisconsin glacial drift plain north central and northeastern Iowa, (c) a Wisconsin valley drift plain in southeastern South Dakota, and (d) local sources along the Des Moines, Skunk, Iowa and Cedar rivers. Loess thicknesses are shown in fig. 5. Locally thick accumulations of loess occur in areas of northeast and east-central Iowa (paha) which are otherwise loess-free or which have thin loess caps over glacial till. The location of some of these areas, is shown in figure B-7.

Loess-derived soils may vary in characteristics from one part of the state to another. Some of the major reasons for the variation include (1) fineness, (2)

thickness of the deposit, (3) rate of accumulation, (4) carbonate content at time of deposition, and (5) mineralogical composition of the loess. Climate, vegetation and topography have also caused differences. Loess-derived soils include the most productive in the state and account for almost 40 percent of Iowa soils.

Alluvium is material which was deposited by water in the floodplains along streams. Two major areas—Missouri bottomlands and Mississippi bottomlands—and numerous smaller areas along tributary streams, have soils developed from alluvium. Medium and moderately fine-textured alluvium predominates in Iowa, although coarser textured alluvium is not uncommon. Fine-textured alluvium is common in the Luton-Onawa-Salix soil association. Alluvium-derived soils are frequently stratified with layers of gravel, sand, silt and clay.

Colluvium is material deposited in footslope positions by the action of gravity, soil creep or local wash. Silty and loamy colluvial materials are most common in Iowa, although rock fragments are common below slopes with rock outcrops. Colluvial soils often occur in small, narrow areas; thus, their suitability for crop production is determined by associated soils.

Residuum, the residue from the weathering of sedimentary rocks in place, is a minor parent material in northeast Iowa and along some of the deeper stream valleys such as the Des Moines River. The sedimentary rocks include limestone, sandstone and shale. Since most of the rock outcrops occur on steep topography, soils formed from sedimentary rocks usually have AC or AR profiles. However, some soil profiles with A, B and C horizons formed from residuum are found in the state.

Organic deposits form the parent materials for peat and muck which occur in small areas, particularly in north central Iowa. Poorly drained conditions have retarded the decay of organic matter which has accumulated over time. The accumulated organic matter, with small amounts of mineral matter, serves as soil parent material.

Climate

Climate both directly and indirectly influences soil development. Direct effects include the influence of temperature and precipitation upon the weathering of rocks and minerals. High temperatures encourage rapid weathering of rocks, minerals and parent material. The speed of chemical reactions increases as temperature increases. Wind, important in soil transport, is a climatic factor that directly affects soil development. High annual rainfall influences the soil directly through its impact on erosion and leaching losses. Climatic changes played important roles in the work of glaciers as discussed in the section on soil parent materials. Climate plays an indirect role in soil formation through its effect upon plant growth and adaptation. Climatic variation between areas was important in determining the location of the broad soil areas of the world.

The climate of Iowa is relatively uniform over the state although some variation in climatic factors occurs. Climate is an important cause of crop yield variation between different sections of Iowa. Although climate probably did not play a major role in distribution of soils in Iowa, differences between soils in northwest Iowa and parts of east-central Iowa may reflect climatic variations. The soils in northwest Iowa are similar to east-central soils in most respects but are less leached, possibly because of lower annual rainfall.

Living Organisms

In addition to mineral matter provided by parent material, soils also include organic matter—living organisms (plant and animals) or the remains of living organisms. Living organisms perform two chief functions in soil development. They are the source of soil organic matter, and in the case of deep-rooted plants, they help bring plant nutrients up from lower depths. The organic matter may be stored in the A horizon and will, upon decomposition, release nutrients for plant use. Soil differences caused by variations in the type of plants and their patterns of growth affect the thickness of the A horizon.

Most native Iowa vegetation consisted of tall prairie grasses. Forest vegetation (chiefly oak and hickory) was more prominent in eastern Iowa and along the major streams in other parts of the state.

Microorganisms also play important roles in soil development. They are a source of organic matter, aid in decomposing organic matter, combine free nitrogen into forms which can be used by plants, and aid in the release of nitrogen and other organic stored nutrients for use by plants.

Man, through his use of the soil, also influences soil development. Man uses soils in ways which may either improve, maintain or permanently decrease soil productivity.

Topography

Topography refers to the lay of the land. It may be very steep or nearly level or somewhere in between. The primary influence of topography on soil development is its effect on drainage, runoff and erosion. Topography is an important factor in determining the pattern and distribution of the soils of a landscape. The aspect or direction a slope faces is an important secondary influence of topography. For example, south-facing slopes normally are warmer and drier than north-facing slopes. This can have an important effect on the kind and amount of vegetation which grows in an area.

Topography may be characterized by the gradient (degree or percent of slope), length, shape, aspect and uniformity of the slopes which make up a particular landscape. Although each of these slope characteristics is important, the topography of Iowa is most frequently expressed in terms of slope gradient or

percent of slope. Seven slope gradient classes have been recognized in Iowa. These slope gradient classes and the percent of Iowa land area represented by each are presented in the following Figure B-8.

Figure B-8

Soil Groups
A = 0 – 2 %
B = 2 – 5 %
C = 5 – 9 %
D = 9 – 14 %
E = 14 – 18 %
F = 18 +

Occasionally, various slope gradient classes occur in extensive areas. More frequently, however, two or more slope gradient classes occur within one field. To show the variation in topography within the state, five major topographic areas were formed by grouping one or more of the slope gradient classes into each area. Areas with a wide range in slope gradient (5-14 percent or 9-30+ percent) generally represent a more complex topography than areas with a narrow range of gradient. In addition, the pattern of the various topographic areas in different sections of the state is an indication of complexity of the topography.

The nearly level gently sloping areas predominate in northwest, north central and northeast Iowa with extensions into east central and southeast Iowa. Southern Iowa is marked by an intricate pattern of narrow ridge tops flanked by gently sloping to strongly sloping and steep side slopes. Western Iowa has a high percentage of strongly sloping to steep topography.

Topography is important in determining the pattern of occurrences of soils within different areas of the state. This pattern is closely related to topography because of topographic influences on drainage, erosion, climate and plant growth. Soil suitability for various uses is also closely related to topography.

In addition to a geometric description of topography, soil scientists also use the concept of the hillslope profile. The high, relatively stable part of the landscape is the summit. Downslope a convexly rounded slope element is the shoulder. Below the shoulder is the backslope, many of which are linear. The backslope descends to a footslope, which is usually concave. The lower part of the profile is usually the toeslope. The shoulder and backslope are subject to erosion while the footslope and toeslope are depostional elements of the landscape. Not all the elements are present on every hillslope.

Time

Time is necessary for the various processes of soil formation to take place. The amount of time may vary from a few days for fresh alluvial deposits to thousands of years for the ”paleosols” of southern Iowa. In general, in Iowa when other factors are favorable, as soils continue to weather over a long period of time, the subsoil texture becomes finer and the soils are more leached of soluable materials. Exceptions are soils formed from materials resistant to weathering such as quartz sand. Such soils do not change much with time. Other exceptions are soils occurring on very steep topography where runoff is high and water infiltration is low. Such soils weather more slowly than soils on less steep topography. Time is an important factor in explaining soil differences among different areas of the state and also within the same area in some parts of the state.

Variations in ages of glacial and loess deposits were discussed in the section on parent materials of Iowa soils. These materials range in age from more than 500,000 years to less than 11,000 years. Many of the older deposits were covered by later sediments laid down by ice, wind or water. The landscape we see today has been and is being influenced by geologic erosion. The landforms of Iowa are shown in figure B-9. The youngest landscapes are in the alluvial areas and in the younger glacial areas of north central Iowa. Although the soils of southern areas of Iowa formed from materials which have been deposited for a long period of time or have accumulated over a long time, the modern landscape has resulted from erosional activities which accompanied the Wisconsin glacial period. Thus, the soils which occur in the modern landscape may be young even though the materials deposited may be old. However, it is not the age of the parent material that is important to understanding the time factor of soil formation. It is the age of geomorphic surface on which the soil develops that is important. A geomorphic surface is defined as a part of the earh’s surface that can be defined in space and time. It may contain many landforms and it is mappable. Some of the younger surface are in the alluvial floodplains and are recent. Landscapes covered with Wisconsin loess have summit positions that are 14,000 years old. However, associated landscape elements are much younger. Many of the upland landscapes, especially the Des Moines and Iowan surface are as young as 3,000 years.

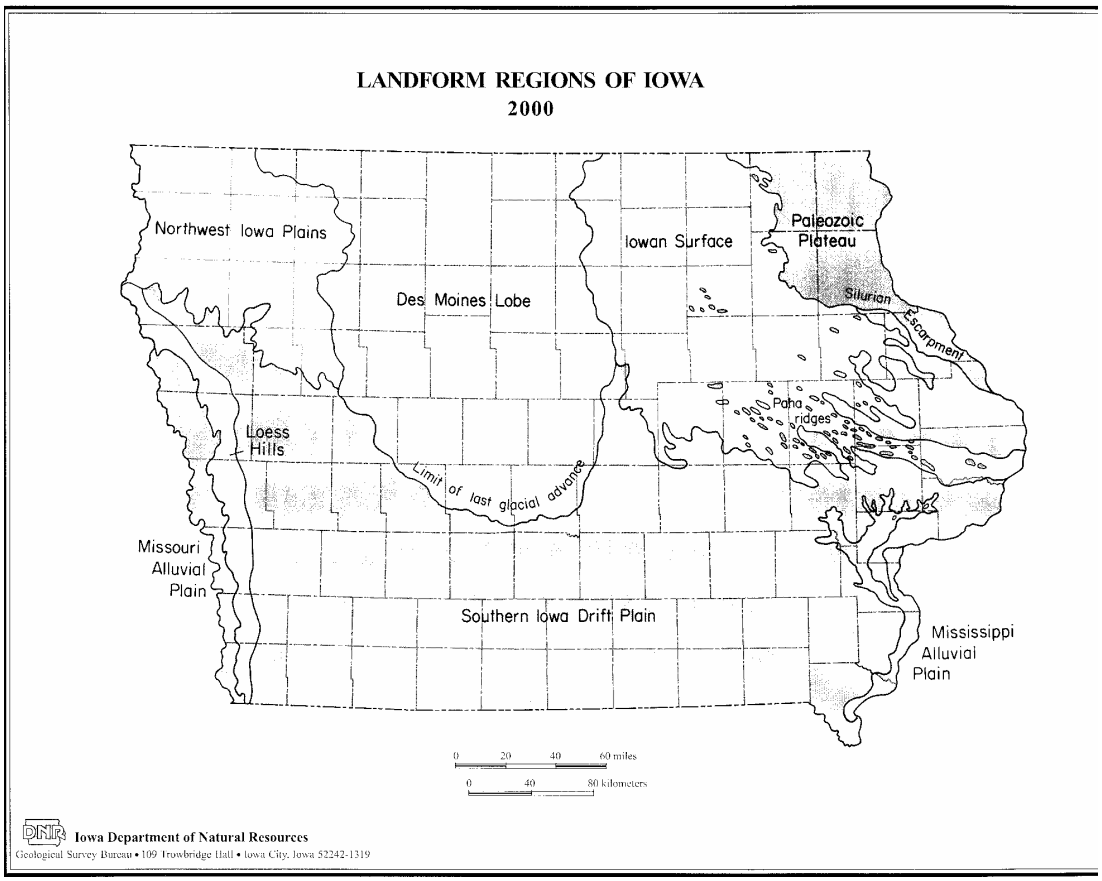


Figure B-9

Sometimes the ages of landscapes may be estimated by a process known as radiocarbon dating if organic materials are buried. If living material such as trees is covered by later deposition through the action of ice, water or wind, the radioactive carbon can serve as an estimator of the time the sediments were deposited. The age of materials less than 35,000 years old may be dated by this technique. Organic materials such as wood have been discovered in many Iowa glacial and loess deposits. These have served as sources for radiocarbon dating.

Soil Profile

Weathering of the parent material forms different layers in the soil called **horizons.** Each horizon has one or more characteristics different from the layer above. The **soil profile** is all of the horizons of a soil (See Figure B-10).

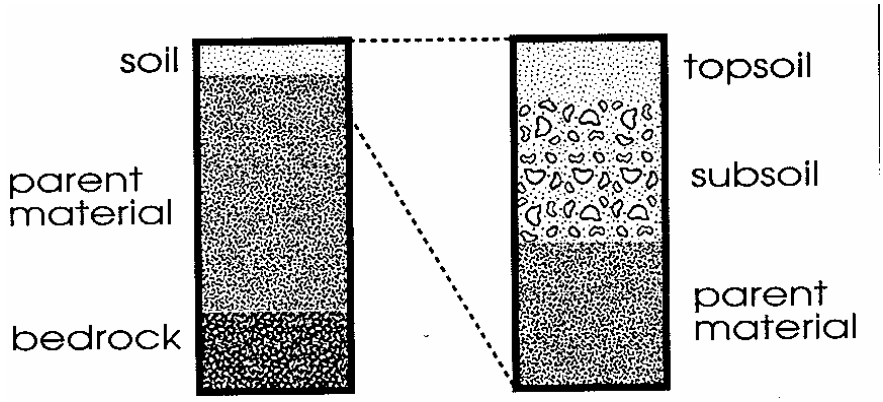


Figure B-9: Soil Profile

A fresh roadcut or the wall of an excavation is a good place to study the soil profile. The soil profile is a vertical section of a soil and consists of one or more soil horizons and the unaltered material underlying the horizons. A soil horizon is a layer of soil approximately parallel to the soil surface with uniform characteristics. Soil horizons are identified by observing changes in soil properties with depth. Soil texture, structure and color changes are some of the characteristics used to determine soil horizons. Soil descriptions are used to identify different horizons and determine if the soil has the ability to treat and dispose of the applied wastewater. Soil descriptions must be objective, complete and clear, and use standard terms, so your observations can be understood by others.

Changes in the soil that will have a significant impact on wastewater movement signal where a new horizon should be noted. This would be where changes in soil texture, color, density, permeability or bedrock occur. The importance of these contact zones, where permeability changes, cannot be overemphasized.

Soils vary widely in the degree to which horizons are expressed. Relatively fresh geologic formations, such as alluvial fans, may have no recognizable horizons, although they may have distinct layers that reflect geologic deposition. As soil formation proceeds, horizons may be detected in their early stages only by very careful examination. As age increases, horizons generally are more easily identified in the field. The term **layer**, rather than horizon, is used if all of the properties are inherited from the parent material and not from soil-forming processes.

Typically, horizon distinction lessens below three to four feet in depth, which corresponds to the depth of structure development. Horizons at this point get thicker and the boundaries between horizons are not easily seen. Technically, the loss of structure development “ends” the soil, so deeper horizons are actually parent material. Each horizon has its own set of characteristics and therefore will respond differently to applied wastewater. Also, the conditions created at the boundary between soil horizons can significantly influence wastewater flow and treatment through the soil.

The more distinct the difference between two adjacent horizons, and the more abrupt that boundary, the more problems there may be in water movement between these layers.

Horizons are described and differentiated from one another on the basis of the following characteristics:

- texture
- matrix color
- mottling (redoximorphic features)
- structure
- consistence
- presence or absence of roots

The depth at which one or more of these characteristics appreciably changes will be described and recorded. A sample soil boring log sheet (Figure B-48) is provided on page B-70, and in **Appendix 4: Site Evaluation Forms** to aid in recording the soil description.

For example: The first soil in Figure B-10 has a clay loam subsoil over a sandy parent material. This texture change occurs abruptly less than one-inch between horizons. This soil would have problems transmitting water across the boundary. The second soil has a sandy loam subsoil over a sandy parent material. This texture change boundary occurs over a five-inch thickness. In order for water to pass across either boundary there would have to be saturation in the upper layer.

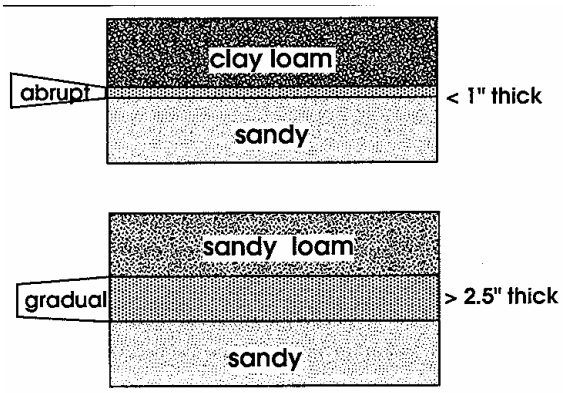


Figure B-10: Boundary Thicknesses

Determining Boundaries

Boundaries between horizons are determined by changes in soil color, soil texture, or other soil properties. **For example:** In Figure B-11, horizon 1 is 12 inches thick and is a black sandy loam. Horizon 2 is from 12 to 36 inches and is a brown sandy loam. Horizon 3 is from 36 to 72 inches and is a brown loam. At the bottom of the soil boring log, the total depth of the boring hole should be entered as well as any evidence of mottling or saturated soil conditions.

Photographs can be taken of the soil profile after the layers have been identified, but before the vertical section has been disturbed for description.

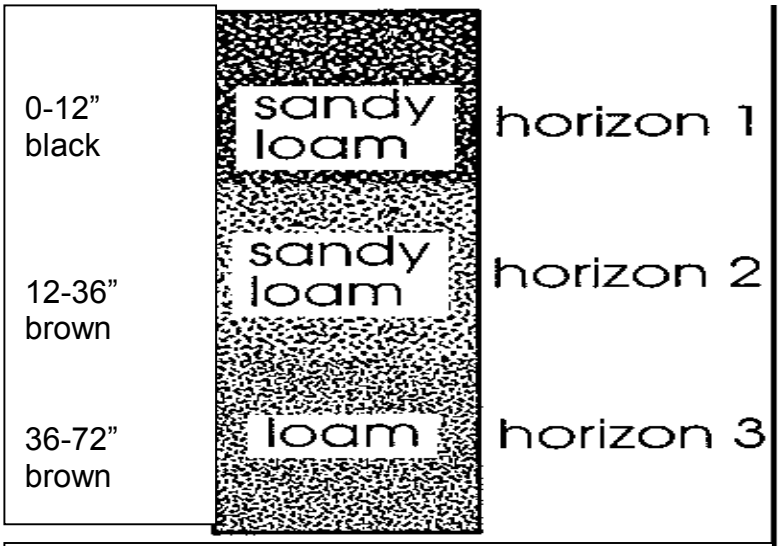


Figure B-11: Soil Profile

PART III:
PHYSICAL PROPERTIES OF SOIL

Soil Texture

Soil texture can be used to estimate the percolation rate, which is then used to estimate the size of the treatment area that needs to be investigated. While soil texture is not an absolute indicator of the percolation rate, it can provide helpful preliminary information. Soil texture is the quantity of various inorganic particle sizes present (sand, silt and clay). The sand-, silt-, and clay-sized particles are called **soil separates.** You can think about texture as the "feel" of the soil.

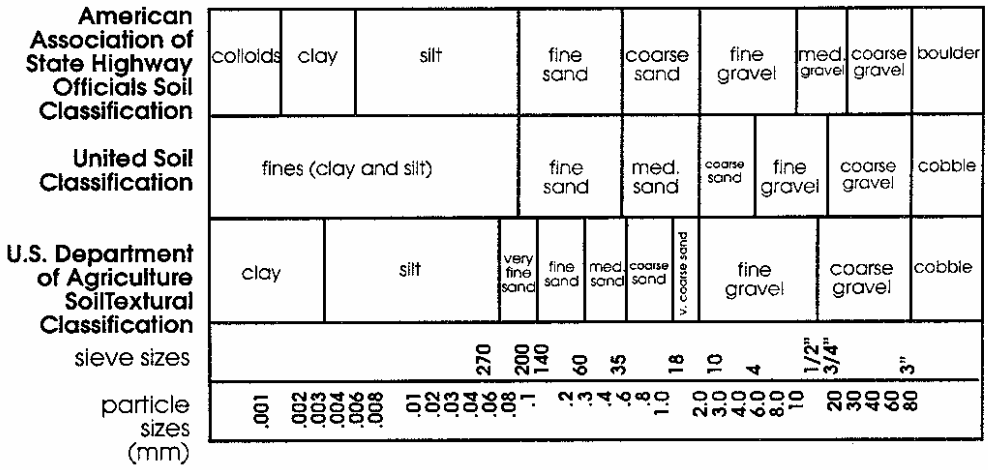
Soil texture is the relative proportion, by weight, of the soil particles finer than two millimeters. These particles are sometimes called the **fine earth fraction.** Materials larger than two millimeters are called **rock fragments.** These fragments influence moisture storage and infiltration, and they dilute the volume of soil material that can provide treatment of the effluent.

While most people have a good idea of what a sand particle looks and feels like, it's impossible to see a single clay particle with the naked eye, and it's difficult to imagine 0.002 millimeters. If a sand particle were magnified to a size ten inches in diameter, a silt particle in comparison would be about one inch in diameter and a clay particle about the size of a grain of sugar.

Soil texture classes are defined according to the distribution of the soil separates. The basic texture classes, in order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further subdivided into coarse, fine or very fine.

Textural classification systems include the U. S. Department of Agriculture (USDA) textural classes, the United Soil Classification, and the American Association of State Highway Officials (AASHO) Classification (see Figure B-12).

Figure B-12: A Comparison of Particle Size Limits in Three Classification Systems



Soil Separate Sizes

particle name	particle size range (mm)	sieve numbers
v. coarse sand	2.0 - 1.0	10 - 18
coarse sand	1.0 - 0.5	18 - 35
medium sand	0.5 - 0.25	35 - 60
fine sand	0.25 - 0.10	60 - 140
v. fine sand	0.10 - 0.05	140 - 270

The USDA textural classification was developed to reflect water movement in soils and is the system used in sizing onsite systems. USDA texture classes are given as percentages of sand, silt and clay. Figure B-13 is a diagram commonly called the soil textural triangle, which is used to identify the soil texture based upon the percent of sand, silt and clay. Be careful to enter the triangle along the proper lines for the three particle sizes. At any point on the soil triangle, the sum of the percentages of sand, silt and clay should total 100 percent.

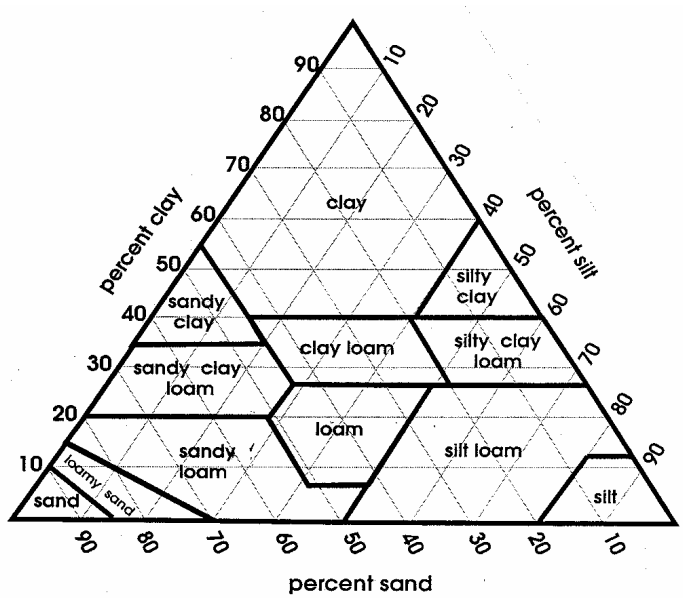


Figure B-13: USDA Soil Textural Classification

For example: Locate the point for a soil having 10 % clay, 40 % silt, and 40 % sand. A soil with this combination of particles is classified as a loam. Note that a clay loam can have as much as 45 % sand and still have the characteristic and percolation rate of a clay loam.

The Twelve Soil Textural Classes

Clay is a fine-textured soil material. When wet, clay is quite plastic and can be very sticky. When the moist soil material is squeezed, it forms a long, flexible ribbon; when moist and smeared, it is shiny. A clay soil material leaves a slick surface when rubbed with a long stroke and firm pressure. Due to its stickiness, clay tends to hold the thumb and forefingers together.

Silty Clay has characteristics similar to clay. It contains approximately equal amounts of silt and clay. It is both sticky and smooth-feeling.

Sandy Clay also has characteristics similar to clay. It has nearly equal parts sand and clay, and very little silt. It has a sticky feel. Individual sand particles may also be felt.

Clay Loam is a fine-textured soil. The moist soil material is plastic and will form a cast that will bear much handling; when formed into a long ribbon, it breaks readily. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.

Silty Clay Loam is a fine-textured soil similar to clay loam. It generally contains more silt than clay, and can have up to 20 percent sand. It has a slightly sticky feel, and is rather stiff. It also feels smooth or floury.

Sandy Clay Loam is composed primarily of sand with small, nearly equal, amounts of clay and silt and has charcteristics similar to clay loam. It is slightly to fairly sticky-feeling. Individual sand grains may be felt.

Silt is too fine to be gritty to the touch, but its smooth, slick, or greasy feel lacks any stickiness.

Silt Loam is a soil material having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called “silt.” When pulverized, it feels soft and floury. When moist, the soil readily runs together and puddles. It cannot be formed into a ribbon.

Loam is a relatively even mixture of sand, silt and clay. A loam feels somewhat gritty, yet fairly smooth and highly plastic. The term “loam” is not related to the term “topsoil.” Loam textures refer to the mineral fraction of the texture and not with how much organic matter (blackness) the soil has.

Sandy loam is similar to loam, but contains a higher percentage of sand, with enough silt and clay to make it somewhat sticky. Individual sand grains can be seen readily and felt.

Loamy Sand is a soft, easily squeezed soil that is only slightly sticky. Individual sand particles can be felt.

Sand is commonly loose and single-grained, but it may be cemented together. Individual grains can be readily seen or felt. Squeezed in the hand when dry, it falls apart when pressure is released and does not form a ribbon. Squeezed when moist, it forms a cast that crumbles when pressure is released or when touched. For adequate sizing of onsite systems in sand, the size of the sand grains must be determined.

Soil Texture Determination

While analysis of soil texture is done routinely by many laboratories, field texturing can provide the necessary accuracy. Therefore, expenditures of time and money for laboratory analyses are not necessary. Field estimates of textures are commonly within plus or minus one-half of the actual textural class. This uncertainty is even less when highly skilled individuals perform the field estimation.

Laboratory Analysis

Texture can be measured in the laboratory by determining the proportion of the various sizes of particles in a soil sample. The analytical procedure is called **particle-size analysis** or **mechanical analysis.** Stone, gravel and other materials greater than two millimeters are sieved out of the sample and do not enter into the analysis of the sample. The amounts are measured separately. Of the material smaller than two millimeters, the amount of the various sizes of sand is determined by sieving. The amount of silt and clay is determined by differential rate of settling in water. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very close but a few samples exhibit wide discrepancies, especially those with high organic matter or high soluble salts.

Detailed procedures are found in *Soil Survey Investigations Report No. 1., Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples*, 1972, by USDA-SCS. The amounts of sand, silt and clay derived from this method are plotted on the textural triangle to determine the soil texture.

Field Determination of Soil Texture

The determination of soil texture is made in the field mainly by feeling the soil with the fingers, and sometimes by examination under a hand lens. This requires skill and experience, but good accuracy can be obtained if the site evaluator frequently checks his or her estimation against laboratory results.

Soil samples of known textural classes can be obtained from:

PSCI
Tom Fenton
Iowa State University
Agronomy Building
Ames, IA 50011
515-294-2414
http://www.agron.iastate.edu/soilsurvey/#PSCI

To determine the soil texture, moisten a sample of soil one to two inches in diameter. There should be just enough moisture so that the consistency is like putty. Too much moisture results in a sticky material, which is hard to work. Press and squeeze the sample between thumb and forefinger. Press the thumb forward to try to form a ribbon from the soil. The amount of sand in the sample can be determined by “washing off” the silt and clay, and feeling for sand particles. Sand particles can be seen individually with the naked eye and have a gritty feel to the fingers. Many sandy soils are loose, but some are not. Silt particles cannot be seen individually without magnification; they have a smooth feel to the fingers when dry or wet. Clay soils are sticky.

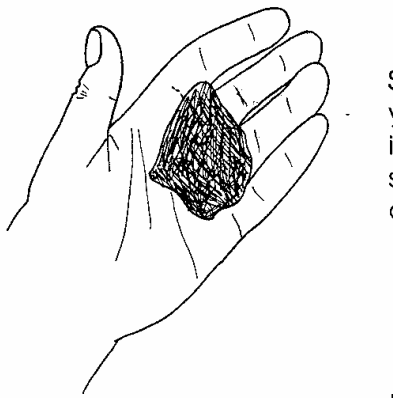
The way a wet soil “slicks out” or develops a long continuous ribbon when pressed between the thumb and fingers gives a good idea of the amount of clay present. If the soil sample forms a ribbon (loam, clay loam or clay) it may be desirable to determine if sand or silt predominate. If there is a gritty feel and lack of smooth talc-like feel, then sand very likely predominates. If there is not a predominance of either the smooth or gritty feel, then the sample should not be called anything other than a clay, clay loam or loam. If a sample feels quite smooth with little or no grit in it, and will not form a ribbon, the sample would be called silt loam.

The content of particles coarser than two millimeters cannot be evaluated by feel. The content of the coarser particles is determined by estimating the proportion of the soil volume that they occupy.

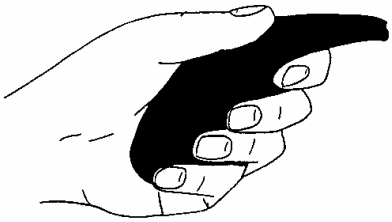
An experienced site evaluator can determine the texture of soil quite accurately using both feel and sight. A good estimate of the textural class can be made using the following procedure. Final sizing of systems without the aid of a percolation test should only be attempted by an experienced site evaluator with adequate training or by a soil scientist who can accurately determine the soil texture and structure.

Procedure

1. Moisten a sample of soil the size of a golf ball, but don't get it very wet. Work it until it is uniformly moist, then squeeze it out between your thumb and forefinger to try to form a ribbon, see figure B-14.



Squeeze a golf ball-sized piece of moist soil in your hand, then release the pressure. If the cast is crumbly, the soil is a **sand.** If the cast retains its shape, bounce it in your hand. If the bounced cast crumbles, the soil is a **sandy loam.**



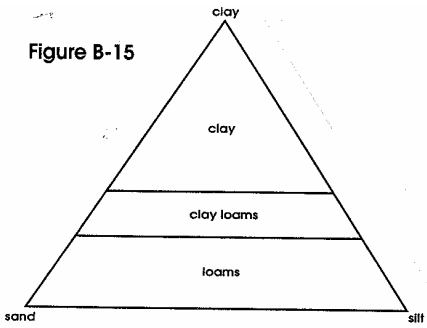
If the bounced cast retains its shape, try to form a ribbon by squeezing and pressing the soil between your thumb and forefinger. If the ribbon breaks when it is less than 1 inch long, the soil is a **loam.** A ribbon that breaks easily when 1 to 2 inches long indicates a **clay loam.** A ribbon more than 2 inches long indicates a **clay** soil.

Figure B-14: Soil Texture Determination in the Field

2. Second decision. If the moist soil is

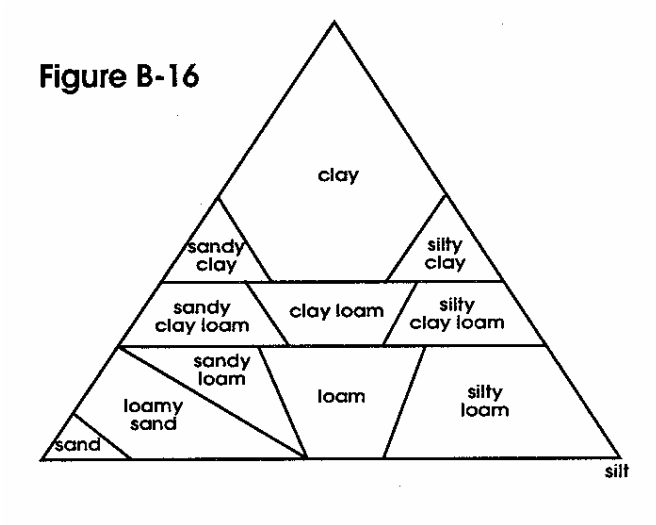
   a) extremely sticky and stiff: one of the **clays**
   b) sticky and stiff to squeeze: one of the **clay loams**
   c) soft, easy to squeeze, only slightly sticky: one of the **loams**
   See Figure B-15.

Figure B-15

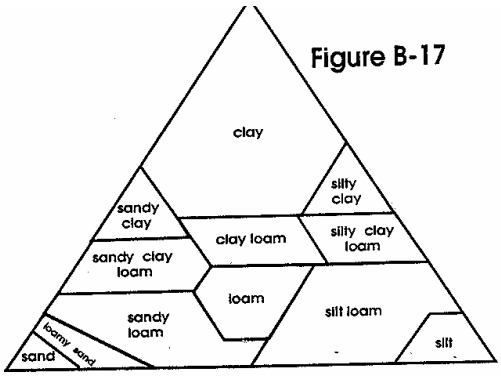


3. Third decision. Try to add an adjective to refine the description.
   a) The soil feels very smooth: **silt** or **silty**
   b) The soil feels somewhat gritty: no adjective
   c) The soil feels very, very gritty: **sandy**

4. At this point, the lines on the triangle jog a bit, and sandy loams are distinguished. If the soil is a sandy loam, determine the amount of sand present.
   a) Very sandy (85% to 100%): **sand**
   b) Quite sandy (70% to 85%): **loamy sand**
   c) Somewhat sandy (50% to 70%): **sandy loam** See Figure B-16.



5. To distinguish between silt loam and silt, consider how slick or floury the soil feels.
   a) very slick: **silt**
   b) somewhat slick: **silt loam**
   See Figure B-17, which is the same as Figure B-13, the USDA soil texture triangle.



Soil Structure

Soil structure has a significant influence on the soil's acceptance and transmission of water. Soil structure refers to the aggregation of the soil separates (sand, silt and clay) into clusters called **peds.** These peds are separated by surfaces of weakness. Some soil horizons contain simple structures, in which each ped is a single entity, without smaller peds contained inside. In many soil horizons, one or more sets of small peds are held together to form discrete bodies recognizable as larger peds. Se Figure B-18

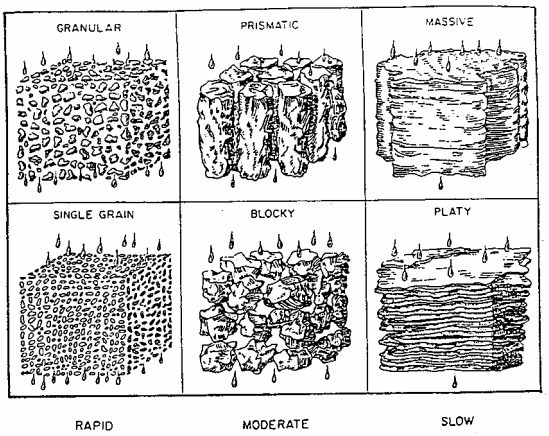


Figure 1. Types of soil structures and their influence on the rate of water movement. (Source: U.S. Department of Agriculture, 1959)

Figure B-18

If a percolation test is not to be conducted for final system sizing, a detailed analysis of the soil structure is necessary. A soil pit or large-diameter probe will be necessary to adequately examine the structure.

The sidewall of a soil pit should be carefully examined, using a pick or similar device, to expose the natural cleavage and planes of weakness. Cracks in the face of the soil profile are indications of breaks between soil peds. If cracks are not visible, a sample of soil should be carefully picked out and, by hand, carefully separated into the structural units until any further breakdown can only be achieved by fracturing.

Since the structure can significantly alter the water transmission of soils, more detailed descriptions of soil structure are sometimes desirable. Size of the structural units provide useful information to estimate hydraulic conductivities.

Clods and Soil Fragments

In Iowa, soil structure usually is developed only in the upper 3.5 to 5 or 6 feet of the soil profile. Soil structure types are distinct from one another in shape, size, grade (strength) and consistence (degree of force required to crush).

If enough force is used, any body of soil material can be broken into smaller pieces. The pieces are **peds** if their form and size are related to persistent planes of weakness. Other pieces that do not have orderly shape and size, or surfaces that indicate persistence, are *not* peds, and the layer is said to be **structureless** or **massive.** The term "massive" should not be taken to mean a hard, cemented layer. Most massive layers are relatively porous and friable to crushing. In these layers, pieces may be broken out, but they have random size and shape, and the same pieces might not form during another wetting and drying cycle. While structureless clayey soils are called massive, structureless sandy soils are called **single grain.**

Soil Structure Determination

In soils that have structure, the size, consistence, shape, and grade (distinctness) of the peds are described**.** Field terminology for soil structure consists of separate sets of terms designating each of these properties. The four terms for soil structure are combined in the order:

- grade
- size
- shape
- consistence

For example, "strong fine granular structure" describes a soil that separates almost entirely into discrete peds, with a range in size from five to ten millimeters, that are loosely packed and roughly spherical.

Grade

Grade describes the distinctness of peds. Determining grade in the field depends on the ease with which the soil separates into discrete peds and also on the proportion of peds that hold together when the soil is handled.

GRADE:
Massive- No observable aggregation, or no orderly arrangement of natural lines of weakness.

Weak- Poorly formed, indistinct peds, barley observable in place.

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

Strong- Durable peds that are quite evident in undisturbed soil, adhere weakly to one another, withstand displacement when soil is disturbed.

Size

There are five size classes: very fine, fine, medium, coarse, and very coarse. The size limits of these classes refer to the smallest dimension of plates, prisms, and columns, and vary according to the shape of the units. If units are more than twice the minimum size of "very coarse," actual size of units is specified. Figure B-19 gives the limits for the size classes for four shapes of soil units.

Figure B-19: Soil Size Classes

	size of structure (millimeters)			
	shape			
size class	platy	prismatic or columnar	blocky	granular
very fine	< 1	< 10	< 5	< 1
fine	1 - 2	10 - 20	5 - 10	1- 2
medium	2 - 5	20 - 50	10 - 20	2 - 5
coarse	5 - 10	50 - 100	20 - 50	5 - 10
very coarse	> 10	>100	> 50	>10

Shape

Several basic shapes of peds are recognized in soils. The following terms, along with Figure B-20, describe the basic shapes and related arrangement of peds.

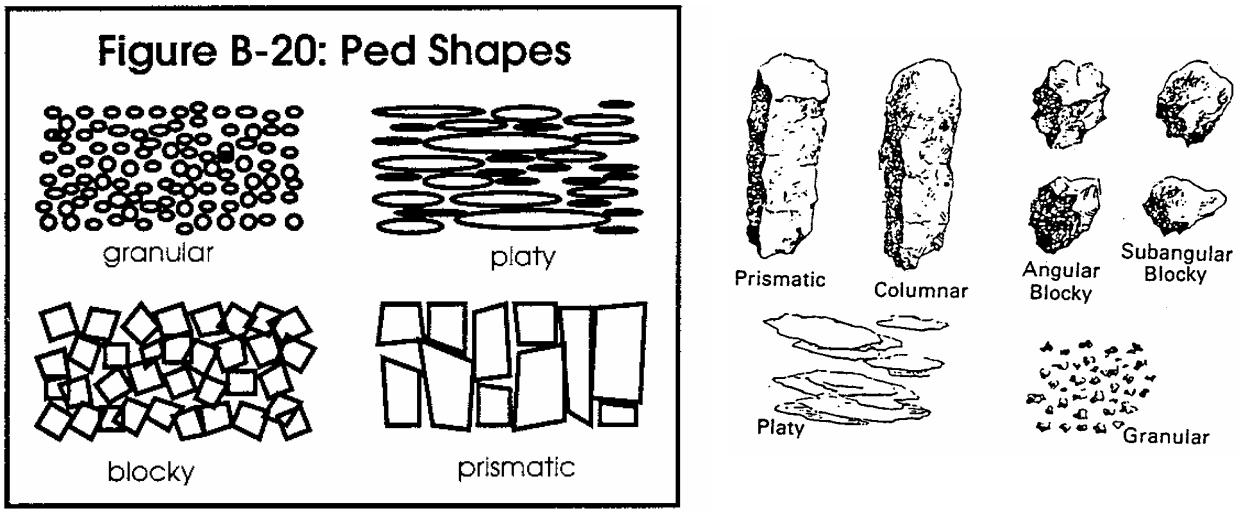


Figure B-20

- **Granular:** The peds are approximately spherical or polyhedral and are found in topsoils. These are the small, rounded peds that hang onto roots when soil is turned over.
- **Platy:** The peds are flat and platelike. They are generally oriented horizontally and are usually overlapping. Platy structure is commonly found in timbered areas just below the leaf litter or shallow topsoil.
- **Blocky:** The peds are block-like or polyhedral, and are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Blocky peds are nearly equidimensional but grade to prisms, which are longer vertically, and to plates, which are longer horizontally. The structure is described as angular blocky if the faces intersect at relatively sharp angles, and as sub-angular blocky if the faces are a mixture of rounded and plane faces, and the angles are mostly rounded. Blocky structure is commonly found in the lower topsoil and subsoil.
- **Prismatic:** The individual peds are bounded by flat or slightly rounded vertical faces. Peds are distinctly longer vertically, and the faces are typically casts or molds of adjoining peds. Prismatic structure is commonly found in the lower subsoil.

Consistence

Soil consistence in the general sense refers to “attributes of soil material as expressed in degree of cohesion and adhesion or in resistance to deformation on rupture. In the field, resistance of soil material to rupture is used. Consistence is highly dependent upon on the soil-water state and should be consistent. Therefore, it is recommended that moist or wet samples be used.

To determine the consistence place a one-inch, block-like specimen between thumb and forefinger. Stress applied in the hand should be over a one-second period, figure B-21

Moist consistence class	specimen fails under
loose	(Intact specimen not available
friable	slight force between fingers
firm	moderate force between fingers
extremely firm	moderate force between hands or foot pressure
rigid	foot pressure

Figure B-21

How Structure Affects Water Movement

Between soil peds are voids or pores. Pores *between* peds are often relatively large and continuous, when compared with the voids between the soil separates *within* the peds. The type of structure determines the dominant direction of the pores and hence, water movement in the soil. Soils with strong structure have distinct pores between peds. Well structured soils with large voids between peds will transmit water more rapidly than structureless soils of the same texture, particularly if the soil has become dry before the water is added. Small structural units create more pores in the soil than large structural units, but fine textured, massive soils (soils with little structure) have very slow percolation rates. See figures B-22

Figures B-22

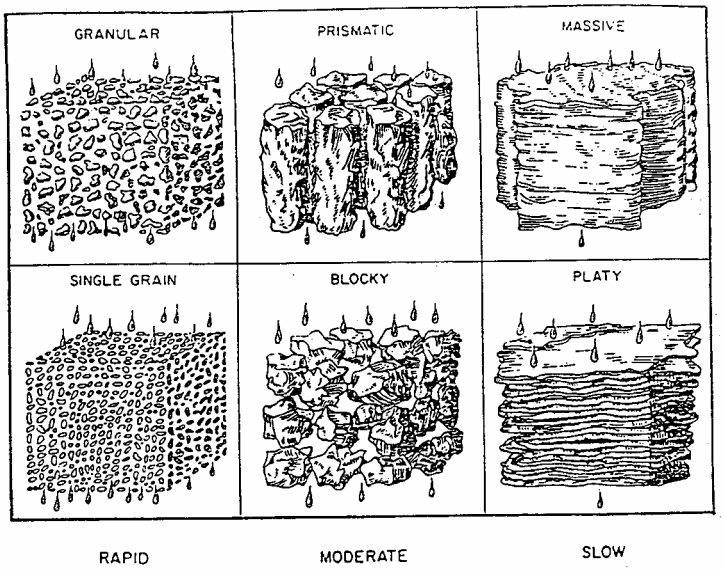


Figure 1. Types of soil structures and their influence on the rate of water movement. (Source: U.S. Department of Agriculture, 1959)

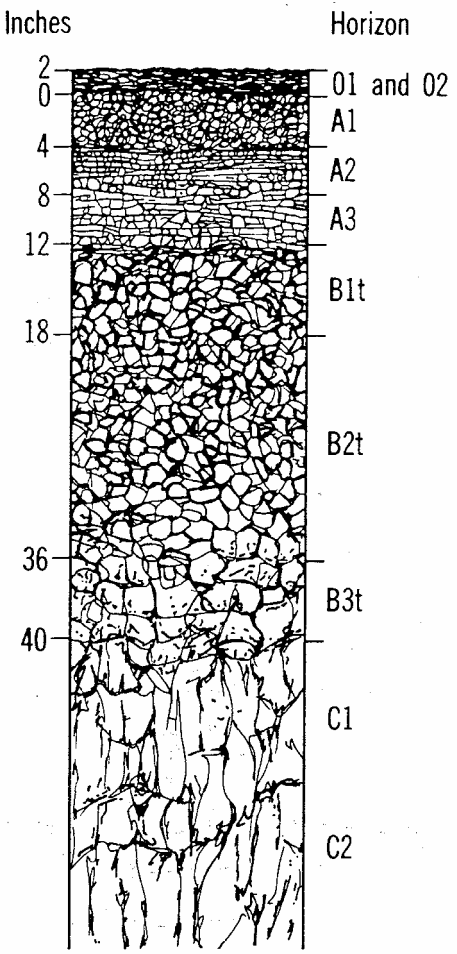


Figure 4. An example of a soil profile formed under mixed oak-hickory forest vegetation. The soil profile illustrates soil subhorizons, thickness of each subhorizon, and shape and size of soil structural units.

Research has shown that percolation rates are correlated with grade and shape of subsoil structure. Faster percolation rates can be expected where soil structure is present. Better soil structure can compensate for higher clay content in some cases. However, soils with well developed structure, such as soils formed under forest vegetation, generally have clay coating which swell

when moisten. Their presence reduces the rate of water movement.

Small peds and single-grained structures will have rapid percolation rates. Soils with granular, blocky, prismatic or columnar structures enhance flow both horizontally and vertically. Platy structures restrict downward movement of water because the ped faces are oriented horizontally. Platy structures are often associated with lateral (sideways) movement of water.

Structure is one soil characteristic that is easily altered or destroyed. Structure is very dynamic, changing in response to moisture content, chemical composition of soil solution, biological activity and management practices. Soils containing minerals that shrink and swell appreciably, such as montmorillonite clays, show particularly dramatic changes. When the soil peds swell upon wetting, the large pores become smaller and water movement through the soil is reduced. Therefore, when determining the hydraulic properties of a soil for wastewater disposal, soil moisture contents should be similar to that expected in the soil surrounding a soil disposal system.

The following tables are reprints of several state wastewater soil loading rates, and one that is used in some counties in Iowa.

In general, finer-textured soils cannot accept as much effluent as coarser-textured soils. Soils with more developed structures can accept more effluent than massive or weak-structured soils.

These values should be reviewed by the designer and modified to fit site specific conditions. There may be other site specific conditions that warrant adjusting the values.

This manual does not recommend one table over the other. We suggest that each county evaluate what is appropriate, work with the local engineers, onsite professionals, and with the local NRCS soil scientist to determine what is best in each area.

Loading rates prepared by Louis Boeckman, Union County sanitarian, january 2003

CLASS	SOIL TEXTURE % C*1	% S*2	PARENT MATERIAL *8	NAT VEG *3	GRADE *4	SOIL STRUCTURE TYPE *5	LOADING RATES G/SQ.FT.
			WIND BLOWN	P	0	sg	1.0
CS & S	< 10	> 85	&	T	0	sg	0.9
			ALLUVIUM	F	0	sg	0.8
			WIND BLOWN	P	0	sg	0.9
LS	< 15	70-90	&	T	0	sg	0.8
			ALLUVIUM	F	0	sg	0.7
			WIND BLOWN	P	1	g,sbk,pris	0.8
SL	< 20	43-85	&	T	1	g,pl,sbk,abk,pris	0.7
			ALLUVIUM	F	2	pl,abk,pris	0.6
			TILL(WI)	P	1	g,sbk,pris	0.75
	7-27	23-52	&	T	1-2	g,pl,sbk,abk,pris	0.65
L			ALLUVIUM	F	2	pl,abk,pris	0.6
			TILL(IES)	P	1	g,sbk,pris	0.6
	18-27	20-45	TILL(IES)	T	1-2	g,pl,sbk,abk,pris	0.55
			TILL(IES)	F	2	pl,abk,pris	0.5
			LOESS	P	1	g,sbk,pris	0.7
SiL	7-27	< 20	&	T	1-2	g,pl,sbk,abk,pris	0.65
			ALLUVIUM	F	2	pl,abk,pris	0.6
			LOESS	P	1	g,sbk,pris	0.65
SiL-SiCL	20-32	< 5	&	T	2	g,pl,sbk,abk,pris	0.55
			ALLUVIUM	F	2-3	pl,abk,pris	0.5
			LOESS	P	1-2	g,sbk,pris	0.6
	32-40	< 20	&	T	2-3	g,pl,sbk,abk,pris	0.45
			ALLUVIUM	F	3	pl,abk,pris	0.4
SiCL			PEDI-	P	1	g,sbk,pris	0.45
	27-40	5-20	SEDIMENT	T	2	g,pl,sbk,abk,pris	0.4
				F	3	pl,abk,pris	0.3
			OLD	P	1-3	g,sbk,pris	0.5
CL-SICL	27-40	25-45	VALLEY	T	2-3	g,pl,sbk,abk,pris	0.4
			ALLUVIUM	F	3	pl,abk,pris	0.3
			TILL(WI)	P	1	g,sbk,pris	0.7
	27-32	20-45	&	T	1-2	g,pl,sbk,abk,pris	0.6
			ALLUVIUM	F	2	pl,abk,pris	0.5
				P	1-2	g,sbk,pris	0.4
CL	32-40	20-45	ALLUVIUM	T	2-3	g,pl,sbk,abk,pris	0.3
				F	3	pl,abk,pris	0.2
			FIRM	P	1-2	g,sbk,pris	0.2
	32-40	20-45	TILL(PRE-IL)	T	2-3	g,pl,sbk,abk,pris	0.1
				F	3	pl,abk,pris	N/S
			ALL	P	1-3	g,sbk,pris,mas	N/S
SiC-C	> 40	< 45	OTHER	T	2-3	g,sbk,abk,pris,mas	N/S
			MATERIALS	F	3	pl,abk,pris,mas	N/S

DEFINTITIONS AND EXPLANATION OF TERMS:

***1 = Percent Sand (% S)**

***2 = Percent Clay (% C)**

***3 = Native Vegetation:**

P = **Prairie** formed under grass vegetation.
Use high range of loading rate.

T = **Transistion** formed under mixed grasses and tree vegetation.
Use the mean or average of low and high loading rates.

F = **Forest** formed under tree vegetation.
Use low range of loading rate.

***4 = Structure Grade:** (General use only. May be affected by soil development or alteration of the site.)

1 = weak - Poorly define individual peds.

2 = moderate - Well formed peds, but not distinct in undisturbed soil.

3 = strong - Durable peds, quite evident in place; will stand displacement.

***5 = Soil Structure:** (General use but may vary on specific site.)

sg = **single grain** - Generally loose with no structural units.
Associated with sandy soils.

g = **granular** - Irregular and rounded faces.
Associated with surface layers of prairies soils.

pl = **platy** - Flat & tubular-like units. Associated with soils formed in tree vegetation and in depressions of prairie vegetation.

sbk = **subangular bocky** - Sub-rounded and planar faces - lack sharp angles.
Associated with subsoil horizons of prairie and transition soils.

abk = **angular blocky** - Sharp anglar faces.
Associated with subsoil horizons in soils fromed under tree vegetation.

pris = **prismatic** - Vertically elongated units with flat tops.
Associated with lower transition horizons of subsoil horizons.

m = **massive** - no structural units - materials is a coherent mass.
Associated with substratum with no development of soils.

cdy = **cloddy** - Irregular blocks created by artificial disturbance by tillage or compaction.
Associated with surface layers of soils under cultivation or compaction by livestock or equipment.

***6 = Range of Loading Rates:** (Ratings are relative values.)

(Low rating = Forest vegetation)

(High rating = Prairie vestation)

***7 = Mean or average loading Rate:**

(Average rating = Transition vegetation)

***8 = Footage calculated for 3-Bedroom Home or 450 gallons per day water usage**

Formula = GPD/Loading Rate = Linear Loading Rate/Trench Width = Total Footage.

Example: 450 gpd/.5 LR = 900 LRR/2 Ft. TW = 450 Ft. TF

Natural drainage of soils:

All ratings assume drainage of soils are excessive, somewhat excessive, well or moderately well drained.

If drainage can be improved by curtain drains, loading rates can be reduced:
poorly drained deduct .1 from loading rate.
somewhat poorly drained deduct .05 from loading rate.

If drainage cannot be improved, then alternative system will need to be design or use only the soil material above the seasonal high water table.

***8 = Parent Materials:**

Till(WI) = Wisconsin Till

Till(IES) = Iowan Erosion Surface

Till(Pre-IL) = Pre-Illionian Till(Includes Kansan & Nebraskan Till)

Sediments include any mantle that may overlay another parent material.

Alluvium include soils formed on terraces or footslopes and toeslopes on flood plains.

Loess include soils formed in uplands and on benches along major streams.

Pedisediment formed in erosional sediments with loess over mantle and till is underlain. Loess and pedisediment are sometimes shallower than 5 feet to the depth of till

Table 83.44-2
MAXIMUM SOIL APPLICATION RATES
BASED UPON MORPHOLOGICAL SOIL EVALUATIONS
Wisconsin

Soil Texture	Soil Structure	Maximum Monthly Average $BOD_5 > 30 \leq 220$ mg/L TSS > 30 $\leq$150 mg/L (gals/sq ft/day)	Maximum Monthly Average $BOD_5 \leq 30$ mg/L TSS $\leq$ 30 mg/L (gals/sq ft/day)
Coarse sand or coarser	N/A	0.7	1.6
Loamy coarse sand	N/A	0.7	1.4
Sand	N/A	0.7	1.2
Loamy sand	Weak to strong	0.7	1.2
Loamy sand	Massive	0.5	0.7
Fine sand	Moderate to strong	0.5	0.9
Fine sand	Massive to weak	0.4	0.6
Loamy fine sand	Moderate to strong	0.5	0.9
Loamy fine sand	Massive to weak	0.4	0.6
Very fine sand	N/A	0.4	0.6
Loamy very fine sand	N/A	0.4	0.6
Sandy loam	Moderate to strong	0.5	0.9
Sandy loam	Weak, weak platy	0.4	0.6
Sandy loam	Massive	0.3	0.5
Loam	Moderate to strong	0.5	0.8
Loam	Weak, weak platy	0.4	0.6
Loam	Massive	0.3	0.5
Silt loam	Moderate to strong	0.5	0.8
Silt loam	Weak, weak platy	0.2	0.3
Silt loam	Massive	0.0	0.2
Sandy clay loam	Moderate to strong	0.4	0.6
Sandy clay loam	Weak, weak platy	0.2	0.3
Sandy clay loam	Massive	0.0	0.0
Clay loam	Moderate to strong	0.4	0.6
Clay loam	Weak, weak platy	0.2	0.3
Clay loam	Massive	0.0	0.0
Silty clay loam	Moderate to strong	0.4	0.6
Silty clay loam	Weak, weak platy	0.2	0.3
Silty clay loam	Massive	0.0	0.0
Sandy clay	Moderate to strong	0.2	0.3
Sandy clay	Massive to weak	0.0	0.0
Clay	Moderate to strong	0.2	0.3
Clay	Massive to weak	0.0	0.0
Silty clay	Moderate to strong	0.2	0.3
Silty clay	Massive to weak	0.0	0.0

Note: > means greater than
$\leq$ means less than or equal to
N/A means Not Applicable

terminology faster than or slower than when referring to percolation rates rather than greater than or less than.

Minnesota

Final Sizing of Onsite Systems from Soil Characteristics

The following is a DRAFT for the purpose of generating comments on the accuracy of sizing onsite systems without a perc test. This proposal is not intended to be used on wide scale until further refinement, or without proper skills in soil texturing and soil structure identification. This procedure currently does no have approval at the county level.

Loading Rate (SQFT/GAL/DAY)

Texture	Single Grain	Massive (no structure)	Structure Granular, Blocky, or Prismatic			Platy	
			Weak	Moderate	Strong	Weak	Moderate or Strong
Co. Sand & Gravel	needs liner size at 1.67 sqft/gpd		needs liner size at 1.67 sqft/gpd			needs liner size at 1.67 sqft/gpd	
Co. & Med. Sands	pressure serial size .83 sqft/gpd		pressure serial size .83 sqft/gpd			pressure serial size .83 sqft/gpd	
Fine & V. Fine Sands	$1.67_{0.6}$		$1.67_{0.6}$			$2.0_{0.5}$	
Sandy Loam		$2.0_{0.5}$	$1.67_{0.6}$	$1.27_{0.8}$	$1.27_{0.8}$	$1.67_{0.6}$	$5.0_{0.2}$
Loam		$2.2_{0.45}$	$2.0_{0.5}$	$1.67_{0.6}$	$1.67_{0.6}$	$2.2_{0.45}$	$5.0_{0.2}$
Silt Loam		$5.0_{0.2}$	$2.2_{0.45}$	$2.0_{0.5}$	$2.0_{0.5}$	$3.3_{0.3}$	$5.0_{0.2}$
Clay Loam		kidd kiss kinn size at 5.0 sqft/gpd	kidd kiss kinn size at 4.2 sqft/gpd	kidd kiss kinn size at 2.2 sqft/gpd	kidd kiss kinn size at 2.2 sqft/gpd	$3.3_{0.3}$	kidd kiss kinn size at 5.0 sqft/gpd
Clay <45% Clay				kidd kiss kinn liner size at 4.2 sqft/gpd	kidd kiss kinn liner size at 4.2 sqft/gpd		
Clay >45% Clay							

If soil is firm when wet, or hard or cemented when dry, the horizon (layer) is not suitable.

9/5F Values

Figure B-22 = not suitable = not found in nature

Slowly Permeable Layers

Slowly permeable layers occur in soils due to many geologic or soil forming events. They may be layers cemented by translocation and deposition of iron, calcium or clay. Dense layers (low porosity) are formed by the weight of glacial ice over soil parent material or by heavy construction equipment.

Other Soil Features

The site evaluator should be aware that there are other features in the soil which have not been previously described. They are important because the site evaluation may confuse some of these features with soil mottling caused by wetness. The site evaluator need not include these in his descriptions unless he feels the inclusion of these features clarifies that the variation in color is not caused by wetness.

B-6-1

Table 83.44-1
MAXIMUM SOIL APPLICATION RATES
BASED UPON PERCOLATION RATES
(Reports on file with county prior to July 2, 1994)
Wisconsin

Percolation Rate (minutes per inch)	Maximum Monthly Average $BOD_5 > 30$ mg/L ≤ 220 mg/L TSS > 30 mg/L ≤ 150 mg/L (gals/sq ft/day)	Maximum Monthly Average $BOD_5 \leq 30$ mg/L TSS ≤ 30 mg/L (gals/sq ft/day)
0 to less than 10	0.8	1.2
10 to less than 30	0.6	0.9
30 to less than 45	0.5	0.7
45 to less than 60	0.3	0.5
60 to 120	0.2	0.3
greater than 120	0.0	0.0

Note: > means greater than
$\leq$ means less than or equal to

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Table IIIa
Soil Absorption System Sizing Chart
(Lineal feet of absorption trench)

BASED ON 24" wide Lateral

Min. Per Inch	Two-Bedroom 300 gal/day[1]	Three-Bedroom 450 gal/day	Four-Bedroom 600 gal/day	Five-Bedroom 750 gal/day	Six-Bedroom 900 gal/day
1-5[2]	160 .94	200 1.13	260 1.15	340 1.10	400 1.13
6-15	200 .75	300 .75	400 .75	500 .75	600 .75
16-30	300 .50	400 .56	500 .60	600 .63	700 .64
31-45	400 .38	500 .45	600 .5	800 .47	900 .5
46-60	500 .30	600 .38	700 .43	900 .42	1,100 .41 (g/SF)

See Appendix A

TABLE 2—Design Septic Tank Effluent Loading Rates for Various Soil Textures and Structures

Group	Soil Characteristics Kansas	Wastewater Loading (in/day)	(cm/day)	(gpd/ft²)
I.	Gravelly coarse sand and coarser.	Not Recommended for conventional soil absorption system[5]		
II.	Coarse sands (not cemented).	1.8	4.6	1.1
III.	Medium sand with single grain structure and loose to friable consistence (not cemented).	1.5	3.7	0.9
IV.	Other sands and loamy sands with single grain or weak structure (not extremely firm or cemented consistence). Sandy loams, loams and silt loams with moderate or strong structure (except platy and loose to friable consistence).	1	2.5	0.6
V.	Sandy loams, silt loams and loams with weak structure (not of extremely firm or cemented consistence). Sandy clay loams, clay loams and silty clay loams with moderate to strong structure (not of platy, of firm, or of cemented consistence).	0.7	1.7	0.4
VI.	Sandy clay loams, clay loams and silty clay loams with weak structure (not massive, not of firm, or of cemented consistence.) Some sandy clays, clays and silty clays with moderate and strong structure (not platy, not of firm, or of cemented consistence).	0.4	1	0.25
VII.	Other soils of high clay content with weak or massive structure, extremely firm or cemented consistence or platy, clay pan, fragipan, and caliche soils.	Not Recommended for conventional soil absorption system[6]		

NOTE: The above descriptions are estimates and assume that the soil does not have large amounts of swelling clays. Soils with platy structure, massive, compacted or high density should be used with extreme caution or avoided.

[4]A trained and qualified person would include a soil scientist, such as one working for NRCS, environmental health specialist, sanitarian, or other person who has received appropriate soil training and through experience is competent.
[5]Soil is too coarse for conventional soil absorption designs, use pressure distribution dosing or other alternative system to prevent too rapid infiltration.
[6]Soils with these conditions may be acceptable for wastewater stabilization ponds or possibly other alternative systems. (See Table 6).

Soil Color

Soil color is an indicator of natural drainage conditions that were present at some time during soil formation. However, in some areas, soil color may be a relict condition related to past climatic and landscape conditions and not related to present natural drainage. One example is the Dow soil in western Iowa. It is important to be aware of the present environment in the area being evaluated.

Significance of Color

The color of the surface layer may be used to judge the organic matter content of the soil. Color may be a mark of the effects of past vegetation or human use or misuse of the soil. Some soils exhibit color directly inherited from the parent rock. These and other relationships are clues for identifying soils and appraising their properties.

There are primarily two coloring agents in the soil: organic matter and iron. Most people recognize the dark surface soil as being humus-enriched. The varying shades or red, yellow and gray of soils are usually due to the quantity and form of iron present. Red means that the iron is oxidized and not hydrated with water. Yellow indicates hydration and sometimes less oxidation. Gray indicates chemical reduction due to wetness and lack of oxygen. **Soil color is an indicator of natural drainage conditions.**

Soil horizons may contain many different colors. The colors are derived from either the native parent material or the soil-forming process. These processes may result in the formation of clay films, silts coats, organic stains, nodules, and oxides, all of different colors. One important soil-forming process that needs special attention is when the soil color indicates a saturated soil condition.

The presence of soil redoximorphic features ("**mottling**") is used to estimate saturated soil conditions throughout the world, and identification of these features help determine the depth of the seasonally high water table. These features identify soil subject to periodic saturation even when the soil is dry.

Organic matter content in a soil is commonly indicated by color, especially in temperate climates such as in Iowa. Dark-colored soils are generally high in organic matter. Soil colors usually range from pale brown to very dark brown or black as organic matter increases, if the horizon is not seasonally saturated. The depth of the dark color depends on the amount and distribution of organic matter. Alternate saturation and drying of the soil horizon results in various shades of gray, brown and yellow, called **mottling.**

Red color in soils is generally due to the natural material in which the soil has developed.

Sands are generally yellow due to iron oxides and small amounts of organic matter. When sands are periodically saturated, the colors are either gray or mottled or both.

Describing Color

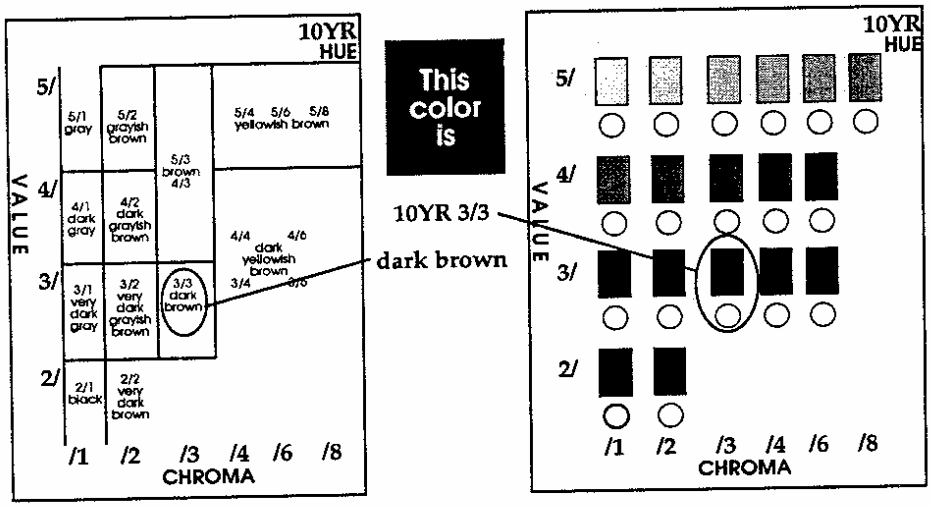
Color is composed of three variables:

- **Hue:** The dominant color, such as red, yellow, green, blue or purple.
- **Value:** The measure of the degree of darkness or lightness of color, in relation to the total amount of light reflected, such as light red or dark red.
- **Chroma:** The measure of the purity or strength of color, or its departure from a neutral of the same lightness, such as dull red or bright red.

Soil color is measured by comparison with a standard color chart. The chart used by site evaluators is the Munsell color system. The standard Munsell chart for soil color consists of about 175 different colored chips, systematically arranged on seven cards assembled into a loose-leaf notebook. Three additional cards, two for the reddest hues of soils and one for the bluish and greenish hues of grayed soils, are also available. (To order Munsell color books, refer to **Appendix B-3: Equipment and Suppliers.)**

The colors displayed on the individual color pages are of constant **hue,** designated by a symbol in the upper right-hand corner of the Munsell Color Chart. The color becomes lighter from the bottom of the card to the top by equal steps. **Chroma** increases from left to right, and grayness from right to left. Chroma notation is indicated by the horizontal scale across the bottom of the chart. The **value** notation of each chip is indicated by the vertical scale in the far left column of the chart. (See Figure B-23.) Opposite each page of color chips is a page of color symbols and corresponding English names, so that color can be expressed both by Munsell notation and color names.

Figure B-23



Read moist color of ped interiors with adequate light.

Conditions for Measuring Color

The quality and intensity of the light falling on a sample of soil affects the amount and quality of the light reflected from the sample to the eye. The moisture content of the sample and the roughness or smoothness of its surface also affect the amount and quality of the light reflected. The visual impression of color from the standard color chips is accurate only under standard conditions of light intensity and quality. As the color standards are used in the field, therefore, it is important that the light be white enough that the sample reflects its true color and that the amount of light be adequate for visual distinction between chips.

Color determination may be inaccurate early in the morning or late in the evening. When the sun is low in the sky, the light reaching the sample is somewhat red and the light reflected from the sample is redder than at midday. Even though the same kind of light reached the color standard and the sample, the reading of the sample color at these times is commonly one or more intervals of hue redder than at midday. Colors also appear different in the subdued light of a cloudy day than in bright sunlight. If artificial light is used, the light source used must be as near the white light of midday as possible. Intensity of the incident light is especially critical when matching soil to chips of low chroma and low value.

The color value of most soils becomes lower as the soil is moistened. Consequently, moisture state of the sample is given for each color determination. The soil can be moistened with water or, if wet, dried by blowing on a small ped. Changing the moisture content should continue until there is no further change in color value. Color determinations of wet soil may be in error because of the effect of light reflected from water films.

Mottling as an Indication of Zones of Soil Saturation

In Iowa, the presence of soil mottling is used as an indication of zones of soil saturation. For most soils, mottling and low chroma colors are good indicators of these zones.

Mottling that indicates periodic saturation is now called “redoximorphic features”. Whatever these soil features are called, they are formed in saturated soil by the processes of reduction, translocation, and oxidation of iron and manganese compounds.

In saturated soil with a temperature above 41F, bacteria soon deplete the available free oxygen needed to digest organic matter. Anaerobic bacteria remove oxygen from the iron and manganese compounds. Removing oxygen changes the iron and manganese compounds, making them water-soluble. These soluble compounds move with the soil water until an oxygen-rich zone is encountered.

Once they encounter the oxygen, the compounds precipitate from solution, accumulating as coatings of reddish or yellowish iron oxide or black manganese oxide on the faces of the peds, walls of pores, or channels, or as accumulations inside of peds (see Figure B-24).

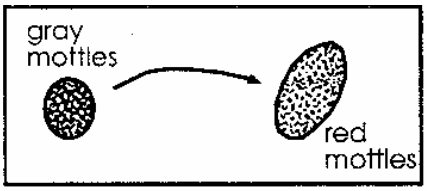


Figure B-24: Oxidation of Iron

Mottles often form *inside* soil peds in well-structured, medium-textured soils. Precipitated iron or manganese oxides also accumulate in pores or voids containing trapped air as cemented concretions or as three-dimensional concretions called **nodules.**

The area from which the iron and manganese oxides are removed becomes a light gray color, known as **gley.** When other properties are equal, the percentage of gley in the saturated zone is proportional to duration of saturation. In depressions, soils waterlogged with stagnant water have not been flushed of dissolved iron oxide. This results in bluish gray or greenish colors, implying that the soil is saturated for long periods.

Periodic saturation of soil cannot always be identified by mottles. Some soils can become saturated without the formation of mottles, because one of the conditions needed for mottle formation is not present. Some soils are wet for significant periods, but the water contains sufficient oxygen to maintain bright, unmottled soil colors. Some soils are wet only during winter when soil temperatures are so low that soil bacteria have a very slow rate of respiration, and chemical reactions virtually stop. These soils are wet only when the processes that would cause mottles and gray colors do not operate.

Mottles will not form during soil saturation under the following conditions:

- the water contains sufficient oxygen to serve the biological needs for organic matter digestion and
- soil or water temperatures are below 41F during the period when a soil zone is saturated, preventing the bacterial activity needed to form mottles.

Experience and knowledge of moisture regimes related to landscape position and other soil characteristics are necessary to make proper interpretations in these situations.

Data furnished on the depth to zones of soil saturation within the soil survey reports can help the site evaluator determine whether the use of the mottling criteria is applicable in a specific area. There are some soils that show mottling characteristics that do not have zones of soil saturation. For instance, once gray coloration or soil mottles are formed, they will remain intact even if the geologic climate changes or if the soil is artificially drained. However, these are a small minority of cases, so that the use of mottling to indicate saturation is generally a good procedure.

Describing Mottling or Redox Features

The color of each layer is recorded in soil descriptions. The aggregate of descriptions of each individual layer describes the color pattern of the soil.

Soil mottles are the soil colors that are in the minority if two soil colors are present (see Figure B-25). Soil mottles commonly are rusty-colored spots in the soil, but may be any color.
Color pattern within soil horizons are described for:

- matrix color (dominate color)
- mottle color (minority color)
- color of soil features (such as silt coats, clay films, organic coats)

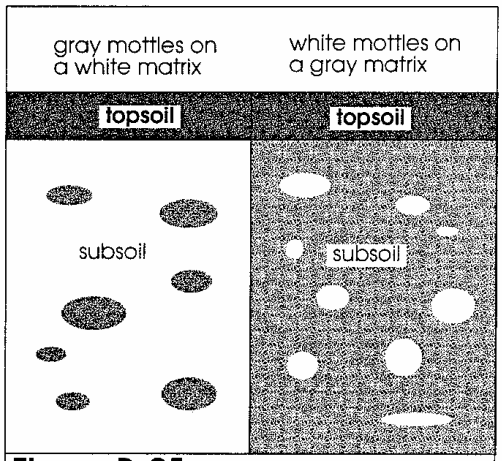


Figure B-25

When looking at a single unbroken ped, you may be viewing a coating on the ped. This coating can be organic material, silt, clay or an iron compound. Breaking or crushing (but not rubbing) will reveal the color of the ped interior, as shown in Figure B-26. If the ped interior has two or more colors, the majority

color is considered the matrix color, and the minority color is the mottled color. If the ped is not coated you will be viewing the matrix and any mottle colors at the ped surface.

The ped exterior, ped interior, and mottle colors should be recorded. The physical state of the sample should be recorded as broken, crushed or cut. In mottled soils with thick ped coatings, the color and patterns of faces of peds, and those of a surface broken through the peds can be markedly different (see Figure B-26). The soil must be in a moist state when examined.

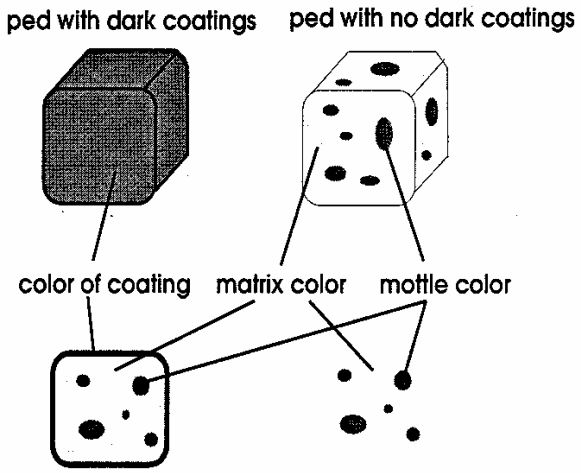


Figure B-26: Broken Peds Cross Section

Contrast refers to the degree of visual distinction that is evident between mottle and matrix colors. Contrast may be described as faint or distinct.

- **Faint:** Evident only on close examination; hue and chroma of mottles and matrix are similar.
- **Distinct:** Readily seen; soil color varies by one or more hue, more than two units of value, or more than one chroma.*

An example of distinct mottles is “pale-brown (10YR 6/3) fine sand, with many coarse, prominent, reddish-brown (5YR 5/4) mottles.” Soil colors are determined by comparison with a standard set of colors as found in the Munsell color chart.

Reading the Color

1. Take a ped from the horizon to be examined. Do not crush or break the ped.
2. Adjust the water content of the ped to “moist.”
3. Estimate the basic soil color (see Figure B-27), and turn to the appropriate Munsell page.

Figure 27

Estimate	Munsell Color
red	10YR to 7.5 YR
brown	10YR
olive	2.5Y or 5Y
gray	5Y

4. With the sun at your back, hold the sample behind the holes of the page. Match as closely as possible.
5. If you are not satisfied with the match, flip the page forward for browner or redder colors, backward for more olive or gray colors.
6. Record the chosen color or colors.
7. Break, cut or crush (but do not rub) the ped to see if the ped interior differs in color from the ped surface. If so, repeat steps 3 to 6 above for the ped interior.

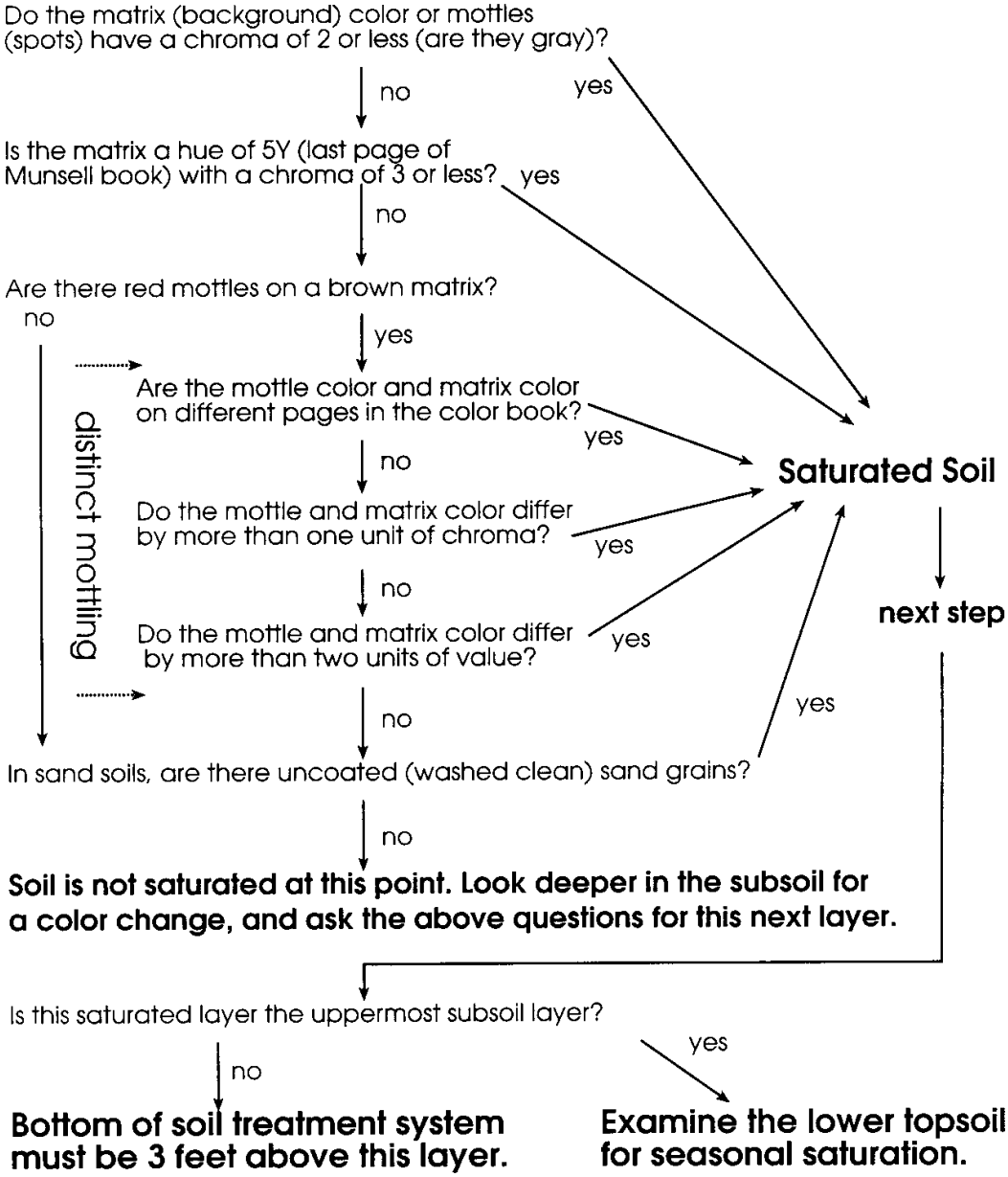
Rarely will the color of the sample be perfectly matched. Select the closest match.

Color Interpretation

Site evaluators must understand not only the mechanics of using Munsell Soil Color Charts, but also how to interpret the meaning of the colors that are described. The color and color patterns in soil are good indicators of the drainage characteristics of the soil. Soil properties, location in the landscape and climate all influence water movement in the soil. These factors cause some soils to be saturated or seasonally saturated, affecting their ability to absorb and treat wastewater. Interpretation of soil color aids in identifying these conditions. Figure B-28 illustrates the process of using color to determine soil saturation.

Figure B-28: Saturated Soil Determination

Determine the soil color using the Munsel color book.
Start with the upper subsoil. Subsoil is the first layer below an E horizon



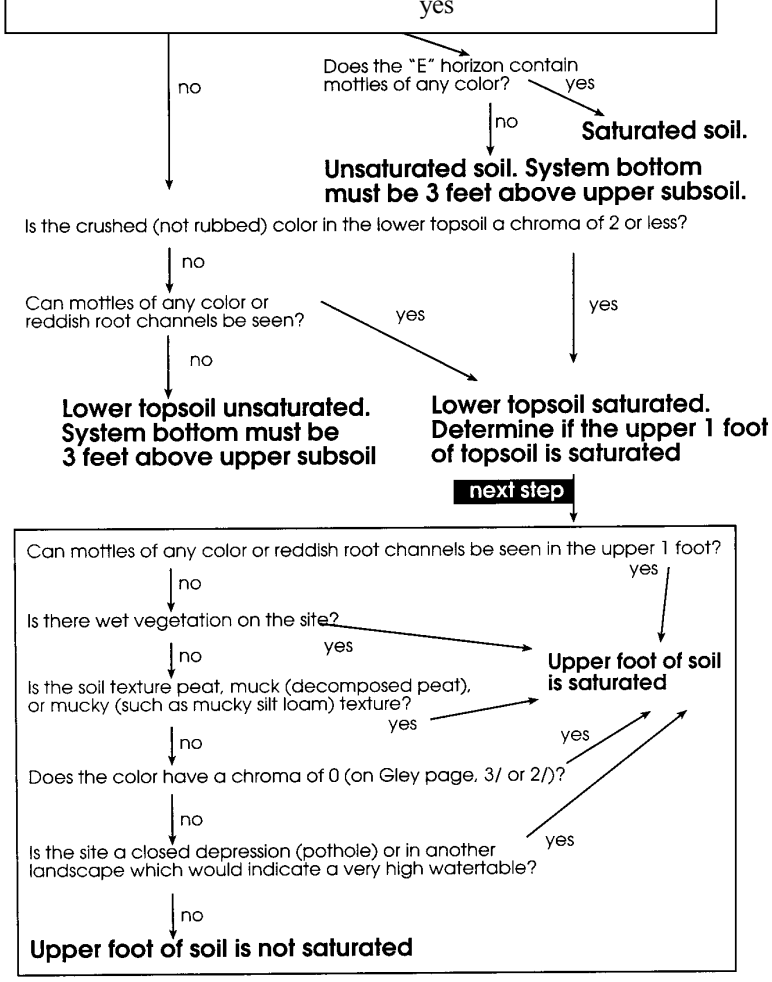
Uniform reddish or brownish soil colors will indicate horizons that are well drained and consistently provide adequate oxygen to provide treatment of effluent. Typically as you go deeper into the soil, it becomes duller in color and mottled. As the abundance and contrast in soil mottles increases, the soil is having difficulty removing the natural precipitation at the site. Gray, olive or bluish colors, with or without mottles, are associated with poor drainage and lack of oxygen.

Topsoil Color

Topsoil is a natural soil layer with a color value less than 3.5, where subsoil has a layer with color greater than or equal to 3.5.

Commonly, dark colors suggest more organic matter than light colors. Humified organic material is commonly dark, however, raw organic material, such as peat, is not necessarily dark. Some soils are nearly black because of organic coatings on peds, but when the peds are crushed, the soil appears significantly lighter. In other soils, the organic matter is disseminated throughout the peds. Usually soils with poorer drainage have deeper, thicker topsoil than well-drained soils in adjacent areas. Figure B-29 describes a process for determining the depth of saturated topsoil.

Figure B-29: Topsoil Examination



Other Soil Features

The site evaluator should be aware that there are other features in the soil which have not been previously described. They are important because the site evaluation may confuse some of these features with soil mottling caused by wetness. The site evaluator need not include these descriptions unless he feels the inclusion of these features clarifies that the variation in color is not caused by wetness.

The presence of iron and/or manganese nodules, particularly in a pale-colored soil matrix, often indicates periodic saturation. Although nodules are not a color, they are often associated with soil colors indicating wetness. Nodules or concretions may be indicative of slow percolation rates, restrictive horizons and/or a seasonal water table. The case for rejecting a proposed drainfield site solely on the presence of nodules is not strong, but nodules are a good indicator of soil/site moisture conditions.

The features discussed here are identifiable bodies embedded in the soil. Some of these bodies are thin and sheetlike; some are spherical; others have irregular shapes. They may contrast sharply with the surrounding material in strength, composition or internal organization.

Nodules and Concretions

Nodules and concretions are discrete bodies. They are commonly cemented. They may also be uncemented but coherent units that separate from the surrounding soil along clearly defined boundaries. They range in composition from material dominantly like that of the soil to concentrations of nearly pure chemical compounds(see Figure B-30).

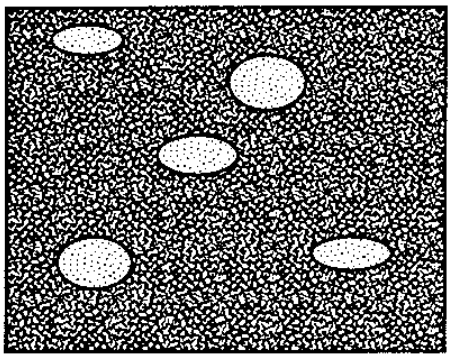


Figure B-30: Nodules

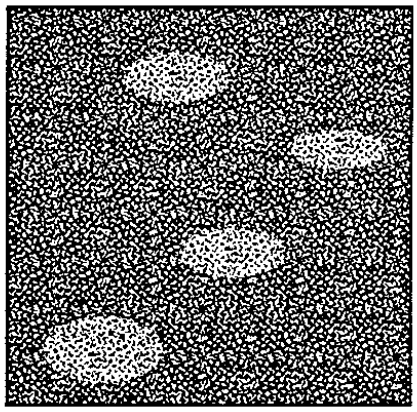


Figure B-31: Soft Accumulations

Soft Accumulations

Soft accumulations contrast with the surrounding soil in color and composition but are not easily separated as discrete bodies, although some have clearly defined boundaries. Most soft accumulations consist of calcium carbonate, iron and manganese (see Figure B-31).

Soft Rock Fragments

Soft rock fragments have rock structure, but break down easily.

Surface Features

The surfaces of individual peds may have coats of a variety of substances unlike the adjacent soil material and covering part or all of the surfaces. Descriptions of surface features may include kind, location, amount, continuity, distinctness, and thickness of the features. In addition, color, texture and other characteristics that apply may be described, especially if they contrast with the characteristics of the adjacent material.

Roots and Root Traces

The presence of roots in each layer is recorded in soil descriptions. The absence of roots or the orientation of roots may indicate hardpan, saturated soil, or bedrock, see Figure B-32.

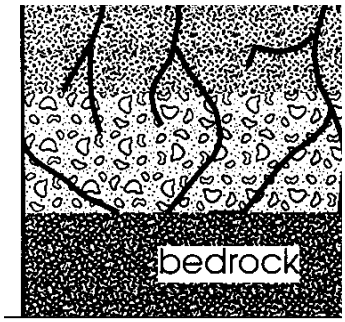


Figure B-32
Roots and Root Traces

Part IV: Soil Drainage

The flow of water in soil depends on the soil's ability to transmit the water and the presence of a force to drive the water. An understanding of how water moves into and through soil is necessary to predict the potential of soil for wastewater absorption and treatment.

The movement of water through the soil is controlled by landscape, internal soil properties, and environmental factors. Soil properties influencing water movement include cracks, coarse fragments, soil structure, total porosity, size, continuity of pores, and water content of the soil. Environmental factors include form and intensity of precipitation, evapotranspiration, and temperature.

Terms Used to Describe Drainage

Bulk density is an indicator of the total porosity of the soil. It is calculated as the weight of a given volume of soil which includes pore spaces. An average bulk density is 1.3 grams per cubic centimeter. Coarse-textured soils will usually have a higher bulk density because they have less pore space than fine-textured soils.

Porosity, or the amount of void space between soil particles, ranges from 40 to 50 percent. In disturbed soils or hardpans, porosity can be much less. Texture, structure, and organic matter are all important in determining soil porosity. Coarser-textured soils have larger pores, but less pore space than finer-textured soils.

Lower horizons in the soil profile tend to have higher bulk densities than upper layers. Subsoils are generally more compacted because of the overlying weight of the upper soil. They usually contain less organic matter, and thus a less open structure. Often subsoils accumulate clays and iron oxides that have washed down from the upper horizons. These clay particles become trapped in larger pores, reducing the overall pore space.

Percolation rate or **perc rate** is the length of time it takes for a depth of water to be absorbed by the soil. It's measured in minutes per inch (mpi). (See **Appendix B-1: Running a Percolation Test.)**

Permeability is a measure of the ease of fluid flow through porous media, and is proportional to the porosity of the media. Permeability is measured in inches per hour.

To convert from permeability units to percolation units, divide the permeability value into the number 60. For example:

60 in./hr. ÷ 0.2 = 300 minutes per inch (mpi).

To convert from percolation rate units to permeability units, divide the percolation rate into 60. For example:

30 mpi = 60 ÷ 30 = 2 inches per hour (in/h).

Soil texture is used as an indirect indicator of soil permeability. Generally, the higher the percent clay in a soil horizon, the slower the percolation rate. But texture alone cannot be used to determine the final sizing of systems. For

instance, a sandy loam soil is *likely* to have a percolation rate in the six to 15 mpi range, however, it is entirely *possible* that a sandy loam soil could have a percolation rate much slower, if the soil had been compacted or cemented by natural processes or human activity.

Hydraulic Conductivity

Hydraulic conductivity is the rate of water movement within the soil. It is a measure of the ease with which water moves through the soil, and is measured in centimeters per hour or feet per day. Soils higher in clay contain more pore space than soils high in sand, but the individual pore spaces are smaller. As the clay content of soils increases, hydraulic conductivity decreases. (See Figure B-33.)

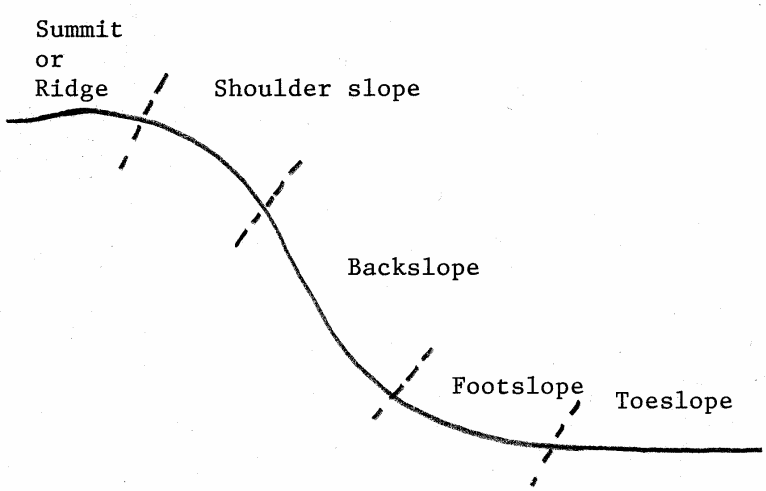
Figure B-33: Porosity and Conductivity of Soils

texture class	mean total porosity %	saturated conductivity (K_S) ft/day
sand	43.7	16.54
loamy sand	43.7	4.81
sandy loam	45.3	2.04
loam	46.3	1.04
silt loam	50.1	0.54
sandy clay loam	39.8	0.34
clay loam	46.4	0.18
silty clay loam	47.1	0.12
sandy clay	43.0	0.09
silty clay	47.9	0.07
clay	47.5	0.05

From Rawls et al., 1989. Estimating soil hydraulic properties from soil data.

Sands and gravelly soils in many landscape positions (e.g summit, shoulder, or back slope - see Figure B-34) can transmit water downward so readily that the soil or layer remains moist for no more than a few hours after a thorough wetting. These soils have large connected voids.

Figure B-34



Sandy loam, loam, and loamy sand commonly remain moist for no more than a few days after thorough wetting. These soils commonly have weak to moderate structure. These soils are often considered favorable for rooting and for supplying water to plants.

Clayey soils commonly transmit water downward so slowly that they remains moist for a week or more after a thorough wetting.

Other soils with low hydraulic conductivity may be structureless or have only fine and discontinuous pores (as in some clays, fragipans or cemented layers). Layers may be massive or platy. There may be few connecting pores that could conduct water when the soil is wet.

Hydraulic conductivity does not necessarily describe the ability of soils, in their natural setting, to dispose of water internally. A soil may have very high conductivity, yet contain free water because there are restricting layers below the soil, or because the soil is in a depression where water from surrounding areas accumulates faster than it can pass through the soil. Therefore, the water may actually move very slowly despite the soil's high conductivity.

Actual rate of water movement is a product of the hydraulic conductivity and the **hydraulic gradient.** The hydraulic gradient at any point is determined by the elevation of that point relative to some reference level. Thus, the higher the water above this reference, the greater its gravitational potential.

Hydraulic conductivity is highly variable. Measured values for a particular soil series can vary by 100-fold or more. Hydraulic conductivity can be given for the

soil as a whole or for a particular layer or combination of layers. The layer with the lowest value determines the hydraulic conductivity classification of the soil.

The above discussion relates to water movement in soils that are saturated with water. However, distinction needs to be made between saturated hydraulic conductivity and unsaturated hydraulic conductivity.

Saturated Flow

Saturated hydraulic conductivity is the greatest rate at which water can move through the soil. Saturated flow occurs when the soil is saturated or nearly saturated. When all the pores are filled with water, most of the water flows by gravity through the large pores. Saturated hydraulic conductivity is a function of such soil properties as pore size distribution, pore geometry, total porosity (water-filled porosity at saturation), and clay mineralogy. Water moves much more easily through large pores than through small ones. The size and continuity of pores in a soil largely determines the rate of internal water movement.

Cracks, structure, coarse fragments and porosity determine the cross-sectional area available for water movement through a soil. Decreasing the cross-sectional area available for flow decreases the rate and amount of water movement through the soil. Sands have the smallest number of pores, yet sands have the fastest percolation rates. This is due to the large pores in sands. Pores in sand are also fairly continuous. While porosity in clayey soils is large, the majority of the pores are very small. Trapped air decreases flow if the soil has free water or water at very low tension, because the air bubbles act like coarse fragments and block water flow.

Unsaturated Flow

Water flow is unsaturated when the soil water is under tension (negative pressure). Unsaturated hydraulic conductivity is a function of the same soil properties as saturated hydraulic conductivity and also of the soil water content. Unsaturated flow is always slower than saturated flow.
The ability of the soil to draw or pull water into its pores is referred to as its **matric potential.** The matric potential is produced by the affinity of water molecules to each other and to solid surfaces. Molecules within the body of water are attracted to other molecules by cohesive forces, while water molecules in contact with solid surfaces are more strongly attracted to the solid surfaces by adhesive forces. The result of these forces acting together draws water into the pores of the soil. The water tries to wet the solid surfaces of the pores due to adhesive forces and pulls other molecules with it due to cohesive forces.

The driving force behind unsaturated flow is not gravity, but a soil tension force (sometimes called “capillary attraction,” “wicking action” or “sucking power”). Under unsaturated conditions, the largest pores drain first since they are able to exert the least tension or sucking power. Water is pulled or sucked through the

smaller pores. Since clays have smaller pores, they can actually transmit water faster under unsaturated conditions than sands.

Water moving by unsaturated flow is moving due to tension, not gravity, so it does not have to go down, but can move sideways or even up, to wherever the soil is the driest. The presence of lush, green grass over the drainfield is evidence of this capillary movement of unsaturated flow of water. Figure B-35 shows how as a biomat develops in a trench, flow under the trench becomes entirely unsaturated.

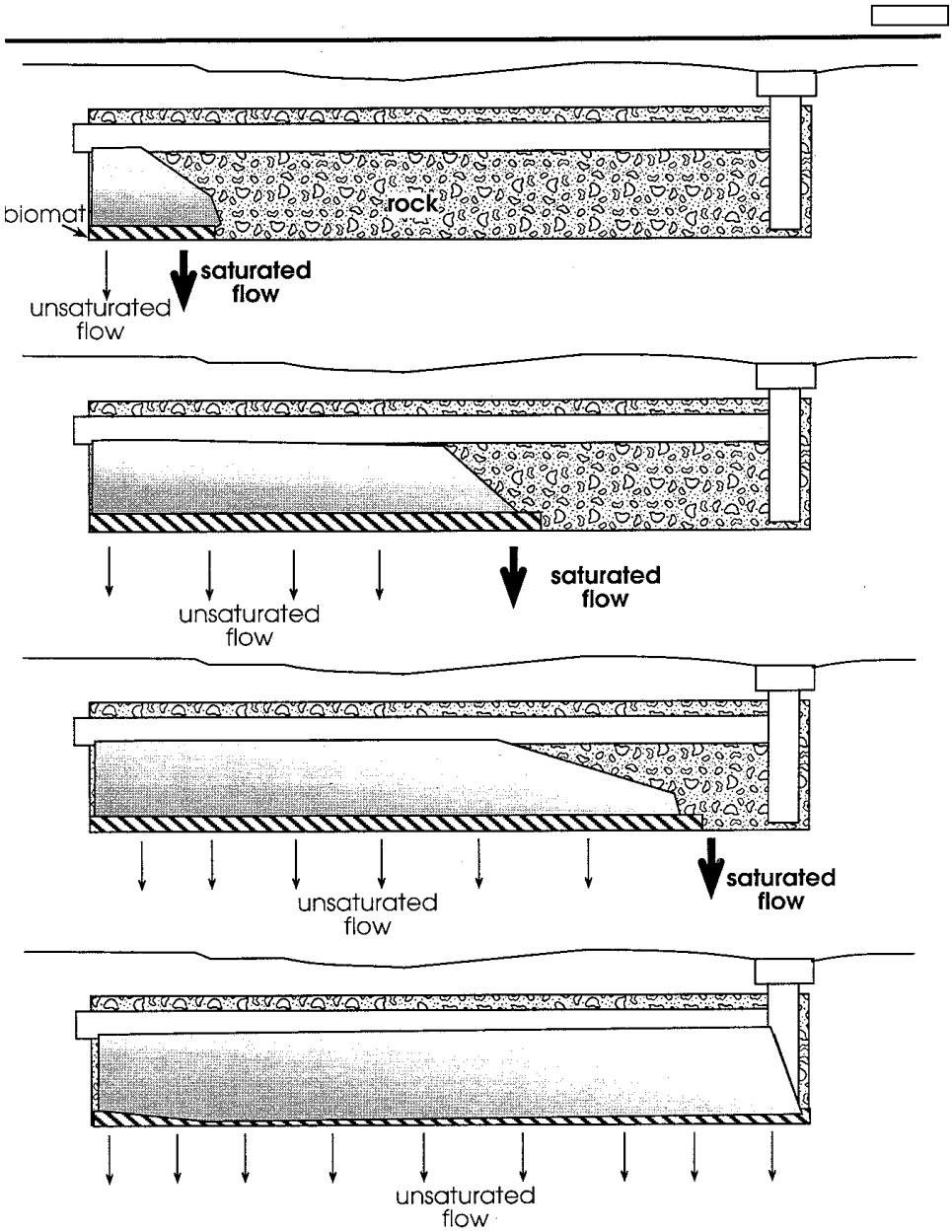


Figure B-35: Biomat Development in a Trench

Percolation Rates and Sizing Systems

Figure B-36 presents the soil sizing factors used for the various ranges of percolation rates.

NOTE: These values are approximations based on averages in soils and should only be used when there is a through knowledge of the percolation test methods and site conditions.

Figure B-36: Soil Characteristics and Required Areas for Sewage Treatment (> 3' separation)

percolation rate in minutes per inch (mpi)	common soil texture	square feet per gallon per day	gallons per day per square foot
faster than 0.1*	coarse sand	0.83	1.20
0.1 to 5	medium sand, loamy sand	0.83	1.20
0.1 to 5	fine sand**	1.67	0.60
6 to 15	sandy loam	1.27	0.79
16 to 30	loam	1.67	0.60
31 to 45	silt loam	2.00	0.50
46 to 60	clay loam, silty clay loam, sandy clay loam	2.20	0.45
over 61***	clay, silty clay, sandy clay	4.2	—

*Soil too coarse for sewage treatment; use systems for rapidly permeable soils.
**Soil having 50% or more fine sand plus very fine sand.
***Soil with too high a percentage of clay for installation of a standard in-ground system

Note that the soil sizing factor increases as the percolation rate slows down. A percolation rate of 60 means that it takes 60 minutes (one hour) for the liquid level to drop one inch in the percolation test hole. A percolation rate of 30 means that it requires 30 minutes for the one inch drop to occur. It is correct to say that 60 is a slower percolation rate than 30. Use the terminology ***faster than*** or ***slower than*** when referring to percolation rates rather than *greater than* or *less than.*

Permeability

Permeability is the rate of water movement through a saturated soil in inches per hour. The percolation test measures only the rate of the drop of water in a test

hole of a specific diameter and does not measure the rate of movement of water through the soil. However, the relative values for permeabilities will give some index of the ability of soil to transmit water. A very slow permeability also indicates a soil which is relatively high in fine material such as silt and clay and thus, may need extreme care during the installation of the soil treatment system.

Slowly permeable layers occur in soils due to many geologic or soil-forming events. They may be layers cemented by translocation and deposition of iron, calcium or clay. Dense layers (low porosity) are formed by the weight of glacial ice over soil parent material or by heavy construction equipment.

Soil Drainage Classes

Seven drainage classes are recognized. The first two, **excessively drained** and **somewhat excessively drained,** describe soils that are dry longer than is typical for the dominant soils of an area. **Well drained** soils are neither unusually dry nor unusually wet. Increasing degrees of wetness limit use of **moderately well drained, somewhat poorly drained, poorly drained** and **very poorly drained soils.**

The following definitions were developed for agronomic purposes, but the basis for water movement and retention given under the definitions can be used for sewage treatment.

- **Excessively drained:** These are soils that have very high and high hydraulic conductivity, and low water-holding capacity. Water table depths are greater than six feet.
- **Somewhat excessively drained:** These soils have high hydraulic conductivity and low water-holding capacity. Water table depths are greater than six feet.
- **Well drained:** These soils have intermediate water-holding capacity. They retain optimum amounts of moisture, but they are not saturated close to the surface.
- **Moderately well drained:** These soils are wet close enough to the surface for long enough that planting or harvesting operations or yields of some field crops are slightly adversely affected. Moderately well drained soils commonly have a layer with low hydraulic conductivity, wet state relatively high in the profile, additions of water by seepage or some combination of these.
- **Somewhat poorly drained:** These soils are wet close enough to the surface or long enough that planting and harvesting operations and/or crop growth are restricted. Somewhat poorly drained soils commonly have a layer with low hydraulic conductivity, wet state high in the profile, additions of water through seepage or a combination of these.
- **Poorly drained:** These soils commonly are wet at or near the surface during a considerable part of the year so that field crops cannot be

grown under natural conditions. Poorly drained conditions are caused by a saturated zone, a layer with low hydraulic conductivity, seepage or a combination of these.

- **Very poorly drained:** These soils are wet to the surface most of the time. These soils are wet enough to prevent the growth of important crops (except rice) unless artificially drained.

Water Tables

Saturated soil conditions are also known as **groundwater** and **the water table.** The relationship between soil and water is critical in evaluating the use suitability for a soil. Soil wetness should be characterized by identifying the depth to the uppermost zone of saturation and the approximate duration of that saturation.

Saturated soil conditions are detrimental to onsite soil absorption systems. Failures occur both in the movement of effluent into the soil and in its treatment. Premature system failure due to saturated soil conditions can be because of

- soil flowing at saturation and clogging the gravel beds or the distribution piping,
- accelerated clogging of the system area by bacteria that operate during saturated or wet soil conditions, *or*
- slow or no movement of effluent out of the system because the soil is already filled with water and is unable to accept additional liquid.

All of the preceding situations lead to effluent either surfacing on the ground or backing up into the home.

Treatment of effluent is not effectively achieved in saturated soil. Contamination of drinking water wells can occur when untreated effluent enters groundwater.

Knowledge of the times and depths at which a soil is wet is important to determine if the soil is suited for onsite sewage treatment. Free water exerts a strong influence on the physical, biological and chemical processes that are necessary for sewage treatment and disposal.

Soil wetness is influenced by climate, slope and landscape position as well as by permeability characteristics of the soil. Precipitation, runoff, amount of moisture entering the soil and rate of water movement through the soil along with evaporations, affect the degree and duration of wetness. Different areas of the same soil may differ in wetness because of landscape position. A soil in a higher position may be deeper to the water table or have a shorter duration of wetness than the same soil downslope. In determining where onsite systems can be located, saturated soil is considered the highest elevation in the soil where redoximorphic features (mottling) is present.

Zones of soil saturation change from day to day, season to season and year to year. Following periods of brief heavy rains, soil moisture contents at any depth may change rapidly as the water percolates through the profile. This may result in horizons being saturated for a very short time (a matter of hours), not long enough for the formation of gray colors or distinct mottles. During extended dry or wet periods, changes in soil moisture contents will be so slow as to appear almost constant.

If a portion of the soil profile is saturated, the depth to saturation can be determined by observing the depth to the water surface in a bore hole. This may be of value during wet periods; however, soil color and mottling are most often used to estimate depth to saturated conditions. Interpretation and identification of soil horizons that are periodically saturated depend on the identification and description of soil mottles.

A seasonal high water table is a zone of saturation in the soil at the highest average depth during the wettest season. It is at least six inches thick, persists in the soil for more than a few weeks and is within six feet of the soil surface. Soils with a seasonal high water table are classified according to water table depth, type, and time of year when the water table is highest.

Water tables can be either **apparent, perched,** or **ponded.**

- **Apparent water table:** An apparent water table is the level at which water stands in a freshly dug, unlined borehole after adequate time for adjustments in the surrounding soil. (See Figure B-37.)

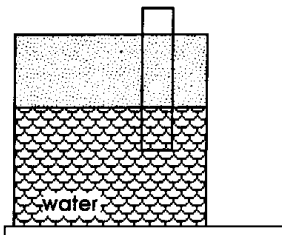


Figure B-37:
Apparent Water Table

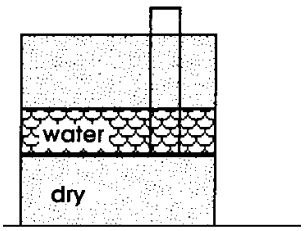


Figure B-38
Perched Water Table

- **Perched water table:** A perched water table exists in the soil above an unsaturated zone. (See Figure B-38.) A water table may be inferred to be perched on the basis of general knowledge of the water level of an area, the landscape position, the permeability of soil layers and from other evidence. To prove that a water table is perched, the water levels in boreholes must fall when the borehole is extended.

Perched and apparent water tables can be seasonal or long-term. Many soils in Iowa have a seasonally high water table

Aquifers

An aquifer is a body of groundwater which is, or can be, used for drinking water purposes. In some cases saturated soil conditions may be the upper level of an aquifer. In other cases these saturated soil conditions may be separated from a deeper aquifer by geologic materials which may impede downward groundwater movement. (See Figure B-39) In either case, there still needs to be a three-foot separation distance from the highest point of soil saturation and the bottom of the soil absorption system.

Groundwater flow rates and directions are controlled by the geologic character of an area. Recharge and discharge areas are an important concept in groundwater geology. A recharge area is usually a topographically high area from which a pressure gradient is established on the water table. From this point, the water table slopes until it intersects the surface in a stream, lake or other groundwater discharge area.

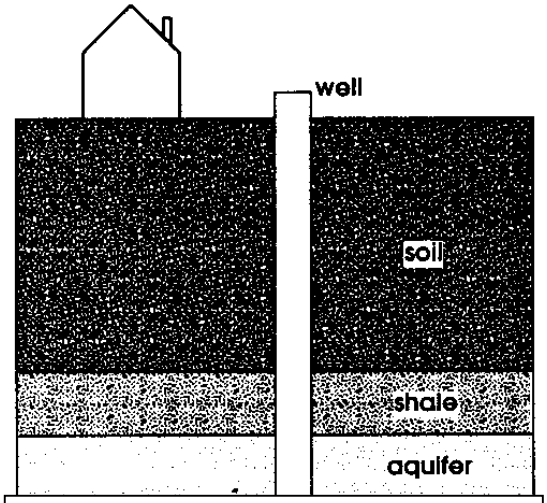


Figure B-39

PART V: SITE EVALUATION

A good site evaluation provides sufficient information to select a suitable, cost-effective treatment system, and is the first phase of the design process. A site evaluation should be a systematic process that provides information with enough detail to be useful.

The evaluation must help an evaluator determine whether or not a lot contains a sufficiently large area with suitable soil to serve the proposed use of the lot. The client should be aware that soil testing will not guarantee that the lot is suitable for the intended use. An unsuitable site is not the fault of the site evaluator. A soil evaluator is not doing his/her client a favor by allowing him/her to believe that a bad site is good.

A site evaluation is much more than just “running a perc test.” The site evaluation must consider placement of the system in relation to setbacks, topography and other factors; select the proposed depth of the system, with accurate soil descriptions noting water table or bedrock depth or other limiting factor; and accurately size the system with the perc test or another appropriate method.

The site evaluation consists of two parts: a preliminary investigation and a field investigation.

Preliminary Evaluation

Determining Homeowner Preferences

Before beginning the preliminary evaluation or physical investigation of the lot, determine the needs and wants of the property owner. The major items for a site evaluator to consider in developing a lot are the following:

- Location of the house/ building improvements.
- Proposed location of the onsite sewage treatment system.
- Location of the water supply wells within 100 feet of the proposed soil absorption area and 50 feet from septic tank.
- Any lot easements or rights-of-way.

To the owner of an undeveloped lot, however, major concerns usually include the location, aspect, view, and type of house proposed. In addition, projected improvements such as a driveway, garage, patio, or swimming pool may conflict with the area most suited for onsite sewage treatment. Therefore, it is important to discuss the site evaluation for the onsite sewage treatment system at an early stage in development plans for the lot. It is a rare instance when all the desired improvements can be located exactly where the lot purchaser wants them to be.

Priorities must be established (a properly designed, sited, and installed sewage treatment system is a high priority), and trade-offs are inevitable.
Figure B-40 is a checklist that may be useful in the preliminary evaluation process.

Testing will not guarantee that the lot is suitable for the intended use. An unsuitable site is not the fault of the site evaluator. A soil evaluator is not doing his/her client a favor by allowing him/her to believe that a bad site is good.

Evaluators must provide reports to the proper authorities and to the client for each site evaluation—both for sites that are suitable and for sites that are found to be unsuitable.

The individual evaluating the site is responsible for all data reported. Soil testers cannot delegate their duties to others. They may use helpers to dig holes and carry water to percolation holes, but the certified soil tester must select the sites for percolation tests and soil bore holes, make measurements, evaluate and describe soil profiles, and personally certify the reported data.

Gathering Information

Conducting a complete site evaluation requires a great deal of information—as well as knowing where to get that information. Keep in mind that a preliminary evaluation, no matter how well done, is no substitute for a field evaluation. The information needed is listed below.

- Location of noncommunity transient public water supply wells within 200 feet of the propsed system, if alternative local standards are in effect.
- Location of community or noncommunity nontranisent water supply, in a drinking water supply area, if alternative local standards are in effect.
- Location of buried pipe within 50 feet of the system.
- Location of easements.
- Location of property lines.
- Location of the ordinary high water level of public waters.
- Soil classifications and applicable characteristics at the proposed soil treatment areas. Consult the soil survey report, if available.
- Floodplain designation and flooding elevation from published data or data that is acceptable to and approved by the local unit of government or the DNR;
- All required setbacks from the system.
- Legal description and lot dimensions.
- Names of property owners.
- Inclusion of the site within an inner wellhead management zone or wellhead protection area of a public water supply.

Figure B-40

Preliminary Evaluation Checklist

Date _____ Client _____

Legal Location _____

System: new replacement (circle one) Type of Establishment _____ (e.g. single family residence, restaurant)

Is the system located in a wellhead protection area, shoreland, or does it serve a food, beverage or lodging establishment? Y / N

House Specifications/Flow Determination

Number of bedrooms _____

150 gpd per bedroom x _____ (# of bedrooms) = _____ gpd

Number of anticipated water-using devices _____
(automatic washer, dishwasher, water softener, garbage disposal, self cleaning humidifier, whirlpool bath.)

Description of well(s) _____

_____

Easements _____

_____

_____

Flooding Information _____

_____

Soil Survey Information:

	Soil #1	Soil #2	Soil #3
Map unit symbol			
Map unit name			
Soil features:			
Landscape position			
Flooding			
Slope			
Watertable depth			
Bedrock depth			

	Soil #1	Soil #2	Soil #3
Possible depth of system:			
Texture at proposed depth of system:			
Permeability at proposed system bottom (in/hr)			
60 divided by inches/hours (MPI)			
SCS suitability for onsite system			

Site Evaluation Map

Date: _____ **Site Evaluator:** _____

Legal Location and Directions to Lot: _____

_____

Any Surface Signs of Compaction: _____

Have the following been drawn on the map?

Easements: phone ____ electric ____ gas ____ **Location:** Dwelling ____ Other Improvements ____

Lot Dimensions: ____ **Location of Existing System:** ____ **Location of Replacement Area:** ____

Slope: percent ____ direction ____ **Setbacks:** Building- 10 feet ____ Property Lines - 10 feet ____

Water Well - 100 feet ____ water suction pipe - 50 feet ____ Pressure Pipe - 10 feet ____

Streams /Lakes - 25, 50, 100 feet ____ **Borings/Perc Tests:** Location ____ Elevation ____

Horizontal and Vertical Reference Point of borings ____ **Indicate North** ____ **Unsuitable Areas:** ____

Is the Proposed Location: Staked and Protected? _____ **Accessible for Pumping?** _____

Field Evaluation

A site investigation is the only way to accurately determine the actual conditions present on the site. A field evaluation should be done regardless of the results of the preliminary evaluation.

All interested parties should be present at the time of the field evaluation so that all can see the same conditions and obvious deficiencies can be explained immediately.

Two days before beginning any digging for soil investigation or system construction, you must (by state law) contact Iowa One Call at 1-800-ONE-CALL for the location of underground utilities.

A site evaluation is a comprehensive investigation and characterization of geological, hydrological, topographic, soil, and setback factors to determine the site suitability. Nearby roadcuts, railroad embankments or other exposed slopes may provide a broad view of the landscape, soil and geology of the area surrounding the site, so don't limit your investigation to the lot itself. A site evaluation should include:

- Identification of lot lines, lot improvements, required setbacks, and easements.
- Description of surface features, including:
  - percent and direction of the slope,
  - vegetation type,
  - any evidence of disturbed or compacted soil, flooding, or run-on potential, and
  - landscape position.
- At least one soil observation, such as a boring, conducted prior to any required percolation tests, to the depth of the seasonally saturated layer, the bedrock, or three feet below the proposed depth of the system, whichever is less.
- Description of each soil observed, including:
  - the depth of each soil horizon,
  - the soil matrix and mottle color,
  - a description of the soil texture and consistence,
  - depth to the bedrock or other limiting layers,
  - depth to the seasonally saturated soil,
  - depth of standing water in the hole, and
  - any other soil characteristic, such as hardpans or restrictive layers.
- How the proposed soil treatment areas will be protected from compaction and disturbance.

Initial Observation

The first observations on the site should rule out areas that are obviously unsuitable. A check of the vegetation and topography will help rule out some areas of wet soil, bedrock outcropping, steep slopes, and drainageways.

After lot boundaries have been established, the process of selecting locations for the various improvements can begin. Carefully evaluate topography, land forms, vegetation (including large trees the owner may want to preserve, or cattails, which indicate a high water table), drainageways, recent construction activities that may have disturbed or removed the topsoil and any other physical features affecting the site. The soil absorption system should be located in original soil, the naturally occurring, inorganic soil that has not been moved, smeared, compacted, or manipulated with construction equipment.

Both the owner and the site evaluator should have a plan on paper to test against the actual lot. Since it is much easier to remove lines on paper than to move structures such as water wells or other improvements, this is the time to determine the suitability of proposed locations.

The crests of knolls and hills, as well as slightly sloping portions of hills, are likely areas for placement of onsite sewage treatment systems. Avoid depressions, drainage swales that collect runoff from the surrounding area, and excessively steep slopes. The landscape and slope forms should be observed and recorded.

Consider future landscaping plans to assure site access not only during the construction phase but also afterward, so that the septic tank can be pumped periodically. Identifying two or three potential sewage treatment sites on the lot provides additional flexibility if the primary site is found to be unsuitable. Some local sanitary ordinances require locating two areas suitable for a sewage treatment system on a lot.

Vegetation

Observations of the growth of both native vegetation and cultivated crops aid in recognizing soil boundaries and provide information about soil drainage.

Native Vegetation. Generally, close relationships exist between native vegetation and kinds of soil; yet there are important exceptions. A reliable field evaluation cannot be made by studying vegetation alone, but with careful observations of both soils and vegetation, excellent correlations can be established. Cattails, alders, dogwood, willows, tamaracks and sedge grasses all indicate wet soil areas. These areas should be noted on the site evaluation map.

Cultivated Vegetation. Over an extended period of cultivation, farmers learn which crops do well and which do poorly on different kinds of soil and adjust their cropping patterns accordingly. If the differences are large—as between crop failure and reasonable performance—the absence of a given crop may reflect the

suitability of that kind of soil for the crop. If the differences are small, many non-soil factors can determine the farmer's choice of fields for a given crop. Relationships observed must be interpreted with caution because of economic factors, management systems and farmer preference. But within fields of a single crop, differences of vigor, stand or color of the crop or weeds commonly mark soil differences and are valuable clues to the location of soil boundaries.

Landscape/Topography

The landscape position and slope form elements (see Figure B-42) for the area should be noted. This information is useful in estimating surface and subsurface drainage patterns. For example, sloping areas typically have good surface and subsurface drainage, while potholes, drainageways and footslopes are more likely to be poorly drained.

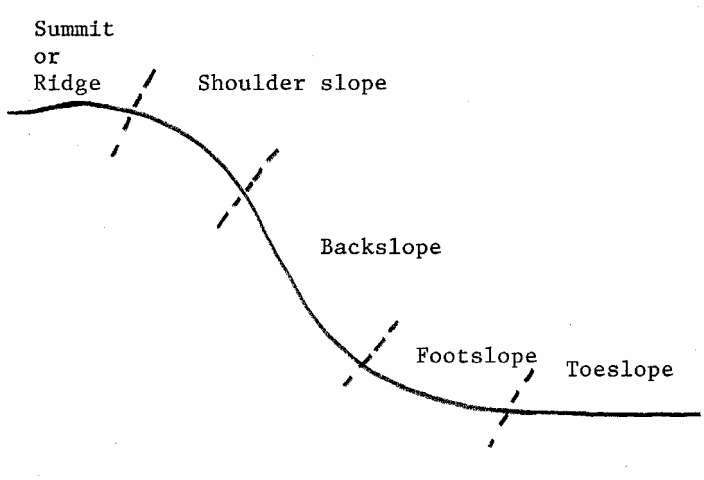


Figure B-42

Landscape is an important factor which determines the surface and subsurface flow of water and should be a major consideration when locating a system. Certain landscapes cause problems for proper waste treatment and disposal.

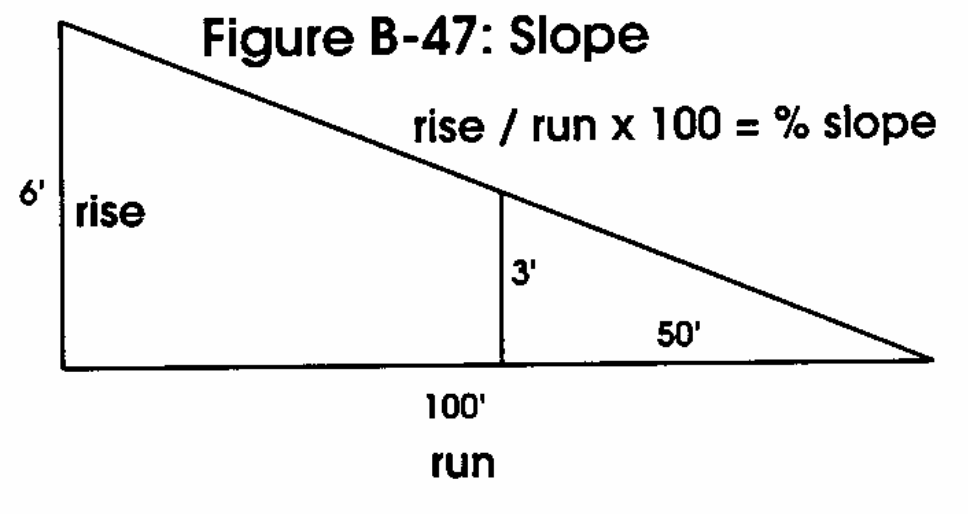
- Swamps, marshes and potholes
- Drainageways, swales or floodplains
- Sinkholes

Aid in determining the landscapes in which the soil is positioned can be gained from the Soil Survey Report.

Soil Slope

The slope of the soil surface has several distinct properties: gradient, complexity, configuration, length and aspect. Slope influences the retention and movement of water, rate and amount of runoff, potential for soil slippage, accelerated erosion, ease with which machinery can be used and soil-water state.

Slope steepness is critical in system design and must be accurately determined and recorded. One method is to use a clinometer. Slope is the ratio of vertical rise or fall to horizontal distance (see Figure B-47). It is usually expressed as a percentage.



Slope plays a significant role in onsite sewage treatment as follows:

- Type of system to be used (no beds on slopes of six percent or greater)
- Type of gravity distribution system to be used (drop box or distribution box)
- Pressure distribution system design (if all laterals are not on the same elevation)
- Layout (trenches parallel to slope)

In Iowa, saturated soils can be found in any landscape position, elevation and on any slope form, although in general, soil drainage is related to steepness of slope. The steeper the slope, the better the soil drainage.

The Evaluation Process

See **Appendix B-3: Equipment and Suppliers** for a list of tools to use during the site evaluation.

Staking the Site

After initially evaluating the site, be sure to stake conspicuously the location of the onsite sewage treatment system, the water supply well, the house, and other pertinent structures.

The area of the proposed onsite sewage treatment system, and the alternate site if required, must be protected from any disturbance during the other construction activities. The next task is to stake off the required setbacks and home improvements. These areas can be measured by a measuring tape or wheel, stadia hairs on a level, or a range finder. Make sure of the accessibility of the tank for pumping.

Because you called Iowa One Call two days before beginning your soil investigation, the locations of all buried utilities have been marked. **(Again, the Iowa One Call number is 1-800-CALL IOWA.**

Soil Investigations

Information must be reported on the thickness in inches of the different soil horizons and their suitability for treatment of sewage. It is recommended, and in some localities required, that a replacement area of equal size be investigated and identified.

To locate the onsite sewage treatment system properly, thoroughly evaluate soil texture, the presence of soil mottling, direct water table measurement and presence of bedrock. Aid in determining parent material may be gained through the Soil Survey Report. In some cases, examination of road cuts, stream embankments or building excavations will also provide useful information. Wells and well driller's logs can also be used to obtain information on groundwater and subsurface conditions.

Before a soil description can be written, the excavated soil from a boring or augering must be laid out on the ground surface with the depths of the excavated soil corresponding with the depth of the hole. A tape measure should be laid alongside the excavated soil. Rain gutters cut to six-foot lengths provide a good "home" for the soil as it is being examined. Too often, site evaluators bring up an auger full of soil, briefly examine the auger bottom, then dump the soil into a spoil pile next to the hole.

When describing the soil it is best to work in adequate natural light, and when the soil is in a moist state. Soil moisture can be altered by wetting the soil from a water bottle or blowing on a small handful to dry.

The exposed soil is usually examined starting at the top and working downward to identify significant differences in any property that would distinguish between adjacent horizons. Boundaries between horizons are marked and described. Horizon depths are measured from the soil surface and recorded.

There are three methods typically used to conduct soil investigations: probings, augerings, and pits. Each method has its own advantages and disadvantages. A soil **probe** is a hollow tube pushed into the soil. When extracted, it displays an undisturbed column of soil for viewing. Probe diameters and lengths vary in size. Probing is probably the quickest method of looking at the soil. It also has the advantage of revealing undisturbed soil in which faint soil mottling or cemented layers may be seen.

One disadvantage of probing is the relatively small diameter of the probes and the inability to penetrate the soil in rocky areas. Extensions can be added to get deeper into the soil. Another problem is that soil can become compacted in the tube.

An **auger** is a hollow cylinder with teeth at the bottom which is twisted into the soil. Augering is labor-intensive and is slower than probing. Auger samples typically are larger than samples from a probe, but the disturbed, mixed and homogenized nature of the sample may not reveal faint mottles, cemented layers or structure.

Augerings have advantages over probing in rocky areas, but still may be ineffective due to rocks. Extensions can be added to get deeper in the soil.

Pits are the best method to view the soil. Pits allow you to view undisturbed soil and see how the soil varies over the length of the pit, and they may be the only reliable method to determine the depth to bedrock. Soil pits should be prepared at the perimeter of the expected soil absorption area. Pits prepared within the absorption area often settle after the system has been installed and may disrupt the distribution network.

In some cases, subtle differences in color need to be recognized. Therefore, it is advantageous to prepare the soil pit so the sun will be shining on the face during the observation period. Natural light will give true color interpretations. Artificial lighting should not be used.

The disadvantage of pits is the necessity of a backhoe, and the associated costs and soil disturbance. Before entering the pit, make sure that it is safe to enter. Be sure that it is constructed properly with a step-type configuration to allow safe

entry and exit. The pit should have no sidewall slumps and show no potential for a cave-in. Be sure that no heavy piece of equipment or large objects—such as rocks or boulders—are resting on the surface immediately adjacent to the pit sidewalls. Grave safety concerns exist, if the soil is sandy or if the pit is excavated below the current water table depth. Pits should be backfilled or fenced to avoid falls or unauthorized entry.

Boring Procedure

After visually eliminating unsuitable areas (including setbacks) you may start the soil investigation. Soil borings and descriptions are challenging, oftentimes frustrating, but always interesting. No two sites are ever alike. The amount of soil investigation will depend upon the site variability.

A typical boring is first done to the depth of five to six feet. The soil information gathered from the boring should include texture, soil horizon depth, changes in soil color and presence of bedrock. It may be helpful to lay out the cores in order as they are removed from the hole.

For example: The first boring (in the middle) is dug to six feet with no indication of bedrock, water table or gray soil coloration. The site evaluator proposes the system depth at two feet, and the remaining borings will then be dug to a five foot depth.

After the initial observation has been completed, evaluated and recorded, proposed system locations may be established.

Soil Boring Log

Figure B-48 is a soil boring log for recording data during soil investigations. When taking a soil boring, enter the soil texture whenever a significant change in texture occurs. For example, the top 12 inches may be a fine sandy loam; from 12 to 18 inches the texture may be loam; from 18 to 36 inches the texture may be a clay loam; and from 36 to 72 inches the texture may be clay.

At the bottom of the soil boring log, the total depth of the boring hole should be entered, as well as any evidence of mottling or standing water.

Depth of water in the bore hole must be measured and recorded. However, this depth should not be used as the estimated high water table for designing a system. Most water tables fluctuate by many feet in a normal year. A single observation of water in a hole probably does not indicate its highest level. The observation of gray soil coloration or distinct mottling is the method to determine this maximum height.

Data is furnished on the depth to zones of soil saturation in the soil survey reports. These reports can help the site evaluator determine whether the use of the mottling criteria is applicable in a specific area.

Soil Boring Log

Client: _____
Address: _____
Legal Description: _____
Date: _____
Location: _____
Soil Type: _____
Disturbed/ Compacted yes no
Type of observation: Probe Pit Boring
Vegetation: Wet Dry Unknown
Parent Material: Till Outwash Loess Bedrock Alluvium
Landscape Position: _____
Slope: _____ %
Drainage: Good Problems Solutions _____
Floodplain: yes no

# of Bedrooms: _____
Garbage Disposal: yes no
Type: I II III IV
Flow: _____

If yes, Elevation: _____
Reference Point: _____
Elevation of Boring: _____
Depth of Water: _____
Depth to Bedrock: _____
Depth of Sat. Soil: _____
Max Depth of System: _____
Soil Sizing Factor: _____
Percolate Rate: _____
Linear Loading Rate: _____
Well Type: _____
Well Location: _____
Depth: _____
Casing Depth: _____
10' of Imp. material: yes no

Depth (inches)	Texture	Color (Matrix - Mottles)	Structure	Consistance
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid
			Single Grain Weak/Platy Moderate Strong Massive	Loose Friable Firm Rigid

Bottom Elevation: _____
Constuction Issues: _____

Additional Notes: _____

Preliminary Design
Trench_____ Bed_____ Atgrade _____ Mound_____ Holding Tank_____
Gravity Dist._____ Pressure Dist. _____
Sand: Serial _____ Pressure_____ Liner_____ Clay: Liner_____

Figure 48

Bedrock Determination

From your preliminary investigation, you should have a good idea if bedrock is present on or near your site. Many Iowa counties have no high bedrock conditions. If bedrock is suspected, methods to determine bedrock are as follows:

- Angular rocks on the ground surface or in the auger.
- Outcroppings on or near the site.
- Bedrock in nearby road cuts or a backhoe pit.

The depth at which the soil "stops" and the term *bedrock* is used is dependent upon the type of bedrock. The method for determining bedrock is presented in Figure B-49.

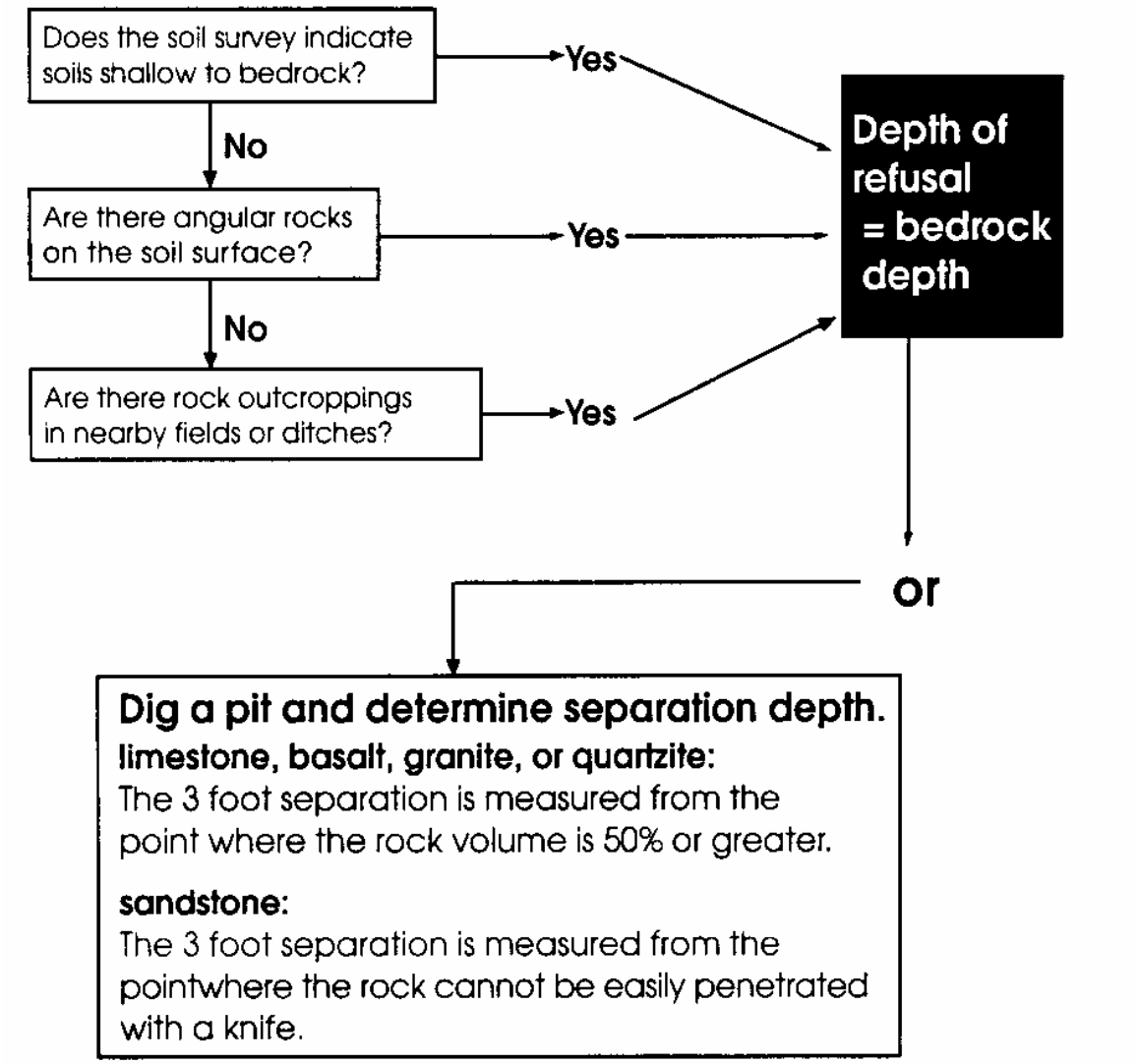


Figure B-49

Lithological Discontinuity

Many soils are formed in more than one kind of parent material. For example, a soil may be formed partly in loess (silty material) and partly in loamy glacial till. This is called a lithologic contact. Lithologic discontinuity is a significant change from one horizon (or layer) to another that is related to geologic processes and not soil-forming processes.

Soil layers of varying hydraulic conductivities interfere with water movement. Abrupt changes in conductivity can cause the soil to saturate or nearly saturate above the boundary regardless of the hydraulic conductivity of the underlying layer. If the upper layer has a significantly greater hydraulic conductivity, the water ponds because the lower layer cannot transmit the water as fast as the upper layer delivers it. If the upper layer has a lower conductivity, the underlying layer cannot absorb it because the finer pores in the upper layer hold the water until the matric potential is reduced to near saturation. Layering of soils is an important item to consider in siting onsite waste disposal systems. Abrupt textural changes can cause problems with water movement and therefore hurt system performance.

Evidence of stratification of the material—textural differences, stone lines and the like—need to be noted. Many soils obviously developed from stratified parent material, others seem to have developed from uniform material like that directly beneath the soil. If layers impede water movement, a lower linear loading rate must be used in designing the soil absoprtion system.

Disturbed Areas

Areas that have been cut, filled, compacted or disturbed in any way frequently have difficulty in accepting wastewater from an onsite system, due to a loss of soil structure. These areas can sometimes be identified by wheel tracks, hummocks, or vegetative growth, or debris. Problems have not been reported in siting systems in agricultural fields that have undergone normal tillage practices.

Fill Soils

Fill soils are soils that have been moved from their geologic origin by mechanical means and deposited in a new location. This creates a man-made lithological discontinuity.

When soils with textures other than clean sand are moved to a new location, the soil structure is destroyed, which liberates the silts and clays that migrate when water is added. This loss of pore space, migration of silts and clays and poor water movement between the different layers ultimately results in percolation problems in the soil, which may be severe. Percolation test results in a single area of loamy fill can range from seven mpi to over 200 mpi. The problem arises on which sizing factor to use.

Problems in determining the depth to the seasonally high water table are also encountered. Water tables can change when the topography is altered and soil coloration of the fill cannot be used as an indication of water table height. Its color was determined by the water table height of the area from which it was excavated, and not that of its present location. Problems can result when excavated mottled soils are placed in a well drained area. Brownish colors will gray and mottle on a wet site, but the mottled soils on a dry site will remain gray and/or mottled.

Fill soils commonly have stratified layers or different colored and textured materials as indicated in Figure B-50. These layers have abrupt boundaries between them. Typically the thickness of subsoil material ranges from 1/8" to a few inches thick, but can vary widely. Probings or pits (not augerings) are necessary to see these layers.

Soils located in a valley or flood plain sometimes have a natural stratification of soil materials which were deposited from sediment carried by floodwaters. Each layer represents deposits from one flooding event. These layers are black to gray in color, have textures in the silt to fine sand range and lack rocks. These stratifications should not be confused with stratifications caused by fill activities.

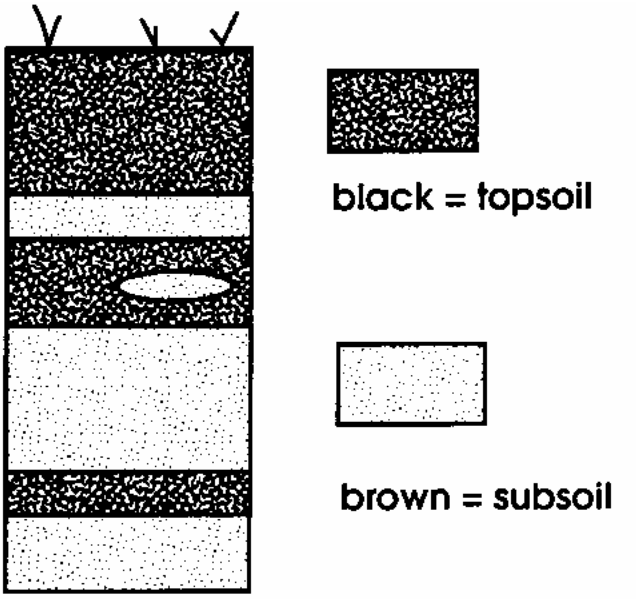


Figure B-50

Fill soils commonly have unnatural looking landscapes such as:

- short steep slopes,
- an unusually flat area in a generally rolling topography,
- higher areas adjacent to wetlands or shorelands,
- man made structures (such as roads or buildings) nearby,
- sparse vegetation (if new fill area) or vegetation lacking vigor as compared to adjacent areas, and/or
- many rocks on the soil surface.

Cut Areas

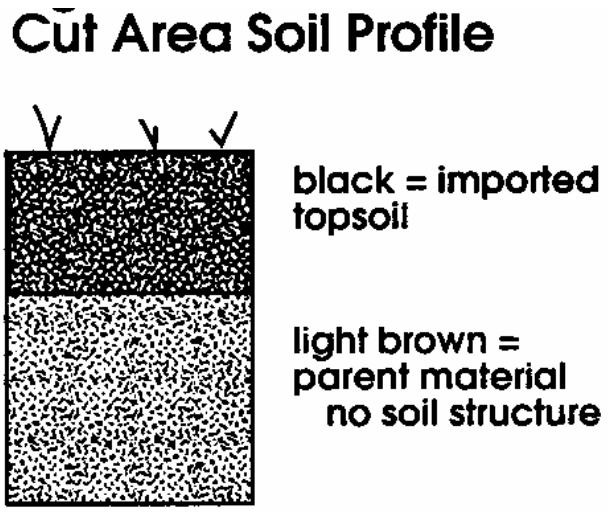
Cut areas are areas where the land surface has been lowered by removal of earthen materials. Cut areas have usually been compacted by machinery during land leveling. This compaction may be localized and spotty, or widespread, depending on wheel traffic patterns.

The topsoil and subsoil have often been removed from the cut area, exposing the native parent material, which usually has little or no soil structure to aid in water percolation. There may be a layer of topsoil added on top of the cut for lawn establishment, figure B-51. A percolation barrier may develop at this interface, slowing the movement of water. This problem is greater if the texture of the topsoil is unlike the texture of the fill.

Altering the landscape typically alters the water table height. The depth to mottles will be less due to removing the soil surface, but may not reflect a change in the water table height due to altering the landscape.

Cut areas typically have an abrupt boundary between the imported topsoil and the top of the cut surface. The parent material exposed from the cut will lack soil structure and be lighter in color (value of five or more on the Munsell color charts).

Figure B-51



Cut areas commonly have unnatural-looking landscapes such as:

- short steep slopes,
- an unusually flat area in a generally rolling topography,
- a level area cut out of a steep hillside, and/or
- a flat crest of a hill.

Man-made structures (for example, roads or buildings) are likely to be nearby. There may be sparse vegetation as compared to adjacent areas. They may be dense, compacted and difficult to probe.

Flooding Determination

The field evaluation should determine whether the site is subject to flooding. Flooding, as defined by the state Department of Natural Resources (DNR) is the temporary covering of soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes or any combination of sources. Shallow water standing or flowing during or shortly after rain, and snowmelt, are excluded from the definition of flooding, but must be considered when designing a soil absorption system. Standing water (ponding) or water that forms a permanent covering is excluded from the definition also.

Information received from the DNR or county should have revealed if the site was located in an identifiable flood plain. **Floodplain** means the area covered by a 100-year flood event along lakes, rivers, and streams as published in technical studies by local, state, and federal agencies, or, in the absence of these studies, estimates of the 100-year flood boundaries and elevations as developed pursuant to a local unit of government's floodplain or related land-use regulations.

Information from the Soil Survey Report should also have identified whether the soil is subject to localized flooding in such landscape positions as upland drainageways or intermittent streams.

If flooding is suspected, the following can be used to determine the potential flooding hazard:

- **Landscape features:** Certain landscape features have developed as the result of past and present flooding, such as former river channels, oxbows, point bars, meander scrolls, sloughs, natural levees, back-swamps, sand splays, and terraces. Most of these features are easily recognizable.
- **Vegetation:** The vegetation that grows in flood areas may furnish clues to past flooding. The survival of trees in flood-prone areas depends on the frequency, duration and time of flooding (dormant season or growing season), and also on the age of the tree and the depth of flooding. Some species are intolerant of flooding and are not found in areas that are flooded. Other species are very tolerant of

flooding and even withstand partial or total submersion during the growing season. Pure stands of these species indicate frequent or long duration flooding. A biologist or forester can help relate the vegetation to flooding frequency, duration and flood period.

- **Soil Profile Characteristics:** The soil profile provides clues to past flooding:
  (1) a thin strata of material of contrasting color or texture or both;
  (2) a soil layer that is darker than the layer above is an indication that the darker layer has been covered by more recent deposition; and
  (3) soil layers that have abrupt boundaries to contrasting kinds of material, indicating that the materials were laid down suddenly at different times from different sources or deposited from stream flows of different velocities.

The Site Evaluation Report

As site information is collected, it must be organized for easy review to determine site suitability. Providing sufficient information to the designer of the system eliminates the need for additional site visits.

Percolation test and bore hole data are of little value if related test sites cannot be located on a property or if the property itself cannot be located. It is essential to relate the property location to field-identifiable reference points, and to be very specific about test hole locations relative to both fixed reference points and each test site. The best approach is to identify the distances between each test site and two reference points, such as a well and the corner of a building.

Preferably, all horizontal distances should be perpendicular to, and referenced to, a north-south line and an east-west line through the horizontal reference point or other fixed reference points or identifiable baselines, such as lot lines, roads or fencelines.

A vertical reference point (also called a **benchmark)** is recommended in addition to a horizontal reference point for locating the distance to test sites—unless they are both the same point. A vertical reference point is an object of permanent elevation, the height or surface of which cannot be easily changed. The vertical reference point may be a lot line corner stake, cornerstone of an existing building, top of a well casing, a point on a centerline of a road, or a stake placed by the soil tester in a location where it will remain undisturbed for future reference.

The elevation of the vertical reference point may be arbitrarily labelled 100 feet (or any other number), as long as the elevation of the test holes are determined in relationship to the elevation of the vertical reference point.

It is the soil tester's responsibility to clearly identify the location of test holes by both vertical and horizontal references. The elevation of the ground surface at a test site and the reported depth of test are used to compute the elevation of the bottom of the trench or bed when the system is constructed or when surface soil is removed. Quick and easy ways to measure elevations are with a builder's level, a surveying transit, or a quality hand level.

Information may be recorded on forms provided in this manual. These forms should be duplicated and distributed to the permitting office and the client, and a copy should be kept with the site evaluator. The soil test report consists of four major portions:

- the preliminary evaluation report,
- the boring log,
- the map of the site, and
- the percolation test sheets.

Sometimes a property is too large to conveniently illustrate all of the required information on the grid provided on the map. In these instances, use a separate sheet to draw a plot plan diagram.

PART VI:
SITE SURVEYING

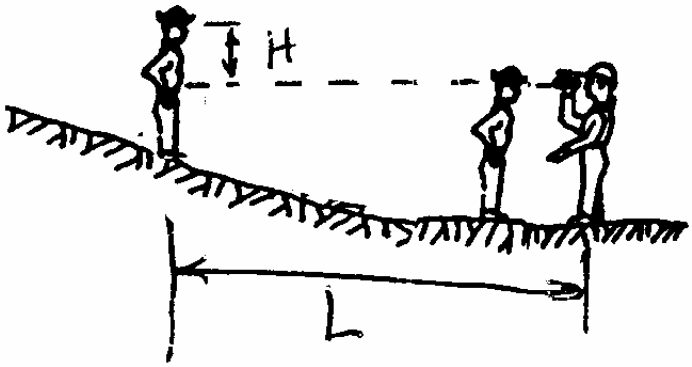
SITE and CONSTRUCTION SURVEYING

There are a number of different types of equipment available to conduct site evaluations, design layouts, and construction staking. The site topography is a critical factor in selecting the type of design and treatment system. There are three basic types of equipment hand level, engineers level often referred to as a level, and transit.

HAND LEVEL

The hand level is what it sounds like a small tube about 1-inch in diameter and 4 to 6-inches long. There is a small bubble level inside that is used to hold the hand level, level. It is the easiest to use and most inexpensive, however it is not as accurate as the others are. For initial site evaluation the hand level is sufficient to accomplish the task.

The following drawings show how to use the hand level.

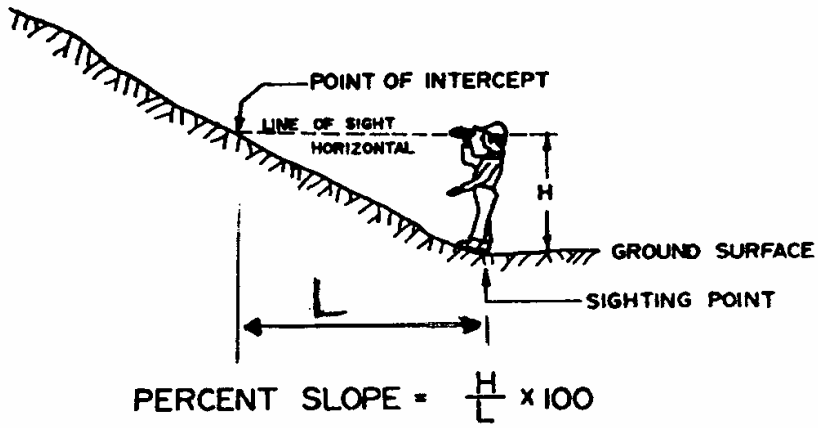


On level ground site through the hand level on a person note the place where the level is level. Have the person walk to the position where you want to know the

slope from where you are to there. Hold the level and note the spot on the person that you are now level on. Measure the distance between the people and then determine the approximate slope.

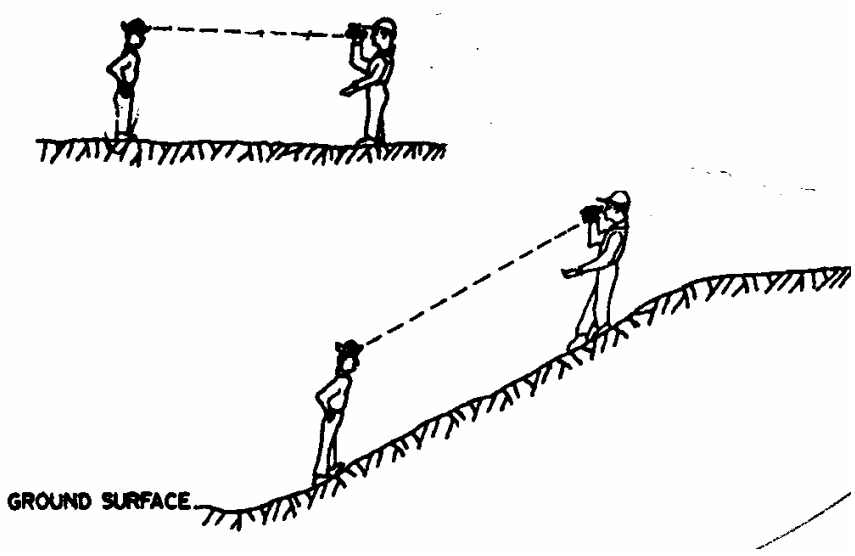
Slope = H ÷L x 100

Another way of approximating the slope is to know your eye height and sight a point that is level and measure the distance as shown below.



Also in the hand level group is the Abney Level and Clinometer. These are used to measure the slope directly, or can be used as a level.

On level ground sight a spot on a person that is level have that person stand at a location and sight the exact same spot then read the slope on the clinometer. The distance between the people is not needed with this instrument. These work for both up and down slope measurements.



ENGINEERS LEVEL

This instrument is set on a tripod and leveled. The operator looks through the eye piece and everything in the cross hairs is level with the instrument height. The distance form the level and the elevation difference is measured and the slope is calculated as follows:

$$\frac{\text{elevation difference}}{\text{distance}} \times 100 = \text{slope}$$

TRANSIT

The transit measures both horizontal and vertical angles and is capable of being used as a level. Because of the added complexity of the trigonometric method it is rarely needed for onsite construction, however it is some times used like an engineers level.

Definitions:

Benchmark (BM)

A relatively permanent object of know or assumed elevation. It may be a high point on a large boulder that will not move, a 2”x2” stake driven into the ground, a spike in a tree, or other object that will be moved during construction. Often times the benchmark is given an elevation of 100.00 for reference on the project, which has no meaning outside of the project.

Backsight (BS)

A rod reading on a point know or assumed elevation. The first reading on the benchmark would be the backsight. A backsight reading is added to the elevation of the benchmark to determine the elevation of the center cross hair of the level instrument.

Height of Instrument (HI)

The elevation of the horizontal cross hair or line of sight of the level instrument. The height of instrument is determined by adding the backsight reading to the elevation of the point being sighted upon.

Foresight (FS)

A rod reading taken on a point for which the elevation is to be determined. The elevation of that point is determined by subtracting the foresight reading from the height of the instrument.

Grade Rod

A rod reading when the bottom of the rod is held on “grade”, or the ground surface.

Turning Point (TP)

A turning point is a temporary position/setup of the level instrument to transfer a known elevation from position to another. If the benchmark is located in the front of the house and the septic system is located in the rear and there is not a clear line of sight for any point to both objects. The level instrument must the repositioned to determine the elevations needed.

NOTES

Before observations are made, focus the eyepiece on the cross hairs and ensure the no parallax is present.

Before taking any readings and in between readings check a see if that the instrument is level.

While making observations do not handle the instrument any more than necessary.

Ensure that the rod being held is vertical while readings are being taken. If the rod is waved slowly forward and back, the lowest observed reading will occur when the rod is vertical. Be familiar with the rod you are using. Some rods are marked off in tenths of feet others are in feet and inches.

With the instrument in one place the rod readings will increase as the objects being shot decrease in elevation. On septic tanks the rod readings for the outlet pipe should always be 3-inches greater than the rod reading for the inlet pipe.

ERRORS IN USING A LEVEL

Parallax occurs when the object lens is not carefully focused on the object and the observer’s eye is not focused on the plane of the instrument cross hairs. The

effect is to cause the relative movement between the image of the cross hairs and the image of the object when the eye is moved up and down.

Imperfect adjustment of the instrument. If the line of sight is not parallel to the axis of the level tube, an upward or downward inclination occurs. This error is minimized by ensuring the instrument is properly adjusted, is level when each reading is made, ant that readings are approximately the same distance from the instrument.

If the rod is not held vertically, the readings will be too large. Appreciable inclinations of the rod must be avoided particularly for high rod readings. The error can be eliminated by using a rod level or by waving the rod.

When the bubble is not centered during a sighting, an error results which is greater the longer the distance between the instrument and rod. Ensure that the instrument is level on each sighting.

Improper reading of the rod. The error can be very large when numbers on the rod are confused. This mistake is not likely to occur if the observer views numbers both above and below the observed reading or when the rodman assists in spotting the observation point.

Not having the rod fully extended will cause the readings to be inaccurate.

Appendix B-1: Running a Percolation Test

The percolation test is an important part of a site evaluation, and it is critical to the successful design of an onsite sewage treatment system. Suitable soil is the key to providing adequate onsite sewage treatment. Soil borings are used to locate a suitable area before beginning the percolation test.

The Percometer and the Hook Gauge

Figure B-52 shows a percometer, which is a device to accurately measure the drop in the liquid level in soil. A rod which is fastened to the float is read by the scale or ruler at the top of the percometer. A four-inch plastic pipe can serve as the body of the percometer. Half-inch holes should be drilled near the bottom to allow water to freely flow in and out. A plastic bottle approximately one quart in size can be used as the float. The stiff wire fastened to the top of the bottle extends through the top brace of the percometer.

A different method of measuring the drop in liquid level may be used (see Figure B-53). In this case, a hook gauge is used to determine the liquid surface and a batter board is used as a reference point. While this is an accurate method of determining the liquid level, it is not as convenient as using the percometer.

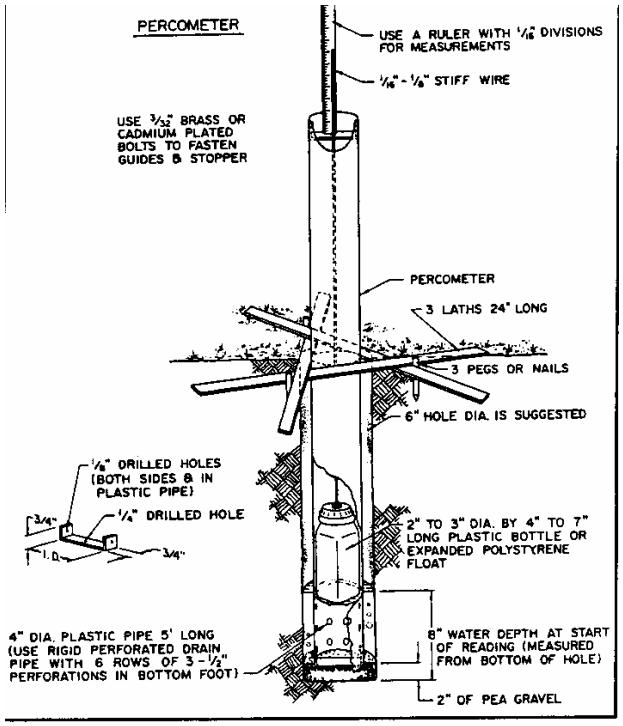


Figure 52

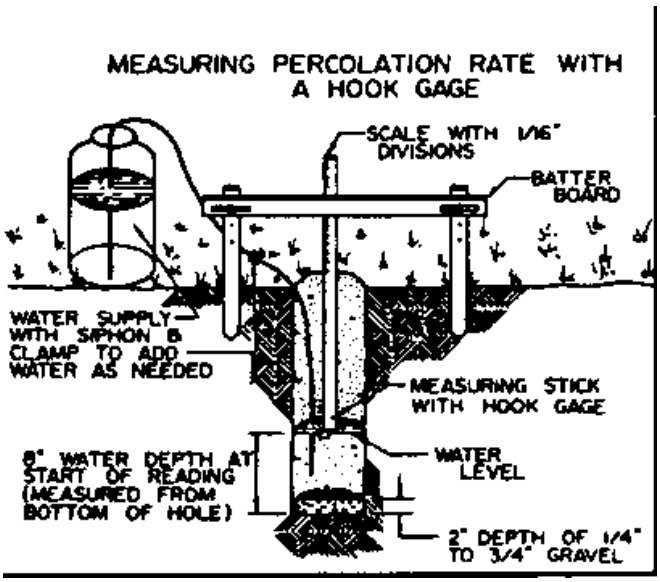


Figure 53

Percolation Test Data Sheet

A percolation test data sheet should be used.

Field ratings of the time and water level should show no erasures. If you make a mistake, cross out the reading and enter the correct value. Erasures can be made on computed values, but erasures made on field readings casts doubt on the validity of that data.

Field readings should be taken until two consecutive percolation rates vary by no more than 1/8 –inch (Chapter 69). Use the last of these thre readings to determine the percolation rate for the test hole. A percolation test should not be run where frost exists below the depth of the proposed soil treatment system.

Steps in a Percolation Test

Dig the Test Holes

The test holes should be round and at 4 to 12 inches in diameter. Dig each test hole as deep as you intend to excavate the soil treatment trench. The bottom of the percolation test hole must be at least three feet above the level of seasonally saturated soil or an impervious layer. A clamshell-type posthole digger can be used.

Prepare the Test Holes

The auger or post hole digger is likely to smear the soil along the sidewalls of the test hole. Therefore, the bottom 12 inches of the sidewalls and bottom of the hole should be scratched or scarified with a sharp, pointed instrument such as a knife. Nails driven into a 1 x 2-inch board will do a good job of scarifying the hole to provide an open, natural soil into which water may percolate. Remove all loose soil material from the bottom of the test hole. Add two inches of 1/4 to 3/4 inch gravel to protect the bottom from scouring when water is added. The gravel can be contained in a nylon mesh bag so it can be removed after the test is performed and used for additional percolation tests.

Distinguish Between Saturation and Soil Swelling

- **Saturation** means that the voids between the soil particles are full of water. This can happen in a short time.
- **Swelling** is caused by intrusion of water into individual soil particles. This is a slow process, especially in clay soils, and is why a prolonged soaking period is necessary for some soils.

Carefully fill the percolation test hole with clear water to a depth of at least 12 inches above the soil bottom of the test hole. Use a hose to prevent the water from washing down the sides of the hole or add the water directly in the percometer. A six-inch diameter hole requires about 1.5 gallons per foot of depth.

Sandy soils containing no clay do not swell. The percolation test may proceed immediately if the 12 inches of water seeps away in ten minutes or less.

For prolonged soil soaking, keep the 12-inch depth of water in the hole for at least four hours, and preferably overnight. Add water as necessary. You may use an automatic siphon or valve to maintain the 12-inch water depth (see Figures B-54 and B-55).

Figure 54

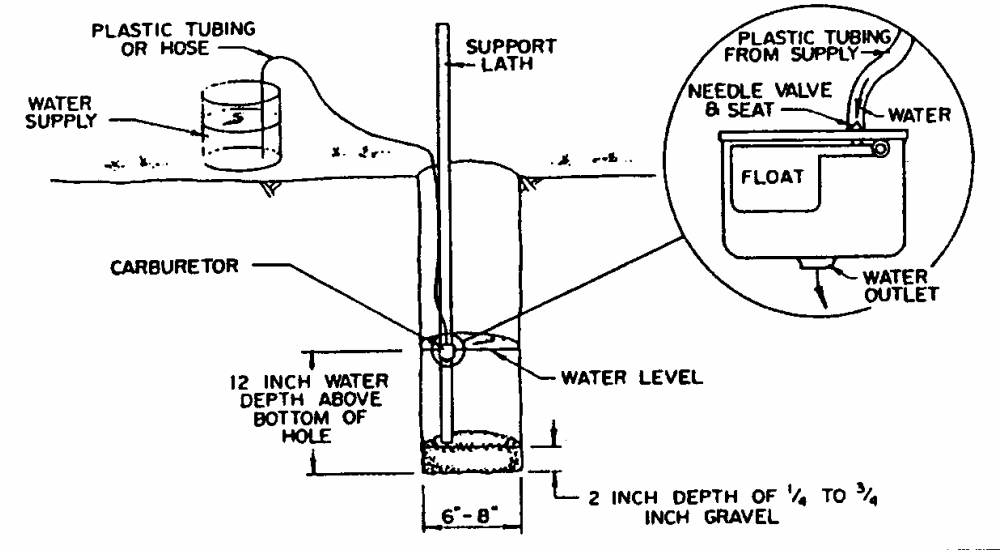
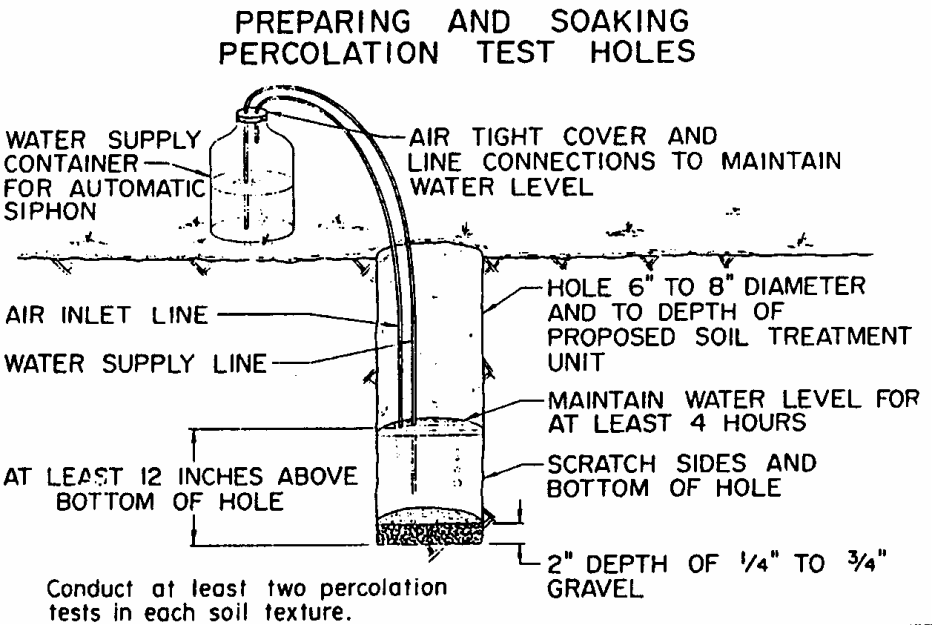


Figure 55



Measure the Percolation Rate

If more than six inches of water remain in the hole after the overnight swelling period, bail out enough water so that six inches of water remains above the gravel (eight inches if measured from the bottom of the hole). Measure the drop in the water to the nearest 1/8 inch approximately every 30 minutes. If possible, use a percometer to determine the change in water level. A batter board can also be used as a reference point together with a hook gauge to accurately locate the water surface. The hook can be made from stiff wire or an 8d nail. After each measurement, refill the water in the hole so that the liquid depth is six inches above the gravel. Continue taking measurements and filling in the percolation test data sheet until 2 consecutive percolation rates vary by a range of no more than 1/8 -inch.

If no water remains in the hole after the overnight swelling period, add six inches of clear water above the gravel. Measure the drop in the liquid level to the nearest 1/8 inch approximately every 30 minutes. After each measurement, refill the water to a depth of six inches above the gravel. Continue taking and recording the water level drop measurements until 2 consecutive percolation rates vary by no more than 1/8 – inch.

In sandy soils, or other soils in which the first six inches of water seep away in less than 30 minutes after the overnight swelling, period, allow about ten minutes between measurements. Refill the percolation test hole after each measurement to bring water to six inches above the gravel. Continue taking readings and filling in the percolation test data sheet for 1- hour and use the last reading for to calculate the percolation rate.

Calculate the Percolation Rate

Divide the time interval by the drop in water level to determine the percolation rate in minutes per inch (mpi).

- If the drop in water level is one inch in 30 minutes, the percolation rate is:

  30 minutes ÷ 1 inch = 30 mpi
- If the drop in water level is 2 1/2 inches in ten minutes, the percolation rate is:

  10 minutes ÷ 2.5 inch = 4 mpi

Calculate the percolation rate for each reading. When three consecutive percolation rates vary by no more than 10%, use the average value of these readings to determine the percolation rate for the test hole. Percolation rates determined for each test hole should be averaged in order to determine the design percolation rate. Compare the percolation rates determined for each test hole to the soil texture to verify the soil sizing factor. The percolation test data sheet showing all measurements and calculations must be submitted.

Note: A percolation test should not be run where frost exists in the soil below the depth of the proposed sewage treatment system.

APPENDIX B-2: USING SOIL SURVEYS

Soil Survey Report Descriptions

Although the Soil Survey alone cannot be used to determine the suitability of a site for an onsite treatment system, it is an excellent source of information for the preliminary evaluation of the site.

The soil descriptions in the soil survey report were prepared by soil scientists who use a technical term to label horizons. It is not critical that a site evaluator understand these labels, however the following information is provided to aid in your understanding of the soil survey report.

A horizons (commonly called **topsoil):** These are mineral horizons that formed at the surface. They are characterized by an accumulation of humidified organic matter intimately mixed with the mineral fraction.

E horizons (bleached horizons): These are mineral horizons in which the main feature is loss of clay, iron and/or aluminum leaving a concentration of sand and silt particles.

- An E horizon is usually, but not necessarily, lighter in color than an underlying B horizon. In some soils the color is that of the sand and silt particles.
- An E horizon is most commonly differentiated from an overlying A horizon by lighter color and generally has measurably less organic matter that the A horizon.
- An E horizon is commonly differentiated from an underlying B horizon by color of higher value or lower chroma, by coarser texture or by a combination of these properties.
- An E horizon is commonly near the surface below an A horizon and above a B horizon. The soil structure is commonly platy, but may be blocky or granular.

B horizons (commonly called **subsoil):** These horizons are formed below an A or E horizon and dominated by weathering of all or much of the original parent material and by concentration of clay, iron, aluminum, or carbonates, or by the removal of carbonates, and has formed granular, blocky, or prismatic structure.

C horizons (commonly called **parent material):** These horizons or layers, excluding hard bedrock, are little affected by weathering. They have no structure development except for random planes of weakness. In Iowa, the soil

development “ends” at the start of the C horizon, which in most cases is less than five feet in deep.

There is no need for a site evaluator to use the *A-B-C* terminology for describing the horizons, but this terminology can be a useful tool.

Using a Soil Survey

For the soil site investigation, consult the soil map to identify the soil type and determine the following soil features:

- landscape position,
- map unit inclusions,
- slope,
- depth to groundwater,
- depth to bedrock,
- flooding potential,
- texture, and
- permeability.

Use some type of preliminary information checklist, such as Figure B-60, to record soil survey information and other information gathered in the preliminary evaluation.

Published detailed soil surveys include a series of maps on a photographic background indicating the occurrence of different soil types. These maps show the occurrence and distribution of each kind of soil.

The delineated areas on the soil map are called “map units,” which consist primarily of the soil for which the unit is named and soils with similar characteristics. In addition, there are areas within the unit consisting of soils that are different.

Soil types occupying an acre or more within the map unit are indicated by a series of map symbols. The minimum size of the map unit, however, depends on the scale of the printed map.

Therefore, while the soils map alone cannot be used to determine the suitability of a specific site, the soil survey information is still useful as background and as an indication of potential problems that may be encountered on the lot.

For counties that do not have published soil surveys, the local Soil and Water Conservation District office can often provide unpublished soils information.

client name _____

legal location _____

map unit symbol _____

map unit name _____

inclusions		_____	_____		
similar soils				_____	_____
soil features					
landscape position	_____	_____	_____	_____	_____
flooding	_____	_____	_____	_____	_____
slope	_____	_____	_____	_____	_____
water table depth	_____	_____	_____	_____	_____
bedrock depth	_____	_____	_____	_____	_____
possible depth of system	_____	_____	_____	_____	_____
texture at proposed system depth	_____	_____	_____	_____	_____
permeability at proposed system bottom (in/hr)	_____	_____	_____	_____	_____
60 ÷ in/hr = mpi	_____	_____	_____	_____	_____
NRCS suitability for onsite system	_____	_____	_____	_____	_____

preliminary design
trenches ___ bed ___ at-grade ___ mound ___ holding tank ___

system size _____

Locate the site on the survey and determine what soils are there:

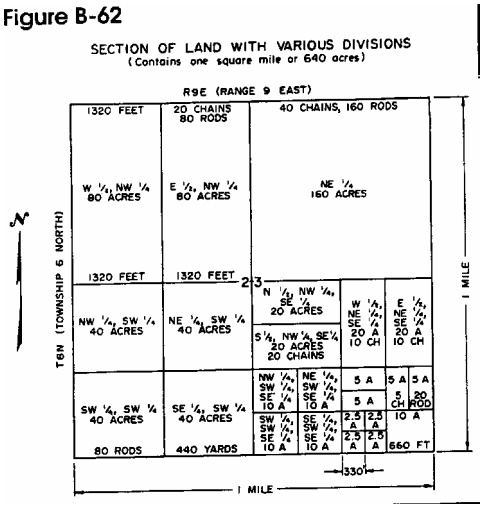
1. Determine the legal description of the location (i.e. section, township and range).
2. Find that location on the “Index to Map Sheets” in the survey. Map sheets are ordered numerically.
3. Refer to the specific map sheet to determine which soil map units are found at your location. Map units are denoted by symbols such as *401C*.
4. List the map unit symbols found at your location.
5. Refer to the “Index to Soil Map Units” to determine which pages have the map unit descriptions for your location. The map unit descriptions have information on limitations for a variety of uses and major soil properties. The information needed to determine suitability is most easily found in the tables just before the map sheets in the survey. The tables are all indexed by the map unit symbols.

Legal Land Survey Description

Legal land surveys in Iowa are based on a township/range description, with a typical township containing 36 sections of land, each of which is one square mile, or 640 acres, in size.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure B-62



Regular-sized townships contain 36 sections of land numbered in a particular sequence starting at the northwest corner of the township. Thus section 7 is immediately below section 6, section 12 is immediately south of section 1, section 13 is south of section 12, section 18 is south of section 7, and so on. Figure B-61 shows the pattern of section numbering.

Within sections, divisions are made on a quarter basis with respect to the four directions. Figure B-62 shows a typical section with its divisions. When subdivisions are platted, individual properties are assigned block lot numbers. A complete legal description includes township and range, section number, section division, block number and lot number.

Townships also have numbers which are counted as north of baselines. The township is also given a range number measured east or west from a principal meridian. Within the section, the division is in quarters with respect to the four directions.

The southwest quarter of section 23 contains 160 acres and the southwest quarter of the southwest quarter (SW 1/4, SW 1/4) contains 40 acres and is found in the extreme southwestern portion of section 23 as is shown in Figure B-62. This designation may be used for the legal description of larger tracts of land. When subdivisions are plotted, the individual properties normally have block and lot numbers.

The zoning map should be checked to make sure the property can be used as intended. At the same time, required setbacks from buildings, property lines, road right of ways, utility easements, surface waters, wells and any other covenants on the property should be determined. A good way to keep track of these requirements is to locate them on a scale map or sketch. Graph or crosshatched paper can be used to sketch a map of a shoreland lot, as shown in Figure B-63.

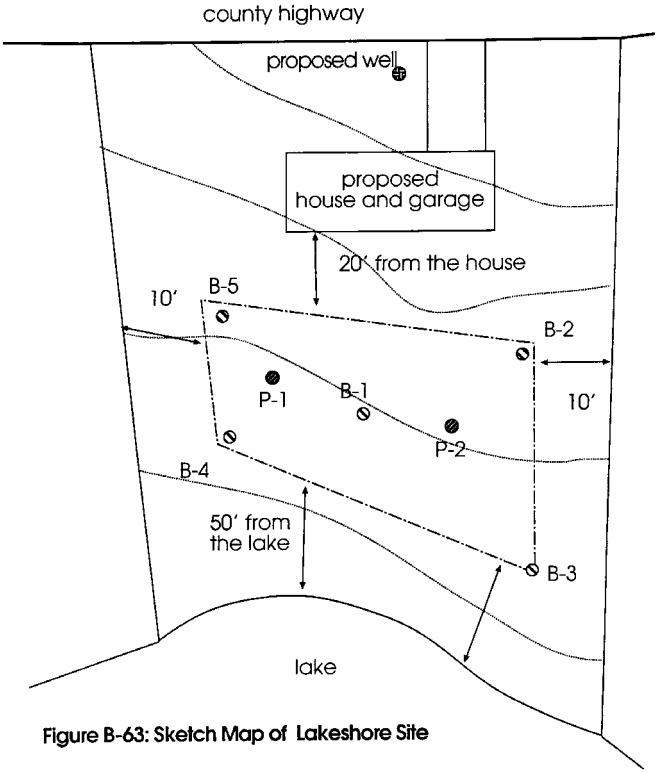


Figure B-63: Sketch Map of Lakeshore Site

The zoning map should be checked to make sure the property can be used as intended. At the same time, required setbacks from buildings, property lines, road right of ways, utility easements, surface waters, wells and any other covenants on the property should be determined. A good way to keep track of these requirements is to locate them on a scale map or sketch. Graph or crosshatched paper can be used to sketch a map of a shoreland lot, as shown in Figure B-63. On this lot, soil borings

On this lot, soil borings and percolation tests have been taken in the area proposed for the onsite sewage treatment system. The proposed house location is shown, along with the proposed well location.

This information is absolutely necessary on a permit application in order to evaluate the suitability of a site for onsite sewage treatment. The information presented by the application should always be checked against the soil survey information together with a brief site investigation before the permit is granted.

If the site is near surface waters, particularly rivers and streams, there may be a floodplain map which gives the dimensions and elevations of areas that may be flooded. This information may be available from the local zoning office. Other potential sources are the Department of Natural Resources Regional offices and local Watershed District offices. Information of required setback distances from lakes and streams are also available in these offices.

Vegetative and topographic information is available on U.S. Geological Survey (USGS) quad or topographic maps. These maps indicate areas of excessively steep slopes, depressions and surface drainage characteristics.

General Soil Survey Maps

All counties in Iowa have detailed reports available. Where this detailed information is not available there is additional published information available.

A general soils map has been published at a scale of 1:1,000,000 (one inch = 16 miles). It delineates areas of major soil groups found in the state. This map is of limited use for determining characteristics of soils for onsite waste treatment, but it provides names of soil series found in these broad areas. This provides a preliminary estimate of the types of soil materials found in the area.

Detailed Soil Survey Maps

To understand how detailed soil survey information can be used in a site evaluation, a site evaluator needs to understand how a detailed survey is made and what is represented on soils maps.

Soil surveys are a representation of how soils occur on landscapes. Soils constantly change across a landscape. The process of classifying and map soils tries to put some order into a very complex system of changes in soil characteristics. Soil characteristics, such as percent organic matter, depth of top soil, texture, depth to water table or bedrock change predictably across the landscape.

The soil scientist making a soil map uses limited and well-defined ranges in soil properties to classify soils, develop map units which describe the occurrence of the soils classified on the landscape and determine the suitability of that soil for specific uses. To accomplish this, the soil scientist walks over the landscape,

looking not only at soil borings, pits and excavations, but also measuring the slopes and observing the occurrence of vegetation.

These observations not only aid in predicting where a soil occurs on the landscape, but also in determining the suitability of that soil for a specific intended use. An experienced soil scientist will map between 300 and 600 acres of soil a day. Soil borings are conducted during the process to confirm the predictions made about the occurrence of soils on the landscape.

During the survey process in a county, data is collected on the physical and chemical properties of the soils as well as on the depth to saturated soil zones and percolation rates.

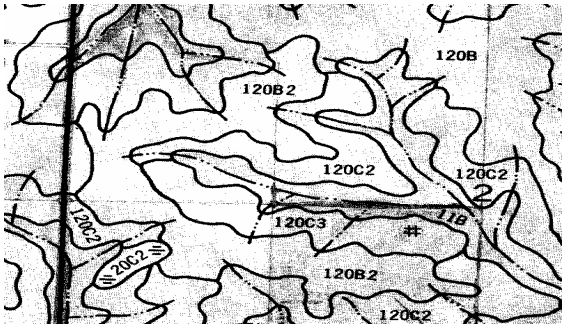
The finished product of a detailed soil survey is a series of soil maps prepared on a photographic base for an entire county. The size of the soil map unit that can be delineated on these maps is dependent on the final scale of the map. A soil map completed at a scale of 1:15,840 (one inch = 1,320 feet) will have the smallest delineation covering about 2.5-3 acres on the land surface.

An onsite waste treatment system will cover only a 1,000 to 5,000 square foot area of lawn area. Therefore, in order to use a soils map to directly determine the site suitability and system design, the map must be nearly 100% accurate to allow for total confidence that the soil mapped at the site is occurring in this 1,000 to 5,000 square foot area. Unfortunately, the only way this could be accomplished is to map out a scale of one inch = one inch, where each inch of the landscape is evaluated for soil type. Obviously, this is not possible.

Therefore, during the soil survey map process, soils different from the map unit name are included within the map unit delineation. These inclusions may at times be as much as 50% or more of the map unit. They can have similar or different soil properties that will determine their suitability for the installation of an onsite waste treatment system. The inclusions present are well-defined and characterized.

For example: The soil map symbol 120B2 appears on the soil map in Tama County, Iowa. (See Figure B-56). Referring to the soil map legend, Tama silty clay loam, 2-5 % slope, moderately eroded. The map unit may also include small areas of other soils that were too small in area to map out or to mention in the name of the unit. In other words, every square foot of the map unit area is not necessarily Tama silty clay loam.

Figure B-56



The second part of the map symbol indicates the different **slope groups** used in Iowa. They are indicated by capital letters such as **B** and defined in percent of slope as follows:

Soil Groups

A = 0 – 2 %
B = 2 – 5 %
C = 5 – 9 %
D = 9 – 14 %
E = 14 – 18 %
F = 18 +

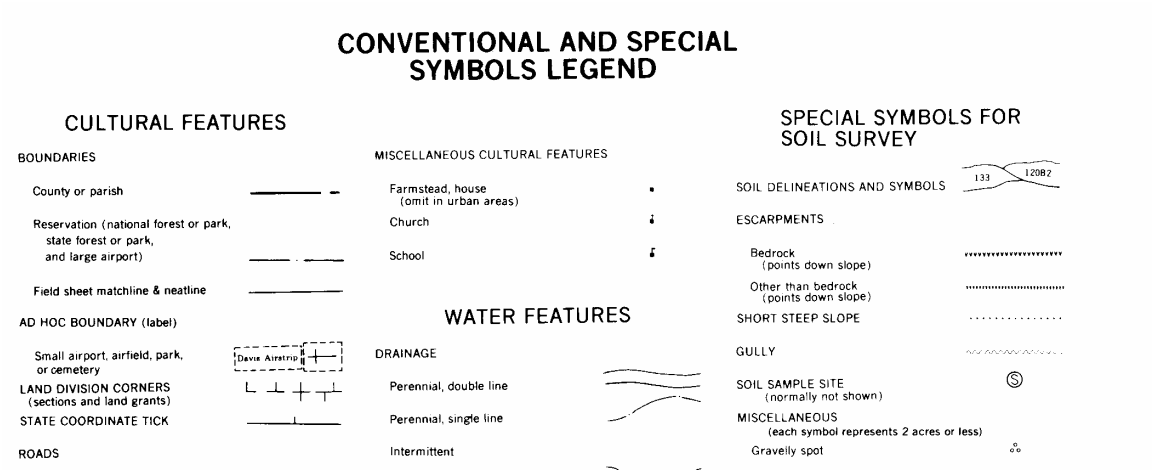
The third part of the symbol is the **erosion class.** The three major recognized erosion classes are slight, moderate, and severe.

Erosion Class

1 - slight or no erosion
2 - moderate erosion
3 - severe erosion

So the map symbol 120B2 indicates Tama silty clay loam with 2-5 percent slopes that are moderately eroded.

Besides providing information on the aerial extent and the kind of soil, the soil map shows other physical features. Since the map has an aerial photo background, it is possible to determine different land features and uses directly from the map, such as woodland, farmland, roads, cities, buildings, lakes, streams, and airports. Drainageways are shown with special map symbols, as are small wet spots, marshy areas, sandy, clayey, gravely, or stony spots. The standard symbols for these features are presented in the legend of the soil survey publication.



To demonstrate how the survey report and accompanying soil maps can be used to help determine suitability and system design, consider another typical map unit found in many Iowa counties. The map unit could be represented on the soils map by .

In either case, by looking at the soil legend in the survey report, the name of the map unit is 120B2 Tama silty clay loam, two to six percent slopes and moderate erosion. Series and map unit descriptions indicate that the Tama silty clay loam soils are well drained soil in narrow ridges in the uplands.

119B	Muscatine silty clay loam, 2 to 5 percent slopes
120	Tama silty clay loam, 0 to 2 percent slopes
120B	Tama silty clay loam, 2 to 5 percent slopes
120B2	Tama silty clay loam, 2 to 5 percent slopes, moderately eroded
120C	Tama silty clay loam, 5 to 9 percent slopes
120C2	Tama silty clay loam, 5 to 9 percent slopes, moderately eroded
120C3	Tama silty clay loam, 5 to 9 percent slopes, severely eroded
120D2	Tama silty clay loam, 9 to 14 percent slopes, moderately eroded

In the physical and chemical properties table it shows that the clay content varies from 27 to 35 percent

In the sanitary facilities table it shows the soils are slight for laterals.

In the soils and water table it shows the water table greater than 6 feet.

All of these features are averages and will need to be field verified before designing a septic system.

APPENDIX B-3: EQUIPMENT AND SUPPLIERS

The field evaluation can be conducted more efficiently and accurately when the proper equipment is used.

A log sheet may be used for entering information from soil borings. (A sample copy is provided in **Section H: Forms.)** The classification system should be checked, as well as the type of sampling procedure (pit, probe or auger) which is used to collect the soil samples. It is important that a relatively undisturbed sample of soil be withdrawn from the boring hole in order to identify soil structure and the presence of mottling, which has previously been discussed.

A hand bucket auger in the 3-1/4 inch size is preferred by many site evaluators. Although more manual labor is necessary to remove the soil sample with a hand auger than with a machine, the hand auger collects a sample that represents the true characteristics of the soil. A hand auger is particularly valuable on wooded lots or other areas not accessible by power equipment.

Drainfield (Keep Off sign

Recording Forms:

procedure list
soil boring logs
perc test data sheet
county recording forms
design forms
graph paper
soil survey information sheet

Recording Instruments:

pencils
calculator
permanent markers
lath/flags
tacks
camera

Reference Material:

Onsite Manual
county ordinances
soil survey report
soil description
Chapter 69

Measuring Devices:

short tape measure
100' tape measure
surveying rod
Dumpy level
hydrometer
clinometer
percometer
color book
(Munsell or Globe)
water bottle for texturing
screens for sand gradation

Hole Digging:

probes with extensions
post hole digger
tile spade
augers: sand, mud, standard

Percolation Test Equipment:

pre-wetting hole device
mesh bag with gravel
hole scarifier
water jugs with water

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Janesville, WI 53547-5277
1-800-241-6401

fax 1-800-628-2068

soil sampling technology
soil augers: regular, mud, dutch, sand, planer, and flighted screw
soil sampling kits
sludge samplers
soil probes
groundwater sampling technology

Forestry Suppliers, Inc.
PO Box 8397
Jackson, MS 39284-8397
1-800-647-5368
(601) 354-3565
fax 1-800-543-4203
earth, life, and environmental science equipment
Munsell soil color charts
soil sampling equipment: augers, probes, and handles
clinometers, levels

Clements Associates Inc.
1992 Hunter Avenue
Newton, IA 50208
1-800-247-6630
(515) 792-8285
fax (515) 792-1361
soil investigation equipment

Giddings Machine Company, Inc.
401 Pine Street
PO Drawer 2024
Fort Collins, CO 80522
1-800-611-0404
(970) 482-5586
fax (970) 482-9628
soil sampling and drilling equipment
trailer-mounted and power-equipped soil sampling machine

Hansen Machine Works
1628 N “C” Street
Sacramento, CA 95814
(916) 443-7755
fax (916) 443-3045
soil sampling outfit and augers

Instrumental Research, Inc.
7813 Madison Street
Minneapolis, MN 55432
(612) 571-36948

soil augers: clay and sand, handles, and extensions

percolation test equipment

Munsell Color Company, Inc.
2441 N Calvert Street
Baltimore, MD 21818

Munsell color charts

Oakfield Apparatus, Inc.
PO Box 65
Oakfield, WI 53065
(414) 583-4114
fax (414) 583-4166

soil samplers: soil safety sampler and others, accessories

deluxe soil sampler kit

Pumpco
4141 Highway 371 N
Brainerd, MN 56401
1-800-448-7867
(218) 829-6910
fax (218) 828-9152

Munsell color chart

backsaver soil sampling tool

percolation test equipment

NorthWest Lasers, Inc.
2200 University Avenue
Suite 100
St. Paul, MN 55114
(612) 645-3828
fax (612) 645-4832

Schlatter's, Inc.
PO Box 548
Francesville, IN 47946
(219) 567-9158
fax (219) 567-9459

tile probes

soil augers

APPENDIX B-4:
Sample Site Evaluation Forms

SOIL EVALUATION REPORT

in accordance with 77 Illinois Administrative Code, Chapter 1, Subchapter r, Section 905

Report prepared for:

NAME:_____ INVESTIGATION NO:_____ DATE:_____

ADDRESS:_____ PROPERTY OWNER:_____

CITY:_____ STATE:_____ ZIP:_____ COUNTY: _____

SITE LOCATION: _____

Detailed Soil Description[1] / Interpretations - Site 1

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.^{2})

Limiting Layer:_____ Depth:_____ Slope: _____

Soil Classification:_____ Parent Material: _____

Physiography: _____

Estimated Drainage Class:_____( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): _____

Remarks:_____

Detailed Soil Description[1] / Interpretations - Site 2

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.^{2})

Limiting Layer:_____ Depth:_____ Slope: _____

Soil Classification:_____ Parent Material: _____

Physiography:_____

Estimated Drainage Class:_____( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): _____

Remarks:_____

Detailed Soil Description[1] / Interpretations - Site 3

Depth (in)	Matrix Color[2]	Texture	Mottles[2]	Structure	Consistence	Coatings[2]	Notes	Permeability & Loading Rate[3] in (G/D/Ft.^{2})

Limiting Layer:_____ Depth:_____ Slope: _____

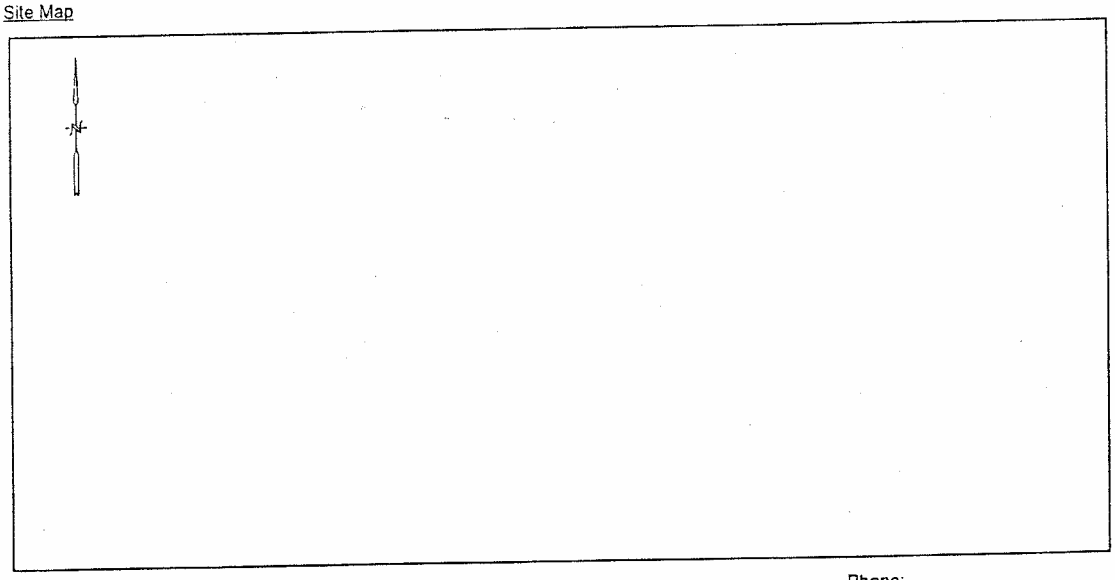
Soil Classification:_____ Parent Material: _____

Physiography: _____

Estimated Drainage Class:_____( )observed saturation at depth (in)_____ Compaction ( )yes ( ) no (depth): _____

Remarks:_____

Site Map



Report Prepared By: (print name) _____ Phone:_____

Address: _____

Signature:_____

[1] USDA Soil Survey Manual, Ag Handbook Nº 18, (1993)
[2] Soil color designations, Munsell Soil Color Charts, (1992).
[3] Private Sewage Disposal Licensing Act and Code, Illinois Department of Public Health, Appendix A Illustration M (1996)

SOIL BORINGS AND TRANSECT OF ON-SITE WASTEWATER TREATMENT AND DISPOSAL SYSTEM SITE

DATE: _____ Time Started:_____ Time Completed:_____ HOME OWNER: _____

Conducted By: _____ Certification:_____ ADDRESS: _____

CITY: _____ ST:____ ZIP: _____

LOCATION: _____ SECTION NO.: _____ T. ____ N. R. ___ W. COUNTY: _____

LANDSCAPE-LANDFORM-SLOPE TYPE: (Place "X" on Diagrams-Back of Sheet) TOWNSHIP: _____ Lat: _____

SOIL SYMBOL: _____ SOIL NAME: _____ Long: _____

ASPECT (°): _____ SLOPE (%): _____ SOIL PERMEABILITY: _____ Elev (ft.): _____

DRAINAGE: _____ DEPTH OF POTENTIAL SEASONAL HIGH WATER TABLE (ft.): _____ No. of Bedrooms: _____

SOIL BORINGS:	NO. 1	NO. 2	NO.3	NO. 4	NO. 5	NO. 6	NO. 7	NO.8	NO. 9
THICKNESS OF SURFACE SOIL (in.):	____	____	____	____	____	____	____	____	____
DEPTH TO Concentrations:	____	____	____	____	____	____	____	____	____
REDOX FEATURES : Depletions:	____	____	____	____	____	____	____	____	____
DEPTH TO GRAY MATRIX:	____	____	____	____	____	____	____	____	____
DEPTH OF LIMITING LAYERS(KD/in.):	___/____	___/____	___/____	___/____	___/____	___/____	___/____	___/____	___/____
	___/____	___/____	___/____	___/____	___/____	___/____	___/____	___/____	___/____
DEPTH TO CLAY MAXIMUM:	____	____	____	____	____	____	____	____	____
DEPTH OF ACTIVE W.T.:	____	____	____	____	____	____	____	____	____

Average Loading Rate = __

GPD = _____ R

LR = _____ nex

LLR = _____ eve

TW = __2__ = _____ ft. =

TW = __3__ = _____ ft. =

Formula:

GPD = LLR = FOOTAGE
LR TW

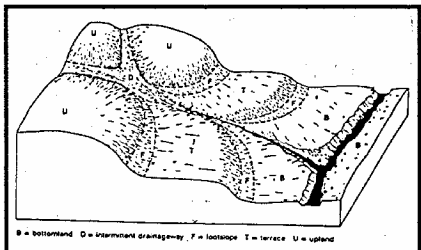
DEPTH (Inches)	HORI-ZON	SOIL TEXTURE	COLOR MATRIX	COLOR REDOX	COATS or CLAY FILMS	STRUC-TURE	CONSIS-TENCY	ROOTS	BOUN-DARY	MOIST STATE	COMPAC-TION	PM or REMARKS	LOADING RATE

PM = PARENT MATERIAL--(1) Loess, (2) Glacial TillL, (3) Weathered Glacial Till, (4) Valley Fill, (5) Outwash, (6) Eolian, & (7) Alluvium

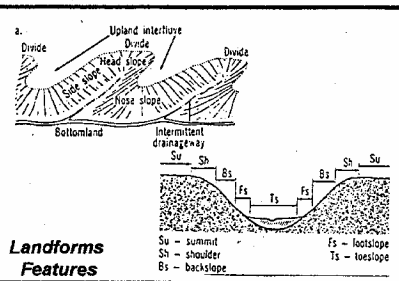
Described By: _____

Revised by LEB

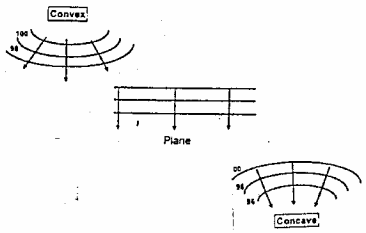
SOIL ANALYSIS 1/03



Landscape Poistion



Landforms Features



Slope Type

Drawing of Home Site Layout

Home Site Checklist:

1. Location of house
2. Location of wells
3. Location of utilities
4. Location of Soil Absorption Field.
5. Location of Street and Driveway
6. Show Direction of Slope
7. Show Orientation from North.
8. Show Owner's Name & Address
9. Show Section & Township
10. Location & Distance of Soil Borings

Cross Sectional View of Test Area

Revised by LEB

SOIL ANALYSIS 1/03

HOLE # ____

DEPTH (FT)	TEXTURE	STRUCTURE	COLOR MATRIX (MOIST)	MOTTLES	COMMENTS
1					
2					
3					
4					
5					
6					

COMMENTS

HOLE # ____

DEPTH (FT)	TEXTURE	STRUCTURE	COLOR MATRIX (MOIST)	MOTTLES	COMMENTS
1					
2					
3					
4					
5					
6					