Session 3
Septic Tank Drainfield Site Suitability and Evaluation Workshop
3-Introduction to Soil DEQ Septic.doc

Frame 1: This training sessions is about soil assessments, in the context of septic tank and on-site drain field site assessment. As an introduction, let's begin with an overview of some key concepts about soil. Soil as it specifically relates to septic tank drain fields. It is helpful in completing a site evaluation to be familiar with some of the commonly used soil terms**: pedons, soil horizons, soil profiles and series, soil colors, and the factors and processes of soil formation.**

Frame 2: Each of these images represents a circumstance or condition related – in some way – to septic tank drain field failure. There is a common element to each of these circumstances. What is that common element? **Water!** When a septic tank drain field fails, it fails as a consequence of inability to or ineffectiveness in dealing with water discharged into the drain field. You will recall that we identified the three most frequently occurring **circumstances related to septic tank drain field failure as: 1) gravelly soils**, i.e., the inability of the soil to properly function and process the waste water; **2) poorly drained, clay soils**, i.e., the inability of the soil to allow for effective processing and transport of water away from the drain field; and **3) shallow groundwater**, i.e., the inability of the soil and condition to either drain or process the waste water. **In each case, and in almost all cases of septic tank drain field failure, the issue is water.**

This explains the reason for emphasis on correct and appropriate evaluation of drain field suitability and location.

Frame 3: Soils are highly variable in their biological, physical, and chemical properties. From the perspective of suitability of a specific soil and location to a septic tank drain field, **the physical properties of the soil are of more importance than the chemical and biological properties**. In fact, the soil will develop a new set of chemical and biological characteristics when wastewater is introduced. However, chemical properties are closely tied to physical properties.

Examination of the soil is necessary to determine the kinds and ranges of these properties. The different properties of soils are then used to evaluate the suitability of the soil for its intended use. Soil is classified on the basis of observing the soil as a three-dimensional body. When we look at a block of soil from a three-dimensional perspective, the unit we are looking at is what is known as a **pedon**. **A pedon is the smallest volume of soil that shows all the characteristic properties of a particular soil**. Usually, the area occupied by a pedon or individual soil unit of description is between 10 and 100 square ft (a size of 2' x 5', 10' x 10'). **The image or picture we see when we look at a cross-section of the soil is known as a soil profile.** We usually think of the depth of "soil" as extending to the maximum depth of rooting by plants. **Material below this depth of "soil" is referred to as subsoil, parent material, or solum.**

Given that it is possible to distinguish a pedon of 10 to 100 square feet, it's particularly critical that a thorough spatial evaluation of the soil in the proposed drain field location be completed.

Frame 4: A **soil series** represents soils that have developed from similar materials by similar processes resulting in similar appearances and properties. The characteristic properties of a soil series are unique. Because of soil variability, there are many possible combinations of properties that make a unique soil or soil series. In fact, there are approximately 17,000 soil series in the United States alone. When we observe or look at a soil series or pedon from the surface to the bottom of the root zone, we are looking at the **soil profile.** The soil profile is usually made up of a series of layers which we call **horizons.**

Frame 5: Soil horizons are zones (or layers) of distinct soil physical, chemical, and/or biological processes. These horizons are sometimes a consequence of depositional sequences of various materials making up the soil profile. In old, well-developed soils, these horizons are essentially formed in place from parent material. Thus, the surface is generally the most different from the parent material, while the soil of the lower horizons progressively reflects more and more of the properties of the parent material.

Soil typically develops from the surface downward and from the parent material upward.

Frame 6: Soil color is an excellent diagnostic tool and can suggest soil properties that influence the functioning of the drain field In addition, soil color is often an expression or reflection of either the parent material, the soil formation processes, or other geologic activities which have affected soil formation. We will deal with soil color with considerable detail later on, but for now, some extrapolations that can be made from soil color include:

Dark soil near the surface **usually indicates a high organic matter content** - resulting from past plant life. This soil is often easy to cultivate and has a high nutrient content.

A soil of uniform color from top to bottom is often indicative of an unweathered, young soil or a soil with good drainage throughout the visible profile. Young soils usually have properties other than color which are uniform as well

Yellow and red colors in the soil well below the surface **are typical of older, weathered soils.** These soils often have a decreased permeability for roots, water, and air.

Gray zones or gray colored blotches indicate poor drainage and a lack of good aeration.

Green/blue colors are often indicators of either **waterlogged conditions or abundance of clay.**

Sudden or abrupt changes in color usually signify changes in wet/dry (redox) conditions.

Rust colors, rust spots, rust blotches, rusted mottles signify alterations between wet and dry conditions; seasonally high – then dropping – water table conditions.

Frame 7: Some comments about different horizons:

- **Organic horizons** are dominated by organic material; these horizons contain identifiable organic litter from plants and animals.

- **Mineral horizons** formed just below the soil surface are called A horizons; these layers or horizons are usually dark in color.

- **Elluviation** is a process otherwise known as leaching, which is a washing or leaching of finer mineral material out of the soil. Horizons which have undergone elluviation are usually referred to as E horizons.

- Mineral horizons in which fine material has accumulated due to elluviation process from above have undergone **illuviation**. The resultant horizon is usually referred to as the B horizon.

- Mineral horizons consisting of unconsolidated, partially weathered material that is neither soil nor rock and in which there is little biological activity are referred to as C horizons. This is likely the soil depth of the drainfield.

Frame 8: Transition frame: Question: So, the question becomes: how does regolith, solum, parent material become soil? When we look at a soil profile, we see a collection of horizons which appear to have been placed there, in some kind of order. Most people are of the opinion that these obvious soil layers are the result of deposition of various layers of material from above. And, yet soil varies from location to location, while some soils repeat themselves across the landscape. We can find relatively striking and contrasting soil conditions even in close proximity.

Thus, the question becomes – what makes a soil what it is? Answer: differences in 'soil forming factors'.

Frame 9: Foundation soil-forming factors. Although intuitively obvious, few of us think about or appreciate the various so-called 'soil-forming factors' and how they affect soil formation and interact to cause soil to be what it is. From a physical-biological perspective, soil scientists attribute soil which is found at a specific location to the consequence of six soil-forming factors:

- **Parent material**
- **Climate**

- **Topography**
- **Living organisms**
- **Time**
- **Human alterations (anthropogenic)**

Concisely, **soil formation is the process whereby climate and living organisms interact and act upon parent material, as influenced by topography, over time.**

It may come as a surprise to you, but if you repeat the condition of the five soil-forming factors at two different locations, you'll find a similar soil at both locations. Thus, once you get the pattern down and realize it repeats itself, septic drain field suitability characterization and evaluation becomes somewhat 'routine'.

Frame 10: The Five Factors of Soil Formation. Let's take a quick look at the diversity of these soil-forming factors and then we'll take a look at each of the factors in detail – because how a soil forms and what soil forms can tell us a lot about how water has influenced the soil formation process. The soil and the soil forming factors can also tell us how water – the central ingredient of septic tank discharge – will behave in a drain field.

This frame consists of a collage of images representing various aspects of the five soil forming factors: parent material is the foundation of all soil and the factor of most significance underlying the actual soil material on the landscape. Climate/weather and topography interact and act upon the soil, creating an environment for living organism activity. Collectively and individually, each of these factors provides very good indicators of soil condition and drain field site suitability.

Let's digress for a moment and consider **the role of parent material – bedrock versus lake bottom sediment versus alluvial sands and gravels versus wind-blown material versus consolidated limestone.** Each of these parent materials has unique physical properties and one needs to consider the interaction of water with these physical properties. We can do a similar assessment of topography – slope, aspect. Water accumulates or infiltrates into flat surfaces while water runs onto or off of sloped surfaces. As for living organisms – worms, ground squirrels, termites thrive best in well-drained soils.

Frame 11: How does a soil actually form and what processes affect soil formation? How does the 'soil profile' come about? In reality, **the soil profile** – that cross-sectional view of the soil when you excavate a 'soil pit' **– is primarily the result of four processes working in concert on the soil material.** Starting with the basic building block of parent material, **those four processes are: additions, losses, translocation, and transformation.** Sometimes additional mineral material is added – wind, flooding, erosion. But, **more often the mineral material essentially 'weathers in place' and the organic material accumulates or remains stable at some equilibrium organic matter content until the soil is disturbed.**

Each of those four processes is detailed in this illustration.

Frame 12: Let's take a little more detailed look at each of the soil forming factors. An understanding of these factors will give us a better appreciation of what has happened to make the soil profile you see when you excavate a pit or auger a hole. Understanding the soil forming factors will also give us a better appreciation of the physical and chemical properties and how soil responds to additions of water which may be loaded with organic material and nutrients.

Parent material – the solum, regolith. The basic mineral or organic material from which the soil is formed. This parent material generally (but not always) dictates the chemistry and predominant physical properties of the soil.

Let's take a little quiz. Before we explain these various parent materials, let's see how well you can define or imagine what the source of soil material is.

A = sorted, uniform lake sediments, lacustrine sediments
B = consolidated glacial till
C = sorted flood-plain deposits
D = bedrock/hardrock
E = sorted streambed cobble
F = loess – fine, sorted, windblown deposits
G = colluvium, coarse, unsorted, unconsolidated rubble from above
H = sorted, intermixed stream and lakebed deposits

Frame 13: A few of the mechanisms and contributing sources of parent material are illustrated here:

Fluvial material – sediments which are deposited in and by rivers, streams, floodplains. These materials are generally interbedded, sorted within bed, very well drained, very porous, with limited water retention capacity. Correspondingly, their ability to provide adequate residence time for treatment of waste water is limited. Make for good drainage material, but may have limited residence time opportunity. Too many coarse fragments.

Stepping back for a moment and addressing waste water treatment – the soil requirements are: 1) capacity to store and temporarily retain water, allowing for residence time for biological activity; 2) ability to accept water under saturated flow (dosing) conditions, and also be able to drain away; 3) ability to allow for gas transport within a short time after wetting.

Consolidated and/or fractured bedrock – requires very long periods of weathering to result in any substantial soil material.

Colluvial/alluvial materials – these are materials sourced from and deposited from upslope areas. They are generally very heterogeneous, very diverse in particle size and pore structure. They have the potential to serve as good drain fields, but are often dominated by coarse fragments – rocks and debris.

Marine, lake sediment, and lacustrine materials – these are sediments which accumulated at the bottom of either ocean or lake environments. Remember – lakes don't often leak! Marine , lake and lacustrine sediments are typically very uniform in particle size – silts and clays. Often they are consolidated and likely to be poorly drained unless they have been exposed to extended periods of soil formation. Then they become excellent drain field sites – assuming the water table is relatively deep.

Glacial till/deposits and remnants – these are highly heterogenous (generally), and substantially consolidated. Generally they are poorly drained and may contain substantial coarse fragements. If they have been exposed to extended periods of soil formation, can become excellent drain field sites – assuming the water table is relatively deep and hydraulic loading is not excessive. These soils are likely to be slow to drain.

Frame 14: Let's take a look at climate and weather – probably the second-most influential soil forming factor.

Frame 15: Climate/weather – rainfall, snowmelt, freezing/thawing, wetting/drying, warm/hot, cold/frigid, wind, beating rain, extended periods of snowpack. All of these circumstances of weather contribute to soil formation. A unique parent material can develop into two or more uniquely different soil profiles when the parent material is exposed to diverse weather conditions.

The maximum extent of soil development occurs in a soil which is neither too warm nor too cold; neither too wet nor too dry.

Here's a snap-shot of Montana's climate. For now, you can see that we experience a wide range in summer and winter temperatures and annual precipitation across Montana. Consequently, we experience substantial diversity and transition in vegetation across Montana. More about this later.

Frame 16 Topography – the 'lay-of-the-land' can be responsible for a unique parent material developing into two or more uniquely different soil profiles when the parent material is exposed to diverse topographic conditions. **Consider the difference in moisture regimes of a soil at the top of a hill, along a side-slope, at the bottom of a hill, and in a stream corridor. Consider the difference in soil forming environments of a parent material on a north-facing slope versus that same parent material on top of a south-facing slope.**

Topography's influence is most pronounced with respect to water – how much remains to infiltrate, how much runs off, whether sunlight strikes the land surface directly or at an angle, how much evaporation occurs at a given location.

Frame 17: Vegetation – plants are generally the living organism having the most significant effect on soil formation, although animals can and do also have a significant effect on soil formation. Suprising as it may seem to many people, **grassland environments generally result in more mature soil formation than soil formation under forest canopies.** Additionally, **the presence of growing plants – contrasted to dryland sites with little vegetation – promotes soil formation. The presence of growing plants also serves as a good indicator of soil development conditions.**

Frame 18: Living organisms – animals can present some pretty good clues about soil properties – in addition to having a significant role in soil formation processes. Ground squirrels, ants, earthworms, centipedes, pocket gophers all bore through the soil, creating channels for gas and water movement. In addition, this digging and burrowing action mixes soil material, nutrients, and microbes.

Frame 19: Time **–** soil is constantly being formed from parent material, although the rate of soil formation is a function of the interaction of the other factors through time. Some soils are relatively young – such as those constantly being formed from colluvium (material eroded in from above) or deposited or worked by water and/or wind. Other soils are thousands and thousands (even millions) of years old – and are still being formed

Time, coupled with climatic events, can have significant bearing on soil formation – and soil removal. Here again, the vision presented by the soil profile provides evidence of what the past circumstances have been for the site being evaluated.

Frame 20: Human activity – Probably the most influential recent introduction of soil forming factors is the human factor. It will be interesting what archaeologists and soil scientists report in another 10,000 years about the soil formation process.

Frame 21: Occasionally, the soil 'on first appearance' is substantially different below ground, as you dig deeper. As shown in these two images, sometimes a pre-existing soil is buried below the surface soil – an act of nature in the soil formation process.

Frame 22: The bottom line **–** sometimes it's necessary to dig deeper. Questions

File 3-Introduction to Soil DEQ Septic.doc (goes with ppt by same name)