SOILS and WATER QUALITY

SOILS

Soil can be defined as a natural body developed from a mixture of broken and weathered mineral material (rocks) and decaying organic material (remains of living organisms). Soil covers the earth in a relatively thin layer. It supplies air, water and nutrients for plant growth. Soil also provides mechanical support for plants, buildings and other types of construction.

Plants and animals derive support and nutrients directly or indirectly from the soil. As plants and animals live and die, their waste products and remains are returned to the earth to form the organic fraction of the soil. The development of *one (1) inch of soil* may require many *hundreds* of years under natural conditions.

Soils differ in their potential to produce food and fiber and in their usefulness for construction sites and other nonagricultural uses. Knowledge of soil characteristics is necessary to determine the appropriate uses, management practices and conservation measures needed to ensure appropriate land use. The best use and management of any given plot of land is based upon the specific characteristics of the soil there.

Soil engineering properties and interpretations also may be determined using soil characteristics and potential problems as a basis. These properties and interpretations may be used for selecting suitable sites for building houses, locating roads, planning parks and playgrounds, and many other construction uses of soil.

SOIL PROFILE

Each soil is unique and made up of distinctive layers called ***soil horizons***. The various horizons or sequence of horizons make up a ***soil profile***. The soil profile develops as the result of the interaction of five soil-forming factors: *climate, organisms, parent material, topography and time*. The soil profile is usually not over 5 feet thick because this is as deep as weathering processes generally go.

Types of Soil Horizons

A soil horizon is a layer of soil usually lying parallel to the surface. It has a unique set of physical, chemical and biological properties. The properties of soil horizons are the results of soil-forming processes. Variations in these properties cause each horizon to be distinct from adjacent horizons.

Soil horizons are named using combinations of letters and numbers. Six general kinds of horizons, called ***master horizons***, may occur in soil profiles. These master horizons are named with capital letters: **O**, **A**, **E**, **B**, **C**, and **R**. A single soil probably never contains all six master horizons. Most Idaho soils have A, B, and C horizons. Other Idaho soils have an A horizon resting directly on a C horizon, or an A-E-B-C horizon sequence, or even an O-E-B-C sequence. The illustration below shows a theoretical soil profile with all 6 master horizons:

O Litter layer

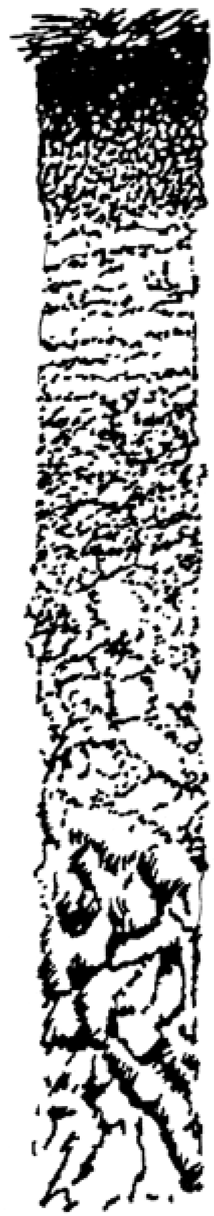
A Mineral surface horizon, dark colored, granular structure

E Strongly leached horizon, light colored, platy structure

B Subsoil horizon of maximum development, “brown”, blocky structure

C Weathered “parent material”, “brown”, massive structure

R Hard bedrock



Each master horizon has a distinct set of properties, which are described on the next page.

O Horizon – An O horizon is composed of organic material (***litter***). It does not have to be 100 percent organic material, but most are nearly so. Forest soils usually have thin organic horizons at the surface. They consist of leaves, twigs, and other plant materials in various stages of decay. Wet soils in bogs or drained swamps often have only O horizons.

A Horizon – The A horizon is the surface horizon of a mineral soil. It has a ***granular*** structure. The unique characteristic of an A horizon is the dark color formed by the ***humus*** (decomposed organic) content. The thickness of A horizons ranges from a few inches in low precipitation (desert) rangeland soils, to 20 inches or more in the Palouse area of northern Idaho.

The A horizons play an extremely important role in maintaining soil fertility and providing a favorable environment for root growth. They should be protected from erosion or compaction. A horizons are usually the horizons that are referred to as "***topsoil***" although topsoil is a less definitive term than A horizon: It usually refers to the top 6 to 12 inches of the profile and may actually include no A horizon, as in the case of severely eroded or scraped areas.

E Horizon – This horizon has a light gray or whitish color. It is present only in areas with relatively high precipitation. It usually occurs immediately beneath an O or A horizon.

E horizons are light colored because nearly all the iron and organic matter has been removed or ***leached*** (washed) out. (**Contest Hint:** *Think of "E" for "Exit" or leaching.*) E horizons exhibit a "***platy***" structure.

B Horizon – The B horizon has the brightest yellowish-brown or reddish-brown color and a "***blocky***" structure. Many B horizons have more clay than any other horizons in the profile and show evidence of clay accumulation. B horizons are part of the subsoil. They are the subsoil horizon with the maximum amount of development.

In cases where the A horizons have been completely lost by erosion or for some other (usually) man-caused reason, the B horizon may be at the surface and thus constitutes the "topsoil."

C Horizon – The C horizon is composed of weathered geologic or ***parent material*** found below the A or B horizon. It is "brown" in color and has a massive structure. Any material that is loose enough to be dug with a shovel but has not been changed appreciably by soil forming processes is considered to be a C horizon. The C horizon is also considered to be part of the subsoil. The sand and gravel deposits of glacial outwash and till in northern Idaho are examples of a C horizon.

R Horizon – The R horizon designation is used for ***bedrock***. Bedrock consists of hard, relatively unweathered rock material. Depending on the depth to bedrock, the R horizon may occur directly beneath any of the other master horizons.

SOIL TEXTURE (Surface and Subsoil)

Texture is the proportion of sand, silt and clay-sized soil particles making up the soil minerals. Texture is an important soil property because it is closely related to many aspects of soil behavior. The ease of tilling the soil and the ease of plant root development within the soil are both influenced by soil texture. Texture affects the amount or air and water a soil will hold and the rate of water movement into and through the soil.

Plant nutrients are also related to soil texture. Tiny silt and clay particles provide more mineral nutrients to plants than large sand grains. The productivity of sandy soils can be improved through proper management but these soils require more fertilizer and more frequent irrigation (watering) than soils with higher percentages of silts and clays.

There are three **size classes of soil particles**:

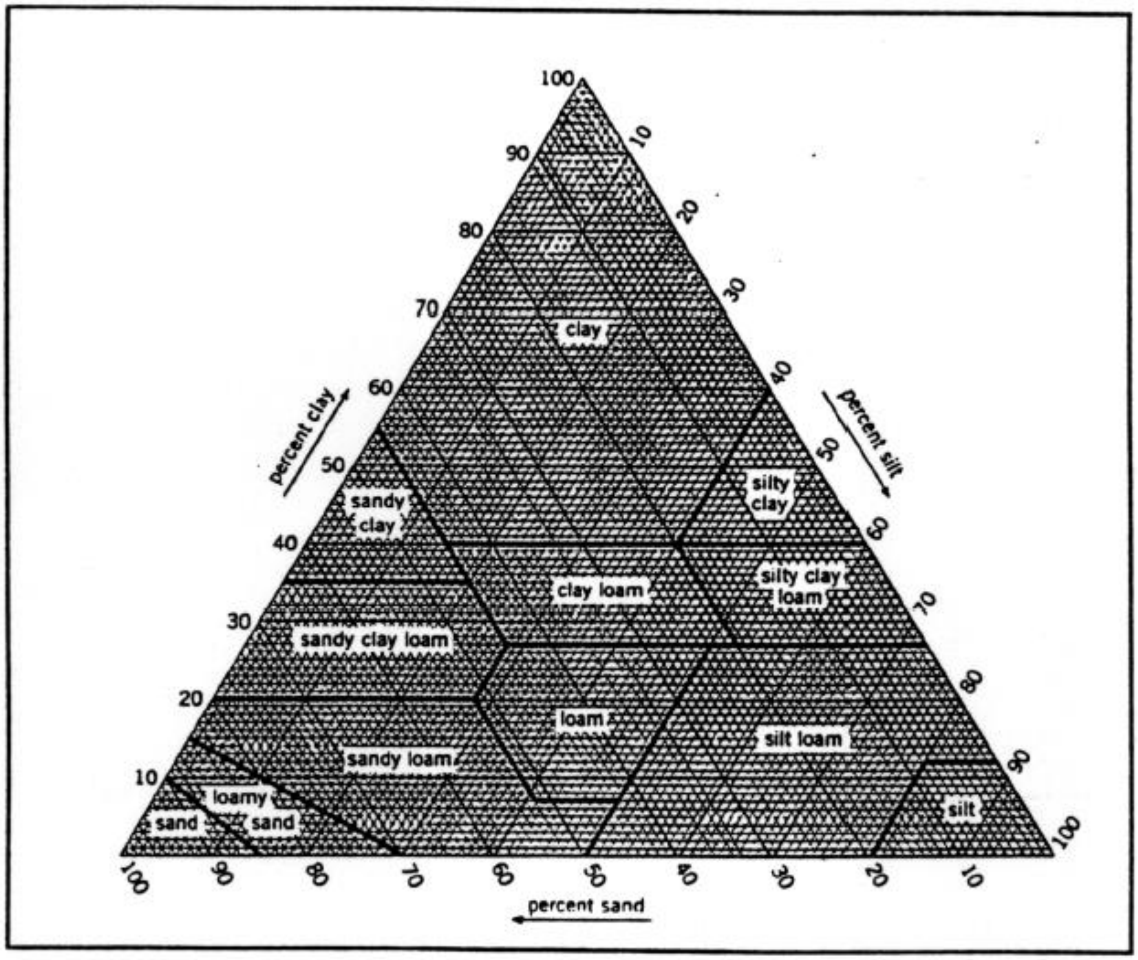
- ***Sand*** particles provide more mineral nutrients to plants than large sand grains. Sand particles range in size from 0.05 mm to 2 mm. They are large enough to see with the naked eye, and they feel gritty.

- ***Silt*** particles cannot be seen without a hand lens or microscope. Silt feels smooth, like flour or corn starch. It is not sticky.

- ***Clay*** particles are less than 0.002 mm in size. They can be seen only with extremely high-powered microscopes. Clay feels sticky when wet and can be molded into “ribbons” or “wires” or other forms much like modeling clay.

FORESTRY CONTEST TIP*:* A sample of soil material taken from the profile at the contest site will be placed in a container to be used for judging textures. You will be asked to name the soil texture (i.e. sandy loam, clay loam, silt loam, etc.), as determined by the relative amounts of sand, silt or clay that are present.

The Textural Triangle



Every soil contains a mixture of various amounts of sand, silt and clay. Since there are three size classes of particles, a three-sided ***textural triangle*** is used to show all the possible combinations.

Precise boundaries between ***textural classes*** are shown in the textural triangle diagram above. Each side of the triangle is the base line or "zero point" for the particle size in the opposite corner. If we know how much sand, silt, and clay a soil has, we can easily plot that soil's location on the triangle and see which textural class it falls into.

A soil that is composed of primarily sand-sized particles would lie very close to the sand corner of the triangle. Its *textural class* name would simply be "*sand.*" Similarly, a soil dominated by clay would lie near the clay corner of the triangle and would be called "clay."

Now, consider a soil with a mixture of sand, silt and clay. All three are present, but not in exactly equal proportions (and it actually takes less clay to "balance" the mixture than either sand or silt). This type of soil will fall into the lower central part of the triangle and would be called a ***loam***.

Determining Soil Texture using the Textural Triangle

Suppose we have a soil that contains 40 percent sand, 45 percent silt, and 15 percent clay.

1. *Start with the clay content*: Find the midpoint of the base line that lies between sand and silt (i.e. the base line at the bottom of the triangle). From there, go vertically up to the 15 percent clay line (the percent of clay is shown on the left side of the triangle). *Every soil on this (horizontal) line contains 15 percent (15%) clay.*

2. *Next, locate the 40 percent (40%) sand line* (the percent of sand is shown on the base line at the bottom of the triangle, opposite the clay corner). The 40% sand line runs diagonally up and to the left (i.e. parallel to the right side of the triangle). Find the point where the 15% clay line and the 40% sand line intersect. Mark that point.

3. *Now, if you wish, you can find the 45% silt line* (on the base line between silt and clay) and follow it diagonally down and to the left until it intersects with the 15% line. However, *it takes only two points to determine the soil texture*. This sample is a *loam*.

Determining Soil Texture in the Field

Soil scientists recognize 12 soil textural classes, as seen in the textural triangle. For the purpose of the Forestry Contest, the soil texture will be identified as one of only the three basic textural classes: ***sandy***, ***silty/loamy***, or ***clayey***.

Basic Soil Textural Classes

	Sand		
Clay	**>50%**	**20-50%**	**<20%**
>40%	sandy or clayey	clayey	clayey
27-40%	sandy	silty/loamy	silty/loamy
<27%	sandy	silty/loamy	silty/loamy

Determining Soil Texture by Feel

1. Fill the palm of your hand with dry soil.

2. **Moisten the soil** enough so that it sticks together and can be worked with the fingers. Don't saturate it into runny mud. If the soil sticks to your fingers, it's too wet to tell texture. Add more dry soil.

3. **Knead the soil** between your thumb and fingers. Take out the pebbles and crush all the soil aggregates. You may need to add a little more water. Continue working the soil until you crush all the aggregates.

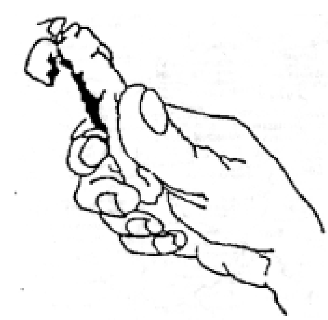
4. **Estimate the sand content** by the amount of textural grittiness you feel.

   a. More than 50% = sand dominates. The textural name is probably *sandy*.

   b. 20 – 50% = sand is noticeably present but not dominant. The texture is most likely *silty/loamy.*

   c. Less than 20% = silt and clay dominate. The textural name is either *silty/loamy* or *clayey.*

5. **Estimate the clay content** by pushing the sample up between your thumb and index finger to form a ribbon.



   a. Less then 27% = the ribbon is less than 1 inch long. The textural name is either *sandy* or *silty/loamy.*

   b. 27 – 40% = the ribbon is 1 to 2½ inches long. The textural name is either *silty/loamy* or *clayey*.

   c. More than 40% = clay dominates and the ribbon will be more than 2½ long. The textural name is *clayey*.

6. **Combine your estimates** of sand and clay to determine the textural name.

Soil Depth

The depth of soil includes the total thickness of the soil horizons readily penetrated by plant roots, water and air. A restrictive layer may be dense clay, hardpan or bedrock. There are *five classes of soil depths*:

1) Very Shallow = soils less than 10 inches deep
2) Shallow = soils 10 to 20 inches deep
3) Moderately Deep = soils 20 to 40 inches deep
4) Deep = soils 40 to 60 inches deep
5) Very Deep = soils more than 60 inches deep

CONTEST TIP: You will be expected to be able to identify the:

→ Texture of the A horizon

→ Thickness of the A and B horizon

→ Percent of rock fragments in the whole soil by volume

FORESTRY INTERPRETATIONS for SOILS

By identifying the properties of a soil, a user can make predictions about the success of various uses. Foresters, for example, can use the knowledge of soil properties to help determine how difficult reforestation will be or how severe the hazard of windthrow is. The two forestry interpretation charts on the next page can be used to determine the ***limitations ratings*** (i.e. the expected difficulties or risks) for *reforestation* and *windthrow*.

Reforestation is the planting or natural regeneration (growth) of tree seedlings. Soil factors that influence tree seedling survival are:

- Rooting depth (depth that roots are able to penetrate through the soil)
- Texture (as related to water-holding capacity)
- Thickness of the A horizon

The chart below shows how variations in effective rooting depth, soil texture, and soil thickness affect tree survival (*Rating*). This chart predicts the likelihood of tree seedling survival in each soil type (for planting site-adapted tree species and for naturally regenerating seedlings).

Effective Rooting Depth	Texture of A Horizon	Thickness of A horizon	Rating
>40 inches	Sandy	0-10”	moderate
		>10”	slight
	Silty/loamy, Clayey	any	slight
20-40 inches	Sandy	0-10”	severe
		>10”	moderate
	Silty/loamy, Clayey	0-10”	moderate
		>10”	slight
<20 inches	Sandy	any	severe
	Silty/loamy, Clayey	0-10”	severe
		>10”	moderate

Windthrow Hazard is an estimate of how susceptible mature trees are to being blown over during strong winds. The soil factors that influence windthrow hazard are *effective rooting depth* and *texture*. The chart below shows the effect these two factors have on windthrow hazard.

Effective Rooting Depth	Surface Texture	Rating
>40 inches	Silty/loamy, Clayey	slight
	Sandy	moderate
20 to 40 inches	Silty/loamy, Clayey	moderate
	Sandy	severe
<20 inches	any	severe

WATER QUALITY

We hear a lot of talk about "water quality," but what does it really mean? How do we know if our water is clean?

Water contains many substances besides "H20." Minerals, for example, give water its taste and are necessary for health. They are found naturally in water, as are many other substances. But when these substances become too plentiful, they can change from being harmless materials to "***pollutants***."

The amount of a substance that is *safe* to allow in water depends on the use of the water. The water from the tap at home should be crystal clear and free of bacteria, right? But what about the water used for livestock or for irrigating the garden? Water used for various activities requires different levels of purity and protection. In Idaho, ***safety levels of pollutants*** have been established for the following activities or uses:

- Domestic Water (drinking and other household activities)
- Cold Water Fisheries (trout and their cousins)
- Warm Water Fisheries (sunfish, bass, and their relatives)
- Trout Spawning
- Swimming
- Wading and Boating
- Irrigation
- Livestock Watering

The ***quality of water*** is determined by its chemical and physical characteristics. If these are outside the safe range, the water is considered polluted. Here are ten important factors that we look at to determine water quality:

1. Suspended Solids

Suspended solids are materials carried in streams and rivers that can be filtered out of the water. They include particles of sewage and animal wastes, decaying plants, industrial wastes, and soil particles. Soil particles in water are called ***sediment***. *Suspended* sediment gets into water through the process of erosion. This occurs when water runs over land not covered with vegetation. Suspended sediment reduces water clarity, fills in reservoirs, increases treatment costs of drinking water, reduces habitat for aquatic organisms, and interferes with irrigation by decreasing pump life and increasing ditch-cleaning costs.

2. Dissolved Oxygen

Creatures that live in water need oxygen that is dissolved in water to survive. Oxygen gets into water from the air or is released by aquatic plants.

Some of the factors that affect the amount of oxygen dissolved in water include:

- ***Temperature*** – Cold water holds more oxygen
- ***Altitude*** – Air is thinner at higher altitudes
- ***Plants in water*** – Photosynthesis releases oxygen into the water
- ***Decaying materials in water*** – The decomposition of dead algae, leaves, and wastes uses up oxygen
- ***Turbulence*** – Rocky stream bottoms increase oxygen
- ***Depth*** – The greater the surface area, the more oxygen is absorbed
- ***Velocity*** – Moving water absorbs more oxygen
- ***Shading*** – Affects temperature and photosynthesis
- ***Ice Cover*** – Prevents contact between air and water

Dissolved oxygen normally ranges between 8 and 15 parts per million (*ppm*). Since oxygen requirements vary among aquatic organisms, Idaho has set a minimum level of 5 ppm for warm water fish, and 6 ppm for cold water fish (except below dams).

3. Parts Per Million

Most pollutants are harmful at very low levels, so their quantity is reported in ***parts per million*** (abbreviated to ***ppm***). One drop of a substance in 26 gallons of water is about 1 ppm. You will also see pollutants reported in ***milligrams per liter*** (***mg/l***), but this still means parts per million. For ***toxic materials***, the units are often ***parts per billion*** (***ppb***). ***Micrograms per liter*** (**μg/l**) also means ppb.

4. Temperature

There is an ideal temperature range for each creature that lives in water. Cold water fish, like trout, do best at temperatures between 50º and 58º F. Water temperatures over 70º F can cause problems for them. Warm water fish, like sunfish and bass, can survive in 92º F water. Temperatures outside fishes' ideal range may not kill them but can cause a lot of stress. At high temperatures, fish can't reproduce, they grow less, and they are more susceptible to disease and harm from pollutants. Creatures that fish eat are sensitive to temperature changes, so warmer water may also cause a reduction in the food supply.

5. pH

pH is a measurement of acidity - in this case, it measures whether water is ***acidic, basic or neutral***. Specifically, pH is a measure of hydrogen ion activity in water. It is measured on a scale from 0 to 14, with 7 representing the neutral point. Values below 7 are acidic (like vinegar or soda pop) and values above 7 are basic (like soap or lye). Most natural waters are buffered by minerals like bicarbonates (the active ingredient in baking soda, for example) that keep pH values in the 6.5 to 9.0 range.

pH is important because it affects most chemical processes that occur in water. For example, in water with a high pH, metals are not toxic but at low pH, metals are actively toxic. pH also affects the makeup and size of communities of creatures in water. Generally, low pH (acidic) waters have fewer species and a much lower rate of productivity, so they support a smaller fish population than waters with higher pH (basic or alkaline) values.

6. Bacteria

Bacteria are measured in water to see if disease-causing organisms are present. It is impossible to test for all the disease-bearing organisms that can occur in water, so tests are done to see if one particular bacterial group, called ***fecal coliform***, is present. This bacterial group consists of beneficial bacteria that exist in the intestines of warm-blooded animals. If fecal coliform bacteria are found in water, it's likely that other organisms that cause health problems are also present.

In Idaho, maximum safety levels for fecal coliform are:

- Wading or Boating: 200 bacteria colonies per 100 ml
- Swimming: 50 bacteria colonies per 100 ml
- Drinking: 1 bacteria colony

7. Nutrients

Nutrients stimulate plant growth in water in the same way they stimulate growth of house plants in a flower pot or crops in a field. Microscopic plant life called ***algae*** causes a green scum on rocks or, as a floating form, causes a "pea soup" color in lakes and ponds. Larger aquatic plants are called "tules" or "seaweed" in lakes and are known as "mosses" when found in irrigation ditches. When aquatic plant growth is excessive, it can interfere with recreational uses such as boating and swimming. It can also cause odors when it decays, clog pipes and ditches, and it reduces oxygen to levels that are harmful to fish. Too many nutrients speed up the natural aging of lakes, a process in which lakes are filled with plant growth and become swamps or bogs.

The most common nutrients in water are nitrogen and phosphorus, the same nutrients that are used on farms and gardens as fertilizer. Nitrogen gets into water from the air (80% of air is nitrogen gas), sewage, animal waste, fertilizer, and soil that washes into the water. Phosphorus does not become a gas. It is leached by rain or irrigation from soil and bedrock into water sources. Generally, concentrations of inorganic nitrogen above 0.3 ppm and concentrations of phosphorus above 0.1 ppm are considered unacceptable.

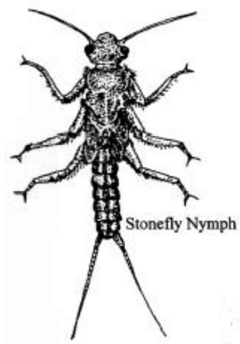
8. Turbidity

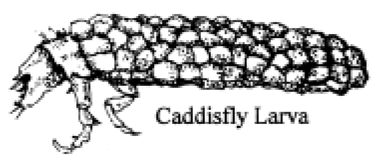
Turbidity refers to the murkiness of water, with zero turbidity indicating clear water. Turbidity is determined by shining a beam of light through a water sample and measuring the amount of light that is reflected off the particles in suspension. Water with turbidity higher than 25 units looks dirty and is considered to be harmful to fish and other aquatic organisms.

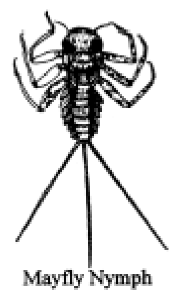
9. Biological Indicators

One way to determine if a body of water is healthy is to look at the creatures living in the water. We can see what kind of ***macroinvertebrates*** live in a stream. “Macro” means big enough to be seen with the naked eye. “Invertebrates” means animals without backbones. Insects, small crustaceans and snails are all macroinvertebrates that live in water.

A healthy stream has a wide variety of macroinvertebrates including some that are sensitive to pollution such as *caddisflies, mayflies and stoneflies*. These creatures are the primary source of food for trout. In a polluted stream, this variety is reduced to only a few species that are more tolerant of pollution. These species often multiply quickly and, in some cases, become nuisances.







10. Toxicity

Many toxic materials are ***soluble*** (i.e. they dissolve) in water. Among the most common are organic compounds (like pesticides and herbicides) and heavy metals such as lead, mercury and cadmium. These compounds may be lethal to fish and other aquatic organisms or may cause more subtle effects such as reduced growth or failure to reproduce.

WATER QUALITY and FORESTRY

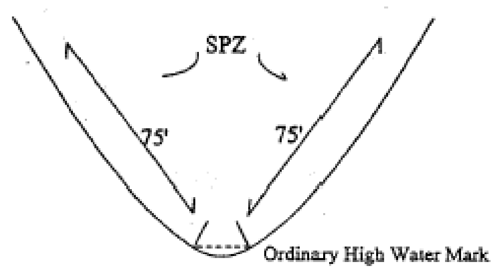
Forestry practices such as timber harvest, road construction, skidding, and log hauling can have a positive or a negative effect on water quality. Poor road construction and/or poor skidding practices can account for up to 90 precent of the soil erosion entering streams. Intermittent streams can contribute a significant amount of sediment to year-round streams. Thus, both intermittent and year-round streams need to be protected.

We can protect our streams by using a set of stream protection guidelines that have been developed for forest practices called ***Best Management Practices (BMPs)***. BMPs address such items as soil protection, drainage systems, and road maintenance. BMPs prescribe the most effective and practical means of preventing or reducing the amount of “***non-point source pollution***” generated by forest practices.

BMP Requirements & Streams

For forest practice purposes, streams are divided into two categories: Class I and Class II. Each category has its own set of BMP requirements.

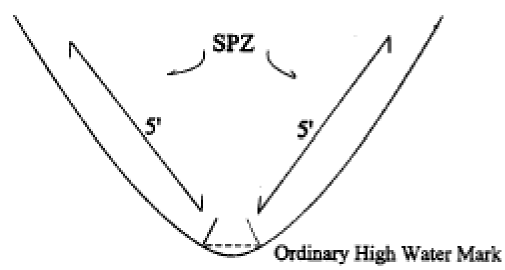
> ***Class I streams*** *are used for domestic water supply or are important for spawning, rearing, or migration of fish. Domestic water supply streams are considered Class I for a minimum of ¼ mile upstream from the point of domestic diversion.*
>
> ***Class II streams*** *are usually minor drainages or headwater streams that do not support fish and are not used for domestic water supply.*



Class I Stream Protection Zone

Class I streams have a ***Stream Protection Zone (SPZ)*** of ***75 feet*** on each side of the "***Ordinary High Water Mark***".

For example, one of the BMPs for Class I streams says that logging can occur inside the Class I stream protection zone (75 feet on either side), *but 75 percent of the current shade over the stream must be maintained*. Shade is important because it helps to maintain the cooler water temperatures needed by fish.



Class II Stream Protection Zones

Class II streams have a stream protection zone (SPZ) of **30 feet** on either side of the "Ordinary High Water Mark", wherever they may potentially impact a Class I stream. The most common example of this is where the Class II stream flows into a Class I stream.

In cases where a Class II stream would have no impact on a Class I stream, the SPZ would be a minimum of **5** feet (as illustrated below). This can occur if, for example, a Class II stream is intermittent, flowing on the surface and then going underground without flowing into a Class I stream.

Here are two more examples of stream-related BMPs:

1. When streams must be crossed, temporary structures must be installed that are adequate to carry stream flows. Skidding logs in or through streams is not permitted. This rule applies to both tracked and wheeled skidders.

2. ***Large organic debris*** (referred to as ***LOD***) must be provided and maintained along a stream. LOD is defined as large, living or dead trees and parts of trees that are buried in the stream bank or bed. LOD is important because it creates diverse fish habitat and stable stream channels by reducing water velocity, trapping stream gravel, and allowing scour pools and side channels to form.

BMPs & Soil Protection

To keep ***sediment*** (dirt) out of streams, the soil must be protected from *erosion* and other damage. To minimize soil erosion during logging, the harvesting method and the type of equipment used must be carefully chosen to suit the conditions of the site (such as slope, landscape, and soil properties).

Specific BMPs have been developed for all aspects of forest management including timber harvest, maintenance of productivity, road specifications and plans, road construction, road maintenance, minimum tree seedling stocking levels, use of chemicals, and slash management. These BMPs can be found in the Idaho Department of Lands publication Rules and Regulations Pertaining to the Idaho Forest Practices Act, Title 38, Chapter 13, Idaho Code.

The following are examples of BMPs that have been developed for tractor ***skidding*** and line skidding:

→ Tracked or wheeled skidders should not be used on geologically unstable, saturated, or easily compacted soils. (Unstable and erosive soils are generally the sands and silts. Clays, loams or soils high in organic matter tend to be less erosive.)

→ Line skidding is usually required on steep slopes, especially adjacent to Class I or Class II streams. Line skidding is required if the slope exceeds 45%.

In the end, the condition of our streams is a reflection of how well we are managing our natural resources. With the proper application of BMPs, our streams will be protected.