Physical evaluation

This portion of the survey includes a wide variety of observations using all senses, making several judgments based on established rating descriptions, as well as collection and measurement procedures. In this section we discuss general physical observations. These observations should be completed prior to or immediately following the water quality analysis.

Table 3 provides a list of the conditions that are assessed as wells as some general guidelines regarding what certain characteristics indicate. Water observations are made in a run or riffles, sediment observations are also made in a run or riffle and benthic algae observations are made in a riffle. These observations should be made multiple times throughout the reach to make sure conditions are consistent. You should write comments on the survey data sheet if any notable differences within the reach are observed.

Table 1 - Stream physical condition characteristics

Water conditions

Colors

Brown: Usually caused by sediment in the water. Some muddiness (brown color) is natural after storms, but if the condition persists look for an activity upstream that has disturbed the soil such as construction sites, logging, storm water runoff from roads or urban areas, or agricultural activities such as cattle in the stream.
Black: Usually caused by coalmine drainage, tar or sometimes waste material from road construction.
Green: Usually due to an algae bloom caused by excessive nutrients in the water. The source could be sewage, fertilizers from farms, homes or golf courses or waste from animal feedlots.
Multi-colored sheen: Can occur naturally in stagnant waters, but a sheen that is moving or does not break up easily may be an indication of oil pollution. The source could be runoff from streets or parking areas or illegal dumping. In some areas the use of all-terrain (ATV's) vehicles may contribute to stream oil pollution.
Orange or **red**: Usually associated with mine drainage.
Tea colored: Usually associated with wetlands.

Substrate conditions

Colors

Brown: An indication of silt deposits from sediment sources. Most stream bottoms are normally brown in color.
Black: This deposit can occur naturally in heavy organic soils but can also be due to fine coal particles, tars, ashes, sludge etc.
Green: Possible indication of excessive algae growth from organic (nutrient) enrichment sources.
Orange, **yellow** or **red**: A coating of flocculates on the sediments is usually due to polluted coalmine drainage.
White or **gray**: A white cottony mass is a sewage fungus common to organic polluted waters. An even coating of white or gray flocculates may be metals (aluminum) precipitated out of solution from contamination due to mine drainage.

Sediment odors

It is good practice to compare sediment odors to odors in the water column. Stirring the bottom sediments and collecting a sample of water and sediment near the area that was disturbed assess

Algae conditions

Color

Algae color varies from brown to dark green in most streams and rivers; although color is a noticeable condition of the algae it is not a particular indicator of the types or of the condition represented by the algal community.

Abundance

Coverage in a riffle is estimated based upon the following: none, scattered, moderate or heavy. A heavy coating of matted and floating algae is often an indication of nutrient rich conditions caused by excess nitrogen and phosphorous.

Growth habit

The growth habit characteristics are critical to understating the algae. Most stream algae will be evenly coated on the rocks and have a smooth or slimy texture; other types will be filamentous and have a hairy texture; and others will be matted. Matted algae are easily removed from the surfaces by slowly scraping with your fingers. If the algal community is

White or **gray**: Can be caused by runoff from landfills, dumps, or sewage.

Odors

Rotten eggs: This strong sulfur-like odor can be an indication of sewage pollution or polluted coalmine drainage.
Musky: This slight organic odor is often natural, but in some cases may indicate nutrient enrichment from organic waste products or sewage contamination.
Oily: This odor may indicate pollution from oil and gas wells.
Chemical: There are a wide variety of chemical odors usually the result of industrial discharges, solvents, and detergents.

sediment odors. The odors in the sediments should be like those described for water.

Streambed composition is either estimated or measured using a pebble count procedure. The major size categories are silt/clay (mud), sand, fine gravel, coarse gravel, cobble, boulder, bedrock, and woody debris.

mostly matted pieces will come off in junks like carpet when it has been removed from flooring.

Foam occurs naturally due to the decomposition of leaves (this foam is generally less than three inches high and cream colored). Excessive white foam may be due to detergent pollution.

Habitat assessment

The **habitat assessment** process involves rating many different habitat conditions as optimal, suboptimal, marginal or poor based upon criteria (descriptions and a rating scale) included on the survey data sheets. The optimal category is a description of conditions that meet natural expectations; suboptimal includes descriptions of criteria that are less than desirable but satisfies expectations under most circumstances; marginal is a description of moderate levels of degradation with severity at frequent intervals throughout the reach; and poor are descriptions of criteria for streams that have been substantially altered with severe degradation characteristics.

Descriptions of the habitat conditions are provided below followed by a brief description of each condition. For additional information go to Chapter 5 of the US EPA's Rapid Bioassessment Protocols. The conditions here should be applied when describing the habitats of rocky-bottom streams and rivers. Level two volunteer monitors assess five conditions: (1) sediment deposition, (2) embeddedness, (3) bank protection, (4) bank stability and (5) riparian buffer width.

Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, fewer living spaces are available to macroinvertebrates and fish for shelter, spawning and egg incubation. To estimate the percent of embeddedness, observe the amount of silt and sand sediments overlying and surrounding the larger gavel and cobble size particles. You should base your embeddedness assessment on the composition of the materials that you observe. Embeddedness is always evaluated in the riffles used for your macroinvertebrate collections. In most cases the best persons to comment about this condition is the person(s) collecting macroinvertebrates. If cobble and gravel are easy to remove from the riffle and there is little sand or silt either in the net or suspended during collections, embeddedness is minimal. In some cases, chemicals can cement (armoring) the substrate together and cause severe embeddedness.

Sediment deposition is an estimate of the amount of sediment that has accumulated and the changes that have occurred to the stream channel because of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of runs and pools. Usually, deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms. Sediment deposition should be rated throughout your reach and should not be confused with embeddedness. Sediment deposition is probably the most difficult condition to assess. It is a natural process and bars often form in streams that are very stable and have little sediment from the surrounding land or few problems with erosion. When assessing this condition look for indicators that are unusual or beyond what is expected to be normal for the stream. The most effective way to learn is to view many different stream types representing both degraded and natural conditions. In most cases island formation, especially in small streams (1st through 3rd order), is an indication of excessive deposition. The most common cause for unusual or un-natural deposition in most streams is human encroachment (i.e., structures such as bridges, roads, culverts etc. to close to the stream or built so that the stream is narrowed) and bank erosion. Steep sloping banks with exposed surfaces are more likely to erode. Undercut banks can often erode but are sometimes very stable if covered with vegetation, tree roots and rocks. Look for deposition around eroding banks, especially if they show bare soils consisting mostly of fine materials (fine gravel, sand, and silt). Hard surfaces no matter how steep or undercut are less likely to erode.

Riffle frequency is a way to measure the sequence of riffles and thus the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna; therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community. For high gradient streams where distinct riffles are uncommon, a run/bend ratio can be used as a measure of meandering or sinuosity. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates because of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refuge for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in some streams, a longer segment or reach than that designated for sampling should be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The "sequencing" pattern of the stream morphology is important in rating this parameter. In headwaters, riffles are usually continuous, and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods.

Attachment sites includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refuge, feeding, or sites for spawning and nursery functions of aquatic macro-fauna. A wide variety and/or abundance of submerged structures in the stream provide macroinvertebrates and fish with many niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbance decreases. Riffles and runs are critical for maintaining a variety and abundance of insects in most high-gradient streams and serving as spawning and feeding refuge for certain fish. The extent and quality of the riffle is an important factor in the support of a healthy biological condition in high-gradient streams. Riffles and runs offer a diversity of habitat through variety of particle size, and, in many small high-gradient streams, will provide the most stable habitat. Snags and submerged logs are among the most productive habitat structure for macroinvertebrate colonization and fish refuge in low-gradient streams. However, "new fall" will not yet be suitable for colonization.

Patterns of velocity and depth are included for high-gradient streams under this parameter as an important feature of habitat diversity. The best streams in most high-gradient regions will have all four patterns present: slow-deep (pools); slow-shallow (glides); fast-deep (runs); and fast-shallow (riffles).

Channel alteration is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control or irrigation purposes. Such streams have far fewer natural habitats for fish, macro-invertebrates, and plants than do naturally meandering streams. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration.

The degree to which the channel is filled with water is the **channel flow status**. The flow status will change as the channel enlarges (e.g., aggrading stream beds with actively widening channels) or as flow decreases because of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing the areas of good habitat. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions. This parameter becomes important when more than one biological index period is used for surveys, or the timing of sampling is inconsistent among sites or annual periodicity.

The next three conditions are evaluated on both sides of the reach. Note: The **LEFT** and **RIGHT** sides are determined by looking downstream.

The **bank stability** parameter evaluates whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks and are therefore considered to be unstable. Signs of erosion include crumbling, un-vegetated banks, exposed tree roots, and exposed soil. Eroded banks indicate a problem of sediment movement and deposition and suggest a scarcity of cover and organic input to streams.

Bank vegetative protection parameter estimates the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of in stream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the native vegetation for the region and stream type (i.e., shrubs, trees, etc.). In some regions, the introduction of exotics has virtually replaced all native vegetation.

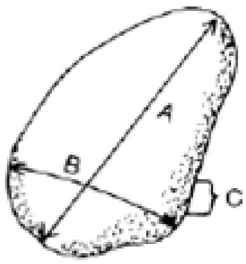
A healthy riparian buffer. Photo by Tim Craddock

Riparian buffer width is an estimate of the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the streambank. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic degradation of the riparian zones. Conversely, the presence of old fields, paths, and walkways in an otherwise undisturbed riparian zone may be judged to be inconsequential to altering the riparian zone and may be given relatively high scores. Riparian buffers are the most valuable protection a stream system has against outside influences.

In most cases healthy riparian directly reflects upon the condition of the stream unless the source of the insult is a specific pollutant. Enhancement of the riparian buffer by re-planting native grasses, forbs, shrubs, and trees is the first step in the recovery of the stream back to a more natural condition. Below are just a few of the benefits of a healthy riparian buffer.

- Provides organic material as food for invertebrate, fish, and wildlife.
- Supplies large and small pieces of woody debris that provide habitat for fish, invertebrates, and amphibians.
- Alters how sunlight reaches the stream and is an important temperature moderator.
- Stabilizes stream banks and reduces erosion.
- Filter’s sediment and materials from overland runoff and roots of many plants traps and holds the sediments.
- Absorbs nutrients from overland and sub-surface flows.
- Reduces the impacts of flooding through temporary storage, interception/diversion, and slow releases.

PEBBLE COUNT



A – Long axis
B – Intermediate axis
C – Short axis

The composition of the streambed and banks is an important facet of stream character, influencing channel form and hydraulics, erosion rates, sediment supply, and other parameters. Observations tell us that steep mountain streams with beds of boulders and cobbles act differently from low-gradient streams with beds of sand or silt. You can document this difference by collecting representative samples of the bed materials using a procedure called a pebble count.

The most efficient basic technique is the Wolman pebble count. This requires a person with a metric ruler who walks through the stream, and a note taker who remains on the bank with the field book or survey data sheet. The note taker records the count is recorded by size classes or categories like those shown in Table 4. Pebble counts can be collected using grids, transects, or a random step-toe procedure. Select the portion of the reach that you wish to measure (this may be the entire reach or riffles only). For stream characterization, sample pools, runs, and riffles in the same proportions as they occur in the study reach. For other purposes, it may be more appropriate to use a more random method. Measure a minimum of 100 particles to obtain a valid count. Use a data sheet to record the count.

Table 2 - Pebble count size classes

Size categories	Size range (mm)
Silt	Determined by feel
Sand	< 2
Fine gravel	2 - 8
Medium gravel	9 - 16
Coarse gravel	17 - 32
Very coarse gravel	33 - 64
Small cobble	65 - 90
Medium cobble	91 - 128
Large cobble	129 - 256
Small boulder	257 - 512
Medium boulder	513 - 1024
Large boulder	> 1025
Bedrock	Large solid surface
Woody debris	Sticks, leaf packs etc.

Start at a randomly selected point near the downstream end of the reach. Start on the shoreline and take steps across the stream. Averting your gaze, pick up the first particle touched by the tip of your index finger at the toe of your wader. Measure the intermediate axis (neither the longest nor shortest of the three mutually perpendicular sides of each particle picked up). Measure embedded particles or those too large to be moved in place. For these, measure the smaller of the two exposed axes. Call out the measurement. The note taker tallies it by size class and repeats it back for confirmation. Continue across the channel slightly upstream in the direction of the opposite bank and repeat the process, continuing to pick up particles until you have the requisite number (100 or more) of measurements. The note taker keeps count. Traverse across the stream perpendicular to the flow or in a zigzag pattern.

Pebble counts should be completed at least once during the index period and is much easier during low-water conditions that are common in the fall season of the index period. They can be incorporated into your bioassessment survey, or they can be completed as a separate survey.