Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers

(As intended for higher gradient, cobble-bed, course-grained streams)

As Revised, May 2005

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Developed in conjunction with the
Colorado Sediment Task Force

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INTRODUCTION

This guidance provides an interpretation of the Colorado Water Quality Control Commission's (Commission) "narrative standards" as they apply to sediments which may form deposits detrimental to the attainment of aquatic life uses. The Basic Standards and Methodologies for Surface Water, Regulation 31 (5 CR 1002-31), are the basis for establishing this guidance. In particular, section 31.11 of this regulation provides the following language:

> *All surface waters of the State are subject to the following basic standards; however, discharge of substances regulated by permits which are within those permit limitations shall not be a basis for enforcement proceedings under these basic standards:*
>
> *(1) Except where authorized by permits, BMP's, 401 Certifications, or plans of operation approved by the Division or other applicable agencies, state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which:*
>
> *(a) for all surface waters except wetlands;*
>
> *(I) can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt, or mud;...*

Although the deposition of sediment on the bottom of surface waters could have an impact to any of the beneficial uses for which Colorado surface waters are classified, this guidance is intended to apply only to the assessment of impacts to aquatic life uses in streams and river environments. Assessment of impacts to other uses or to reservoir and lake systems is not covered in the guidance and would require a site-specific assessment. Guidance to address these other impacts is being developed through the Colorado Sediment Task Force under the direction of the Division.

Streams Types Covered By This Guidance

This guidance is intended to apply to the assessment of impacts to aquatic life uses in higher gradient, cobble-bed, course-grained, mountainous stream and wadeable river environments. (For example, Rosgen stream types A1-A4, B1-B4, C1-C4.) The guidance can also apply to transition-zone streams that fit the above description. It is not intended to cover sandy-bottom, lower-gradient plains streams, large unwadeable rivers, and lakes and reservoirs. The Division with the assistance of the Sediment Task Force is currently working on guidance to assess these other waterbodies, as well as other beneficial uses.

Introduction to Sediment Impairment

The scope of this guidance is limited to the assessment of bottom deposition of sediment. It is not intended to address sediment suspended in the water column or turbidity. Turbidity and suspended sediment are aspects of sediment transport, which is a complex relationship of streamflow, the type and size of sediment in rivers. However, it is important to understand that an increase in suspended sediment concentrations will reduce light penetration, and a sustained high concentration of suspended sediment can reduce primary production. Increased suspended sediment can cause problems with water treatment, clog irrigation canals, and reduce reservoir storage capacity.

Sediment can be dichotomously classified in overlapping ways – clean or contaminated, and organic or inorganic. This guidance addresses only clean sediment, not sediment that is contaminated by toxic substances such as heavy metals. Organic matter can become abundant enough to cause water quality problems, typically below outfalls where decay can depress dissolved oxygen levels. The distinction between inorganic and organic fractions is not always made in the monitoring or study of sediment, nor is it the intent of this guidance to do so. Inorganic sediment, the product of physical weathering of geologic materials and sediment caused by human induced erosion, is the main focus of this guidance.

This guidance applies to sediment causing stress to aquatic life through the deposition of materials. The guidance is not intended to provide a complete analysis of aquatic life use attainment; it is necessary to perform other analysis (e.g. chemical and toxicity analysis) to determine a full range of possible stressors which may be impacting aquatic life. Only human-caused discharges in amounts, concentrations, or combinations are considered in this guidance. Therefore, natural erosive processes over a variety of geologic conditions must be considered in the implementation of this guidance, in order to determine natural or background conditions.

Excessive deposition of sediment on the bottom substrate of streams and rivers is an important cause of impacts to aquatic life. These impacts usually result from the loss of critical habitat for many fish, aquatic invertebrates, and algae. These kinds of impacts have been addressed in a detailed review in by Waters (1995) and in other literature reviews. Impacts to fish can include the smothering of fish spawning gravels and cobble surfaces with fine sediment resulting in decreased intergravel oxygen and a reduction in survival and growth rates; loss of fish food sources; and loss of pool and other habitat types through changes in stream channel morphology. Impacts to aquatic invertebrates can include the smothering and infilling of the interstitial spaces normally found in clean such as gravel and cobble. This loss of habitat space can result in changes to the normal aquatic invertebrate community including changes in abundance, community structure, distribution, and in the loss of sensitive species.

One of the fundamental questions regarding sediment in streams and its effect on biota is particle size. Stream channels and floodplains are constantly adjusting to the amount of water and sediment supplied by the watershed. Four physical characteristics of a stream are in a dynamic state of equilibrium called Lane's Balance. These characteristics are streamflow, channel slope, sediment load, and particle size. If one of these characteristics changes in a stream, one or more of the other three must also change to accommodate and achieve equilibrium again. A change in sediment load is the first thing to change in response to a disturbance to restore equilibrium and it is the most sensitive measures of change. Chapman and Mcleod (1987) found that bed material size is related to habitat suitability for fish and Macroinvertebrates and that excess sediment decreased both density and diversity of aquatic insects. Specific aspects of sediment-invertebrate relationships may be described as follows: 1) invertebrate abundance is correlated with substrate particle size; 2) fine sediment reduces the abundance of original populations by reducing interstitial habitat normally available in large-particle substrate (gravel, cobbles); and 3) species type, species richness, and diversity all change as substrate particle size changes from large (gravel, cobble) to small (sand, silt, clay) (Waters, 1995).

This guidance is designed to provide a consistent approach for the Division, for other agencies, and stakeholders, to gather data to document the effects of bottom deposits on aquatic life uses. The guidance also provides a means for the Division and the Commission to consider the impacts of bottom deposits on the attainment of the aquatic life uses. In Colorado, surface waters may be assigned any of the following four aquatic life classifcations: class 1 coldwater, class 1 warmwater, class 2 coldwater and class 2 warmwater. The guidance presents a procedure for determining whether a particular stream segment is attaining the narrative standard based on the concept of comparing the actual sediment conditions of a study stream with the **expected conditions** for the same stream. A wide variety of factors including, aquatic life use classification, geology, elevation, climate, hydrology, and land use will influence the selection of appropriate expected conditions.

For the purposes of determining the status of water quality as required in §305(b) of the federal Clean Water Act, and establishing a listing of waterbodies requiring TMDL's under §303(d) of the Act, the standards attainment categories found in Section 4 shall be used by the Division. Classified stream segments or portions of classified segments which are determined to be not attaining the narrative sediment standard after such an analysis may be proposed by the Division for 303(d) listing. Streams which are attaining the standard should not be listed for 303(d) purposes. This guidance is intended for identifying impairment due to sediment but is not intended to address the development of TMDL's for sediment, and therefore does not address how to solve sediment problems or how to identify sediment sources or allocate loads.

1. APPROACH TO ASSESSING SEDIMENT IMPACTS TO AQUATIC LIFE

The assessment approach described in this guidance is based on the combined concepts of the use of thresholds and comparing the **actual conditions** of a specific study stream reach or segment with the **expected conditions** for the same stream to determine attainment of the narrative standard. This guidance uses the term **expected condition** rather than the EPA terminology of reference condition. Expected condition is used in this guidance in an attempt to avoid the concern that sometimes arises when reference condition is narrowly interpreted to mean pristine or minimally impacted streams. Expected condition is intended to include a wide range of aquatic conditions that can reflect more than only minimal impact, including those impacts associated with historical and dominant land and water use activities. Nevertheless, it can still serve as a reasonable and readily attainable target or goal for improvement to the aquatic life use in a sediment impacted water-body.

This approach is directly patterned after the reference condition approach found in U.S. Environmental Protection Agency (EPA) guidance for a number of programs including water quality standards, assessment and reporting, biocriteria development, rapid bioassessment protocols (RBP), use attainability analysis, and §319 monitoring. The expected condition approach, and its many modifications, is widely used across the country. By adopting this guidance, Colorado can assess and report sediment conditions in a manner consistent with other states and can take advantage of the experience gained by other states in their assessments.

Section 2 of this guidance provides detail on selecting an expected condition and those factors that need to be considered in such a selection. It provides a tiered approach that starts with site-specific expected condition sites and progresses through regional conditions. Finally it employs the use of expert opinion to determine what uses are attainable in areas where water and land resources are heavily managed, resulting in multiple and essentially irreversible impacts.

It should be noted, that to fully utilize the EPA approach requires the development of regional or statewide biocriteria. These biocriteria are then used for the direct assessment of use impairment or condition. In Colorado, regional or statewide biocriteria are currently under development and have not yet been developed. Although we still lack the ability to compare the aquatic life in impacted conditions to regional biocriteria, we can still provide a sound sediment assessment framework in Colorado by using a case-by-case or site-specific expected conditions approach to assess impacted stream segments until regional or statewide narrative or numeric biocriteria become available.

Assessment Study Design

Before any assessment work is undertaken, a study design and plan must be formulated through a stakeholders process with involvement of the Division staff. A number of issues have to be considered at this stage and detailed guidance on this can be found in the references section. There are several important aspects to consider and these are listed below.

Whenever practical, assessment studies should be conducted through a cooperative arrangement among the various stakeholders, state and federal agencies and others. Ideally, study groups should consist of multi-disciplinary teams built of personnel with the appropriate skill levels required to complete an assessment. These teams would select study methods, assessment endpoints and indicators, and complete an overall design including frequency and locations of sampling. Quality control and data quality objectives need to be formulated in quality assurance plans that are implemented as part of each study.

It is recommended that stakeholders interested in performing sediment deposition assessment work consult with the Division before initiating the assessment to insure that the design of the work is appropriate for the specific study stream, and to meet the needs of the Division and Commission for decision-making.

Proper site selection and determination of sample size are very important pieces of the assessment. Pebble counts should be conducted in the same sample reach as the collection of macroinvertebrates. Pebble counts must also be conducted using the same procedure in both the expected condition site and study site. Sampling reach location should be selected with care. A sampling reach should capture the “big picture” of the situation in the stream and be representative of the majority of the conditions in the stream. For example, it is not acceptable to “skip” certain areas of the stream because of the existence of beaver dams and for ease of sampling. Beaver dams are natural conditions in the stream and need to be captured in the assessment. Neither is it acceptable to choose a “good corner” of the stream to sample and not cover an area representative of the entire stream reach. The sampling site should include at least two riffle-run-pool sequences where possible, or at least 20x the bankfull width. The assessor should document what procedure was followed to select the sampling reach.

The number of counts in a pebble count necessary to characterize the reach is also a very important piece of the assessment. A minimally statistically acceptable number is 100 counts. The CDPHE pebble count SOP requires 400 counts. Bevenger and King (1995) have provided a table of sample sizes necessary to detect different levels of change. Four hundred counts are more than is required to detect a 10% change. To detect a change of 0.10 (20% fines in the expected condition site) requires about 200 – 300 counts in the study and expected condition sites. Performing more counts (300 – 400) to characterize the expected condition reaches would be beneficial to better characterize natural variability and reduce error, as these reaches will become a data set which can be used for multiple projects. The Division highly encourages the assessor to conduct 300 – 400 counts during their assessment.

2. EXPECTED CONDITION

A key element in implementing the narrative sediment standard is determining the expected condition for each candidate stream with suspected sediment deposits detrimental to the aquatic life use. An expected condition should be based on an individual expected condition site, a combination of expected condition sites, or an estimated condition, depending on the availability of acceptable sites. The expected condition establishes the basis for making comparisons and for detecting aquatic life use impairments. Initially, expected conditions will likely be established on a site-specific basis for each candidate stream. Whether expected conditions are applicable to a larger population of similar streams depends on several factors, including the spacial scale of interest, extent of impairment of the expected condition, and the need for site-specific information. This guidance presents a tiered approach to establishing the expected condition, and the specific characteristics of acceptable expected condition sites.

Approaches to Establishing Expected conditions

A tiered approach to establishing the expected condition (Figure 1) is based on the quality of expected condition sites, and is consistent with EPA technical guidance (EPA 1996). The first step to identifying an expected condition is to conduct a preliminary assessment to determine the feasibility of using expected condition sites. Expected condition sites refer to locations in the same or similar stream and habitat type at which data can be collected for comparison with candidate streams of interest. Typical expected condition sites include sites that are upstream from point and/or nonpoint sources; sites that occur at the recovery end of a gradient of impact; sites in nearby comparable watersheds; and regional expected condition sites that may be applied to a group of candidate streams of the same stream type.

Tier 1 -Expected condition sites are acceptable and are minimally disturbed. Expected condition sites would be characterized as “natural”. EPA describes these sites as the “biological integrity expectation”. An example of a stream type for which tier 1 expected condition sites may be available would be some mountain headwater streams.

Tier 2 -Expected condition sites are acceptable but are more than minimally disturbed. No “natural” sites exist; therefore the best available sites are selected and sampled for determination of expected conditions. EPA describes these sites as the “interim expectation”. An example of a stream type for which tier 2 expected condition sites may be available would be some segments of large rivers on the plains. This interim expectation could be revisited after restoration efforts have been initiated and evaluated, and may become the final expectation.

Tier 3 -Expected condition sites are not acceptable or no expected condition sites exist. Expected conditions would be based on models, historical data, data from neighboring sites, ecological information, and/or expert opinion as appropriate. EPA describes this type of expected condition as the “hypothetical expectation”. The expected condition may be regarded as temporary until more realistic attainment goals can be developed. Some examples of stream types for which tier 3 expected conditions may be appropriate would be stream types that are significantly impaired statewide but have some recovery potential (i.e., expected condition sites are unacceptable) or very unique stream types (i.e., no expected condition sites exist).

Determining the expected condition primarily from expected condition sites is based on the premise that streams minimally affected by human activity will exhibit biological conditions representative of what is most natural and attainable for streams in the region. Anthropogenic effects include human influences, for example, watershed disturbances, habitat alteration, non-point source runoff, point source discharges, and atmospheric deposition. Sites that are undisturbed by human activities may be ideal expected condition sites. However, land and water use practices and atmospheric pollution have so altered water resources that truly undisturbed sites are rarely available. In practice, most expected condition sites will reflect some of these impacts. The selection of expected condition sites may be made from those sites with the least anthropogenic influences. Expected condition sites should represent the best attainable conditions that can be achieved by similar streams within a particular ecological region (EPA 1996). They reflect the actual potential of the candidate stream, that is, stressors that can be controlled are controlled, although other stressors may be irreversible. The use of actual expected condition sites to establish expected conditions is always important, as such sites represent achievable goals and can be regularly monitored (EPA, 1996).

If expected condition sites are not acceptable or there are no expected condition sites, then the alternative is to derive expected conditions using models, historical data, data from neighboring sites, ecological information, ecoregion and/or expert opinion. Guidance on the use of these methods to derive expected conditions can be found in *Biological Criteria: Technical Guidance for Streams and Small Rivers* (EPA, 1996). This approach may be the only means of examining some significantly altered systems. The expected condition may be regarded as temporary until more realistic attainment goals can be developed.

Although this guidance presents three tiers or individual approaches for establishing expected conditions, expected conditions may be established using multiple approaches. For example, expected conditions may be determined for a specific study stream using a combination of data from expected condition sites, and historical data, along with expert opinion and best professional judgment.

In addition, the inherent variability between streams can be accounted for if a suite of expected condition reaches is used as opposed to one expected condition site. Additional expected condition sites of the same stream type or similar morphology may be necessary to survey if the expected condition site chosen is questionable by the trained data collectors. The use of multiple expected condition reaches is a good approach to assessing impairment of aquatic life due to sediment.

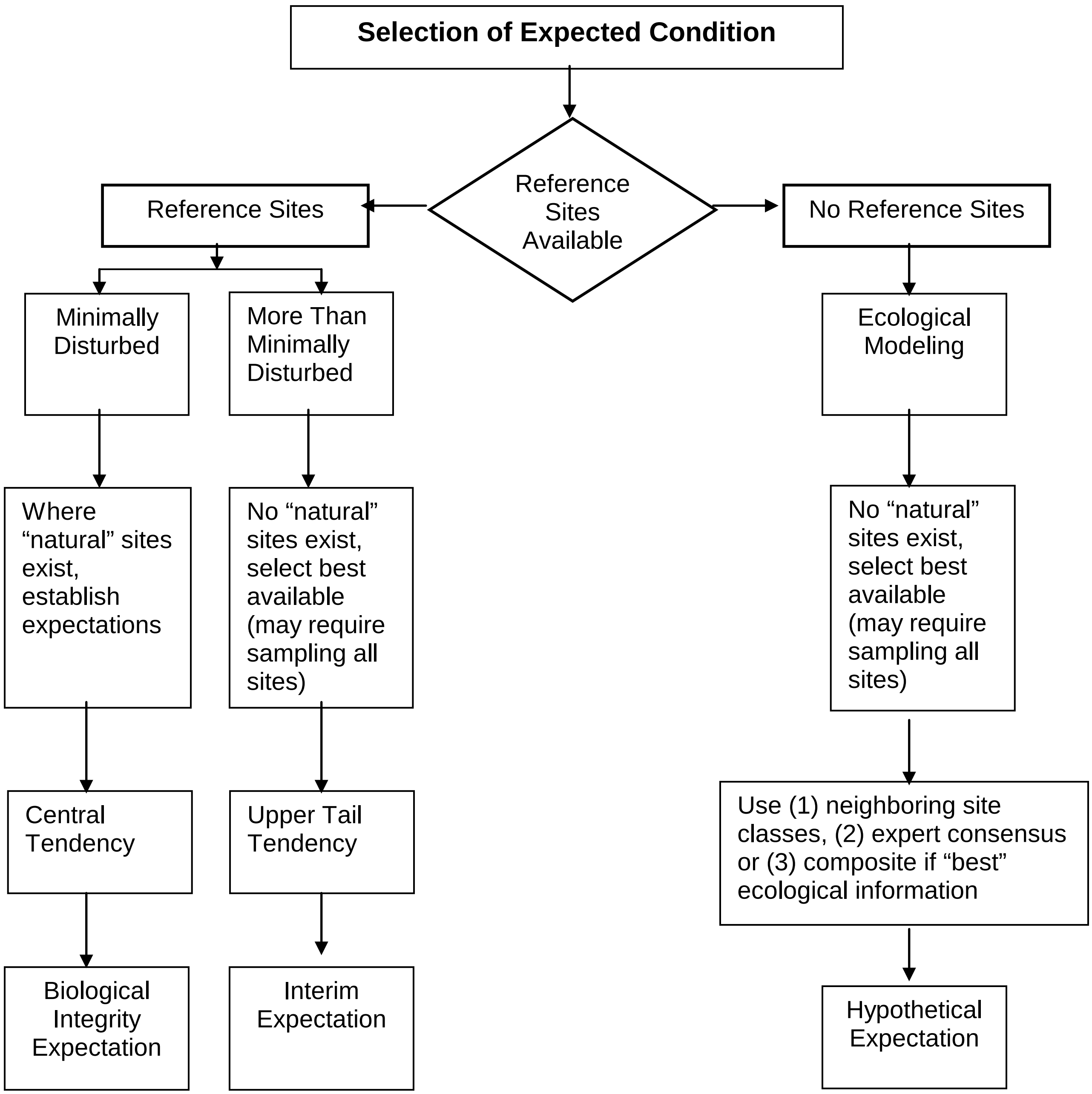


Figure 1. A tiered approach to establishing the expected condition. (After: *Biological Criteria – Technical Guidance for Streams and Small Rivers*; USEPA 1996, p.30)

Characteristics of Acceptable Expected condition Sites (Tier 1 and Tier 2)
Ideally, the expected condition and study sites should share similar or common characteristics such as elevation, geology, hydrology, hydraulics, watershed size, in-stream habitat (pools, substrate, etc), and riparian habitat. Characteristics that cannot change over time should be used as primary attributes of similarity between expected condition and study sites. Examples of parameters to study between expected condition and study site are included in table 1.

The overall goal in the establishment of the expected condition from expected condition sites is to describe the expected biota and habitat at sites of interest. Expected condition sites must be carefully selected because they will be used as benchmarks against which specific study streams will be compared. The conditions at expected condition sites should represent the best attainable conditions that can be achieved by similar streams within a particular geographic region. Two primary considerations guide the selection of expected condition sites within each class: representativeness and minimal impairment.

<u>Representativeness</u> - Expected condition sites must be representative of the stream and habitat types of interest. In general, the following characteristics are typical of minimally disturbed (tier 1) expected condition sites:

* Physical characteristics typical of the region (e.g., ecoregion (Hughes et al 1986) climate, topography, surficial geology, soil).
* Natural stream morphology typical of the region (e.g., Rosgen (1996) channel type, pools, riffles, runs, backwaters, and glides).
* Representative diversity of substrate materials (fines, gravel, cobbles, boulders, woody debris) appropriate to the region.
* Banks representative of undisturbed streams in the region (generally covered by riparian vegetation with little evidence of bank erosion, or undercut banks stabilized by root wads.) Banks should provide cover for aquatic biota.
* Natural color and odor - in some area, clear, cold water is typical of the waterbody types in the region; in others, the water is turbid or stained.
* Extensive, natural riparian vegetation representative of the region.
* Presence of animals, such as birds, mammals, amphibians, and reptiles, that are representative of the region and derive some support from aquatic ecosystems.

For expected condition sites that are identified as more than minimally disturbed (tier 2), decisions will need to be made and documented regarding whether such sites are representative of the candidate stream type and reflect the best attainable conditions that can be achieved by the candidate stream.

<u>Minimal Impairment</u> **-** Sites that are undisturbed by human activities are ideal expected condition sites. However, truly undisturbed sites are rarely available. Therefore, minimally impaired sites must be used to determine the selection of expected condition sites. This would include acceptable expected condition sites described as “minimally disturbed” (tier 1) as well as “more than minimally disturbed” (tier 2). For locations

where even such minimally impaired expected condition sites are significantly degraded, the search for suitable expected condition sites could be extended over a wider area, to include sites outside the watershed or Colorado. This may be particularly true for unique streams or very large rivers.

The purpose of selecting minimally impaired sites to represent expected conditions is primarily goal-setting. Sites with notable degraded conditions that can be controlled should not be accepted as expected condition sites.

A critical element in establishing expected conditions, particularly for situations where undisturbed sites are not available, is to determine if a site is “minimally impaired”. How much degradation can be allowed? What constitutes an acceptable expected condition site will differ among geographic regions because stream morphology, physiography, soil conditions, vegetation, and dominant land uses differ among regions. After considering all watersheds within an ecoregion of interest, the following factors should be considered in selecting “minimally impaired” expected condition sites. In general, these characteristics are typical of ideal minimally disturbed (tier 1) expected condition sites.

* No upstream impoundments or significant diversions.
* No known point source discharges or contaminants in place.
* No known spills, pollution incidents, or hazardous waste sites.
* Low human population density.
* Low agricultural activity.
* Low road and highway density.
* Minimal nonpoint source problems (e.g., agriculture, urban, logging, mining, feedlots, acidic deposition).
* No known intensive fish stocking or other management activities that would substantially shift the community composition.

For expected condition sites that are identified as more than minimally disturbed (tier 2), decisions will need to be made and documented regarding whether such sites are the best available sites and reflect the best attainable conditions that can be achieved by the candidate stream (i.e., acceptable expected condition sites).

Table 1. Expected condition Site Selection Characteristics

Water	**Land**	**Vegetation**
Area	Geology % Area	Cover Type % Area
Perimeter	Biotite	Trees
Basin Length	Glacial Moraine	Shrubs
Basin Aspect	Alluvium	Grass
Compactness Coefficient	Basalt	Non-Vegetated
Drainage Density	Shale/Sandstone Interbedded	Bank Vegetation
Stream Order at Mouth	Granite	
Total Stream Length	Shale	
Bifurcation Ratio	Elevation	
Watershed Size	Accessibility	
Channel Morphology	Bank Structure	
Stream Type	Gneiss	
Stream Velocity	Schist	
Water Depth	Magmatite	
Substrate Type		
Stream Gradient		
Watershed Yield		

3. MEASURING PHYSICAL HABITAT CONDITION AND BIOLOGICAL CONDITION

Introduction

In order to assess the stream bottom for excess sediment that may impair aquatic life and significantly alter the physical properties of the bottom, physical measurements of the stream bottom substrate must be made alongside measurements being made of the biological component if the sediment threshold is exceeded. Physical measurements or indicators of the stream bottom need to take into account those attributes or characteristics that potentially promote the best physical habitat or environment for aquatic life independent of water quality. This concept can be seen in Figure 2, which shows the conceptual relationship between habitat and biological quality. In this figure, the dashed red line indicates the expected stream habitat to biological condition curve. Figure 2 can best be summarized by the following four points relating to specific areas of the graph.

1. The upper right-hand corner of the curve is the ideal situation where optimal habitat quality and biological condition occur.
2. The decrease in biological condition is proportional to a decrease in habitat quality.
3. The lower right-hand corner is where degraded biological condition can be attributed to something other than habitat quality.
4. The upper left-hand corner is where optimal biological condition is not possible in a severely degraded habitat.

Section 3 of the guidance presents methods to be used in evaluating in-stream physical habitat, through the measurement of **stream bottom substrate** indicators. It also identifies methods for evaluating the **biological condition** of macroinvertebrates or fish. Methods for assessing biological impairment due to causes other than sediment deposition are not considered in this guidance. To determine the overall attainment of the sediment standard the combination of results from substrate evaluation and biological condition are plotted in the Sediment Standard Attainment Matrix in Section 4. Assessment categories and the percent comparability to the expected condition in the matrix are based on those in Figure 2.

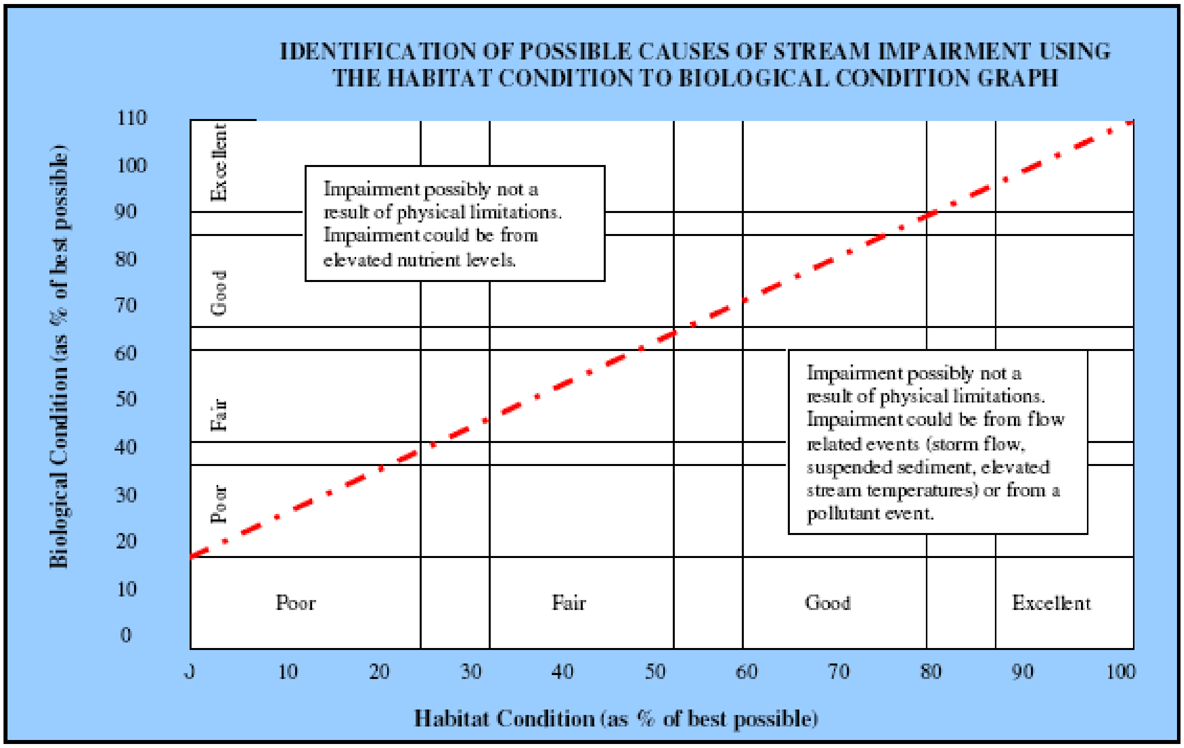


Figure 2. Conceptual Relationship between Habitat and Biological Condition
(Dashed line represents expected stream habitat to biological condition curve.)

Footnote: The above figure shows the general relationship between habitat and biological condition. However, it should be noted that sustainable, healthy biological communities can exist that are adapted to poor habitat conditions. Expected condition stream habitat quality may be poor, but it can have a robust, sustainable biologic community, with unique and important adaptation of species assemblages.

Natural Sources of Sediment

All stages of a sediment impairment assessment should consider natural sources of sediment. If a determination is made that the sediment responsible for the observed impairment is being contributed from natural sources then the sediment deposition analysis should be terminated. The evidence used to determine that natural sources are responsible should be well documented. This guidance does not discuss methods for determining if the sediment observed in a channel is the result of natural geologic sources and processes. However, if a study group determines that natural geologic sources and processes contribute all or most of the sediment to a candidate reach, then further assessment of the attainment of the narrative standard would not be warranted.

Temporal Scale Considerations

EPA guidance for sediment TMDL development (EPA 1999) discusses several important temporal factors that should be considered during each phase of a sediment impairment analysis such as the seasonal variability of sediment discharges and associated beneficial use impacts. Like most nonpoint source pollutants, sediment discharges are not continuous in magnitude and effect, and are more likely to increase as runoff increases.

The EPA guidance points out that sediment discharges vary substantially in their timing, depending primarily on the sources, watershed geology and landform, and precipitation/runoff patterns. Some sources are always vulnerable to erosion (e.g. bank erosion and continuously cultivated land), while other sources are vulnerable only during and shortly after land disturbing activities. In addition, some areas do not function as significant sediment sources except in response to extreme events. Analysts should assess whether sampling schedules and field methods are capable of adequately accounting for, or detecting temporal variability. The sampling schedule and field methods used during the assessment should be well documented in the project SAPP (Sampling and Analysis Project Plan) to address these concerns.

Stream Bottom Substrate Evaluation

Chapman and McLeod (1987) suggest that geometric particle size and percent of the bed surface covered by fines should be used to define habitat quality. These criteria can be determined by performing a pebble count. Pebble counts provide not only particle size distributions (D50, D84, etc…) and percent class sizes (% sand, % cobble, etc…), but offer a relatively fast and statistically reliable method for obtaining this information.

Sufficient and varied sizes of stream bottom substrate are necessary for biological colonization, protection, and reproduction. However, the full biological potential may not be realized if the substrate surfaces are surrounds by fine sediment. In streams containing excess amounts of sediment, the coarser particles become surrounded or partially buried by fine sediment. Insect populations decline substantially as interstitial

spaces become smaller and filled. Embeddedness quantitatively measures the extent to which larger particles are surrounded or buried by fine sediment (Mc Donald et al., 1991).
By performing a pebble count and/or measuring embeddedness, the amount of aquatic habitat can be characterized compared to an expected condition, and then cautiously evaluated for impairment due to stream bottom deposits. If it is determined excess stream bottom deposits exist beyond the expected condition, then confirmation of impairment takes place when a stream site is biologically assessed.

Pebble Count

The pebble count (Wolman, 1954) may be performed separately or as part of a larger stream inventory and assessment study (Rosgen, 1996). The Division has a pebble count protocol and recommends that assessing parties make use of the protocol when performing pebble counts. Other appropriate pebble count methods include Wolman, Bevenger and King, Bunte and Abt. Pebble counts may be recorded, tallied, and represented either by using forms in the SOP or on a computer laptop at streamside using the Expected condition Reach (channel materials) software package (Mecklenberg, 1998) which can be downloaded from the State of Ohio Department of Natural Resources website (http: www.dnr.state.oh.us/soilandwater/streammorphology.htm). Another software that can be used is the Size-Class Pebble Count Analyzer VI 2001.xls (651KB) by John Potyondi and Kristin Bunte from the US Forest Service's Stream System Technology Center (aka "Stream Team") website (www.stream.fs.fed.us) under their Download PDF Documents and Software Tools menu. Specific information concerning the program's use, application, sample size, data input, statistical analysis, and case studies are included in various document sections of the software and should be read prior to setting up a study and collecting data.

In a study of 1134 streams located in four northwestern states, Relyea et al. (2000) suggested that changes to invertebrate communities as a result of fine sediment (2mm or less) occur between 20 – 30% fines. A strong correlation between the health of macroinvertebrate communities and percent surface fines for particles <2mm has been shown in her work. The most sensitive species were affected at 20% surface fines. For streams with aquatic life of fish concerns, measurement of particles <6.35mm are commonly used to describe spawning gravel quality and includes the size range typically generated by land management activities (Weaver and Fraley, 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material <6.35mm and the emergence success of trout species.

The Division has considered various particle sizes between ≤2mm and ≤8mm for a defined particle size for this guidance. Various state and federal agencies in Colorado have conducted studies using the range of particle sizes, but the prevalent size used to define percent fines is 6.35mm. 6.35mm is a particle size well grounded in fisheries literature as the 0.25 inch threshold considered detrimental to coldwater fish species. (Chapman 1988). This protocol does not preclude the use of studies using other particle sizes if the data is available. Site-specific studies may utilize a differently defined particle size, such as 2mm for percent fines. According to the above-mentioned work done by Relyea in Idaho, 2mm is protective of macroinvertebrates, although in some trout streams, 2mm may not be a large enough particle size to protect the fisheries aquatic life.

When conducting a pebble count, the assessor uses the pebble count software streamside at the study site, to calculate the percent fines for ≤6.35mm. If the percent fines are ≤ 20%, the study site should be evaluated as fully supporting (FS) for substrate. Percent fines of ≤ 20% is the percent fines stated in literature and recent studies as a threshold for damage to habitat conditions and macroinvertebrates. On the other side of the coin, the threshold value for damage that is not supporting of aquatic life use is percent fines ≥ 40%. If the percent fines for a study site is ≥ 40%, the stream should be evaluated as not supporting (NS) for substrate. The assessment will then move along to the biological assessment and there is no need to compare substrate analysis with the expected condition in an expected condition reach.

If the results for percent fines of the study stream are not one of the threshold values listed above (≤20% and ≥40%), the expected condition should be identified and assessed for substrate analysis as well. The study stream would then be assessed as a percentage of the expected condition and the percentage would then be applied in the final assessment matrix.

Embeddedness

A preferable technique for ascertaining embeddedness is the Burton and Harvey method (1990). This method should only be used on cobble-bottom or cobble-dominated streams, where the greatest percent fraction of any group is cobble. This method is labor intensive and its use is recommended when data from the pebble count and biological sampling does not provide a satisfactory answer as to the degree of impairment. Embeddedness measurements should be performed on the same stream reach where the pebble count was performed, only upstream of the actual pebble count transects, so as not to measure the areas disturbed by the earlier measurements.

Studies by Bjorn et al. (1974, 1977) concluded that approximately one-third embeddedness (33%) or less is probably the normal condition in proper functioning streams. Above this condition, however, insect populations decline substantially as habitat spaces become smaller and filled. After completing embeddedness measurements at the study site, calculate the percent embeddedness. If the percent embeddedness is ≤ 33%, the study site should be evaluated as FS for substrate. If the percent embeddedness is ≥ 60%, the study site should be evaluated as NS for substrate. The assessment will then move along to the biological assessment and there is no need to compare substrate analysis with an expected condition reach. If the results for embeddedness are not within the threshold values above (≤33% and ≥60%), an expected condition should be identified and assessed in a expected condition reach for embeddedness as well. The study stream would then be assessed as a percentage of the expected condition and the percentage would then be applied in the final assessment matrix.

Although percent fines and percent embeddedness are the preferred methods for ascertaining substrate support status, there are other methodologies available. Table 2 contains a list of methods for commonly measured indicators with expected conditions that can be used to compare the substrate of the study reach with the expected condition. It is important that whatever method is chosen, the data collection sampling, amount and intensity must be the same for expected condition and impacted sites and under similar climate/flow conditions.

The list in table 2 is not exhaustive, and some assessments may use other established or documented methods. These additional methods do not have established threshold values or ranges. If the assessor wishes to utilize these other methods to determine substrate impairment, an expected condition will have to be selected and the results expressed as a percentage of the expected condition. There are basically only two requirements in selecting an indicator(s). First the indicator(s) must be quantitative. Second, the result of measuring the indicator at the candidate reach must be expressed as a percentage of the result at the expected condition reach. Detailed documentation of the selected indicator and how it was measured in the field should be included in every sediment impact assessment.

Degree of Aquatic Life Use Support for Substrate

The information collected during the stream bottom substrate evaluation is applied to the use support matrix in Table 3. Percent fines and percent embeddedness **not falling within the threshold values** are compared to the expected condition values for percent fines and percent embeddedness and expressed as percent of the expected condition. The use support categories for substrate are as follows: 90 – 100% of expected is FS, 73 – 89% of expected is Supporting, Impacts Observed, and $\leq$72% of expected is NS.

Additional statistical analysis is not necessary to compare the measured condition with the expected condition to compare to the support categories. There is error associated with conducting pebble counts and field analyses, but these are addressed with the methodology utilized and with the streamside software used to calculate % fines. The percentages associated with use support categories are comparable to percentages used by other states and agencies for substrate analysis. Designating a number signifying acceptable or unacceptable aquatic life health is difficult without a single best answer. The above percentages designated for use support for substrates are similar to the concept of the ratios used in RBP protocols and T-Walk (USFS) protocols to compare measured with expected conditions.

Table 2.   Selected stream bottom substrate indicators and references.

INDICATOR	QUANTITY MEASURED	REFERENCES
Intergravel living space using embeddedness	Salmonid living space available in coarse particle substrate	Burton and Harvey, 1990
CDPHE-WQCD Riffle/Run Habitat Analysis Parameter 4	Percent of stream bed composed of fines $\leq$2mm, $\leq$6.35mm	Colorado Department of Public Health and Environment, Water Quality Control Division, (not dated)
CDPHE-WQCD Glide/Pool Habitat Analysis Parameter 6	Percent of pool bottom affected by sediment deposition	Colorado Department of Public Health and Environment, Water Quality Control Division, (not dated)
V^* for pools	Volume of pool occupied by fine sediment	Lisle and Hilton, 1992
In-situ flow through samplers	Accumulation of fine particles in interstitial spaces of coarse particle substrate	Carling and McCahon, 1987; Frostick et al., 1984
Freeze core sampling	Subsurface particle size distribution	Petts, 1988; Lisle, 1989
In-situ sampling of known volume	Subsurface particle size distribution	Lambert and Walling, 1998; MacDonald et al., 1991, p.119; Platts et al., 1983, p.17
Embeddedness	Extent to which large particles are embedded or buried by fine sediment	MacDonald et al., 1991, p. 121
Pebble Counts	Surface particle size distribution	Wolman, 1954, Bevenger and King, 1995

Table 3: Degree of aquatic life use support affected by stream bottom deposits (sediment) evaluated by increase in either fines or embeddedness, relative to an expected condition.

Pebble Count Fines **≤ 2mm, ≤6.35mm** (% Of Expected)	**% Embeddedness** (% Of Expected)	**Degree of Aquatic Life Use Support** **For Substrate (Presumptive)**
90 – 100%	**90 – 100%**	**Fully Supporting[1]**
73 - 89%	**73 - 89%**	**Supporting, Impacts Observed**
≤ 72%	**≤ 72%**	**Not Supporting[2]**

[1]Raw percent values of ≤ 20% fines, ≤ 33% embeddedness calculated at a study site should be evaluated as supporting for substrate regardless of the percent attained at the expected condition site.
[2]Raw percent values of ≥ 40% fines, ≥ 60% embeddedness calculated at a study site should be evaluated as not supporting for substrate regardless of the percent attained at the expected condition site.

Bioassessment

The bioassessment step is accomplished by assessing the condition of the benthic macroinvertebrate community and/or the fish community at the same location that the stream bottom substrate assessment is conducted. Benthic macroinvertebrates will be assessed in most studies because they are generally better indicators of impairment due to sediment deposition than are fish. However, there can be situations where fish assessments should be conducted because they will provide a more sensitive or definitive assessment of the impacts to aquatic life. The results of the bioassessment are combined with the stream substrate evaluation results in the final assessment matrix to determine whether standards are attained (Section 4).

The recommended field and laboratory protocols for the benthic macroinvertebrate assessments are the *Standard Operating Procedures for the Collection and Processing of Benthic Macroinvertebrates* (Basic Protocol) and the *Standard Operating Procedures for the Collection and Processing of Benthic Macroinvertebrates by the Enhanced Protocol,* which are found in Water Quality Monitoring in Colorado (Colorado Water Quality Forum, 1995, draft). Similar protocols such as the EPA's Rapid Bioassessment RBP-III for benthic invertebrates (Plafkin et al., 1989) are also recommended. Sampling of fish populations should be conducted according to Colorado Division of Wildlife methods for inventory and population estimates.

> The choice of the Basic (or RBP-III) or Enhanced Protocol depends on the resources available and the desired degree of analytical rigor. Benthic macroinvertebrate data generated by these protocols is typically used to calculate various indices of community structure such as those found in RBP III. Sometimes these measures of community structure are not sensitive enough to detect sediment impacts. In order to provide more sensitive measures of sediment impacts it is recommended that biomass, abundance, and the presence of sediment tolerant and intolerant taxa be measured in addition to the common measures of community structure found in the RBP.

Application of the biological assessment or degree of impairment is a percentage comparison of the sum of selected metric scores at the study site compared to a selected expected condition (site). The value will be expressed as a percentage of expected condition. Apply the value calculated to the use support matrix Table 4. The use support categories for biological assessment are as follows: 80 – 100% of expected condition is FS, 51 – 79% of expected condition is Supporting, Impacts Observed, $\leq$50% of expected condition is NS.

Table 4: Biological Integrity Attainment Matrix.

% Comparison to Expected	Biological Condition Category	Attributes[1]
80 – 100%	Supporting	Comparable to best situation to be expected within ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.
51 – 79%	Supporting, Impacts Observed	Community structure less than expected. Composition (species richness lower than expected due to loss of some intolerant forms. % Composition of tolerant forms increases.
≤ 50%	Not Supporting	Fewer species due to loss of most intolerant forms. Reduction in EPT index. Densities of organisms dominated by one or two taxa.

[1]Biological attributes from EPA's Rapid Bioassessment Protocols for Use in Stream and Rivers, (Plafkin et al., 1989).

In order to assure the appropriate metrics are being analyzed to show impairment due to excess sediment, biological metrics are listed in table 5 that have shown to be sensitive to sedimentation. Determining which metrics to use in an assessment will require best professional judgment.

Table 5.a **Macroinvertebrate Metrics Sensitive to Sedimentation Effects**
* See footnote below

Metric Categories	**Metric**	**Definition**	**Predicted response to increasing perturbation**
Richness	Total Taxa	Number of distinct taxa in the macroinvertebrate assemblage	Decrease
	Ephemeroptera Taxa	Number of Mayfly taxa	Decrease
	Plecoptera Taxa	Number of Stonefly taxa	Decrease
	Tricoptera Taxa	Number of Caddisfly taxa	Decrease
Composition	Percent Plecoptera	Percent of sample that is stonefly nymphs	Decrease
Pollution Tolerance	Hilsenhoff Biotic Index	Abundance-weighted average tolerance of organisms to pollution (Hilsenhoff 1987)	Increase
Diversity	Percent Five Dominant Taxa	Percent of sample in the most abundant five taxa	Increase
Feeding Group	Scraper Taxa	Number of taxa that scrape periphyton from substrates	Decrease
Habit	Clinger Taxa	Number of taxa that have fixed retreats or adaptations for attachment to surface in flowing water	Decrease

(Jessup and Gerritson 2000)

Footnote: Recent EPA studies in mountainous areas have shown that the number of clinger taxa provides the strongest indication of sediment impairment. The percentage of clinger taxa is also a supplemental indicator.

Table 5.b Macroinvertebrate Metrics and Changes Following Disturbances

Metric	Definition	Change
Number of Taxa	Number of distinct taxa	Decrease
Number of EPT Taxa	Number of distinct taxa in EPT	Decrease
Simpson's Dominance Index	An index measuring the dominance of the community by one or a few taxa	Increase
Percent Dominant Taxon	Relative abundance of the most common taxa	Increase
Hilsenhoff's Biotic Index	Calculated using tolerance values for invertebrates	Increase
Percent Elmidae	Relative abundance of the riffle beetles (Coleoptera: Elmidae)	Decrease
Percent Hydropsychidae	Relative abundance of the net-spinning caddisflies (Tricoptera: Hydropsychidae)	Increase
Percent Hirudinea	Relative abundance of leeches	Increase
Percent Chironomidae	Relative abundance of midges (Diptera: Chironomidae)	Increase
Percent Oligochaeta	Relative abundance of aquatic worms	Increase
Percent Gatherers	Relative abundance of this functional group	Variable
Percent Scrapers	Relative abundance of this functional group	Decrease
Percent Shredders	Relative abundance of this functional group	Decrease
Percent Filterers	Relative abundance of this functional group	Increase
Percent Miners	Relative abundance of this functional group	Increase

Table 5.c Fish Metrics and Response to Increasing Perturbation

Metric Categories	Metric	Definition	Predicted Response to Increasing Perturbation
Richness and Composition	Number of cold water native species	Number of native fish species typically found in cold water streams. Excludes introduced or tolerant native fish species.	Decrease
	% Cold water individuals	Percent of individuals found in cold water streams. Includes introduced trout species.	Decrease
	% Sensitive native individuals	Percent of native individuals sensitive to perturbations	Decrease
Reproductive Function	Number of age classes	Number of age classes (use measured size classes to infer) reflects the availability of unembedded cobble	Decrease
Abundance	Catch per unit effort	Number of cold water individuals per minute of single-pass electrofishing	Decrease

(Jessup and Gerritson 2000)

Secondary Channel Characteristics

Macroinvertebrate analyses are time consuming and often expensive for agencies and individuals with too few resources. Channel characteristics can be used as secondary measures to confirm the results of substrate analyses. If the stream bottom substrate analysis provides assessed numbers between 20% and 40% for percent fines or 33 and 60 percent embeddedness and fines or embeddedness are 89 – 73% of the expected condition, secondary channel characteristics are used to verify the presence of sediment deposits that may impair the aquatic life use. If these channel measures are similar to expected conditions (>72% of expected), the substrate is evaluated as fully supporting and no additional assessment is needed. If the channel measures are significantly different from expected conditions, the assessor would then move on to the biological assessment.

Stream channel assessments should be done at the reach scale and should analyze stream channel condition and geomorphology. A comparison between expected and suspected impaired conditions is necessary. The assessor should be aware of riparian condition, since riparian vegetation is extremely important in maintaining channel stability, natural filter, groundwater/surface water interactions, etc. This will be the case for perennial and some intermittent streams. For ephemeral streams, vegetation may not be critical, and an assessment of channel morphology characteristics will be sufficient. The morphologic variables and riparian components to collect are suggested blow.

Channel Characteristics

The following are some common channel metrics or parameters that indicate good habitat and channel stability. These channel metrics are compared to expected conditions according to the percentages for "Habitat Quality" from Figure 1:

90 - 100% of Expected Condition = Supporting

89 – 73% of Expected Condition = Partially Supporting

≤ 72% of Expected Condition = Nonsupporting

Use of past and recent aerial photographs to determine changes in sinuosity and stream length. Has sinuosity and concomitant stream length decreased over time?

Percent of raw banks for the reach compared to expected conditions

RSI – Riffle Stability Index (very applicable to cold water biota) not applicable to plains

Riffle-riffle spacing

Pool-pool spacing

Bank Stability % eroding banks

Bank erosion potential (Rosgen 1996)

Channel stability based upon bankfull indicators (e.g. entrenchment, width/depth ratio, channel materials (D16, D50, and D84), sub pavement particle size distribution, and slope

V*

D50 – median particle size

Pool Frequency

Intergravel DO (dissolved oxygen)

Suspended sediment/dissolved solids

Riparian vegetation assessment using BLM/USFS guidance – *A user guide to assessing proper functioning condition*, or similar methodology

The assessor should select 3 metrics to measure from these channel measurements. If 2 out of 3 are "Supporting", the stream can be evaluated as FS for sediment. If 2 out of 3 are "Partially Supporting", the stream would be evaluated as "Supporting, Impacts Observed" for sediment and the assessment would then proceed to the biological analysis. If 2 out of 3 are "Nonsupporting", the stream would be evaluated as "Not Supporting" for sediment and the assessment would then proceed to the biological analysis. It is important for the assessor to document the methodologies utilized and the comparison between expected condition reach and study reach.

Steps of Sediment Analysis

This guidance is intended to represent a common approach to assessing streams for the impacts of sediment deposition. The guidance may be utilized by agencies, watershed groups, or other stakeholders; however, it is recommended that those proposing to utilize this guidance consult with the Division before designing a stream study. Such consultation may help improve the focus of such a study, and also help insure that such a study is performed properly, such that it can be utilized by the Division and Commission. Figures 4 and 5 show the flowchart for determining aquatic life use impairment due to excess sediment.

Step 1. Identify candidate sediment impacted segments

This step is a screening level identification of stream reaches or segments where sediment impacts are known to occur or suspected to occur. Existing information can be compiled from information in the §303(d) list, and the §305(b) report, watershed protection program reports, and in reports from other governmental agencies. In addition, data can be gathered by screening level reconnaissance surveys. Other means to identify these segments can include land use information, agency resource assessments, anecdotal reports, and public comment, where such are found to meet a threshold of reliability.

Step 2. Perform sediment substrate analysis

This step is explained in full in section 3. The assessor will perform a pebble count or measure percent embeddedness. Percent fines and/or percent embeddedness will be used in table 3 to determine if the values are within the threshold values. If % fines is ≤ 20% and/or % embeddedness is ≤ 33%, the assessment is assumed FS for substrate regardless of expected condition and the assessment is complete. If the values are not within the threshold values, an expected condition must be defined and substrate values expressed as a percent of expected condition. If the % fines are ≥40% and/or % embeddedness is ≥60%, the assessment for substrate is considered NS and the assessment continues on to biological assessment.

Step 3. Establish expected condition criteria

Step 3 is the process of characterizing and classifying the study stream by identifying the watershed, ecoregion, flow regime, channel morphology or type, geological, physical, and other relevant chemical, and biological attributes that are crucial for the selection of a matching expected condition. This information is then used to match the candidate stream to the expected condition to the maximum extent practicable. Data is collected through field assessments and by mapping and GIS techniques.

Step 4. Identify expected condition

Step 3 and Step 4 are closely related and when completed provide the expected condition that provides the basis of comparison to the specific study stream site or stream reach. In step 4, the actual expected condition is identified through a tiered approach that can range from site-specific sites to the use of conceptual or modeled expected conditions developed by expert consensus. This process is described in more detail in Section 2. Field surveys and mapping techniques similar to those used in Step 3 can be used to identify actual expected condition streams or sites, with the expected condition classified according to Step 3 criteria.

Step 5.   Comparison of study segment with expected condition

Step 5 provides the comparison of the stream bottom substrate habitat (as it relates to sediment deposition) and accompanying aquatic life with that of the expected condition. This requires the use of the methods identified in Section 4 for collecting the data at the expected condition and study sites. The field data collection for this step can be performed concurrently with Steps 3 and 4 or can be conducted later in the process or at multiple times during the assessment. This process provides the information necessary to determine the percentage of expected condition for the habitat and biological metrics or assessment endpoints

Step 6.   Secondary Channel Measurements

Step 6 is an option for those streams whose values are fall between the threshold values for substrate for raw data, i.e. 20 – 40% fines and 33 – 60% embeddedness. Assessors may choose to use secondary channel measurements discussed in section 3. If the values indicate FS, the assessment is complete. If the values do not show FS, the assessment moves on to biological assessment.

Step 7.   Assess condition or degree of sediment impacts

This is the final step in the process of determining the status of the aquatic life uses as impacted by sediment deposition. At this step, categories of narrative standard attainment are assigned, based on the combination of percentage of expected condition for physical habitat and percentage of expected condition for biology. Section 4 shows suggested matrices of narrative sediment standard attainment.

FIGURE 4

Figure 4. Flow chart for Determining Sediment Impairment Assessment

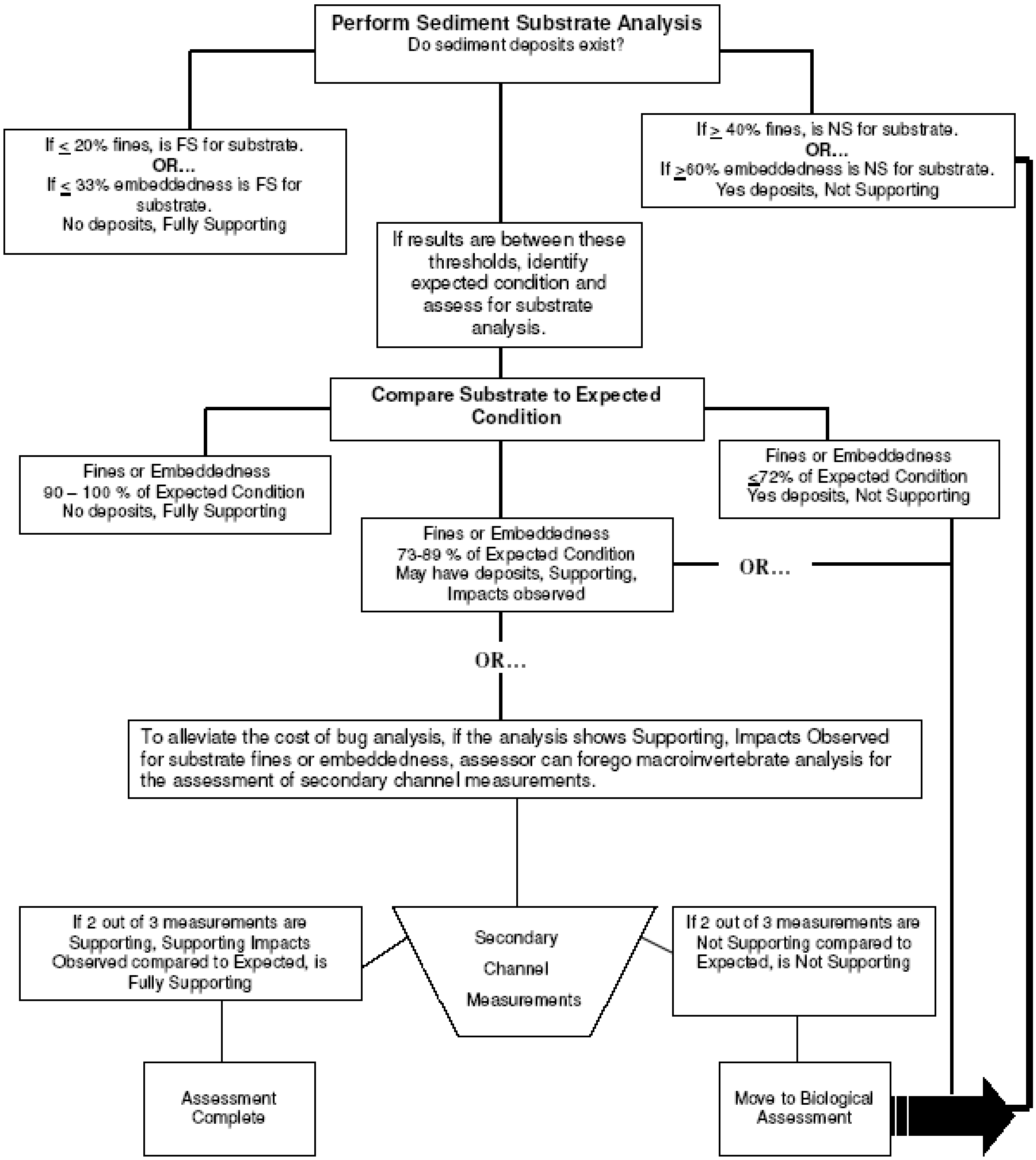
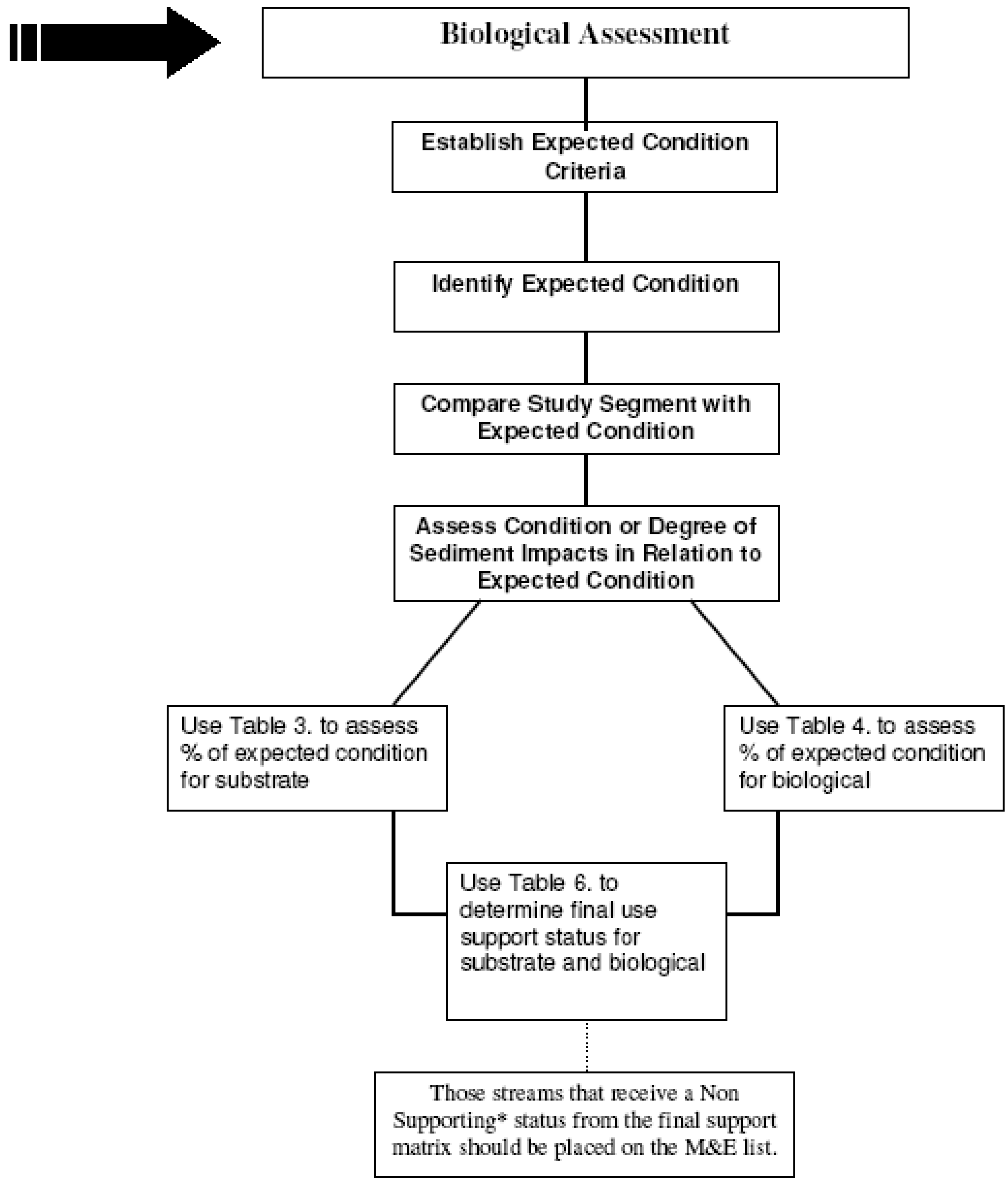


FIGURE 5

Figure 5. Flowchart for Determining Biological Impairment for Sediment Assessment



4. ATTAINMENT OF THE NARRATIVE STANDARD

The narrative standard states that the waters of the state will be free from substances which “can settle to form bottom deposits detrimental to the beneficial uses ”. The process to determine whether the narrative standard is attained is described below and involves comparing the stream substrate condition to the biological condition present at the same location. This process requires the use of a reasonable expected condition, which allows for the determination of percent of expected condition.

The standards attainment criteria in Table 6, the final attainment matrix, have been extrapolated from Figure 2, which illustrates the general relationship between habitat quality and biological conditions. Figure 2, and EPA's Rapid Bioassessment Protocols, indicate that the aquatic biological community varies with habitat quality and that as habitat quality declines discernible biological impairment results, assuming the absence of other confounding instream effects (water chemistry or toxic substances).

This guidance is designed to determine impacts to the aquatic life uses that result from the physical deposition of sediment. In order for there to be a non-attainment of the narrative standard there must be a concurrent demonstration of biological impact and sediment deposition to the stream substrate. For those assessments where either substrate alone or biology alone shows an impact as a percent of expected condition then the sediment standard is attained.

In the case of moderate to severe biological impacts found in streams attaining the narrative standard, the impairment is due to chemical toxicity or physical factors (flow, temperature, flooding) that can cause discernible biological impairment and must be considered. In these cases a finding of nonsupport of the aquatic life uses may be made, but some cause other than deposition of sediment must be observed, and listed as the cause of such nonsupport. Streams showing a determination of impairment biologically, but not physically, should be assessed for further determination of the source of impairment. It is then important that a complete habitat assessment and chemical studies and other sampling and monitoring protocols be utilized at locations in order to insure a full understanding of stream health.

Table 6: Final assessment matrix for determining aquatic life use support categories by combining physical (% fines and embeddedness) and biological assessments as sediment indicators.

Biological → % of expected / Physical ↓ % of expected	**NS** **≤ 50%**	**Supporting, Impacts Observed** **51 – 79%**	**Supporting** **80 – 100%**
NS **≤72%**	Not Supporting	Supporting, Impacts Observed	Supporting, Impacts Observed
Supporting, Impacts Observed **89 – 73%**	Not Supporting, Other Pollutant Likely*	Supporting, Impacts Observed	Supporting
Supporting **90 – 100%**	Not Supporting, Other Pollutant Likely*	Supporting	Supporting

*** Impairment in this support level for aquatic life is probably not due to sediment. It is likely the result of other impairment, alone or in combination with sediment. These streams should be evaluated for impairment source determination.**

Raw percent values of < 20% fines, < 33% embeddedness calculated at a study site should be evaluated as supporting for substrate regardless of the percent attained at the expected condition site.

Raw percent values of > 40% fines, > 60% embeddedness calculated at a study site should be evaluated as not supporting for substrate regardless of the percent attained at the expected condition site.

5. APPLICATION OF THE GUIDANCE

The Commission is hopeful that this guidance will prove to be a useful step toward providing a consistent approach to implementation of the statewide narrative basic standard that addresses sediment deposition for those streams which this guidance is intended to address, i.e. high gradient, montaine streams and not sandy – bottom plains streams. In approving this guidance the Commission recognized that there might be a number of technical issues that will need further refinement and that as the guidance is used and data is gathered, the guidance will periodically need to reviewed and updated. The Commission determined that, where possible, the Division should focus on segments with stakeholders, broadly defined, in its implementation of this guidance, for both conducting and participating in sediment impact evaluations; that an advisory group should be reconvened to help evaluate implementation of the guidance, and the Division should maintain a data base listing sediment assessment projects. Should the experience gained from implementation indicate that the guidance needs to be modified, or supplemented, appropriate action can be taken at that time. There are also several new developments on clean sediment guidance that the Federal Government has been working on that could prove to be helpful additions/revisions for this guidance. For example, the EPA will soon release clean sediment criteria guidance. Once published, the Division will evaluate how this guidance can be updated to reflect EPA's recommendations. The EPA is also developing a Fine Sediment Index (FSI) applicable to mountain streams. An FSI would be an ideal goal for the Division to reach in the future. For information about this guidance please contact the Water Quality Control Division at (303) 692-3500 and ask for the Monitoring Unit.

Appendix A – References

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Appendix B– Examples of Calculation

Examples assume that an appropriate stream reach has been selected for the stream in question and that the study reach adequately captures the evident stream features. The examples also assume that the assessor has selected the appropriate number of counts to be conducted in the pebble count.

Example 1.

The first step is to determine if sediment deposits are present. Using the CDPHE SOP for pebble counts, 400 counts have been recorded. For the stream in question, the ≤6.35mm particle size will be assessed for impairment of aquatic life.

Soapy Creek: After the pebble count was performed, the assessor uses the Potyondi and Bunte Size-Class Pebble Count Analyzer VI 2001.xls to calculate percent fines. The calculation is performed streamside.

Percent fines ≤6.35mm = 10.7%

Following the assessment flowchart, because the stream meets the threshold of ≤20% fines, Soapy Creek is automatically determined to be Fully Supporting for substrate and no further assessment is necessary.

Example 2.

The first step is to determine if sediment deposits are present. Using the CDPHE SOP for pebble counts, 400 counts have been recorded. For the stream in question, the ≤6.35mm particle size will be assessed for impairment of aquatic life.

Barrel Creek: After the pebble count was performed, the assessor uses the Potyondi and Bunte Size-Class Pebble Count Analyzer VI 2001.xls to calculate percent fines. The calculation is performed streamside.

Percent fines ≤6.35mm = 42.3%

Following the assessment flowchart, because the stream meets the threshold of ≥40% fines, Barrel Creek is automatically determined to be Non Supporting for substrate and the assessment continues on to biological assessment.

For the biological assessment of Barrel Creek, a reference site (Wagon Creek) has been selected and macroinvertebrates have been collected for both Barrel Creek and Wagon Creek using the same protocols.

The macroinvertebrate metric used for this example is total number of EPT taxa.

Barrel Creek = 3 of 9 taxa present are EPT taxa
Wagon Creek = 8 of 15 taxa present are EPT taxa

3 / 8 = 37.5% of expected condition

Using table 4, the biological integrity attainment matrix, ≤50% of expected condition is Non Supporting.

Looking at table 6, the final attainment matrix, a NS for substrate and a NS for biological is determined to be Non Supporting. This stream would therefore be eligible for 303(d) listing.

Example 3.

The first step is to determine if sediment deposits are present. Using the CDPHE SOP for pebble counts, 400 counts have been recorded. For the stream in question, the ≤2mm particle size will be assessed for impairment of aquatic life.

Alcohol Creek: After the pebble count was performed, the assessor uses the Potyondi and Bunte Size-Class Pebble Count Analyzer VI 2001.xls to calculate percent fines. The calculation is performed streamside.

Percent fines ≤2mm = 39.7%

Following the assessment flowchart, the study creek may have deposits detrimental to aquatic life. Because the percent fines falls between the two thresholds, a comparison to expected condition for substrate is required.

A expected condition creek, Straight Creek, is selected and the same pebble count protocols are applied.
Straight Creek is determined to have 9% fines ≤2mm.

To calculate percent of expected condition the following calculations are made:

Alcohol Creek has 39.7% fines, which means that 60.3% of Alcohol Creek is >2mm.
Straight Creek has 9% fines, which means that 91% of Straight Creek is >2mm.

.603 / .91 = .6626 * 100 = 66.3% of expected condition.

Looking at table 3, the substrate attainment matrix, 66.3% of expected condition is Non Supporting. The assessment would then move on to biological assessment.

The macroinvertebrate metric used for this example is percent taxa EPT.

Alcohol Creek = 5 of 11 taxa were EPT
Straight Creek = 8 of 15 taxa were EPT

5 / 11 = 0.45
8 / 15 = 0.53

0.45 / 0.53 = .849 * 100 = 85% of expected condition for biological.

Using table 4, the biological integrity attainment matrix, 85% of expected condition is Supporting, Impacts Observed.

Looking at table 6, the final attainment matrix, NS for substrate and Supporting, Impacts Observed for biological, the final determination is Supporting, Impacts Observed.

Example 4.

The first step is to determine if sediment deposits are present. Using the CDPHE SOP for pebble counts, 400 counts have been recorded. For the stream in question, the ≤6.35mm particle size will be assessed for impairment of aquatic life.

Migraine Creek: After the pebble count was performed, the assessor uses the Expected condition Reach Channel Materials software package to calculate percent fines. The calculation is performed streamside.

Percent fines ≤6.35mm = 25%

Following the assessment flowchart, the study creek may have deposits detrimental to aquatic life. Because the percent fines falls between the two thresholds, a comparison to expected condition for substrate is required.

A expected condition creek, Tylenol Creek, is selected and the same pebble count protocols are applied.
Tylenol Creek is determined to have 24% fines ≤6.35mm.

To calculate percent of expected condition the following calculations are made:

Migraine Creek has 25% fines, which means that 75% of Migraine Creek is >6.35mm.
Tylenol Creek has 24% fines, which means that 76% of Tylenol Creek is >6.35mm.

.75 / .76 = .986 * 100 = 98.6% of expected condition.

Looking at table 3, the substrate attainment matrix, 98.6% of expected condition is Fully Supporting for substrate and no further assessment is necessary.

Example 5.

The first step is to determine if sediment deposits are present. Using the CDPHE SOP for pebble counts, 400 counts have been recorded. For the stream in question, the ≤8mm particle size will be assessed for impairment of aquatic life. .

Dead Cow Creek: After the pebble count was performed, the assessor uses the Potyondi and Bunte Size-Class Pebble Count Analyzer VI 2001.xls to calculate percent fines. The calculation is performed streamside.

Percent fines ≤8mm = 30%

Following the assessment flowchart, the study creek may have deposits detrimental to aquatic life. Because the percent fines falls between the two thresholds, a comparison to expected condition for substrate is required.

A expected condition creek, Happy Cow Creek, is selected and the same pebble count protocols are applied. Happy Cow Creek is determined to have 20% fines ≤8mm.

To calculate percent of expected condition the following calculations are made:

Dead Cow Creek has 30% fines, which means that 70% of Dead Cow Creek is >8mm.
Happy Cow Creek has 20% fines, which means that 80% of Happy Cow Creek is >8mm.

.70 / .80 = .875 * 100 = 87.5% of expected condition

Looking at table 3, the substrate attainment matrix, 87.5% of expected condition is Supporting, Impacts Observed.

Following the assessment flowchart, the assessor has two options at this point. The assessor may either go to biological assessment, or has the option of assessing secondary channel characteristics. For the sake of the example, the assessor chooses the channel characteristics.

The assessor chooses 3 metrics to measure for both Dead Cow and Happy Cow Creeks. They are:

Bank Stability % eroding banks
Riffle Stability Index (RSI)
Pool Frequency

These are compared between both the study stream and expected condition stream for % of expected condition.

Bank Stability:
Dead Cow Creek = 15% eroding banks
Happy Cow Creek = 16% eroding banks
Here the study stream has a better percentage than the expected condition. This metric would be Fully Supporting according to table 3.

Riffle Stability Index (RSI) (Greater than 70 RSI is a good value range.):
Dead Cow Creek = 72 RSI
Happy Cow Creek = 80 RSI
72 / 80 = .9 * 100 = 90% of expected condition. This metric is Fully Supporting according to table 3.

Pool Frequency:
Dead Cow Creek = 10%
Happy Cow Creek = 60%
.10 / .60 = .1666 * 100 = 16.6% of expected condition. This metric is Not Supporting according to table 3.

For secondary channel characteristics, 2 metrics are fully supporting, and 1 metric is Not Supporting. Dead Cow Creek would therefore be determined as Fully Supporting for substrate and the analysis is considered final.
(If 1 metric was fully supporting, 1 was partially supporting, and 1 was not supporting, the determination would be fully supporting. If 2 metrics were not supporting, and 1 was fully supporting, the determination would be not supporting. At this point, the assessment would move on to biological assessment.)