LONGITUDINAL FIELD METHODOLOGY FOR THE ASSESSMENT OF TMDL SEDIMENT AND HABITAT IMPAIRMENTS

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1.0 INTRODUCTION

This document describes the methodology employed by the Montana Department of Environmental Quality to collect sediment and habitat related data on stream segments listed as impaired due to sediment and habitat alterations on the 303(d) List. The stream survey site assessment techniques described within this document will be implemented following the development of an aerial assessment database and the creation of a Sampling and Analysis Plan (SAP). Stream segments will be divided into reaches and sub-reaches during the development of the aerial assessment database through the use of GIS data layers and aerial imagery, while the specific locations at which stream surveys should be performed will be described in the SAP. The SAP will include hydrologically relevant data, such as an estimate of the expected bankfull width, mean bankfull depth and cross-sectional area based on regional reference data. The SAP will also include a review of the past 5-10 years of streamflow data for the area using USGS gaging station data along with SNOTEL data and other climatic data. This information will be recorded in the **Sediment and Habitat Assessment Site Information Form** prior to going into the field.

1.1 Field Reconnaissance and Site Selection

Once the aerial assessment database is compiled, a preliminary SAP will be prepared and the field reconnaissance will be performed to select stream survey sites that are representative of the overall reach/sub-reach conditions. During field reconnaissance, any potential issues with the site, such as a lack of access or the presence of beaver dams, will be resolved. The survey site assessment length will also be determined during field reconnaissance based on the estimated bankfull channel width of the stream. Following field reconnaissance, the SAP will be refined based on observed "on-the-ground" conditions.

1.2 Survey Site and Survey Cell Lengths

During field reconnaissance, the bankfull channel width of the stream will be estimated. This estimate will be used to determine the appropriate stream survey site length based on the bankfull channel width criteria described in **Table 1-1**. Each survey site will be divided into five cells, which will be numbered from downstream to upstream. If the bankfull width is near a cutoff, it will be the responsibility of the field leader to determine if 500 feet, 1000 feet or 2000 feet of stream should be assessed. As general guidance, survey site length should be increased to 1000 feet for streams with bankfull widths of approximately 10 feet, while the 1000-foot survey length should be retained for streams with bankfull widths of approximately 30 feet. If it appears that the bankfull width estimated during field reconnaissance is incorrect, it will be the responsibility of the field leader to determine if the length of the survey site should be modified.

Table 1-1. Survey Site and Survey Cell Lengths.

Bankfull Channel Width (Feet)	Survey Site Length (Feet)	Length of Survey Cell (Feet)				
		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5
< 10	500	0-100	100-200	200-300	300-400	400-500
> 10 to < 30	1000	0-200	200-400	400-600	600-800	800-1000
> 30 to < 60	2000*	0-400	400-800	800-1200	1200-1600	1600-2000
> 60		Survey site length determined on an individual basis				

* Alternatively, assess two 1000-foot reaches.

1.3 Work Flow

Field crews will be established and tasks will be assigned by the field leader, who will be in Crew A. Tasks are designed to be completed by 2-person crews. Each crew should include at least one member that is experienced in the assessment techniques. A general division of labor and recommended work flow scenario is provided in **Tables 1-2** and **1-3** for 4-person and 6-person field crews, respectively. Tasks are organized in a progressive order, with a specific set of data collected in each "pass" of the survey site. Each "pass" will involve taking measurements from downstream to upstream, progressing through each of the survey cells. Thus, each crew will perform all of the measurements required in a task along the entire survey site before starting on the next task at the downstream end of the survey site.

Table 1-2. Recommended Work Flow and Division of Labor, 4-Person Field Crew.

Task	Crew
Pass 1	
String tape, GPS, site photos, examine bankfull indicators	A
Riffle Pebble Counts and RSI	B
Pass 2	
Determine Bankfull, XS and BEHI	A
Pools, LWD and Bed Morphology	B
Pass 3	
Slope	A
Greenline	B

Table 1-3. Recommended Work Flow and Division of Labor, 6-Person Field Crew.

Task	Crew
Pass 1	
String tape, GPS, site photos, examine bankfull indicators	A
Pools, LWD and Bed Morphology	B
Riffle Pebble Counts and RSI	C
Pass 2	
Determine Bankfull, XS, Slope	A
BEHI	B
Greenline	C
Pass 3	
Slope	A

Since field tasks will likely take varying amounts of time depending on site complexity, crews may not be working in the same cell at the same time. However, it is important that crews communicate when measurement sites overlap (i.e. riffle cross-sections and riffle pebble counts), since some measurements may affect other measurements. Specifically, the field crew should be aware of the following, especially in situations where the streambanks cannot be easily walked due to dense riparian vegetation:

1. The field crew should avoid disturbing the streambed in riffles were pebble counts and grid tosses will be performed. These riffles will be marked with green flagging.
2. The field crew should avoid disturbing the streambed in pool tail-outs, since grid tosses will potentially be performed at these locations.

1.4 Common Abbreviations

When recording field notes, several shorthand notations should be applied:

RR = river right
RL = river left
bkf = bankfull
RBF = right bankfull
LBF = left bankfull
d/s = downstream
u/s = upstream
xs = cross-section
BEHI = Bank Erosion Hazard Index
NBS = Near Bank Stress

Note that river right and river left are always described based on a downstream orientation.

1.5 Field Photos

Field photos are specified at several places in this assessment, including the upstream and downstream ends of the survey site, at each cross-section and at each eroding streambank. In general, field photos will be the responsibility of the field leader. If two cameras are used at a site, photo information should be entered on separate **Photo Logs**. When entering the field photo number, be sure to enter the number that appears on the camera's screen. Examples of appropriate photo descriptions to be entered in the **Photo Log** include:

"u/s view at d/s end"
"d/s view at xs1"
"view from RR at xs1"
"d/s view at BEHI 1"
"view toward bank at BEHI 1"

Photo documentation should also be made when extensive pugging and hummocking is observed (**Figure 1-1**), when there are crossings or access points that have lead to channel over-widening, to document the level of browse of woody vegetation, to note any obvious signs of human caused disturbance, and to provide a general overview of site conditions. The goal of these additional photos is to provide supporting information regarding human caused sediment sources observed at the survey site.

Figure 1-1. Examples of Pugging and Hummocking.

2.0 METHODS

In this section, a detailed methodology is presented for assessing sediment and habitat impairments to Montana streams. Additional information regarding assessment methodologies can be found in the sources of information used to develop this methodology. Field forms associated with this methodology are provided in accompanying spreadsheets. An equipment checklist is presented in **Attachment A**.

2.1 Survey Site Delineation

The stream survey site will be delineated beginning at a riffle crest and extending upstream the pre-determined length. When no riffles are present, the field leader will be responsible for selecting an appropriate starting point. To delineate the survey site, perform the following steps:

1. When first arriving at a site, it is the responsibility of the field leader to establish the downstream end of the survey site at a riffle crest.
2. At this time, the field leader should review the information on the **Sediment and Habitat Assessment Site Information Form** with the entire field crew so that the crew is aware of the expected bankfull width and cross-sectional area.
3. From the riffle crest at the downstream end of the survey site, string a tape measure along the river right streambank at approximately the bankfull elevation along the entire length of the survey site.
4. While the tape measure is being strung, the field leader will record the GPS location of the downstream and upstream ends of the survey site on the **Sediment and Habitat Assessment Site Information Form**. Standard methods for recording GPS measurements can be found in *Field Procedures Manual for Water Quality Assessment Monitoring* (MDEQ 2005).
5. Digital photos will be taken looking in both the upstream and downstream directions at both the upstream and downstream ends of the survey site. Photo numbers and a brief description (i.e. "u/s view at d/s end") will be recorded in the **Photo Log**. In the GPS column of the **Photo Log**, indicate that photos are taken at sites that correspond to GPS points using the following notation:

   d/s end = photos taken at the downstream end of the survey site
   u/s end = photos taken at the upstream end of the survey site

6. As the tape is being strung, the field leader will proceed upstream and delineate the boundary between each cell with pink/orange colored flagging. The field leader will also mark the appropriate riffles where cross-sections and pebble counts will be performed using green flagging.
7. As the field leader proceeds upstream, they will mark potential bankfull indicators with pin flagging. At this time, the field leader will measure the height ("elevation") of potential bankfull indicators and record the bankfull elevation on the **Bankfull Elevation & Slope Assessment Field Form** (see Section 2.2). The other members of the field crew

should also be examining potential bankfull indicators as they begin on their respective tasks.

8. During this phase of the assessment, the field leader should also note any tributary inputs and irrigation diversions or return flows on the **Bankfull Elevation & Slope Assessment Field Form**.
9. Crew B and Crew C should begin their first set of measurements while Crew A delineates the reach.

2.2 Field Determination of Bankfull

Determination of the bankfull elevation is one of the most important aspects of field data collection, since an accurate bankfull elevation is necessary for many of the measurements. The ***bankfull elevation*** in this assessment will be measured as the height of the selected bankfull indicator (i.e. top of bar) above the surface water level. In the field, this will be measured by placing the base of the measuring rod at the surface water "elevation", which will be zero, and measuring the height of the bankfull "elevation" at the selected bankfull indicator. When making this measurement, it can be helpful to place a flat object, such as a clipboard, at the selected bankfull indicator. A measuring rod can also be placed at the bankfull indicator and extended out to the location of the surface water elevation parallel to the ground. This distance will remain fairly constant throughout a survey site, unless a disturbance has lead to unexpected variability in the overall channel form.

On the **Bankfull Elevation & Slope Assessment Field Form,** record the bankfull elevation measurements to the nearest tenth of a foot and note the type of feature that the measurement is made on. Also note which side of the channel the bankfull measurement is made on and which type of feature was identified as a bankfull indicator. The field leader should keep in mind that channel cross-sectional measurements will be performed in riffles and, thus, should be looking to see if there are any riffles with clear bankfull indicators. At least **5** (and up to 15) separate bankfull elevation measurements should be recorded on the **Bankfull Elevation & Slope Assessment Field Form**. These measurements will then be reviewed and a bankfull elevation for the site will be established. The final bankfull determination will be made by the person with the most experience, which will generally be the field leader, though the entire field crew will be expected to provide input. Potential bankfull indicators include (Leopold 1994, Rosgen 1996):

> The elevation of the highest depositional feature, such as the **top of a point bar** or other relatively flat surface.
>
> A **change in vegetation type**, such as from a gravel bar to perennial vegetation, or from herbaceous vegetation to woody vegetation. Note that during times of drought vegetation may colonize the active channel. Willows frequently occur below the bankfull level, while alders frequently grow above the bankfull level.
>
> A **change in slope (slope break),** such as a change from a sloping depositional bar to a vertical bank or from a vertical bank to a more level surface at the floodplain elevation.
>
> A distinct **change in the particle size distribution** on the surface of streambanks.

Evidence of an **inundation feature**, such as a small bench along an otherwise entrenched channel.

Staining of rocks may be used in some circumstances.

Exposed root hairs may be used in some circumstances.

Other channel features, such as the **top of the bank,** the **bottom of an undercut**, and **debris in the riparian vegetation** are also useful measures to examine when assessing the bankfull elevation, though these features do not necessarily correspond with the bankfull elevation.

2.3 Channel Cross-sections

Channel cross-section measurements will be performed at a riffle in each cell using a line level and a measuring rod. Data collected during the Channel Cross-section assessment should be entered in the **Channel Cross-section Field Form**. The steps to performing channel cross-section measurements go as follows:

1. Review the **Bankfull Elevation & Water Surface Slope Field Form** to determine the expected bankfull elevation.
2. Select the first riffle encountered in the cell progressing in the upstream direction. If no riffle is encountered in a cell, follow these criteria:

    If there is a riffle in 4 out of 5 cells, then 4 cross-sections will be performed.

    If there is a riffle in 3 out of 5 cells, then 3 riffle cross-sections will be performed.

    If there are only 2 cells with riffles, then 1 cross-section measurement will be performed at the first riffle encountered in each cell progressing in an upstream direction. If there are additional riffles in either of these cells, then a "second pass" will be made starting at the downstream cell, where the next riffle upstream will be assessed. Thus, there will be a total of 3 riffle cross-sections from three distinct riffles ensuring that no riffle is measured twice.

    If there are only 1 or 2 riffles in the entire assessment reach, then only 1 or 2 cross-sections will be performed.

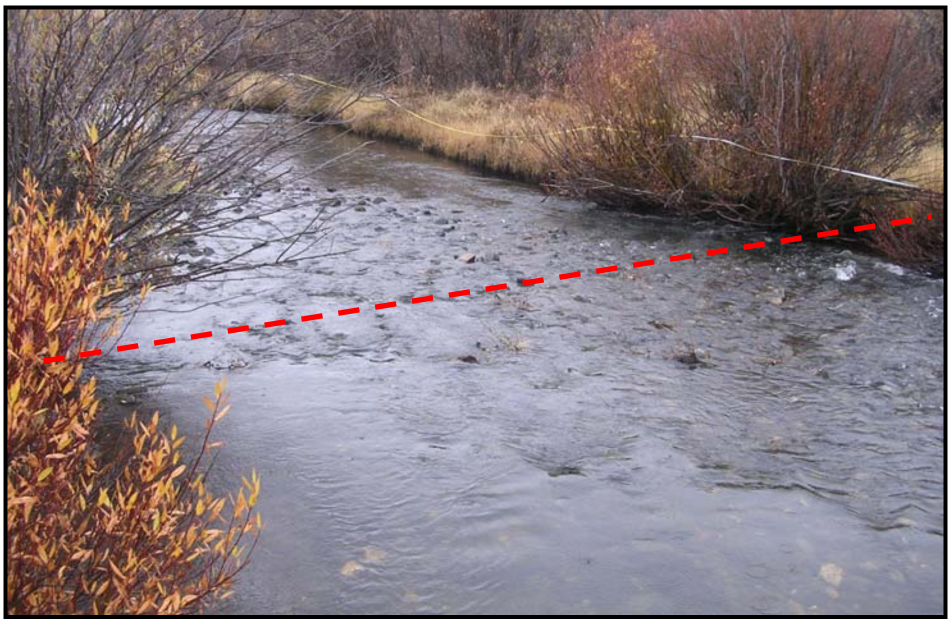
    If there are no riffles in the survey site, perform one cross-section measurement in the shallowest run. Note on the **Sediment and Habitat Assessment Site Information Form** that this measurement was made in a run.

3. Examine the streambanks along the riffle for potential bankfull indicators and make additional measurements to confirm the bankfull elevation. Bankfull indicators both upstream and downstream of the riffle can also be reviewed at this time. Record additional measurements on the **Bankfull Elevation & Water Surface Slope Field**

Form (if space remains), or in the *calculations and notes* box for the individual cross-section.

4. String a 200-foot tape ("line level") from the bankfull elevation on the river left streambank (looking downstream) to the bankfull elevation on the river right streambank at the most "well-defined" portion of the riffle and perpendicular to the bankfull channel. One crew member should hold the tape measure in place on the left bank, while the second crew member secures the tape to the right bank. Be sure that the tape is strung tightly, since a sagging tape will lead to inaccurate measurements.
5. If the riffle is situated at an angle to the overall bankfull channel direction, perform the cross-section measurement where the riffle comprises the greatest portion of the stream channel or the area where the riffle is most clearly defined, as depicted in **Figure 2-1**.

Figure 2-1. Example of a Riffle Situated at an Angle to the Bankfull Channel.



6. If there is a mid-channel bar at the along the riffle, move the line level cross-section to a portion of the riffle lacking this feature. If the mid-channel bar extends the length of the riffle, then include it the bankfull channel measurement if the top elevation is below the bankfull elevation. If the top of the mid-channel bar is above the bankfull elevation, divide the channel into two cross-sections extending from bankfull to bankfull and perform depth measurements at the appropriate interval based on the overall bankfull width of both channels. Use the cross-section table at the end of the **Channel Cross-section Field Form** to enter this information.
7. If there is a side channel along the riffle, include it in the bankfull channel measurement if it is flowing. If it is not flowing, include it in the bankfull channel measurement if the thalweg elevation is below the bankfull elevation (Heitke et al. 2006) and divide the channel into two cross-sections extending from bankfull to bankfull and perform depth measurements at the appropriate interval based on the overall bankfull width of both channels. Use the cross-section table at the end of the **Channel Cross-section Field Form** to enter this information. If the side channel is not flowing and the thalweg depth

is above the bankfull elevation or the side channel is discontinuous, exclude it from the bankfull channel assessment (Heitke et al. 2006).

8. Do not perform cross-section measurements at sites used for human or animal crossings (Kershner et al. 2004). If this situation is encountered at the first riffle in the cell, progress to the next riffle upstream or to a portion of the riffle that is relatively un-impacted by the crossing. In the *calculations and notes* box of the field form, record the type adjustment made.
9. If no riffles are identified within the entire stream survey site, perform the cross-section measurement in a run. The selected run should represent the longest section of the channel that has the shallowest bed elevation. Record that the measurement was performed in a run on the **Sediment and Habitat Assessment Site Information Form**.
10. Note that there is often a “good” (i.e. easily discernable) bankfull indicator on only one side of the channel. The other side of the channel can be “set” at this elevation, based on the measured distance between the surface water elevation and the bankfull elevation that was established during the bankfull elevation assessment. When the line level is strung tightly, the distance from the water surface to the tape (“line level”) should be the same on both sides of the channel.
11. Record the station location of the cross-section.
12. Record the latitude and longitude at the center of the cross-section on the **Cross Section Field Form**.
13. Take a picture of the cross-section, preferably facing downstream. Record the photo number on the **Cross-section Field Form** and in the **Photo Log**. Record whether the photo was taken facing downstream or upstream in the **Photo Log** (i.e. “d/s view at xs1”). Take a second photograph of the cross-section looking across the channel and record which side of the channel the cross-section is taken from (i.e. “view from RR at xs1”). Take an optional third photograph of the streambank with the “best” bankfull indicator, including the line level and the measuring rod, and record which streambank this was taken on. The measuring rod should be placed with the base (“zero”) at the surface water elevation. In the GPS column of the **Photo Log**, indicate that the photo was taken at a cross-section using the following notations:

    xs1 = Photo taken at cross-section 1
    xs2 = Photo taken at cross-section 2
    xs3 = Photo taken at cross-section 3
    xs4 = Photo taken at cross-section 4
    xs5 = Photo taken at cross-section 5

14. Measure the bankfull width to the tenth of a foot.
15. Calculate the interval at which depth measurements will be performed based on the following criteria and record this interval:

    For streams <10 feet wide, collect depth measurements at equally spaced intervals at 20% of the bankfull channel width (divide bankfull channel width by 5).

    For streams >10 but <30 feet wide, collect depth measurements at 10% intervals (divide bankfull channel width by 10).

For streams >30 feet wide, collect measurements at 5% intervals (divide bankfull channel width by 20).

16. Once the interval at which depth measurements will be performed is determined, one crew member will make the measurements across the channel progressing from river left to river right (facing downstream), while the second crew member records the data. Measurements should be recorded to the tenth of a foot as the distance from the channel bed to the line level.
17. Record the thalweg depth, which is found at the deepest part of the channel. If the thalweg depth is not captured during the equally spaced depth measurements, be sure to measure this depth and record it for use in the floodprone width calculation (note that this measurement will not be included when determining the mean bankfull depth).
18. From the cross-section measurements, calculate the mean depth and then calculate the cross-sectional area and the width/depth ratio (optional) using the following equations (note that calculations performed in the field should be reviewed during post-field data processing to assure accuracy):

    Mean depth = sum of depth measurements / number of depth measurements (exclude the RBF and LBF measurements, unless they are greater than zero, such as when there is a vertical bank)

    Cross-sectional area = bankfull width x mean bankfull depth

    Width/depth ratio = bankfull width / mean bankfull depth

19. Compare the measured cross-sectional area to the expected cross-sectional area based on regional reference data as cited on the **Sediment and Habitat Assessment Site Information Form**. If the measured cross-sectional area is not within the expected range based on regional reference data as cited on the form, review the bankfull elevation. If it appears that the bankfull elevation was in error, re-perform the measurements. Otherwise, note the reasoning behind the discrepancy in the *calculations and notes* box of the field form. As discussed in Section 2.2, the cross-sectional area should remain relatively constant among the five riffle cross-sections. If they are not, then the bankfull elevation should be reviewed.
20. Leave the line level in place while performing the floodprone width measurements.

2.4 Floodprone Width Measurements

The floodprone width measurement is made at the same location as the channel cross-section measurement and the data should be recorded on the **Channel Cross-section Field Form**. The floodprone elevation is defined as twice the maximum (thalweg) depth (Rosgen 1996). The floodprone width is measured perpendicular to the valley, which may or may not be the same as being perpendicular to the bankfull channel at a given cross-section (Heitke et al. 2006). The steps to performing floodprone width measurements go as follows:

1. The floodprone elevation is calculated based on the maximum depth, which is determined during the cross-section assessment, using the following equation:

    Floodprone elevation = 2 x maximum depth

2. Starting at the left streambank, place the measuring rod on top of the tape ("line level") at the bankfull channel margin so that "zero" on the rod is at the bankfull elevation.
3. Identify the height of the maximum bankfull depth on the measuring rod.
4. Place the clinometer at the height of the maximum depth on the measuring rod and look "through" the clinometer towards the floodplain.
5. Level the clinometer using the "zero" percent slope reading.
6. The second member of the crew will measure the floodprone width using a 200-foot tape and starting at the bankfull channel margin.
7. The crew member with the clinometer will guide the crew member with the tape to the point where the "zero" percent slope reading on the clinometer meets the ground elevation. This is the edge of the floodprone area and corresponds with the floodprone elevation at "2 x maximum depth".
8. Measure the floodprone distance out as far as possible, or to 200 feet, whichever is encountered first. If the floodplain distance is >200 feet, circle ">200 feet" on the field form.
9. Be sure to measure a total floodprone width of at least 300 feet when applicable (i.e. the stream is 60-feet wide), including the bankfull channel width and the floodprone distances on both sides. A total distance of 300 feet is recommended when the stream is 60-feet wide, since this would lead to an entrenchment ratio of 5, which indicates the stream is not entrenched. On smaller streams, field personnel can use Best Professional Judgment to determine an adequate distance to measure along the floodplain to assess whether a stream is entrenched or not. When the entrenchment ratio is >5, circle this on the field form.
10. When a clear "line-of-site" is precluded by dense riparian vegetation, the edge of the floodprone area should be estimated using Best Professional Judgment. When this is done, circle the "estimated" box on the field form. Dense vegetation can also preclude the use of the tape measure. In this situation, it is acceptable to "pace" the floodprone distance or to provide a visual estimate of the floodprone width. When this is done, be sure to mark the "estimated" box on the field form.

    Note that field members responsible for estimating distances by pacing should measure their "stride" prior to making field measurements. This can be accomplished by laying out 100 feet of tape, and then counting how many paces it takes to go 100 feet. Divide 100 by the number of paces to determine the distance traveled in one "stride". The field member can the count their paces when making distance estimates and multiply this by the length of the "stride".

11. If a "localized" high point of the floodplain is encountered along this transect, such as a mound associated with riparian vegetation, continue past this point until the actual terrace is reached. A high point should generally be considered "localized" if there are areas of the floodplain below the floodprone elevation upstream or downstream of the high point,

as well as farther back on the floodplain from the high point. When in doubt, try to visualize where the water will be when it leaves the bankfull channel.

12. Repeat this measurement on the river right side of the channel.
13. In situations where there are side channels separated by large distances and/or elevations that are higher than the identified floodprone elevation, additional analysis of the floodprone area may be necessary using GIS and aerial imagery.

2.5 Identification of Channel Bed Morphology

The length of the survey site occupied by pools and riffles will be identified during this assessment. The data should be recorded on the **Pools, Riffles and Large Woody Debris Field Form.** This assessment will be performed concurrently with the pool habitat quality, percent surface fine sediment in pool tail-outs, and large woody debris assessments. The steps to identifying the bed morphology go as follows:

1. Starting at the downstream end of the cell, record the downstream and upstream station of the following bed morphology features: riffles and pools. A feature will be considered the "dominant bed morphology" when it occupies >50 percent of the bankfull channel (Heitke et al. 2006). Use the following definitions to assign the dominant channel bed morphology:

   Riffles are sections of the channel bed with the steepest bed slopes, causing the surface water to flow swiftly and turbulently over submerged or partially submerged particle materials. The substrate of a riffle is generally comprised of gravels or cobbles (Overton et al. 1997). The "riffle crest" at the upstream end of this feature distinctly marks the start of a riffle and can be identified as the area where the surface water flow changes from smooth to turbulent. Riffles tend to have an indistinct thalweg and are considered a ***"fast, shallow"*** habitat unit.

   Pools are depressions in the streambed that are concave in profile and bounded by a "head crest" at the upstream end and "tail crest" at the downstream end (see additional description in the Residual Pool Depth section). Pools can be formed by scour or damming. Pools are considered a "***slow, deep*"** habitat unit. Pool length should be measured along the thalweg from the head crest to the tail crest (Kershner et al. 2004).

2. Besides riffles and pools, streams are comprised of two other dominant channel bed morphology features: glides and runs. Definition for glides are runs are provided, though the stationing of these features will not be recorded on the field forms.

   Runs differ from riffles in that depth of flow is typically greater and the slope of the channel bed is less than that of riffles. The surface water in a run has little or no turbulence, though the flow is still relatively swift. Runs will often have a well defined thalweg and are considered a ***"fast, deep"*** habitat unit.

Glides occur at the transition from the pool to the crest of a riffle. The slope of the channel bed through a glide is negative (upward bed slope in the downstream direction), while the slope of the water surface is positive. Glides have a uniform U-shaped channel bottom with no defined thalweg (Overton et al. 1997). The head of the glide can be identified by examining the location of increased flow velocity coming out of the pool and/or the location of a break in slope in the channel bed rising out of the pool decreases to a lesser gradient. Note that this feature is often absent/indistinguishable in the transition from a pool to a riffle. Glides are considered a ***"slow, shallow"*** habitat unit.

2.6 Residual Pool Depth

The residual pool depth measurements will be performed at all pools encountered. Data collected during this portion of the assessment should be recorded on the **Pools, Riffles and Large Woody Debris Field Form**. This assessment will be performed concurrently with the pool habitat quality, percent surface fine sediment in pool tail-outs, and large woody debris assessments. The steps to performing the residual pool depth assessment go as follows:

1. Starting at the downstream end of the cell, approach each pool from the downstream end.
2. Record the pool number, starting a "1" and progressing upward through the survey site.
3. Record the upstream and downstream station of the pool, with the downstream end being located at the same point that the residual pool depth measurement is made.
4. For this assessment, a ***pool*** is defined as a depression in the streambed that is concave in profile, is bounded by a "head crest" at the upstream end and "tail crest" at the downstream end, and has a maximum depth that is 1.5 times the pool-tail depth (Kershner et al. 2004). Dammed pools will also be assessed, though backwater pools will not. When in doubt, measure the pool, since the measurement can be removed from the dataset during post-field data processing if it is determined to be inappropriate.
5. For this assessment, the ***residual pool*** is defined as the portion of the pool that is deeper than the riffle crest forming the downstream end of the pool (Hilton and Lisle 1993). To identify the "residual" pool, visualize the shape of the pool and evaluate where "standing" water would remain if all the "flowing" water were drained from a stream. The pool tail crest tail is located at the most downstream end of this "residual" or "remaining" pool.
6. To determine the residual pool depth, identify and measure the depth of the pool tail crest to the tenth of a foot. The pool tail crest depth should be measured at the deepest point along the tail crest where there is a slope break as the pool transitions into another channel bed feature (Overton et al. 1997, Heitke et al. 2006). This area generally coincides with the thalweg. Note that the depth of the pool tail crest tends to remain relatively constant along a stream reach at a given streamflow.
7. Note that "dammed" pools will not have a tail crest and no depth measurement is necessary. When a "dammed" pool is encountered, write "N/A" in the *Pool Tail Crest Depth* column of the field form.
8. Measure the maximum depth of the pool to the tenth of a foot. It often takes several measurements while "probing" the pool to determine which point is the deepest. Once the maximum depth of the pool is identified, record this value on the field form.

9. When working within a dry channel, measure the depths of the pool and hydraulic control from the channel bed surface to the bankfull height.

2.7 Pool Habitat Quality

An assessment of pool habitat quality will be performed at all pools encountered. Data collected during this portion of the assessment should be recorded on the **Pools, Riffles and Large Woody Debris Field Form**. This assessment will be performed concurrently with the residual pool depth, percent surface fine sediment in pool tail-outs and large woody debris assessments. The steps to performing the pool habitat quality assessment go as follows:

1. Determine the pool type as (Overton et al. 1997):

    S = Scour, when formed by the scouring action of water flowing over/around an obstruction or at a meander bend
    D = Dammed, when formed by downstream damming action

2. Pool size will be determined based on the proportion of the bankfull channel width occupied by the pool. Describe each pools as:

    S = Small, when <1/3 of the bankfull channel
    M = Medium, when >1/3 and <2/3 of the bankfull channel or is >10 feet wide
    L = Large when >2/3 of the bankfull channel wide or is >20 feet wide

3. The pool formative feature will be described for each pool as (cite primary type) (Overton et al. 1997):

    LS = Lateral scour, when formed by scour at a meander bend
    P = Plunge, when formed by scour from vertically falling water
    B = Boulder, when formed by a boulder
    W = Woody Debris, when formed by overhanging vegetation or woody debris

4. The pool cover type will be described for each pool as (cite primary type):

    V = Overhanging Vegetation
    D = Depth
    U = Undercut
    B = Boulder
    W = Woody Debris
    N = No apparent cover

5. The depth of the undercut streambank will be measured, if present, using the measuring rod. This measurement should be made by inserting the measuring rod horizontally into the undercut streambank. The "depth" of the undercut will be the distance from the back of the undercut to the edge of the overhanging streambank. It may take several

measurements to determine the maximum depth of the undercut. The maximum depth of the undercut should be recorded on the field form to the tenth of a foot.

2.8 Fine Sediment in Pool Tail-outs

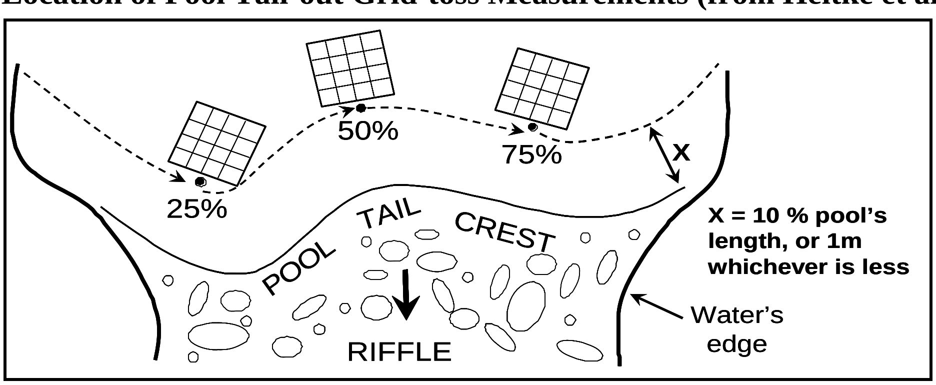
An assessment of the percent of fine sediment in pool-tail outs using the grid toss method will be conducted at the first and second scour pool encountered in each cell. Data collected during this portion of the assessment should be recorded on the **Pools, Riffles and Large Woody Debris Field Form**. This assessment will be performed concurrently with the residual pool depth, pool habitat quality and large woody debris assessments.

Note that it is often expedient to perform this measurement prior to the residual pool depth measurements and the pool habitat quality assessment since clear water is required for this procedure.

The steps to performing the percent fine sediment assessment in pool tail-outs using the grid toss go as follows:

1. Approach the first ***scour*** pool encountered in the cell from the downstream end so as to not disturb fine sediment on the streambed since this can impede visibility.
2. Identify the "pool tail-out", which is located just upstream of the pool tail crest in situations where the pool transitions directly to a riffle. The pool tail-out will usually be identifiable as an "arc" at the downstream end of the pool. In situations where the pool transitions to a glide, the pool tail-out will extend to the riffle crest of the downstream riffle (see definitions in Section 2.5).
3. The grid toss measurement should be performed in the "arc" just upstream of the pool tail crest in situations where the pool flows directly into a riffle. Approximately 10% of the pools length upstream of the tail crest can be include as the pool tail-out, or approximately 1 meter, whichever is less (Heitke et al. 2006). Note that the grid toss measurement is not to be made in the scoured portion of the pool itself or in the thalweg.
4. When the pool transitions to a glide, the grid toss measurement can be made anywhere upstream of the riffle crest of the downstream riffle.
5. Perform the grid toss at approximately the 25%, 50% and 75% of the wetted channel width within the "arc" of the pool tail-out (Kershner et al. 2004) (**Figure 2-1**).

Figure 2-1. Location of Pool Tail-out Grid-toss Measurements (from Heitke et al. 2006).



6. Since part of the salmonid spawning cycle occurs during baseflow conditions in the spring and the fall, it is up to the observer to determine which portion of the pool could potentially support spawning.
7. The appropriate size of spawning gravels varies based on stream size and the expected fish species, since larger fish are capable of moving larger substrate particles. As fish length increases from 200mm to 1000mm, the median particle size (D50) of spawning gravel increases from 10mm to 40mm (Kondolf and Wolman 1993). An example of appropriate sized spawning gravels is presented in **Figure 2-2** (Note each "square" of the grid is equal to approximately 40mm).

Figure 2-2. Example of Appropriate Sized Spawning Gravels.

8. The observer should record the potential for spawning as:

   Y = Pool tail-out has the appropriate sized gravels for spawning
   N = Pool tail-out lacks appropriate spawning gravels
   ? = It is unclear if the pool-tail would support spawning

9. To perform the grid toss, randomly "toss" the grid in each zone sequentially. Note that the grid can break if it lands on an edge, so the "toss" should be made gently and grid should land on the channel bed relatively flat.
10. Use a Plexiglas viewer to improve visibility by placing it on the waters surface with the upstream edge out of the water.
11. To assess the percent of fine sediment <6mm, count how many intersections "cover" (or intersect with) particles <6mm. Note that the standard size of the grid is 12"x12" and the intersection size is approximately 6mm. There are 49 "internal" intersections. Do not count intersections along the edge of the grid.
12. Record the number of intersections covering particles <6mm on the field form.
13. If a portion of the grid lands on a large cobble or boulder, pick up the grid and re-perform the toss. If large cobbles and boulders cannot be avoided, do not assess grid intersections

that fall on the large cobble or boulder. On the field form, record the number of particles <6mm out of the number assessed (i.e. 6/35).

14. In small streams, the grid tosses may overlap. When this occurs, place an "X" in the appropriate column of the field form to indicate that the measurements overlap.
15. If algae or organic debris on the streambed hinders identification of the particle under the grid intersections, try and gently clear away the obstruction without disturbing the streambed. In some instances, the observer can "probe" the grid intersection to "feel" if there is fine sediment underneath it. When the particle size cannot be determined under one or more intersections, record the number of particles <6mm out of the number assessed (i.e. 6/35). If the pool tail-out is large enough, the observer can choose to re-toss the grid in an area lacking obstructions.
16. Repeat this measurement in the second scour pool encountered in the cell. If there are no scour pools in the cell, progress to the next cell.

2.9 Fine Sediment in Riffles

An assessment of the percent of fine sediment in riffles using the grid toss method will be performed at same location in which pebble counts are performed. The grid toss measurements should be performed before the pebble count measurements are performed. Data collected during this portion of the assessment should be recorded on the **Riffle Pebble Count Field Form**. The steps to performing the percent fine sediment assessment in riffles using the grid toss go as follows:

1. The riffle grid toss measurement will be performed in the same riffle as the riffle pebble count as described in Section 2.11.
2. Perform this measurement mid-way down the riffle at distances 25%, 50% and 75% progressing from the bankfull channel margin on river left.
3. Count the number of intersections on the 49-point grid with particles <6mm as described in Section 2.8.

2.10 Woody Debris Quantification

The amount of large woody debris (LWD) will be assessed along the entire assessment reach. This assessment will be performed concurrently with the residual depth, pool habitat quality and percent surface fine sediment in pool tail-outs assessments. Data collected during this portion of the assessment should be recorded on the **Pools, Riffles and Large Woody Debris Field Form**. The steps to performing the large woody debris assessment go as follows:

1. Large pieces of woody debris located within the bankfull channel that are relatively stable and appear to influence channel form at bankfull flows will be counted based on the following categories:

    A **single** piece of large woody debris will be counted if it is greater than 3 meters long or two-thirds of the wetted stream width, and 10 cm in diameter at the small end (Overton et al. 1997). On the field form this will be recorded as "1" if there is one single piece. If several single pieces are located near each other, but are not functioning as an aggregate (i.e. not collectively influencing channel bed morphology), then the actual number of single pieces should be recorded.

An **aggregate** of large woody debris is comprised of two or more single pieces that are in contact with one another and are collectively influencing channel bed morphology. An estimate of the number of pieces that meet the definition of a single piece should be made. This number of individual pieces will be recorded on the field form as the number of single pieces per one aggregate.

A **willow bunch** will be denoted on the field form with and "X" when a dead willow or decadent branches of a live willow are influencing channel bed morphology. The term "willow bunch" is used in this assessment to apply to all riparian shrub species that may be encountered (i.e. alders, red osier dogwood, etc.).

2.11 Riffle Pebble Count

One Wolman (1954) pebble count will be performed in the first riffle encountered in Cells 1, 3 and 5 progressing in an upstream direction for a total of 300 particles within the assessment reach. Data collected during this assessment will be recorded on the **Riffle Pebble Count Field Form**. The steps to performing the riffle pebble count go as follows:

1. The riffle pebble count will be performed in the first riffle encountered within Cells 1, 3 and 5. This will be the same riffle that the channel cross-section measurements will be performed in. If one or more cells lacks a riffle, use the following criteria to select an appropriate riffle to sample:

    If Cell 1 lacks a riffle, perform the pebble count in Cell 2 in the same riffle in which the cross-section measurement is performed.

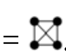
    If Cell 3 lacks a riffle, perform the pebble count in Cell 4 in the same riffle in which the cross-section measurement is performed.

    If Cell 5 lacks a riffle, perform the pebble count in Cell 2. If Cell 2 was assessed, perform the pebble count in Cell 4.

    If a total of three pebble counts are not obtaining using these criteria, begin again in Cell 1 and collect samples at the second riffle until a total of three riffle pebbles counts are obtained.

    If there are only 1 or 2 riffles in the entire assessment reach, then only 1 or 2 pebble counts will be performed.

    If there are no riffles in the survey site, collect one pebble count from the shallowest run. Note on the **Sediment and Habitat Assessment Site Information Form** that this measurement was made in a run.

2. Particles will be collected using the "heel-to-toe method" where the assessor progresses across the channel perpendicular to the bankfull channel flow while placing one foot in front of the other and collecting the first particle encountered by the tip of their finger at the toe of their leading foot. If a particle is encountered more than once (i.e. large boulder or bedrock), the feature is counted as many times as it is encountered.
3. The pebble count will be performed for particles fluvially deposited on the streambed within the bankfull channel margin and for particles deposited by streambank erosion. Particles will not be collected from streambanks below the bankfull elevation that were not deposited by fluvial processes or streambank erosion.
4. The assessor should begin the pebble count on the channel bed at the left side of the bankfull channel at the mid-point of the riffle when the streambank angle is >90º.
5. When the streambank angle is <90º, particles will be collected from the streambank within the bankfull channel margin if the particle was deposited by fluvial or streambank erosion processes.
6. The first "pass" will be conducted across the riffle progressing from left to right. Once the assessor reaches the right bank, the process is repeated just upstream of the "line" where particles were just collected.
7. At least 100 particles must be assessed in each riffle pebble count and each "pass" must be completed from bankfull to bankfull. If 100 particles are not collected in the first two passes, the assessor should move to the lower third of the riffle for the third and forth passes and then to the upper third of the riffle for the fifth and sixth pass, if necessary.
8. Particles will be collected using a template (also called a gravelometer), since this technique provides higher accuracy than measurements with rulers and reduces variability between different operators (Bunte and Abt 2001).
9. A template is used to reduce errors in defining the *b*-axis, which is the intermediate length axis of the particle (see **Figure 2-3** in Section 2.11). However, when using the template, it is possible to insert particles that have a comparatively small *c*-axis (i.e. flat rocks) "diagonally" into a template hole that is actually smaller than their *b*-axis. Thus, it is important when using the template to assess particle size based its ability to pass through the vertical or horizontal sides of the template hole, which correspond to the actual size classes used to determine the particle size distribution.
10. When using the template, measure and record particles by the smallest diameter template hole that they will pass through. Start with the template hole whose diameter appears larger than the sample particle and move to progressively smaller template holes. The smallest template hole that the particle passes through is the upper end of the size class. When the sampler calls out "16" for the recorder, this means that the particle is "***less than 16mm"*** and passed through the 16mm template hole, but not the 11.3mm template hole. Therefore, the particle is within the 11.3mm to 16mm size class and the recorder will enter the data accordingly.
11. Particle size data will be recorded using the "dot/slash" system, where, 10 = . The four dots should be filled in first, followed by the outside lines of the box, and, finally, the diagonal lines.
12. There are spaces on the field form to tally the results for each size class if there is additional time in the field. Otherwise, this can be performed during post-field data processing.

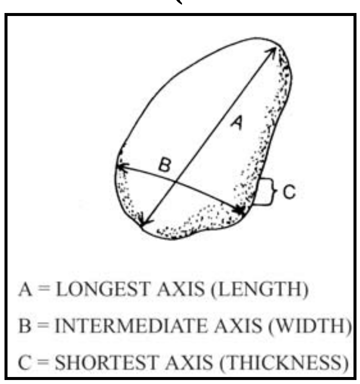
13. Note that templates with square holes will be modified so that the <2mm and <6mm categories have round holes. This will allow greater accuracy in the fine sediment assessment.

2.12 Riffle Stability Index

The riffle stability index (Kappesser 2002) will be assessed in each cell for streams that have developed point bars. Data collected during this assessment will be recorded on the **Riffle Pebble Count Field Form**. The steps to performing the riffle stability index go as follows:

1) Within each survey cell, locate the gravel bar closest to the riffle in which the pebble count and channel cross-section measurements were made. If there is no gravel bar in the cell, do not perform this measurement.
2) Identify the dominant large particle size that has been recently deposited on the gravel bar. Dominant large particles are defined here as the largest particles that occur on the depositional bar at an estimated frequency of 10% or greater. Recently deposited particles can be identified as having a brighter color, a lack of attached algae, a lack of staining, and are not embedded.
3) Measure the *b*-axis for 15 freshly moved dominant large particles and record measured value on the field form. The *b*-axis is the intermediate size axis as depicted in **Figure 2-3**.
4) The riffle stability index is calculated as the geometric mean of the dataset during post-field data processing.

Figure 2-3. Intermediate Axis Measurement (from Harrelson et al. 1994).



2.13 Riparian Greenline Assessment

A greenline assessment of riparian vegetation quantifies the ground cover, understory and overstory along the assessment site by general community type as a percent at approximately bankfull. Data collected during the riparian greenline assessment should be recorded on the **Riparian Greenline Field Form**. The steps to performing the riparian greenline assessment go as follows:

1. Starting at the downstream end of the cell, perform measurements at 10-foot intervals progressing upstream along the ***greenline***, which is located at approximately the bankfull channel margin (Windward 2000).
2. Every 10-feet, the ground cover (<1.5 feet tall), understory (1.5 to 15 feet tall) and overstory (>15 feet tall) riparian vegetation will be assessed (USEPA 2004).
3. The ground cover (<1.5 foot tall) vegetation will be described in the following categories:

    W = Wetland vegetation, such as sedges and rushes
    G = Grasses or forbs
    B = Bare/disturbed ground
    R = Rock, when a large cobble or bolder is encountered
    RR = Riprap

4. When the 10-foot interval falls at the base of a shrub or tree, place a dash (-) on the field form.
5. When pugging and hummocking due to the mechanical hoof action of grazing ungulates is observed, add "/H" to the field form (i.e. "G/H" indicates grass or forb ground cover with evidence of pugging and hummocking). See **Figure 1-1** for an example of pugging and hummocking.
6. The understory vegetation (1.5 to 15 feet tall) and overstory vegetation (>15 feet tall) will be described in the following categories:

    C = Coniferous
    D = Deciduous, riparian shrubs and trees with sufficient rooting mass and depth to provide protection to the streambanks
    M = mixed coniferous and deciduous

7. When assessing understory and overstory vegetation along the greenline, envision an imaginary vertical "line" extending up from the 10-foot interval at the bankfull margin. If this vertical "line" intersects the canopy a shrub or tree, then record the data in the appropriate category.
8. Shrubs or trees that are not encountered along the "imaginary" vertical line should also be included when their base is within 5 feet of the bankfull channel margin. This distance can be assessed using the measuring rod.
9. If no shrub or tree is encountered, place a dash (-) in the column on the field form.
10. When the bankfull channel margin is comprised of exposed sand or gravel due to streambank erosion, the greenline measurement should be made at the top of the bank.
11. When the channel margin is along a gravel bar, the greenline measurement should be made at the estimated bankfull elevation. When this is the case, place an "X" on the field form to denote the measurement was made along the bankfull channel margin at a gravel bar.
12. At 50-foot intervals, the field crew will estimate the riparian belt width along both sides of the stream. This can be accomplished with a tape measure in areas where the riparian zone is small or the vegetation is not dense. The riparian belt width can also be estimated by pacing, visual estimate or with the use of a range finder. This distance should

generally correspond with the floodprone area and, in many instances, will be bound by terraces or other distinct topographic features.

13. When performing the greenline assessment on smaller streams, one crew member should walk along the tape, designate where the 10-foot interval is and record the data, while the second crew member performs the measurements.
14. When performing the greenline assessment on larger streams, crew members should progress along opposite sides of the channel simultaneously. In this case, crew members will be responsible for performing the greenline assessment on their respective sides of the channel, though only one crew member will be responsible for recording the data. The crew member assessing the river left side of the channel that lacks the tape should estimate the location of each 10-foot interval based on the guidance of the crew member progressing along the tape measure.
15. Following the completion of greenline measurements, the total number of times each canopy type was observed is tallied. The box at the bottom of the field form can be used if the greenline assessment crew has extra time at the end of the site assessment. Otherwise, this can be completed during post-field data processing.
16. Note that the greenline assessment is specifically designed for areas in which streambank erosion is influenced by riparian shrub coverage. This measurement is optional in situations were riparian shrubs do not play an important role in streambank stability, such as steep mountain streams in coniferous forests.

2.14 Streambank Erosion Assessment

An assessment of all eroding streambanks along the assessment reach will be conducted. This assessment involves delineating the eroding streambank, performing Bank Erosion Hazard Index and Near Bank Stress measurements, and evaluating the sources of streambank erosion. Data collected during the streambank erosion assessment should be recorded on the **Streambank Erosion Field Form**. The steps to performing the streambank erosion assessment are outlined in the following sections.

2.14.1 Eroding Streambank Delineation

1. Identify the upstream and downstream end of each eroding streambank and record the stationing on the field form. An eroding streambank can be identified by the presence of bare, exposed or “raw” substrate along the streambank and/or collapsing or slumping of the streambank.
2. Assess streambank erosion in one cell at a time, numbering streambanks in ascending order progressing upstream.
3. If a cell lacks an eroding streambank, no streambanks will be assessed in that cell.
4. If an eroding streambank extends between two cells, include it in the downstream cell, which will be the first cell assessed in the upstream progression.
5. If an eroding streambank extends beyond the boundaries of the delineated stream survey site, do not include the portion of the streambank outside of the site.
6. Estimate the mean height of the eroding streambank from the toe of the bank to the top of the bank by making several measurements along the eroding streambank. The ***toe*** of the streambank is defined as the point where the streambank meets the channel bed. Note

that the toe of the streambank will not necessarily be in the water during baseflow conditions.

2.14.2 Bank Erosion Hazard Index and Near Bank Stress

1. Identify the most representative portion of the streambank and perform the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) measurements at this spot based on methods developed by Rosgen (1996, 2001, 2006) and adopted by the USEPA (2006).
2. The BEHI score is a metric derived from the following measurements which will be performed in the field: bank height, bankfull height, root depth, bank angle, and surface protection (**Figure 2-4**). For each bank, the BEHI score is then adjusted for bank materials and stratification.

    Bank height is measured from the toe of the bank to the top of the bank (note that this is labeled "study bank height" in **Figure 2-4**).

    Bankfull height is measured from the toe of the bank to the bankfull elevation. Unless the toe of the bank is at or above the surface water elevation, this height will be greater than the bankfull elevation identified along the survey site.

    Root depth is measured as the depth that the predominant roots extend into the soil from the top of the bank.

    Root density is estimated as a percent of the area assessed for root depth that is comprised of plant roots. Record estimates to the nearest 10%.

    Bank angle is measured from a horizontal plane in degrees from the toe of the bank to the top of the bank, with 90º being a vertical bank and >90º being an undercut bank. The angle of an undercut bank is determined by inserting the measuring rod into the deepest portion of the undercut and gently "prying" it back as close as it will go to vertical. Record measurements to the nearest 5º.

    Surface protection is measured as the percent of the streambank that is exposed to erosion. Surface protection can be provided by sod mats (i.e. vegetated slumps), large woody debris or boulders. Record measurements to the nearest 10%.

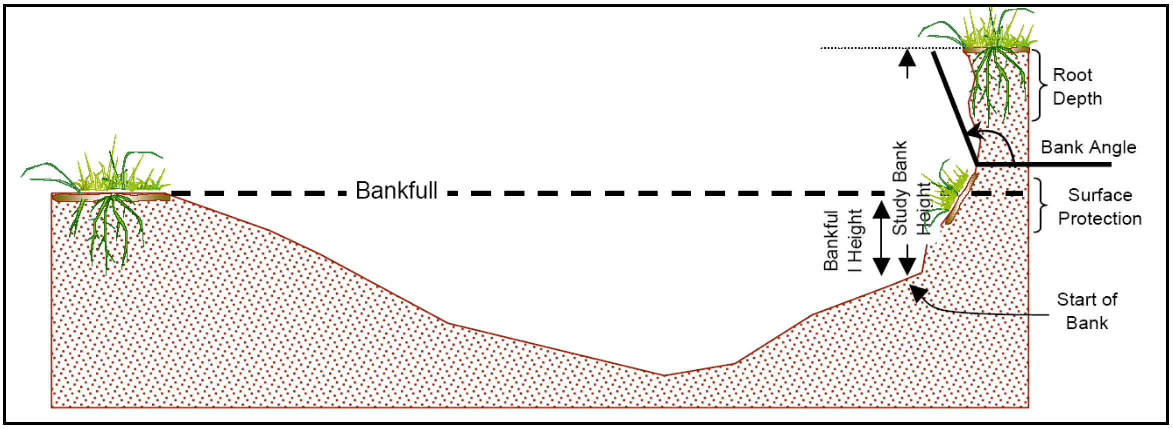
    The **bank material adjustment** is applied as follows:

    > Subtract 10 points if the bank is comprised of cobbles.
    >
    > Add 5-10 points if the bank is comprised of gravel and sand, depending on the amount of sand.
    >
    > Add 10 points if the bank is comprised of sand.

No adjustment is necessary for clay banks.

The **stratification adjustment** is applied depending on the position of the layers in relation to the bankfull stage. A streambank should be considered stratified when a more erosive layer is situated or "sandwiched" between two less erosive layers within the bankfull zone.

Figure 2-4. BEHI Measurement Variables (from EPA 2006).



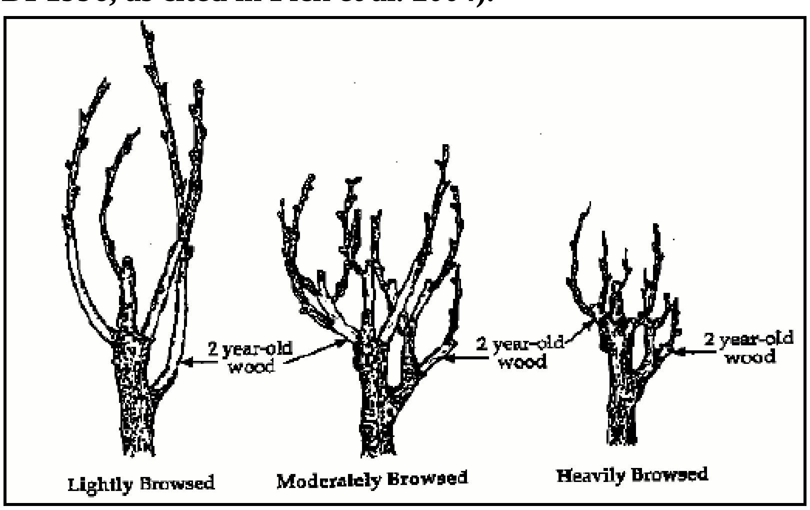
3. To perform the NBS assessment, it is necessary to string a 100-foot tape across the channel at the bankfull elevation. Record the bankfull channel width on the field form.
4. Perform approximately 5 bankfull depth measurements at roughly equal spacing across the stream channel. Record these measurements in the *Bankfull mean depth calculations* box on the field form and calculate the mean bankfull depth.
5. Measure the *near bank maximum depth*, which is the deepest bankfull channel depth (measured from the channel bed to the bankfull elevation) within the 1/3 of the channel closest to the eroding bank along the cross-section. Record this depth on the field form.
6. Once the BEHI and NBS measurements have been made take one photo looking downstream at the eroding streambank and second photo facing the streambank at the site where the BEHI and NBS assessment was performed (**Figure 2-5**). Include the measuring rod and the line level in the photo for reference, with the base of the rod placed at the toe of the streambank. Provide a brief description in the **Photo Log** (i.e. "d/s view at BEHI 1", "view toward bank at BEHI 1").
7. If the eroding streambank is "complex" and appears to have more than one BEHI value and/or more than one NBS value, then the streambank may need to be broken into two or more "eroding streambanks" for the purposes of this assessment. If only the NBS changes along the streambank, then two separate NBS measurements can be performed for one eroding bank so long as the length of eroding bank associated with each NBS measurement is recorded.

Figure 2-5. Example of Appropriate Photos of Eroding Streambanks.

2.14.3 Streambank Composition and Erosion Source Assessment

1. Visually estimate the streambank material composition and identify the sources of streambank erosion.
2. When assessing the streambank composition, first estimate the percent comprised of coarse gravel, cobbles and boulders (>6mm). Next, evaluate and the percent comprised of sands and clays (<2mm). Finally, assessed the amount of streambank comprised of fine gravels (2mm-6mm). Assess each category to the nearest 10%.
3. Indicate if hoof shear is observed by circling either "present" or "absent" on the field form. If hoof shear is observed, document it with a photograph and provide a brief description in the **Photo Log**.
4. Indicate the level of browse of woody vegetation by circling "low", "moderate" or "high" on the field form. If there is no woody vegetation on the streambank, circle "N/A". Examples of browse levels on second-year growth are presented in **Figure 2-6**.

Figure 2-6. Guide to Estimating Browse Utilization on Second-year Growth of Woody Plants (from USDI 1996, as cited in Pick et al. 2004).



5. Identify sources of streambank instability and estimate a percent in the following categories:

   Transportation
   Riparian Grazing
   Cropland
   Mining
   Silviculture
   Irrigation-shifts in stream energy
   Natural Sources
   Other (provide a description of the source)

6. If a source of streambank erosion is not observed, do not record a value. The exception is for natural sources, which must always be estimated, even if that value is 0%. Eroding streambanks at the outside of meander bends, for example, are likely due at least partially to natural sources, though human sources may be leading to increased instability and erosion.

2.15 Water Surface Slope Estimation

The water surface slope will be estimated and recorded on the **Bankfull Elevation & Water Surface Slope Field Form**. The steps to assessing the water surface slope go as follows:

1. This assessment will be performed in all cells that have portion of their length with a clear "line-of-site" between two riffles.
2. This measurement is performed at the surface water elevation from the top of one riffle (riffle crest) to the top of the next riffle in a relatively straight section of the channel. Other channel bed features (i.e. "pool-to-pool") may be utilized as long as distinct points can be identified in both features. Record the feature that was used on the field form.
3. To perform the slope assessment, two crew members will stand at the surface water elevation on the same side of the channel, with one crew member in each riffle. In situations where standing at the surface water precludes a direct "line-of-site", crew members can stand in the channel. When this is done, be sure to stand at the same elevation (i.e. 0.4 feet deep) in the same type of feature (i.e. riffle crest). The depth can be measured using the measuring rod and relayed between the two crew members.
4. Slope will be measured with a clinometer in percent, which is on the right hand side of the clinometer.
5. To measure slope, the crew member with the clinometer must first establish where their "eye-level" meets on the other crew member (i.e. the top of their head, their sunglasses, their shoulders, etc.). This "eye-level" point will be used as a pseudo stadia rod. If this spot is above the persons head, then the crew members should switch roles.
6. Measure the slope in percent from upstream to downstream and record this value on the field form.
7. If there are less than two riffles in a cell, or if there is not a clear "line-of-site" between two riffles (or other identified feature) due to dense riparian vegetation, then do not

perform this measurement. In this case, slope measurements at the reach scale as assessed from aerial photos will be used.

2.16 Field Notes

Field notes will be taken once the stream survey site assessment is complete. Field notes should be recorded by the field leader, but will include the inputs of the entire field crew. Field notes should be taken in the following four categories:

1. Description of human impacts and their severity
2. Description of stream channel conditions
3. Description of streambank erosion conditions
4. Description of riparian vegetation conditions

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Attachment A

EQUIPMENT CHECKLIST

Equipment Checklist	
	waders
	field forms
	pencils
	1 role green flagging
	1 role pink/orange flagging
	pin flagging
	2 calculators
	3 300-foot tape measures
	2 100-foot tape measures
	1 200-foot tape measure
	4 stakes/pins for cross-sections
	2 "clips" for cross-sections
	2 measuring rods
	1 metal grid for pool tail-out grid toss
	1 plastic shield for pool tail-out grid toss
	1 gravelometer
	1 clinometer
	resource grade GPS unit
	1 range finder
	1 camera
	1 flashlight
	extra batteries for GPS, range finder, camera, other
	sunscreen, bug repellent
	sunglasses
	first aid kit
	bear spray (when warranted)