LAND MANAGEMENT

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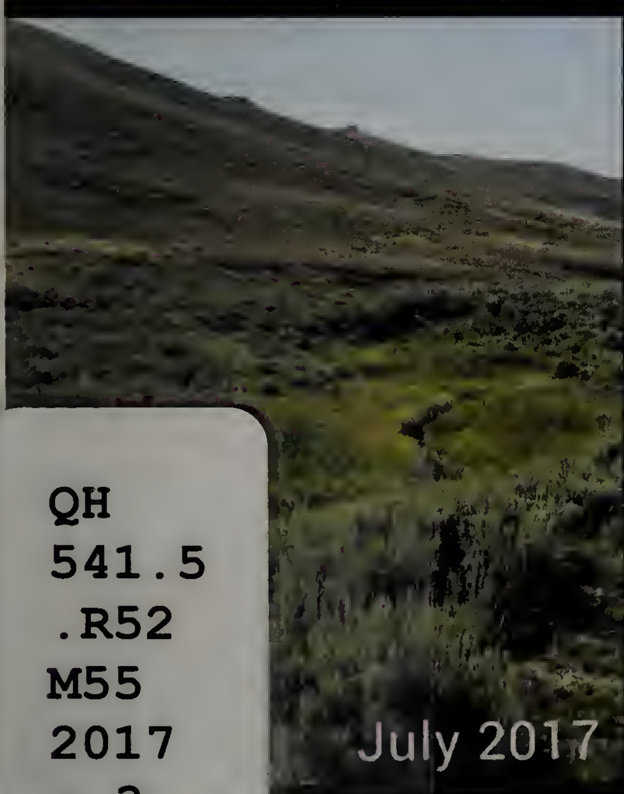
AIM National Aquatic Monitoring Framework: Field Protocol for Wadeable Lotic Systems

Technical Reference 1735-2



July 2017

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1. Introduction

The Bureau of Land Management (BLM) developed the National Aquatic Monitoring Framework (NAMF) (Miller et al. 2015) to monitor the condition and trend of aquatic systems as part of the Assessment, Inventory, and Monitoring (AIM) Strategy (Toevs et al. 2011). Following the AIM principles, the NAMF standardized aquatic core indicators, field sampling methodologies, electronic data capture, and the use of statistically valid sample designs for wadeable streams and rivers (i.e., lotic systems). The protocol in this technical reference outlines the field methodologies for the collection of the core and contingent indicators for lotic systems, as well as suggested covariates.

The BLM AIM Aquatic Core Indicator Work Group (ACIWG), with guidance from an external science advisory team, identified 11 core indicators, 7 contingent indicators, and several covariates applicable to lotic systems (Table 1). The 11 core indicators represent a consistent, quantitative approach for determining the attainment of BLM land health standards for perennial wadeable streams and rivers, among other applications (Miller et al. 2015). AIM aquatic ***core indicators*** are applicable across many different ecosystems, management objectives, and agencies and are recommended for application wherever the BLM implements monitoring and assessment of lotic systems. To help determine the potential of a stream reach to support a given condition or to assist in interpreting monitoring data, the ACIWG also identified six aquatic ***covariates***—slope, bankfull width, wetted width, human influence, photos, and flood-prone width (Table 1). For example, slope is useful in interpreting pool frequency, large woody debris retention, and percent fine sediment. Measurement of the field covariates is recommended in conjunction with the core indicators.

Table 1. Core and contingent aquatic indicators for use in wadeable perennial streams. The indicators are grouped by the BLM's four fundamentals (43 CFR 4180.1).

Fundamentals	Indicator	Core	Contingent	Covariate
Water quality	pH	X		
	Specific conductance	X		
	Temperature (instantaneous and seasonal)	X	X	
	Total nitrogen and phosphorous		X	
	Turbidity		X	
Watershed function and instream habitat quality[1] (i.e., physical habitat)	Residual pool depth, length, and frequency	X		
	Streambed particle sizes	X		
	Bank stability and cover	X		
	Floodplain connectivity	X		
	Large woody debris	X		
	Bank angle[1]		X	
	Ocular estimate of instream habitat complexity[1]		X	
	Thalweg depth profile		X	
	Bankfull width			X
	Wetted width			X
	Slope			X
	Flood-prone width			X
Biodiversity and riparian habitat quality	Macroinvertebrate biological integrity	X		
	Ocular estimates of riparian vegetative type, cover, and structure	X		
	Canopy cover	X		
	Quantitative estimates of riparian vegetative cover and composition[2]		X	
Ecological processes	See indicators from other fundamentals[3]	NA	NA	
Other	Photos			X
	Human influence			X

[1] Bank angle and ocular estimate of instream habitat complexity were included as contingent indicators to be collected in all regional and national surveys on a research basis; consult your monitoring objectives and the AIM team to determine potential relevance for local applications.

[2] Methods for the quantification of riparian vegetative cover and composition are pending. In the interim, use the multiple indicator monitoring (MIM) methods.

[3] Indicators used to assess ecosystem function are redundant with other indicators, such as temperature; total nitrogen and phosphorous; streambed particle sizes; macroinvertebrate biological integrity; and ocular estimates of riparian vegetative type, cover, and structure.

The ACIWG also identified seven aquatic ***contingent indicators*** (Table 1) that have the same cross-program utility and definition as core indicators, but they are measured only where applicable. Contingent indicators are not expected to be informative or cost effective for every monitoring application and, thus, are only measured when there is reason to believe they will be important for management purposes. The use of contingent indicators should be considered during the design phase of monitoring project development and be selected to address specific management and monitoring objectives.

The aquatic core and contingent indicators and covariates are not expected to be inclusive of all BLM lotic data needs, as additional indicators may be required (i.e., ***supplemental indicators***). Specific methodological recommendations are not made in this technical reference for potential supplemental indicators; however, existing peer-reviewed protocols should be used when possible, as well as the indicator screening process outlined in BLM Technical Reference 1735-1 (Miller et al. 2015).

Methods for measurement of the aquatic indicators and covariates were selected by the AIM ACIWG with the goals of maximizing compatibility with existing monitoring programs, accurately and precisely estimating condition and trend, and meeting BLM lotic data needs as specified by BLM policy and plans and state and federal regulations. The indicator measurement methods described in this protocol were compiled from the following previously established aquatic monitoring programs (compatibility of the AIM NAMF with each of the following four protocols is presented in Appendix A):

- **Multiple Indicator Monitoring** (Burton et al. 2011): bank stability and cover (supplemented) and streambed particle sizes (modified from Wolman 1954).
- **PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program** (Archer et al. 2015) and **Aquatic and Riparian Effectiveness Monitoring Program** (Lanigan 2010): reach setup (Harrelson et al. 1994), targeted-riffle benthic macroinvertebrate collection (Hawkins et al. 2003), bank angle (Platts et al. 1987), bankfull width and height (Harrelson et al. 1994), pool dimensions (Lisle 1987; Lanigan 2010), seasonal temperature monitoring, slope, and photographs.
- **National Rivers and Streams Assessment Protocol** (USEPA 2009): reachwide benthic macroinvertebrate collection, canopy cover (Mulvey et al. 1992), floodplain height, large woody debris (supplemented), thalweg depth profile, visual estimates (instream habitat; riparian type, cover, and complexity [supplemented]; human influences [supplemented]), water

chemistry (pH, specific conductance, instantaneous temperature, total nitrogen, total phosphorous)).

- **Surface Water Ambient Monitoring Program** (2007): turbidity.

1.1 Site Selection and Indicator Precision

The NAMF lotic protocol can be used to assess the condition and trend of an individual stream reach (e.g., designated monitoring area used for a grazing permit renewal) or a population of stream reaches (e.g., random sampling of all wadeable streams managed by the BLM Bruneau Field Office). Monitoring objectives established by project managers will determine the number of reaches to be sampled and whether a randomized, targeted, or mixed site selection approach is appropriate. Site selection and survey design are not covered in this field manual, but practitioners should reference BLM Technical Reference 1735-1 (Miller et al. 2015) for guidance on random site selection and BLM Technical Reference 1737-23 (Burton et al. 2011) for guidance on establishing designated monitoring areas. In all instances, it is recommended that practitioners work with the BLM AIM team to optimize site selection procedures with monitoring objectives.

Depending on whether a monitoring effort is designed to make inference to a single stream reach (e.g., designated monitoring area) or a population of stream reaches, the unit of replication can differ. AIM monitoring and assessments generally seek to make inference to a group or population of stream reaches through use of statistically valid sample designs. In this approach, the unit of replication is the stream reach, and multiple reaches are required to derive average indicator estimates and associated confidence intervals. Thus, where this protocol prescribes multiple measurements for a given indicator throughout a reach (Table 2), the intent is to improve the accuracy of reach-scale indicator values (e.g., average bank stability), and the individual measurements are not intended to be statistical replicates. The use of multiple measurements per reach as replicates is subject to pseudoreplication, in which the replicates are not statistically independent (Hurlbert 1984). Pseudoreplication can lead to artificially low variance estimates and the detection of differences when they really do not exist (i.e., type I errors). The methods described in this field manual should provide acceptable levels of accuracy for deriving population-scale condition estimates, as long as a sufficient number of independent reaches are sampled.

Table 2. Core, contingent, and covariate field measurements and their associated measurement location for perennial lotic systems. Italics indicate a contingent or covariate measurement.

	Field Measurement	Main Transects	Intermediate Transects	Reach Center	Reachwide
Water Quality	pH			X	
	Specific conductance			X	
	Temperature			X	
	Total nitrogen and phosphorous			X	
	Turbidity			X	
Physical Habitat	*Bank angle*	X			
	Bank stability and cover	X	X		
	Bankfull width	X			
	Floodplain connectivity (bankfull and floodplain height)	X			
	Flood-prone width [1]				X
	Ocular estimate of instream habitat complexity	X			
	Large woody debris				X
	Residual pool depth, length, and frequency (pool dimensions)				X
	Slope				X
	Streambed particle sizes	X	X		
	Thalweg depth profile				X
	Wetted width	X	X		
Biodiversity and Riparian Habitat Quality	Canopy cover	X			
	Macroinvertebrate biological integrity [2]	X			
	Ocular estimates of riparian vegetative type, cover, and structure	X			
Other	GPS coordinates				X
	Human influences	X			
	Photos				X

[1] Flood-prone width is only measured in riffles or straight reaches located at or near transects A and K.

[2] Macroinvertebrates will either be sampled at all main transects or within targeted-riffles depending on how many riffles are present within the reach. See Section 6 of this document for more guidance on which approach to use.

In contrast, for questions addressing an individual stream reach, such as detecting site-specific trends in condition through time or assessing attainment of state water quality standards, additional indicator precision or numbers of samples may be required. Example indicators that might be considered for this situation include water quality and bank stability. If the monitoring objectives are site specific and a higher level of precision is necessary, users should increase the number of replicate measurements for the indicators of interest by adding additional plots or taking additional samples within the reach. For example, practitioners might increase the number of bank stability and cover plots beyond 42. Such changes can be made while still maintaining compatibility in indicator measurement among sites. Again, to avoid pseudoreplication, the desired level of replication should be achieved by collecting multiple independent samples through time or among reaches, not from replicate measurements within a reach during a single sampling event.

1.2 Timing of Field Data Collection

In addition to establishing adequate sample sizes within or among reaches, this protocol seeks to maximize the precision of indicator estimates by specifying an index period within which data should be collected. With a few exceptions, all data collection should occur between June 1 and September 30. This time period generally corresponds to base flow water levels (although exceptions exist), when streams can be safely waded, and when daily variability in chemical, physical, and biological indicators is minimized. Exceptions can be made where climatic conditions (e.g., monsoonal rains in the desert southwest) preclude sampling during this time period.

2. How to Use This Protocol

Individuals should not implement this protocol without first attending a lotic AIM NAMF training or similar training conducted by the U.S. Forest Service, Environmental Protection Agency, or state department of environmental quality; individuals should consult with the AIM team before attending a partner's training to ensure compatibility of the indicators and methods (e.g., Appendix A). It should not be assumed that expertise in ecology, hydrology, or geomorphology is a substitute for training. Training is required to ensure that the methods are followed correctly and consistently, thus maximizing data accuracy and precision. Method calibration, which is an important part of the data quality assurance and quality control (QA/QC) process, is also a training component in which the accuracy and precision of field personnel in implementing the protocol are assessed.

This protocol does not include technical explanations regarding indicator and method development or background information on the chemical, physical, and biological processes relevant to lotic systems. Rather, it is assumed that the requisite skills for protocol implementation will be obtained through training. To help facilitate the correct and consistent application of the protocol, Appendix B is a glossary that defines the technical terms used throughout the protocol. Glossary terms are distinguished throughout the protocol with bold and italics.

2.1 Protocol Overview

This protocol contains instructions on how to collect core, contingent, and covariate AIM data for wadeable streams and rivers (Table 1). The indicator methods are described in a manner that allows each indicator to be measured independently. However, for projects in which more than one indicator or all indicators will be collected, the indicators are presented in the general order in which they should be collected. For projects seeking to estimate the condition and/or trend of a population of stream reaches in relation to the BLM's land health standards, the intent is for data collection to include all of the core indicators and covariates. In contrast, individual indicators may be selected and measured for monitoring projects targeting individual reaches (e.g., restoration or reclamation effectiveness) or previously identified stressors (e.g., excessive thermal, sediment, or nutrient loading).

Data is collected along the length of a stream called a "reach." Reach lengths are a minimum of 150 m or 20 x ***bankfull width***. Eleven main transects (A-K) and 10 intermediate transects, oriented perpendicular to the ***thalweg***, are established within each sample reach (Figure 1). Most measurements are taken at transects, but a few are taken between transects and at the reachwide scale (Table 2). Detailed descriptions of each measurement are provided in the respective sections of this protocol.

The methods described in this protocol are appropriate for the majority of streams on BLM land. However, special or unusual situations (e.g., braided channels, beaver-impacted streams, dry channels) may warrant slight procedural modifications. For unusual streams, please refer to Appendix C: Special Situations. For further questions, call your project manager or the National Aquatic Monitoring Center for advice, and take careful notes on how the data were collected.

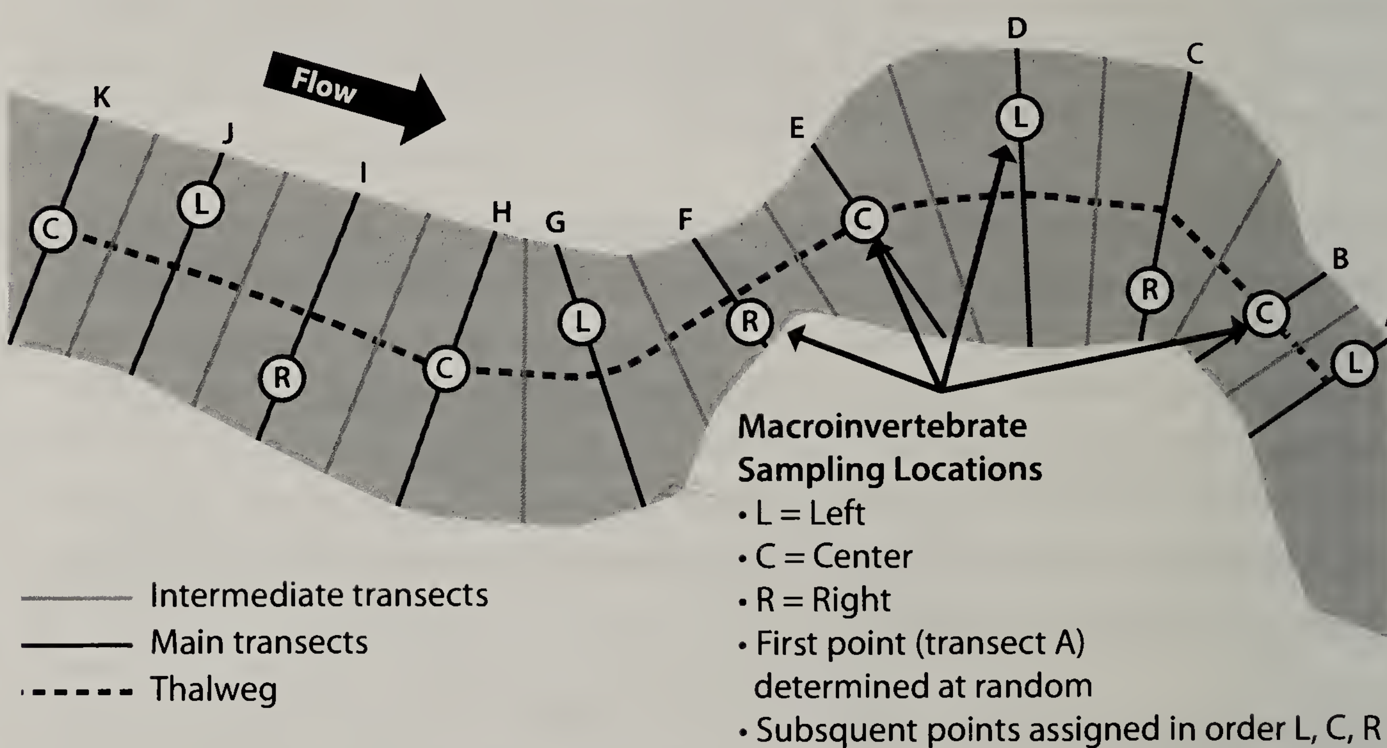


Figure 1. Typical reach setup with 11 main transects (A–K; black lines) and 10 intermediate transects (gray lines) oriented perpendicular to the thalweg. Reach lengths are equal to 20 x bankfull width or a minimum of 150 m. Circled letters represent alternating benthic macroinvertebrate sampling locations for the reachwide protocol (USEPA 2009).

2.2 Critical Concepts

2.2.1 Identifying Bankfull —

Bankfull is the height on the streambanks where water flow fills the channel and begins to overflow onto the floodplain. In incised streams, the bankfull height is often below that of the floodplain, and other indicators are required to identify the elevation. Bankfull is important because it corresponds to the discharge associated with channel formation, maintenance, and thus observed channel dimensions under current climatic conditions. For example photos of bankfull, see Appendix D.

To identify bankfull, look for the following features. Note that not all bankfull features will be present in any one location.

- An active floodplain adjacent to the streambanks. The active floodplain will be a relatively flat depositional area that is commonly vegetated and above the base flow water level.
- Depositional features such as ***point bars***. Bankfull will typically be above all ***point bars***. The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage.
- Changes in streambank slope. Bankfull will often correspond with the location on the streambank where a change in slope occurs (i.e., streambank changes from relatively steep to relatively flat on the floodplain).
- Changes in streambed particle size distributions. Bankfull elevation is often found above the location where particle sizes change from coarser bed particles to finer particles deposited on the streambanks during high flow events.
- The elevation above the stream where woody riparian vegetation transitions from being shrubs to trees or where the vegetation transitions from being grassy and herbaceous to woody. The lowest elevation of cottonwood, birch, and alder can be a useful indication of the bankfull elevation, whereas dogwood and willows are often found both below and above the bankfull elevation.
- The ceilings of undercut banks, which are often just below the bankfull elevation.
- Stain lines on rocks. Bankfull is typically at or above the highest stain line on rocks, which may coincide with the lowest limit of mosses or lichens.

In the absence of clear indications of bankfull, look for evidence of the previous season's flooding, including:

- Drift debris (leaf mats, thickets of wood).
- Deposits of unvegetated sand, gravel, or mud.
- The elevation where deciduous leaves, small branches, etc., are absent from the ground surface because they were carried away by high water.

Keep in mind that bankfull height will be more or less consistent throughout the reach. Significant changes in bankfull height among transects should only be observed when there are also significant changes in the physical structure of the reach (e.g., increased or decreased channel constraint or gradient).

For large or gaged rivers, consult the following resources before leaving for the field:

- U.S. Geological Survey stream gages, from which stage height at bankfull can be ascertained.
- Regional rating curves, from which bankfull channel dimensions can be estimated.
- U.S. Geological Survey StreamStats, from which a number of basin characteristics and flow statistics can be ascertained.

2.2.2 Identifying Scour Line —

Scour line is used to define the active channel. The scour line is identified by the elevation of the ceiling of undercut banks, the top of vertical banks located below bankfull in desert systems, or the lower limit of sod-forming vegetation. Scour line generally corresponds to the location of the average annual flow and, thus, will be below bankfull and above the base flow elevation. For example scour line photos, see Appendix D.

Keep in mind that the scour line will be more or less consistent throughout the reach. Significant changes in the scour line location relative to the channel should only be observed when there are also significant changes in the physical structure within the reach (e.g., increased or decreased channel constraint or gradient). Scour line will always be below the bankfull elevation.

The best place to identify scour line is in a straight, well-vegetated section of the stream channel. The following indicators can be used to identify scour line:

- The lowest consistent limit of sod-forming or perennial vegetation on the banks or ***point bars***.
- The ceiling of undercut banks will often correspond with the scour line.
- On depositional features, such as ***point bars***, the scour line is often defined by an indentation in the bar (locally steep area).

If you cannot identify the scour line at a specific location or transect, then use the average scour line elevation measured throughout the reach.

2.2.3 Identifying Thalweg —

The thalweg is the longitudinal path of a stream connecting the deepest part of the channel. The thalweg is used to quantify the longitudinal profile of a reach and thus the heterogeneity of the streambed morphology and associated channel units.

The thalweg can be identified by finding the location laterally across a stream that has the deepest and fastest moving water. One should be able to walk up- or downstream and consistently follow the thalweg. In low gradient, sinuous systems, the thalweg will alternate between left and right bank, generally corresponding with the location of pools. While in riffles, the location of the thalweg can be harder to identify and generally corresponds to the center of the riffle.

2.2.4 Identifying Where Bed-Meets-Bank —
Bed-meets-bank is the location where the streambed begins to become constrained by its streambanks. The location of where bed-meets-bank is used to define the location of bank angle measurements.

The location of where bed-meets-bank can be identified by performing the following steps:

- Identify the scour line; bed-meets-bank should be below the scour line.
- Look for a pronounced change in slope. Bed-meets-bank is generally located where the relatively steep streambank transitions to a more gently sloping streambed.
- Look for a rapid change in the substrate particle size from relatively coarse particles in the streambed to finer particles on the streambank. Streambed particles are usually unconsolidated, while bank particles are usually consolidated.
- Look for the lowest extent of perennial vegetation. The streambed should support very little to no vegetation, except in cases where the stream has been extensively dewatered.

2.3 Equipment

A detailed gear list is provided in Appendix E. Sampling equipment should be obtained well in advance of the field season, as some items may take a while to obtain from manufacturers. Note that felt-bottomed wading boots are strongly discouraged, as they are known to aid in the spread of aquatic invasive species. Additionally, all equipment used in field sampling that comes in contact with stream water or substrate should be properly decontaminated before moving to a new site. For guidelines, see Section 10, "Gear Decontamination."

2.4 Predeparture Site Scouting

Crew success in accessing and sampling sites will rely heavily upon predeparture investigation or "scouting" of sites, especially for randomly chosen sites. The value of this preparatory work cannot be underestimated as it is critical to field crew efficiency.

The purpose of site scouting is threefold: (1) to determine whether a site meets the definition of the ***target population*** (e.g., ***perennial*** wadeable stream on land managed within the BLM Bruneau Field Office); (2) to assess the accessibility of a site; and (3) to plan a travel and access route to the site.

For statistically valid sample designs, three possible site outcomes include: (1) Data is successfully collected (i.e., sampled); (2) The point does not meet the definition of the target population (i.e., nontarget); or (3) Data are not collected at the site because of access issues, safety concerns, etc., but the site is a member of the target population (i.e., temporarily or permanently inaccessible). Field office or desktop evaluations can be used to determine whether a site is a member of the target population, but field office evaluations of the existence of perennial flow should always be based on two types of evidence (e.g., aerial imagery and local knowledge indicate that the site is dry) to justify classifying a point as nontarget. Any site that is rejected during the predeparture scouting process needs to be assigned a failure category (see Section 3.1.2) and a reason as described in Table 3.

A stream or river is rejected as nontarget during the predeparture site scouting if:

- The point coordinates do not fall on BLM land.
- No stream is present, but rather a wetland or impoundment.
- The point coordinates fall on an artificial stream such as a canal or ditch.
- There is no evidence that a waterbody or stream channel was ever present at the site.
- The selected stream is dry, and no evidence of perennial flow exists up- or downstream of the point coordinates.

In addition to these rejection criteria, individual projects may have additional criteria such as the point coordinates needing to fall on BLM land located within a specific administrative unit (e.g., allotment, field office, district).

Scouting may be conducted by any staff member that is intimately involved with the field work and, whenever possible, should be completed before the start of the field season to allow for adequate time to deal with access issues or other impediments. Scouting can include, but is not limited to: visiting the site in person, looking over topographic maps and aerial imagery, consulting with field office resource specialists, contacting private landowners to obtain access permissions and instructions, and checking water gaging stations for current flow conditions. Careful consideration should be given to identifying the best possible window of time for sampling, which can be influenced by local precipitation regimes, flow variation associated with dams, and irrigation withdrawals and returns.

All scouting and access information obtained during scouting should be given to the field crew prior to departure. If the person who performed the scouting is not going into the field, the crew should be given the opportunity to review the scouting information prior to departing for the field in case they have questions. Once crews are familiar with the scouting information and their planned route, they will need to assemble their navigational supplies and equipment.

Before leaving the office for the field, ensure the field crew has all of the following:

- Road and topographic maps, with BLM land ownership boundaries, for all areas the crew will visit. State gazetteers and 1:24k-scale BLM maps are strongly recommended.
- GPS and compass.
- Reach packet with information pertaining to the streams slated for sampling, including:
    - Stream name and site code.
    - Point coordinates.
    - Closest city or town and highway.
    - Any available site access information, such as directions on which roads to take; possible access routes; and scouting comments from field crew managers, project managers, and field office staff.
    - Landowner contact information and access instructions, if applicable.

3. Site Evaluation

Overview: Navigate to the point coordinates and document how the crew obtained access or attempted to access the site. If the point coordinates are accessible, determine if the reach can be sampled, and if so, set up the sample reach. If the point coordinates are inaccessible or the reach is unsampleable, classify the failed site using one of the categories from Table 3. Use the flow diagram in Figure 2 to help with the decisionmaking process.

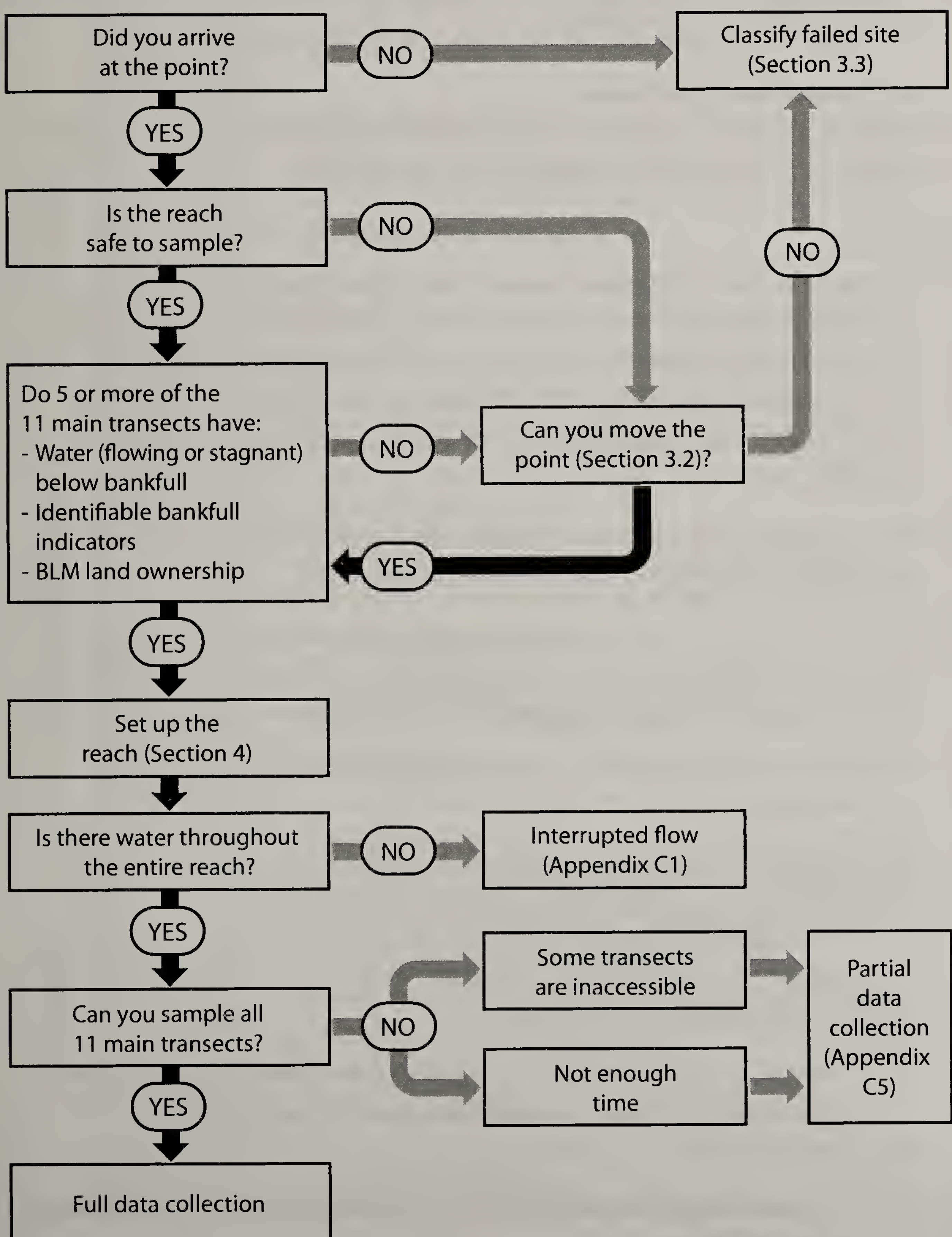


Figure 2. Flow diagram of site evaluation and sampling status decisionmaking process.

3.1 Locating the Point Coordinates

The GPS coordinates correspond to the potential location of the center of the sample reach. If the reach is sampleable, these coordinates will be the location of the F transect (Figure 1).

3.1.1 Targeted Reaches —

For designated monitoring areas or targeted reaches, where the sample reach is selected using stratification and/or best professional judgment, skip to Section 4, "Setting Up the Reach."

3.1.2 Probabilistic Reaches —

Navigate to the reach using the point coordinates. If you cannot access the coordinates, provide detailed documentation as to why.

Methods:

1. Navigate as close to the point coordinates as possible. Note that if the provided coordinates do not fall on a stream (sometimes they are adjacent to the stream), navigate to the location on the stream that is closest to the coordinates (usually within approximately 50 m). Use maps or other resources to ensure that you are on the stream originally selected for sampling.
2. Ensure that you do not cross onto private property without obtaining permission, while trying to access the sample reach.
3. After all efforts have been made to navigate to the point coordinates, record whether you arrived at transect F. Take a GPS coordinate of the location of transect F or the closest location that you were able to access.
   a. If you arrived at transect F, continue to Section 3.2, "Determining Reach Status."
   b. If you did not arrive at or within view of transect F, classify the reach as "revisit," "permanently inaccessible," or "nontarget," and provide a specific description of the complication (Table 3) (Section 3.3). Record notes where applicable (e.g., need to come in from the top of the drainage rather than the bottom).
      - **Revisit**: Access is possible via another route, at another time, with additional equipment or guidance, or with private landowner permission.
      - **Permanently inaccessible**: Access to the reach is not possible now or in the future.

- **Nontarget**: The reach is not in the target population (e.g., point coordinates did not fall on a perennial wadeable stream or river located on lands managed by the BLM).

Table 3. Reasons for which aquatic AIM sites are not sampled and respective categories for unsampled sites.

Site Status	Reason Not Sampled	Description
Revisit	Different route or permission needed	The crew was unable to gain access to the reach but could gain access at a later date with landowner permission or by taking a different route.
	Not wadeable	The water is too deep or swift to wade. Specify if the reach: (1) could be sampled when the water recedes or (2) must be sampled by boat because the water will always be too high for wading. If it can't be sampled by boat, see not wadeable/not boatable below.
	Other	The crew started to access or sample but ran out of time; the crew was turned back by inclement weather; the reach will require a backpacking crew, more capable truck, or all-terrain vehicle because it is remotely located or access road is too rugged; or various reasons not listed above, including illegal activities or active wildfire in the vicinity of the stream.
Permanently Inaccessible	Access denied, private	This reach can only be accessed by crossing private land, and landowner permission was explicitly denied.
	Access denied, terrain	All possible routes were attempted, but natural barriers such as cliffs, slopes greater than 50 percent, waterfalls, extremely dense vegetation, or beaver complexes prevented access.
	Not wadeable/not boatable	This reach will always be unsafe to wade or boat. Examples include reaches with long segments of class V whitewater and very steep creeks in highly constrained gorges.
Nontarget	Dry	The reach was determined to be dry (< 5 main transects with water) either by field visit or by two lines of evidence reviewed during office point evaluation. Specify if the reach was ***intermittent*** or ***ephemeral*** using the definitions of intermittent and ephemeral streams provided in Appendix B. Provide detailed notes if dry due to irrigation withdrawal.
	Lentic	The reach is a wetland, pond, or is otherwise impounded and no defined channel is present. Do not use this classification for lotic sites inaccessible due to beaver ponds.
	Map error	There is no evidence that a water body or stream channel exists, or the reach is actually an artificial channel such as a diversion ditch, or 5 or more transects do not fall on BLM land.

3.2 Determining Reach Status

Overview: After locating the point coordinates, determine if the reach is sampleable.

Methods:

1. Measure the bankfull width of the stream to determine approximate reach length.
   a. If bankfull width is ≤ 7.5 m, reach length will be 150 m.
   b. If bankfull width is > 7.5 m, reach length will be 20 x bankfull width.
2. Use the distance from point coordinates, as displayed on the GPS, to walk the approximate length of the reach. Take note of the approximate location of the 11 transects, assuming transects are placed at 1/10 the reach length (i.e., if the reach is 150 m long, transects will be set up every 15 m).
3. While walking the reach, determine if the reach meets the following criteria:
   a. You can safely access and wade 5 or more transects.
   b. Five or more transects are located on land managed by the BLM.
   c. Five or more transects have water and are not impounded (i.e., contained in a lake, reservoir, pond, or beaver ponds).
   d. You can identify bankfull at 5 or more transects.
   e. The current discharge level is below bankfull and is not at or approaching bankfull because of heavy rainfall, snowmelt, or dam releases.
      - If the reach does not meet each of these 5 criteria, continue to step 4, and determine if you can move the point coordinates to meet the minimum criteria.
      - If the reach meets these 5 criteria, it is sampleable; continue to step 5.
4. If the reach does not meet one or more of the five criteria listed in step 3, determine if you can move the point coordinates up- or downstream. "Moving the point coordinates" means that you will move your sample reach up- or downstream of the original location so that you can sample a stream that was otherwise unsampleable. Point coordinates should only be moved to meet the minimum requirements listed in step 3; do not move the point further than needed.
   a. Follow these guidelines to determine how far the point coordinates can be moved:

- For reaches 150-500 m in length, the point coordinates can be moved up- or downstream a maximum distance of 250 m from the original point coordinates, following the ***thalweg*** (Figure 3A).
- For reaches > 500 m in length, the point coordinates can be moved up- or downstream, but the original point coordinates must be contained within the new sample reach (Figure 3B).
- When in doubt, contact the field crew or project manager to discuss your decision.
- In relatively straight channels, use the GPS to estimate the distance a point can be moved, but for more meandering channels, measure the distance along the ***thalweg***.
- Point coordinates should not be moved if the stream size category (small stream - SS, large stream - LS, or river - RV) would change because of a tributary junction. Refer to the site code and the NHD Plus GIS stream layer to determine what stream size category the point is and whether moving it would change stream size category.
- Point coordinates for targeted reaches should not be moved without careful consideration from field office staff (e.g., what are your objectives relative to detecting trend).
- Point coordinates and reach locations should not be moved from their original locations during repeat sampling events for trend analysis.

b. If the reach can be sampled after moving the point coordinates, record that you moved the point coordinates, and continue to step 5.

c. If the reach still cannot be sampled after attempting to move the point coordinates, continue to step 6.

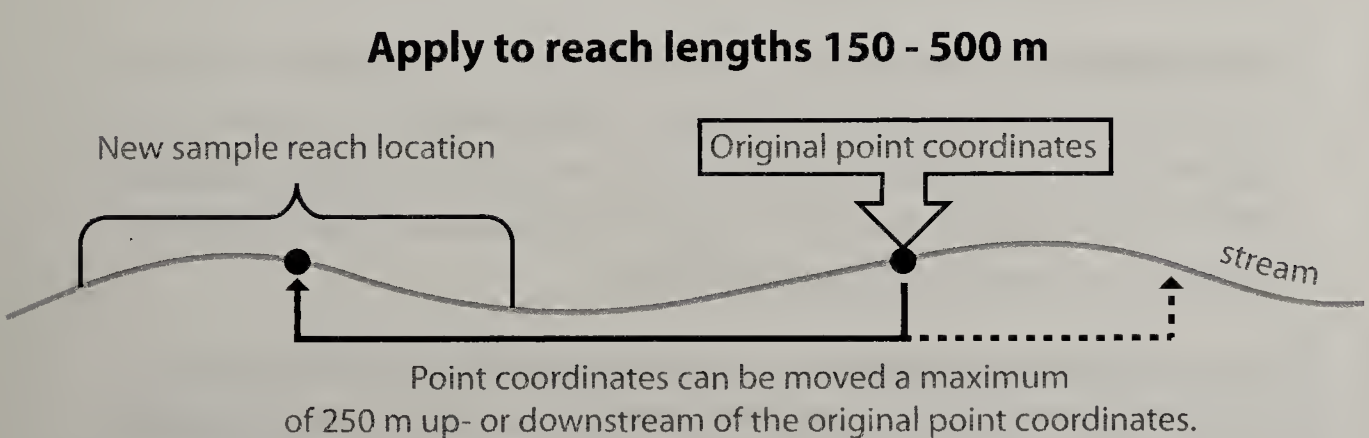


Figure 3A. Example of the maximum distance the point coordinates can be moved for reaches 150-500 m in length. The original coordinates can be moved a maximum distance of 250 m up- or downstream.

Apply to reach lengths > 500 m

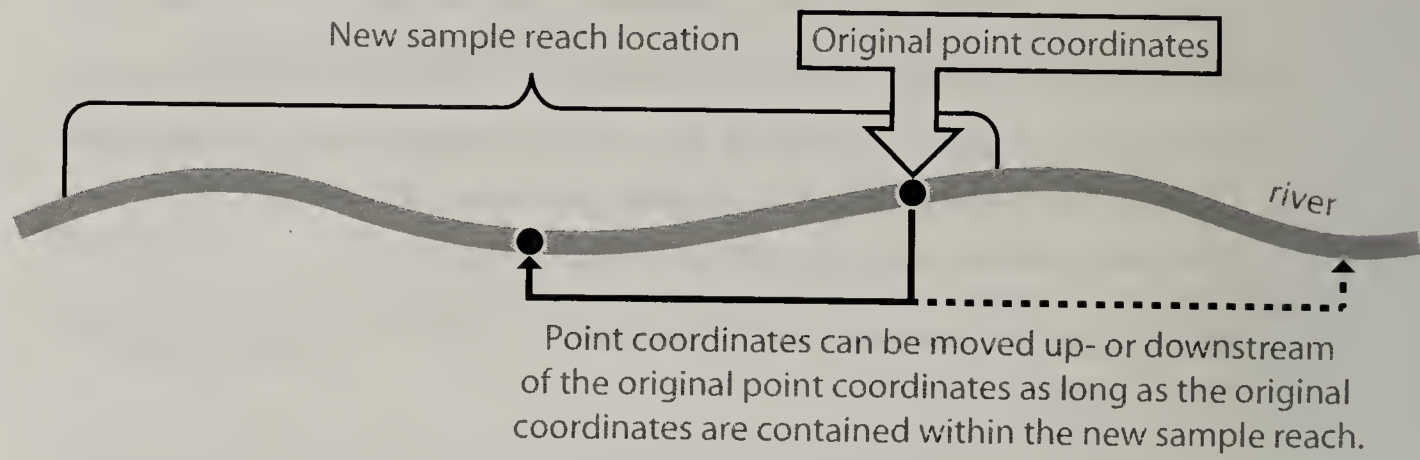


Figure 3B. Example of the maximum distance the point coordinates can be moved for reaches > 500 m in length. The original location can be moved up- or downstream, but the original point coordinates must be contained within the new sample reach.

5. If the reach can be sampled (before or after moving the point coordinates), classify it into one of the subsequent categories. Then, fill out the rest of the verification form, including comments about: overall site conditions, the weather, local contacts (e.g., landowners or field offices), and any other important information that might help crews get back to the reach in future years. Next, continue to Section 4, "Setting Up the Reach."
   - **Sampled**: All transects can be sampled (i.e., full data collection).
   - **Partially sampled**: Less than 11 but at least 5 main transects can be sampled. This situation occurs when some transects cannot be sampled because they are inaccessible, or the water is too deep or swift (be sure to note which transects). Only use this category when one or more complete transects cannot be sampled. See Appendix C for guidance on sampling partial reaches.
   - **Interrupted flow sampled**: Some portions of the reach are dry, but 5 or more transects have water, even if the water is not flowing. See Appendix C for guidance on sampling interrupted reaches. Because field methods differ for these sites, it is critical that these sites are properly recorded as "interrupted flow."
6. If the reach does not meet the criteria for sampling and if the point coordinates cannot be moved, the reach is considered unsampleable. If the reach can be sampled under different conditions, classify it as needing a revisit. If the reach cannot be sampled because it is nontarget or permanently inaccessible, classify it appropriately and provide a reason as to why you placed it in the chosen category (Table 3). Finally, fill out the rest of the reach verification form (Section 3.3).

3.3 Documentation of Failed Reaches

Overview: If you were not able to access the reach and associated point coordinates, or if the reach is unsampleable for any reason, fill out the relevant information on the verification page of the data collection app or data sheets. Provide detailed information on all attempts made to access and sample the reach, including directions, GPS coordinates, and photographs. If the reach could be accessed and sampled at a different time, be sure to note any stipulations that could help ensure the success of a revisit to the reach.

Methods:

1. If you have not already done so, record the GPS waypoints at transect F or the location closest to transect F that you were able to access.
2. If you reached the F transect, take a photo of this location. Additionally, take notes, photos, and GPS waypoints of all barriers or complications that prevented sampling or accessing the point coordinates and associated reach (be specific).
3. Record the reason that the reach was not sampled using the categories in Table 3. Make sure to provide the details presented in the "Description" column in Table 3 and not just the category.
4. If you were unable to access the reach, provide detailed route information about how you attempted to access the reach, and if applicable, provide possible alternate route suggestions for future crews.

4. Setting Up the Reach

Overview: After determining that the reach is sampleable and after collecting water quality data (Section 5), use the average of 5 bankfull widths to establish the reach length. Use the reach length to determine the distance between transects, and then set up all transects.

Methods:

1. If you encounter any of the following, reference Appendix C, "Special Situations," and then continue to step 2:
   a. Interrupted flow (Appendix C1)
   b. Side channels (Appendix C2)
   c. Beaver activity (Appendix C3)
   d. Braided stream morphology (Appendix C4)
2. Work as a crew to identify the following geomorphic features:
   a. Bankfull elevation (Section 2.2.1)
   b. Floodplain height (Section 7.2.2)
   c. Scour line (Section 2.2.2)
3. Measure (using a surveyor's rod, measuring tape, or laser range finder) the bankfull width at 5 locations of "typical" width. Measurements should be taken within 5 bankfull channel widths, upstream and downstream, of transect F.
4. Record the 5 measurements, and compute reach length using the following rules:
   - Reach length should be 20 times the average of the 5 bankfull width measurements.
   - If the average bankfull width is less than or equal to 7.5 m, use 150 m for the reach length.
   - If the average bankfull width is greater than 200 m, use 4 km for the maximum reach length.
5. Set up the F transect at the point coordinate location or in the middle of the reach if the location of the original point coordinates was slid.
6. Identify the location of all other transects.
   a. Start at the point coordinates (F transect), or if you slid the reach, start in the middle of the reach at the F transect.

b. Measure upstream and along the thalweg 1/20 of the reach length to the first intermediate transect.

c. Identify the transect location by placing a pin flag (or hanging flagging) on each bank.

d. Repeat steps a.-c. until you have established 5 main (transects G–K) and 5 intermediate transects upstream of the point coordinates. It can be helpful to label each main transect with the corresponding letter, or alternate pin flag colors between main and intermediate transects. If measuring thalweg depth, the flagging of intermediate transects is optional, as they can be established while performing the thalweg depth measurement process.

e. While at the top of the reach, stand mid-channel and record a waypoint.

f. Return to transect F, and repeat steps a.-d., this time moving downstream (transects E–A)

g. Main transects will be labeled A–K; transect A = bottom of the reach, and transect K = top of the reach.

5. Water Quality

Overview: The core methods and indicators for water quality are specific conductance and temperature. The contingent methods and indicators are total nitrogen, total phosphorous, continuous stream temperature, and turbidity (Table 1). Regardless of which indicators are measured, water quality measurements should be taken before any instream work is done to minimize disturbance of stream sediments and their influence on water quality measurements. All water quality measurements are taken at the F transect. See Appendix C for where to take water quality in reaches with interrupted flow or beaver impacts. Note water quality is always taken, even at sites with partial data collection.

5.1 pH, Specific Conductance, and Temperature

All field protocols were written for YSI brand sondes. However, it should be noted that other brands may be used as long as they are capable of collecting the core indicators and meet the precision requirements:

- pH: ±0.1 SU
- specific conductance: ±2 µS/cm or ±10%
- turbidity: 2 NTU or ±10%

Methods:

1. Review the calibration log to ensure the sonde was calibrated for both pH and specific conductance following manufacturer recommendations or within the last 7 days, whichever is shorter.
2. Record the most current calibration date.
3. If the sonde has not been calibrated in the last 7 days or within the manufacturer's recommended timeframe, the sonde will need to be recalibrated following the manufacturer's directions.
4. Standing mid-channel at transect F and in flowing water, if present, lower the probe to a depth of 0.5 m below the water surface, taking care to avoid contacting the stream bottom. If water depth is < 1 m, take measurements at mid-depth.
5. Wait for the readings on the screen to stabilize (this could take up to a few minutes).
6. Record the pH, temperature (°C), and specific conductance (µS, not mS). Ensure the sonde is set to measure indicators in the appropriate units and that temperature-corrected conductivity (i.e., specific conductance) is being measured.

5.2 Total Nitrogen and Phosphorus (contingent)

Overview: Take a single "grab sample" that will be analyzed for total nitrogen and phosphorus, and preserve the sample by freezing.

Methods:

1. Obtain a pair of new surgical gloves, and place them on both hands, being careful not to contaminate the outside of the gloves with substances such as sunscreen. Dispose of gloves after use.
2. Obtain a sterile 50 ml centrifuge vial (new or acid washed), and rinse the vial with stream water five times. Be careful not to overly disturb the stream bottom.
3. Fill the vial directly from the stream with 30-35 ml of stream water; this will leave head space in the vial for freezing.
4. Fill out a water quality label with the full site code, stream name, date, and your initials. Record the day, month, and year, making sure to spell out the month rather than using numerals (e.g., 27Aug2015).
5. Tape the label on the outside of the vial with clear packing tape.
6. Immediately after collecting and labeling, place the sample on ice and freeze the sample within 24 hours. If in the field for longer than 24 hours, the sample will need to be frozen using dry ice. Record the number of hours that the vial was unfrozen between sampling and when the vial was permanently frozen back in the office.

5.3 Turbidity (contingent)

Overview: Measure the suspended solids in the water column that cause the water to become turbid. This protocol was written for use with a LaMotte turbidimeter (see manufacturer instructions for other instruments).

Methods:

1. Inspect the calibration log to ensure the meter has been calibrated within the last 7 days. If not, calibrate the meter following the manufacturer instructions.
2. Obtain a sample vial from the LaMotte turbidimeter, and rinse it 5 times with stream water.
3. From the ***thalweg***, collect a water sample. Be very careful not to disturb stream bottom sediments prior to or while collecting the water sample.
4. Pour off water from the vial such that the meniscus is level with the white line.

5. While holding onto the cap only, thoroughly wipe the sample vial with Kimwipes to remove any fingerprints or debris.
6. Place the sample vial in the meter, aligning the vertical white line with the black arrow.
7. Close the meter, and obtain a measurement using the provided meter instructions.
8. Remove and invert the vial, while only handling the cap, and obtain a second reading. Repeat this for a third reading. Record all three readings.
9. If any one of the three readings is more than double that of a single reading, it is recommended that you take additional readings of the same water sample until three homogeneous readings are obtained.
10. Provide comments if unusual values or stream conditions are observed.
11. Do not store the meter in the sun. When the meter is exposed to heat, it will frequently produce erratic readings.

5.4 Seasonal Temperature Monitoring (contingent)

Overview: Thermistors can be easily deployed to obtain a more temporally integrated picture of the thermal regime of a stream reach. A minimum deployment time of June 1 through September 15 is recommended to capture the annual thermal maxima. Many organisms can only survive within a narrow temperature range, and higher temperatures can limit the population viability of certain organisms.

Methods: More detailed protocols regarding thermistor setup and deployment are provided by Isaak et al. 2013 and Dunham et al. 2005.

1. Use the manufacturer's software to program the thermistor to record at hourly intervals, and if the option exists, set the thermistor to not overwrite data when the memory is full.
2. Record the thermistor number and the date and time that the thermistor was deployed. Carefully check to ensure the number is correct. Then, check again.
3. Deploy the thermistor, and secure it with a metal cable or other attachment methods. When considering where to place the thermistor, think about high and low flows, and place it in a location that will not be affected by strong current or become dry at a later date. Adhere to the following guidance to select an appropriate location:
    - Attach the temperature logger cable to a tree trunk, a root wad, or the bank.

- Pick one of the deepest locations in the channel that you can access, focusing on the thalweg.
- If possible, do not attach the cable to rocks in the stream that are smaller than two times the size of a basketball, as higher flows can dislodge the rock and the probe could be lost. Use a longer cable to reach the bank.
- Use rocks to hold the thermistor in place by placing rocks on the cable and not the probe (if the flow drops, the rocks can absorb heat).
- If in a high traffic area, place the thermistor in a location that will be camouflaged from people. You can use grass, dirt, or moss to cover the wire.
- Avoid areas just downstream of tributaries and obvious groundwater seeps, as water temperatures in these areas will not be representative of the stream reach. If there is a steep bank on one side of the stream, try to place the logger near the opposite side such that runoff from the hillside does not influence the temperature readings.

4. Draw a map, record GPS coordinates, and provide a written description of where you placed the thermistor.
   - Note that the better you hide the temperature logger, the better your map and description need to be. When documenting the thermistor's location, draw the map and write the description relative to the bottom of the reach.
   - Record whether the thermistor is on the right or left bank, and use landmarks (e.g., wire attached to roots of enormous ponderosa pine, logger hidden underneath river left undercut bank).

6. Benthic Macroinvertebrates (BMIs)

Overview: Determine whether the targeted-riffle or reachwide protocol will be used to collect BMIs to assess macroinvertebrate biological integrity using a Surber sampler or kick net as described in Section 6.3. Collection of BMIs with a Surber sampler is the preferred method and should be used where possible. BMIs should be collected prior to collecting physical habitat data. See Appendix C on where to collect BMIs when interrupted flow or beaver ponds are present or when collecting partial data. Note BMIs are not collected on side channels.

There are two methods for sampling BMIs: targeted-riffle and reachwide. The targeted-riffle approach is designed for reaches containing fast-water or riffle habitats and should be the default BMI method if there are fast-water habitats within the reach. In contrast, the reachwide protocol is designed for low gradient reaches void of fast-water or riffle habitats. The targeted-riffle approach is regarded as the default BMI method because it maximizes sampling and sample processing efficiency. For either approach, you must specify the sampled habitat (i.e., targeted-riffle or reachwide) and the total number of replicate samples collected and composited.

While agencies like the Environmental Protection Agency are now using the reachwide method for all sampling, the two methods have been shown to result in comparable data; thus the data from the two approaches should be considered interchangeable (Gerth and Herlihy 2006; Rehn et al. 2007). Both methods specify that samples should be collected while moving upstream.

6.1 Targeted-Riffle

Methods: Using the targeted-riffle method, BMIs are collected within riffle or fast-water habitats for a total of 8 Surbers or kick nets composited into a single sample. See Appendix C on where to collect BMIs when interrupted flow, side channels, or beaver ponds are present or when collecting data.

1. Identify riffles located within the sample reach. If the entire reach is comprised of riffle or fast-water habitat, use the targeted-riffle method by applying the randomization process in step 2 to locate the 8 Surber/kick net sample locations.

    a. If ≥ 4 riffles are present, collect invertebrates at 2 locations within the first 4 riffle or fast-water habitats for a total of 8 locations sampled.

    b. If only 2-3 riffles are present, collect Surber/kick net samples from 3-4 locations within all the fast-water habitats for a total of 8 locations sampled (i.e., 8 Surber or kick net samples).

   c. If only one riffle exists that does not span the majority of the reach length, use the reachwide protocol.

2. Determine the sample location(s) within each fast-water habitat by generating pairs of random numbers between 1 and 9, and multiply each number by 10. This can be done by using the last two numbers from the time displayed on a digital face watch.
   a. The first number in each pair represents the percent upstream along the riffle's length.
   b. The second number in each pair represents the percent of the stream's width from river left looking downstream.
   c. Using the calculated perentages from steps a. and b., visually estimate where the two intersect for the sampling location.
   d. Repeat this process to locate the other sampling locations.
   e. If it is not possible to collect BMIs at one of these locations (e.g., log in the way, too deep, cannot seal bottom of net, etc.), generate an additional set of random numbers, and sample the new location.
3. Begin at the riffle closest to the bottom of the reach, and collect a total of 8 Surber or kick net samples.
4. Follow the general collection and preservation methods described in Section 6.3.

6.2 Reachwide

Methods: Using the reachwide method, BMIs are collected just downstream of the 11 main transects, resulting in the collection of 11 Surbers or kick nets composited into a single sample. See Appendix C on where to collect BMIs when interrupted flow, side channels, or beaver ponds are present or when collecting partial data.

1. Use the last number from the time displayed on a digital face watch to randomly select the starting location at transect A.
   - 1 to 3 = Left (15% from the left wetted edge)
   - 4 to 6 = Center (50% from the left wetted edge)
   - 7 to 9 = Right (15% from the right wetted edge)
2. Sample at the randomly determined starting location.
3. Continue moving upstream, collecting just downstream of each transect. Alternate from left, to center, to right, depending on the randomly

selected starting location (e.g., if the starting location was at the center for transect A, the next collection would be at the right for transect B).

4. See the general collection and preservation methods in Section 6.3.

6.3 General Methods and Sample Preservation

Whenever possible, collect samples using a Surber sampler. Locations that are too deep to use the Surber sampler may be sampled with a kick net. If at any point during the sampling or washing process the sample is compromised (e.g., dolphin bucket falls off, sample is spilled while cleaning, etc.), the sample will need to be discarded and retaken.

Follow these methods when using a Surber sampler:

1. Place the Surber sampler at the first randomly selected position so the mouth of the net is facing upstream.
   a. If the stream is only one net wide at a transect, place the net across the entire stream width, and consider the sampling point to be "Center," if using the reachwide method.
   b. If the stream lacks a sufficient amount of flow to move the water through the Surber sampler, the water may need to be manually scooped into the net.
   c. If a sampling point is located in water that is too deep or unsafe to wade, randomly select an alternate sampling location.
2. Carefully scrub all stones contained within the frame of the Surber sampler, focusing on cracks and crevices of large stones that are stuck to the bottom of the stream.
3. After removing all large stones, disturb small substrates (e.g., sand, gravel) to a depth of about 5 cm, if possible, by raking and stirring with hands or scrub brush.
4. After the area contained within the sample frame has been thoroughly cleaned, lift the net straight up off the streambed to ensure that all materials are retained within the net.
5. Repeat steps 1-4 for the remaining sample locations. If the dolphin bucket is full midway through the reach, empty contents into wash tub, bucket, or tray and continue.
6. Once sample collection is complete, rinse the net thoroughly into a wash tub, bucket, or tray with the squirt bottle, making sure to get all organic matter and any BMIs clinging to the net.

7. Move contents into the 500 μm sieve, and rinse thoroughly to remove fine sediment. During this process, all organic and inorganic materials should be retained and placed into sample jars unless thoroughly washed. Algae cannot be throughly washed, for example, and should be retained in the sample jar.
8. Spoon or spatula the sample into sample jars, being careful to only fill jars halfway. Fill the remainder of the jar with 95% ethanol to preserve the sample.
9. Fill out a BMI label for the inside and outside of all the jars. Include the stream name, site code, date, and number of jars (e.g., 1/5, 2/5, etc.). Make sure to use the full site code and the date (e.g., XE-SS-4120, 06May2014). Place clear packing tape over the outside label to protect against spilled ethanol.
10. Tighten the lid of the sample jar, and secure it in place with electrical tape wrapped clockwise around the jar and lid.
11. Record the number of jars, number of transects, area sampled, and type of sampler used.
12. Store jars upright.
13. Before leaving the site, thoroughly rinse and clean the Surber net, dolphin bucket, and sieve in order to prevent contamination of future samples. Do not re-attach the dolphin bucket to the Surber net until all gravel and sand have been removed from the threads.

Use a kick net to sample transects that are too deep to sample with a Surber sampler. Follow these steps to collect a kick net sample:

1. Hold the net firmly on the bottom of the stream so that the mouth of the net is facing upstream.
2. Stand upstream of the net, and use your feet to disturb the sediment in an area roughly 30 x 30 cm.
3. After the area has been thoroughly disturbed by foot, remove the net from the water, pulling it straight up so that any invertebrates and debris move downward in the net.
4. Repeat steps 1-3 at all transects requiring a kick net.
5. After all transects have been sampled, empty the net contents into the sieve as described in the Surber sampler steps.
6. If both a Surber sampler and kick net were used, combine the samples into one sample. Provide comments on the number of transects in which the kick net was used. Only record "kick net" as the sampling method if it was used at > 50% of transects.
7. Before leaving the site, thoroughly rinse and clean the kick net and sieve in order to prevent contamination of future samples.

7. Physical Habitat (PHAB) and Canopy Cover

Overview: The core PHAB methods covered in this section include measurements of: floodplain connectivity (bankfull and floodplain height), bank stability and cover, streambed particle sizes, large woody debris, and pool dimensions. The contingent methods include measurements of bank angle and thalweg depth profile, and the covariates include bankfull width, wetted width, flood-prone width, and slope. Canopy cover is also included in this section. The measurement locations are outlined in Table 2. See Appendix C on where to collect PHAB and canopy cover data when interrupted flow, side channels, or beaver ponds are present or when collecting partial data.

Example work flow (see Appendix F for a suggested work flow of all measurements): After collecting water quality and benthic macroinvertebrates, the purpose of the second pass through the reach is to collect PHAB and canopy cover data at all 21 transects and between each transect.

1. Start at transect A. One technician measures select PHAB indicators, while the second technician records data. If not already complete, the recorder can also conduct visual estimates of riparian vegetation, human influences (covariate), and instream habitat complexity (fish cover) (contingent) during this time.
2. Measure bankfull width (covariate), wetted width (covariate), and mid-channel bar width (if present).
3. Examine floodplain connectivity (on the lower of two banks, first) by measuring:
    a. Bankfull height
    b. Floodplain height
4. On the same bank, measure:
    a. Bank stability and cover
    b. Bank angle (contingent)
    c. Canopy cover
5. Moving across the stream, measure streambed particle sizes.
6. Repeat steps 3 and 4 on the opposite bank.
7. Before continuing to the next transect, return to the middle of the stream and measure canopy cover.
8. Move upstream measuring the thalweg depth profile (contingent) to

the intermediate transect between transects A and B. The data recorder should also tally large woody debris while moving up the stream.

9. At the intermediate transect, measure:
    a. Wetted width (covariate)
    b. Bank stability and cover
    c. Streambed particle sizes
10. Continue working upstream, measuring the thalweg depth profile (contingent) until you arrive at transect B. Make sure to finish the large woody debris tally.
11. Repeat steps 1-10 until all transects have been completed.

When all transect-based measurements have been completed, walk a third pass through the reach to delineate and measure pool dimensions and flood-prone width. Measure slope (covariate) during the fourth pass along the reach.

7.1 Channel Widths

Overview: Measure the bankfull width along each main transect and the wetted width along each main and intermediate transect.

7.1.1 Wetted Width —

Overview: Measure the width of the wetted channel at all main and intermediate transects. See Appendix C for guidance on measuring wetted width at dry transects.

Methods:
1. Measure wetted width in meters rounded to the nearest 0.01 m using a tape measure, depth rod, or laser range finder (for large streams only).
2. Include the width of any mid-channel bars in the wetted width measurement (but not ***islands***), and exclude disconnected backwaters.
3. For channels with undercut banks, wetted width is measured as aerial width and does not include water under the banks that cannot be viewed when looking down on the stream. This refers to undercut banks only and not vegetation.
4. Measure and record the width of any mid-channel bars.

7.1.2 Bankfull Width —

Overview: Measure the width between the bankfull elevation on one side of the channel to the bankfull elevation on the opposite side of the channel. Measurements should be taken perpendicular to the thalweg at all 11 main transects. See Appendix C for guidance on measuring bankfull at beaver-impacted reaches and Appendix D for examples of bankfull locations.

Methods:

1. Identify bankfull using the indicators described in the critical concepts in Section 2.2.1.
2. Using a tape measure, depth rod, or laser range finder, measure from bankfull on the left bank to bankfull on the right bank.
3. Record the measurement in meters rounded to the nearest 0.01 m.

7.2 Floodplain Connectivity

Overview: Floodplain connectivity is derived from measurements of bankfull height and floodplain height taken at each of the 11 main transects. Accurate measurements of floodplain connectivity depend on the proper identification of bankfull and floodplain height.

7.2.1 Bankfull Height —

Overview: Identify the vertical distance (height) from the observed water surface up to the bankfull elevation on one side of the channel (Figure 4). See Appendix C for guidance on measuring bankfull height at dry transects and Appendix D for photos illustrating bankfull height.

Methods:

1. Identify bankfull using the indicators described in the critical concepts in Section 2.2.1.
2. Using two depth rods, place the metal end of depth rod A so that it is touching the bankfull elevation.
3. Keeping the metal end in place, lower depth rod A so that it is parallel to the water surface and level (as indicted by the bubble level on the end of the depth rod).
4. Hold depth rod B so that it is touching, and perpendicular to, depth rod A with the metal end pointing down (Figure 4).
5. Lower the metal end of depth rod B vertically until it reaches the water's surface.

6. Measure the height in cm where depth rod A (the horizontal rod) crosses depth rod B (the vertical rod) to the nearest 1 cm. The measurement is taken from the bottom of the horizontal depth rod.

Figure 4. Example of how to use two depth rods to measure bankfull or floodplain height.

7.2.2 Floodplain Height —

Overview: Measure the vertical distance (height) from the water surface to the elevation of the first flat depositional surface at or above bankfull (Figure 5). See Appendix C for guidance on measuring floodplain height at dry transects or on side channels and Appendix D for photos illustrating floodplain height.

Guidance for locating and measuring floodplain height:

- Examine both left and right banks, and attempt to identify the first flat depositional surface at or above the bankfull elevation (Figure 5). This feature is either an active floodplain or an abandoned floodplain (i.e., terrace). To count as a floodplain, the geomorphic surface must have formed from fluvial processes (i.e., sediment deposited by the stream or river) and can either be an active or an abandoned floodplain. Active or abandoned floodplains may be present on one or both sides of the stream or may be completely absent (see Appendix D for photos).

- If the only flat depositional feature present is the surface associated with bankfull (e.g., some spring-fed systems) or if there is no flat depositional feature present at all (e.g., a V-shaped valley or gorge), bankfull height and floodplain height will be the same.
- The floodplain can either be an active floodplain or an old inactive or abandoned floodplain.
- If the height of the floodplain differs between left and right banks at the transect, measure the lower of the two surfaces. Note that floodplain height cannot be lower than bankfull height.
- The top of a ***cut bank*** against a steep hillside should not be considered a depositional surface and, therefore, should not be used to measure floodplain height.
- Be careful not to mistake a flatter area of a hillside for a fluvial depositional feature (e.g., cattle or hiking trail).
- A floodplain does not need to be consistent throughout the reach. For example, some systems may have a floodplain in certain areas and in other areas there will be no floodplain present.

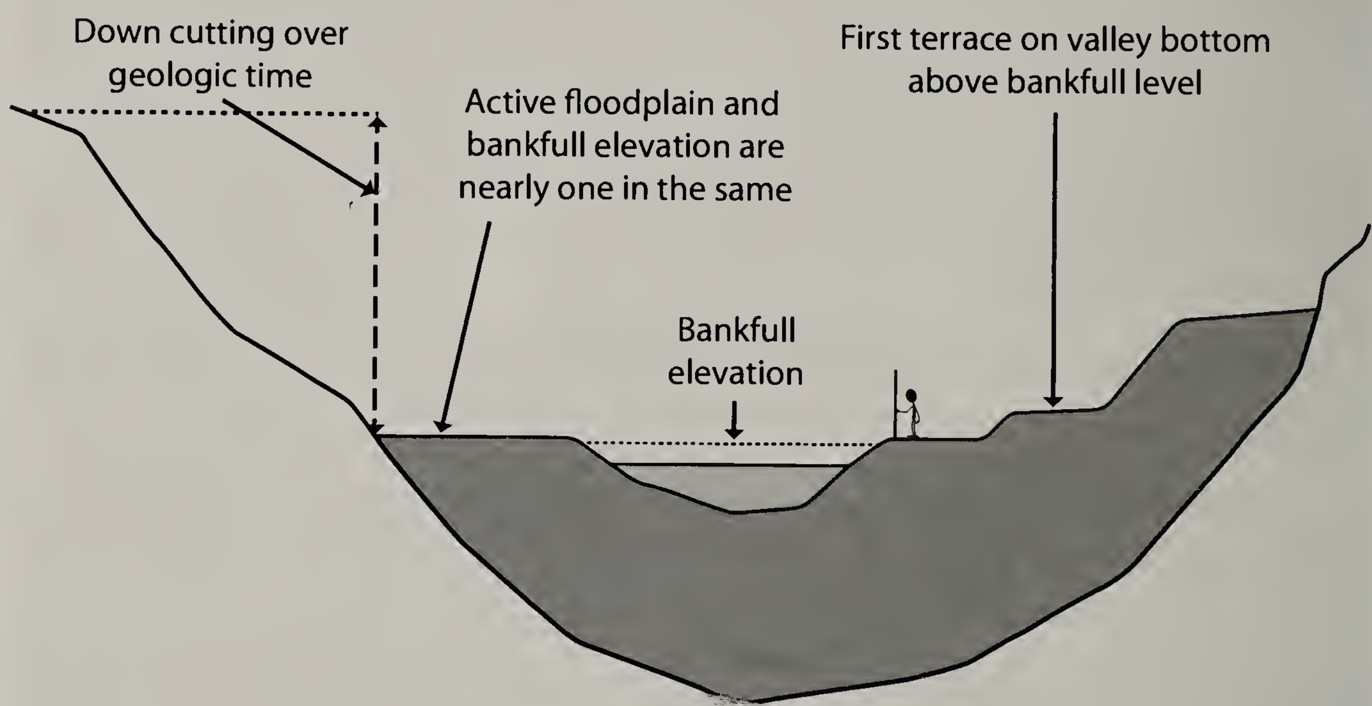
Methods:

1. Place the metal end of depth rod A so that it is touching the flat depositional surface at or above bankfull (i.e., floodplain).
2. Keeping the metal end in place, lower depth rod A towards the water surface until the rod is level (as indicated by the bubble level on the end of the depth rod).
3. Place depth rod B vertical on the water's surface.
4. Measure the height to the nearest 1 cm where the horizontal rod crosses the vertical rod, taking the measurement from the bottom of the horizontal depth rod (Figure 4).
5. If the floodplain is too far from the water and requires multiple measurements:
    a. "Leap frog" the rods by taking rod B and lowering it towards the ground until level (being careful not to move it from its previous position).
    b. Take rod A and hold it horizontal next to the vertical rod, and measure the height.

c. Repeat this until the surface of the water is reached, and then add all the measurements to get floodplain height.

d. Alternatively, floodplain height can be measured with an auto level or laser range finder, as long as measurement precision is equal to or less than 0.1 m.

A. Channel Not Incised



B. Incised Channel

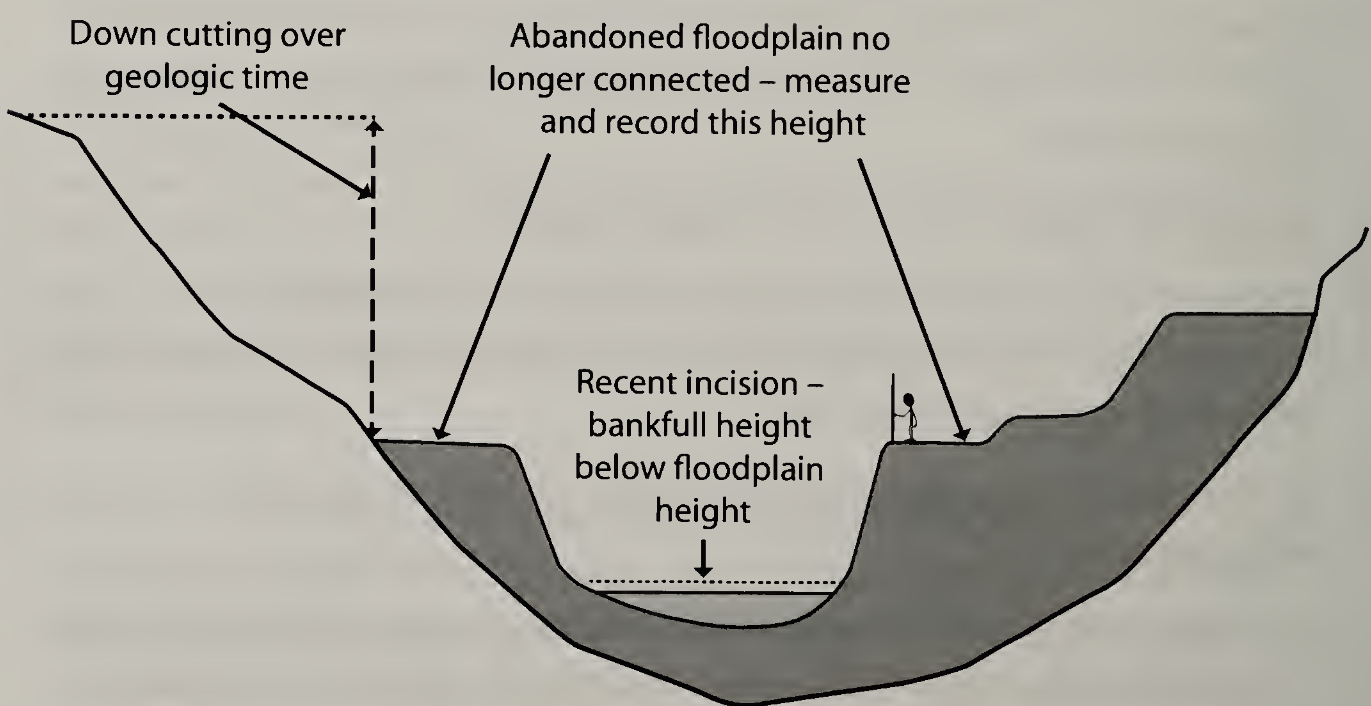


Figure 5. (A) An unincised channel where the height of the active floodplain is similar to the bankfull height. (B) An incised channel where the elevation of the floodplain is above bankfull height. (C) Determining bankfull and floodplain heights for streams in V-shaped valleys (USEPA 2009). If bankfull geomorphic indicators are absent, evidence of recent flooding can be used as a substitute for identifying bankfull elevation.

C. Small Stream Constrained in V-Shaped Valley

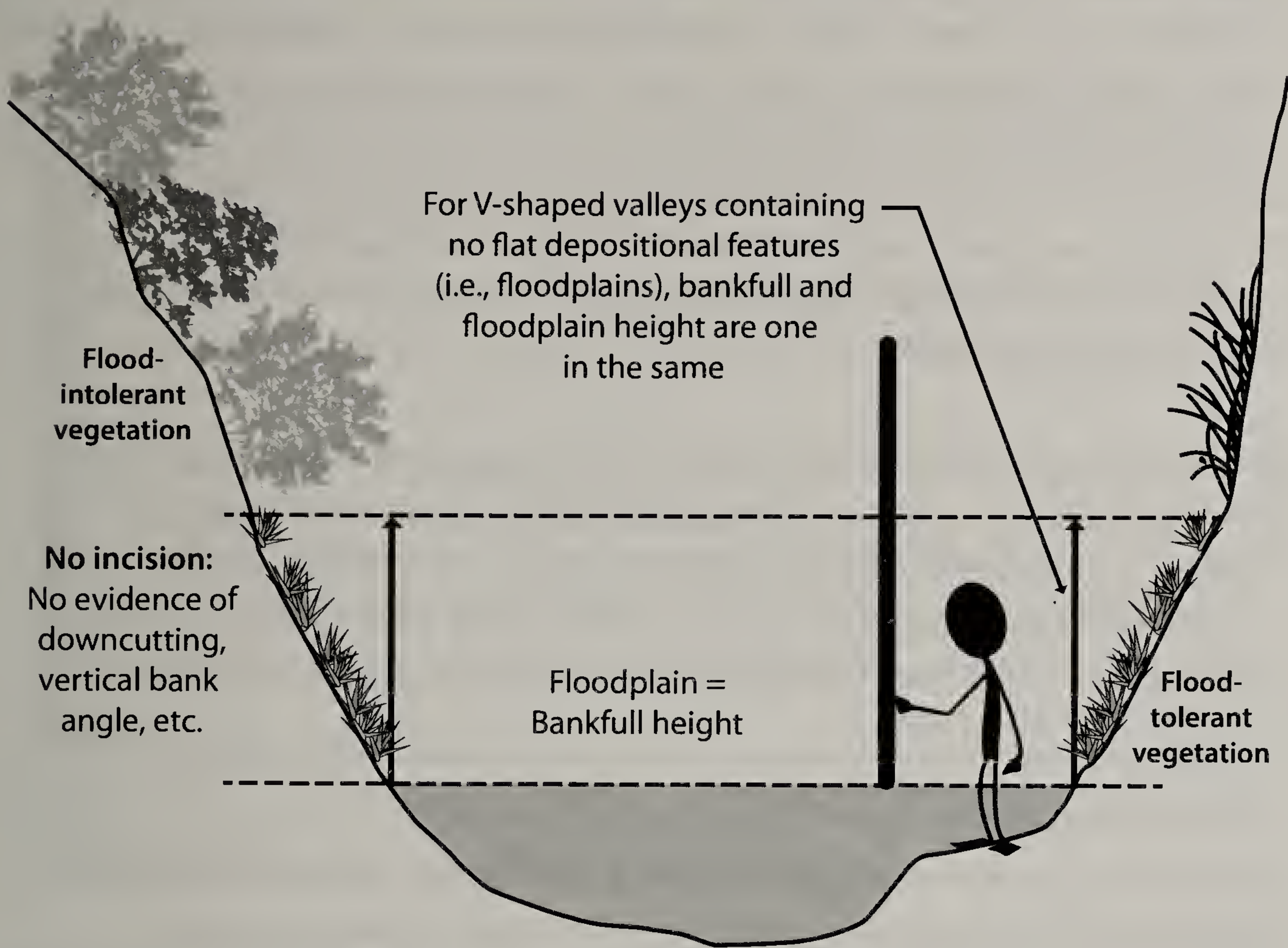


Figure 5 continued.

7.3 Bank Stability and Cover

Overview: Determine if the transect and associated bank stability and cover plot is in an erosional or depositional area, and evaluate bank stability and cover. These indicators are measured at a minimum of all 11 main and 10 intermediate transects on the left and right banks.

The bank stability and cover plot area is defined as follows:

1. The plot extends up the bank from the scour line to the lip of the first flat depositional feature at or above bankfull.
2. The plot extends parallel to the stream 25 cm up- and downstream of the transect flag (50 cm wide total). Plot width can be delineated with a depth rod.

Guidance for identifying erosional and depositional areas:
Determine if the bank stability and cover plot is located on a depositional or erosional bank. See Figures 7-11 for photographic examples.

Depositional (D) streambanks are associated with sand, silt, clay, or gravel deposited by the stream. These are recognizable as bars in the channel margins at or above the scour line. Stream bars are typically lenticular-shaped mounds of deposition on the bed of the stream channel adjacent to or on the streambank. For a bank and associated plot to be classified as depositional, the deposition needs to extend above the scour line. Depositional streambanks are usually at a low angle from the water surface and are not associated with a bench.

Erosional (E) streambanks are all banks that are not depositional. Erosional streambanks are normally at a steep angle to the water surface and are usually associated with a bench and/or terrace. Such banks typically occur on the outside of meander bends and on both sides of the stream in straight reaches. When there is sufficient stream energy, they may also occur on the inside bank of a meander.

7.3.1 Bank Cover —

Estimate and record the absolute cover of each of the following categories within the plot to the nearest 10% (values for cover classes are added together after the fact to make "covered" or "uncovered" designations following the 50% criteria specified in multiple indicator monitoring (Burton et al. 2011)).

- Perennial vegetation (including roots that are holding the soil in place). Note moss does not count as cover.
- Cobbles that are 15 cm or larger.
- Bedrock.
- Anchored large woody debris with a diameter > 10 cm.

7.3.2 Bank Stability —

Examine the same plot used to evaluate bank cover, and determine if the plot contains any obvious erosional features (subsequently described) that span at least 1/4 (13 cm) of the plot width. If multiple erosional features are present, record the single most prominent feature.

MORE Stable

Absent (A): None of the erosional features subsequently described are present.

Fracture (F): An obvious crack on the top of a bank that has not yet separated from the bank and resulted in downward displacement of the detached block (Figure 6).

Slump (S): A portion of a streambank that has obviously slipped down resulting in a block of soil/sod that is completely separated from the bank (Figures 6 and 7).

Slough (SL): Generally disaggregated soil (loose and not bound together in clumps) or sod material that has been shed or cast from the bank and usually accumulates near the base of the bank. Sloughing typically occurs on banks that are less than vertical and void of herbaceous or grassy vegetation (Figures 7, 9, 10, and 11).

Eroding (E): Banks that are bare and nearly vertical (between 80 and 90 degrees). Eroding banks are usually located on the outside curves of meander bends in the stream (Figure 11).

LESS Stable

Note: Undercut banks are not considered "eroding" banks even if they are scoured or eroded below the elevation of the base of sod or the roots of vegetation. This is because such erosion occurs mostly below the scour line which is outside the plot frame. Such undercut banks are stable as long as there is no slough, slump, fracture, and/or erosion above the scour line or ceiling of the undercut bank.

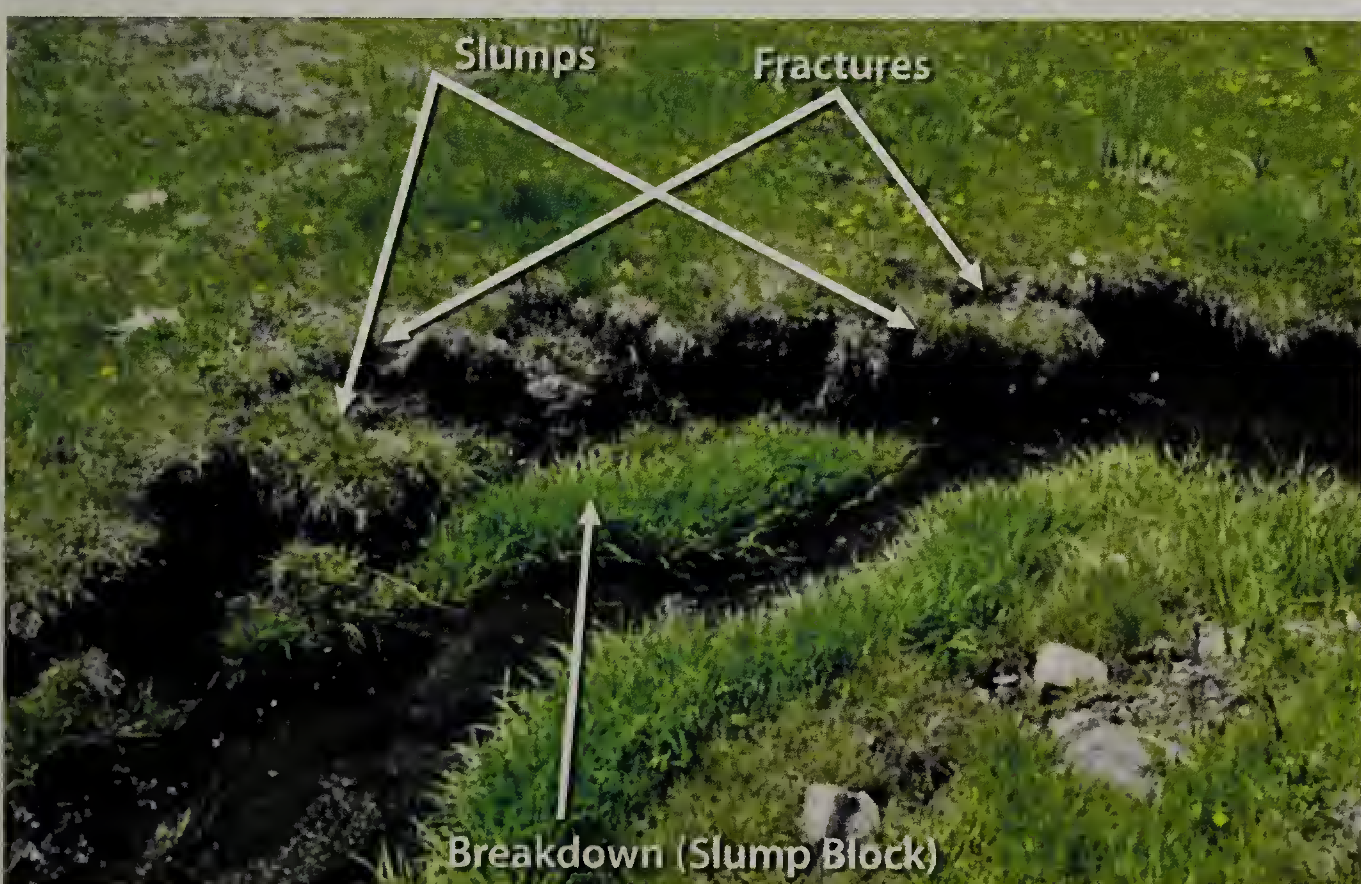


Figure 6. Slump blocks that are detached from the streambank and isolated to the channel are not considered part of the streambank. Slumps must be obviously sliding down but still attached as part of the streambank. Fractures must be obvious at the top of the bank or on the bench (Burton et al. 2011).

Figure 7. Four different conditions are shown in this picture. The left side is an outside bend that is erosional (E) with a slough (SL), which grades into a slump (S). To the right of the slump is a streambank that slumped in the past but reattached and is now erosional (E) and absent (A). The right streambank is a point bar that is depositional (D) (Burton et al. 2011).

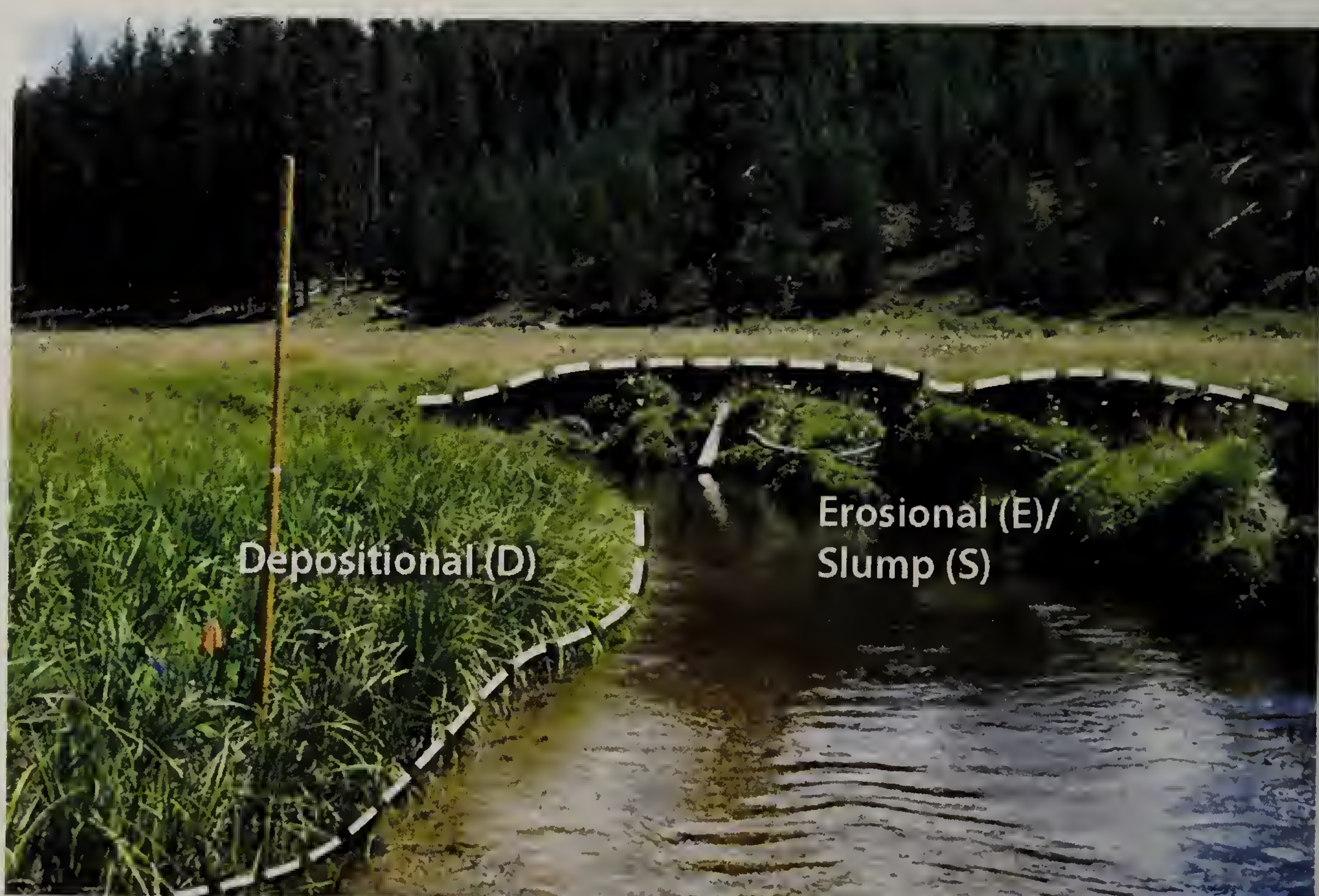


Figure 8. Two different conditions are shown at this location. The far bank shows an outside bend that is erosional (E) and contains several slump (S) blocks. The closer streambank shows a point bar that is depositional (D) (Burton et al. 2011).

Figure 9. The streambank is erosional (E). It has a bank angle of more than 10 degrees from vertical with no bench to capture the sediment, and thus the sediment enters directly into the stream as slough (SL) (Burton et al. 2011).

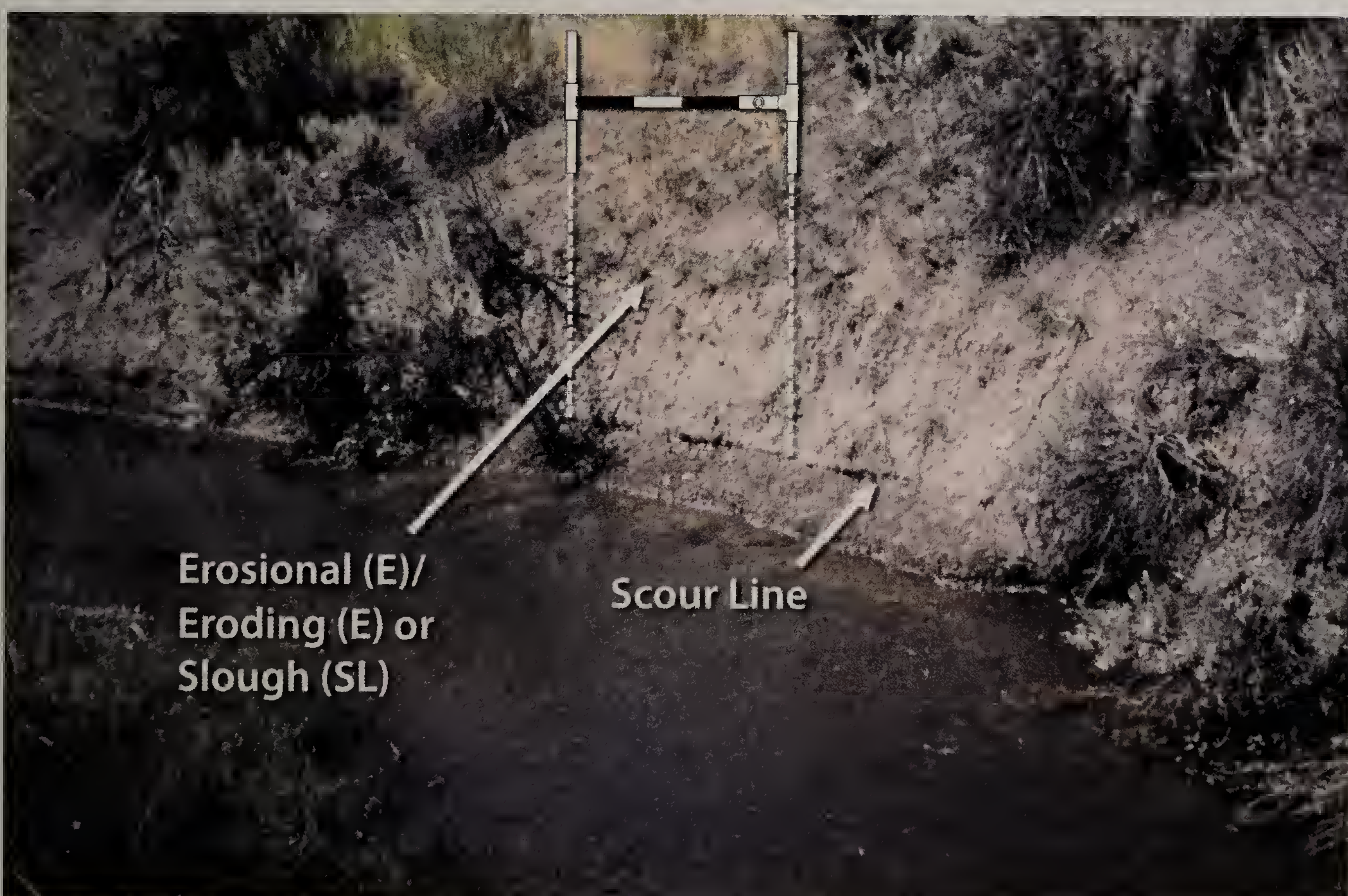


Figure 10. The streambank has an obvious scour line. The bank evaluated is above the scour line to the first bench and is recorded as erosional (E) and slough (SL) or erosional if the bank angle is within 10 degrees of vertical (Burton et al. 2011).

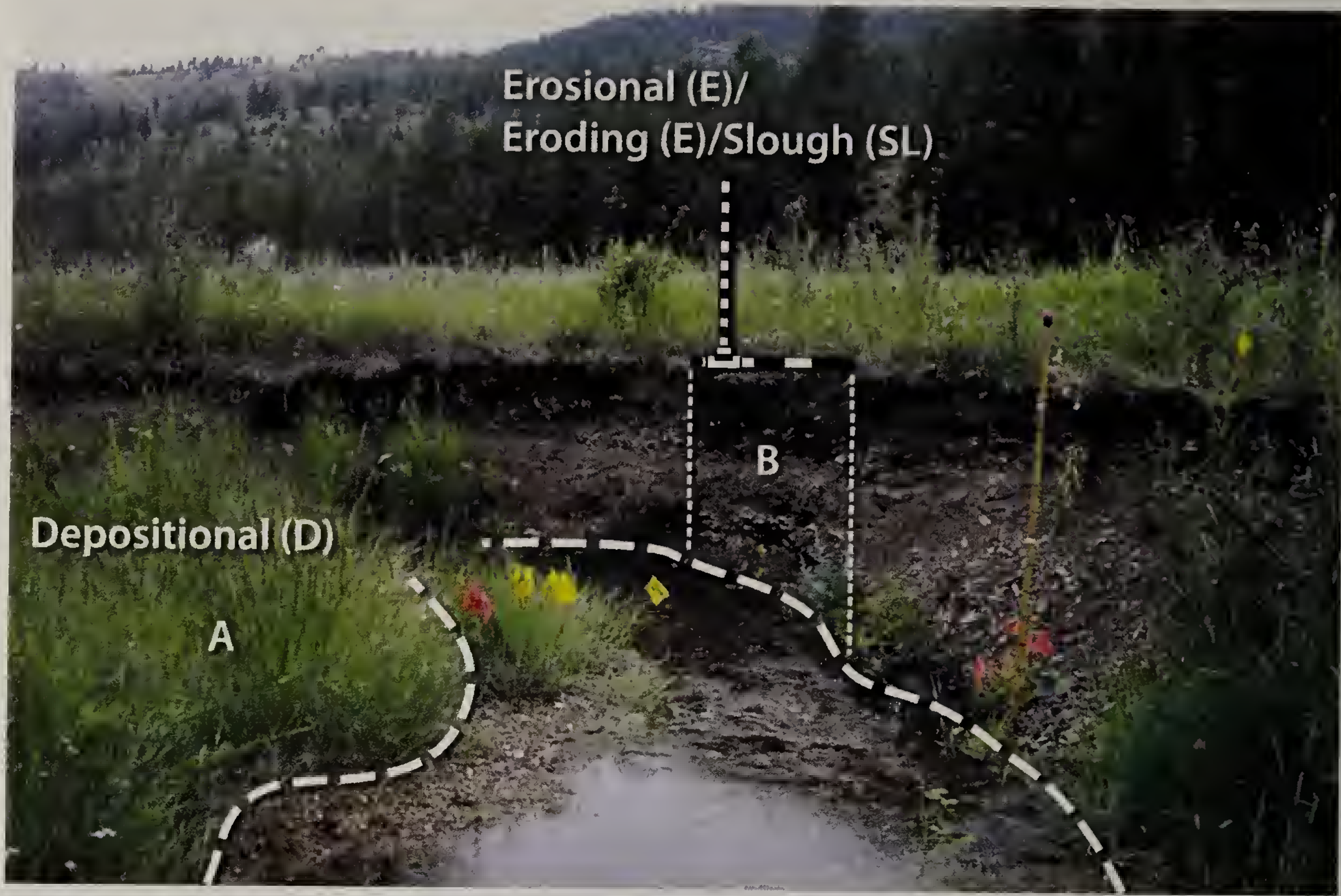


Figure 11. The thicker dotted line represents the scour line. "A" is a point bar; thus it is depositional (D). "B" shows the length of streambank evaluated. The streambank evaluated is erosional (E) and eroding (E) or slough (SL) (Burton et al. 2011).

7.4 Canopy Cover

Overview: Measure the amount of vegetation or other features shading the stream with a modified densiometer at all 11 main transects. At each transect, a total of six measurements are taken: one at each bank and four in the center of the wetted channel. See Appendix C for guidance on measuring canopy cover at dry transects.

Methods:

1. Face the bank, and stand such that you can hold the densiometer at the scour line.
2. Hold the densiometer 0.3 m (30 cm) above the water's surface at the location of the scour line with the mirror surface facing up. Or, hold the densiometer 0.3 m (30 cm) above the dry scour line if water does not extend to the scour line. Level the densiometer, and position yourself to look down on the densiometer, such that the top of your head is just barely visible at the apex of the taped "V" (Figure 12).
3. Count and record the number of grid intersection points within the "V" (0-17) that are covered by any form of vegetation or any object that creates shade such as a canyon wall or bridge.
4. Move to the center of the wetted channel and face upstream. Repeat steps 2-3 with the height of the densiometer 0.3 m (30 cm) above the water's surface.

5. Rotate your body a quarter turn, and repeat steps 2-3. Repeat two more times so that you end up with four total measurements at the center of the wetted channel: center up, center right, center down, and center left.

6. Move to the other bank, and repeat steps 2-3.

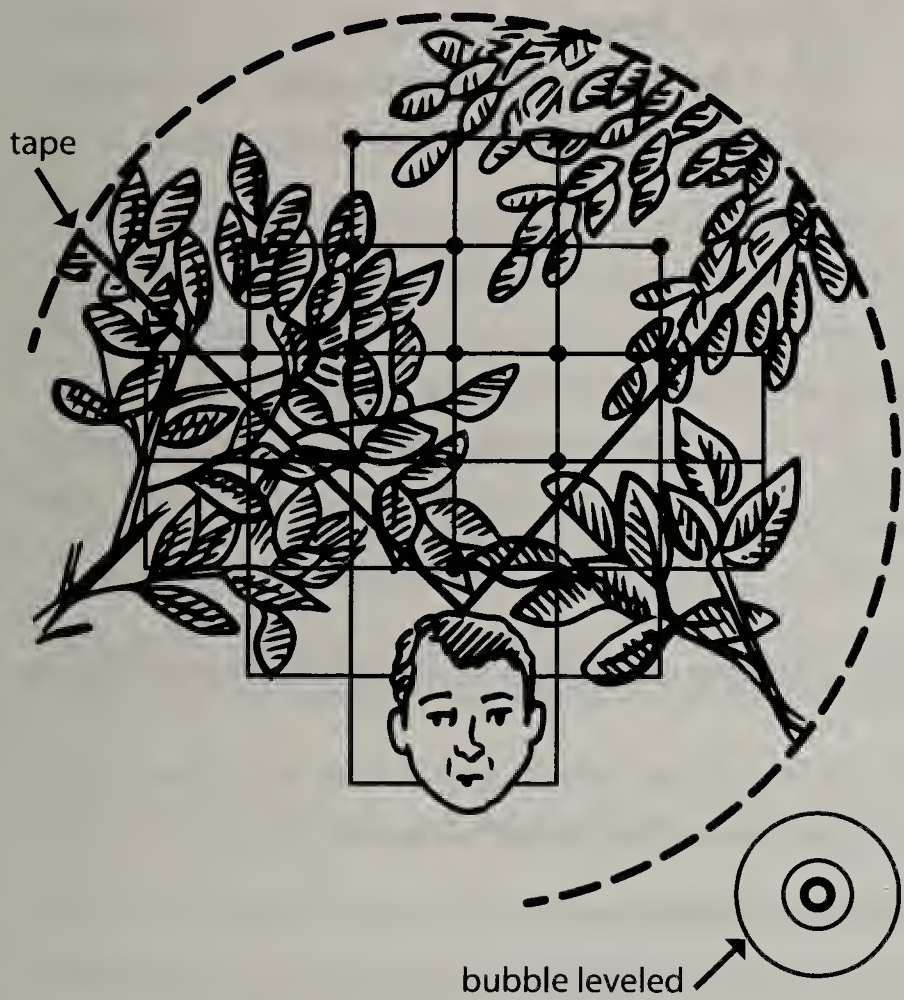


Figure 12. Modified densiometer. Count intersections in the V covered by vegetation or other objects. In this example, the score would be recorded as 10 (USEPA 2009).

7.5 Streambed Particle Sizes

Overview: Streambed particle sizes are measured at 10 points on each main and intermediate transect: at 5%, 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85%, and 95% from the scour line on one side of the stream to the scour line on the opposite side of the stream. See Appendix C for guidance on measuring pebbles at dry transects.

Methods:

1. Identify the streambed by delineating the scour line on both sides of the channel (Section 2.2.2).

2. Start on one side of the stream at the scour line, regardless of whether this location is wetted or not. Without looking, select a substrate particle located roughly 5% across the width of the bed.

3. Measure and record the intermediate axis (B axis) of the particle (Figure 13) in millimeters.

4. If the particle is smaller than 2 mm, classify it as either fines (silt and clay) or sand. Fines will feel smooth to the touch when rubbed in your palm, and sand will be gritty.

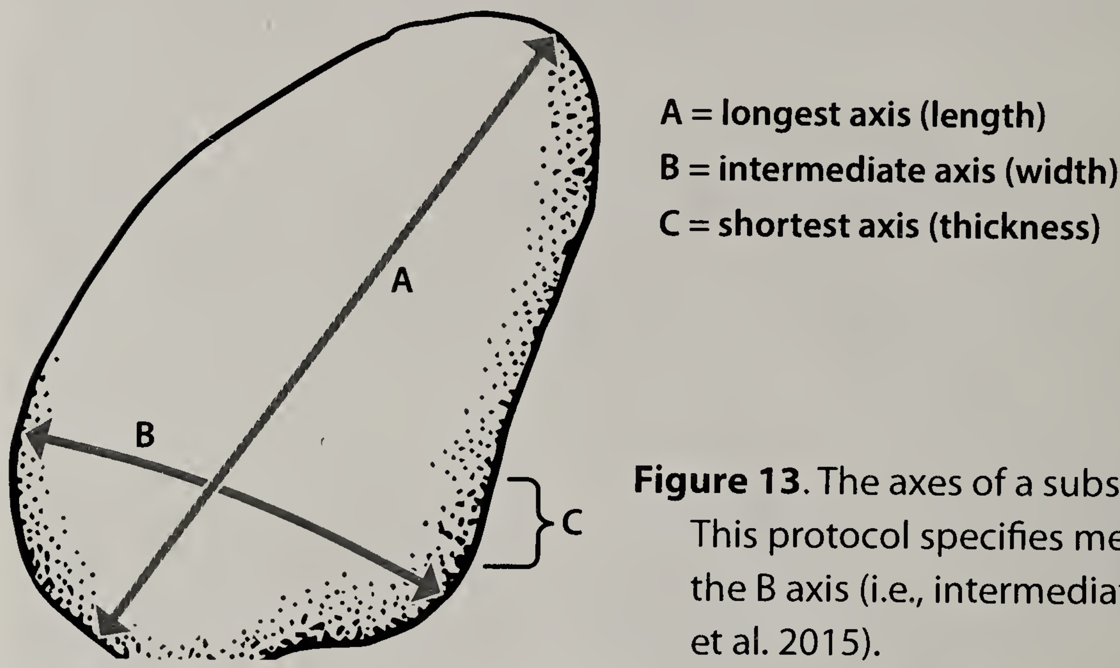


Figure 13. The axes of a substrate particle. This protocol specifies measurement of the B axis (i.e., intermediate axis) (Archer et al. 2015).

5. Record whether the particle was selected from one of the following locations:
   - Wetted streambed.
   - Dry in the middle of the streambed (e.g., mid-channel bar).
   - Dry from the edge of the streambed.
6. Move an additional 10% across the streambed, and repeat steps 2-5 until you sample the remaining nine locations on the transect. Note that large substrate particles may not be counted more than once. If the same particle is encountered multiple times along the transect (e.g., a large boulder), move up- or downstream the distance required to avoid measuring the same particle twice.
7. If you reach the last streambed measurement and have measured fewer than five particles from the combined wetted channel (i.e., from wetted edge to wetted edge, including dry particles in the middle of the channel):
   - Move up- or downstream from the original transect (0.5 m should be adequate in most situations to avoid measuring any of the same particles twice), and take measurements at equal intervals across the wetted channel to obtain the remaining number of particles.
   - Record the distance across the transect that additional particles were measured (e.g., 20%, 50%, and 80%).

Additional rules for selecting and measuring particles include:

- Avoid looking down when selecting substrate particles to minimize bias toward small or large particles.
- If a particle cannot be picked up because the water is too deep or if the particle is too large or "cemented" into the streambed, identify the B axis of the particle based on the portion of the particle you can see or feel, and measure as best you can using the depth rod or a measureable portion of your body (e.g., finger or foot). Flag such measurements as "estimated."
- If the substrate is covered by macrophytes, algae, etc., sample the inorganic or mineral substrate below the growth. Alternatively, if the substrate is organic matter and no mineral substrate exists below, select an alternative particle for measurement or flag as not collected and make a comment if no alternative particles are present.
- If a substrate particle is covered with enough fine sediment or sand to "pinch" between your fingers, record the particle as either fines or sand. If a substrate particle is covered with fine sediment or sand but not enough to be "pinched," measure the particle below the fines or sand.
- Depositional features (e.g., ***point bars***) can be located above or below the scour line. Only measure particles located below the scour line.
- If the substrate is bedrock or ***hardpan***, record as such. Note that boulders larger than 4 m along the B axis are considered bedrock.
- Partially wetted particles (i.e., those that extend above the water's surface) should be considered as "wet." This is especially common with larger particles including boulders.

7.6 Large Woody Debris (LWD)

Overview: Count the number of large woody debris pieces throughout the main channel of the sample reach.

Large woody debris qualifications:

To qualify, each piece of LWD:

- Must be greater than 0.1 m (10 cm) in diameter for at least 1.5 m in length. If the diameter of the piece is less than 10 cm at any point, visually cut the log, and do not use this portion for length estimates.
- Must be at least partially within or bridging the main bankfull channel. Ignore any LWD located in side channels.
- If a root mass with many stems or a forked piece of wood is encountered, measure the qualifying stem or branch with the largest diameter.

- Can include dead vegetation and standing dead vegetation. Dead trees are defined as being devoid of needles or leaves or where all of the leaves or needles have turned brown.

Methods:

1. Starting at either the bottom or top of the reach, scan each stream segment between two transects for LWD. Identify whether pieces are above or below the bankfull channel.
2. Place each qualifying piece of LWD in the appropriate size category based on both the diameter at the large end and the length. Tally all the pieces of LWD for each size category and whether they were found: (1) entirely or partially below the bankfull elevation or (2) bridging above bankfull channel (Figure 14).
   a. LWD diameter size categories (large end):
      - 0.1 m to < 0.3 m
      - 0.3 m to < 0.6 m
      - 0.6 m to < 0.8 m
      - ≥ 0.8 m
   b. Length categories (considering the section of LWD where the diameter is greater than 0.1 m):
      - 1.5 m to < 3.0 m
      - 3 m to < 5 m
      - 5 m to < 15 m
      - ≥ 15 m

   Note: If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood of the same volume with a circular cross section.

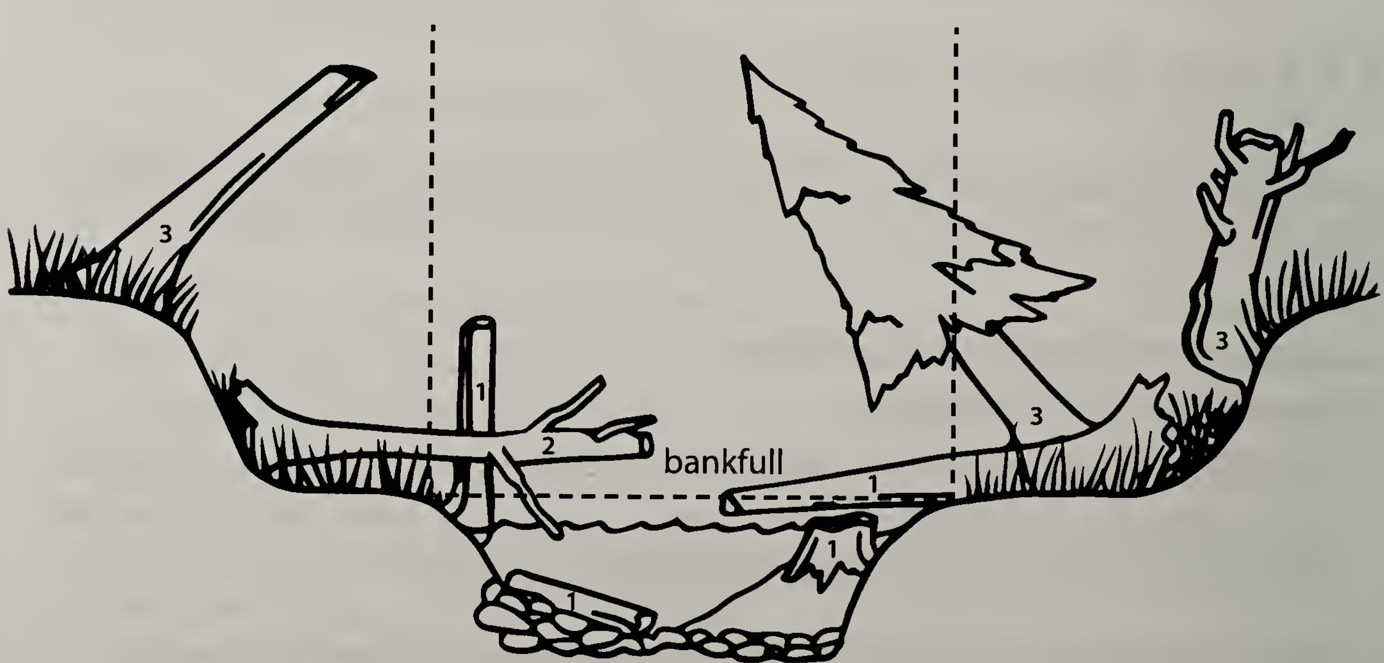


Figure. 14. Pieces of wood labeled with a 1 are within the bankfull channel; pieces labeled with a 2 are spanning the bankfull channel; and pieces labeled 3 are not counted (Archer et al. 2015).

3. Repeat steps 1-2 for the next stream segment between transects, ensuring that no pieces are double counted.

7.7 Pool Dimensions

Overview: Identify and measure the dimensions of qualifying pools throughout the reach. The dimensions measured are pool tail depth, maximum pool depth, and pool length. Do not delineate stagnant pools. See Appendix C for specific guidance on delineating pools in reaches with interrupted flow. Note pools are not delineated on side channels.

Pool qualifications:
A pool is defined as a depression in the streambed that is laterally and longitudinally concave (i.e., bowl shaped) and characterized by water that is slower and flatter than up- or downstream waters at baseflow. Pools are bound by a "head crest" (an upstream increase in streambed slope) and a "tail" (a downstream leveling of the streambed slope and reduction in depth) (Figure 15). The pool tail is the shallowest downstream location in the pool from which water would spill if the flow were reduced to a trickle.

This protocol distinguishes between qualifying and nonqualifying pools, and the dimensions of nonqualifying pools should not be measured. To qualify, the pool must meet the following six criteria:

1. The profile of the pool must be laterally and longitudinally concave.
2. The pool must span at least 50% of the wetted channel at any location within the pool.
3. The pool must have a maximum water depth that is at least 1.5 times the pool tail depth.
4. The pool must be contained within the main channel.
5. The thalweg must run through the pool.
6. The pool must be longer than it is wide, unless the pool is a plunge pool (i.e., formed when the thalweg drops vertically off an obstruction such as a boulder or log). To qualify as a plunge pool, the max pool depth must be within 20% of the total length of the pool from the obstruction (e.g., if the plunge pool is 10 m long, then the max depth must be within 2 m of the obstruction). Plunge pools are the only pools that can be wider than they are long.

Note: Side channel or backwater pools should not be considered. Also, long sections of stream that are laterally but not longitudinally concave and/or that do not possess the requisite bowl-like shape should not be considered pools. These features are commonly referred to as "runs."

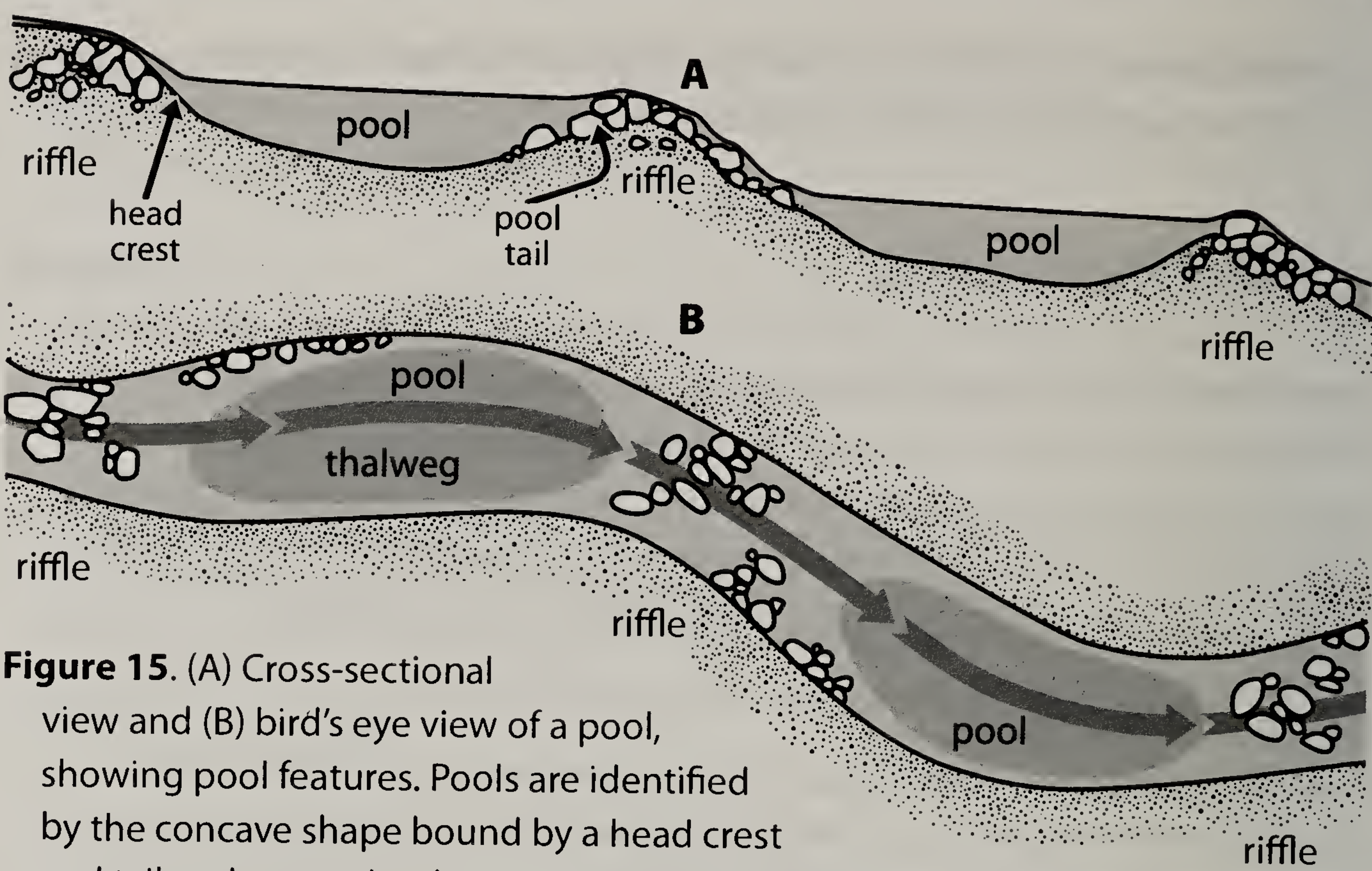


Figure 15. (A) Cross-sectional view and (B) bird's eye view of a pool, showing pool features. Pools are identified by the concave shape bound by a head crest and tail and a max depth more than 1.5 times the pool tail depth.

Methods:

1. Starting at transect A, walk upstream looking for a change in slope on the streambed that could indicate the presence of a pool.

2. When a potential pool is identified, determine if it has the required bowl-like shape and if it spans at least 50% of the wetted channel at any point. In the context of pool criterion, wetted width includes water extending beneath the undercut banks.

3. Find and measure the pool tail and maximum pool depths to the nearest 1 cm.

4. Determine if the pool qualifies by checking that the max pool depth is ≥ 1.5 times the pool tail depth. If the pool qualifies, record the pool tail and max pool depths, and determine if it is a full-channel or partial-channel pool.

   - **Full-channel pool**: The concave shape of the pool (measured perpendicular to the thalweg) at any location is > 90% of the wetted channel width.

   - **Partial-channel pool**: The concave shape of the pool (measured perpendicular to the thalweg) at any location is between 50% and 90% of the wetted channel width.

5. Measure and record the length of the pool (m) from the pool tail to the pool head crest, rounding to the nearest 0.01 m.

   a. If any portion of the pool is outside of the sampling reach, only measure the length of the pool that is contained within the reach. Such pools must still meet all pool qualifications. However, the pool tail or max depth point can fall outside the reach.

6. Record the length of the reach over which pools were delineated.

Methods for cases in which there appear to be two consecutive potential pools (Figure 16):
Group adjacent or closely spaced low points in the bed into a single pool if their depth at a theoretical zero discharge stage is controlled by the height of a single downstream pool tail. This can be assessed quantitatively by measuring the depth of questionable pool tails. For example, if the downstream pool tail is deeper than the questionable upstream pool tail, then two pools are present. Measure these two pools individually if all other pool qualifications are met for both pools. In contrast, if the downstream pool tail is shallower than all other questionable pool tails, only a single pool exists.

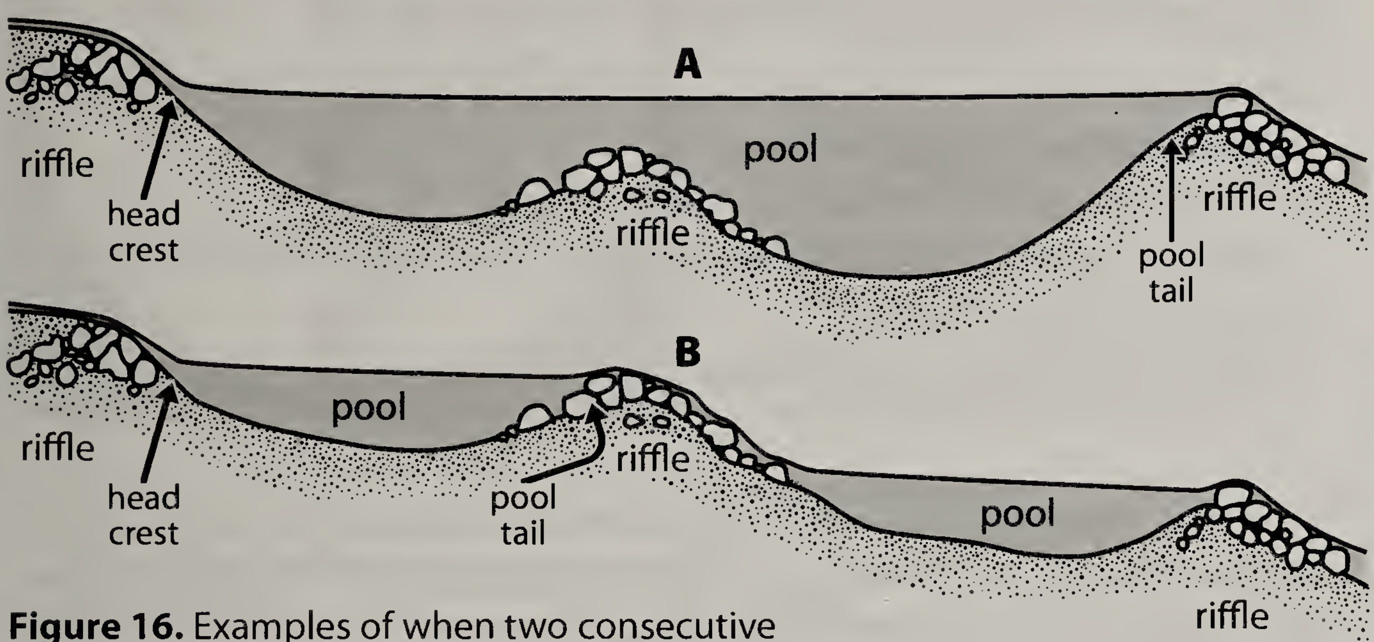


Figure 16. Examples of when two consecutive pools should be (A) lumped together because the pool is controlled by a single downstream pool tail that is shallower than the questionable upstream pool tail or (B) measured separately.

7.8 Flood-Prone Width (covariate)

Overview: Measure the width of the flood-prone area at riffles located nearest to transects A and K. The flood-prone area has the potential to be inundated with water in the event of a flood.

Methods:

1. Locate the riffle associated with transects A or K. If no riffle is present at the transect, use the closest riffle, up- or downstream, to the transects, while staying within the sample reach. If no riffles are present, take measurements within uniform, straight reaches closest to transects A or K.
2. Measure the maximum water depth along the transect.
3. Add the maximum water depth measurement to the bankfull height measurement (Section 7.2.1) to calculate the maximum bankfull depth.
4. Multiply the maximum bankfull depth by two to determine the height at which the flood-prone width should be measured (i.e., flood-prone height).

5. While one person holds a stadia or depth rod for reference, another person stretches the tape measure perpendicular to the valley at the height at which the flood-prone width should be measured.

6. Once the measuring tape is level and in contact with the ground on both sides of the stream channel, record the flood-prone width to the nearest 0.01 m (Figure 17). If the flood-prone width is greater than 3 times the bankfull width (Section 7.1.2), stop measuring and record the value as 3 x bankfull width. Note, it may be easier to measure flood-prone width from the center of the channel to the left bank and then from the center of the channel to the right bank and add the measurements together, rather than stretching the tape measure across the entire channel.

   Example:
   - Maximum water depth = 50 cm
   - Bankfull height (from water surface) = 65 cm
   - Measure flood-prone width at a height of 2 x (65 + 50) = 230 cm
   - Bankfull width = 1.05 m
   - Max recorded flood-prone width is 1.05 x 3 = 3.15 m

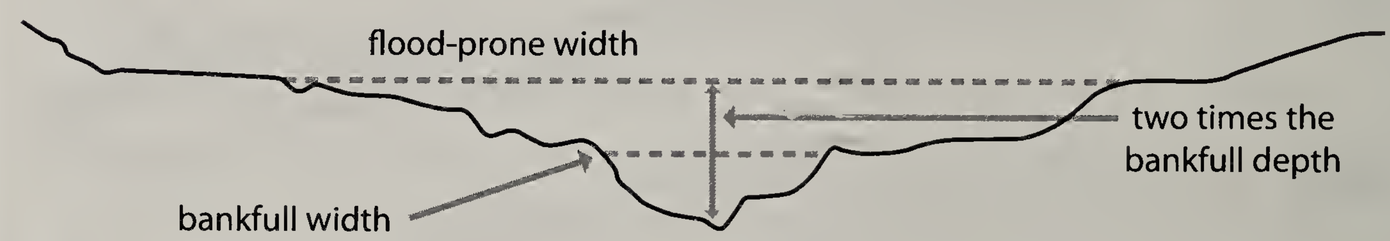


Figure 17. Location of the three measurements critical to determining flood-prone width: bankfull depth, bankfull width, and flood-prone height (Harman et al. 2012). Note that if the flood-prone width is greater than 3 times the bankfull width, stop measuring and record that value.

7.9 Slope (covariate)

Overview: Measure the change in elevation (slope) over the entire length of the sampled reach. See Appendix C for guidance on where to collect slope data for reaches with interrupted flow and when collecting partial data. Note slope is not taken on side channels.

7.9.1 Stadia Rod and Auto Level —

How to read a stadia rod:
Stadia rods are typically 5 m in length and usually alternate between black and red 1-m sections. Each 1-m section is broken up into 10-cm increments that are often identified by a large number on the right side and a line that stretches all the way across the stadia rod (Figure 18). Within each 10-cm section, individual centimeter increments are identified by color blocks or lines. In the case of blocks, the top and bottom of each block indicates a 1-cm increment.

Methods:
Slope requires two people to collect measurements. One person sets up the auto level and takes the measurements, and the other person holds the stadia rod. The procedure is repeated two or more times until there is less than a 10% difference between independent slope measurements.

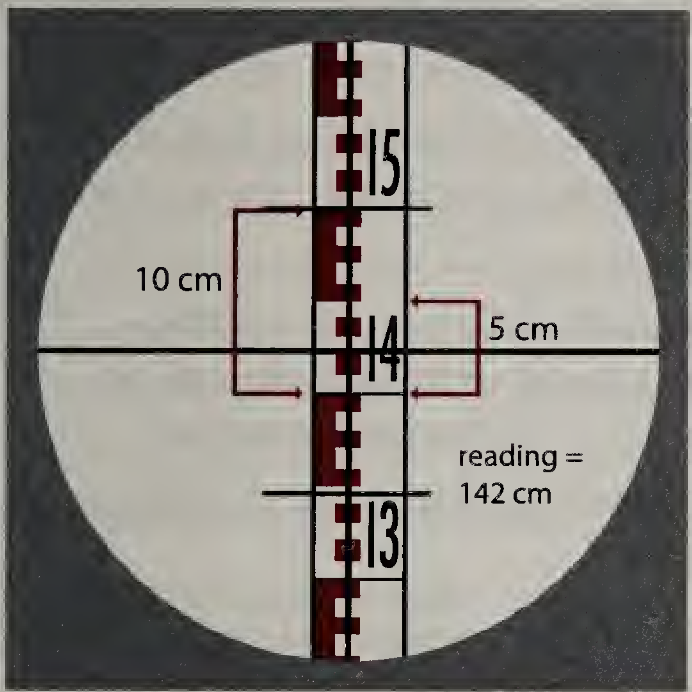


Figure 18. A stadia rod as viewed through the auto level. Stadia rods are broken up into 10-cm sections, denoted by the large number on the right. On this stadia rod, each cm is identified by alternating red and white blocks. The top and bottom of each block are equal to 1 cm. In this image, the measurement would be recorded as 142 cm.

Part A. Set up the tripod and auto level: The most challenging part of measuring slope is finding the best place to set up the tripod and auto level. Ideally, the tripod will only need to be set up and leveled once per pass, but this requires that the entire reach be visible from one location. In heavily vegetated reaches, the tripod may need to be moved multiple times.

1. Find a location that allows you to see the stadia rod from both the bottom and top of the reach when extended vertically.
2. Set up the tripod by extending the tripod legs and firmly setting them into the ground. Adjust the legs so that the tripod does not wobble.
3. Place the auto level on the base plate, and tighten the center screw.
4. Adjust the tripod legs until the bubble is approximately in the center of the level.
5. Adjust the foot or fine screws until the bubble is exactly in the center of the circle.
6. Gently swivel the instrument to make sure it is level in all planes.

Part B. Take measurements:
1. While the person holding the stadia rod stands at the bottom of the reach, the recorder sights the stadia rod through the auto level and records the height reading to the nearest 1 cm (Figure 18). Hold the stadia rod as vertical as possible with the bottom end at the water's surface and the numbers facing toward the auto level.

2. Move the stadia rod to the top of the reach (or the farthest location that can still be seen through the level), and gently swivel the level to face the new stadia rod location. Make sure the bubble stays inside the center of the level. If the bubble is not level, it is an indication that the base screw was not tight or the tripod legs were not stable, and you must start over.
3. Hold the stadia rod vertically, with the bottom end at the water's surface and the numbers facing toward the auto level.
4. Sight the stadia rod through the auto level, and record the height to the nearest 1 cm, being careful to record the number that intersects the center of the cross hairs.
5. If the top of the reach is not visible from the auto level, do not move the stadia rod after the second reading has been taken. Instead, hold the stadia rod in the exact position (this serves as a reference point connecting the next line of readings - back sight) while the recorder moves the auto level to a new location.
6. Move the auto level to a new location (and an unmeasured section) along the stream reach from which you can see the stadia rod. Set up the auto level as before, making sure to readjust the level.
7. Back sight (BS) to the stadia rod, and record the measurement. The stadia rod can now be moved.
8. Move the stadia rod as far up the reach as possible, while remaining within sight of the auto level. Take a new foresight (FS) reading.
9. Continue repeating steps 4-8 until the stadia rod is sighted at the top of the reach.
10. Once at the top of the reach, repeat steps 1-9, working from the top of the reach to the bottom of the reach to complete a second pass (i.e., to get a second measurement of the total change in slope throughout the reach). Note that at the beginning of the second pass, the auto level can remain in the same general location, but it must be picked up, set down, and releveled.
11. Calculate the total change in elevation for each pass and the percent difference between the two measurements. If the percent difference is greater than 10%, conduct additional passes, until you have two passes that are within 10% of each other.
    a. The total change in elevation from the bottom of the reach to the top of the reach = (Transect A - FS1) + (BS1 - FS2) + (BS2 - FS3) + (BS3 - Transect K), accounting for all shots.

b. The total change in elevation from the top of the reach to the bottom of the reach = (FS1 - Transect K) + (FS2 - BS1) + (FS3 - BS2) + (Transect A - BS3), accounting for all shots.

c. Elevation of pass (cm) x 0.1 = 10% of elevation (cm)

d. Add and subtract the calculated 10% (in cm) from the original elevation to get the acceptable range of values that the elevation of your second pass must fall within. For example:

- Total elevation for pass 1 = 100 cm
- 100 cm x 0.1 = 10 cm (10% of pass one)
- 100 cm + 10 cm = 110 cm (upper limit)
- 100 cm - 10 cm = 90 cm (lower limit)
- Thus, the elevation of pass 2 must be between 90 and 110 cm to be within 10% of pass 1.

12. Record the length of the reach over which slope was measured.

Tips for measuring slope:

- To avoid obstructions such as vegetation, set the tripod and auto level in as high a position on the landscape as possible, while still being able to read the stadia rod.
- Gently waving the rod around through vegetation can help the recorder see the rod through the level.
- Sometimes modest vegetation trimming is required.
- Sighting across land can be easier than trying to move up the stream channel. Remember the stadia rod only needs to be at the water surface for the bottom and top of the reach, but it can be placed anywhere (e.g., bank, upland) between these two locations.
- It is reasonable to have a negative slope for a section of the reach, as long as the total reach slope is positive.
- When working in regions that are prone to afternoon thundershowers, it is wise to collect slope data early in the day.

7.9.2 Alternative Slope Methods —

Overview: In some cases, such as very remote streams that require overnight trips, it can be too cumbersome to collect slope using the preferred method of a stadia rod, tripod, and auto level. In these cases, crews should measure slope with a stadia rod and hand level. Additional time is needed to complete slope measurements with this method.

How to use the hand level:
Look through the eyepiece of the hand level (with the clear window facing up). The field of view is split vertically; the left side has three horizontal black lines, and the right side contains a bubble used to level the device. To level the instrument, hold the hand level on top of a depth rod, and adjust the tilt until the bubble on the right side aligns with the center of the three black lines on the left side. Use both the eyepiece and the lens end telescope to focus while standing as close to the stadia rod as needed to accurately read the height on the stadia rod (this may be less than 10 meters).

Methods:

1. While the person holding the stadia rod stands at the bottom of the reach, the recorder sights the stadia rod through the hand level and records the number (to the nearest 1 cm) that aligns with the middle line in the hand level's field of view. Hold the stadia rod as vertical as possible with the bottom end at the water's surface and the numbers facing toward the recorder.
2. Move the stadia rod 10-12 m upstream of the recorder. Hold the stadia rod as before, vertically with the numbers facing the recorder.
3. Pivot the hand level to face the stadia rod. Relevel the hand level without moving the depth rod.
4. Sight the stadia rod through the hand level, and record the reading (to the nearest 1 cm).
5. Do not move the stadia rod after the second reading has been taken. Instead, hold the stadia rod in the exact position (this serves as a reference point connecting the next line of readings) while the recorder moves the hand level to a new location.
6. Move the hand level to a new location (and an unmeasured section) of the stream reach from which you can see the stadia rod. Set up the level as before.
7. Back sight to the stadia rod, and record the measurement. The stadia rod can now be moved.
8. Move the stadia rod 10-12 m up the reach while remaining within sight of the hand level. Take a new reading.
9. Continue repeating steps 4-8 until the stadia rod is sighted at the top of the reach.
10. Once at the top of the reach, repeat steps 1-9 working from the top of the reach to the bottom of the reach to complete a second pass (i.e., to get a second measurement of the total change in slope throughout the reach). Note that at the beginning of the second pass, the hand level and depth

rod can remain in the same general location, but the depth rod must be physically picked up and set down and the hand level must be releveled.

11. As with the auto level method, pass 1 and pass 2 elevations must be within 10%, or another pass will need to be completed until two passes are within 10%. See calculation details in step 11 from Part B of Section 7.9.1.
12. Record the length of the reach over which slope was measured.

Tips for measuring slope with a hand level:

- Avoid setting the depth rod on soft substrate where it may sink. If this is unavoidable, push the rod down into the mud or sand until it meets resistance, or set it on a sizeable flat rock before taking measurements.
- If you are having trouble reading the stadia rod, try shorter distances and/or ask the person holding the rod to move their finger to the reading on the stadia rod.

7.10 Bank Angle (contingent)

Overview: Measure the angle of both left and right banks at all 11 main transects. At each transect, bank angle is measured from where the bed-meets-bank (lower limit) to the first flat depositional surface at or above bankfull (upper limit). Many rules apply to measuring bank angle; make sure to thoroughly read Sections 7.10.1 and 7.10.2 before attempting to apply the bank angle protocol.

Methods:

1. Make sure that the dial on the compass is set so that the north arrow is in line with the 90° or 270° mark to ensure that the clinometer readings, measured using the compass, will be accurate.
2. Identify where to take the bank angle measurement by noting the locations of bed-meets-bank (Section 2.2.4), bankfull (Section 2.2.1), and scour line (Section 2.2.2).
3. Record whether the bank is obtuse or acute (Figure 19). For all transects with acute bank angles including undercuts, record the undercut as one of the following three categories:
   - Nonqualifying undercut: < 5 cm deep, < 10 cm high, or < 10 cm wide
   - Qualifying undercut: ≥ 5 cm deep, ≥ 10 cm high, and ≥ 10 cm wide
   - NA: ceiling above bankfull (this is also a nonqualifying undercut)
4. Determine the location to measure bank angle(s) and which angle(s) will be measured based on Sections 7.10.1 and 7.10.2.

5. Lay or hold the depth rod on the bank, in-line with transect flags, and perpendicular to the channel.
6. Place the thin edge of the compass on the upward facing side of the depth rod, so that it is oriented parallel to the rod.
7. Record the angle displayed on the compass to the nearest degree.

A. obtuse B. acute

Figure 19. The general shape of (A) obtuse and (B) acute banks.

7.10.1 Determining the Location to Measure Bank Angle —
The upper and lower limit of the bank angle measurement depends on whether the bank is depositional or erosional, the types of features the bank possesses, and the location of those features relative to the scour line and bankfull elevation. Adhere to the following specific rule sets to determine which angles should be measured, but in general, consider that:

- If there is no identifiable flat depositional surface at or above bankfull, the upper limit is 0.5 m above the local bankfull elevation.
- If depositional features, slump blocks, or embedded logs and rocks are present, the lower limit of the measurement may need to be adjusted.
- If an undercut bank is present, bank angle is measured using different criteria than nonundercut banks. Several rules govern how to measure the angle of undercut banks.

Banks with depositional features:
- Unvegetated depositional features, such as ***point bars***, are not considered part of the bank. The lower limit of measurement is where the top of the unvegetated depositional feature meets the streambank (Figure 20A).
- Use the point where the depositional feature becomes ≥ 50% vegetated with perennial species to define where the deposition ends and the bank begins.
- If the top elevation of the depositional feature is found at or above the first flat floodplain-like feature (Figure 20B), record the bank angle as not collected (flag code "N") and make a comment.

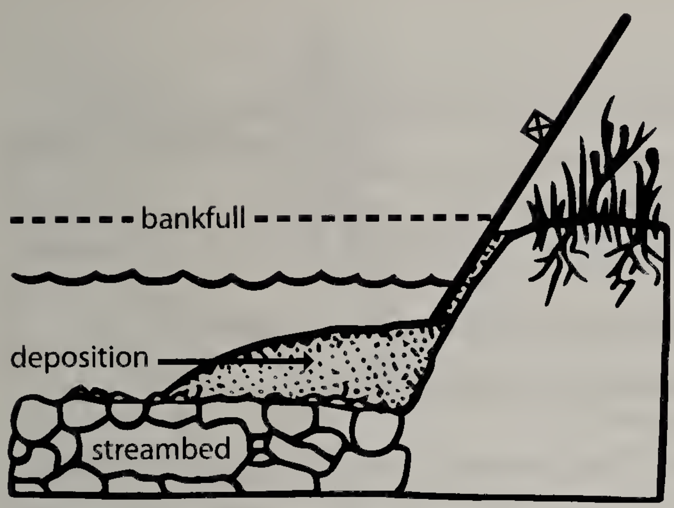


Figure 20A. Begin measuring the angle from the point where the deposition and bank meet (Archer et al. 2015).

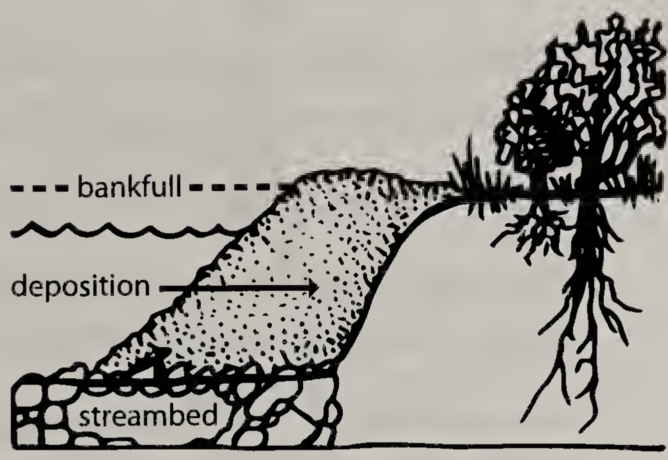


Figure 20B. When the depositional feature covers the first flat floodplain-like feature, do not measure an angle (Archer et al. 2015).

Erosional banks:

1. A fracture is a piece of the bank that is detaching from the streambank. If the piece of the bank has completely detached and slipped down, resulting in a block of soil/sod that is completely detached from the streambank, it is a slump bank.
   - If the connection point (i.e., where the fracture or slump block meets the bank) is below the scour line, the lower limit of your measurement is the connection point (Figure 21B).
   - If the connection point is above the scour line, the lower limit of your measurement is where bed-meets-bank (Figure 21A).
   - Do not consider slump blocks that are not attached to the streambank.

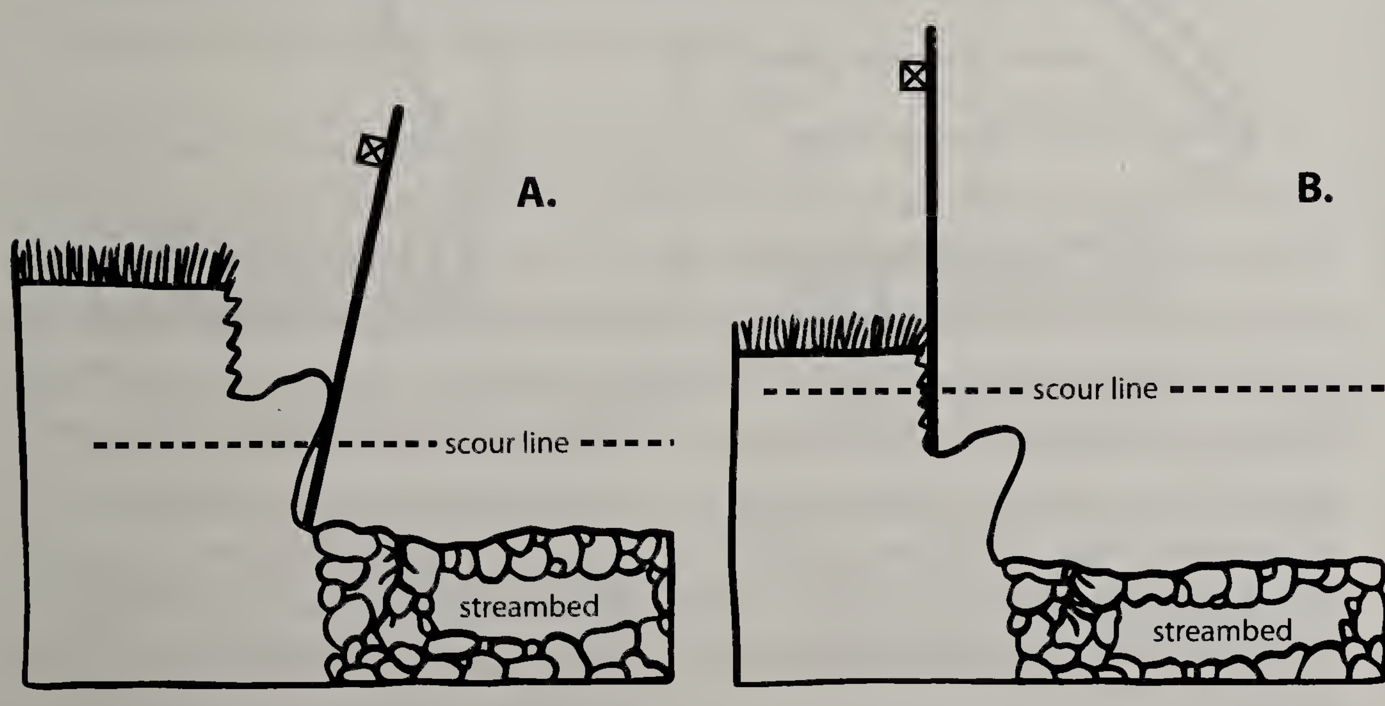


Figure 21. Location of bank angle measurements with (A) a fracture still attached above the scour line and (B) a fracture still attached below the scour line (Archer et al. 2015).

2. **Undercut banks**

- Qualifying undercut banks are measured from the deepest point of the undercut to the bottom edge of the overhang (Figure 22).
  - A qualifying undercut must be ≥ 5 cm deep, ≥ 10 cm high, and > 10 cm wide.
  - The idea is that you could "hide" a box of this size in the undercut, without being able to see it from above.
  - Occasionally the depth at the back of the undercut is consistent, thereby lacking a deepest point. In this case, measure bank angle at the highest elevation of the undercut, resulting in the smallest angle (Figure 23).
  - Enter the angle as "1°" if the deepest part of the undercut is elevationally above the ceiling (Figure 24).
- Nonqualifying undercuts (< 5 cm deep, < 10 cm high, and ≤ 10 cm wide) should be measured in the same manner as banks that are not undercut.
- Undercut banks with a ceiling above bankfull are considered nonqualifying and should be measured from where bed-meets-bank to the outside edge of the undercut (Figure 25).

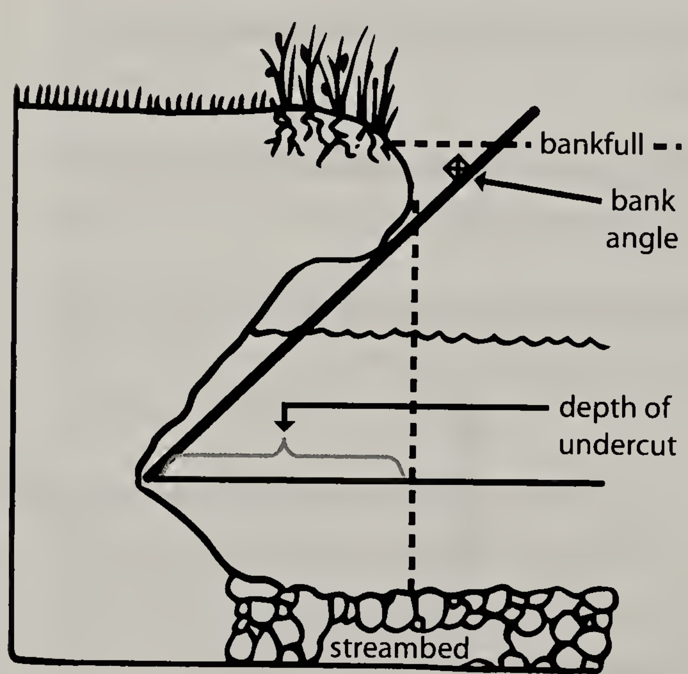


Figure 22. Measure undercut bank angle from the deepest point to the ceiling of the undercut; determine if the undercut has a qualifying depth (≥ 5 cm) by lowering your depth rod until it is horizontal (Archer et al. 2015).

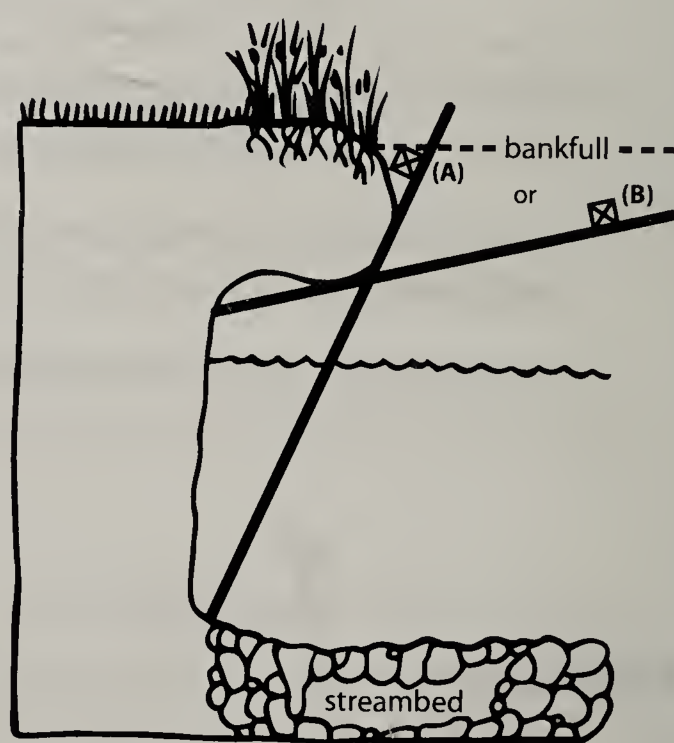


Figure 23. Bank angle is typically measured at the deepest point of a qualifying undercut (angle A). However, if the depth of the back of the undercut is consistent, measure bank angle at the highest elevation of the undercut (angle B), not angle A (Archer et al. 2015).

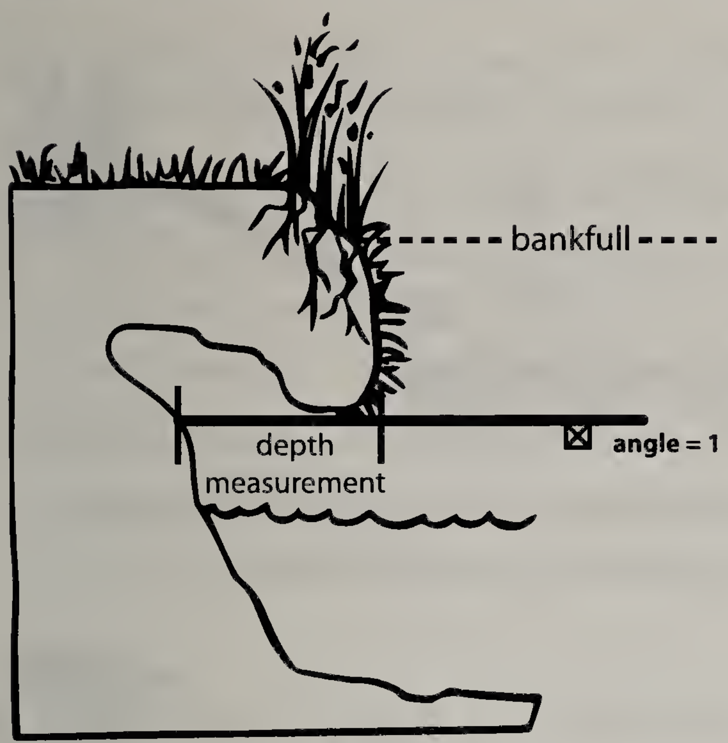


Figure 24. An undercut bank where the deepest point is elevationally above the ceiling of the undercut. These types of undercuts are recorded as 1° (Archer et al. 2015).

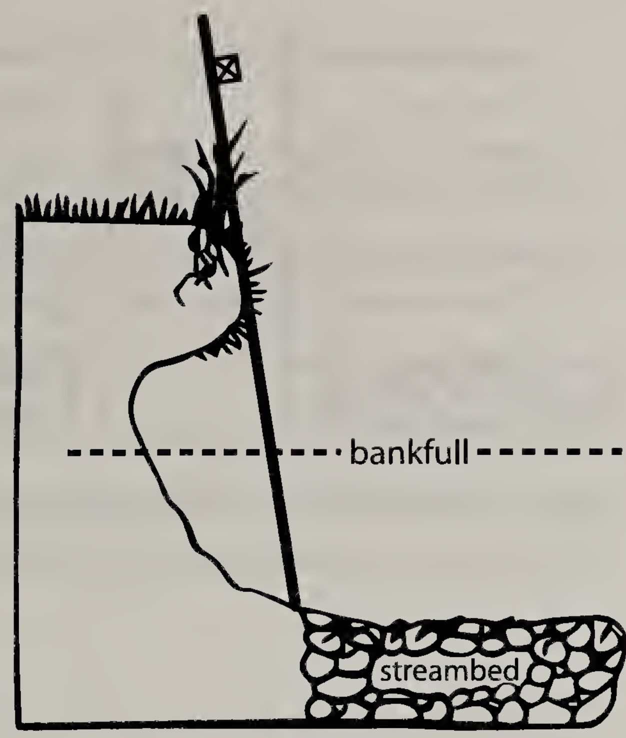


Figure 25. Undercut banks with the ceiling above bankfull are measured from where the streambed and bank meet to the outside edge of the undercut (Archer et al. 2015).

Adjustments for banks with embedded logs and rocks:

- If within the bank, consider logs (≥ 10 cm diameter) and rocks (≥ 15 cm B-axis diameter; Figure 13) as part of the bank.
- As with slump blocks, determine if the connection point (i.e., where the top of the log or rock meets the bank) is elevationally below the scour line. If so, the lower limit of your measurement is the connection point.
- If the connection point is above the scour line, the lower limit of your measurement is where bed-meets-bank.

7.10.2 Determining which Angle(s) to Measure —

Bank angles can be simple, meaning that there is one dominant angle to measure, or complex, meaning that there are multiple angles that could be measured. In the case of simple bank angles, follow the guidance provided in Section 7.10.1 regarding plot location, and measure the bank angle according to the methods provided in Section 7.10. For complex banks, adhere to the following guidance:

- Only consider measuring angles for portions of the bank ≥ 10 cm in height.
- For banks with 2 dominant angles, both corresponding to portions of the bank ≥ 10 cm in height (Figure 26), measure the angle of the tallest section of bank.
- For banks with 3 or more angles, all corresponding to portions of the bank ≥ 10 cm in height (Figure 27), measure the average angle by laying the depth rod in a position where it is most representative of the overall bank angle.

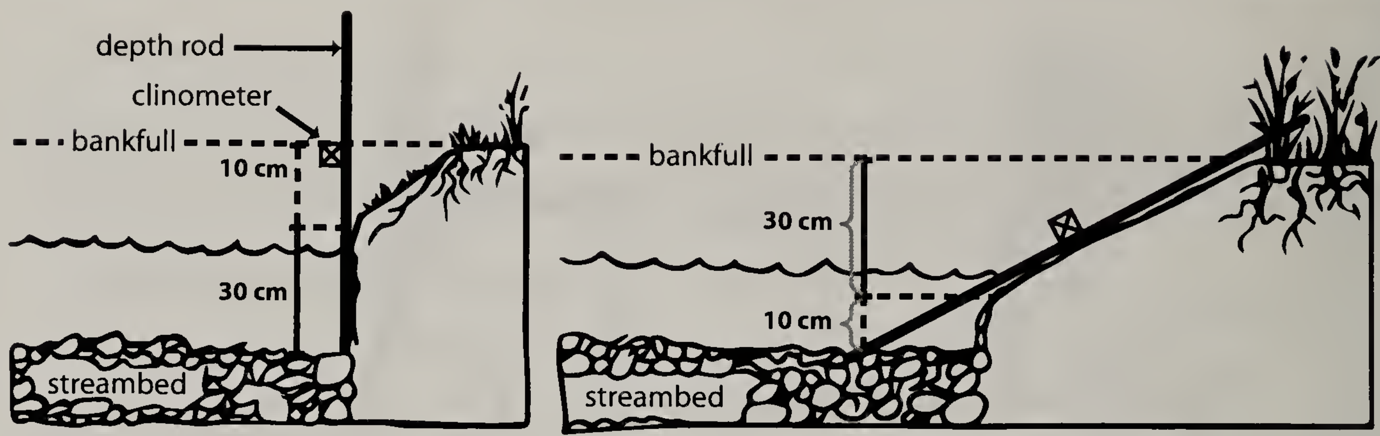


Figure 26. Measure the bank angle corresponding to the highest portion of the bank when the bank has two dominant angles (Archer et al. 2015).

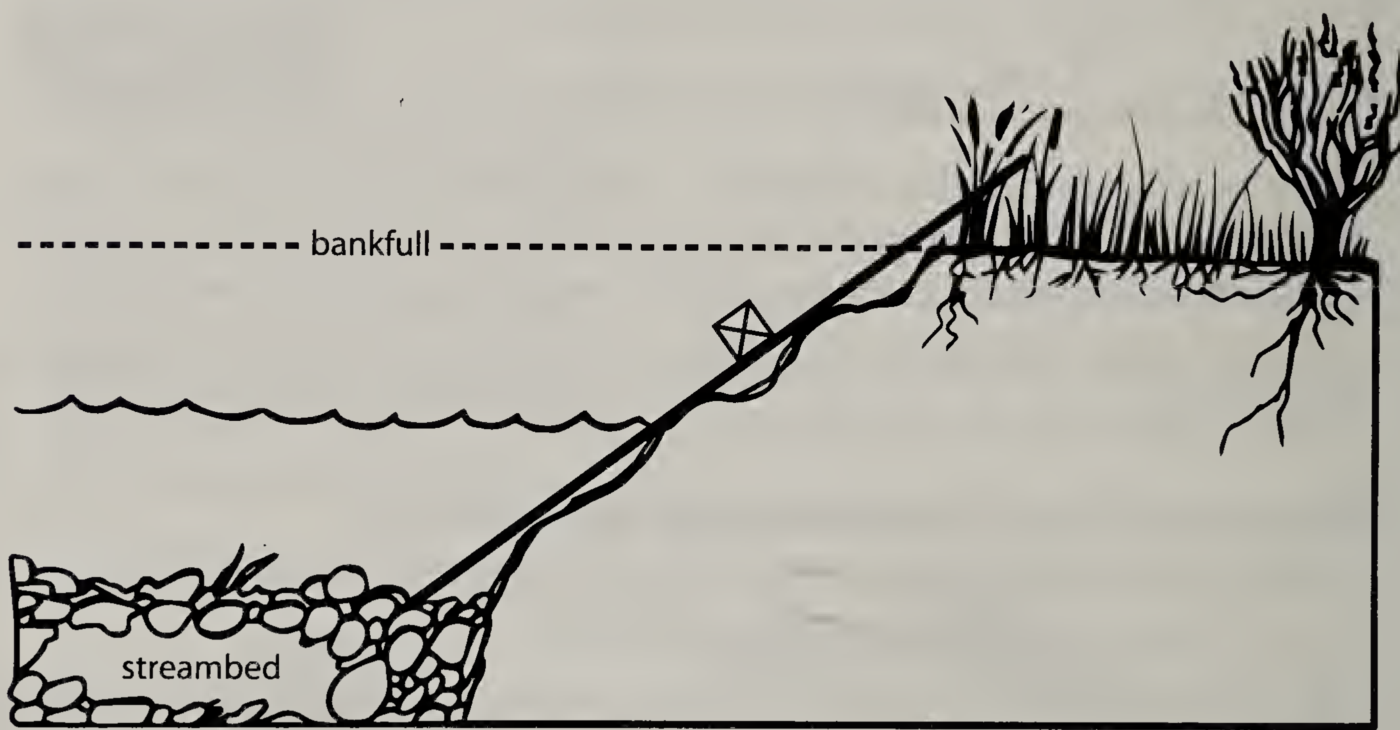


Figure 27. Measure the angle of banks with three or more angles by laying the rod along outer edges to best represent overall bank angle (Archer et al. 2015).

7.11 Thalweg Depth Profile (contingent)

Overview: Measure water depth along the thalweg for the entire sample reach. The spacing between thalweg depth measurements is determined as a function of stream width. See Appendix C for guidance on how to take thalweg measurements in reaches with interrupted flow. Note thalweg measurements should not be taken on side channels or in pools on the side of the main channel that the thalweg does not flow through.

Guidance for determining where to measure thalweg depths:
The location of the thalweg can be identified using the criteria in Section 2.2.3. Once identified, the distance between thalweg measurements is determined by the width of the stream. Follow these rules to determine the appropriate distance between measurements:

- For bankfull widths ≤ 2 m, measure thalweg depth every 0.5 m (30 measurements between main transects).

- For bankfull widths > 2 and ≤ 5 m, measure thalweg depth every 1 m (15 measurements between main transects).
- For bankfull widths > 5 m, measure thalweg depth at increments equal to 1/10 of the distance between transects (10 measurements between main transects). For example, a 400-m reach would have 40 m between each main transect, and therefore, thalweg measurements should be taken every 4 m.
- Note that thalweg depths are only measured along the main channel even if a side channel exists.

Methods:

1. Starting at transect A, use a depth rod to locate the deepest point within the thalweg, which may not always be found at mid-channel.
2. Measure the depth of the water (from the substrate surface to the water surface) with the depth rod to the nearest cm. Read the depth on the side of the rod to avoid inaccuracies caused by holding the rod in moving water.
3. Use a depth rod, stadia rod, or tape measure to estimate or measure the distance to the next thalweg measurement location.
4. Record the presence/absence of flowing water at each thalweg measurement. If water is completely absent, record a thalweg depth of 0.
5. Repeat steps 1-4 until you reach the next main or intermediate transect.
6. Once thalweg measurements have been completed between all main and intermediate transects, measurements are complete.
7. Note that having continuous thalweg measurements is critical for analysis. Always make every attempt to estimate the measurement and flag it as such, rather than leaving a measurement completely blank and skipping it. Even an estimate to the nearest 0.5 m is better than no data, as long as it is appropriately flagged as an estimated measurement.

If the thalweg is too deep to measure directly, follow this procedure:

1. Stand in shallower water, and extend the stadia rod at an angle to reach the maximum thalweg depth.
2. Determine the angle by resting the compass on the upper surface of the rod and reading the angle on the external scale of the clinometer on the compass.
3. Record the water level on the rod and the rod angle to calculate the depth.

8. Visual Estimates

Overview: Visually estimate the aerial cover of vegetation adjacent to the stream, the presence of human influence, and the availability of fish cover (i.e., instream habitat complexity) at all 11 main transects.

Plot size and location:
Whenever possible, all visual estimates should be performed while standing at the scour line (Section 2.2.2). The area of the riparian and human influence plots is 10 m x 10 m, centered on each main transect (i.e., 5 m upstream and 5 m downstream). The plot extends 10 m away from the scour line, even if the extent of the plot is beyond that of riparian vegetation (Figure 28). Estimate the distance into the riparian zone as if it were projected down from an aerial view. If side channels are present, see Appendix C for guidance on defining plots and recording measurements. If riparian plots overlap in aerial extent (e.g., small sinuous streams), derive estimates of aerial cover for each plot independently.

Fish cover plots extend 5 m upstream and downstream of each main transect and are laterally constrained by the wetted channel (Figure 28). If the transect is dry, see Appendix C for guidance on recording fish cover.

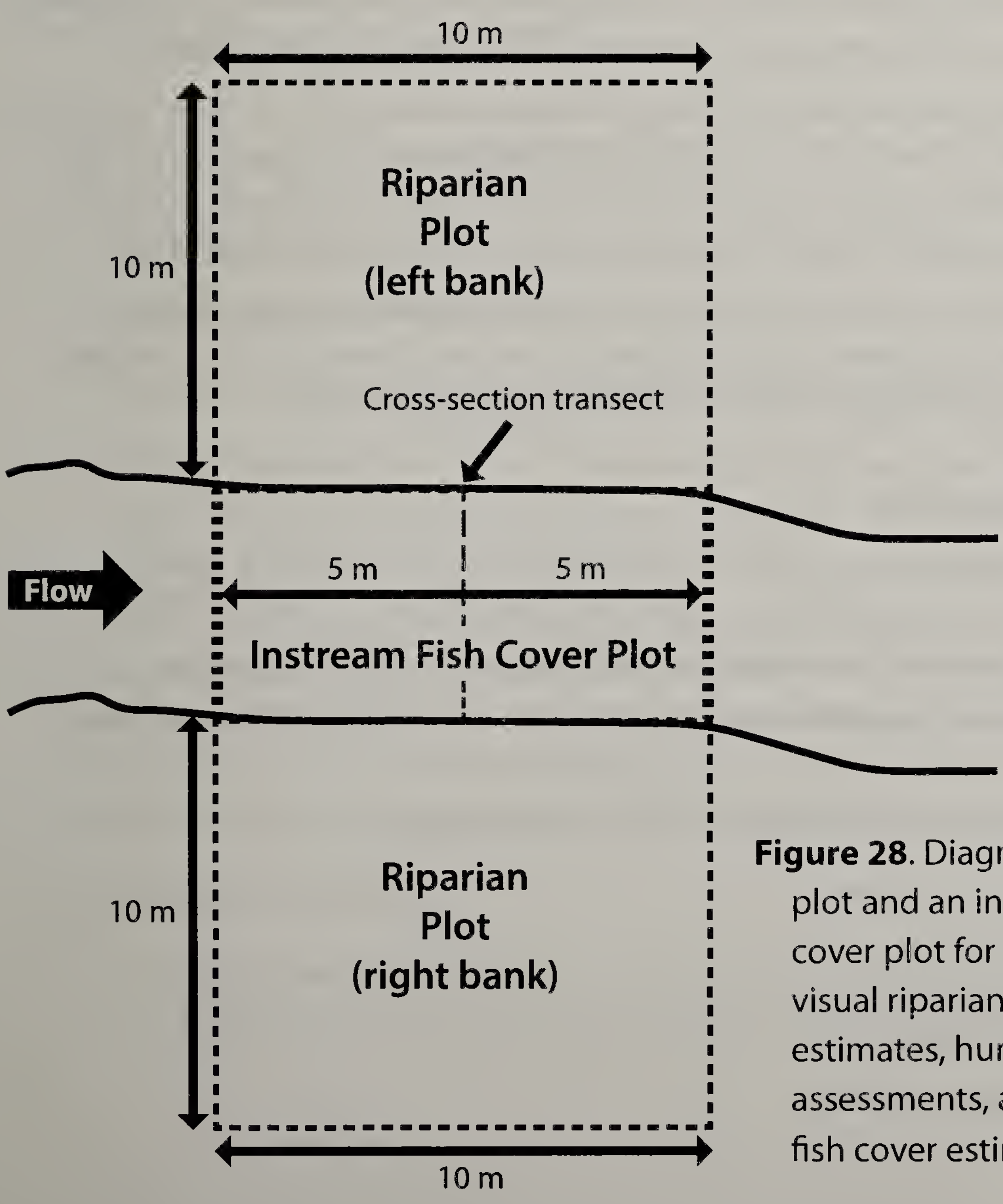


Figure 28. Diagram of a riparian plot and an instream fish cover plot for conducting visual riparian vegetative estimates, human impact assessments, and instream fish cover estimates.

8.1 Riparian Vegetation Estimates

Overview: Within each riparian plot, visually estimate the percent aerial cover of three different vegetation layers (canopy, understory, and groundcover - see height requirements, which follow) to determine vegetative complexity. Vegetative complexity is assessed across all vegetative types. In addition to vegetative complexity, the aerial cover of woody riparian obligates and facultative species is separately estimated in each riparian plot, as well as sedges and rushes.

A note on the intent of this protocol:
This protocol is meant to provide a coarse estimate of vegetative complexity and cover. Species or even genus-level plant identification is not required. However, practitioners will need a basic knowledge of native and nonnative plants commonly found in riparian zones within the region. Riparian plants are generally defined as those with a facultative wetland or obligate wetland indicator status (*http://wetland-plants.usace.army.mil/nwpl_static/index.html*). It is recommended that crews work with BLM field offices for which they are collecting data to compile a list of riparian plants and spend time in the field with a botanist before collecting data. Consult with your state riparian lead, local riparian lead, botanist, and/or weed specialist for assistance in compiling basic plant lists and to obtain photographic identification guidebooks.

Common native riparian plants found in the Western U.S. include cottonwood, willow, dogwood, birch, alder, wild rose, gooseberry, currant, and various sedges and rushes. Nonnative species commonly found in riparian zones in the Western U.S. include burdock, musk thistle, Canada thistle, teasel, Russian olive, and saltcedar (tamarisk). These lists should be customized for each region in which data is being collected.

Estimating aerial cover:
Vegetative complexity and cover are estimated for three vertical layers: canopy, understory, and ground cover within the 10 m x 10 m plot. Aerial cover is an estimate of the amount of shadow that would be cast by a particular category of vegetation if the sun were directly over the plot area.

- Aerial cover estimates are based on five cover classes:

  a. 0 = absent: zero cover
  b. 1 = sparse: < 10%
  c. 2 = moderate: 10-40%
  d. 3 = heavy: 41-75%
  e. 4 = very heavy: > 75%

- Percent cover estimates within each layer are relative to each other. This means that the total vegetative cover for any layer cannot be greater than 100%.
- Estimates among different layers are independent of each other, so the sum of the aerial cover for the three layers combined could add up to 300%.
- Total percent cover for the canopy and understory layers can be less than 100%, but percent cover for the ground cover layer must equal 100% because bare ground is included in the estimates.

Methods:

1. Stand at the scour line, and visualize the 10 m x 10 m plot (Figure 28), which starts at the scour line along each streambank. If you cannot see the full depth of the plot (e.g., 10 m into the riparian zone), move from the scour line to obtain a better view. If you cannot view the plot, record "not applicable" for no data collected.
2. Within the plot area, conceptually divide the riparian vegetation into three layers:
   a. Canopy (> 5 m high)
   b. Understory (0.5 to 5 m high)
   c. Ground cover (< 0.5 m high)
3. Categorize the dominant woody vegetation type for the canopy and understory layers as one of the following:
   a. Deciduous (e.g., willow, cottonwood, alder, tamarisk)
   b. Coniferous (e.g., juniper, cedar, pine, fir)
   c. Broadleaf evergreen (e.g., sagebrush, rhododendron, manzanita)
   d. Mixed - greater than 10% of the aerial vegetative cover is made up of two or more of the three previous categories
   e. No canopy
4. Considering each layer independently, determine which cover class (see previous page) most accurately represents the percent aerial cover provided by each of the following vegetation types. Include standing dead trees and both riparian and nonriparian species as cover.
   a. Canopy (> 5 m high)
      - Large trees - greater than 1 ft (0.3 m) diameter at breast height
      - Small trees - less than 1 ft (0.3 m) diameter at breast height

b. Understory (0.5 to 5 m high)

- Trees, shrubs, and saplings
- Herbaceous vegetation - forbs and graminoids (including ferns, sedges, rushes, and equisetum)

c. Ground cover (< 0.5 m high)

- Trees, shrubs, and saplings
- Herbaceous vegetation - forbs and graminoids (including ferns, sedges, rushes, and equisetum)
- Bare ground or duff

5. Again, considering each layer independently, record the percent aerial cover of the plot provided by riparian vegetation only (i.e., facultative wetland or obligate wetland, including invasive species meeting this criteria) for:

   a. Canopy (> 5 m high): consider only the percent aerial cover of woody riparian vegetation.

   b. Understory (0.5 to 5 m high): consider only the percent aerial cover of woody riparian vegetation.

   c. Ground cover (< 0.5 m high): consider the percent aerial cover of both woody and nonwoody (including ferns, sedges, rushes, and equisetum) riparian species combined, excluding grasses.

6. For all layers combined, record the presence or absence of the following types of vegetation:

   a. Nonnative woody (e.g., Russian olive, saltcedar)
   b. Native woody
   c. Nonnative herbaceous (e.g., Canada thistle)
   d. Native herbaceous (including ferns and fern allies)
   e. Sedges and rushes

7. Repeat steps 1-6 for the opposite bank, and continue repeating steps 1-6 until all measurements are collected along all main transects.

8.2 Human Influence (covariate)

Overview: Visually estimate the amount of human influence at all 11 main transects on both the left and right banks. Human influences are assessed both within and outside of the defined riparian plot area and are recorded by location (Figure 29).

Methods:
Human influences are considered present if they can be seen from the cross-section transect. The same human influence may be marked present at more than one transect but should not be counted again if it must be sighted through another transect or riparian plot.

1. Stand in the middle of the stream, and examine the channel, bank, and 10 m x 10 m riparian plot area adjacent to the stream for the following human influences:
    - Walls, dikes, bank stabilization structures, and dams
    - Buildings
    - Pavement/cleared lots (e.g., paved, graveled, dirt parking lot or foundation)
    - Roads or railroads, including culverts
    - Inlet or outlet pipes
    - Landfills or trash (e.g., cans, bottles, trash heaps)
    - Parks or maintained lawns
    - Row crops
    - Pastures, rangeland, hay fields, or evidence of historic or recent livestock use
    - Logging
    - Mining (including gravel mining)
    - Hydrologic alterations (irrigation diversions, impoundments)
    - Presence of livestock or wild horses and burros, including fresh feces
    - Grazing exclosure
    - Recreation
2. For each type of influence that is detected, determine its proximity to the stream and riparian plot area (Figure 29). Proximity classes are:
    - **B (Bank)**: Present within the defined 10-m stream segment (5 m up- and downstream of the transect) and located in the stream or on the streambank.
    - **C (Contained)**: Present within the 10 m x 10 m riparian plot area but away from the bank.
    - **P (Present)**: Present but outside the riparian plot area.
    - **Absent**: Not present within or adjacent to the 10-m stream segment or the riparian plot area at the transect.
3. Repeat steps 1-2 for the opposite bank, and continue repeating steps 1-2 until human influence is evaluated along all main transects.

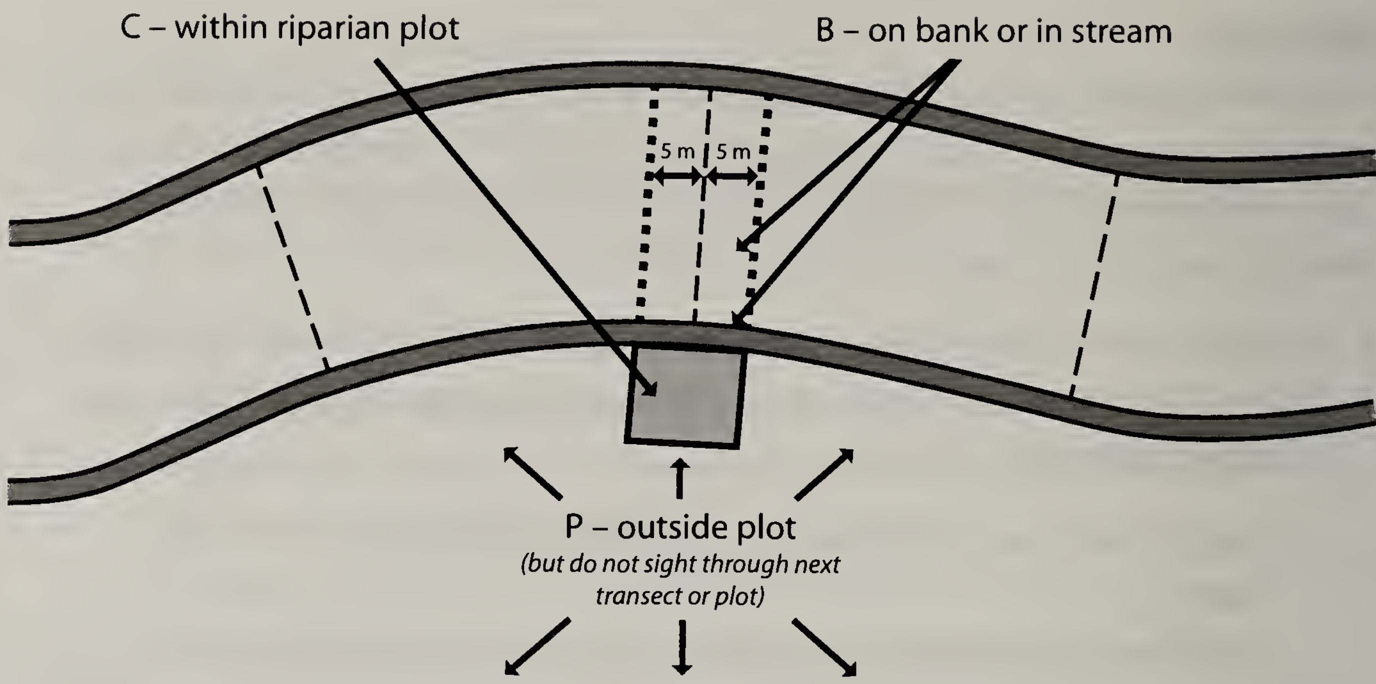


Figure 29. The location of human influences are recorded as: (B) on the bank or instream, (C) contained within the riparian plot, or (P) present outside of the riparian plot (USEPA 2009).

8.3 Instream Habitat Complexity (Fish Cover) (contingent)

Overview: Visually estimate the instream habitat complexity (i.e., available fish cover) within the defined instream fish cover plot (Figure 28). Fish cover is estimated at all 11 main transects. See Appendix C for guidance on how to conduct visual estimates of instream habitat complexity for reaches with interrupted flow.

Estimating fish cover:

Fish cover is estimated from an aerial view, and estimates should be based on the amount of shadow that would be cast by a particular cover category if the sun were directly over the plot area. Each cover type is assessed independent of other cover types (i.e., when all cover types are considered, total fish cover could be more than 100%).

Methods:

1. Visualize the instream fish cover plot (5 m upstream and 5 m downstream of the transect and across the entire wetted width; Figures 28 and 29).
2. Examine the plot for the following fish cover classes:
   a. **Filamentous algae**: long-streaming algae that often occur in slow-moving waters.
   b. **Aquatic macrophytes**: water-loving plants, including mosses, found growing in the stream. Macrophytes can provide cover for fish and macroinvertebrates. If the stream channel contains sedges and rushes, include these as aquatic macrophytes.

c. **Large woody debris**: larger pieces of wood that can influence cover and stream morphology (i.e., those pieces that would be included in the large woody debris tally; Section 7.6).

d. **Brush and small woody debris**: smaller wood pieces that primarily affect cover but not morphology.

e. **In-channel live trees or roots**: living trees that are within the channel (estimate the aerial cover provided by the parts of these trees or roots that are inundated).

f. **Overhanging vegetation**: includes tree branches, brush, twigs, or other small debris that are not in the water but close to the stream (within 1 m of the surface) and provide potential cover.

g. **Undercut banks**: any bank that has an undercut > 5 cm deep.

h. **Boulders**: basketball to car-sized particles.

i. **Artificial structures**: structures designed for fish habitat enhancement, as well as in-channel structures that have been discarded (e.g., concrete, asphalt, cars, or tires) or deliberately placed for diversion, impoundment, channel stabilization, or other purposes.

3. For each cover type, estimate and record the percent aerial cover, by cover class. Fish cover classes are:

   - 0 = absent: zero cover
   - 1 = sparse: < 10%
   - 2 = moderate: 10-40%
   - 3 = heavy: 41-75%
   - 4 = very heavy: > 75%

9. Photos (covariate)

Overview: Take a minimum of five representative photos of each sample reach. Clear photos should be taken at the bottom of the reach, F transect, top of the reach, an overview containing as much of the reach as possible, and at least one monumenting photo to assist subsequent crews with relocating the sample reach.

If necessary, additional photos can be taken that: (1) are representative of the reach in ways that the previous photos do not portray; (2) display special situations such as side channels, interrupted flow, or beaver impacts (see Appendix C for more specific guidance); (3) display impacts or signs of degradation to the stream or riparian area (e.g., head cuts, excessive grazing, recreation); or (4) are characteristic of problematic features that created challenges for protocol implementation.

Purpose of taking photos:
Photo documentation of sample reaches can provide valuable insight regarding the overall character of each reach. An understanding of reach character can be invaluable when interpreting data. Data interpretation can sometimes take place years or even decades after the sampling event, when the character of the reach could have changed drastically. Therefore, it is important to accurately capture the reach character at the time of sampling. A few high-quality photos are much more valuable than many poor quality photos.

The purpose of taking monumenting photos is to help future crews relocate the sample reach and to capture visible changes in the reach over time. Therefore, monumenting photos should be taken in locations where obvious features can be identified. Strive to combine photos that show a prominent feature(s) of the area (e.g., large tree, boulder, or human structure) with a narrative of the reach description. In addition to taking field-based photos, it is recommended to use Google Earth or similar aerial photography to mark the top and bottom of the reach and any other distinguishing features. Archiving such aerial photos can greatly assist with relocating the reach for future sampling.

If the reach was targeted for monitoring condition and trend, then photos on repeat visits should be taken of the same exact photo frame that was photographed in previous visits. The exception to this rule is when the previous photos were poor quality. Photos from previous visits should be taken into the field so that the repeat photos can be properly aligned.

Adhere to the following guidelines to capture high-quality photos:
- Use a depth rod, placed at the same elevation that the photographer is standing, as a stand for the camera to get a consistent height on all photos.
- Do not zoom in for any photo.

- Make sure that both left and right banks are present in all pictures.
- Try to include scour line, bankfull, and floodplain surfaces in at least one photo.
- Always have something in the photo for scale, preferably a depth rod. Make note of the location of the depth rod (or other item for scale) in the photo (e.g., right bank).
- Take reach overview photos from a location where as much of the reach is visible in the photo as possible. Ideally, reach overview photos should be taken from a hillside that overlooks the reach, but this will not always be practical.
- Avoid taking photos looking into the sun; try to take photos with the sun at your back.
- Try to avoid taking photographs where part of the frame is in the shadows and part in the sun.
- Do not take photos of unprofessional behavior.

Methods:

1. Considering stream size, vegetation, and sunlight, decide if it will be best to take the photograph looking upstream, downstream, or at a cross section.
2. Place or hold a depth rod within the frame of the photo for scale.
3. Stand approximately 5 meters from the scale item or depth rod and in a location where you can see both banks.
4. Hold a depth rod vertically, set the camera on top of the depth rod, and take a photo.
5. Preview the photo on the screen of the camera to ensure you captured the key elements. If the photo did not turn out well, delete it and try again.
6. For all photos, record the following information:
    a. Camera make and model (not applicable when taking photos with the data collection tablet)
    b. Photo number (not applicable when taking photos with the data collection tablet)
    c. Photo location or type (e.g., bottom of the reach, F transect, top of the reach, monument, overview, other)
    d. Direction facing (upstream, cross section, downstream)
    e. Letter of the closest transect
    f. For monument photos, describe the monument feature and the approximate distance and direction to the feature from the location that the photo was taken.
7. Repeat steps 1-6 for all necessary photos.

10. Gear Decontamination

Overview: After every reach you sample and while in the field, decontaminate waders and all equipment that came into contact with the water to prevent the spread of aquatic invasive species. Gear decontamination will be conducted in the field with the dilute solution prior to sampling a new reach. At the end of each hitch, gear decontamination can occur in the field or upon returning to town.

Methods:

1. The recommended disinfectant is Super HDQ Neutral. A concentration of 0.4% is required for effective decontamination with this chemical. This can be obtained with 3.1 ounces of Super HDQ Neutral per gallon of water (e.g., a 5-gallon jug of water requires 15.5 ounces of Super HDQ Neutral).
2. Prior to leaving for the field, mix the solution in a well-sealed 5-gallon jug (labeled toxic). When it is time to disinfect equipment, pour the mixture contained in the 5-gallon jug into a much larger tote bin (at least 10 gallons) for gear decontamination.
3. Debris, mud, and vegetation must be cleaned off equipment and waders before placing in the decontamination solution.
4. Soak all gear items (e.g., waders, boots, and bug nets) for at least 10 minutes in the solution.
5. When decontamination is complete, allow gear to air dry. If possible, rinse gear with clean tap water to protect equipment from degradation caused by repeated exposure.
6. Pour the Super HDQ Neutral solution back into its designated container, using a funnel to minimize skin contact.
7. Muddy gear or repeated use of the solution can reduce its efficacy, and the mixture may need to be replaced. To check the effectiveness of the solution, make a 1:5 mixture of the solution and water (1 cup solution to 5 cups water). Then, use "Quat Check 1000" strips to ensure the solution is ≥ 600 ppm. If it is < 600 ppm, the solution must be replaced (step 1).
8. Discard used Super HDQ Neutral solution down a drain that leads to a wastewater treatment facility. Run a faucet or hose while pouring down a drain. Do not pour into waterways or storm sewers.

10.1 Safety Precautions

Overview: Concentrated Super HDQ Neutral has toxic ingredients and:

a. Is harmful if swallowed.
b. Is harmful if inhaled.
c. Can cause severe skin burns and serious eye damage.
d. May cause an allergic reaction of the skin.

When handling concentrated or diluted Super HDQ Neutral solution, be sure to wear proper personal protective equipment. It is strongly advised that concentrated Super HDQ Neutral not be taken into the field and that diluted solutions are only mixed prior to leaving for the field where running water and emergency medical care is readily accessible. Do not repackage Super HDQ Neutral; if a hazardous level of exposure occurs, the label will be readily available to provide to an emergency responder or poison control center.

Follow these guidelines to avoid harmful exposure:

1. Mix concentrate prior to leaving for the field.
2. Make sure to wear chemical-resistant gloves, eye protection, boots, and long sleeves when mixing concentrate and decontaminating equipment.
3. Wash hands and any exposed skin thoroughly after handling.
4. Do not eat, drink, or smoke when using this product.
5. Use only outdoors or in a well-ventilated area.
6. Do not breathe mist vapors or spray.

In case of exposure:

- If in the eyes, rinse with water for several minutes.
- If swallowed, rinse mouth. Do not induce vomiting. Contact poison control if necessary.
- If inhaled, move to fresh air, and keep at rest in a position comfortable for breathing.

Appendix A: Protocol Compatibility

Comparison of the AIM NAMF protocol for wadeable streams to other stream protocols commonly used in the Western U.S. Protocols are categorized as compatible (methods are nearly identical); largely compatible (methods have minor differences that are not likely to significantly influence data comparisons); not compatible (methods significantly differ and data comparability is not advised); and NA (corresponding method does not exist for a given protocol). If the AIM NAMF protocol is largely compatible or not compatible to another protocol, the NAMF protocol differences are summarized. Protocols include Multiple Indicator Monitoring (Burton et al. 2011), Aquatic and Riparian Effectiveness Monitoring Program (AREMP) (Lanigan 2010), PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) (Archer et al. 2015), and National Rivers and Streams Assessment Protocol (USEPA 2009).

AIM NAMF Indicator	Multiple Indicator Monitoring	Aquatic and Riparian Effectiveness Monitoring Program	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program	National Rivers and Streams Assessment Protocol
pH	NA	Compatible	Compatible	Largely compatible: Field measurement only with multiparameter sonde
Conductivity	NA	Compatible	Compatible	Largely compatible: Field measurement only with multiparameter sonde
Temperature	NA	Largely compatible: Thermistor deployment is optional	Largely compatible: Thermistor deployment is optional	Compatible
Total nitrogen and phosphorous	NA	Compatible	NA	Largely compatible: Frozen water compatible; sample for estimation of total nitrogen and phosphorous only

Appendix A: continued

AIM NAMF Indicator	Multiple Indicator Monitoring	Aquatic and Riparian Effectiveness Monitoring Program	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program	National Rivers and Streams Assessment Protocol
Turbidity	NA	NA	NA	Largely compatible: Field measurement only with turbidimeter
Macroinvertebrate biological integrity	NA	Compatible: Option to collect targeted-riffle or reachwide sample	Compatible: Option to collect targeted-riffle or reachwide sample	Compatible: Option to collect targeted-riffle or reachwide sample
Reach length	Largely compatible: 110 m minimum or 20 x greenline to greenline width	Compatible	Compatible	Largely compatible: 150 m minimum or 20 x bankfull width
Streambed particle sizes	Largely compatible: Particles measured with ruler and not gravelometer	Largely compatible: Particle selection limited to the active channel (scour line to scour line)	Largely compatible: Particle selection limited to the active channel (scour line to scour line). Increase the number of particles to 210	Largely compatible: Particle sizes measured and not estimated; particle selection expanded to active channel, but those from wetted channel noted
Pool dimensions	Not compatible: Pool length actually measured; pool criteria follows AREMP and PIBO	Compatible	Compatible	Not compatible: Pools delineated via an objective criteria following AREMP and PIBO; pool tail and max pool depth measured in addition to pool length

AIM NAMF Indicator	Multiple Indicator Monitoring	Aquatic and Riparian Effectiveness Monitoring Program	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program	National Rivers and Streams Assessment Protocol
Bank stability and cover	Compatible	NA	Largely compatible: Plot size and upper extent of plot location differ	NA
Bank angle	NA	NA	Compatible	Not compatible: Location of where bed-meets-bank differs; rule set for how or where measurements are taken differs
Floodplain connectivity	NA	NA	NA	Compatible
Large woody debris	NA	Largely compatible: Size requirements = 1.5 m length and 10 cm diameter; length is estimated	Largely compatible: size requirements = 1.5 m length and 10 cm diameter; length is estimated	Compatible
Instream habitat complexity	NA	NA	NA	Compatible
Thalweg depth profile	NA	NA	NA	Compatible
Bankfull width	NA	Compatible	Compatible	Compatible
Slope	NA	Compatible	Compatible	Largely compatible: Estimated over entire reach and not transect to transect; two reach-long measurements taken to ensure estimate accuracy

Appendix A: continued

AIM NAMF Indicator	Multiple Indicator Monitoring	Aquatic and Riparian Effectiveness Monitoring Program	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program	National Rivers and Streams Assessment Protocol
Riparian vegetative cover and composition	NA	NA	NA	Largely compatible: Supplemented to include riparian obligates and invasive species; plot starts at scour line
Riparian vegetative type, cover, and structure	To be determined	NA	To be determined	NA
Canopy cover	NA	Not compatible: Densiometer used as opposed to solar pathfinder	NA	Compatible for center readings; largely compatible for bank readings, which are measured where bed-meets-bank
Flood-prone width	NA	Compatible	NA	NA

Appendix B: Glossary

bankfull: The lowest bank height at which the stream overtops its banks and spills out onto the active floodplain; the elevation at which flooding begins. This volume of flow occurs every 1.5 years on average and is the channel-forming flow.

braided river or stream: A river or stream that has multiple mid-channel bars below bankfull that form short and small subchannels, often with no obvious dominant channel.

contingent indicator: measureable ecosystem component with the same characteristics of cross-program utility and consistent definition as core indicators, but that are measured only where applicable. Contingent indicators are not informative everywhere and, thus, are only measured when there is reason to believe they will be important for management purposes.

core indicator: measurable ecosystem component applicable across many different ecosystems, management objectives, and agencies. Core aquatic indicators are recommended for application wherever the BLM implements monitoring and assessment of wadeable perennial streams.

covariate: measured or derived parameter used to account for natural spatial or temporal variation in a core, contingent, or supplemental indicator (e.g., gradient); covariates help determine the potential of a given stream reach or other aquatic system.

cut bank: outside portion of a river bend or meander that is actively eroding and often near vertical in slope.

ephemeral: a discharge pattern that is temporary, inconsistent, or infrequent through time. Ephemeral streams have less flow than intermittent streams and only flow in response to precipitation events. Definable scour or bankfull features are not present, and there may be upland vegetation within the stream channel.

floodplain: relatively flat valley floor formed by floods and subsequent sediment deposition that extends to the valley walls.

hardpan: firm, consolidated fine sediment forming the stream bottom; fine sediment that has been compacted and/or wetted and dried to the point that it resembles bedrock.

intermittent: a discharge pattern that is not continuous on an annual basis. Intermittent streams have flowing water during the wet season or following spring snowmelt. For intermittent streams, the channel may not be as well-defined as those observed for perennial systems, but evidence of erosion and deposition must be present, such as scour line, bankfull width, and point bars. Note that for field purposes, intermittent reaches in this protocol are reaches that have < 5 transects with water at the time of visit (constrained to the index period of June through October) but have definable erosional and deposition features, such as those previously listed.

islands: stream sediment deposits found in the active channel that have an elevation above bankfull; islands are almost always vegetated.

left and right bank: left or right bank is determined when facing downstream.

meander: a bend in a stream or river.

mid-channel bars: stream sediment deposits found in the active channel that have an elevation above the base flow water level, but below the bankfull elevation. Mid-channel bars are almost always unvegetated.

perennial: a discharge pattern that is continuous on an annual basis. Note, for the purposes of this field protocol, perennial streams are defined in a two-stage process. Potential perennial streams are identified using their flow classification in the National Hydrography Dataset, and then reaches must have ≥ 5 transects with water to be classified as perennial.

point bar: point bars are typically convex-shaped mounds of substrate that are typically found adjacent to the stream channel on the inside bend of meanders at or below bankfull.

pool: streambed depression that is laterally and longitudinally concave (i.e., bowl shaped) and characterized by water that is slower and flatter than up- or downstream waters at baseflow. Pools are bound by a "head crest" (an upstream increase in streambed slope) and a "tail" (a downstream leveling of the streambed slope and reduction in depth). The pool tail is the shallowest downstream location in the pool from which water would spill if the flow were reduced to a trickle.

riffle: a length or reach of a stream or river that is locally steeper, shallower, and dominated by coarser streambed particles sizes than adjacent reaches. The velocity is generally faster in riffles than adjacent reaches and choppier on the surface.

scour line: the elevation of the ceiling of undercut banks at or slightly above the base flow elevation and below the bankfull elevation. Scour line is often associated with the lower limit of sod-forming vegetation.

side channel: stream or river channel separated directly from the main channel by an island, not a mid-channel bar, and containing less than 50% of streamflow.

sinuosity: ratio of channel length to valley length; curves departing from a linear course.

supplemental indicator: a measureable ecosystem component that is specific to a given ecosystem, land use, or management objective. No specific supplemental indicators or associated methods are recommended in the NAMF, given the diversity of probable indicators.

stain line: deposition of water precipitates, generally white, that forms over time on mineral substrates at a consistent elevation at or below bankfull.

target population: in statistical surveys, the target population refers to the group of individuals or things that one seeks to make inference to (e.g., college freshman, wadeable streams in Utah, lakes less than 1 acre).

thalweg: the line along a stream channel connecting the lowest points or deepest water depths. The thalweg would be the last portion of the stream or river to contain water if it were to dry up, and it tends to move back and forth across the stream channel.

Appendix C: Special Situations

C1. Interrupted Flow

Overview: Reaches with interrupted flow have some portion of the reach that is dry, but 5 or more transects have at least standing water. Field methods at these sites differ for transects without water and for reachwide measurements. Make sure to record which transects were dry and which had water.

Follow the modified methods for:

- **Reach setup**: For dry sections of the reach, measure along the center of the dry channel to establish the distance between transects. In areas with water, follow the original methods (measure along the thalweg). All 21 transects are established if ≥ 5 main transects have water. Use the average of 5 bankfull widths to determine reach length.
- **Water quality**: If the F transect is dry, collect water quality at the next closest location that has water > 10 cm deep and > 1 m^2 surface area. If no location exists, find the best available location (deepest with largest surface area), and record a comment.
- **Macroinvertebrate biological integrity**: Only collect macroinvertebrates where water is present; the water can be stagnant. If there is not enough flow (or no flow), you may need to scoop the sample into the net. For targeted-riffle methods, collect a total of 8 Surber or kick net samples from wetted riffles, even if only one riffle is present. For reachwide methods, collect a total of 11 Surber or kick net samples. Collect samples at main transects where water is present. Collect the remainder of needed samples at intermediate transects, or collect multiple Surber samples at different locations along a main transect, as water allows, to obtain a total of 11 Surber or kick net samples. Always record the number of Surber or kick net samples collected, and make a comment if not equal to 8 or 11 for targeted-riffle and reachwide methods respectively (e.g., 2 transects were dry and no sample collected; macroinvertebrate samples were taken at 9 transects all in stagnant pools).
- **Wetted width**: Record 0 at dry transects; follow original methods for transects with water.
- **Bankfull and floodplain height**: At dry transects, measure the height from the deepest point in the stream channel along the transect. Follow original methods for transects with water.
- **Pool dimensions**: Only measure pools that have outflow from the pool tail (even a trickle), following the original methods. Do not measure stagnant pools. Measure and record the lengths of pools that have flow. If flow is separated

by a dry section, be sure to add the length of all flowing sections together. For example, if 70 m of the reach has flowing water, the pool reach length is 70 m.

- **Canopy cover**: At dry transects, take left and right bank densiometer readings by holding the densiometer 0.3 m (30 cm) above the dry scour line. For center densiometer readings, take measurements at the center of the dry channel by holding the densiometer 0.3 m (30 cm) above the dry channel bed.
- **Substrate particles**: Follow original methods, but classify all pebbles as being collected from the "dry middle."
- **Slope**: If the A or K transect is dry or not flowing, place the stadia rod at bankfull (instead of the water's surface), and take slope measurements at bankfull for both A and K transects. If both the A and K transects have flowing water, follow original methods using the water's surface for stadia rod placement.
- **Thalweg depth profile**: Record depths as 0 when the bed is dry. Record the depth of water for stagnant pools, but record that the water was not flowing. Follow original methods for areas with flow. Make sure to record which thalweg locations were flowing or were not flowing.
- **Instream habitat complexity (fish cover)**: If the transect is dry, record all fish cover as 0%, even if a portion of the plot has water. Follow original methods for transects with water. If any portion of the transect has water, estimate fish cover as normal for the wetted perimeter contained by the fish cover plot.
- **Flood-prone width**: Strive to take measurements from wetted riffles close to transects A and K. If wetted riffles are absent, take measurements from uniform, straight portions of the channel. For flood-prone height measurements, measure bankfull height from the deepest point of the stream channel and multiply by two. Use the standard protocol for the remaining measurements of flood-prone width.
- **Follow original methods for**: bankfull width, bank stability and cover, large woody debris, bank angle, riparian vegetation, and human influence.

C2. Side Channels

Overview: Use the following guidance when sampling a reach with a side channel. A side channel is defined as a channel that is separated from the main channel by an island (not a mid-channel bar). This protocol differentiates between major and minor side channels. Data should only be collected on major and not on minor side channels. Note if more than one major side channel is present, determine which major side channel has the most flow, and only collect data on that side channel.

Major side channel: If the wetted channel is split by an island, with the side channel containing 16-49% of the total flow, this is a major side channel in which data should be collected.

Minor side channel: If the wetted channel is split by an island, with the side channel containing less than or equal to 15% of the total flow, this is a minor side channel in which data should not be collected.

Dry side channel: If the side channel is dry, take no measurements, and do not recognize it in the thalweg profile since it does not meet the flow requirement.

Setting up transects on qualifying side channels:

1. Visualize the main channel transect continuing over the island to the bank of the side channel that is closest to the main channel (Figure C1).
2. From the point where the transect would intersect the bank of the side channel, reorient the transect so that it is perpendicular to the streamflow (Figure C1).
3. Note which side of the main channel the side channel is on as you are facing downstream.

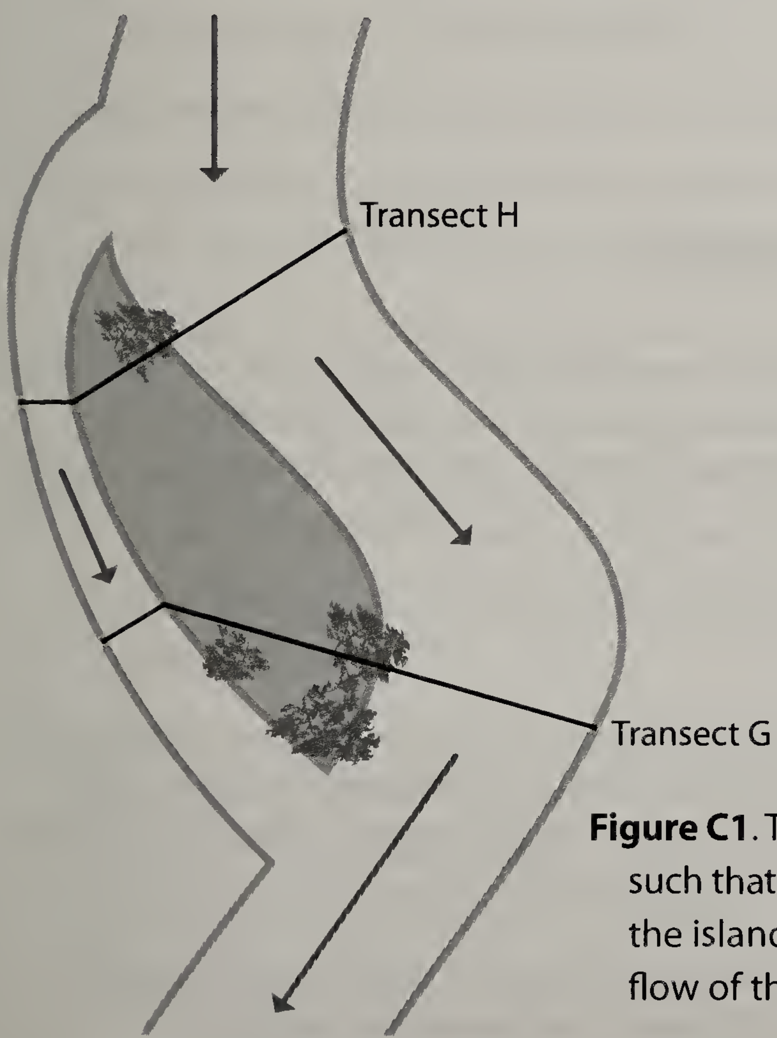


Figure C1. Transects are set up on side channels such that they are projected linearly across the island and turned perpendicular to the flow of the side channel.

What to measure on side channel transects (major side channels only):

1. Bankfull width and height
   - Floodplain height, but do not use the island for the floodplain height measurements; use the outside bank of the side channel.

2. Streambed particle sizes
3. Bank stability and cover
4. Bank angle (contingent)
5. Canopy cover
6. Instream habitat complexity (fish cover) estimates (contingent)
7. Human influence (covariate)
8. Riparian vegetation
    - Note: If the side channel riparian plot contains water from the main channel, ignore the water and only consider the portion of the plot overlaying the island.
    - Riparian plots from the main transect and the side channel may overlap. In this case, treat each plot as an individual measurement.

Do not measure the following on side channels:
- Macroinvertebrates
- Pool dimensions
- Thalweg depth profile
- Large woody debris
- Slope

C3. Beaver-Impacted Reaches

Overview: If more than 6 transects are inundated by beaver ponds, try to move the point coordinates so that 5 or more transects are not impacted by the beaver pond(s). If this is not possible, but you can still wade 5 or more transects, adhere to the following guidance to sample the beaver-impacted reach.

Methods:
1. **Reach setup**
    a. Orient transects that run across beaver ponds perpendicular to the thalweg of the beaver pond. If the thalweg cannot be identified, orient transects perpendicular to the pool's center (Figure C2).
    b. Note which transects are impacted by beavers using the comments field, and make sure to flag the site as influenced by beavers.
    c. If multiple side channels exist, try to identify the channel with the most flow, and use that as the "main side channel."

   d. If side channels exist and meet the requirements for sampling, follow the side channel protocol in Section C2 to determine if any additional channels should be sampled (but only if scour line and bankfull indicators can be identified).

2. **Photos**: Take photos of the following features such that you can see as much of the feature as possible.
   - The beaver dam, upstream and downstream.
   - Overview of each beaver pool.
   - Take all other photos as outlined in the photo section of the protocol (Section 9).

3. **Water quality and temperature**: Measure these indicators in a location with flowing water. Do not take water quality samples or measurements in or directly below a beaver pond.

4. **Macroinvertebrate biological integrity**
   a. Sample beaver ponds that are safe to wade and that do not have deep "bottomless" fine sediments.
   b. Kick nets will frequently need to be used in beaver ponds as they can be very deep and have low flow.

5. **Pool dimensions**: a beaver pond should be measured as a pool.
   a. Use the top of the beaver dam on the downstream end of the pool as the pool tail. Record all pool tail depth measurements as 0 cm.
   b. To define the head crest (upstream extent) of the beaver pool, look for:
      - Flowing water
      - A defined channel entering the pool
      - Normal substrate
   c. Beaver dams do not have to be actively maintained to qualify as beaver pools.

6. **Physical habitat**: Collect all measurements as normal to the best of your ability. For inundated transects, measure bankfull and wetted widths as the same. For bankfull height, record the height as zero, and flag the value, noting that the transect was inundated.

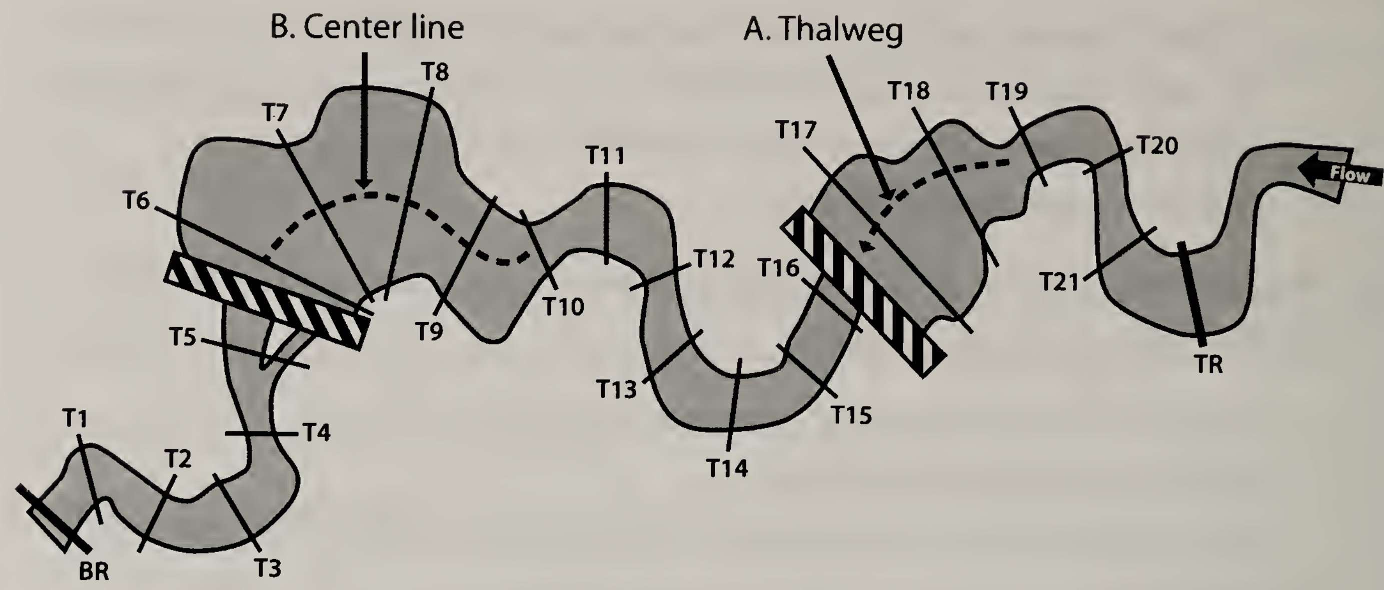


Figure C2. (A) Set up transects on a beaver-impacted stream following the flow of the thalweg if visible. (B) Set up transects perpendicular to the center line of the beaver pool if the thalweg is not visible (Archer et al. 2015).

C4. Braided Systems

Overview: Braided reaches have several ***mid-channel bars*** (below bankfull) that often do not have a dominant channel. Rather, they are comprised of a series of sub-channels. Some field methods will differ for braided streams. In general, collect as much data as possible at all transects, and make comments for all suspect or estimated values.

Methods:

- **Reach setup**

  1. Determine reach length using one of the two following rule sets, whichever results in the shortest reach length.
     - 20 x bankfull width
     - 40 x wetted width, where wetted width is measured as the total distance from the far right wetted edge to the far left wetted edge, minus the sum of all mid-channel bar widths.
  2. When establishing transects, follow the thalweg along the sub-channel with the most flow. If all sub-channels have similar flow, choose the most representative of the entire reach.
  3. Flag each confluence and diffluence to ensure you sample the same sub-channel for thalweg and pools throughout the reach.

- **Macroinvertebrate biological integrity**: Follow original methods, alternating among sub-channels (separated by bars) for left, center, or right sampling locations. Do not alternate and sample in a side channel (separated by islands).

- **Wetted width**: Measure from the far right wetted edge to the far left wetted edge including all bars.
- **Bar width**: Add the widths of all mid-channel bars.
- **Canopy cover**: Measure center densiometer readings in the center of the wetted channel as defined by the far right wetted edge to the far left wetted edge, including bars. Follow original methods for all other densiometer measurements.
- **Pool dimensions**: Sample pools only in the channel used to set up the reach.
- **Thalweg depth profile**: Measure along the thalweg of the channel used to set up the reach.
- **Instream habitat complexity (fish cover)**: Fish cover plots are delineated from the far right wetted edge to the far left wetted edge and 5 m upstream and downstream of the transect. Consider dry bars as 0% cover.
- **Scour line**: Only identify scour line on the left and right banks.

Follow original methods for: water quality, bankfull width, bankfull and floodplain height, bank stability and cover, streambed particle sizes, large woody debris, slope, flood-prone width, bank angle, riparian vegetation, and human influence.

C5. Partial Data Collection

Overview: Crews should always attempt to collect all data at any given reach. However, extenuating circumstances occasionally arise in which full data collection is not possible. There are usually two main situations in which crews will collect partial data: (1) A portion of transects are inaccessible (e.g., extremely dense vegetation, dangerous rapids); or (2) Insufficient time exists, and returning to the site is impossible. Examples of circumstances that could make returning to the site impossible include: your site visit required coordinating with a private landowner and rescheduling is not possible, inclement weather forces you out of the area, or you have backpacked into the site and cannot stay an extra day. These circumstances do not include repeating a 5-mile hike.

For the first situation (inaccessible transects), consider the subsequent guidance, but always do your best to collect all data. When possible, estimate measurements that cannot be directly measured (use data Flag E for all such estimates). For the second situation (insufficient time), follow the subsequent guidance to prioritize which measurements to collect.

Methods:

1. Determine if you will be able to collect data for water quality, macroinvertebrate biological integrity, and a minimum of 5 transects of physical habitat and pool dimensions data.
   a. If you cannot collect these data, do not attempt to collect any data, and walk away from the site.
   b. If these data can be collected, proceed to step 2.
   c. If collecting thalweg measurements, it is important to collect data on 5 consecutive main transects. If this cannot be accomplished, do your best to collect thalweg measurements on as many consecutive transects as possible, and when possible, estimate those thalweg measurements you cannot access (use data Flag E for all estimates).
2. Collect water quality at the location within these 5 transects that is closest to the F transect.
3. While staying within the reach, collect 8 Surber samples of macroinvertebrates using the targeted-riffle method, even if the riffles are outside of the 5 transects. If no fast-water habitat is present, use the reachwide method, and collect 11 Surber samples within the 5 transects. To meet the requirement of 11 Surber samples, sample intermediate transects and/or sample twice along a given transect. Always record the number of Surber or kick net samples collected, and make a comment if not equal to 8 or 11 for targeted-riffle and reachwide methods respectively.
4. Collect physical habitat and pool dimensions data for the 5 transects.
5. If you have more time, complete one pass of slope measurements only on the 5 sampled transects. Be sure to record and make a note about the reach length over which slope was measured.
6. If you still have more time, collect more physical habitat and pool dimensions data on as many transects as possible, making sure to note the total reach length over which physical habitat and pool data was able to be collected.
7. If possible, collect additional slope data for the additional transects sampled.
8. When you have completed data collection, take GPS coordinates at the topmost (instead of at the top of the reach) and bottommost (instead of at the bottom of the reach) transects that were sampled.
9. Make notes about which data were and were not collected and why the data are incomplete.

Appendix D: Bankfull, Floodplain, and Scour Line Photos

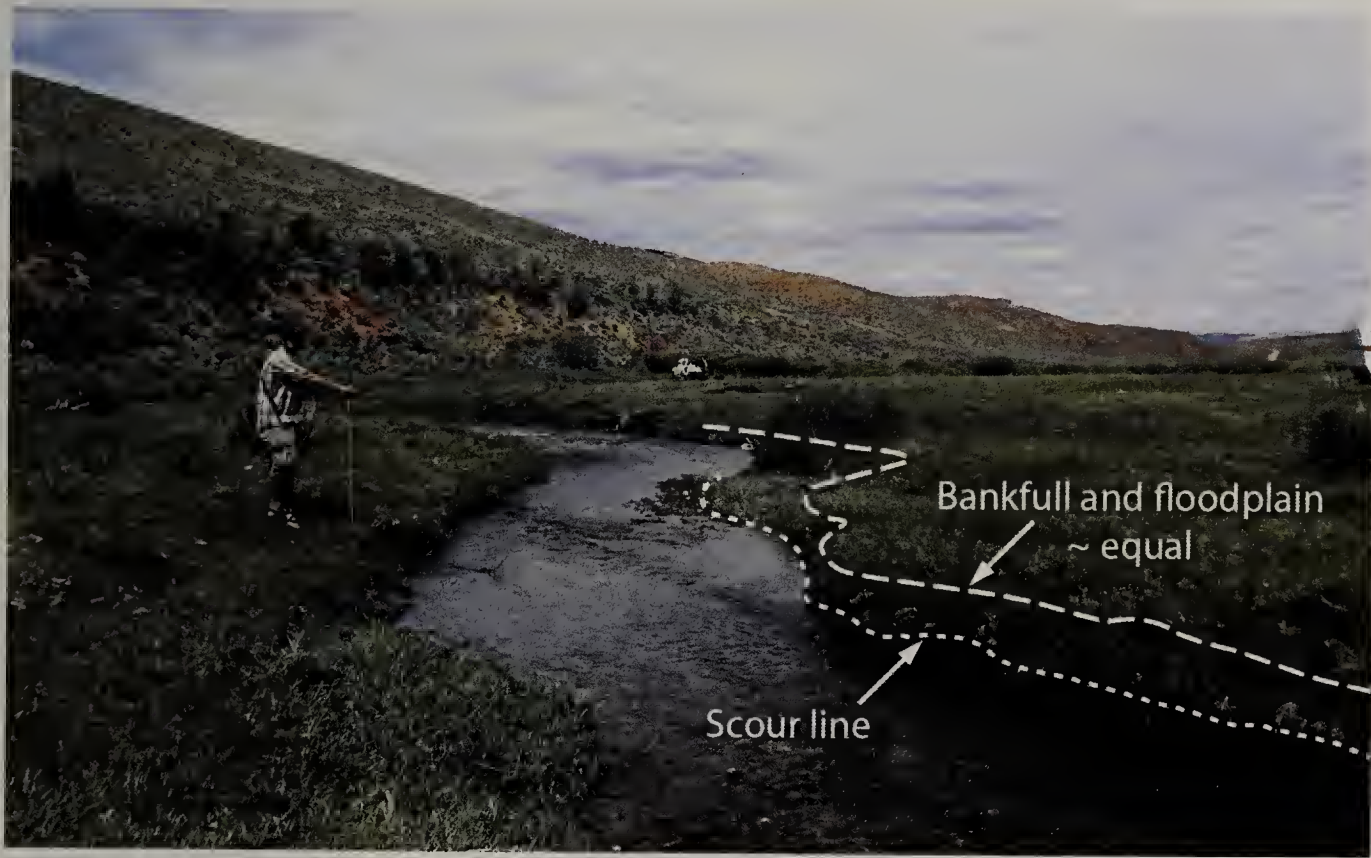


Figure D1. Location of bankfull, floodplain, and scour line heights. Bankfull and floodplain heights are approximately equal for this system.

Figure D2. Bankfull and floodplain heights in a V-shaped valley are equal. Note that this system is not capable of supporting a floodplain.

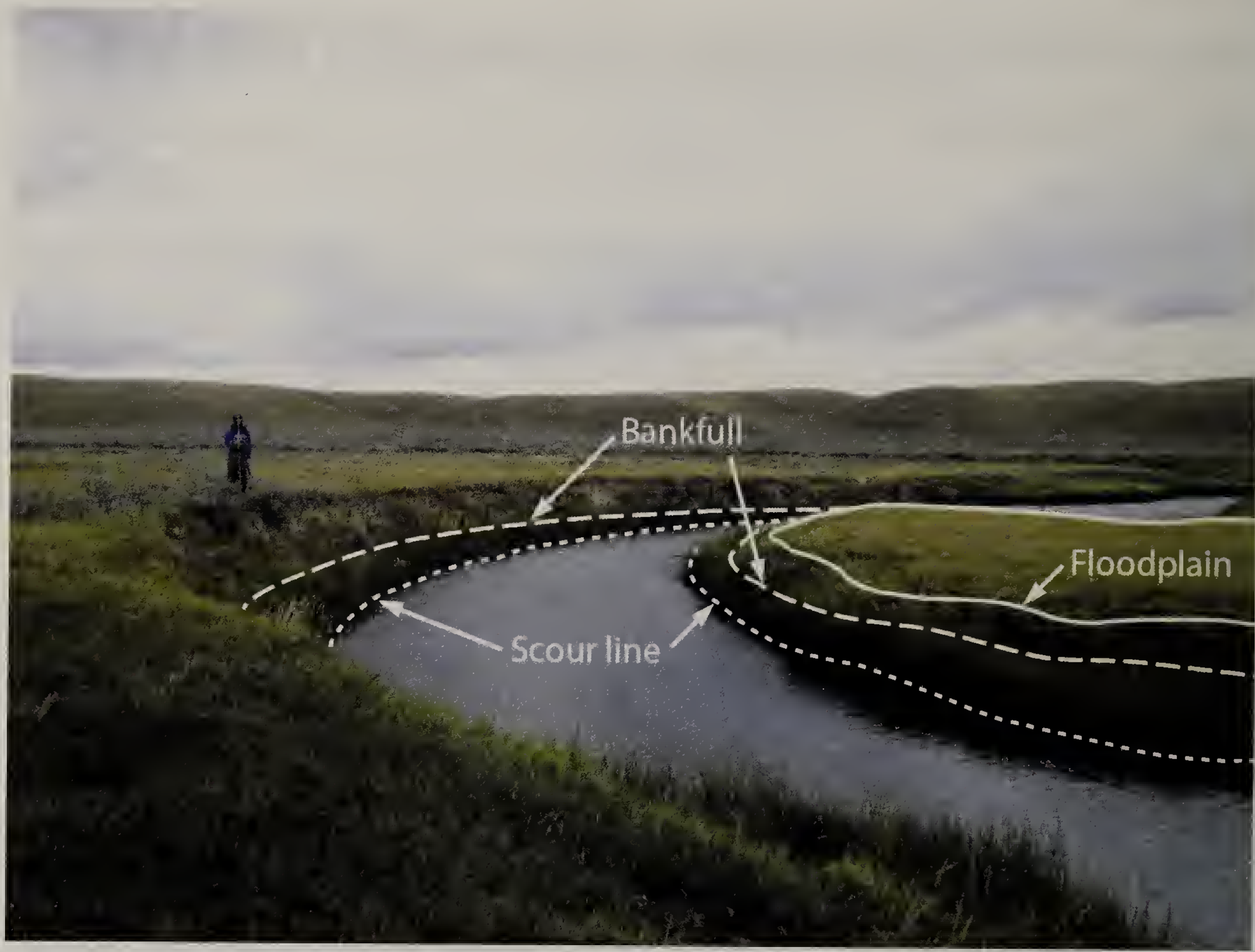


Figure D3. Location of bankfull, floodplain, and scour line heights. Bankfull and floodplain heights differ when no flat depositional feature (i.e., a floodplain) exists at bankfull height.

Figure D4. Location of bankfull and floodplain heights. Bankfull and floodplain heights differ when no flat depositional feature exists at bankfull height.

Figure D5. Bankfull and floodplain heights are approximately equal. In this instance, channel incision occurred historically, and a new inset floodplain has formed.

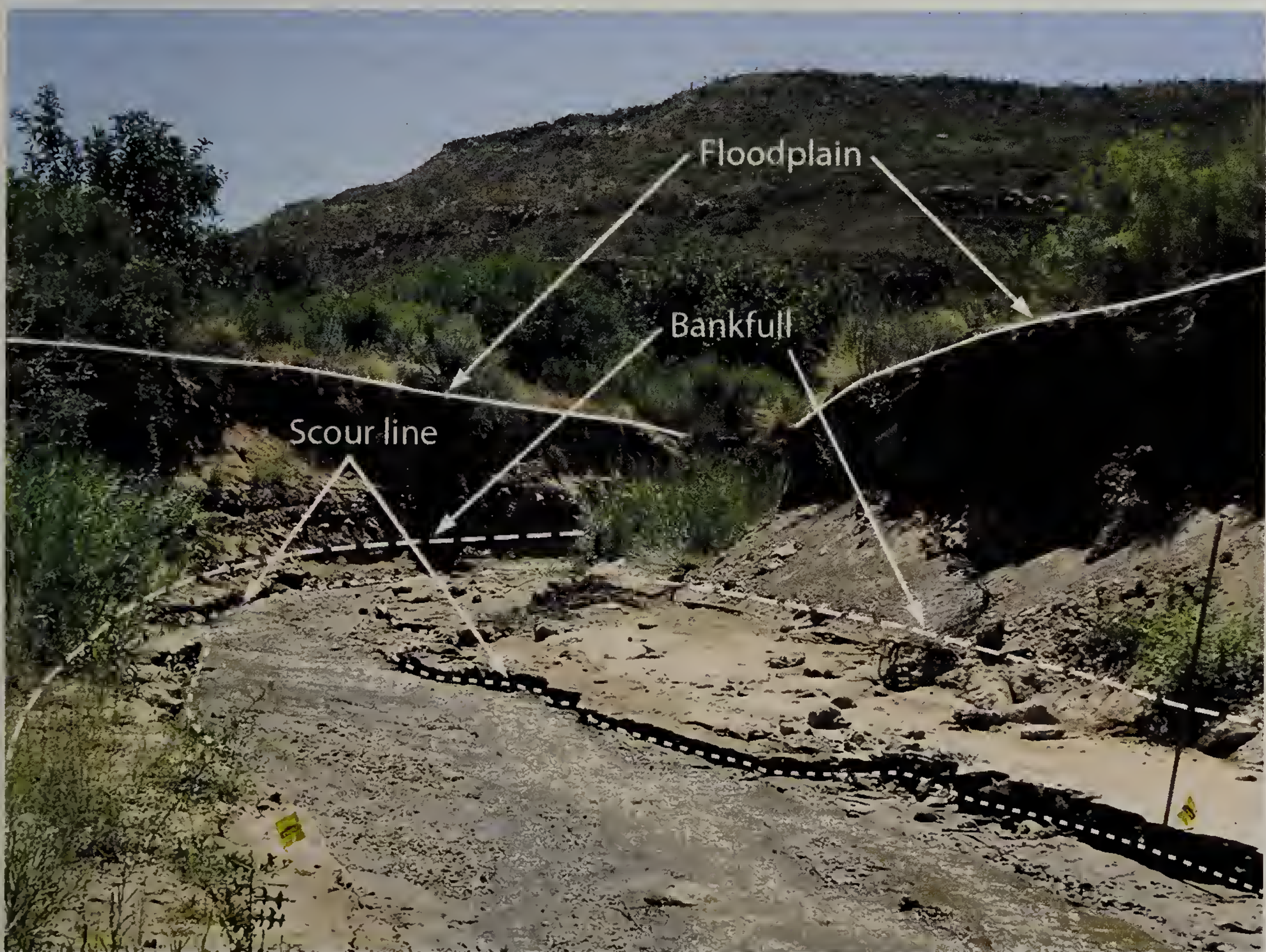


Figure D6. Location of bankfull, floodplain, and scour line heights. Bankfull and floodplain heights differ when no flat depositional feature exists at bankfull height.

Appendix E: Gear List

Table E1. AIM NAMF gear list for sampling wadeable streams.

Sampling Items	Need Based on Core/ Contingent Methods	Quantity
Electronics		
iPad Air (1st generation) with cellular data plan	Required	1
iPad Air screen protector	Required	1
LifeProof case for iPad Air	Required	1
OtterBox iPad strap	Required	1
Car and wall charging devices	Required	1
Portable USB power bank	Optional	1
Camera	Optional	1
GPS	Required	1
Emergency response communication device	Required	1
Water Quality		
YSI (water quality sonde)	Required	1
Pelican 1520 case for YSI storage	Optional	1
YSI calibration fluid and deionized water	Required	1 of each: pH 4, 7, 10
Storage bottles for deionized water and calibration fluid	Required	1 per solution
HOBO temperature probe	If collecting seasonal temperature	1 per site
Turbidimeter	If collecting turbidity	1
Centrifuge vials/alternative bottle	If collecting nutrients	1 per site
Water quality cooler	If collecting nutrients	1
Sterile gloves	If collecting nutrients	1
Water quality labels	If collecting nutrients	1 per site
Slope		
Auto level	Required	1
Tripod	Required	1
Stadia rod (metric)	Required	1
Hand level	Required	1
Benthic Macroinvertebrates		
Surber sampler (500 µm net)	Required	1
Kick net (500 µm net)	Required	1

Sampling Items	Need Based on Core/ Contingent Methods	Quantity
Benthic Macroinvertebrates continued		
Sieve (500 µm mesh)	Required	1
Lobster claw rubber gloves	Required	1
Bug jars	Required	3 per site
95% ethanol (20 L)	Required	1 for every 20 sites
Bug sample labels	Required	6 per site
Squeeze bottles (500 ml)	Required	2
Ethanol bottles (500 ml)	Required	2
Forceps/tweezers	Required	1
Metal spoon	Required	1
Clear packing tape	Required	1
Electrical tape	Required	2
Dish tub/bin	Required	1
Storage bin	Recommended	1
Aquaseal (fast drying)	Required	1
Physical Habitat		
50 m tape measure	Required	1
30 m tape measure	Required	2
Large nails/stakes	Required	2
Ruler with millimeters	Required	1
Densiometer	Required	1
Compass with clinometer	If collecting bank angle	1
Depth rods	Required	2
Pool tail fines grid	If collecting pool tail fines	1
Pool tail fines viewer	If collecting pool tail fines	1
General Sampling Gear		
Pin flags	Required	50
Roll of flagging	Required	1
Action packer	Required	1
Rite in the Rain paper for field forms	Required	1
Waders (breathable)	Required	2
Wading boots (no felt bottoms)	Required	2
Small Tupperware for small items	Recommended	1
Extra batteries	Required	20

Sampling Items	Need Based on Core/ Contingent Methods	Quantity
General Sampling Gear continued		
Clipboard	Required	1
Field forms	Required	20
Pencils and sharpies	Required	20
Calculator	Optional	1
Shears or "loppers" for vegetation	Recommended	1
Duct tape	Required	1
Parachute cord	Required	1
Disinfectant Items	**All are Required**	**Quantity**
Super HDQ Neutral	Required	1
Hydrion strips (Quat Check 1000)	Required	1
Funnel (large)	Required	1
Rubbermaid/Tupperware (about 14 gallon)	Required	1
Scrub brush (long handle)	Required	1
5-gallon water jug (labeled toxic)	Required	2
Safety goggles	Required	1

Appendix F: Suggested Work Flow

This work flow is specific to a two-person crew and is inclusive of all core and contingent indicators and covariates. Sampling can be conducted in a series of "passes" up or down the reach, keeping in mind that more or less passes might be desirable depending on how difficult it is to walk up- or downstream.

1. **Reach Establishment**
   a. Locate point coordinates.
   b. Determine reach length and if the reach can be sampled. If the reach cannot be sampled, classify it as a "failed site."
   c. Set up the reach.
      i. Both technicians measure and flag transects.
      ii. One technician takes coordinates and photos at the F transect, bottom of the reach, and top of the reach.
      iii. The second technician starts on pass 1.
2. **Pass 1**: Collect water quality data, deploy temperature probe (contingent), collect benthic macroinvertebrates, and begin visual assessments.
   a. One technician samples macroinvertebrates.
   b. The other technician:
      i. Fills out the reach verification form.
      ii. Collects water quality data.
      iii. Starts assessing riparian vegetation, human influences (covariate), and instream habitat complexity (fish cover) (contingent).
3. **Pass 2**: One technician measures physical habitat, while the second technician records data and conducts visual estimates of riparian vegetation, human influences (covariate), and instream habitat complexity (fish cover) (contingent).
   a. At each main transect, measure:
      i. Bankfull and wetted width (covariate).
      ii. Bankfull and floodplain height (lower of the two banks).
      iii. Bank stability and cover.
      iv. Bank angle (contingent).
      v. Canopy cover.
      vi. Streambed particle sizes.
   b. Measure large woody debris and thalweg depth profile (contingent) between all transects.

c. At each intermediate transect, measure:
    i. Wetted width (covariate).
    ii. Bank stability and cover.
    iii. Streambed particle sizes.

4. **Pass 3**: Measure pool dimensions.
5. **Pass 4**: Measure slope and flood-prone width (covariate). One technician uses the auto level and records data, and the other technician uses the stadia rod.
6. **Reach completion**
    a. The crew lead runs data quality control and reviews data.
    b. The second technician collects any missing data and cleans up the reach.
7. **Decontaminate gear** (both technicians).

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