BLM

Western

Rivers and Streams

Assessment

(WRSA)

Protocol

2013 Field Season

Compiled by Scott Miller, Sarah Judson,

Nicole Cappuccio, and Jennifer Courtwright

Last updated: 31 May 2013

Field Communication

When contacting Field Office staff directly, please introduce yourself and the project as follows:

- "My name is ___ and I work for the BLM National Aquatic Monitoring Center (aka the BugLab). We are sampling BLM streams and rivers as part of the BLM's Western Rivers and Streams Assessment; I believe Sarah Judson has been in contact with you regarding the accessibility of ___ stream/river and I have some follow up questions. Specifically…"
- Field Offices should be familiar WRSA and should have received email communication
- Field Offices received an online map with specific site numbers
- If they have questions you do not feel qualified to answer, refer them to Jennifer, Sarah, or Scott

Check-in EVERY night by 6pm using the SPOT: If you do not check-in, we will assume a problem!

- Take the SPOT with you to each and every site
- The SPOT "Ok" and "Help" buttons contact the relevant field managers
- Emergency buttons send search and rescue (helicopter). Take this seriously!
- Leave the SPOT on according to the manual instructions training. The following are instructions from the SPOT manual:
    - "To turn SPOT on, press the ON/OFF button. You must wait an additional 2 seconds before activating any SPOT function. When power is on, the indicator light will blink every 3 seconds. To turn SPOT off, press and hold the ON/OFF button for 3 seconds."
    - "For all functions, SPOT lets you know what it's doing. While preparing to send a message, the function indicator and ON/OFF lights will blink green every 3 seconds, in unison. Once SPOT has determined your GPS coordinates and sent your message, the indicator lights will turn solid green for 5 seconds and then continue flashing in unison. If the lights blink out of unison, this indicates that the messenger was not able to determine GPS coordinates, usually due to a blocked view of the sky. To correct, move the SPOT messenger to an area with a clearer view of the sky, where SPOT will automatically continue searching for a GPS signal. The lights will blink in unison once it is successful."
    - To activate a Help or 911 message, press and hold the button for at least 2 seconds. A distress signal and your exact location will be sent to an Emergency Response Center every 5 minutes until cancelled. Once activated, the indicator light will blink green every 3 seconds, and turn solid green for 5 seconds when a message is being sent.
    - To cancel a Help or 911message, press and hold the button for at least 3 seconds. The blinking green light will blink red to indicate that it is preparing to send a "Cancel" message, and will then turn solid red for 5 seconds to indicating a cancelled message.

Check-in by phone with the field manager (Jennifer Courtwright; cell: 985-502-7530) if you have any questions or concerns. Scott Miller (720.545.8367) should be your secondary contact

- Call Jennifer every 2-3 days to communicate your progress and current projected date for returning. If she cannot be reached, please leave a detailed message about your status. If the field manager cannot be reached and you have an urgent need, contact the crew, data, or project managers (Sarah Judson, Scott Miller, or Ryan Leonard). The Field Office may also be contacted if contacts are available in the site packet.

Safety

Driving – This is the most dangerous task we are charged with and we will be logging many hours behind the wheel covering a lot of territory during the summer.

- The driver is not to talk on a cell phone or text while driving! Ask your passenger to text/call for you, particularly if you need to communicate with the field manager.
- **Never** attempt to multi-task while you are driving (e.g. reading maps, iPod, etc). Pull over at a safe spot to take care of miscellaneous activities.
- Road conditions will vary so drive accordingly!
- **You are not to drive after 9 pm**
    - Plan your next night stop considering time for field work and driving before leaving camp to prevent this situation.
    - In an emergency or unexpected situation (e.g., flat tire) that prevent you from reaching you destination before dark, make sure you get in touch with your field contact.
- You are not to drive more than 12 hours per day without supervisor authorization
    - This means the total number of hours spent in the vehicle
    - If it takes >12 hours to get to a field site you can get a hotel room for the evening.
    - One person is NOT to drive more than 6 consecutive hours
        - Passengers: You are the navigator, pay attention, and help your driver.
- You must fill-out the truck usage form every time you get fuel and for every day of use!
- NO alcohol in trucks! Alcohol is not supposed to be transported in government or state vehicles.

Hiking – We will be hiking alone in remote areas often. Be smart!

- Know your own and your crew's limits. Our safety is the most important thing while in the field.
- Be aware of broader conditions of where you are hiking to and where you need to drive to get out.
- If you are bushwhacking, record GPS coordinates at the truck or trailhead before proceeding. Use logical waypoint names and check that the waypoint saved.
- Always carry a daypack including: SPOT, first aid kit, satellite phone, GPS, maps, compass, warm clothing, food, waterproof matches or lighter ,and a headlamp.
- Be conscious of weather patterns and fire danger. DO NOT work in streams during thunderstorms.

Can't access a site - If you can't get to a site safely because of road conditions or high flows, skip the site AFTER consulting with the field manager.

Work Related Illness and Accident Reporting -- If an employee is injured or suffers an occupational illness at work, they must report this to their supervisor immediately and fill out the proper forms provided in the glove box of each vehicle.

Protocol Summary and Amendments

1. Locate the X-site and determine sampling status (p. 21-25; Verification form)
   - Sliding the reach (p. 29-30): except for the following examples, the reach should not be slid so that it no longer contains the X-site:
     - If your site contains < 50% water, you can slide the reach to obtain more water
     - Unsafe to access, incoming trib that changes stream order, beaver ponds creating continuous lentic habitat
     - Change in landownership with access denied

     In all instances, where the reach is slid to not contain the X-site, these restrictions apply:
     - For 150 m reaches: maximum deviation from X-site is 150 m
     - For reaches > 150 m: maximum deviation from X-site is 250 m
     - Do not slide the reach if the stream will then change stream order

     When in doubt, contact Jennifer to discuss the pros and cons of your decision process

2. Laying out the reach (p. 26-28; Verification form)
   - Determine reach length
     - If width is < 3.75 m use 150 m as reach length
     - If width is >100 m use 4 km as reach length
     - Otherwise the reach length is 40 times wetted width
   - Do not move transects if there are barriers. Estimate measurements as best you can

3. Site coordinates (Verification & Bank Stability form)
   - In addition to the X-site coordinate, coordinates are recorded for BR and TR (p. A7)

4. Photos (p. A5; Assessment form: comments section)

5. YSI (p. 33-34; Field Measurement form**)** & water sample (Sample Collection form)
   - Calibrate the YSI at least once per week or if erratic/unusual values are observed
   - Take in-situ pH, conductivity, and temperature at X-site, skip DO
   - Deploy temp probe immediately upon arrival (p. A6)
   - Take ONLY the water chemistry sample and marks others as "No Sample Collected"

6. Benthic inverts (p. 41-48; Sample Collection form)
   - Always use Surber sampler, if possible. If Surber used, ignore time constraint

7. PHAB
   - Wetted width and bar width (p. 88-89)
   - Bankfull and incision height (p. 75, 78-81)
     - If the first terrace above or at bankfull has recent depositional features, incision height should be measured at the second terrace. Unless there is no incision present.
   - Bank angle (p. 75-78)
     - If wetted width < 1 m, use 20% of average reach wetted width for the comfortable criteria to determine bank angle instead of 50 cm
   - Bank stability (p. A7-8;Bank Stability form)
   - Water depth
   - Substrate (p. 73-75)
     - Measure the b-axis (mm) of all particles and then place into the appropriate bin
   - Embeddedness (p. 74-75)

    - Assess particles within a 10 cm radius circle around depth rod and do not include leaves or calcite deposits.
- Canopy cover (p. 82-83)
- Fish cover (p. 85-86)
    - Estimate the linear extent of the L and R banks and NOT the aerial cover
    - Include artificial wood (i.e. 2X4s, RR ties etc.), but note as such
- Riparian vegetation cover (p. 83-85)
    - Vegetative cover should be considered for three separate strata (>5 m, 5 – 0.5 m and < 0.5 m), where vegetation spans multiple strata, cut at the respective height criteria
    - <0.5 m category must add up to 100%
    - Include boulders in the barren, bare dirt, or duff category but note it
- Human influence (p. 86-88)

8. Longitudinal Profile (p. 56-64; PHAB: Thalweg Profile & Woody Debris form)

9. Large woody debris (p. 64-66; PHAB: Thalweg Profile & Woody Debris form)
    - Only measure the length of the wood corresponding to > 10 cm in diameter
    - If LWD is only partially in the stream, measure the entire length > 10 cm in diameter
    - Include artificial wood (i.e. 2X4s, RR ties etc.), but note as such

10. Slope (PHAB: Slope and Bearing form) (p. 66-70)
    - Make sure to properly adjust for moving the tripod and back-sighting
    - Do not take bearing, unless BR and TR coordinate accuracy < 10 m (p. A7)

11. Overall site assessment
    - Torrent Evidence Assessment form (p. 94-95)
    - Channel Constraint form (p. 91-92)
    - Assessment form (p. 152)

12. Pickup temperature probe (p. A6)

13. Decontaminate gear

14. Label samples: Use the pre-populated labels that match your tracking form

15. Sample tracking
    - Site and Sample Status/Water Chemistry Lab Tracking form: Fill-in the bubbles for: "Hand delivery", "Sent to State" for the CHEM sample and "Collected" for the BERW (BERB is benthic sample at boatable sites).
        - SampleID will be prepopulated for CHEM to correspond to labels
    - Tracking Batch Samples form: Fill-in the bubbles for: "Hand delivery"
        - SampleID will be prepopulated for BERW to correspond to labels
        - State lab address: NAMC, 5210 Old Main Hill, Logan, UT 84322-5210

16. Field form review
    - The crew leader is responsible for initialing each form to ensure correctness and completeness

Photos

Objectives: Document reach condition, unique features and to provide visuals for reports

Follow these directions when taking photographs:

- Always take the SiteID/Date photo first (Assessment form: comments section)
- Take 3 photos at the X-site: 1. Upstream; 2. Downstream and 3. Overview (taken at a greater distance to show a general reach overview)
- Until notified, take a photo(s) for discussing bankfull and terrace elevations in the lab
- Take photos of unique features (e.g., waterfalls, beaver dams, rip-rap, grazing, dams)

Photo tips:

- Do not use the zoom feature
- Avoid taking photos into the sun, take photos with the sun at your back
- Hold the camera 1.5 meters from the ground. (use a depth rod to standardize)
- A depth rod should be in all photos.
- Try and get both banks in the photo. For smaller streams stand back from the object of interest a distance of 5 meters. For larger streams (> 8 meters wide) stand back 10 meters or at the best distance to assure you can see both banks.

Collect the following information as required for each photo in the designated area of the "General Assessment and Comments" section on the back of the "Assessment" form. For additional photos beyond the 3 per site, repeat the line "PhotoID: Location:Transect: Description: " exactly as it appears on the form and then fill in the specific photo details.

- PhotoID: Record the picture number from the display screen after you take the photo.
- Location: Number of the closest transect from which the photo was taken (if taken at a location other than the X-site)
- Description: additional details about the photo (e.g., cardinal direction, features of interest)

Temperature probes

Objectives: to quantify the maximum daily temperature.

Deploy a temperature probe immediately upon arrival at a site. The probe should be deployed for the entire time that you are at a site (the optimal time for probe deployment is between 14:00 and 18:00; therefore, deploy the probe upon arriving at a site even if you will not be setting up the reach that day).

- Use the same probe for five site intervals. We want you to switch the prbe after five sites in the event that the probe is lost or forgotten
- Before deployment, ensure that the red light is blinking on the temperature probe (cup end of probe in hands to assist with viewing the blinking light). If you cannot see the blinking light, deploy a new probe
- All probes should be contained within a PVC case
- If you are at a site overnight, keep the probe deployed in the water

Anchoring instructions

- Use the provided anchor weight to locate the temperature probe in an area of water greater than knee deep.
- If knee deep water is not present, place the temperature probe in the deepest possible water. In some cases it might be necessary to excavate the substrate, but the temperature probe should not be buried or exposed at the water surface
- The probe should settle in the water channel and should not bob on the surface
- Avoid locating the probe in areas just downstream of tributaries, obvious groundwater seeps and beaver ponds

Enter the following information on the "Field Measurement" form in the designated area

- ProbeID
    - When documenting the probeID, be certain to record the serial number (e.g., 7 or 8 digit serial number on a white sticker) and NOT the model number (e.g., Model # U22-001)
    - Start Time and End Time
        - 4-digit Military format (12:10 = 10 min after Noon; 14:17 = 2:17 PM)
        - Add Start and End Dates if deployment spanned multiple days

Sinuosity

Objective: to measure valley length for computation of sinuosity

In addition to the X-site coordinate, coordinates will be recorded for both the bottom of reach (BR) and top of reach (TR). The coordinates are to be recorded on the "Bank stability form" in decimal degrees and accuracy is recorded in meters. This replaces the need to take bearings while doing slope, but ONLY if the accuracy is less than 10 meters for BOTH BR and TR. If this level of accuracy cannot be achieved, the EPA-NRSA bearing method must be used (see p.66-72, with method steps on p. 72).

Saving coordinates (i.e., way points): The waypoint names are to be saved in the GPS as follows:

- #### - AA
    - The four numbers are the numeric digits at the end of the SiteID
    - The two letters are the location of the coordinate
        - XS = X-site (midpoint)
        - BR = Bottom of Reach
        - TR = Top of Reach
    - Ex: 5555-BR

Bank stability/cover

Objective: Classify bank stability and cover to estimate the percentage of stable or unstable stream banks.

Bank stability and cover are evaluated at both left and right banks for the main 11 transects and the 10 additional intermediate cross-sections. Note: substrate size is also taken at these two locations, therefore the stability measurement can be taken at the start and end of each substrate cross-section and in conjunction with bank angle on the main transects.

The following protocol is copied with slight modification from BLM Multiple Indicator Monitoring (MIM), pages 47-50 and Appendix E:

- Determine Streambank Location: Streambanks are defined as that part of the channel between the scour line and the edge of the first relatively flat bench above the scour line (Fig. E1 & E2).
- Determine Plot Frame: The plot (area observed for streambank stability) extends parallel to the stream a distance of 50 cm (25 cm to each side of transect flag) and perpendicular to the stream between the scour line to the first flat or depositional feature. If depositional features are absent, use 1 m above bankfull as the upper most extent.
    - Establishing Scour Line: The demarcation between streambed and bank. Typical scour line indicators are the ceiling height of undercut banks at or slightly above the summer low-flow elevation or, on depositional banks, the lower limit of sod-forming or perennial vegetation.
    - Establishing First Bench: The first flat depositional feature at or above bankfull. The lip of the first bench is at the point on the bench where the slope changes from the relatively flat top to the slope toward the stream.
- Assess bank type, cover, and stability:
    - Bank type: What kind of bank is it?
        - **Depositional (D)**: This applies to all streambanks associated with sand, silt, clay, or gravel deposited by the stream. These are recognizable as "bars" in the channel margins adjacent to the greenline, typically lenticular-shaped mounds of deposition on the bed of the stream channel adjacent to or on the streambank.
        - **Erosional (E)**: This applies to all banks that are not "Depositional."

- Bank cover
  - **Covered (C)**: This applies to banks with at least 50% cover within the plot frame of the following types or combination thereof (Fig. E3 & E4):
    - perennial vegetation (including roots)
    - cobbles 15 cm or larger
    - anchored large woody debris (LWD) with a diameter >10 cm
    - Moss does not count as cover
  - **Uncovered (U)**: This applies to all banks that are not "Covered." (Fig. E6)

- Bank stability
  - Record the single most prominent feature of the following 5 types:
    - To qualify, a feature must be obvious and span at least one-fourth (13 cm) of a frame width or greater.
    - If no feature meets the minimum criteria, the bank stability is classified as **Absent (A).**
  - **Fracture (F):** This applies to the top of the bank where a visible crack is observed (Fig. E4). The fracture has <u>not</u> separated into two separate components or blocks of a bank.
  - **Slump (S)**: This applies to a streambank that has obviously slipped down resulting in a separate block of soil/sod separated from the bank (Fig. E3 & E5). Slumps may be created by excessive animal trampling.
  - **Slough (L)**: This applies to banks where soil or sod material has been shed or cast off and has fallen from and accumulated near the base of the bank and typically occurs on banks that are steep and bare (Fig. E1).
  - **Eroding (E)**: This applies to banks that are bare and steep (within 10 degrees of vertical), usually located on the outside curves of meander bends in the stream (Fig. E6). 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, and because such erosion occurs mostly below the scour line (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.

APPENDIX E: STREAMBANK STABILITY AND COVER EXAMPLES

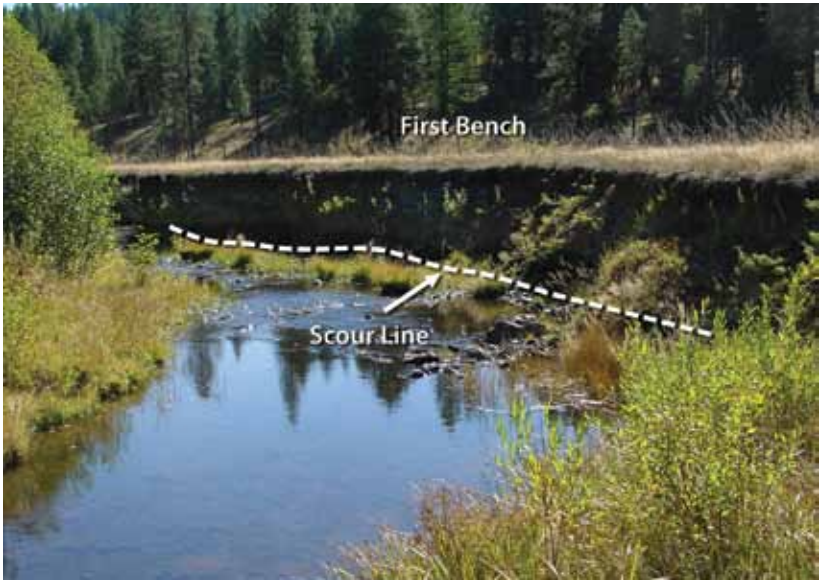


Figure E1. The first bench is the first relatively flat area above the scour line or edge of the water. An abrupt steep face from the edge of the bench to the scour line is characteristic of a "cut bank." Slough from the bank wall has direct access to the stream.

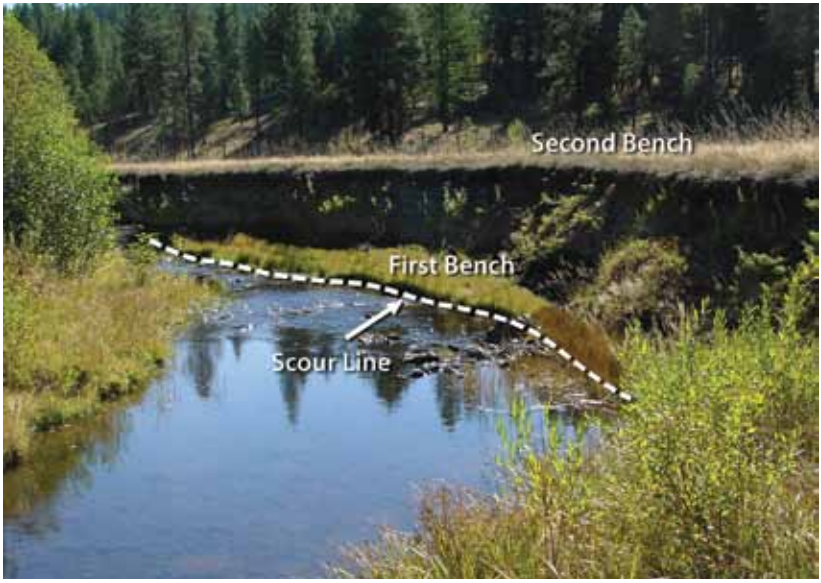


Figure E2. A new floodplain has developed creating the first bench at a lower elevation. Slough from the second bench does not go directly into the stream, as it is filtered by the first bench or new floodplain.

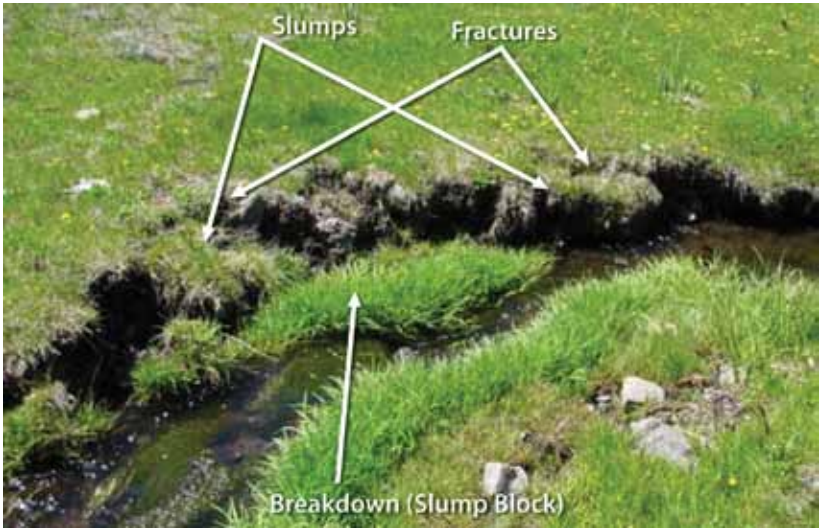


Figure E3. Erosional features help determine the stability of a streambank. Slump blocks that are detached from the streambank and now isolated to the channel are not considered part of the streambank. Slumps must be obviously sliding down but still attached as part of the streambank. Fractures must be obvious at the top of the bank or on the bench.

Figure E4. This large fracture has at least 50 percent vegetation cover and is thus recorded as erosional (E), covered (C), and fracture (F).

Figure E5. The stream in this photo is flowing at the scour line. The streambank is erosional (E), slump blocks are mostly covered (C), and slump (S) is recorded.

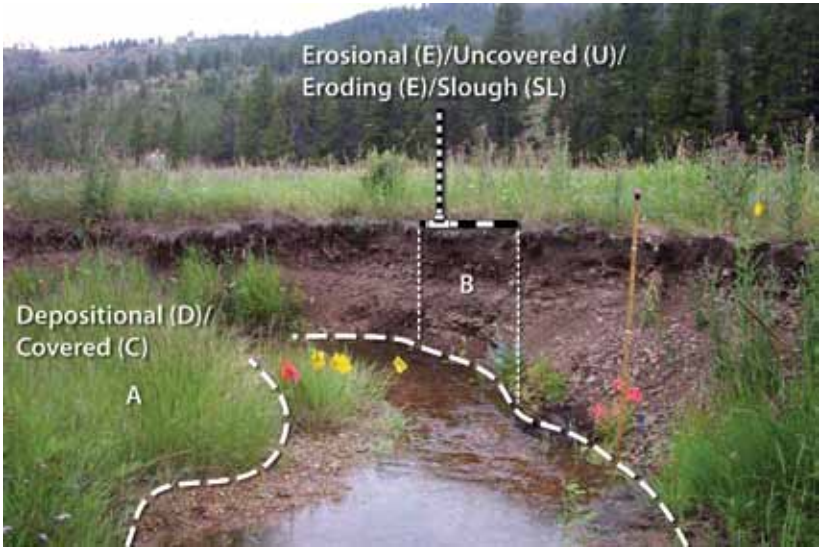


Figure E6. The dotted line represents the scour line. "A" is a point bar, thus it is depositional (D) and covered (C). "B" shows the length of streambank evaluated. The streambank evaluated is erosional (E), uncovered (U), and eroding (E) or slough (SL). Photo - PIBO, U.S. Forest Service.

Figure E7. The left streambank is a point bar that is depositional (D) and covered (C). Slump blocks on the right bank are mostly covered with vegetation and are still attached to the streambank above the scour line and therefore are recorded as erosional (E), covered (C), and slump (S). The dashed line is the greenline. Photo - PIBO, U.S. Forest Service.

Figure E8. Slump blocks and slumping banks covered with vegetation are recorded as erosional (E), covered (C), and slump (S). The dashed line is the greenline.

United States Environmental Protection Agency
Office of Water
Office of Environmental Information
Washington, DC
EPA-841-B-12-009

National Rivers and Streams Assessment 2013/14

Field Operations Manual

Wadeable

Draft Version 1

March 2013

TABLE OF CONTENTS

TABLE OF CONTENTS ..... **i**

3 INITIAL SITE PROCEDURES **21**

3.1 SITE VERIFICATION ACTIVITIES 21
3.1.1 Locating the X-Site *21*
3.1.2 Determining the Sampling Status of a Stream *22*
3.1.3 Sampling During or After Rain Events *25*
3.1.4 Site Photographs *25*
3.2 LAYING OUT THE SAMPLING REACH 26
3.2.1 Sliding the Reach *29*
3.3 MODIFYING SAMPLE PROTOCOLS FOR HIGH OR LOW FLOWS 30
3.3.1 Streams with Interrupted Flow *30*
3.3.2 Braided Rivers and Streams *31*

4 WATER CHEMISTRY / CHLOROPHYLL-A SAMPLE COLLECTION AND PRESERVATION **33**

4.1 IN SITU MEASUREMENTS OF DISSOLVED OXYGEN, PH, TEMPERATURE, AND CONDUCTIVITY 33
4.1.1 Summary of Method *33*
4.1.2 Equipment and Supplies *33*
4.1.3 Sampling Procedure *34*
4.2 WATER CHEMISTRY SAMPLES 36
4.2.1 Summary of Method *36*
4.2.2 Equipment and Supplies *36*
4.2.3 Water Chemistry and Chlorophyll-a Sampling Procedure *36*

6 BENTHIC MACROINVERTEBRATES 41

6.1 SUMMARY OF METHOD 41
6.2 EQUIPMENT AND SUPPLIES 41
6.3 SAMPLING PROCEDURE 43
6.4 SAMPLE PROCESSING IN FIELD 47

8 PHYSICAL HABITAT CHARACTERIZATION 53

8.1 EQUIPMENT AND SUPPLIES 53
8.2 SUMMARY OF METHODS APPROACH 54
8.3 COMPONENTS OF THE HABITAT CHARACTERIZATION 54
8.4 WORK FLOW FOR THE PHYSICAL HABITAT COMPONENTS 55
8.4.1 Thalweg Profile and Large Woody Debris Tally 55
8.4.2 Channel/Riparian Cross-Sections 55
8.4.3 Channel Constraint and Torrent Evidence 56
8.4.4 Stream Discharge 56
8.5 HABITAT SAMPLING LOCATIONS WITHIN THE REACH 56
8.5.1 Thalweg Profile and Large Woody Debris Measurements 59
8.6 CHANNEL AND RIPARIAN MEASUREMENTS AT CROSS-SECTION TRANSECTS 66
8.6.1 Slope and Bearing 66
8.7 SUBSTRATE SIZE AND CHANNEL DIMENSIONS 73
8.7.1 Bank Characteristics 75
8.8 CANOPY COVER MEASUREMENTS 82
8.9 VISUAL RIPARIAN ESTIMATES 83
8.9.1 Riparian Vegetation Structure 83
8.10 INSTREAM FISH COVER, ALGAE, AND AQUATIC MACROPHYTES 85
8.11 HUMAN INFLUENCE 86
8.12 CROSS-SECTION TRANSECTS ON SIDE CHANNELS 88
8.13 CHANNEL CONSTRAINT, DEBRIS TORRENTS, RECENT FLOODS, AND DISCHARGE 91
8.13.1 Channel Constraint 91
8.13.2 Debris Torrents and Recent Major Floods 94
8.14 STREAM DISCHARGE 97
8.14.1 Velocity-Area Procedure 97
8.14.2 Timed Filling Procedure 101
8.14.3 Neutrally Buoyant Object Procedure 102

:=

13 FINAL SITE ACTIVITIES 151

13.1 OVERVIEW OF FINAL SITE ACTIVITIES 151
13.2 GENERAL SITE ASSESSMENT 152
13.2.1 Watershed Activities and Disturbances Observed 152
13.2.2 Site Characteristics 152
13.2.3 General Assessment 152
13.3 PROCESSING THE FECAL INDICATOR, CHLOROPHYLL-*A*, AND PERIPHYTON SAMPLES 154
13.3.1 Equipment and Supplies (Fecal Indicator Filtering) 154
13.3.2 Procedures for Processing the Fecal Indicator Sample 154
13.3.3 Equipment and Supplies (Chlorophyll-a from Water Sample Filtering) 156
13.3.4 Procedures for Processing the Chlorophyll-a Water Sample 156
13.3.5 Equipment and Supplies (Periphyton Sample) 157
13.3.6 Procedures for Processing the Periphyton Samples 158
13.4 DATA FORMS AND SAMPLE INSPECTION 161
13.5 LAUNCH SITE CLEANUP 161

3 INITIAL SITE PROCEDURES

When you arrive at a site, you must first confirm you are at the correct site, and then determine if the site meets the criteria for sampling and data collection activities (See Site Evaluation Guidelines EPA-841-B-12-008). Inspect the selected reach for appropriate access, safety, and general conditions. Decide whether the site is at base flow condition and not unduly influenced by rain events which could affect the representativeness of field data and samples. If you determine that the site can be sampled, lay out a defined reach within which all sampling and measurement activities are conducted.

3.1 Site Verification Activities

3.1.1 Locating the X-Site

River and stream sampling points were chosen using the National Hydrography Dataset (NHD), in particular NHD-Plus, following a systematic randomized selection process (Stevens and Olsen, 2004). Each point is referred to as the "X-site." The "X-site" is the mid-point of the sampling reach, and it will determine the location and extent for the rest of the sampling reach. The latitude/longitude of the "X-site" is listed on the site spreadsheet that was distributed to each field crew leader. Table 3.1 provides the equipment and supplies needed for site verification.

Note that the coordinates provided on the site spreadsheet may not be located in the middle of the stream or river; and in some cases, the coordinates may be on dry land next to the stream or river. In these cases, it is important for crews to locate the x-site at a point that is in the middle of the stream or river (e.g. midway between the left and right banks). To do this, simply measure the distance between banks and move the point perpendicular to the nearest bank until it is half-way between the left and right banks. Record these coordinates as the x-site on the verification form. If the site falls on dry land near a stream, move the X site to the nearest blue line. Record the coordinates as the x-site on the verification form.

Table 3.1 Equipment and Supplies List for Site Verification

For locating and verifying site	Sampling permit and landowner access (if required). Field Operations Manual and laminated Quick Reference Guide. Site dossier, including access information, site spreadsheet with map coordinates, street and/or topographic maps with "X-site" marked. NRSA Community Fact Sheets. GPS unit (preferably one capable of recording waypoints) with manual, reference card, extra battery pack. Surveyor's flagging tape (to mark transects). Laser rangefinder. 50 m or 100 m measuring tape with reel (if not using rangefinder).
For recording measurements	Clipboard #2 pencils Site Verification Form Fine-tipped indelible markers to write on flagging

3.1.2 Determining the Sampling Status of a Stream

After you confirm the location of the X-site, evaluate the stream reach surrounding the X-site and classify the stream into one of three major sampling status categories: sampleable, non-sampleable, or no access (Table 3.2). The primary distinction between "Sampleable" and "Non-Sampleable" streams is based on the presence of a defined stream channel, water content during base flow, and adequate access to the site.

There must be greater than 50% water throughout the channel reach. If the channel is dry at the X-site, determine if water is present within 75 m upstream and downstream of the X-site. If there are isolated pools of water within the reach that equal greater than 50% of the reach length, proceed to sample using the modified procedures outlined in Section 3.1.1. Do not drop the site if it is dry at the X site, as long as there is greater than 50% water throughout the channel. If less than 50% of the reach has water, classify the site as "Dry-visited" on the verification form. NOTE: Do not "slide" the reach (Section 3.2.1) for the sole purpose of obtaining more water to sample (e.g., the downstream portion of the reach has water, but the upstream portion does not).

Record the sampling status and pertinent site verification information on the Verification Form (Figure 3.1). If the site is non-sampleable or inaccessible, no further sampling activities are conducted. Replace the site with the first oversample site on the state list within the same category based on Strahler order and whether it is a 2008/09 resample site (Section 1.3).

Table 3.2 Site Verification Procedures

1. **Find the stream/river location in the field corresponding to the X-site coordinates**. Record the routes taken and other directions on the Verification Form so that others can visit the same location in the future. If the site is non-wadeable, locate public or private launch sites.
2. **Use a GPS receiver to confirm the latitude and longitude at the X-site** with the coordinates provided for the site (datum = NAD 83). Record these on the Verification Form.
3. **Use all available means to insure you are at the correct stream/river** as marked on the map, including 1:24,000 United States Geological Society (USGS) maps, topographic landmarks, road maps, signs, local contacts, etc.
4. **Scan the channel upstream and downstream from the X-site, decide if the site is sampleable, and mark the appropriate bubble on the verification form**.
5. If the channel is dry at the X-site, determine if water is present within 75 m upstream and downstream of the X-site. Assign one of the following sampling status categories to the stream. Record the category on the Verification Form.

Sampleable Categories

Wadeable: Continuous water, sampled by wading.

Boatable: Continuous water, too deep to sample by wading.

Partial wadeable: Sampled by wading (>50% of reach sampled).

Partial boatable: Sampled by boat (>50% of reach sampled).

Wadeable Interrupted: not continuous water along reach, >50% water in reach.

Boatable Interrupted: not continuous water along reach, >50% water in reach.

Altered Channel: Stream/river channel present but differs from map.

Non-Sampleable Categories

PERMANENT

Dry Channel: Less than 50% water within the reach. Record as “Dry-Visited.” If site was determined to be dry (or otherwise non-perennial) from another source and/or field verified before the actual sampling visit, record as “Dry-Not visited”.

Wetland: Standing water present, but no definable stream channel. If wetland is surrounding a stream channel, define the site as Target but restrict sampling to the stream channel.

Map Error: No evidence that a water body or stream channel was ever present at the X-site.

Impounded stream: Stream is submerged under a lake or pond due to manmade or natural (e.g., beaver dam) impoundments. If the impounded stream is still wadeable, record it as “Altered” and sample.

Other: Examples would include underground pipelines, or a non-target canal. A sampling site must meet both of the following criteria to be classified as a non-target canal:

The channel is constructed where no natural channel has ever existed.

The sole purpose/usage of the reach is to transfer water. There are no other uses of the waterbody by humans (e.g., fishing, swimming, and boating).

TEMPORARY

Not Boatable: need a different crew.

Not Wadeable: need a different crew.

Other: The site could not be sampled on that particular day, but is still a target site. Examples might include a recent precipitation event that has caused unrepresentative conditions.

No Access to Site Categories

Access Permission Denied: You are denied access to the site by the landowner.

Permanently Inaccessible: Site is unlikely to be sampled by anyone due to physical barriers that prevent access to the site (e.g., cliffs).

Temporarily Inaccessible: Site cannot be reached due to barriers that may not be present at a future date (e.g. forest fire, high water, road temporarily closed, unsafe weather conditions).

6. Do not sample non-target or "Non-sampleable" or "No Access" sites. Fill in the "NO" bubble for "Did you sample this site?" and mark the appropriate bubble in the "Non-Sampleable" or "No Access" section of the Verification Form; provide a detailed explanation in comments section.

3.1.3 Sampling During or After Rain Events

Avoid sampling during high flow rainstorm events. It is often unsafe to be in the water during such times. In addition, biological and chemical conditions during such episodes are often quite different from those during baseflow. On the other hand, sampling cannot be restricted to only strict baseflow conditions. It would be next to impossible to define "strict baseflow" with any certainty at an unstudied site. Such a restriction would also greatly shorten the index period when sampling activities can be conducted. Thus, some compromise is necessary regarding whether to sample a given stream because of storm events. To a great extent, this decision is based on the judgment of the field crew. Some guidelines to help make this decision are presented in Table 3.3. The major indicator of the influence of storm events will be the condition of the stream itself. **If you decide a site is unduly influenced by a storm event, do not sample the site that day**.

Table 3.3 Guidelines to Determine the Influence of Rain Events

- If it is running at bank full discharge or the water seems much more turbid than typical for the class of stream do not sample it that day.
- Do not sample that day if it is unsafe to be in the water.
- Keep an eye on the weather reports and rainfall patterns. Do not sample a stream during periods of prolonged heavy rains.
- If the stream seems to be close to normal summer flows, and does not seem to be unduly influenced by storm events, sample it even if it has recently rained or is raining.

3.1.4 Site Photographs

Taking site photographs is an optional activity, but should be considered if the site has unusual natural or manmade features associated with it. If you do take photographs with a digital camera at a site, date stamp the photograph and include the site ID. Alternatively, start the

sequence with one photograph of an 8.5 × 11 inch piece of paper with the site ID, waterbody name, and date printed in large, thick letters. After the photo of the site ID information, take at least two photographs at the X-site, one in the upstream direction and one downstream. Take any additional photos you find interesting after these first three pictures. Keep a log of your photographs and briefly describe each one.

3.2 Laying out the sampling reach

Many of the biological and habitat structure measures require sampling a certain length of a stream to get a representative picture of the ecological community. **A length of 40 times the channel width is necessary to characterize the habitat and several biotic assemblages associated with the sampling reach.** Establish the sampling reach about the X-site using the procedures described in Table 3.4 (wadeable sites).

When you arrive at the site, scout the sampling reach to make sure it is clear of obstacles that would prohibit sampling and data collection activities. Record the channel width used to determine the reach length, and the sampling reach length upstream and downstream of the X-site on page 2 of the Verification Form as shown in Figure 3.2. Figure 3.3 illustrates the principal features of the established sampling reach for wadeable sites, including the location of 11 cross-section transects used for collecting samples and physical habitat measurements. The figures also show the specific sampling stations on each transect for collection of periphyton, and benthic macroinvertebrate samples.

Before leaving the stream, complete a rough sketch map of the stream reach you sampled on page 2 of the Verification Form (Figure 3.2). In addition to any other interesting features that should be marked on the map, note any landmarks/directions that can be used to find the X-site for future visits.

Table 3.4 Laying Out the Sampling Reach at Wadeable Sites

1. Locate the X-site using the coordinates provided for the site.
2. Use a surveyor's rod, tape measure, or laser range finder to determine the wetted width of the channel at 5 places of "typical" width within approximately 5 channel widths upstream and downstream from the X-site. Average the 5 readings together and round to the nearest 1 m. If the average width is <4 m, use 150 m as a minimum reach length. If the average width is >100 m, use 4 km as a maximum reach length. Record this width on page 2 of the Site Verification Form.
3. *For channels with "interrupted flow", estimate the width based on the unvegetated width of the channel (again, with a 150 m minimum and 4 km maximum).*
4. Check the condition of the stream about the X-site by having one crew member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 20 times the average channel width (equal to one-half the sampling reach length) determined in Step 2.
5. Determine if the reach needs to be adjusted about the X-site due to confluences with higher order streams (downstream), transitions into lower order streams (upstream), impoundments (lakes, reservoirs, ponds), physical barriers (e.g., falls, cliffs), or because of access restrictions to a portion of the initially determined sampling reach. Refer to Section 3.2.1..
6. Starting at the X-site (or the new midpoint of the reach if it had to be adjusted as described in Step 4), measure a distance of 20 channel widths down one side of the stream using a GPS unit, laser rangefinder, or tape measure. Be careful not to "cut corners". Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach, and is flagged as Transect "A".

7. At Transect A, use the seconds display on a digital watch to select the initial sampling station for standard transect samples: 1-3="Left", 4-6="Center", 7-9=Right. Mark "L", "C", or "R" on the transect flagging; the 3 potential collection points are roughly equivalent to 25%, 50%, and 75% of the channel width, respectively. Note that left and right sides of the stream are determined while you are facing downstream. It is at these locations that you will collect benthic macroinvertebrate and periphyton samples.
8. Measure 1/10 of the required reach length upstream from transect A. Flag this spot as transect B. Assign the sampling station systematically after the first random selection following the repeating pattern L, C, R as you move upstream (Figure 3.3).
9. Proceed upstream with the tape measure and flag the positions of 9 additional transects (labeled "C" through "K" as you move upstream) at intervals equal to 1/10 of the reach length. Continue to assign the sampling stations systematically.

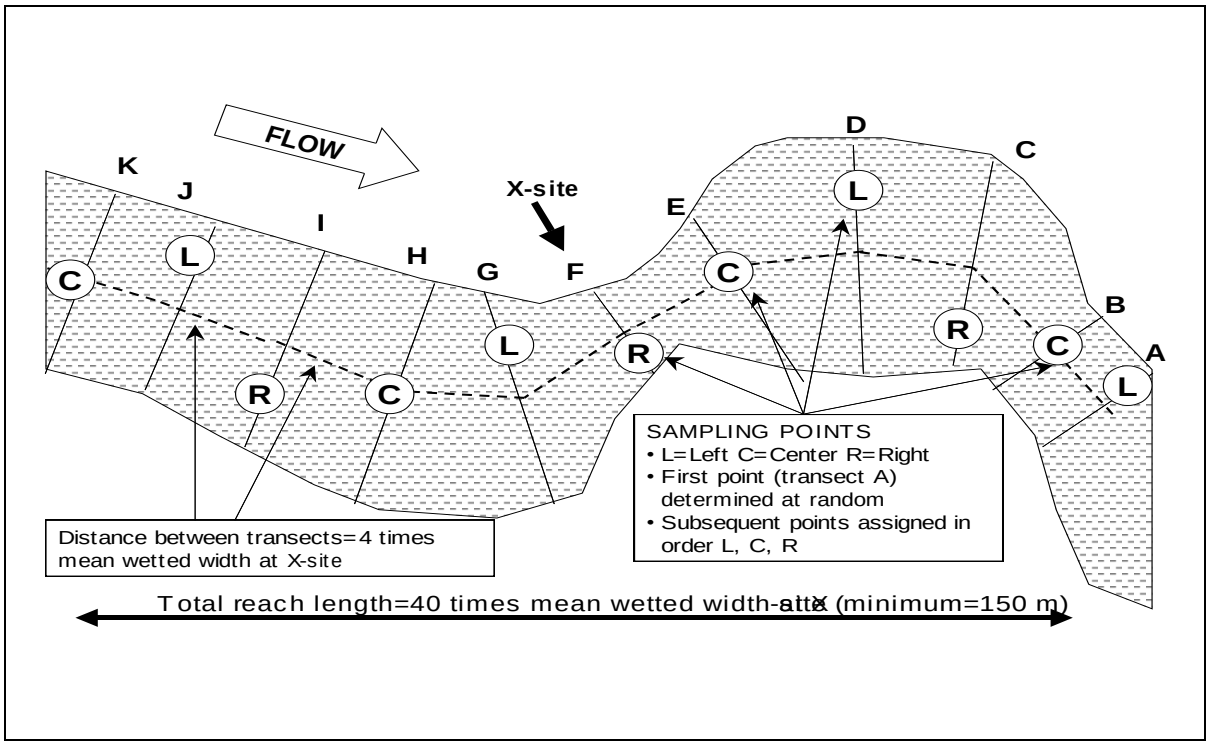


Figure 3.3 Sampling Reach Features for a Wadeable Site

3.2.1 Sliding the Reach

There are some conditions that may require sliding the reach about the X-site (i.e., the X-site is no longer located at the midpoint of the reach) to avoid features we do not wish to or physically cannot sample across. Reasons for sliding the reach include:

- Landowner access;
- Confluence with higher order waterbody;
- Impoundment;
- Impassable barrier.

Sliding the reach involves noting the distance of the barrier, confluence, or other restriction from the X-site, and flagging the restriction as the endpoint of the reach. Add the distance to the other end of the reach, such that the total reach length remains the same, but it is no longer centered about the X-site. Table 3.5 describes when you should and should not slide the sampling reach.

Table 3.5 Sliding the Sampling Reach

1. Slide the reach if you run into an **impoundment** (lake, pond, or reservoir), so that the lake/stream confluence is at one end.
2. Slide the reach if you run into an **impassible barrier** (e.g., waterfall, cliff, navigation dam) so that the barrier is at one end.
3. Slide the reach if you run into a **confluence** (another stream meeting the water-body you are sampling) with a higher Strahler Order.
4. When you are d**enied access permission** to a portion of the reach, you can slide the reach to make it entirely accessible; use the point of access restriction as the endpoint

of the reach.

5. Note the distance of the **barrier, confluence, or other restriction** from the X-site, and flag the restriction as the endpoint of the reach. Add the distance to the other end of the reach, so the total reach length remains the same, but it is no longer centered about the X-site.
6. **Do not slide the reach so that the X-site falls outside of the reach boundaries**.
7. **Do not proceed upstream into a lower order stream or downstream into a higher order stream** when laying out the stream reach (order is based on 1:100,000 scale maps).
8. **Do not slide a reach to avoid man-made obstacles** such as bridges, culverts, rip-rap, or channelization. These represent important features and effects to study.
9. **Do not slide a reach to gain more water** to sample if the flow is interrupted.
10. **Do not slide a reach to gain better habitat** for benthos or fish.

3.3 Modifying Sample Protocols for High or Low Flows

3.3.1 Streams with Interrupted Flow

You cannot collect the full complement of field data and samples from streams that are categorized as "Interrupted" (Table 3.6). Note that no data should be collected from streams that are completely "Dry" as defined in Table 3.6. Interrupted streams will have some cross-sections amenable to biological sampling and habitat measurements and some that are not. To be considered target, streams must have greater than 50% water in the reach length within the channel (can be isolated pools). Modified procedures for interrupted streams are presented in Table 3.6. Samples for water chemistry (Section 4) will be collected at the X-site (even if the reach has been adjusted by "sliding" it). If the X-site is dry and there is water elsewhere in the sample reach, collect the sample from a location having water with a surface area >1 m^2 and a depth >10 cm.

.

Collect data for the physical habitat indicator along the entire sample reach from interrupted streams, regardless of the amount of water present at the transects. Obtain depth measurements along the deepest part of the channel (the "thalweg") along the entire sampling reach to provide a record of the "water" status of the stream for future comparisons (e.g., the percent of length with intermittent pools or no water). Other measurements associated with characterizing riparian condition, substrate type, etc., are useful to help infer conditions in the stream when water is flowing.

Table 3.6 Reach Layout Modifications for Interrupted Streams

Streams with less than 50% of reach length containing water (not necessarily continuous) are considered dry and are not sampled. If more than 50% of the channel has water and if the X-site is dry but there is flowing water or a pool of water having a surface area > 1 m^2 and a depth > 10 cm somewhere along the defined sampling reach, take the water sample at the pool or flowing water location that is nearest to the X-site. Note that the sample wasn't collected at the X-site and where on the reach the sample was collected on the field data form. Do not collect a water sample if there is no acceptable location within the sampling reach. Record a "K" flag for the water chemistry sample on the sample collection form and explain why the sample was not collected in the comments section of the form.
Physical Habitat, Periphyton and Benthic Macroinvertebrates
Obtain a complete thalweg profile for the entire reach. At points where the channel is dry, record depth as 0 cm and wetted width as 0 m. At each of the transects (cross-sections), sample the stream depending on flow status: DRY CHANNEL: No surface water anywhere in cross-section; collect all physical habitat data. Use the unvegetated area of the channel to determine the channel width and the subsequent location of substrate sampling points. Record the wetted width as 0 m. Record substrate data at the sampling points located in the unvegetated, but dry, channel. Do not collect periphyton or benthic macroinvertebrates from this transect. DAMP CHANNEL: No flowing water at transect, only puddles of water < 10 cm deep; collect all physical habitat data. Do not collect periphyton or benthic macroinvertebrates from this transect. WATER PRESENT: Transect has flow or pools > 10 cm deep; collect all data and measurements for physical habitat, periphyton, benthic macroinvertebrate, and fish indicators, using standard procedures.

3.3.2 Braided Rivers and Streams

Depending upon the geographic area and/or the time of the sampling visit, you may encounter a stream having "braided" channels, which are characterized by numerous sub-channels that are generally small and short, often with no obvious dominant channel. If you encounter a braided stream, establish the sampling reach using the procedures presented in Table 3.7**.** Figuring the mean width of extensively braided rivers and streams for purposes of setting up the sampling reach length is challenging. For braided channels, measure the mean width and bankfull width as defined in the physical habitat protocols (Section 0). For relatively small streams (mean bankfull width ≤15 m) the sampling reach is defined as 40 times the mean bankfull width. For larger streams (>15 m), sum the actual wetted width of all the braids and use that as the width for calculating the 40 channel width reach length. If there is any question regarding an appropriate reach length for the braided system, it is better to overestimate. Make detailed notes and sketches on the Verification Form (Figure 3.1 and Figure 3.2) about what you did. It is important to remember that the purpose of the 40 channel width reach length is to sample enough streams to incorporate the variability in habitat types. Generally, the objective is to sample a long enough stretch of a stream to include 2 to 3 meander cycles (about 6 pool riffle habitat sequences). In the case of braided systems, the objective of this protocol modification is to avoid sampling an excessively long stretch of stream. In a braided system where there is a 100 m wide active channel (giving a 4 km reach length based on the standard procedure) and only 10

m of wetted width (say five, 2 m wide braids), a 400 m long sample reach length is likely to be sufficient, especially if the system has fairly homogenous habitat throughout its length.

Table 3.7 Modifications for Braided Rivers and Streams

1. Estimate the mean width as the bankfull channel width as defined in the physical habitat protocol.
    - If the mean width is ≤15 m, set up a 40 x channel width sample reach in the normal manner, using the mean bankfull width for your calculations.
    - If >15 m, sum up the actual wetted width of all the braids and use that as the width for calculating the 40 x channel width reach length. Remember the minimum reach length is always 150 m.
    - If the reach length seems too short for the system in question, set up a longer sample reach, taking into consideration that the objective is to sample a long enough stretch of a stream to include at least 2 to 3 meander cycles (about 6 pool riffle habitat sequences).
2. Make detailed notes and sketches on the Verification Form about what you did.

4 WATER CHEMISTRY / CHLOROPHYLL-a SAMPLE COLLECTION AND PRESERVATION

4.1 In Situ Measurements of Dissolved Oxygen, pH, Temperature, and Conductivity

4.1.1 Summary of Method

Measure dissolved oxygen (DO), pH, temperature, and conductivity using a calibrated multi-parameter water quality meter (or sonde). Take the measurements mid-channel at the X-site. Take the readings at 0.5 m depth. Measure the site depth accurately before taking the measurements. If the depth at the x-site is less than 1 meter, take the measurements at mid-depth. Take care to avoid the probe contacting bottom sediments, as the instruments are delicate. Record the measurements on the Field Measurement Form, as seen in Figure 4.1

4.1.2 Equipment and Supplies

Table 4.1 provides the equipment and supplies needed to measure dissolved oxygen, pH, temperature, and conductivity.

Table 4.1 Equipment and Supplies - DO, pH, Temperature, and Conductivity

For taking measurements and calibrating the water quality meter	▪ Multi-parameter water quality meter with pH, DO, temperature, and conductivity probes. ▪ Extra batteries ▪ De-ionized (DI) and tap water ▪ Calibration cups and standards ▪ Barometer or elevation chart to use for calibration
For recording measurements	▪ Field Measurement Form ▪ Pencils (for data forms)

4.1.2.1 Multi-Probe Sonde

Dissolved Oxygen Meter

Calibrate the DO meter prior to each sampling event. We recommend that the probe be calibrated in the field against an atmospheric standard (ambient air saturated with water) prior to launching the boat. Follow your manufacturer's guidelines for calibration of the DO probe.

pH Meter

Calibrate the pH meter prior to each sampling event. Calibrate the meter in accordance with the manufacturer's instructions and with the crew agency's existing Standard Operating Procedures (SOP).

Temperature Meter

You must check the accuracy of the sensor against a thermometer that is traceable to the National Institute of Standards (NIST) at least once per sampling season. The entire temperature range encountered in the NRSA should be incorporated in the testing procedure and a record of test results kept on file.

Conductivity Meter

Calibrate the conductivity meter prior to each sampling event. Calibrate the meter in accordance with the manufacturer's instructions. The entire conductivity range encountered in the NRSA should be incorporated in the testing procedure and a record of test results kept on file.

4.1.3 Sampling Procedure

Table 4.2 presents step by step procedures for measuring dissolved oxygen, pH, temperature, and conductivity.

Table 4.2 Sampling Procedure - Temperature, pH, Conductivity and Dissolved Oxygen

1. Check Meter and probes and calibrate according to manufacturer's specifications.
2. Check the calibration against the QCS solution for pH and conductivity and record the results on the field sheet as the QCS Measured value. This should be done at least once a week.
3. Record the true value of the QCS solution from the stock solution container on the field sheet as QCS True.
4. Samples are taken mid-channel, at the X site, at a depth of 0.5 meters or at a mid-depth if less than 1 meter deep.
5. Lower the sonde in the water and measure DO, pH, temperature, and conductivity at 0.5 m depth (or at mid-depth if less than 1 meter deep).
6. Record the measurements on the Field Measurement Form
7. Flag any measurements that the crew feels needs further comment or when a measurement cannot be made.

4.2 Water Chemistry Samples

4.2.1 Summary of Method

The water chemistry samples will be analyzed for total phosphorus (TP), total nitrogen (TN), total ammonia nitrogen (NH_4), nitrate (NO_3), basic anions, cations, total suspended solids (TSS), turbidity, acid neutralizing capacity (ANC, alkalinity), dissolved organic carbon (DOC), and total organic carbon (TOC). All field crews must collect a grab sample in one 4-L cube container and in one 2-L amber Nalgene bottle from the X site at the midpoint of the reach. Store all samples on ice in a closed cooler.

4.2.2 Equipment and Supplies

Table 4.3 provides the equipment and supplies needed to collect water samples at the index site. Record the Water Sample Collection and Preservation data on the Sample Collection Form, as seen in Figure 4.2.

Table 4.3 Equipment and Supplies - Water Chemistry Sample Collection and Preservation

For collecting samples	Nitrile gloves 4-L cube container 2-L amber Nalgene bottle 3-L Nalgene beaker Cooler with ice DI water (for cleaning beaker between sites) Field Operations Manual and laminated Quick Reference Guide
For recording measurements	Sample Collection Form Water Chemistry sample label with pre-printed Sample ID Clear tape strips Field Measurement Form Pencils (for data forms) Fine tipped indelible markers

4.2.3 Water Chemistry and Chlorophyll-*a* Sampling Procedure

Table 4.4 presents step-by-step procedures for collecting water chemistry samples at wadeable sites.

6 BENTHIC MACROINVERTEBRATES

6.1 Summary of Method

Collect benthic macroinvertebrate composite samples using a D-frame net with 500 µm mesh openings. Take the samples from the sampling stations at the 11 transects equally distributed along the targeted reach. Multiple habitats will be encountered and sampled using this approach. They include bottom substrate as well as woody debris, macrophytes, and leaf packs. Composite all sample material and field-preserve with ~95% ethanol.

6.2 Equipment and Supplies

Table 6.1 shows the checklist of equipment and supplies required to complete the collection of benthic macroinvertebrates. This checklist is similar to the checklist presented in Appendix A, which is used at the base location to ensure that all of the required equipment is brought to the site. Record collection data on the back of Sample Collection Form (Figure 6.1).

Table 6.1 Equipment and Supplies List for Benthic Macroinvertebrate Collection at Wadeable Sites

For collecting samples	Modified kick net (D-frame with 500 µm mesh) and 4-ft handle Watch with timer or stopwatch Buckets, plastic, 8 to 10 qt (optional) Sieve bucket with 500 µm mesh openings (U.S. std No. 35) Watchmakers' forceps Wash bottle, 1-L capacity labeled "STREAM WATER" Funnel, with large bore spout	Small spatula, spoon, or scoop to transfer sample Sample jars, 1-L HDPE plastic suitable for use with ethanol 95% ethanol, in a proper container Cooler (with absorbent material) for transporting ethanol & samples Plastic electrical tape Scissors Field Operations Manual or laminated Quick Reference Guide
For recording measurements	Composite benthic sample labels with & without preprinted ID Sample ID numbers Blank labels on waterproof paper for inside of jars	Soft (#2) lead pencils Fine-tip indelible markers Clear tape strips Sample Collection Form

6.3 Sampling Procedure

Figure 6.2 summarizes how samples will be collected from wadeable sites. The transect sample design for collecting benthic macroinvertebrates is shown in Figure 6.3. Collect a sample from **1-m downstream** of each of the 11 cross-section transects at the assigned sampling station. The process for selecting the sample stations is described in the Initial Site Procedures (Section 3). At transects assigned a "Center" sampling point where the stream width is between one and two net widths wide, pick either the "Left" or "Right" sampling point instead. 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 a sampling point is located in water that is too deep or unsafe to wade, select an alternate sampling point on the transect at random.

The procedure for collecting samples at each transect is described in Table 6.2. At each sampling point, determine if the habitat is a "riffle/run" or a "pool/glide" (any area where there is not sufficient current to extend the net is operationally defined as a pool/glide habitat). Record the dominant substrate type (fine/sand, gravel, coarse substrate (coarse gravel or larger) or other (e.g., bedrock, hardpan, wood, aquatic vegetation, etc.) and the habitat type (pool, glide, riffle, or rapid) for each sample collected on the Sample Collection Form as shown in Figure 6.1. As you proceed upstream from transect to transect, combine all samples into a bucket.

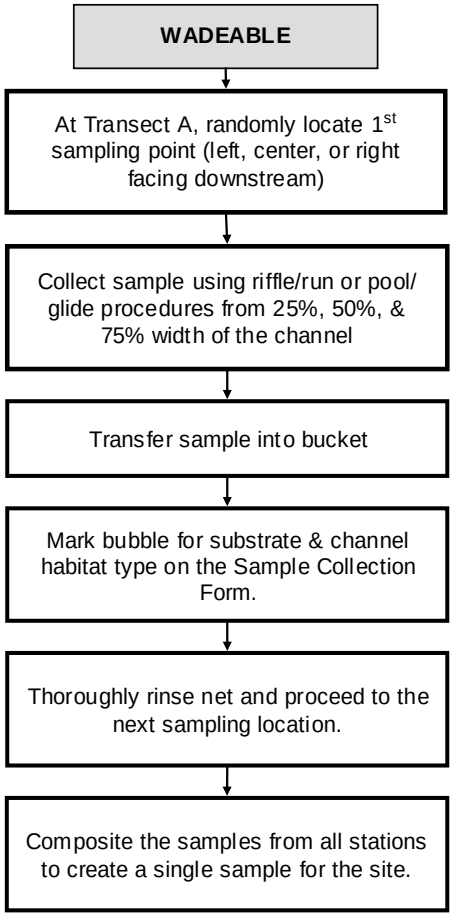
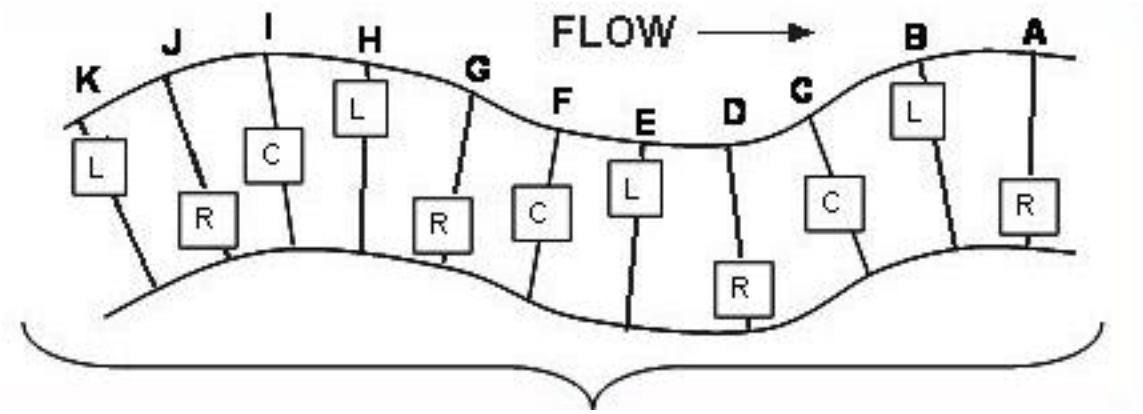


Figure 6.2 Benthic Macroinvertebrate Collection at Wadeable Sites



Combine **ALL** kick net samples collected from **ALL** transects

TRANSECT SAMPLES (1 per transect)

Sampling point at each transect selected systematically after random start

Sampling points proceed in L, C, R pattern upstream

Modified D-frame kick net

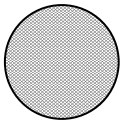
1 ft2 quadrat sampled for 30 seconds

COMPOSITE SAMPLES FROM ALL TRANSECTS

- Seive bucket or other bucket(s)

SIEVE SAMPLE

- 500 µm sieve bucket
- Remove and wash large objects



COMPOSITE AND PRESERVE SAMPLE

- 1 liter bottle(s) (*max of 4 bottles if possible*)
- Fill no more than 50% with sample
- Preserve with ~95% ethanol for a final concentration of at least 70%

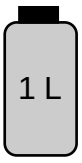


Figure 6.3 Transect Sample Design for Collecting Benthic Macroinvertebrates at Wadeable Sites

Table 6.2 Procedure for Benthic Macroinvertebrate Sampling at Wadeable Sites

Collecting Benthic Macroinvertebrate Sample
1. At 1 m downstream of each transect, beginning with Transect "A", randomly locate the first sampling station (Left, Center, or Right as you face downstream) as 25%, 50%, and 75% of the wetted width, respectively. If you cannot collect a sample at the designated point because of deep water or unsafe conditions, relocate to another random point on the same transect. 2. Determine if there is sufficient current in the area at the sampling station to fully extend the net. If so, classify the habitat as "riffle/run" and proceed to Step 3. If not, use the sampling procedure described for "pool/glide" habitats starting at Step 9. *NOTE: If the net cannot be used, hand-pick a sample for 30 seconds from about 1 ft^2 of substrate at the sampling point. For vegetation choked sampling points, sweep the net through the vegetation within a 1 ft^2 quadrat for 30 seconds. Place this hand-picked sample directly into the sample container. Assign a "U" flag (non-standard sample) to the sample and indicate which transect(s) required the modified collection procedure in the comments section. Go to Step 13.*
Riffle/Run Habitats:
3. With the net opening facing upstream, quickly position the net securely on the stream bottom to eliminate gaps under the frame. Avoid large rocks that prevent the net from seating properly on the stream bottom. *NOTE: If there is too little water to collect the sample with the D-net, randomly pick up 10 rocks from the riffle and pick and wash the organisms off them into a bucket which is half full of water.* 4. Holding the net in position on the substrate, visually define a quadrat that is one net width wide and long upstream of the net opening. The area within this quadrat is 1 ft^2 5. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball sized or larger and which are at least halfway into the quadrat. After scrubbing, place the substrate particles outside of the quadrat. 6. Hold the D-net securely in position. Starting at the upstream end of the quadrat, vigorously kick the remaining finer substrate within the quadrat for 30 seconds (use a stopwatch). *NOTE: For samples located within dense beds of long, filamentous aquatic vegetation (e.g., algae or moss), kicking within the quadrat may not be sufficient to dislodge organisms in the vegetation. Usually these types of vegetation are lying flat against the substrate due to current. Use a knife or scissors to remove only the vegetation that lies within the quadrat (i.e., not entire strands that are rooted within the quadrat) and place it into the net.* 7. Pull the net up out of the water. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. Avoid having any water or material enter the mouth of the net during this operation. 8. Go to Step 13.
Pool/Glide Habitats:
9. Visually define a quadrat that is one net width wide and long at the sampling point. The area within this quadrat is 1 ft^2. 10. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball sized or larger and which are at least halfway into the

quadrat. After scrubbing, place the substrate particles outside of the quadrat.

11. Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

NOTE: If there is too little water to use the kick net, stir up the substrate with your gloved hands and use a sieve with 500 µm mesh size to collect the organisms from the water in the same way the net is used in larger pools.

12. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

All samples:

13. Invert the net into a sieve bucket and transfer the sample. Remove as much gravel as possible so that the organisms do not get damaged. Inspect the net for any residual organisms clinging to the net and deposit them into the bucket. Use forceps if necessary to remove organisms from the net. Carefully inspect any large objects (such as rocks, sticks, and leaves) in the bucket and wash any organisms found off of the objects and into the bucket before discarding the object. Remove as much detritus as possible without losing organisms.

NOTE: •It is recommended that crews carry a sample bottle containing a small amount of ethanol with them to enable them to immediately preserve larger predaceous invertebrates such as hellgrammites and water beetles. Doing so will help reduce the chance that other specimens will be consumed or damaged prior to the end of the field day.

14. Determine the **predominant** substrate size/type you sampled within the sampling quadrat. Mark the appropriate substrate type for the transect on the Sample Collection Form. The substrate types are:

    - **Fine/sand (F)**: not gritty (silt/clay/muck <0.06 mm diam.) to gritty, up to ladybug sized (2 mm)
    - **Gravel (G)**: fine to coarse gravel (ladybug to tennis ball sized; 2 mm to 64 mm)
    - **Coarse (C)**: Cobble to boulder (tennis ball to car sized; 64 mm to 4000 mm)
    - **Other (OT)**: bedrock (larger than car sized; > 4000 mm), hardpan (firm, consolidated fine substrate), wood of any size, aquatic vegetation, etc.). Note type of "other" substrate in comments on field form.

NOTE: If there are co-dominant substrate types, you may indicate more than one substrate type; note the co-dominants in the comments section of the form.

15. Identify the channel habitat type where the sampling quadrat was located. Indicate the appropriate channel habitat type for the transect on the Sample collection Form. The channel habitat types are:

    - **Pool (P)**: Still water; low velocity; smooth, glassy surface; usually deep compared to other parts of the channel
    - **Glide (GL)**: Water moving slowly, with smooth, unbroken surface; low turbulence
    - **Riffle (RI)**: Water moving, with small ripples, waves, and eddies; waves not breaking, and surface tension is not broken; "babbling" or "gurgling" sound.
    - **Rapid (RA)**: Water movement is rapid and turbulent; surface with intermittent "white water" with breaking waves; continuous rushing sound.

- **Other (OT)**: Note type of "other" channel habitat in comments on field form.

16. Thoroughly rinse the net before proceeding to the next sampling station. Proceed upstream to the next transect (through Transect K, the upstream end of the reach) and repeat steps 1 - 15. Combine all kick net samples from riffle/run and pool/glide habitats into the bucket.

6.4 Sample Processing in Field

Use a 500 μm mesh sieve bucket placed inside a larger bucket full of site water while sampling to carry the composite sample as you travel around the site. Once the composite sample from all stations is sieved and reduced in volume, store in a 1-liter jar and preserve with 95% ethanol. Do not fill jars more than ½ full of material. Multiple jars may be required if detritus is heavy (Table 6.3). Try to use no more than 4 jars per site. If more than one jar is used for a composite sample, use the "extra jar" label provided; record the SAME sample ID number on this "extra jar" label. **DO NOT use two different sample numbers on two jars containing one single sample**. Cover the labels with clear tape. The sample ID number is also recorded with a No. 2 lead pencil on a waterproof label that is placed inside each jar. Be sure the inside label and outside label describe the same sample.

Record information for each composite sample on the Sample Collection Form as shown in Figure 6.1. Place the samples in a cooler or other secure container for transporting and/or shipping to the laboratory (see Appendix C). If the sample contains primarily organic material, or if adverse weather conditions exist (i.e. hot humid weather) process the sample at each station by placing it in a 1-L Nalgene jar with ethanol.

Table 6.3 Procedure for Compositing Samples for Benthic Macroinvertebrates at Wadeable Sites

Compositing Benthic Macroinvertebrate Sample
1. Pour the entire contents of the bucket into a sieve bucket with 500 μm mesh size. Remove any large objects and wash off any clinging organisms back into the sieve before discarding. Remove any large inorganic material, such as cobble or rocks.
2. Using a wash bottle filled with river water, rinse all the organisms from the bucket into the sieve. This is the composite sample for the reach.
3. Estimate the total volume of the sample in the sieve and determine how many 1-L jars will be required. Try to use no more than 4 jars per site.
4. Fill in a sample label with the Sample ID and date of collection. Attach the completed label to the jar and cover it with a strip of clear tape. Record the sample ID number for the composite sample on the Sample Collection Form. For each composite sample, make sure the number on the form matches the number on the label.
5. Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large bore funnel if necessary. If the jar is too full pour off some water through the sieve until the jar is not more than ½ full, or use a second jar if necessary. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar.
• *If a second jar is needed, fill in a sample label that does not have a pre-printed ID number on it. Record the ID number from the pre-printed label prepared in Step 4 in the "SAMPLE ID" field of the label. Attach the label to the second jar and cover it with a strip of clear tape. Record the number of jars required for the sample on the Sample Collection Form. Make sure the number you record matches the actual number of jars used. Write "Jar N of X" on each sample label using a waterproof marker ("N" is the individual jar number, and "X" is the total number of jars for the sample).*

Compositing Benthic Macroinvertebrate Sample	
6. Place a waterproof label inside each jar with the following information written with a number 2 lead pencil:	
Site ID	Collectors initials
Type of sampler and mesh size used	Number of stations sampled
Name of site	
Date of collection	Jar "N" of "X"

7. Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%.

NOTE: Composite samples can be transported back to the vehicle before adding ethanol if necessary. In this case, fill the jar with stream water, which is then drained using the net (or sieve) across the opening to prevent loss of organisms, and replace with ethanol.

8. Replace the cap on each jar. Slowly tip the jar to a horizontal position, then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape.

9. Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

8 PHYSICAL HABITAT CHARACTERIZATION

Field measurements for physical habitat are made at two scales of resolution along the mid-channel length of the reach the results are later aggregated and expressed for the entire reach. The protocol defines the length of each sampling reach proportional to river wetted width and then systematically places measurements to statistically represent the entire reach.

8.1 Equipment and Supplies

Table 8.1 lists the equipment and supplies required to conduct all the activities described for characterizing physical habitat. This checklist is similar to the checklist presented in Appendix A, which is used at the base location to ensure that all of the required equipment is brought to the river. Use this checklist to ensure that equipment and supplies are organized and available at the river site in order to conduct the activities efficiently.

Table 8.1 Checklist of Equipment and Supplies for Physical Habitat

For making measurements	• Convex spherical canopy densiometer (Lemmon Model B), modified with taped "V" • GPS • 1 roll each colored surveyor's flagging tape (2 colors) • 2 pair chest waders • 1 or 2 fisherman's vest with lots of pockets and snap fittings. • Digital camera with extra memory card & battery • 50 m or 100 m measuring tape with reel • Meter stick for bank angle measurements • Laser rangefinder (400 ft. distance range) and clear waterproof bag • Clinometer • Binoculars • Bearing compass (Backpacking type) • Current velocity meter, probe, and operating manual • Top-set wading rod for use with current velocity meter • Surveyor's telescoping leveling rod • Sounding rod or wading staff • Level tripod • CST Berger SAL 20 Automatic Level • Field Operations Manual and/or laminated quick reference guide
For recording data	• 2 covered clipboards (lightweight, with strap or lanyard) • Soft (#2) lead pencils • 11 plus extras Channel/Riparian Transect Forms • 11 plus extras Thalweg Profile Forms • 1+ extras field Form: Stream Verification Form • 1+ extras field Form: Field Measurement Form • 1+ extras field Form: Sample Collection Form • 1+ extras field Form: Channel Constraint • 1+ extras field Form: Visual Assessment Form

8.2 Summary of Methods Approach

Physical habitat in streams includes all those physical attributes that influence or provide sustenance to organisms within the stream. The physical habitat of a stream varies naturally, thus expectations differ even in the absence of anthropogenic disturbance. The procedures are employed on a **reach length 40 times its baseflow wetted width**. Measurement points are systematically placed to statistically represent the entire reach. Stream depth and wetted width are measured at very tightly spaced intervals, whereas channel cross-section profiles, substrate, bank characteristics and riparian vegetation structure are measured at larger intervals. Woody debris is tallied along the full length of the sampling reach, and discharge is measured at one location. The tightly spaced depth and width measures allow calculation of indices of channel structural complexity, objective classification of channel units such as pools, and quantification of residual pool depth, pool volume, and total stream volume.

8.3 Components of the Habitat Characterization

There are six components of the physical habitat characterization (Table 8.2). Measurements are recorded on 11 copies of a two-sided field form, and separate forms for recording slope and bearing measurements, assessing the degree of channel constraint, recording evidence of debris torrents or recent major flooding, and for stream discharge measurements.

Table 8.2 Summary of Components of Physical Habitat Characterization at Wadeable Sites

Component	Description
Thalweg Profile	• Measure maximum depth, classify habitat and pool forming features, and check presence of backwaters, side channels and loose, soft deposits of sediment particles at 10-15 equally spaced intervals between each of 11 transects (100 or 150 individual measurements along entire reach).
Wetted Width / Bar Width	• Measure wetted width and bar width (if present) and evaluate substrate particle size classes at 11 cross-section transects and midway between them (21 width measurements and substrate notations along entire reach).
Woody Debris Tally	• Between each of the channel cross-sections, tally large woody debris numbers within and above the bankfull channel according to specified length and diameter classes (10 separate tallies).
Channel and Riparian Characterization	• At 11 transects placed at equal intervals along reach: • Measure channel cross-section dimensions, bank height, bank undercut distance, bank angle, slope and compass bearing (back sight), and riparian canopy density (with densiometer). • Visually Estimate[a]: substrate size class and embeddedness; areal cover class and type (e.g., woody trees) of riparian vegetation in Canopy, Mid-Layer and Ground Cover; areal cover class of fish concealment features, aquatic macro-phytes and filamentous algae. • Observe & Record[a]: Presence and proximity of human disturbances.
Assessment of Channel Constraint, Debris Torrents, and Major Floods	• After completing thalweg and transect measurements and observations, identify features causing channel constraint, estimate the percentage of the channel margin that is constrained for the whole reach, and estimate the ratio of bankfull/valley width. Check evidence of recent major floods and debris torrent scour or deposition.
Discharge	• Measure water depth and velocity at 0.6 depths at 15 to 20 equally spaced

	intervals across one carefully chosen channel cross-section. • In very small streams, measure discharge by timing the passage of a neutrally buoyant object through a segment whose cross-sectional area has been estimated or by timing the filling of a bucket.

[a] *Substrate size class is estimated for a total of 105 particles taken at 5 equally spaced points along each of 21 cross-sections. Depth is measured and embeddedness estimated for the 55 particles located along the 11 regular transects A through K. Cross-sections are defined by laying the surveyor's rod or tape to span the wetted channel. Woody debris is tallied over the distance between each cross-section and the next cross-section upstream. Riparian vegetation and human disturbances are observed 5m upstream and 5m downstream from the cross-section transect. They extend shoreward 10m from left and right banks. Fish cover types, aquatic macrophytes, and algae are observed within the channel 5m upstream and 5m downstream from the cross-section stations. These boundaries for visual observations are estimated by eye.*

8.4 Work Flow for the Physical Habitat Components

The six components (Table 8.2) of the habitat characterization are organized into four grouped activities described below in the following sections.

8.4.1 Thalweg Profile and Large Woody Debris Tally

Thalweg spacing is calculated such that either 10 or 15 evenly spaced measurements are made between each transect (see section 8.5). Two people proceed upstream from the downstream end of the sampling reach making observations and measurements at the calculated increment spacing. One person is in the channel making width and depth measurements and determining whether soft/small sediment deposits are present under his/her wading staff. The other person records these measurements, classifies the channel habitat, records presence/absence of side channels and off channel habitats (e.g., backwater pools, sloughs, alcoves), and tallies large woody debris. Each time this crew reaches a flag marking a new cross-section transect, they start filling out a new copy of the Thalweg Profile and Woody Debris Form. They interrupt the thalweg profile and woody debris tallying activities to complete data collection at each cross-section transect as they come to it. When the crew member in the water makes a width measurement at channel locations midway between regular transects (i.e. at the fifth or seventh thalweg measurement in each sub-reach), she or he also locates and estimates the size class of the substrate particles on the left channel margin (0%) and at positions 25%, 50%, 75%, and 100% of the distance across the wetted channel. Procedures for this substrate tally are the same as for those at regular cross-sections, but data are recorded on the thalweg profile side of the field form.

8.4.2 Channel/Riparian Cross-Sections

At each of the 11 transects, one person proceeds with the channel cross-section dimension and substrate notations as described above; and also makes measurements of bank angle (using rod and clinometer) and canopy cover (using densitometer). The second person records those measurements on the Channel/ Riparian Cross-section Form while making visual estimates of riparian vegetation structure, instream fish cover, and human disturbance specified on that form. Slope is measured by measuring the difference in elevation between each transect and bearing is determined by backsighting to the previous transect. Supplementary points may need to be located and flagged (using a different color) if the stream is extremely brushy, sinuous, or steep to the point that you cannot sight for slope and bearing measures between two adjacent transects.

The work flow for the thalweg profile and channel cross-section described above can be modified by delaying the measurements for slope and bearing and the woody debris tally until after reaching the upstream end of the reach. Backsighting and wood tallies can be done on the way back downstream (Note that in this case, the slope and bearing data form would have to be completed in reverse order).

8.4.3 Channel Constraint and Torrent Evidence

After completing observations and measurements along the thalweg and at all 11 transects, the field crew completes the overall reach assessments of channel constraint and evidence of debris torrents and major floods.

8.4.4 Stream Discharge

Discharge measurements can be performed during or at the end of the field sampling, but need to be made after collecting the water chemistry sample so as not to disturb the water and compromise the sample. The measurements are taken at a chosen optimal cross-section (but not necessarily at a sampling transect) near the X-site. However, do not use the electromagnetic current meter close to where electrofishing is taking place. Furthermore, if a lot of channel disruption is necessary and sediment must be stirred up, wait on this activity until all chemical and biological sampling has been completed.

8.5 Habitat Sampling Locations within the Reach

Measurements are made at two scales along the length of the reach; the results are later aggregated for the entire reach. Figure 8.1 illustrates the locations within the reach where data for the different components of the physical habitat characterization are collected. Most channel and riparian features are characterized on 11 cross-sections and pairs of riparian plots spaced at 4 channel width intervals (i.e., transect spacing = 1/10th the total reach length). The thalweg profile measurements must be spaced evenly over the entire reach. In addition, they must be sufficiently close together that they do not miss deep areas and major habitat units.

Follow these guidelines for choosing the increment between thalweg profile measurements:

Channel Width < 2.5 m:

- Minimum reach length of 150 m is used
- Thalweg increment = 1.0 m (resulting in 15 thalweg measurements per subreach);
- A total of 150 evenly spaced thalweg profile measurements will be made, 15 between each channel cross-section
- Mid-subreach measurements are made at the 7th thalweg location

Channel Width 2.5 to 3.5 m:

- Minimum reach length of 150 m is used
- Thalweg increment = 1.5 m (resulting in 10 thalweg ,measurements per subreach);
- A total of 100 evenly spaced thalweg profile measurements will be made, 10 between each channel cross-section

- Mid-subreach measurements are made at the 5th thalweg location

Channel Width > 3.5 m:

- Reach length is 40 times channel width
- Thalweg increment = 0.01 × reach length (resulting in 10 thalweg measurements per subreach).
- A total of 100 evenly spaced thalweg profile measurements will be made, 10 between each channel cross-section
- Mid-subreach measurements are made at the 5th thalweg location

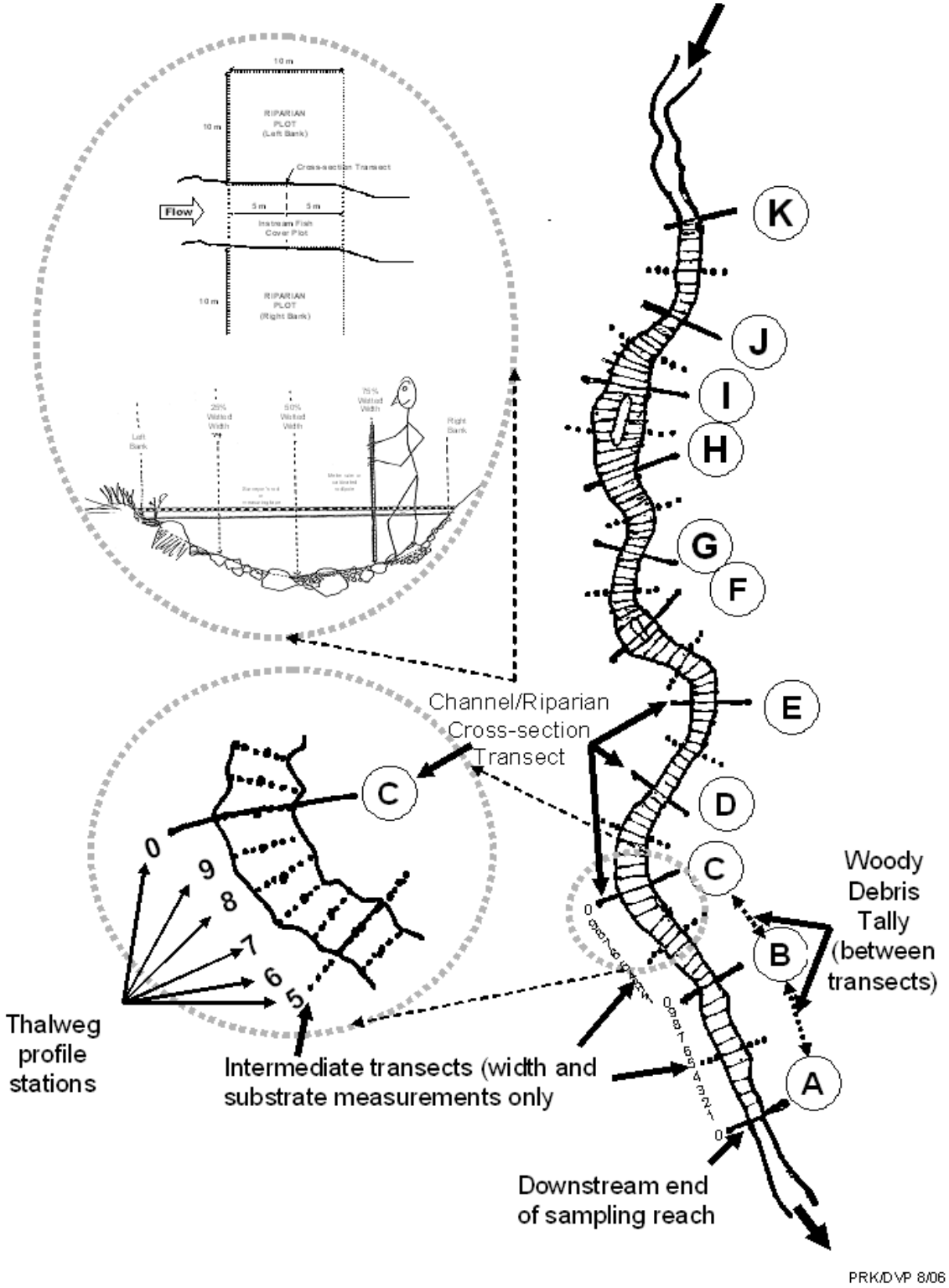


Figure 8.1 Reach Layout for Physical Habitat Measurements (plan view)

8.5.1 Thalweg Profile and Large Woody Debris Measurements

8.5.1.1 Thalweg Profile

Thalweg refers to the flow path of the deepest water in a stream channel. The *thalweg profile* is a longitudinal survey of maximum flow path depth. Data from the thalweg profile allows calculation of indices of residual pool volume, stream size, channel complexity, and the relative proportions of habitat types such as riffles and pools.

The procedure for obtaining thalweg profile measurements is presented in Table 8.3. Record data on the Thalweg Profile and Woody Debris Data Form as shown in Figure 8.2. Use the surveyor's rod and a metric ruler or calibrated rod or pole to make the required depth and width measurements at each station, and to measure off the distance between stations as you proceed upstream. You may need to make minor adjustments to align each 10th measurement to be one increment short of the next transect. In streams with average widths less than 2.5 m, make thalweg measurements at 1 meter increments. Because the minimum reach length is set at 150 meters, there will be 15 measurements on a field data form: Station 0 at the transect plus 14 additional stations between it and the next transect upstream. Use the five extra lines on the thalweg profile portion of the data form (Figure 8.2) to record measurements 10-14.

Measure thalweg depths at all stations. Flag any missing measurements using a K code and explain the reason in the comments section of the field data form. At points where a direct depth measurement cannot be made, make your best estimate of the depth, record it on the field form, and flag the value using a U code (nonstandard measurement), explaining that it is an estimated value in the comments section of the field data form. Where the thalweg points are too deep for wading, measure the depth by extending the surveyor’s rod or weighted line at an angle to reach the thalweg point. On the field form enter a U code in the thalweg depth column (to indicate a nonstandard technique), and record the water level on the rod or line, and the rod/line angle, as determined using the external scale on the clinometer (vertical = 90) in the comment field (i.e. “depth of xx cm taken at an angle of xx degrees”). If a direct measurement of the thalweg depth is not possible, make the best estimate you can of the depth, record it, and use a U flag and a comment to note it is an estimated value.

Table 8.3 Thalweg Profile Procedure

1. Determine the increment distance between measurement stations based on the wetted width used to determine the length of the reach. Using a laser rangefinder or surveyor's rod:
    - For widths ≤ 2.5 m, establish stations every 1 m (150 total).
    - For widths > 2.5 and ≤3.5 m, establish stations every 1.5 m (100 total).
    - For widths > 3.5 m, establish stations at increments equal to 0.01 times the reach length (100 total).
2. Complete the header information on the Thalweg Profile and Woody Debris Form, noting the transect pair (downstream to upstream). Record the increment distance determined in Step 1 in the *INCREMENT* field on the field data form used for subreach A-B. Also record the total reach length on this form. It is not necessary to repeat these calculations on the remainder of the Thalweg Profile and Woody Debris forms.
3. Begin at the downstream end (*station 0*) of the first transect (transect *A*).
4. Measure the wetted width at station *0*, and at either station *5* (if the stream width defining the reach length is ≥ 2.5 m), or station *7* (if the stream width defining the reach length is < 2.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the width on the field data form to the nearest 0.1 m. For streams with interrupted flow, where no water is in the channel at the station or transect, record zeros for wetted width.

    NOTE: If a mid-channel bar is present at a station where wetted width is measured, measure the wetted width across and including the bar, but also measure the bar width and record it on the field data form.
5. At station *5* or *7* (see above) classify the size of the bed surface particle at the tip of your depth measuring rod at the left wetted margin and at positions 25%, 50%, 75%, and 100% of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections (transects *A* - *K*), except that for these midway supplemental cross-sections, substrate size is entered on the thalweg profile side of the field form.
6. At each thalweg profile station, use a calibrated pole or rod to locate the deepest point within the deepest flow path (*the thalweg*), which may not always be found at mid-channel (and may not always be the absolute deepest point in every channel cross-section). Measure the thalweg depth to the nearest cm from the substrate surface to the water surface, and record it on the thalweg profile form. Read the depth on the **side** of the rod to avoid inaccuracies due to the wave formed by the rod in moving water.

    NOTE: For streams with interrupted flow if there is no water at a transect, record zeros for depth.

    *NOTE: Obtain thalweg depths at all stations. If the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor's rod or pole at an angle to reach the thalweg. Determine the angle by resting the clinometer on the upper surface of the rod and reading the angle on the external scale of the clinometer. Record a U flag in the thalweg depth column to indicate a non-standard procedure was used. Record the water level on the rod and the rod angle in the comments section of the field data form. For deeper depths, use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line, and toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the clinometer exactly as done for the surveyor's rod. If a direct measurement cannot be obtained, make the **best estimate** you can of the thalweg depth, and use a U flag to identify it as an estimated measurement.*
7. At the point where the thalweg depth is determined, observe if unconsolidated, loose (*soft*)

deposits of small diameter (≤16mm) sediments are present directly beneath your ruler, rod, or pole. *Soft/ small sediments* are defined here as fine gravel, sand, silt, clay or muck readily apparent by "feeling" the bottom with the rod. Record presence or absence in the *SOFT/SMALL SEDIMENT* field on the field data form. *Note: A thin coating of fine sediment or silty algae coating the surface of cobbles should not be considered soft/small sediment. However, fine sediment coatings should be identified in the comments section of the field form when determining substrate size and type*.

8. Determine the channel unit code for the station. Record this on the field data form using the standard codes provided. For dry and intermittent streams, where no water is in the channel, record habitat type as dry channel (*DR*).
9. If the station cross-section intersects a mid-channel bar, indicate the presence of the bar by filling in the bubble in the *BAR WIDTH* field on the field data form. However, a measurement of the bar width is only taken if the bar intersects a transect at either the endpoint or midpoint of a subreach.
10. Record the presence or absence of a side channel at the station's cross-section in the *SIDE CHANNEL* field on the field data form.
11. Record the presence or absence of quiescent off channel aquatic habitats, including sloughs, alcoves and backwater pools in the *BACKWATER* column of the field form.
12. Proceed upstream to the next station, and repeat Steps 2 through 11.
13. Repeat Steps 2 through 12 until you reach the next transect. At this point complete Channel/ Riparian measurements at the new transect (Section 8.4.2). Then prepare a new Thalweg Profile and Woody Debris Form and repeat Steps 2 through 12 for each of the reach segments, until you reach the upstream end of the sampling reach (transect *K*). At transect *K*, you will have completed 10 copies of the Thalweg Profile and Woody Debris Form, one for each segment (*A* to *B*, *B* to *C*, etc.).

At every thalweg station, determine by sight or feel whether deposits of *soft/small sediments* are present on the channel bottom. These particles are defined as substrate equal to or smaller than fine gravel (≤ 16 mm diameter). These soft/small sediments are **different** from *Fines* described when determining the substrate particle sizes at the cross-section transects (Section 8.7). If the channel bottom is not visible, determine if soft/small sediment deposits are readily obvious by feeling the bottom with your boot, the surveyor's rod, or a calibrated rod or pole.

Measure wetted width at each transect (station *0*), and midway between transects (station *5* for larger streams having 100 measurement points, or station *7* for smaller streams having 150 measurement points). The wetted width boundary is the point at which substrate particles are no longer surrounded by free water. Estimate substrate size for five locations evenly spaced across each midway cross-section using procedures described for substrate at regular cross-sections (Figure 8.1), but at the supplemental cross-sections, only the size class (not distance and depth) data are recorded.

While recording the width and depth measurements and the presence of soft/small sediments, the second person evaluates and records the habitat class (Table 8.4) applicable to each of the 100 (or 150) measurement points along the length of the reach. Make channel unit scale habitat classifications at the thalweg of the cross-section. The habitat unit itself must meet a minimum size criteria in addition to the qualitative criteria listed in Table 8.4. Before being considered large enough to be identified as a channel unit scale habitat feature, the unit should be at least as long as the channel is wide. For instance, if there is a small deep (pool like) area at the thalweg within a large riffle area, do not record it as a pool unless it occupies an area about as wide or long as the channel is wide. If a backwater pool **dominates the channel**, record *PB* as the dominant habitat unit class. If the backwater is a pool that **does not dominate** the main channel, or if it is an **off channel** alcove or slough (large enough to offer refuge to small fishes), fill in the *Y* bubble to indicate presence of a backwater in the *BACKWATER* column of the field form, but classify the main channel habitat unit type according to characteristics of the main channel. *Sloughs* are backwater areas having marsh like characteristics such as vegetation, and *alcoves* (or *side pools*) are deeper areas off the main channel that are typically wide and shallow (Helm 1985, Bain and Stevenson 1999). When trying to identify the pool forming element for a particular pool, remember that most pools are formed at high flows, so you may need to look for elements that are dry at baseflow, but still within the bankfull channel (e.g., boulders or large woody debris).

Table 8.4 Channel Unit Categories

Channel Unit Habitat Classes [a]	
Class (Code)	**Description**
Pools: Still water, low velocity, a smooth, glassy surface, usually deep compared to other parts of the channel:	
Plunge Pool (*PP*)	Pool at base of plunging cascade or falls.
Trench Pool (*PT*)	Pool like trench in the center of the stream
Lateral Scour Pool (*PL*)	Pool scoured along a bank.
Backwater Pool (*PB*)	Pool separated from main flow off the side of the channel (large enough to offer refuge to small fishes). Includes sloughs (backwater with marsh characteristics such as vegetation), and alcoves (a deeper area off a wide and shallow main channel)
Impoundment Pool(*PD*)	Pool formed by impoundment above dam or constriction.
Pool (*P*)	Pool (unspecified type).
Glide (*GL*)	Water moving slowly, with a *smooth, unbroken surface*. Low turbulence.
Riffle (*RI*)	Water moving, with *small ripples, waves and eddies* waves not breaking, *surface tension not broken*. Sound: babbling, gurgling.
Rapid (*RA*)	Water movement rapid and turbulent, surface with *intermittent white-water* with breaking waves. Sound: continuous rushing, but not as loud as cascade.
Cascade (*CA*)	Water movement rapid and very turbulent over steep channel bottom. Much of the water surface is broken in *short, irregular plunges, mostly whitewater.* Sound: roaring.
Falls (*FA*)	*Free falling water* over a vertical or near vertical drop into plunge, water turbulent and white over high falls. Sound: from splash to roar.
Dry Channel (*DR*)	No water in the channel, or flow is submerged under the substrate (*hyporheic flow*).

[a] Note that in order for a channel habitat unit to be distinguished, it must be at least as wide or long as the channel is wide (except for off channel backwater pools, which are noted as present regardless of size).

8.5.1.2 Large Woody Debris Tally

Large Woody Debris (LWD) is defined here as woody material with a small end diameter of at least 10 cm (4 in.) **and** a length of at least 1.5 m (5 ft.). The procedure for tallying LWD is presented in Table 8.5. The tally includes all pieces of LWD that are at least partially in the baseflow channel (Zone 1), in the *bankfull channel* (Zone 2, flood channel up to bankfull stage), or spanning above the bankfull channel (Zone 3), as shown in Figure 8.3. LWD in zones 1 and 2 will be tallied together (considered all or in-part within the bankfull channel). The *bankfull channel* is defined as the channel that is filled by moderate sized flood events that typically recur every one to two years. LWD in or above the bankfull channel is tallied over the entire length of the reach, including the area between the channel cross-section transects. Pieces of LWD that are not at least partially within Zones 1, 2, or 3 are not tallied.

Table 8.5 Procedure for Tallying Large Woody Debris

Large Woody Debris Tally Form
Note: Tally pieces of large woody debris (LWD) within each segment of stream while the thalweg profile is being determined. Include all pieces in the tally whose large end is found within the subreach.
1. Scan the stream segment between the two cross-section transects where thalweg profile measurements are being made.
2. Tally all LWD pieces within the segment that are at least partially within the bankfull channel. Determine if a piece is LWD (*small end diameter ≥10 cm [4 in.], and length ≥1.5 m [5 ft.]*)
3. For each piece of LWD, determine the class based on the *diameter of the large end* (0.1 m to < 0.3 m, 0.3 m to <0.6 m, 0.6 m to <0.8 m, or >0.8 m), and the class based on the *length of the piece* (1.5m to <5.0m, 5m to <15m, or >15m). If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with circular cross-section that would have the same volume. When estimating length, include only the part of the LWD piece that has a diameter >10 cm (4 in)
4. Place a tally mark in the appropriate diameter × length class tally box in the *PIECES ALL/PART IN BANKFULL CHANNEL* section of the Thalweg Profile and Woody Debris Form.
5. Tally all LWD pieces within the segment that are not actually within the bankfull channel, but are at least partially spanning (bridging) the bankfull channel. For each piece, determine the class based on the diameter of the large end (0.1 m to < 0.3 m, 0.3 m to <0.6 m, 0.6 m to <0.8 m, or >0.8 m), and the class based on the length of the piece (1.5 m to <5.0 m, 5 m to <15 m, or >15 m).
6. Place a tally mark for each piece in the appropriate diameter × length class tally box in the *PIECES BRIDGE ABOVE BANKFULL CHANNEL* section of the Thalweg Profile and Woody Debris Form.
7. After all pieces within the segment have been tallied, write the total number of pieces for each diameter × length class in the small box at the lower right-hand corner of each tally box.
8. Repeat Steps 1 through 7 for the next subreach, using a new Thalweg Profile and Woody Debris Form.

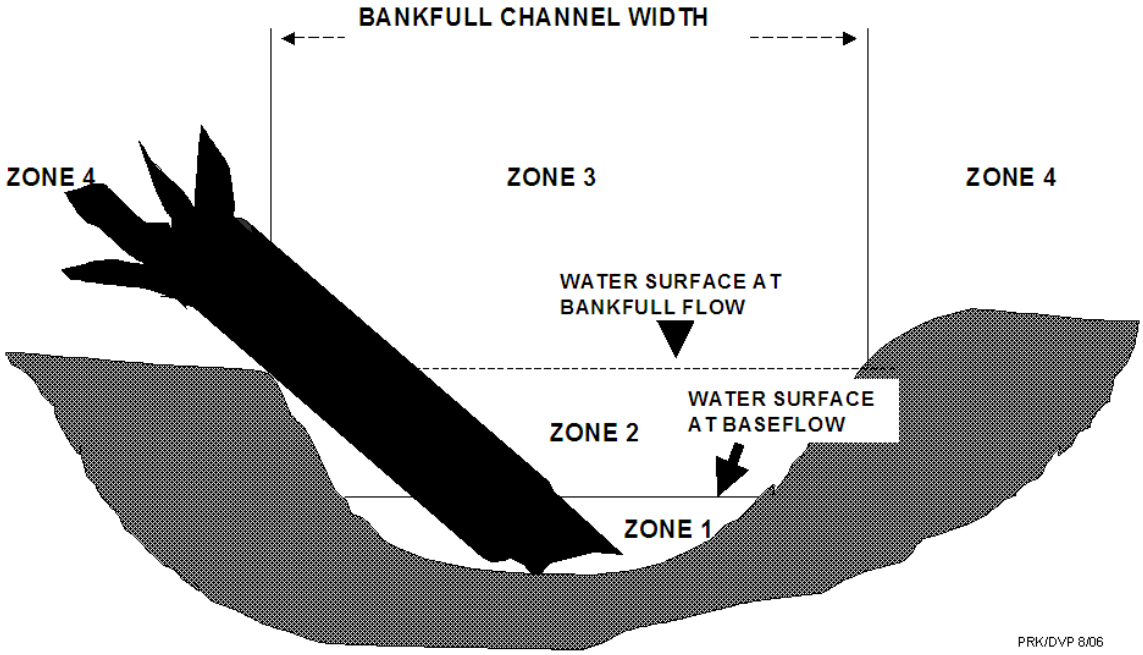


Figure 8.3 Large Woody Debris Influence Zones (modified from Robison and Beschta, 1990).

8.6 Channel and Riparian Measurements at Cross-Section Transects

8.6.1 Slope and Bearing

Measure slope and bearing by *sighting* between transects (e.g., transect *B* and *A*, *C* and *B*, etc.). To measure the slope between adjacent transects, follow the procedure presented in Table 8.6. Measure bearing following the procedure presented in Table 8.8. Record slope and bearing data on the Slope and Bearing Form as shown in Figure 8.4.

Slope is typically measured by two people, one holding a surveyor's rod and the second sighting through the surveyor's level. Be sure that the person is holding the marked pole or rod at the surface of the water. The intent is to get a measure of the *water surface* slope, which may not necessarily be the same as the bottom slope. The surveyor's level is leveled according to the manufacturer's recommendations, which is generally to adjust the three leveling feet until the bubble is centered. Level is checked in all planes to be measured. If the level does not "self level" in all measured planes the user should check the instruction manual for suggested options. Elevation readings are made at each transect and the difference between each elevation reading is recorded as the change in elevation. **NOTE: Multiple transect elevations can often be made for each setup of the level, but every time the tripod and level are moved a second measurement of the last transect elevation from the last setup is required. You cannot use elevations from previous setups because the relative height of the level has changed.**

To calculate sinuosity from bearing measurements, it does not matter whether or not you adjust your compass bearings for magnetic declination, but it is important that you are **consistent** in the use of magnetic or true bearings throughout all the measurements you make on a given reach. Note in the comments section of the Slope and Bearing Form which type of bearings you are taking, so the measurements can be used to describe reach aspect. Also, guard against

recording *reciprocal bearings* (erroneous bearings 180 degrees from what they should be). The best way to do this is to know where the primary (cardinal) directions are in the field: (north [0 degrees], east [90 degrees], south [180 degrees], and west [270 degrees]), and insure that your bearings "make sense."

As stated earlier, it may be necessary to set up intermediate (supplemental) bearing points between a pair of cross-section transects if you do not have direct line-of-sight along (and within) the channel between stations Figure 8.5. This can happen if brush is too heavy, or if there are sharp slope breaks or tight meander bends. *If you would have to sight across land to measure bearing between two transects, then you need to make one or more supplemental measurements* (i.e., do not "short-circuit" a meander bend). Mark these supplemental locations with a different color of plastic flagging than used for the cross-section transects to avoid confusion. Record these supplemental bearing measurements, along with the proportion of the stream segment between transects included in each supplemental measurement, in the appropriate sections of the Slope and Bearing Form (Figure 8.4). Note that the main bearing observations are always downstream of supplemental observations (i.e., **to** the downstream transect). Similarly, first supplemental observations are always downstream of second supplemental observations.

Because measurements of slope are a calculation of the elevation difference between transects, you may sight over land for the purposes of slope only (Figure 8.5). You may need to use supplemental points in your measurement of slope if visibility is severely limited, but supplemental points are not required as they are for measurements of bearing. As a result, there may be times when you record bearing data for a supplemental point (or two) on the Slope and Bearing Form; but only record the total elevation change in the MAIN column.

Table 8.6 Procedure for Obtaining Slope Data

Slope Method with Surveyors Level
Instrument Setup: 1. Extend the tripod legs to approximately eye level and set the legs firmly into the ground; adjust the legs so that they form a regular triangle and are firmly set with no wobble. Adjust the legs so that the base plate is approximately level. 2. Hold the instrument on the tripod and start the centering screw. Ensure the adjustable feet are roughly evenly adjusted. While the centering screw is still loose slide the instrument on the base plate until the bubble is approximately centered in the circular level. Tighten the centering screw. 3. Adjust the leveling foot screws until the bubble is exactly level in the center circle. 4. Self-Leveling instruments can now be swiveled gently on the base plate and should maintain level as long as the tripod remains steady. Check to ensure the bubble indicates the instrument is level across all planes at which measurements are to be made. 5. Adjust focus, brightness and parallax according to manufactures specifications. The instrument is ready to make measurements. Taking Measurements: 1. Determine a location at transect K to hold a surveyor's rod that will be visible from a point between transect J and transect K: a. Set up the instrument at a point approximately halfway between transects J and K and where a clear line of sight is possible. If visibility allows, the instrument may be placed farther upstream, as long as transect K is still visible. b. Position the staff at transect K, holding the bottom of the staff at the water level and the staff as

vertical as possible and the numbers facing the instrument.

c. Site the staff through the instrument and record the reading to the nearest centimeter in a field notebook or other workspace (this value is **not** entered on the field form).

d. Move the staff to transect J and gently swivel the instrument to face the next reading. Hold the staff as before, vertically, with the bottom at the water level and the numbers facing the instrument.

e. Site the staff and record the reading to the nearest centimeter (again in a field notebook or elsewhere).

f. Subtract the elevation reading at transect J from the reading at transect K.

g. The difference in the readings is the elevation difference that is recorded on the Slope and Bearing Form.

h. Repeat measurements between each transect.

Note: In small streams with a clear line of site it may be possible to set the instrument up once and make readings to several transects from a single set up. Simply record the readings for each transect and do not skip transects.

- If you are back sighting to a supplemental point, you may record the elevation difference in the appropriate *SUPPLEMENTAL* section of the Slope and Bearing Form.

2. Proceed to the next cross-section transect (or supplementary point), and repeat Steps a - h above.

[a] Method codes are: *CL*=clinometer, *TR*=transit, *HL*=hand level, *WT*=Water tube, *LA*=laser level, *OTHER*=method not listed (describe in comments section of form).

instrumentation (e.g., surveyor's level), and have field personnel who are experienced in the use of these instruments. The Slope and Bearing Form (Figure 8.4) is designed to allow for different methods and/or different units of measuring slope. Mark the appropriate method bubble (instead of *CL*; method codes are identified in Table 8.6) and mark the *% BUBBLE* (instead of the *CM* bubble) if the method or instrument measures the percent slope rather than the change in elevation (Table 8.7).

Table 8.7 Modified Procedure for Obtaining Slope Data (without Surveyor's Level)

Modified Slope Method - Only Use if Surveyor Level is NOT Possible

Use this procedure if you are starting at the upstream transect (*K*), after completing the thalweg profile and other cross-section measurements at transects *A* through *K*. **It should only be used if you cannot use the surveyor's level.**

1. Stand in the channel at the upstream cross-section transect. Determine if you can see the next cross-section transect downstream.. If not, you may have to take supplementary slope measurements. While sighting over land is not prohibited during any slope measurement, the clinometer method is more difficult to use over larger distances, so supplementary measurements are more likely to be needed.
2. Mark a surveyor's rod and a calibrated rod (or meter ruler) at the same height. If a shorter pole or ruler is used, measure the height from the ground to the opening of the clinometer when it is resting on top.
3. Have one person take the marked surveyor's rod to the downstream transect. Hold the rod vertical with the bottom at the same level as the water surface. If no suitable location is available at the stream margin, position the rod in the water and note the depth.

   If you have determined in Step 1 that supplemental measurements are required for this segment, walk downstream to the furthest point where you can stand in the center of the channel and still see the center of the channel at the upstream cross-section transect.. Mark this location with a different color flagging than that marking the cross-section transects.
4. Place the base of the calibrated rod at the level as the surveyor's rod (either at the water surface or at the same depth in the water).
5. Place the clinometer on the calibrated rod at the height determined in Step 2. With the clinometer, sight downstream to the flagged height on the surveyor's rod at the downstream transect (or at the supplementary point).

   If you are sighting to the next downstream transect, read and record the percent slope in the *MAIN* section on the Slope and Bearing Form for the downstream transect (e.g., *J* < *K*), *which is at the bottom of the form* (i.e., you are completing the form in reverse order). Record the *PROPORTION* as 100%.

   If you are backsighting from a supplemental point, record the slope (%) and proportion (%) of the stream segment that is included in the measurement in the appropriate *SUPPLEMENTAL* section of the Slope and Bearing Form. The last sighting to a downstream transect (from either the upstream transect or the nearest upstream supplemental point) is always recorded as the *MAIN* reading.
6. Stand in the middle of the channel at upstream transect (or at a supplemental point), and sight with your compass to the middle of the channel at the downstream transect (or at a supplemental point). Record the bearing (degrees) in the same section of the Slope and Bearing form (Supplemental or Main) as you recorded the slope in Step 6.
7. Proceed to the next cross-section transect (or to a supplementary point), and repeat Steps 3 through 7 above.

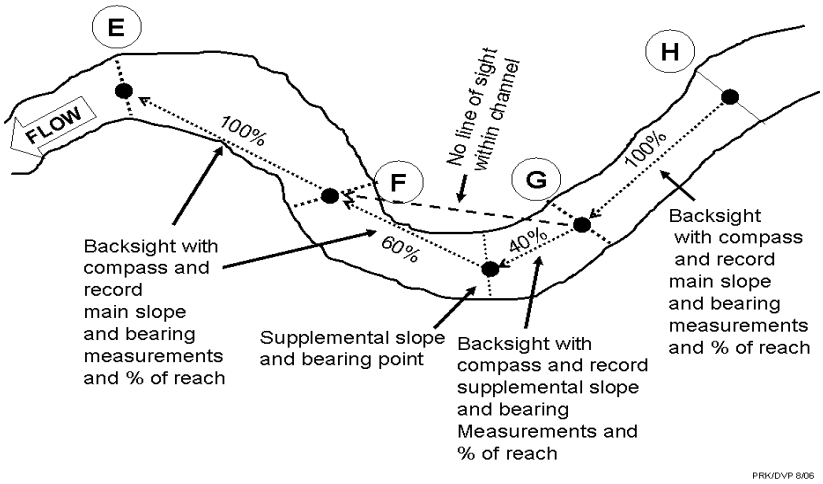


Figure 8.5 Measurements of Bearing Between Transects

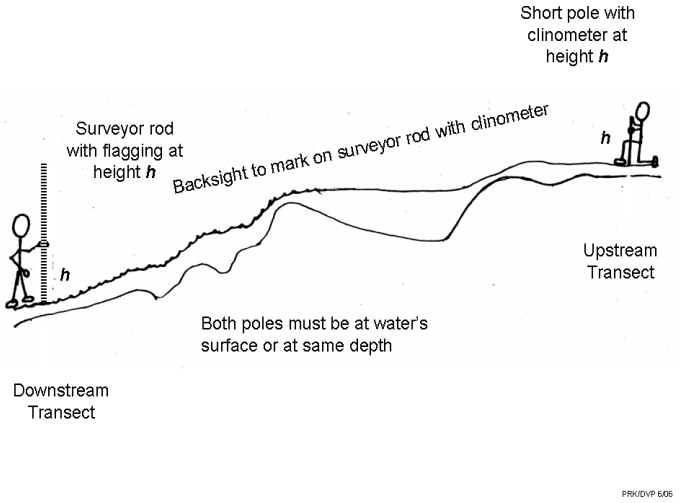


Figure 8.6 Channel Slope Measurement using a Clinometer

Table 8.8 Procedure for Obtaining Bearing Data

Bearing Method
Use this procedure to backsight from one transect to another with the use of a sighting compass. Readings (in degrees) are taken from the center one of transect to the center of the next transect downstream. It does not matter whether you use true or magnetic bearings as long as you are consistent for each reading. Take care not to accidentally take a reciprocal reading (one that is 180 degrees off). 1. Stand in the center of the channel at the upstream cross-section transect. Determine if you can see the next cross-section transect downstream without sighting across land (i.e., do not "short-circuit" a meander bend). If not, you will have to take supplementary bearing measurements 2. Hold the compass in line with your body and sight down the "lubber line" or through the sight window to the center of the next transect downstream (or supplemental point). It will help to have another person at the center of the transect to which you are sighting. Remember that your line of sight cannot "cross land." 3. While pointing the compass toward the middle of the transect or supplemental point, read the bearing (in degrees) • For many navigational compasses, you will rotate the bezel until the index marks are centered over magnetic north needle. The base of the lubber line or index mark on the sight now points to the compass heading on the bezel. • For some direct reading compasses, the bearing will be displayed already 4. Record the reading on the Slope and Bearing Form. 5. If you are sighting to the next downstream transect, read and record the bearing in the *MAIN* section on the Slope and Bearing Form. Record the *PROPORTION* as 100%. 6. If you are backsighting from a supplemental point, record the bearing and proportion (%) of the stream segment that is included in the measurement in the appropriate *SUPPLEMENTAL* section of the Slope and Bearing Form. The last sighting to a downstream transect (from either the upstream transect or the nearest upstream supplemental point) is always recorded as the *MAIN* reading. 7. Proceed to the next transect (or supplemental point), and repeat steps 1 through 6 above.

8.7 Substrate Size and Channel Dimensions

Substrate size and embeddedness are evaluated at 5 points at each of the 11 transects (refer to Figure 8.7). Substrate size is also evaluated at 10 additional cross-sections located midway between each of the 11 regular transects (*A-K*). In the process of measuring substrate particle sizes at each channel cross-section, the wetted width of the channel and the water depth at each substrate sample point are measured (at the 10 midway cross-sections, only substrate size and wetted width are recorded). If the wetted channel is split by a mid-channel bar (Section 8.4.1), the five substrate points are centered between the wetted width boundaries regardless of the mid-channel bar in between. Consequently, substrate particles selected in some cross-sections may be "high and dry". *For cross-sections that are entirely dry, make measurements across the* ***unvegetated portion*** *of the channel.*

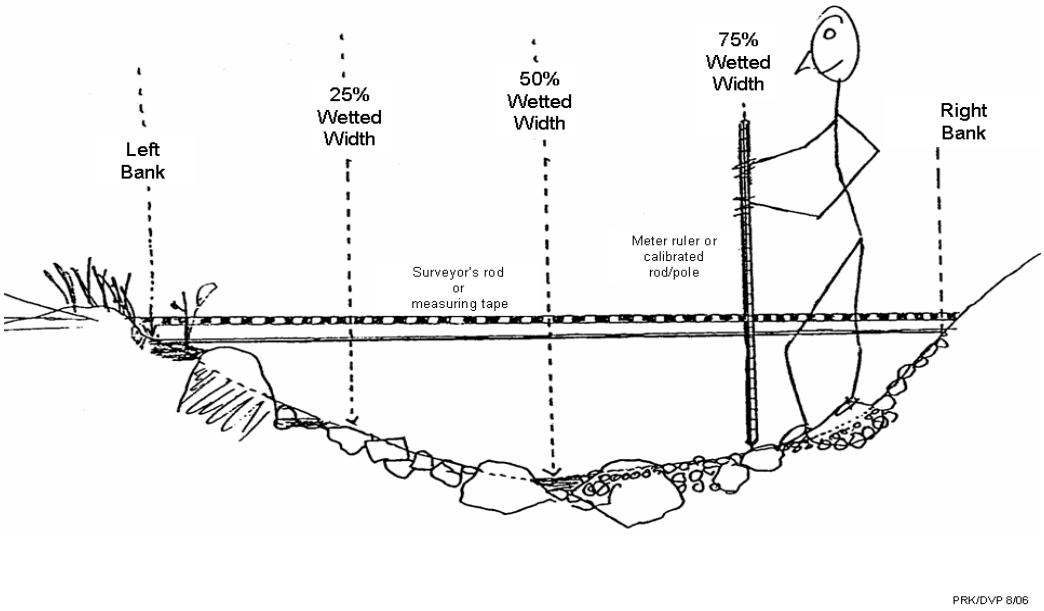


Figure 8.7 Substrate Sampling Cross-Section

The substrate sampling points along the cross-section are located at 0, 25, 50, 75, and 100 percent of the measured wetted width, with the first and last points located at the water's edge just within the left and right banks. The procedure for obtaining substrate measurements is described in Table 8.9 (including all particle size classifications). Record these measurements on the Channel/Riparian Cross-section side of the field form, as shown in Figure 8.8.

For the supplemental cross-sections midway between regular transects, record substrate size and wetted width data on the thalweg profile side of the field form. To minimize bias in selecting a substrate particle for size classification, it is important to concentrate on correct placement of the measuring stick along the cross-section, and to select the particle right at the bottom of the stick (not, for example, a more noticeable large particle that is just to the side of the stick). Classify the particle into one of the size classes listed on the field data form (Figure 8.8) based on the middle dimension of its length, width, and depth. This *median dimension* determines the sieve size through which the particle can pass. When you record the size class as

Other, assign an *Fn* flag on the field data form and describe the substrate type in the comments section of the field form, as shown in Figure 8.8.

At substrate sampling locations on the 11 regular transects (*A-K*), examine particles larger than sand for surface stains, markings, and algal coatings to estimate embeddedness of all particles in the 10 cm diameter circle around the substrate sampling point. Embeddedness is the fraction of a particle's volume that is surrounded by (embedded in) sand or finer sediments on the stream bottom. By definition, record the embeddedness of sand and fines (silt, clay, and muck) as *100 percent*, and record the embeddedness of hardpan and bedrock as *0 percent*.

Table 8.9 Substrate Measurement Procedure

1. Fill in the header information on page 1 of a Channel/Riparian Cross-section Form. Indicate the cross-section transect. At the transect, extend the surveyor's rod or metric tape across the channel perpendicular to the flow, with the "zero" end at the left bank (facing downstream).

   NOTE: If a side channel is present, and contains 16 - 49% of the total flow, establish a secondary cross-section transect. Use a separate field data form to record data for the side channel, designating it as a secondary transect by marking both the EXTRA SIDE CHANNEL bubble and the associated primary transect letter (e.g., A, B, etc.). Collect all channel and riparian cross-section measurements from the side channel.

2. Divide the wetted channel width channel by 4 to locate substrate measurement points on the cross-section. In the *DISTLB* fields of the form, record the distances corresponding to 0% (*LEFT*), 25% (*LCTR*), 50% (*CTR*), 75% (*RCTR*), and 100% (*RIGHT*) of the measured wetted width. Record these distances at Transects *A-K*, but just the wetted width at midway cross-sections.

3. Place your sharp ended meter stick or calibrated pole at the *LEFT* location (0 m). Measure the depth and record it on the field data form. (Cross-section depths are measured only at regular transects *A-K*, not at the 10 midway cross-sections).
   - Depth entries at the left and right banks may be 0 (zero) if the banks are gradual.
   - If the bank is nearly vertical, let the base of the measuring stick fall to the bottom (i.e., the depth at the bank will be > 0 cm), rather than holding it suspended at the water surface.

4. Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder), and visually estimate its particle size, according to the following table. Classify the particle according to its median diameter (the middle dimension of its length, width, and depth). Record the size class code on the field data form. (Cross-section side of form for transects A-K; special entry boxes on Thalweg Profile side of form for midway cross-sections.)

Code	Size Class	Size Range (mm)	Description
RS	Bedrock (Smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (Rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan	>4000	Firm, consolidated fine substrate
LB	Boulders (large)	>1000 to 4000	Yard/meter stick to car size
SB	Boulders (small)	>250 to 1000	Basketball to yard/meter stick size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (Coarse)	>16 to 64	Marble to tennis ball size
GF	Gravel (Fine)	> 2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size; gritty between fingers
FN	Fines	≤0.06	Silt Clay Muck (not gritty between fingers)

WD	Wood	Regardless of Size	Wood & other organic particles
RC	Concrete	Regardless of size	Record size class in comment field
OT	Other	Regardless of Size	Metal, tires, car bodies etc. (describe in comments)

5. Evaluate substrate embeddedness as follows at each of the five points. For particles larger than sand, examine the surface for stains, markings, and algae. Estimate the average % embeddedness of particles in the 10 cm circle around the measuring rod. Record this value on the field data form. For sand and smaller particles, you will not be able to pick up an individual particle, but a "pinch" of fine particles between your fingers. Determine and record the dominant size of particles in the "pinch." By definition, sand and fines are embedded *100%*; bedrock and hardpan are embedded *0%*.
6. Move to the next location on the transect, and repeat Steps 3 - 5 at each location. Repeat Steps 1 - 5 at each transect, including any additional side channel transects established if side channels are present.

8.7.1 Bank Characteristics

The procedure for obtaining bank and channel dimension measurements is presented in Table 8.10. Data are recorded in the *BANK MEASUREMENTS* section of the Channel/Riparian Cross-section Form as shown in Figure 8.8. Bank angle and bank undercut distances are determined on the left and right banks at each cross-section transect. Figure 8.9 illustrates how bank angle is determined for several different situations. The scale at which bank angle is characterized is approximately 0.5 m. A short (approx. 1 m long) pole is used to determine bank angle. The angle is determined based on the pole resting on the ground for about 0.5 m. Other features include the wetted width of the channel (as determined in Section 8.4.1), the width of exposed mid-channel bars of gravel or sand, estimated incision height, and the estimated height and width of the channel at bankfull stage as described in Table 8.10. *Bankfull height* and *incised height* are both measured relative to the present water surface (i.e. the level of the wetted edge of the stream). This is done by placing the base of the small measuring rod at the bankfull elevation and sighting back to the survey rod placed at the water's edge using the clinometer as a level (i.e., positioned so the slope reading is *0%*.). The height of the clinometer above the base of the smaller rod is subtracted from the elevation sighted on the surveyor's rod. Bankfull flows are large enough to erode the stream bottom and banks, but frequent enough (every 1 to 2 years) to not allow substantial growth of upland terrestrial vegetation. Consequently, in many regions, it is these flows that have determined the width and depth of the channel.

Table 8.10 Procedure for Measuring Bank Characteristics

1. To measure *bank angle*, lay a meter ruler or a short (approx. 1 m long) rod down against the left bank (determined as you face downstream), with one end at the water's edge. At least 0.5 m of the ruler or rod should be *resting comfortably* on the ground to determine bank angle. Lay the clinometer on the rod, and read the bank angle in degrees from the external scale on the clinometer. Record the angle in the field for the left bank in the *BANK MEASUREMENT* section of the Channel/Riparian Cross-section Form.

- A *vertical bank* is 90°, *overhanging banks* have angles >90° approaching 180°, and more gradually sloped banks have angles <90°. To measure bank angles >90°, turn the clinometer (which only reads 0 to 90°) over and subtract the angle reading from 180°.
- If there is a large boulder or log present at the transect, measure bank angle at a nearby point where conditions are more representative.

2. If the bank is *undercut*, measure the horizontal distance of the undercutting to the nearest 0.01 m. The undercut distance is the distance from the water's edge out to the point where a vertical plumb line from the bank would hit the water's surface. Record the distance on the field data form. Measure submerged undercuts by thrusting the rod into the undercut and reading the length of the rod that is hidden by the undercutting.
3. Repeat Steps 1 and 2 on the right bank.
4. Hold the surveyor's rod vertical, with its base planted at the water's edge. Examine both banks, then determine the channel *incision* as the *height up from the water surface to elevation of the **first terrace** of the valley floodplain* (Note this is at or above the bankfull channel height). Whenever possible, use the clinometer as a level (positioned so it reads 0% slope) to measure this height by transferring (back sighting) it onto the surveyor's rod. Record this value in the *INCISED HEIGHT* field of the bank measurement section on the field data form.
5. While still holding the surveyor's rod as a guide, and sighting with the clinometer as a level, examine both banks to measure and record the *height of bankfull flow above the present water level*. Look for evidence on one or both banks such as:
    - An obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel.
    - A transition from exposed stream sediments to terrestrial vegetation.
    - Moss growth on rocks along the banks.
    - Presence of drift material caught on overhanging vegetation.
    - A transition from flood and scour tolerant vegetation to that which is relatively intolerant of these conditions.
6. Record the *wetted width* value determined when locating substrate sampling points in the *WETTED WIDTH* field in the bank measurement section of the field data form. Also determine the *bankfull channel width* and the *width of exposed mid-channel bars* (if present). Record these values in the *BANK MEASUREMENT* section of the field data form.
7. Repeat Steps 1 through 6 at each cross-section transect, (including any additional side channel transects established when islands are present). Record data for each transect on a separate field data form.

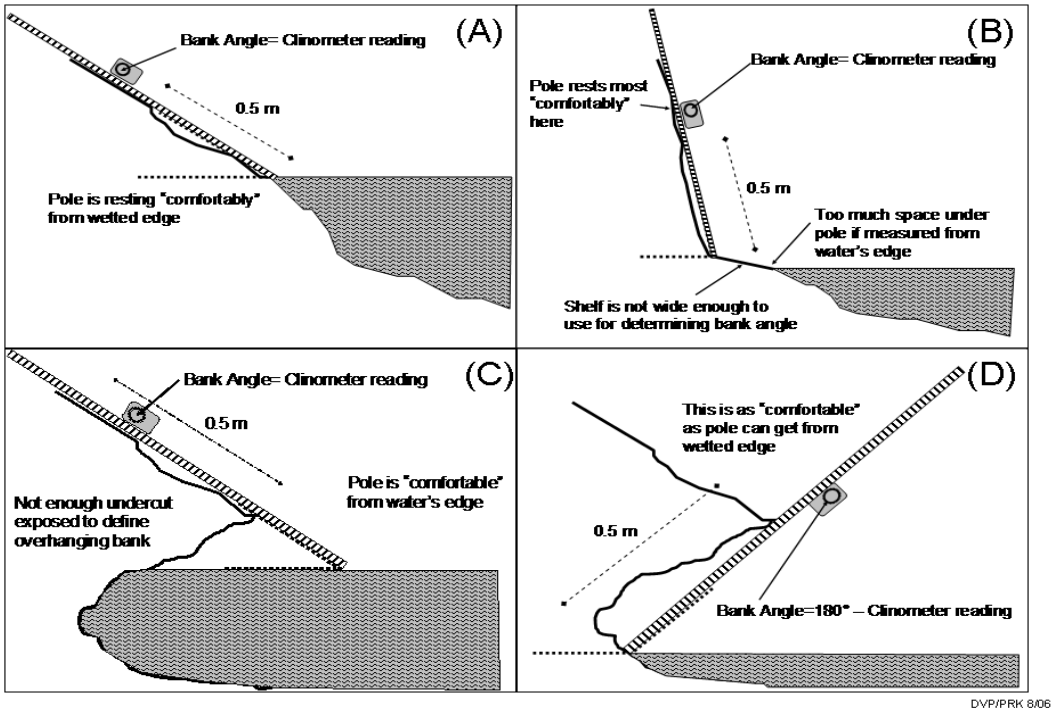


Figure 8.9 Determining Bank Angle Under Different Types of Bank Conditions (A) typical, (B) incised channel, (C) undercut bank, and (D) overhanging bank.

Unfortunately, we have to depend upon evidence visible during the low flow sampling season. If available, consult published rating curves relating expected bankfull channel dimensions to stream drainage area within the region of interest. Graphs of these rating curves can help you get a rough idea of where to look for field evidence to determine the level of bankfull flows. Curves such as these are available from the USGS for streams in most regions of the U.S. (e.g., Dunne and Leopold 1978; Harrelson et al. 1994, Leopold 1994). To use them, you need to know the contributing drainage area to your sample site. Interpret the expected bankfull levels from these curves as a height above the streambed in a riffle, but remember that your field measurement will be a height above the present water surface of the stream. Useful resources to aid your determination of bankfull flow levels in streams in the United States are video presentations produced by the USDA Forest Service for western streams (USDA Forest Service 1995) and eastern streams (USDA Forest Service 2002).

After consulting rating curves that show where to expect bankfull levels in a given size of stream, estimate the bankfull flow level by looking at the following indicators:

First look at the stream and its valley to determine the active floodplain. This is a depositional surface that frequently is flooded and experiences sediment deposition under the current climate and hydrological regime.

Then look specifically for:

- An obvious break in the slope of the banks.

- A change from water loving and scour tolerant vegetation to more drought tolerant vegetation.
- A change from well sorted stream sediments to unsorted soil materials.

In the absence of clear bankfull indications, consider the previous season's flooding as the best evidence available (note: you could be wrong if very large floods or prolonged droughts have occurred in recent years.). Look for:

- Drift debris ("sticky wickets" left by the previous seasons flooding).
- The level where deciduous leaf fall is absent on the ground (carried away by previous winter flooding).
- Unvegetated sand, gravel or mud deposits from previous years flooding.

In years that have experienced large floods, drift material and other recent high flow markers may be much higher than other bankfull indicators. In such cases, base your determination on less transient indicators such as channel form, perennial vegetation, and depositional features. In these cases, flag your data entry and also record the height of drift material in the comments section of the field data form.

We use the vertical distance (height) from the observed water surface up to the level of the first major valley depositional surface (Figure 8.10) as a measure of the degree of *incision* or *downcutting* of the stream below the general level of its valley. This value is recorded in the *INCISED HEIGHT* field. It may not be evident at the time of sampling whether the channel is downcutting, stable, or aggrading (raising its bed by depositing sediment). However, by recording incision heights measured in this way and monitoring them over time, we will be able to tell if streams are incising or aggrading.

If the channel is not greatly incised, bankfull channel height and incision height will be the same (i.e., the first valley depositional surface is the active floodplain). However, if the channel is incised greatly, the bankfull level will be below the level of the first terrace of the valley floodplain, making bankfull channel height less than incision height (Figure 8.11). *Bankfull height is **never** greater than incision height.* You may need to look for evidence of recent flows (within about one year) to distinguish bankfull and incision heights. In cases where the channel is cutting a valley sideslope and has over-steepened and destabilized that slope, the bare "cutbank" against the steep hillside at the edge of the valley is not necessarily an indication of recent incision. In such a case, the opposite bank may be lower, with a more obvious terrace above bankfull height; choose that bank for your measurement of incised height. Examine both banks to more accurately determine incision height and bankfull height. Remember that incision height is measured as *the vertical distance to the first major depositional surface above bankfull* (whether or not it is an active floodplain or a terrace. If terrace heights differ on left and right banks (both are above bankfull), choose the lower of the two terraces. In many cases your sample reach may be in a "V" shaped valley or gorge formed over eons, and the slope of the channel banks simply extends uphill indefinitely, not reaching a terrace before reaching the top of a ridge. In such cases, record incision height values equal to bankfull values and make appropriate comment that no terrace is evident. Similarly, when the stream has extremely incised into an ancient terrace, (e.g., the Colorado River in the Grand Canyon), you may crudely estimate the terrace height if it is the first one above bankfull level. If you cannot estimate the terrace height, make appropriate comments describing the situation.

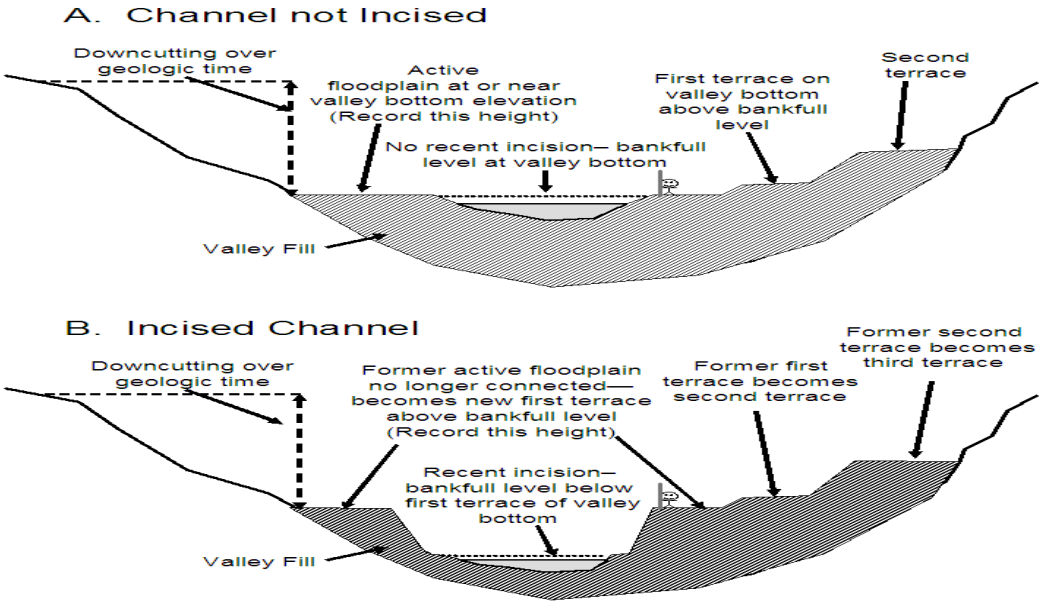


Figure 8.10 Schematic Showing Relationship Between Bankfull Channel and Incision
(A) Not recently incised, and (B) recently incised into valley bottom. Note level of bankfull stage relative to elevation of first terrace (abandoned floodplain) on valley bottom. (Stick figure included for scale).

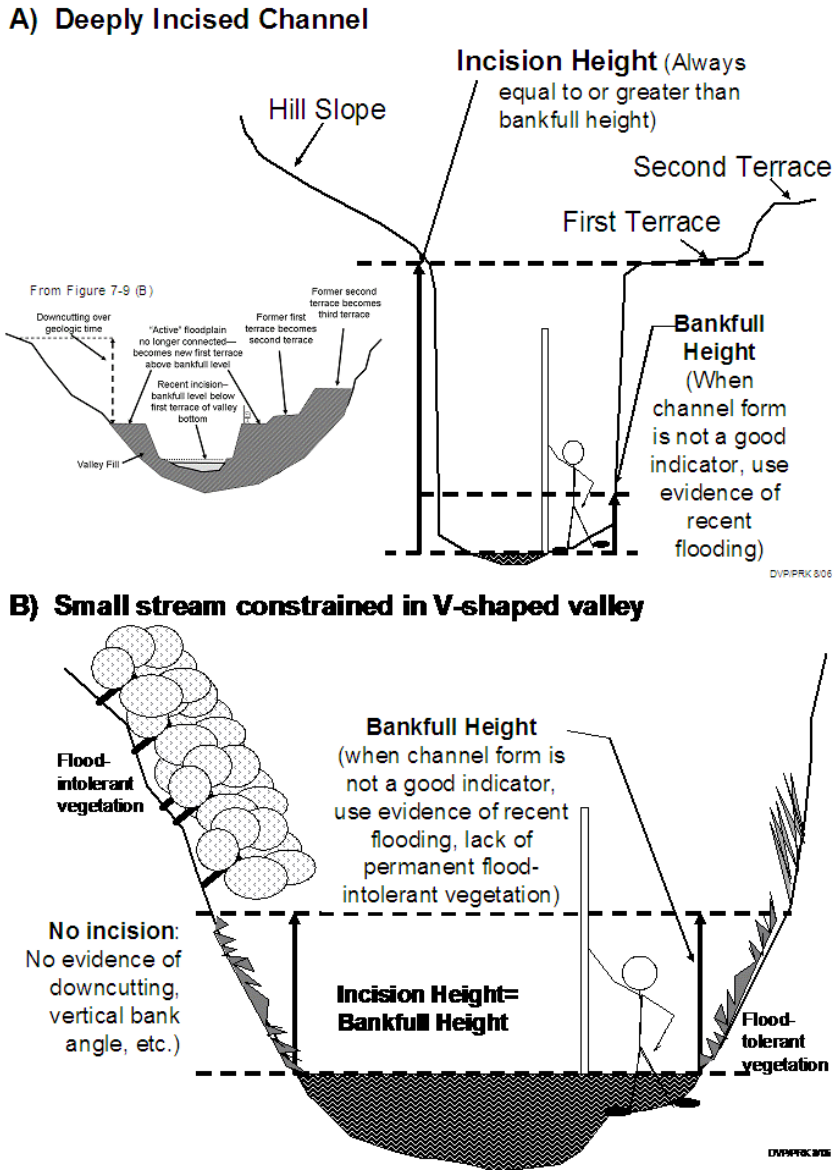


Figure 8.11 Determining Bankfull and Incision Heights for (A) Deeply Incised Channels, and (B) Streams in Deep V Shaped Valleys (Stick figure included for scale).

8.8 Canopy Cover Measurements

Canopy cover over the stream is determined at each of the 11 cross-section transects. A spherical densiometer (model *A* **convex type**) is used (Lemmon 1957). Mark the densiometer with a permanent marker or tape exactly as shown in Figure 8.12 to limit the number of square grid intersections read to 17. Densiometer readings can range from 0 (no canopy cover) to 17 (maximum canopy cover). Six measurements are obtained at each cross-section transect (four measurements in each of four directions at mid-channel and one at each bank).

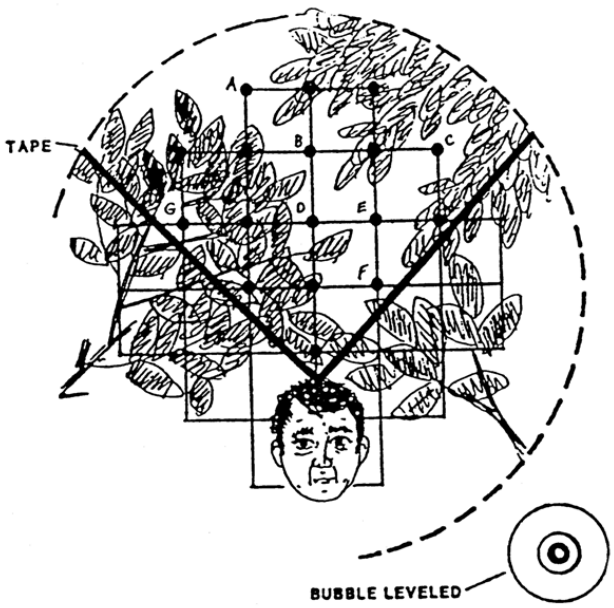


Figure 8.12 Schematic of Modified Convex Spherical Canopy Densiometer
From Mulvey et al. (1992). Note proper positioning with the bubble leveled and face reflected at the apex of the "V". In this example, 10 of the 17 intersections show canopy cover, giving a densiometer reading of 10.

The procedure for obtaining canopy cover data is presented in Table 8.11. Hold the densiometer level (using the bubble level) 0.3 m above the water surface with your face reflected just below the apex of the taped "V", as shown in Figure 8.12. Concentrate on the 17 points of grid intersection on the densiometer that lie within the taped "V". If the reflection of a tree or high branch or leaf overlies any of the intersection points, that particular intersection is counted as having cover. For each of the six measurement points, record the number of intersection points (maximum=17) that have vegetation covering them in the *CANOPY COVER MEASUREMENT* section of the Channel/Riparian Cross-section Form as shown in Figure 8.8.

Table 8.11 Procedure for Canopy Cover Measurements

Canopy Cover Measurements with Densiometer
1. At each cross-section transect, stand in the stream at mid-channel and face upstream. 2. Hold the densiometer 0.3 m (1 ft) above the surface of the stream. Level the densiometer using the bubble level. Move the densiometer in front of you so your face is just below the apex of the taped "V". 3. Count the number of grid intersection points within the "V" that are covered by either a tree, a leaf, or a high branch. Record the value (0 to 17) in the *CENUP* field of the canopy cover measurement section of the Channel/Riparian Cross-section and Thalweg Profile Form. 4. Face toward the left bank (left as you face downstream). Repeat Steps 2 and 3, recording the value in the *CENL* field of the field data form. 5. Repeat Steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the *CENDWN* and *CENR* fields of the field data form. 6. Move to the water's edge (either the left or right bank). Repeat Steps 2 and 3 again, this time facing the bank. Record the value in the *LEFT* or *RIGHT* fields of the field data form. Move to the opposite bank and repeat. 7. Repeat Steps 1 through 6 at each cross-section transect (including any additional side channel transects established when islands are present). Record data for each transect on a separate field data form.

8.9 Visual Riparian Estimates

8.9.1 Riparian Vegetation Structure

The previous section described methods for quantifying the cover of canopy over the stream channel. The following visual estimation procedures supplement those measurements with a semi-quantitative evaluation of the type and amount of various types of riparian vegetation.

Riparian vegetation observations apply to the riparian area upstream 5 meters and downstream 5 meters from each of the 11 cross-section transects. They include the visible area from the stream back a distance of 10m (~30 ft.) shoreward from both the left and right banks, creating a 10 m $\times$ 10 m riparian plot on each side of the stream (Figure 8.13). The riparian plot dimensions are estimated, not measured. On steeply sloping channel margins, the 10 m $\times$ 10 m plot boundaries are defined as if they were projected down from an aerial view.

Table 8.12 presents the procedure for characterizing riparian vegetation structure and composition. Figure 8.8 illustrates how measurement data are recorded on the Channel/Riparian Cross-section Form. Conceptually divide the riparian vegetation into 3 layers: the *Canopy* layer (> 5 m high), the *Understory* layer (0.5 to 5 m high), and the *Ground cover* layer (< 0.5 m high). Note that several vegetation types (e.g., grasses or woody shrubs) can potentially occur in more than one layer. Similarly note that some things other than vegetation are possible entries for the *Ground cover* layer (e.g., barren ground).

Before estimating the areal coverage of the vegetation layers, record the type of *woody* vegetation (*broadleaf **D**eciduous*, ***C**oniferous*, *broadleaf **E**vergreen*, ***M**ixed*, or ***N**one*) in each of

the two taller layers (Canopy and Understory). Consider the layer *Mixed* if more than 10% of the areal coverage is made up of the alternate vegetation type. If there is no woody vegetation in the understory layer, record the type as *None*.

Estimate the areal cover separately in each of the three vegetation layers. Note that the areal cover can be thought of as the amount of shadow cast by a particular layer alone when the sun is directly overhead. *The maximum cover in each layer is 100%, so the sum of the areal covers for the combined three layers could add up to 300%.* The four areal cover classes are *Absent*, *Sparse* (<10%), *Moderate* (10 to 40%), *Heavy* (40 to 75%), and *Very Heavy* (>75%). These cover classes and their corresponding codes are shown on the field data form (Figure 6.2-7). When rating vegetation cover types for a single vegetation layer, mixtures of two or more subdominant classes might all be given *Sparse* (*1*), *Moderate* (*2*), or *Heavy* (*3*) ratings. One *Very Heavy* cover class with no clear subdominant class might be rated *4* with all the remaining classes rated as either *Moderate* (*2*), *Sparse* (*1*) or *Absent* (*0*). Note that within a given vegetation layer, two cover types with 40-75% cover can both be rated *3*, but no more than one cover type could receive a rating of *4*.

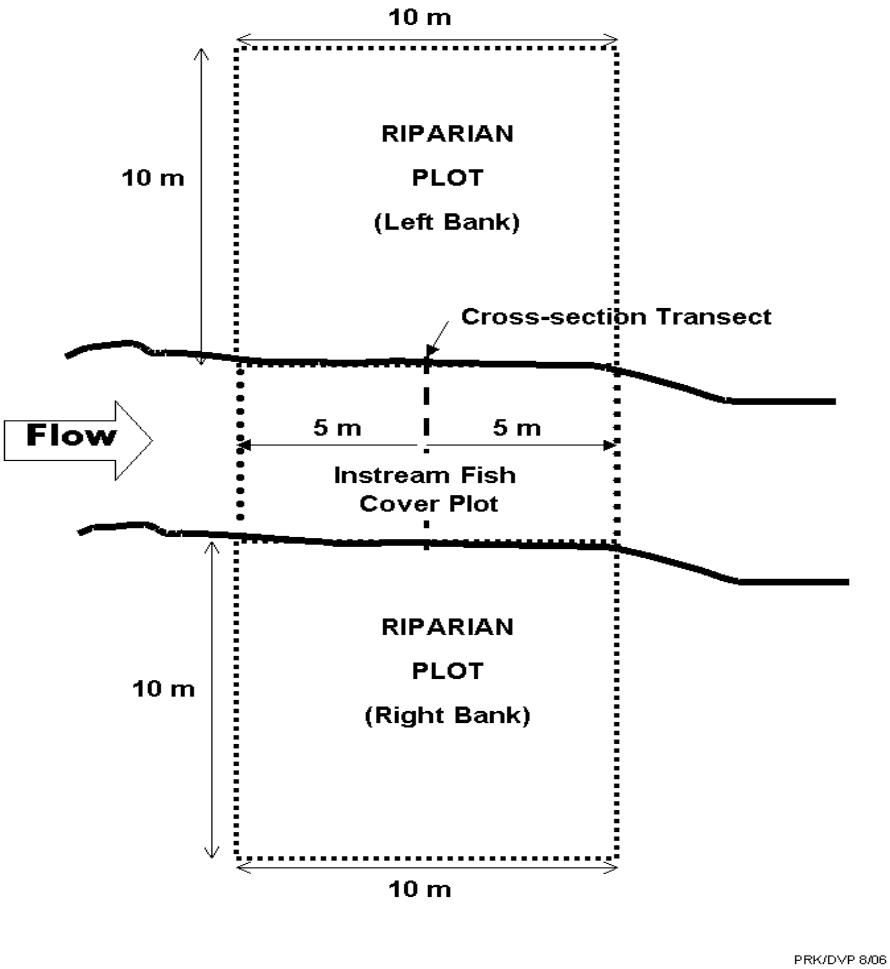


Figure 8.13 Riparian Zone and Instream Fish Cover Plots for a Stream Cross-Section Transect

Table 8.12 Procedure for Characterizing Riparian Vegetation Structure

Riparian Vegetative Structure Measurements
1. Standing in mid-channel at a cross-section transect, estimate a 5 m distance upstream and downstream (10 m total length). 2. Facing the left bank (left as you face downstream), estimate a distance of 10 m back into the riparian vegetation. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view. 3. Within this 10 m × 10 m area, conceptually divide the riparian vegetation into 3 layers: a *Canopy Layer* (>5 m high), an *Understory* (0.5 to 5 m high), and a *Ground Cover* layer (<0.5 m high). 4. Within this 10 m × 10 m area, determine the dominant vegetation type for the *CANOPY LAYER* (vegetation >5 m high) as; Deciduous, *Coniferous*, *broadleaf Evergreen*, *Mixed*, or *None*. Consider the layer *Mixed* if more than 10% of the areal coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the *VISUAL RIPARIAN ESTIMATES* section of the Channel/Riparian Cross-section Form. 5. Determine separately the areal cover class of large trees (≥0.3 m [1 ft] diameter at breast height [dbh]) and small trees (<0.3 m dbh) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (*0=absent*: zero cover, *1=sparse*: <10%, *2=moderate*: 10-40%, *3=heavy*: 40-75%, or *4=very heavy*: >75%). 6. Look at the *UNDERSTORY* layer (vegetation between 0.5 and 5 m high). Determine the dominant woody vegetation type for the understory layer as described in Step 4 for the canopy layer. If there is no woody vegetation in the understory layer, record the type as *None.* 7. Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in Step 5 for the canopy layer. 8. Look at the *GROUND COVER* layer (vegetation <0.5 m high). Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in Step 5 for large canopy trees. 9. Repeat Steps 1 through 8 for the right bank. 10. Repeat Steps 1 through 9 for all cross-section transects (including any additional side channel transects established when islands are present). Uses a separate field data form at each transect.

8.10 Instream Fish Cover, Algae, and Aquatic Macrophytes

Over a defined area upstream and downstream of the sampling transects (Figure 8.13), crews shall estimate by eye and by sounding the proportional cover of fish cover features and trophic level indicators including large woody debris, rootwads and snags, brush, live trees in the wetted channel, undercut banks, overhanging vegetation, rock ledges, aquatic macrophytes, filamentous algae, and artificial structures.

The procedure to estimate the types and amounts of instream fish cover is outlined in Table 8.13. Data are recorded on the Channel/Riparian Cross-section Form as shown in Figure 8.8. Estimate the areal cover of all of the fish cover and other listed features that are in the water and on the banks 5 m upstream and downstream of the cross-section (Figure 8.13). The areal

cover classes of fish concealment and other features are the same as those described for riparian vegetation (Section 8.9.1).

The entry *FILAMENTOUS ALGAE* refers to long streaming algae that often occur in slow moving waters. *AQUATIC MACROPHYTES* are water loving plants, including mosses, in the stream that could provide cover for fish or macroinvertebrates. If the stream channel contains live wetland grasses, include these as aquatic macrophytes. *WOODY DEBRIS* are the 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 8.5.1]). *BRUSH/WOODY DEBRIS* refers to smaller wood pieces that primarily affect cover but not morphology. *LIVE TREES OR ROOTS* are living trees that are within the channel – estimate the areal cover provided by the parts of these trees or roots that are inundated. *OVERHANGING VEGETATION* includes tree branches, brush, twigs, or other small debris that is not in the water but is close to the stream (within 1 m of the surface) and provides potential cover. *BOULDERS* are typically basketball- to car-sized particles. *ARTIFICIAL STRUCTURES* include those 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.

Table 8.13 Procedure for Estimating Instream Fish Cover

Instream Fish Cover Measurements
1. Standing mid-channel at a cross-section transect, estimate a 5m distance upstream and downstream (10 m total length). 2. Examine the water and both banks within the 10 m segment of stream for the following features and types of fish cover: *filamentous algae, aquatic macrophytes, large woody debris, brush and small woody debris, in-channel live trees or roots, overhanging vegetation, undercut banks, boulders, and artificial structures*. 3. For each cover type, estimate the areal cover. Record the appropriate cover class in the *FISH COVER/OTHER* section of the Channel/Riparian Cross-section Form: *0=absent*: zero cover, *1=sparse*: <10%, *2=moderate*: 10-40%, *3=heavy*: >40-75%, or *4=very heavy*: >75%). 4. Repeat Steps 1 through 3 at each cross-section transect (including any additional side channel transects established when islands are present). Record data from each transect on a separate field data form.

8.11 Human Influence

For the left and right banks at each of the 11 detailed Channel and Riparian Cross-sections, evaluate the presence/absence and the proximity of 11 categories of human influences with the procedure outlined in Table 8.14. Relate your observations and proximity evaluations to the stream and riparian area within 5 m upstream and 5 m downstream from the station (Figure 8.14). Four proximity classes are used: In the stream or on the bank within 5 m upstream or downstream of the cross-section transect, present within the 10 m × 10 m riparian plot but not

in the stream or on the bank, present outside of the riparian plot, and absent. Record data on the Channel/Riparian Cross-section Form (Figure 8.8). If a disturbance is within more than one proximity class, record the one that is closest to the stream (e.g., C takes precedence over P).

You may mark "P" more than once for the same human influence observed outside of more than one riparian observation plot (e.g. at both Transect D and E). **The rule is that you count human disturbance items as often as you see them, BUT NOT IF you have to site through a previously counted transect or its 10x10 meter riparian plot**.

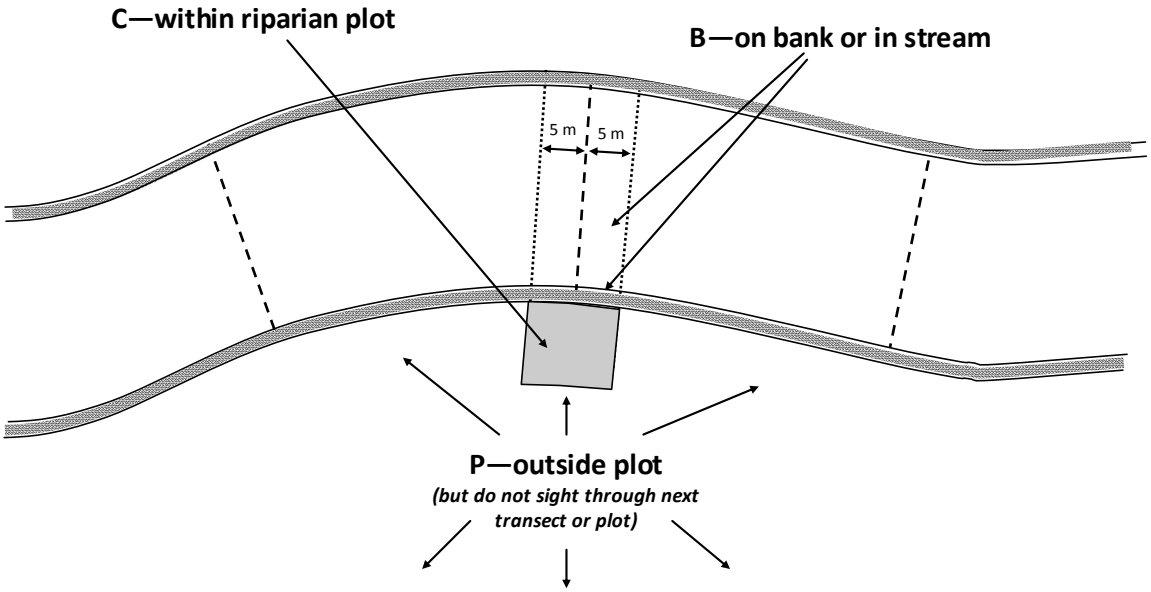


Figure 8.14 Proximity Classes for Human Influences in Wadeable Streams

Table 8.14 Procedure for Estimating Human Influence

Estimate Human Influence	
1.	Standing mid-channel at a cross-section transect, look toward the left bank (left when facing downstream), and estimate a 5 m distance upstream and downstream (10 m total length). Also, estimate a distance of 10 m back into the riparian zone to define a riparian plot area.
2.	Examine the channel, bank and riparian plot area adjacent to the defined stream segment for the following human influences: (1) *walls, dikes, revetments, riprap, and dams*; (2) *buildings*; (3) *pavement/cleared lots* (e.g., paved, gravelled, dirt parking lot, foundation); (4) *roads or railroads*, (5) *inlet or outlet pipes*; (6) *landfills or trash* (e.g., cans, bottles, trash heaps); (7) *parks or maintained lawns*; (8) *row crops*; (9) *pastures, rangeland, hay fields*, or *evidence of livestock*; (10) *logging*; and (11) *mining* (including gravel mining).
3.	For each type of influence, determine if it is present and what its proximity is to the stream and riparian plot area. Consider human disturbance items as present if you can see them from the cross-section transect. Do not include them if you have to sight through another transect or its 10 m ×10

Estimate Human Influence

m riparian plot.

4. For each type of influence, record the appropriate proximity class in the *HUMAN INFLUENCE* part of the *VISUAL RIPARIAN ESTIMATES* section of the Channel/Riparian Cross-section Form. Proximity classes are:

B (*Bank*)	Present within the defined 10 m stream segment and located in the stream or on the stream bank.
C (*Close*)	Present within the 10 × 10 m riparian plot area, but away from the bank.
P (*Present*)	Present, but outside the riparian plot area.
0 (*Absent*)	Not present within or adjacent to the 10 m stream segment or the riparian plot area at the transect

5. Repeat Steps 1 through 4 for the right bank.
6. Repeat Steps 1 through 5 for each cross-section transect, (including any additional side channel transects established when islands are present). Record data for each transect on a separate field form.

8.12 Cross-section Transects on Side Channels

If the wetted channel is split by an island, and the estimated flow in the side channel is less than or equal to 15% of the total flow, the bank and riparian measurements are made at each side of the main channel (the minor side channel is ignored other than to note its presence on the thalweg profile form), so one riparian plot is established on the island as shown in Figure 8.15 (side A). If an island is present that creates a major side channel containing **more than 15%** of the total flow, an additional cross-section transect is established for the side channel as shown in Figure 8.15 (side B). Separate substrate, bank and riparian measurements are made for side channel transects. Data from the additional side channel transect are recorded on a separate Channel/Riparian Cross-section Form as shown in Figure 8.16. Riparian plots established on the island for each transect may overlap (and be < 10 m shoreward) if the island is less than 10 m wide at the transect.

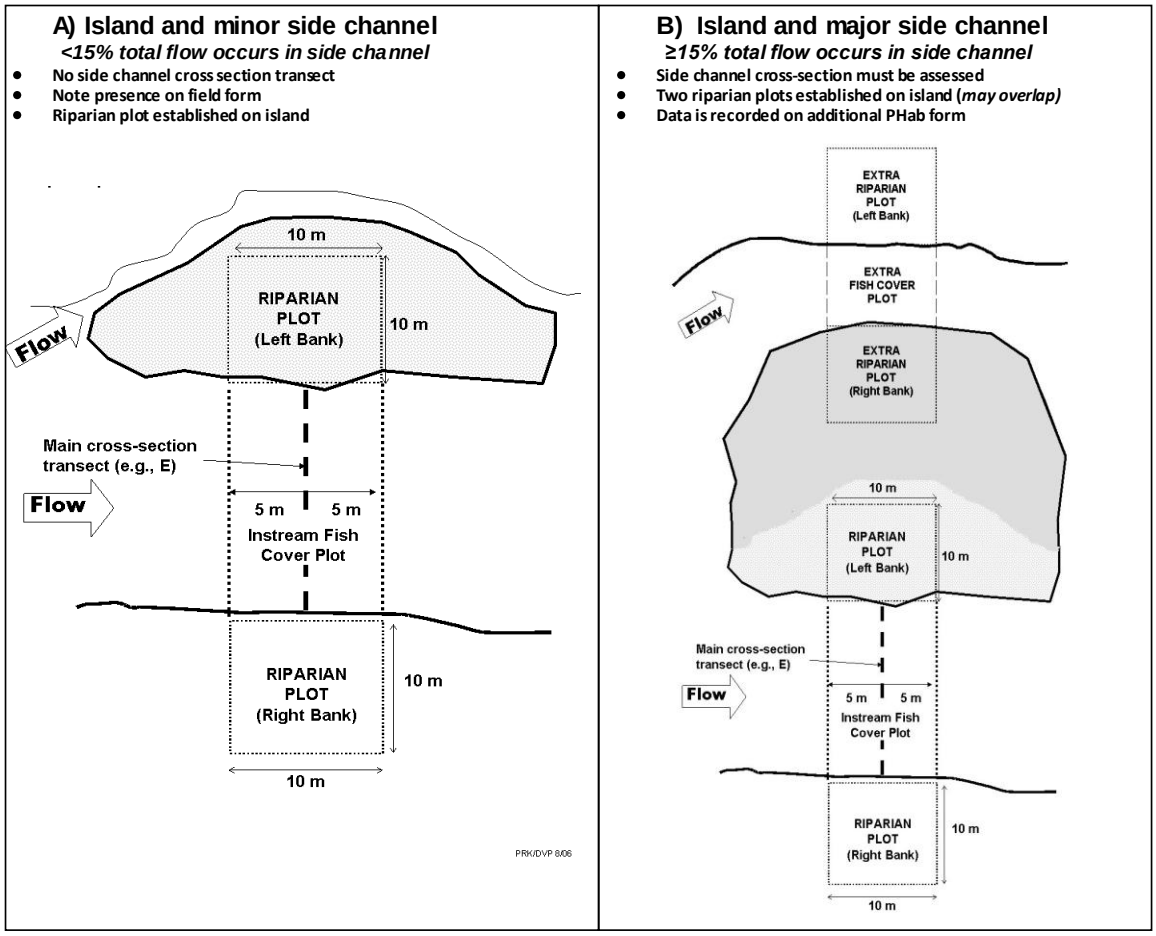


Figure 8.15 Riparian and Instream Fish Cover Plots for a Stream with Minor and Major Side Channels

8.13 Channel Constraint, Debris Torrents, Recent Floods, and Discharge

8.13.1 Channel Constraint

After completing the thalweg profile and riparian/channel cross-section measurements and observations, envision the stream at bankfull flow and evaluate the degree, extent and type of channel constraint, using the procedures presented in Table 8.15. Record data on the Channel Constraint Assessment Form (Figure 8.17). First, classify the stream reach channel pattern as predominantly a *single channel*, an *anastomosing channel*, or a *braided channel* (Figure 8.18):

1. Single channels may have occasional in-channel bars or islands with side channels, but feature a predominant single channel, or a dominant main channel with a subordinate side channel.
2. Anastomosing channels have relatively long major and minor channels (but no predominant channel) in a complex network, diverging and converging around many vegetated islands. Complex channel pattern remains even during major floods.
3. Braided channels also have multiple branching and rejoining channels, (but no predominant channel) separated by unvegetated bars. Channels are generally smaller, shorter, and more numerous, often with no obvious dominant channel. During major floods, a single continuous channel may develop

After classifying the channel pattern, determine whether the channel is constrained within a narrow valley, constrained by local features within a broad valley, unconstrained and free to move about within a broad floodplain, or free to move about, but within a relatively narrow valley floor. Then examine the channel to ascertain the bank and valley features that constrain the stream. Entry choices for the type of constraining features are bedrock, hillslopes, terraces/alluvial fans, and human land use (e.g., a road, a dike, landfill, rip-rap, etc.). Estimate the percent of the channel margin in contact with constraining features (for unconstrained channels, this is 0%). To aid in this estimate, you may wish to refer to the individual transect assessments of incision and constraint. Finally, estimate the “typical” bankfull channel width and estimate the average width of the valley floor either with a topographic map or visually. If you cannot directly estimate the valley width (e.g., it is further than you can see, or if your view is blocked by vegetation), record the distance you can see and mark the appropriate bubble on the field form.

Table 8.15 Procedures for Assessing Channel Constraint

Channel Constraint
NOTE: These activities are conducted after completing the thalweg profile and littoral-riparian measurements and observations, and represent an evaluation of the entire stream reach. *CHANNEL CONSTRAINT*: Determine the degree, extent, and type of channel constraint based on envisioning the stream at bankfull flow. 1. Classify the stream reach channel pattern as predominantly a single channel, an anastomosing channel, or a braided channel. • *Single channels may have occasional in-channel bars or islands with side channels*, but feature a predominant single channel, or a dominant main channel with a subordinate side channel. • *Anastomosing channels have relatively long major and minor channels* branching and rejoining in a complex network separated by vegetated islands, with no obvious dominant channel. • *Braided channels also have multiple branching and rejoining channels,* separated by unvegetated bars. Subchannels are generally small, short, and numerous, often with no obvious dominant channel. 2. After classifying the channel pattern, determine whether the channel is constrained within a narrow valley, constrained by local features within a broad valley, unconstrained and free to move about within a broad floodplain, or free to move about, but within a relatively narrow valley floor. 3. Then examine the channel to ascertain the bank and valley features that constrain the stream. Entry choices for the type of constraining features are bedrock, hillslopes, terraces/alluvial fans, and human land use (e.g., a road, a dike, landfill, rip-rap, etc.). 4. Based on your determinations from Steps 1 through 3, select and record one of the constraint classes shown on the Channel Constraint Form. 5. Estimate the percent of the channel margin in contact with constraining features (for unconstrained channels, this is 0%). Record this value on the Channel Constraint Form. 6. Finally, estimate the "typical" bankfull channel width, and visually estimate the average width of the valley floor. Record these values on the Channel Constraint Form. NOTE: To aid in this estimate, you may wish to refer to the individual transect assessments of incision and constraint that were recorded on the Channel/Riparian Cross-Section Forms. NOTE: If the valley is wider than you can directly estimate, record the distance you can see and mark the bubble on the field form.

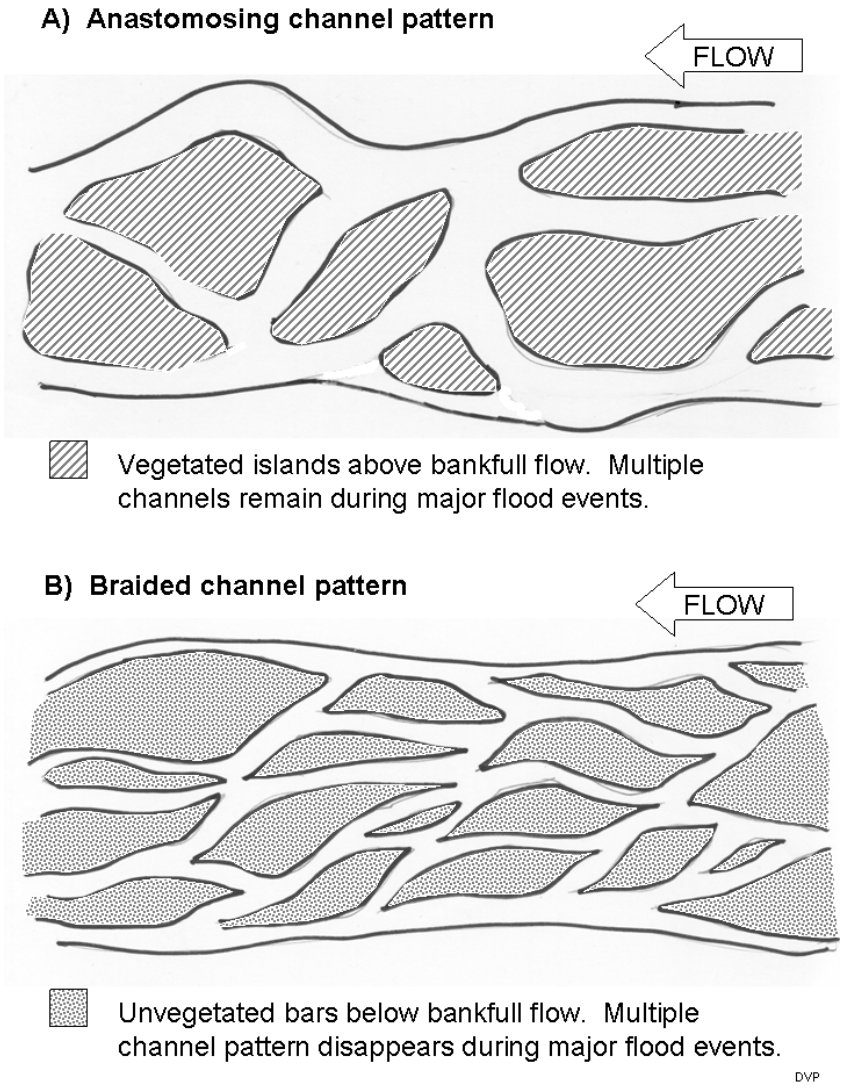


Figure 8.18 Types of Multiple Channel Patterns

8.13.2 Debris Torrents and Recent Major Floods

Debris torrents, or *lahars*, differ from conventional floods in that they are flood waves of higher magnitude and shorter duration, and their flow consists of a dense mixture of water and debris. Their high flows of dense material exert tremendous scouring forces on streambeds. For example, in the Pacific Northwest, flood waves from debris torrents can exceed 5 meters deep in small streams normally 3 m wide and 15 cm deep. These torrents move boulders in excess of 1 m diameter and logs >1 m diameter and >10 m long. In temperate regions, debris torrents occur primarily in steep drainages and are relatively infrequent, occurring typically less than once in several centuries.

Because they may alter habitat and biota substantially, infrequent major floods and torrents can confuse the interpretation of measurements of stream biota and habitat in regional surveys and monitoring programs. Therefore, it is important to determine if a debris torrent or major flood has occurred within the recent past. After completing the thalweg profile and channel/riparian measurements and observations, examine the stream channel along the entire sample reach,

including its substrate, banks, and riparian corridor, checking the presence of features described on the Torrent Evidence Assessment Form (Figure 8.19). It may be advantageous to look at the channel upstream and downstream of the actual sample reach to look for areas of torrent scour and massive deposition to answer some of the questions on the field form. For example, you may more clearly recognize the sample reach as a torrent deposition area if you find extensive channel scouring upstream. Conversely, you may more clearly recognize the sample reach as a torrent scour reach if you see massive deposits of sediment, logs, and other debris downstream.

13 FINAL SITE ACTIVITIES

13.1 Overview of Final Site Activities

Prior to leaving the site, make a general visual assessment of the site and its surrounding catchment. The objective of the site assessment is to record observations of catchment and site characteristics that are useful for future data interpretation, ecological value assessment, development of associations, and verification of stressor data. Your observations and impressions are extremely valuable.

You will filter and process the fecal indicator, chlorophyll-a, and periphyton samples, as well as. Conduct a final check of the data forms, labels and samples. The purpose of the second check of data forms, labels and samples is to assure completeness of all sampling activities. Finally, clean and pack all equipment and supplies, and clean the launch site and staging areas. After you leave the site, report the sampling event to the Information Management Coordinator, and ship or store the samples. Activities described in this section are summarized in Figure 13.1.

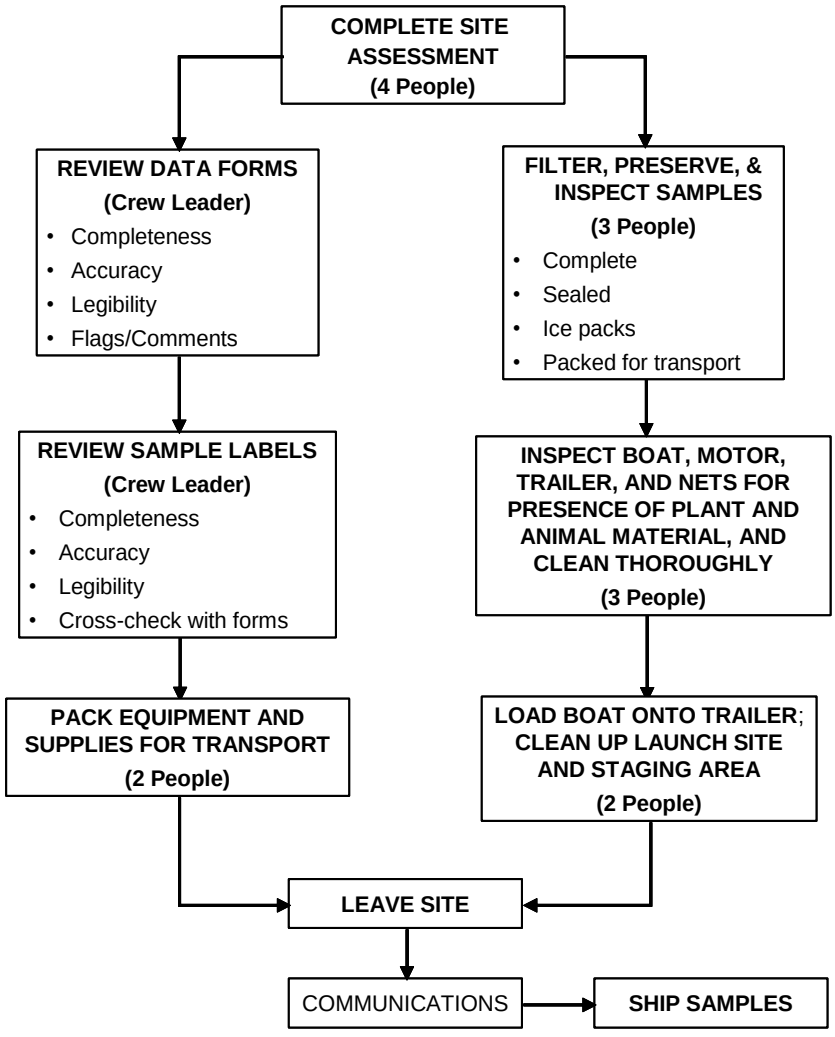


Figure 13.1 Final Site Activities Summary

13.2 General Site Assessment

Complete the Site Assessment Form (Figure 13.2) after sampling, recording all observations from the site that were noted during the course of the visit. This Site Assessment Form is designed as a template for recording pertinent field observations. It is by no means comprehensive, and any additional observations should be recorded in the General Assessment section.

13.2.1 Watershed Activities and Disturbances Observed

Record any of the sources of potential stressors listed in the "Watershed Activities and Disturbances Observed" section on the Site Assessment Form (Figure 13.2). Include those that were observed while on the site, while driving or walking through the site catchment, or while flying over the site and catchment. For activities and stressors that you observe, rate their abundance or influence as low (L), moderate (M), or heavy (H) on the line next to the listed disturbance. Leave the line blank for any disturbance not observed. The distinction between low, moderate, and heavy will be subjective. For example, if there are two to three houses on a site, circle "L" for low next to "Houses." If the site is ringed with houses, rate it as heavy (H). Similarly, a small patch of clear-cut logging on a hill overlooking the site would rate a low ranking. Logging activity right on the site shore, however, would get a heavy disturbance ranking. This section includes residential, recreational, agricultural, industrial, and stream management categories.

13.2.2 Site Characteristics

Record observations regarding the general characteristics of the site on the Site Assessment Form (Figure 13.2). When assessing these characteristics, look at a 200 m riparian distance on both banks. Rank the site between "pristine" and "highly disturbed", and between "appealing" and "unappealing." Document any signs of beaver activity and flow modifications. Record the dominant land use and forest age class. Document the weather conditions on the day of sampling, and any extreme weather conditions just in the days prior to sampling.

13.2.3 General Assessment

Record any additional information and observations in this narrative section. Information to include could be observations on biotic integrity, vegetation diversity, presence of wildlife, local anecdotal information, or any other pertinent information about the site or its catchment. Record any observations that may be useful for future data interpretation.

13.4 Data Forms and Sample Inspection

After the Site Assessment Form is completed, the Field Team Crew Leader reviews all of the data forms and sample labels for accuracy, completeness, and legibility. The other team crew members inspect all sample containers and package them in preparation for transport, storage, or shipment. Refer to Appendix C for details on preparing samples for shipping.

Ensure that all required data forms for the site have been completed. Confirm that the SITE-ID, the visit number, and date of visit are correct on all forms. On each form, verify that all information has been recorded accurately, the recorded information is legible, and any flags are explained in the comments section. Ensure that written comments are legible, with no "shorthand" or abbreviations. Make sure there is no marking s in the scan code boxes. Make sure the header information is completed on all pages of each form. After reviewing each form initial the upper right corner of each page of the form.

Ensure that all samples are labeled, all labels are completely filled in, and each label is covered with clear plastic tape. Compare sample label information with the information recorded on the corresponding field data forms (e.g., the Sample Collection Form) to ensure accuracy. Make sure that all sample containers are properly sealed.

13.5 Launch Site Cleanup

Load the boat on the trailer and inspect the boat, motor, and trailer for evidence of weeds and other macrophytes. Clean the boat, motor, and trailer as completely as possible before leaving the launch site. Inspect all nets for pieces of macrophyte or other organisms and remove as much as possible before packing the nets for transport. Pack all equipment and supplies in the vehicle and trailer for transport. Keep equipment and supplies organized so they can be inventoried using the equipment and supply checklists presented in Appendix A. Lastly, be sure to clean up all waste material at the launch site and dispose of or transport it out of the site if a trash can is not available.