BLM
Western
Rivers and Streams
Assessment
(WRSA)
Protocol

2014 Field Season

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Introduction

The Bureau of Land Management (BLM) is developing a National Aquatic Monitoring Strategy (NAMS) for both wadeable and non-wadeable streams and rivers under the BLM's Assessment, Inventory and Monitoring (AIM) strategy. The objective of the NAMS is to standardize aquatic core indicators, sampling methodologies and survey designs to facilitate consistent condition and trend determinations of BLM lotic resources at multiple spatial scales (e.g., stream reach, BLM district, ecoregional).

Under the BLM's NAMS, this protocol was compiled for use by the Western Rivers and Streams Assessment, a partnership between the BLM and the U.S. Environmental Protection Agency (EPA), as well as numerous step-down monitoring efforts being conducted at local, district, state and ecoregional scales. The field parameters and resulting indicators were selected by the BLM AIM Aquatic Core Indicator Working Group to maximize compatibility with existing monitoring programs (e.g., EPA NRSA, BLM MIM, USFS/BLM AREMP and PIBO-EM), while also meeting BLM's aquatic data needs as specified by the Fundamentals of Rangeland Health. Upon completion of the NAMS, this protocol will be amended and developed into a Technical Reference by the BLM for use under the AIM strategy.

This protocol was compiled from the following protocols:

- Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. http://www.fs.fed.us/biology/fishecology/emp.
- Burton, T. A., S. J. Smith, and E. R. Cowley. 2011. Riparian area management: Multiple Indicator Monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737-23. BLM/OC/ST-10/003+1737. Page 153. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.
- Lanigan, S. H. 2010. Field Protocol Manual: Aquatic and Riparian Effectiveness Monitoring Program; Regional

Interagency Monitoring for the Northwest Forest Plan for the 2010 Field Season. http://www.reo.gov/monitoring/reports/watershed/2010.FieldProtocol.Final.pdf.

- USEPA. 2009. National Rivers and Streams Assessment Field Operations Manual. EPA-841-B-07-009. Page 220. U.S. Environmental Protection Agency, Washington, D. C.

Protocol Overview

Table 1. Measurements that are to be taken at all sampled reaches.

All 11 Main Transects	Intermediate Transects	Between transects	Reach wide
• Invertebrates • Wetted width • Bar width • Bankfull height • Bankfull width • Incision height • Bank angle • Bank stability • Substrate size • Embeddedness • Densiometer • Canopy cover • Fish cover • Human influences	• Wetted width • Bar width • Substrate size • Bank Stability	• Large woody debris • Thalweg profile • Side channel presence • Bar presence • Backwater presence	• Pool delineation • Photos • Water chemistry • GPS Coordinates • Temperature probes • Reach map • Channel constraint • Torrent Evidence • Watershed activities • Watershed Characteristics

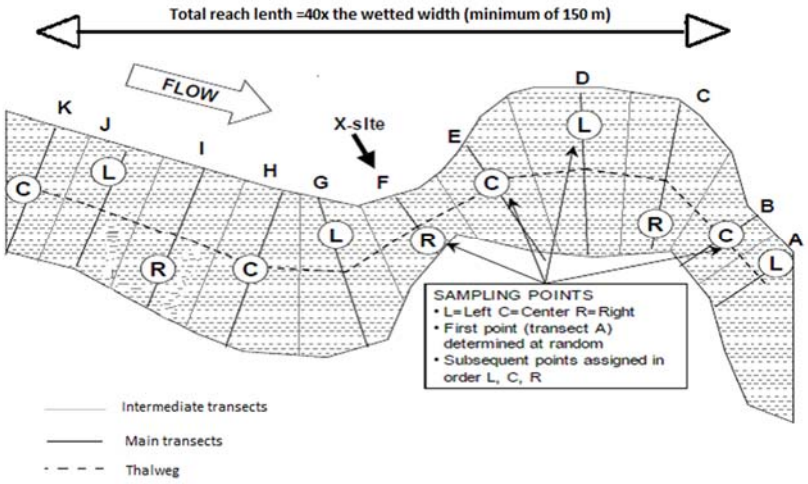

Fig. 1. Typical reach setup with 11 main transects (A – K; black lines) and 10 intermediate transects (gray lines). Circled letters represent alternating benthic macroinvertebrate sampling locations.

Suggested Work Flow

1. Locate X-site
2. Determine reach length and sampleability of the reach
3. Set up reach
    a. Both technicians measure and flag transects
    b. 1st technician takes coordinates at BR and TR (or wait till step 5b)
4. Deploy temp probe
5. X-site activities, visual assessments, and macroinvertebrates
    a. 1st technician macroinvertebrates
    b. 2nd technician
        i. Fill out verification form and draw reach map
        ii. Photos
        iii. Water quality (YSI and grab sample)
        iv. Start riparian, human influences and fish cover estimates
6. Pool delineation
    a. 1st technician measures depths and length of pools
    b. 2nd technician records data
7. Physical habitat
    a. Both technicians
        i. 1st technician measures the following:
            1. Bankfull and wetted widths
            2. Bankfull and incision height
            3. Left bank angle, bank stability and canopy
            4. Substrate/embeddedness and canopy cover
            5. Right bank angle, bank stability and canopy cover
        ii. 2nd technician logs data and finishes filling out human influence, fish cover, and riparian cover
8. Longitudinal profile
    a. 1st technician measures depth and determines substrate sizes
    b. 2nd technician records data, counting large woody debris and classify habitat
9. Intermediate transects
    a. 1st technician, measures substrate and width
    b. 2nd technician, records data
10. Slope
    a. 1st technician uses auto level and records data
    b. 2nd technician uses stadia rod
11. Overall site assessment
    a. Both technicians
12. Reach cleanup
    a. Both technicians
13. Gear decontamination
    a. Both technicians
14. Reach data review
    a. Crew leader

Important Definitions

Left and right bank- Left or right bank is determined when facing downstream.

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

Side channel: any channel separated directly from the main channel by an island (NOT a mid-channel bar).

- **Island:** stream sediments within the channel with an elevation above bankfull; islands are almost always vegetated.
- **Mid-channel bar:** stream sediments within the channel that are above current water level but below bankfull and are almost always unvegetated.

Bankfull: The lowest floodplain height at which the stream over tops its banks and spills out onto the active floodplain. This volume of flow occurs every 1.5 years on average and the elevation can be determined using the following indicators: (Appendix A pg. 89)

- **Examine stream banks for an active floodplai**n: Relatively flat, depositional area that is commonly vegetated and above the current water level unless there is a large amount of spring runoff or there has been a substantial rain event (i.e. stream running at bankfull stage).
- **Look for depositional features such as point bars:** The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage.
- **Identify breaks in slope of the banks and / or change in the particle size distribution:** from coarser bed load particles to finer particles deposited during bank overflow conditions.
- **Identify the elevation where a transition from perennial vegetation to mature key riparian woody vegetation occurs:** The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.

- **Examine the ceiling of undercut banks:** which is normally just *below* the bankfull elevation.
- **Stain lines:** Bankfull is at or above the highest stain line on rocks which may coincide with the lowest limit of mosses or lichens.

In the absence of clear bankfull indications, 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.

Where stream bed and stream bank meet

- Break in the relatively steep stream bank slope to a more gently sloping streambed.
- Associated with a rapid fining of particles from relatively coarse streambed particles to the finer stream bank particles.
- Normally (but not always) below the current water level.
- The streambed has <50% terrestrial vegetative cover.
- The stream bank is usually consolidated, the streambed is usually unconsolidated.
- In a few situations, it can be difficult to determine differences between the streambed and stream bank in reaches with cobble or bedrock substrate. Begin assessing all stream bank measurements at the scour line in these situations.

Scour line (used for bank stability only): Active channel as determined by these indicators: (Appendix A pg. 89)

- The lowest consistent limit of sod forming or perennial vegetation.
- The ceiling of undercut banks.
- On depositional features such as point bars, the scour line is often defined by the limit of perennial vegetation, or by an indentation in the bar (locally steep area).
- The best place to identify scour line is in a straight, well-vegetated section of the stream channel.

Incision height: the vertical distance (height) from the observed water surface up to the level of the first major valley depositional surface at or above bankfull (Appendix A pg. 89).

Thalweg: The flow path corresponding to the deepest part of the stream channel; almost always the area of fastest flow in any river. The thalweg will alternate back and forth across the channel from left to right bank and visa-versa.

Strahler stream order: Strahler stream order is determined from the NHD stream layer on your reach map using the following rules: (Fig. 2)

1. When two **first-order** streams (streams with no incoming tributaries) come together, they form a **second-order** stream.
2. When two second-order streams come together, they form a **third-order** stream and so on.
3. Streams of lower order joining a higher order stream do not change the order of the higher stream. Thus, if a first-order stream joins a second-order stream, it remains a second-order stream. It is not until a second-order stream combines with another second-order stream that it becomes a third-order stream.

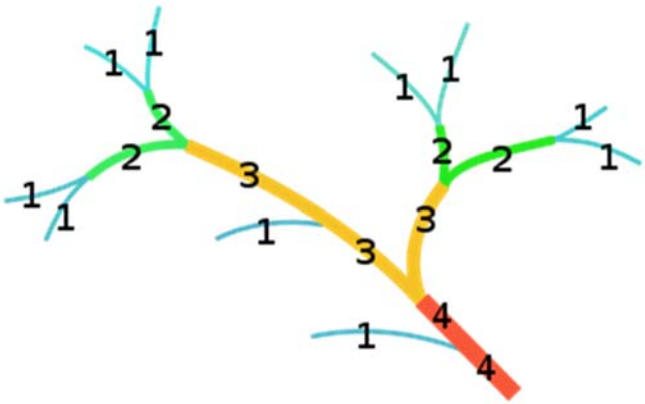

Fig. 2. Visual representation of how Strahler stream order is determined.

Site code: An eight digit code that uniquely identifies each site (i.e. XE-SS-1234).

1. The first two letters of the site code refer to the ecoregion (Fig. 3). Our goal is to sample approximately 40 sites in each of the three mountain and three xeric ecoregions, in addition to 40 sites in the other category by 2015.

    Mountains

    - MN- Northern Rockies Ecoregion
    - MS- Southern Rockies Ecoregion
    - MP- Pacific Northwest Ecoregion

    Xeric

    - XE- Eastern Xeric Plateaus Ecoregion
    - XN-Northern Xeric Basins Ecoregion
    - XS- Southern Xeric Plains Ecoregion

    Other

    - OT-Rangeland Plains, Xeric California, Southwestern Mountains

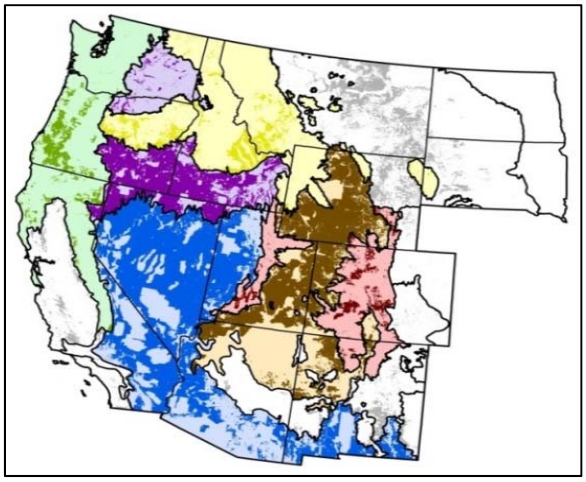

Fig. 3. Six hybrid Level III Ecoregions that encompass 95% of the linear extent of BLM's rivers and streams in the contiguous western U.S.

1. The middle two characters of the site code indicate the approximate stream size (Strahler stream order) at the site. Our goal is to sample streams of the following sizes in portion their occurrence on the landscape:

    - SS- Small stream- orders 1-2

- LS- Large stream- orders 3-4
- RO- Rivers other- order 5
- MR- Major rivers- orders >5

2. The 4 digits at the end of the code are unique to each site and **MUST** be correct on all forms.

Flag codes: The following standard codes should be used for all data flags. Explain all flags in comment sections. Comments are required for any fields that are left blank.

- U = Suspect sample (incl. estimated)
- K = Sample not collected
- F = custom flag.

Initial Site Procedures

Overview: Locate the X-site and determine the sampling status of the stream. If the stream is deemed sampleable, set up the reach for sampling.

Locating X Site

Overview: Locate the X-site of the reach to be sampled.

Methods:

1. Crews will be given site packets with information pertaining to the streams they are to sample. All sites will have an individual site sheet with the following information:
    - Site name and code
    - Site coordinates
    - Closest city and HWY, and the gazetteer page and cell
    - Possible driving directions
    - Comments from the NAMC office
    - Comments from the respective field office
    - Landowner contact information
    - A georeferenced pdf map of the surrounding area
2. Using the given information, navigate as close to the X-site as possible, either by driving or hiking once road access terminates.
3. Crews will be equipped with multiple maps, map software (iPad) and a GPS receiver to help facilitate navigation.
    a. Use google earth in the lab to plan overall driving routes.
    b. Use the gazetteer for regional navigation and campsite information (black gazetteers are better than red and have BLM land ownership).
        i. If needed, you can plot your current GPS location using the latitude and longitude increments along the side of the page.
    c. Use the georeferenced pdf maps of the appropriate scale for fine scale navigation.
    d. Use the GPS for fine scale navigation as well but there are no base maps.
        i. Click “mark waypoint” and change the latitude and longitude to the site’s coordinates. The suggested name for the waypoint is the site code.

ii. Click the "where to" page and navigate to your waypoint. Click the waypoint and click go. The map will then appear with the distance to the waypoint and a line indicating the direction you need to travel.
iii. Alternatively you can use the map or compass page to navigate to the site.

4. After all efforts have been made to reach then X-site, record whether you arrived at or not and the sources used to verify the x-site location. Then take a GPS coordinate of the X-site or the closest location to the X-site that you were able to get to.
    a. If you arrived at the x-site continue to determining the sampling status (pg. 23).
    b. If you did not arrive at or within view of the x-site, classify into the following categories below and complete the failed site (attempts) form (pg. 28).

Access permission denied

- Permission was explicitly denied by a landowner or permittee. Every possible attempt was made to access the site, but private access issues ***permanently*** prevent this site from being accessed.

Other no access

- Access is possible via another route or additional landowner/ field office contact needed due to gates etc.

Permanently inaccessible

- Cliffed out or otherwise physically unable/unsafe to reach site, and no alternate route is possible.
- Unsafe due to marijuana grows.

Temporarily inaccessible

- Unsafe due to wildfire.
- Need different gear (backpacking), truck, ATV, or crew.
- Cliffed out but access may be possible via a different route.

Dry-not visited

- A barrier prevented access to the actual x-site, but **substantial** evidence existed to suggest that the site was dry. Make sure to specify how close you were able to get to the x-site and any evidence that it was

dry on failed site (attempts) form (e.g., talked with locals that have been to the exact site).

Determining the Sampling Status

Overview: After locating the X-site, determine if the reach is sampleable upstream and downstream of the X-site.

Method:

1. Visually estimate the wetted width of the stream to determine approximate reach length.
    a. If width is < 4 m, reach length will be 150 m.
    b. If width is > 4 m, reach length will be 40 X wetted width.
    c. If width is >100 m, reach length will be 4 km.
2. Use the distance from the X-site on displayed on the GPS to walk the approximate length of the reach. Take note of the approximate location of 11 transects, assuming transects are placed at 1/10 the reach length (i.e. if the reach is 150 m long transects will be set up every 15 m).
3. While walking the reach, determine if the reach meets the following criteria:
    - You can safely access and wade >50% of transects.
    - > 50% of transects have water.
    - You can identify bankfull at > 50% of transects.
    - The current discharge level is not above the scour line or is not **unduly** influenced by a previous or current rain event.
        - Do NOT sample if:
            - High flow rainstorm events are occurring or have occurred recently (keep an eye on the weather reports and rainfall patterns).
            - The stream is flowing above scour line or water seems more turbid than typical for the class of stream.
            - There is unusually high discharge released from dams above the reach.
            - It is unsafe to be in the water.

    a. **If the reach meets these 5 criteria, it is sampleable**; continue to step 5.
    b. **If the reach DOES NOT meet the 5 criteria,** go to step 4 to determine if the reach can be slid to meet the sampleable criteria.

4. Sliding the reach.
    - Reasons to slide the reach:
        - Incoming tributary that changes stream size category (SS, LS, RO or RM) (pg. 17) in the middle of the reach.
        - Impoundments (lakes, reservoirs, ponds, beaver ponds) with >50% of transects inundated.
        - < 50% of transects with water.
        - Physical barriers making it unsafe to access (e.g., falls, cliffs).
        - Access restrictions or change in landownership with access denied.
    - When sliding the reach, these restrictions apply (Fig. 4):
        - For 150 m reaches: maximum deviation from X-site is 150 m (i.e., Reach may start or end a maximum of 150 m upstream or downstream of the X-site).
        - For reaches > 150 m: maximum deviation from X-site is 250 m.
        - **DO NOT** slide the reach if doing so will result in the stream changing Strahler stream order (pg. 17) such that it is in a **different** stream size sampling category (Small stream (SS) changing to a large stream (LS) and so on).

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

    a. If sliding the reach results in a sampleable reach, record that you slid the reach on the sampling event form and continue to step 5.
    b. If not the reach is still unsampleable, continue to step 6.

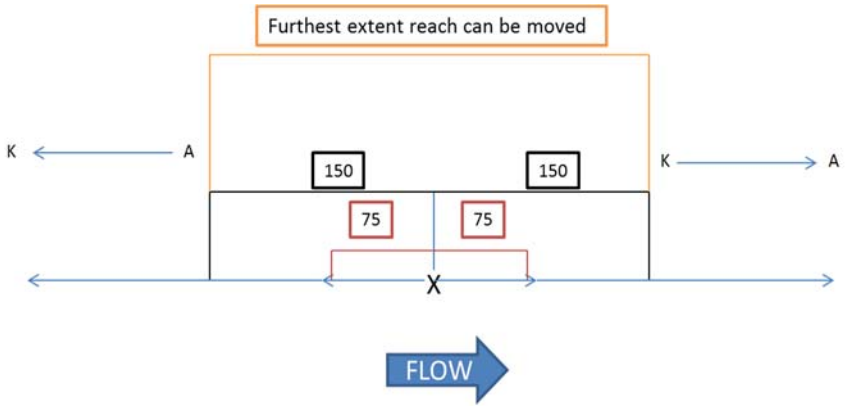

Fig. 3. Example of the maximum distance a 150 m reach can be slid.

5. If the reach is deemed sampleable before or after sliding the reach, classify it into one of categories below. Then fill out the rest of the verification form including comments about: the weather, local contacts (i.e. landowners or field offices), observations and any other important information that might help crews get back to the reach in future years.

Wadeable

- Continuous water, sampled by wading.

Boatable

- Continuous water, too deep to sample by wading. **Only classify as boatable and use the boatable protocol if >50% of transects CANNOT be safely waded.**

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.

a. If the reach is deemed sampleable under any of the wadeable categories, continue to the "Setting Up the Reach" section of the protocol (pg. 29).
b. If the reach is deemed sampleable under any of the boatable categories, obtain a copy of the boatable protocol.

6. If the reach does not meet the sampleable criteria and it cannot be slid, it is considered unsampleable. Classify it into one of the following categories regarding why the reach was not sampled. Fill out the rest of the verification form and continue on to the failed site (attempts) form (pg. 28).

Non-target:

Non-target

- BLM no longer owns this land.

Wetland

- Standing water present, but no definable stream channel (i.e., bankfull and a thalweg could not be consistently identified). If wetland is surrounding a stream channel, define the site as "Wadeable" but restrict sampling to the stream channel. Includes "beaver lakes".

Dry-visited

- Reach does not have water at > 50% of transects.

Impounded

- 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.

Map error

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

Non-sampleable temporary:

Not wadeable

- Reach is not wadeable but could be sampled with boat assistance. Indicate on failed site form whether a ducky, kayak, or canoe could be used to sample the reach versus a motorized boat and take note of any

potential boat launches. **Only use this category if >50% of transects CANNOT be waded.**

Not boatable

- Reach could not be boated with a motorized raft, ducky, kayak, or a canoe but could be waded.

Temporarily inaccessible

- Not wadeable due to rain.
- Unsure how to sample- (e.g. braided systems or large beaver impact but could be sampled with further instruction).
- People recreating prevented sampling.
- Started to attempt to access or sample but simply didn't have time.

Other temporary

- Only use if the situation does not fit any of the above categories and provide detailed comments on failed site (attempts) form if used.

Non-sampleable permanent:

Permanently inaccessible

- Vegetation too dense to get to at least 50% of transects.
- Not-wadeable and not boatable at least 50% of transects.
- Permanently denied access by land owners.
- Hike is too dangerous due to cliffs, large scree fields, and steep hill slopes.
- Marijuana growth in the vicinity of the stream.

Failed Site Form- Attempts

Overview: Fill out the relevant information on the failed site form to provide us with more details on all attempts made to sample the site and what could be done to sample the site if we were to revisit it.

Methods:

1. If you have not already done so, record the GPS waypoints of the x-site OR **the closest location to the X-site that you were able to get to**.
2. Take photos of all barriers that prevented reaching the site or pictures of multiple transects including:
    - Gate or private land access issues
    - Vegetation- Indicate vegetation type (i.e. rosebush). Use a person or a depth rod in the photos for scale.
    - Cliffs
    - Rapids
    - Poor road conditions
    - If the site was dry, take a photo of the X-site with comments specifying if moisture was present, if there was any riparian vegetation, and if there was a definable channel.
3. Check all barriers that prevented you from accessing or sampling the reach.
4. Provide **DETAILED** route information about how you attempted to access the site and provide alternate routes to the site for future crews if applicable.
5. If landownership was an issue, provide who, when, where, and why landowners, field offices, and field managers were contacted.
6. Field managers should be notified of all failed sites every 2-3 days during check in. If there is ANY doubt as to whether the site is sampleable, field managers should be notified before leaving a 1-2 hour driving radius of the site if possible and cell phone reception allows.

Setting up the Reach

Overview: After determining if the reach is sampleable, use the average of 5 wetted widths to establish sample reach length. Set up the 11 main transects, and take GPS coordinates of bottom of reach (BR) and top of reach (TR).

Methods:

1. Measure (surveyor's rod, tape, or laser range finder) channel wetted width at 5 places of "typical" width. Measurements should be taken within 5 wetted channel widths upstream and downstream from the X-site.
2. Record these 5 measurements and confirm the app calculated reach length. The reach length should follow the rules below:
    - Reach length should be 40 times the average of the 5 wetted width measurements.
    - If the average wetted width is < 4 m, use 150 m for the minimum reach length.
    - If the average wetted width is > 100 m, use 4 km for the maximum reach length.
3. Starting at the X-site (or if the reach is slid, start at the middle of the reach known as transect "F") (Fig. 5).
    a. Measure upstream, along the thalweg, the length of 1/10 the total reach length (The app displays this for you.).
    b. Place 2 pin flags, 1 on each bank, **perpendicular** to the wetted channel.
    c. Repeat 4 more times upstream for a total of 5 transects upstream of the x-site.
    d. While at the TR, stand mid-channel and use the iPad to record a waypoint.
        - On the main reach form, click the "obtain GPS coordinates" button for the appropriate field.
        - If the reach is slid, record this on the sampling event form and record the **new X-site,** BR, and TR coordinates (after the reach as been set up).
    e. Return to the X-site and repeat steps a-d this time moving downstream.
    f. Transects will be labeled A-K, transect "A" = BR and transect "K" = TR.

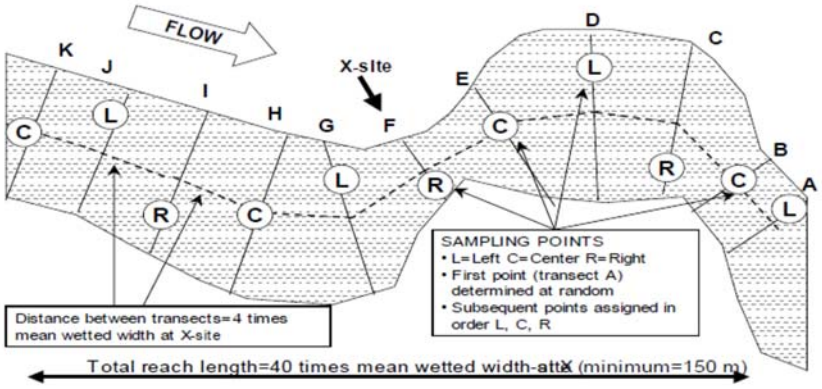

Fig. 4. A reach that has been fully set up with the locations of the 11 main transects.

Special situations: Appendix B pg. 92

Interrupted flow:

- See page 92

Side channel:

- See page 94

Temperature Probes

Overview: Deploy temperature probes into a deep shaded pool to quantify the maximum daily temperature.

Methods:

1. Deploy a temperature probe immediately upon arrival at a site.
    - 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.
    - 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).
2. 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.
3. The probe should settle in the water channel and should not bob on the surface.
4. Avoid locating the probe in areas just downstream of tributaries, obvious groundwater seeps and beaver ponds.
5. Record the probe ID number located on the white sticker, the deploy date and time.
    - Take care not to record the model number (e.g., Model # U22-001); ensure that the probe ID number matches between the temperature probe and the PVC casing.
    - Use military time format when recording all times 4-digit Military format (12:10 = 10 min after Noon; 14:17 = 2:17 PM).
6. After all site activities have been completed and the site has been cleaned up, remove the temperature probe and record the date and time the temperature probe was removed.
    - If you are at a site overnight, keep the probe deployed in the water.

7. Use the same probe for five site intervals. We want you to switch the probe after five sites in the event that the probe is lost or forgotten.

Photos

Overview: Take photos of the BR, X-site, TR, monumenting location, and a reach overview, in addition to pictures of interesting features throughout the reach.

Methods

1. Use a depth rod as a stand for the camera to get a consistent height on all photos.
2. Do not to zoom in for any photo.
3. A depth rod should be visible in as many photos as possible. Make note what bank the depth rods is on (i.e. right bank or left bank (pg. 15)).
4. Make sure that both left and right banks are present in all pictures.
5. For all photos record the following information:
    - Photo type (e.g., BR, X-site, TR, monument, overview, other)
    - Letter of the closest transect
    - Direction facing (upstream, cross-section, downstream)
    - Comment or monument feature
6. Take the following photos:
    a. Reach overview:
        - Should be taken from a location where the greatest extent of the reach can be observed - A hillside overlooking the reach is ideal, but will not always be practical.
    b. The bottom (BR), X-site, and top of the reach (TR):
        - Considering vegetation and sunlight, take a photograph looking either upstream, cross-section, or downstream standing at a distance of ~5 meters from the channel (if you cannot see both banks, move further back).
    c. Misc. Stream:
        - Take a minimum of 2 misc. stream photos, more is always better. Your goal is to take photos of the stream channel (include both banks) that are either:

a. Representative of the reach (special situations such as side channels or interrupted flow).
b. Characteristic of problematic features for protocol implementation.

d. Monumenting photo:
   - The purpose of these photos is to help future crews re-locate the sample reach.
   - Photo or multiple photos showing a prominent feature(s) of the area (e.g., large tree, boulder or human structure).

General photo do's and don'ts:

- Do not take photos displaying unprofessional behavior.
- Avoid taking photos looking into the sun; take photos with the sun at your back.
- Try to avoid taking photographs where part of the frame is in the shadows and part in the sun.

Special situations: Appendix B pg. 92
Beaver impacted reaches:

- See Page 97

Water Quality

Overview: Sampled at the X-site or Transect "F" (reaches that have been slid not to contain the X-site) before any mid-channel measurements are taken.

Methods:

In-situ measurements: pH, specific conductance, temperature

1. Review the calibration log (located in the pelican case the YSI is transported in) to ensure the sonde was calibrated for both pH and specific conductance within the last 7 days.
2. Input the most current calibration date into the calibration tab of the app (Note: you will not be able to enter in your measurements until you do this and if the calibration date is older than one week, the YSI will need to be recalibrated (Appendix C pg. 99).
3. Standing mid-channel, in flowing water, lower the probe into the water to a depth of 0.5 m below the water surface. If water depth is < 1 m, take measurements at mid-depth.
    - Avoid contacting the stream bottom with the YSI, as the instrument is delicate.
4. Use the MODE key to navigate between screens.
5. Record the pH, specific conductance (µS), and temperature (C°).
    - For specific conductance make sure to navigate to the screen where the temperature (C°) is flashing in the lower right corner. This indicates the YSI is correcting for temperature (i.e. measuring specific conductance and not conductivity).

Grab sample for total nitrogen and phosphorus

1. Obtain a 50 ml centrifuge vial (new or acid washed) and rinse it with stream water three times. Be careful not to overly disturb the stream bottom; increasing suspended solids.
2. Using the 50 ml vial, collect water sample at the X-site or transect "F". Fill the vial 75% full, this will leave head space in the vial for freezing.

3. Fill out water quality label with the full site code and the date written in the following format: **XE-SS-4120, May 06 2014.** Make sure to spell out the month and keep two digits for the day.
4. Place on outside of vial. Tape over vial with clear packing tape and put in a plastic bag to prevent water from degrading the label..
5. Immediately after collecting and labeling, place the sample on ice. If in the field for longer than 24 hours, the sample will be frozen using dry ice. For a list of known places to purchase dry ice see (Appendix D pg. 101)

Special situations: Appendix B pg. 92

Interrupted flow:

- See page 92

Beaver impacted reaches:

- See Page 97

Benthic Macroinvertebrates (BMI)

Overview: Sampled at each of the 11 main transects after water quality sampling has been completed.

Methods

1. Using the last number in the time of a digital face watch, randomly select the starting location for the sampling reach.
    - 1-3="Left"
    - 4-6="Center"
    - 7-9= "Right"
2. Place the Surber sampler or kick net 1 m below the first transect at the randomly selected position so the mouth of the net is facing into to the flow.
3. Carefully scrub all stones focusing on crack and crevices of large stones that are stuck to the bottom.
4. After removing all large stones, disturb small substrates (i.e. sand or gravel) to a depth of about 10 cm by racking and stirring with hands or scrub brush.
5. After area has been thoroughly cleaned of all animals, lift net frame straight up off the stream bed ensuring that all materials are retained within the net.
6. Continue moving upstream repeating steps 1-4 at all 11 transects.
7. If dolphin bucket is full midway through the reach, empty into wash tub and continue.
8. Rinse the net thoroughly into the wash tub with the squirt bottle, making sure to get all organic matter and any bugs that are clinging to the net. Move contents into the 500 µm sieve.
9. Spoon or spatula the sample into the peanut butter jars and preserve with 95% ethanol.
10. Fill out a BMI label for the inside and outside of the all jars. Include the stream name, site code, date, and number of jars (i.e. 1/5, 2/5 and so on). Make sure to use the full site code and the date written in the following format: **XE-SS-4120, May 06 2014.** Tape over outside label with packing tape to protect against spilt ethanol.
11. Record the number of jars, number of transects, area sampled, and sampler used.

- The app calculates the area sampled by multiplying the number of transects by the Surber area (0.093 m^2).

If at any point in the sampling or washing process the sample is compromised, (dolphin bucket falls off, mouth net goes under water in-between samples, sample is spilt while cleaning etc.) the sample will need to be discarded and retaken.

Special situations Appendix B pg. 92

Interrupted flow:

- See page 92

Side channel:

- See page 94

Beaver impacted reaches:

- See page 97

Other:

- Use a kick net to sample transects that are too deep to collect a bug sample with the Surber (i.e. You cannot reach the bottom of the stream without being submersed.)
- Sampling with a kick net:
  a. Hold mouth of net firmly on stream bottom into the flow of the stream.
  b. Stand upstream of net and use your feet disturb the sediment in an area roughly 12 in X 12 in.
  c. After the area has been thoroughly disturbed with your foot, lift the net pulling upstream to send any invertebrates and debris to the bottom of the net.
  d. Repeat above steps at all transects requiring a kick net.
  e. After all transects have been sampled composite all samples into the sieve and proceed as a normal sample.
  f. Only record the kick net as the method used if it was used at >50% of transects; however, make sure note how many transects the kick net was used for in the comments section even if it was only one transect.

Pool Delineation

Overview: Define habitat units throughout the reach.

Types of pools:

1. **Plunge:** A pool formed when the thalweg drops vertically off an obstruction (e.g. boulder, log…)
    a. To qualify as a plunge pool the max depth of the pool must be within 20% of the total width from the obstruction.
2. **Dam:** Water is backed up by a wood obstacle with **ALL** water flowing over the obstruction. If any water is flowing under or around the obstruction it is a scour pool (least common pool type)
3. **Beaver:** Water backed up by a beaver dam (beaver impacted)
4. **Scour:** Formed through scouring of the stream by floods (most common pool type)

Full channel or partial channel pools

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

Methods:

1. Starting at transect A walk upstream looking for a break in slope that could be a pool tail.
    - The pool tail is the shallowest point in the pool that would still have water flowing out if the flow were reduced to a trickle.
2. Measure the depth of the pool tail to the nearest 1 cm. **(All depths/heights are recorded in cm and all widths are recorded in m).**
3. Find and measure the max depth of the pool to the nearest 1 cm.
    - Check the max depth making sure that it is >1.5 times the pool tail depth.
4. Measure the length of the pool from the pool tail to the pool head rounding to the nearest 0.01 m.

a. Make sure the pool is longer than it is wide.
   - If width> length: is it a plunge pool?
b. If any portion of the pool is outside of the sampling reach, measure the whole pool and make a comment.

5. Check all pool criteria confirming that it is a qualifying pool.
   - Depressions in the streambed that are concave in profile, laterally and longitudinally.
   - Bound by a 'head' crest (upstream break in streambed slope) and a 'tail' crest (downstream break in streambed slope).
   - Span at least 50% of the wetted channel width at **any** location within the pool.
     - So a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool.
   - Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
   - Must be longer than it is wide
     - Plunge pools are the only pool that can be wider than they are long.
6. If the pool doesn't meet the criteria, then consider it a riffle/run.

If there are two consecutive potential pools: To lump or to split?

1. Measure the pool tail of the upstream pool.
2. If it is > 10 cm deeper than the downstream pool tail depth, lump them into 1 pool.
3. If it is ≤ 10 cm deeper than the downstream pool tail, split the 2 pools in to separate pools.
   a. Input a 0.01 m riffle in between the two pools to separate them in the data.

Special situations: Appendix B pg. 92

Side channels:

- See page 94

Interrupted flow:

- See page 92

Beaver impacted reaches:

- See page 97

Physical Habitat (PHAB)

Overview: Measurements will be made at the 11 main transects, along the longitudinal profile, and at 10 intermediate transects (pg. 12). Both technicians will participate in PHAB measurements; Technician 1 will conduct all measurements, while technician 2 records all data and makes the visual estimates. Transect measurements are to be started on the left bank (when looking down stream) moving to the right bank.

Methods:

1. Begin PHAB at transect A.
2. First measure:
    a. Wetted width
    b. Bankfull width
    c. Bankfull height
    d. Incision height (if possible on the left bank to make work flow easer)
3. Starting on the left bank measure:
    a. Bank angle
    b. Bank stability
4. Moving across the stream towards the right bank start:
    a. Substrate
    b. Embeddedness
5. Continue with substrate and embeddedness measurements until finished on the right bank.
6. At the right bank measure:
    a. Bank angle
    b. Bank stability
7. Canopy density can be measured with bank and substrate measurements; alternatively crews could do a separate pass for all canopy density measurements.
8. When all transect measurements are completed, work upstream conducting the longitudinal profile between transects.

    a. Technician 1 will take the measurements while technician 2 records data and large woody debris tallies.
9. At thalweg stations 5, 7, or 14 (dependent on reach length) intermediate transects will be set up, measurements include:
    a. Wetted width, bank stability and substrate (start on the left bank and finish on the right bank).
10. Continue upstream to the next transect, finishing the longitudinal profile.
11. Repeat until all transects have been completed.

Wetted Width

Overview: Measured at all main (11) and intermediate (10) transects.

Methods:

1. Measure width **to the nearest 0.01 m** from left edge of water to the right edge of water using the tape measure, depth rod, or laser range finder.
2. Include the width of any mid-channel bars in the wetted width measurement, but not islands.
    a. Measure and record the width of a mid-channel bar.
3. For channels with undercut banks, wetted width is measured as aerial width and does not include water that cannot be viewed when looking down on the stream.

Special situations: Appendix B pg. 92
Interrupted flow:

- See Page 92

Bankfull Height and Width

Overview: Measured at all main (11) transects using the lowest most consistent indicator of bankfull.

Identify bankfull: The lowest height at which the stream over tops its banks and spills out onto the active floodplain. This volume of flow occurs every 1.5 years on average and the elevation can be determined using the following indicators: (Appendix A pg. 88)

- **Examine stream banks for an active floodplai**n: Relatively flat, depositional area that is commonly vegetated and above the current water level unless there is a large amount of spring runoff or there has been a substantial rain event (i.e. stream running at bankfull stage).
- **Look for depositional features such as point bars:** The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage.
- **Identify breaks in slope of the banks and / or change in the particle size distribution:** from coarser bed load particles to finer particles deposited during bank overflow conditions.
- **Identify the elevation where a transition from perennial vegetation to mature key riparian woody vegetation occurs:** The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.
- **Examine the ceiling of undercut banks:** which is normally just *below* the bankfull elevation.
- **Stain lines:** Bankfull is at or above the highest stain line on rocks which may coincide with the lowest limit of mosses or lichens.

In the absence of clear bankfull indications, 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.

Methods:

Measure bankfull height:

1. Place one depth rod with the metal end touching the bankfull mark.
2. Lower the depth rod so that it is parallel to the water surface and level.
3. Place the second depth rod vertical on the water's surface.
4. Measure the height where the horizontal rod crosses the vertical rod to the **nearest 1 cm**. The measurement is taken from the bottom of the horizontal depth rod. **(All depths/heights are recorded in cm and all widths are recorded in m.)**

Measure bankfull width:

1. Using the tape measure, depth rod, or laser range finder, measure from bankfull on left bank to bankfull on right bank.
2. Record measurement in meters rounded to the **nearest 0.01 m.**

Special situations: Appendix B pg. 92

Interrupted flow:

- See page 92

Incision Height

Overview: Measured at all main (11) transects using the first terrace at or above bankfull.

Identifying incision height:

Examine both left and right banks to identify the vertical distance (height) from the observed water surface up to the level of the first major valley depositional surface at or above bankfull (Fig. 6 & 7). This is the incision height, as measured from the water surface. (More photos in Appendix A pg. 88)

- Incision height can either be an active floodplain or a terrace.
- If the height of this surface differs between banks, use the lower of the two surfaces.
- The top of a "cutbank" against the steep hillside at the edge of the valley is not necessarily an indication of recent incision.
- If the channel is not greatly incised, bankfull height and incision height can be the same (i.e., the first depositional surface is the active floodplain) (Fig. 6A).
- Bankfull height CANNOT be greater than incision height.
- Incision height is equal to bankfull if the system is:
  - A spring system with a wide valley and s no visible terrace.
  - A "V" shaped valley or gorge with no visible terrace (Fig. 7B).
- If the channel is incised greatly, the bankfull height will be less than the incision height. (Fig. 6B)
- Estimate incision height if: (Fig. 7A).
    - The first terrace above bankfull is an ancient terrace (i.e. the Colorado River in the Grand Canyon) that the stream has extremely incised into.

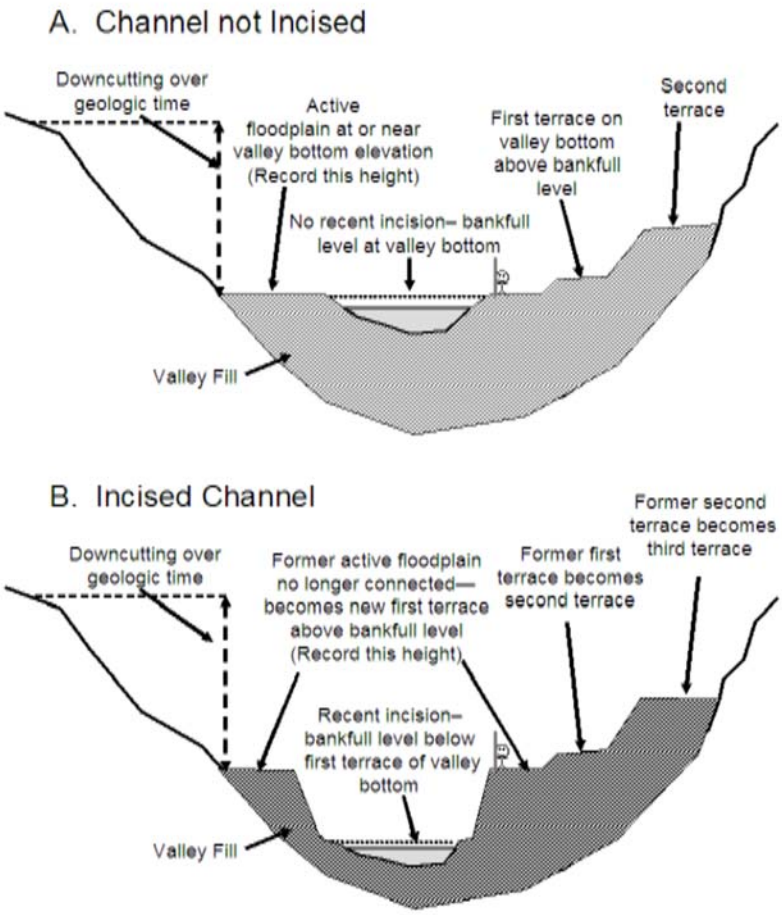

Fig. 5. (A) Channel with low incision where the active floodplain is similar to the bankfull height. (B) incised channel where the elevation of the floodplain is above bankfull height.

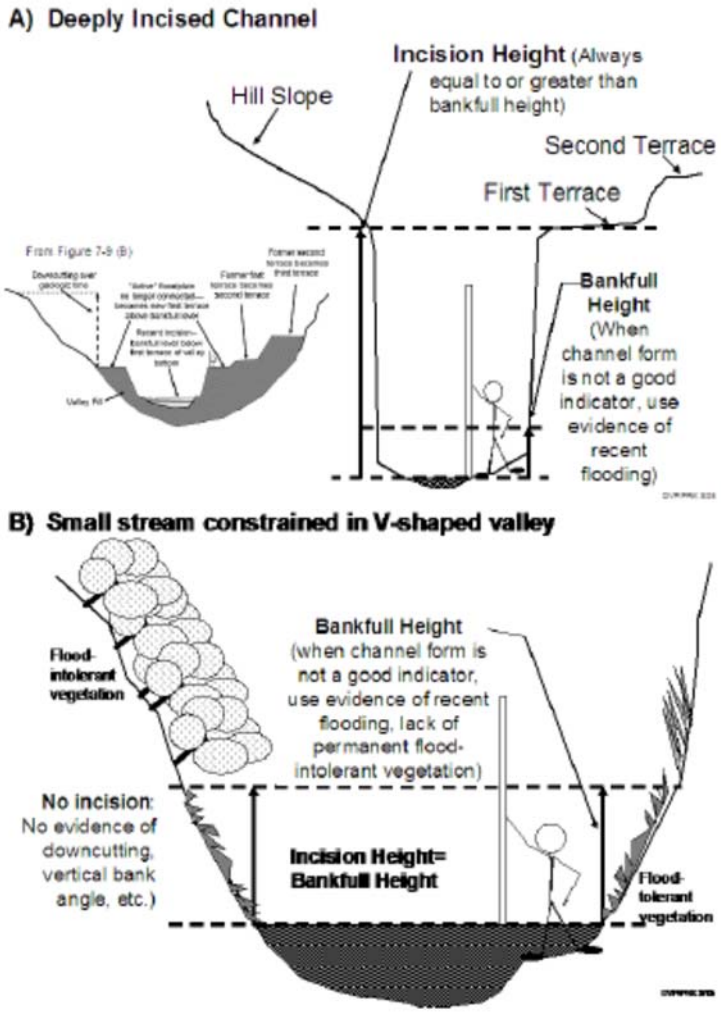

Fig. 7. Determining bankfull and incision heights for (A) deeply incised channels, and (B) streams in deep V shaped valleys.

Methods:

1. Place 1 depth rod (rod A) with the metal end touching the terrace.
2. While keeping the metal end in place, lower the depth rod towards the water surface until the rod is level.
3. Place the second depth rod (rod B) vertical on the water's surface.
4. Measure the height **to the nearest 1 cm** where the horizontal rod crosses the vertical rod, taking the measurement from the bottom of the horizontal depth rod.
5. If the terrace is too far from the water and requires multiple measurements:
    a. "Leap frog" the rods by taking rod "B" and lower it towards the ground until level (being careful not to move it from its previous position).
    b. Take rod "A" and hold it horizontal next to the vertical rod and measure the height.
    c. Repeat this until the surface of the water is reached then sum all the measurements to get incision height.

Special situations: Appendix B pg. 92

Interrupted flow:

- See page 92

Side channel:

- See page 94

Bank Angle

Overview: Measure the bank angles at all main (11) transects for the left and right banks.

Methods:

1. Use the point where the bed meets bank as the lower limit for measurements.
   - Depositional bank: if deposition of streambed material extends above the scour line, the lower limit of measurements is where deposition meets the streambank.
   - Slump blocks, logs or rocks: if the connection point (i.e. where the top of the slump block, logs or rocks meets the bank) is below the scour line, the lower limit of your measurement is there.
2. Use the first flat depositional feature at or above bankfull as the upper limit.
   - If this feature is not present, the upper limit is 0.5 m above the local bankfull elevation (Fig. 8).

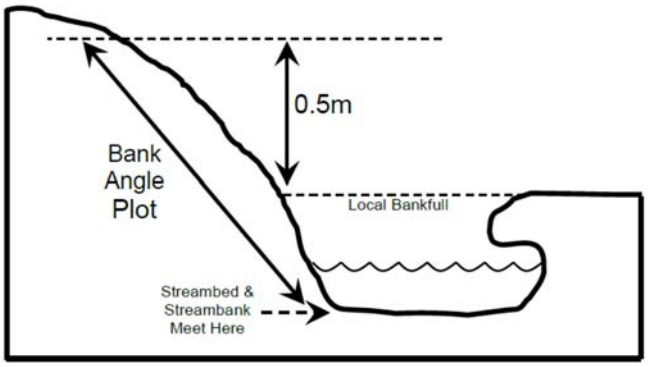

Fig.8 . Upper limit of bank angle measurements if no flat deposition feature is present.

3. Record whether the bank is obtuse or acute (fig. 8)

A. Obtuse B. Acute

Fig. 9. An obtuse bank (A) and an acute bank (B).

4. Lay depth rod perfectly in-line with transect flags, perpendicular to the channel.
5. Place a compass on top of the depth rod (not on the sides) and record the angle displayed on the compass to the nearest degree.
    - Compass come with a built in clinometer and must be set at 90° or 270° for accurate readings.
    - If the angle is obtuse, the app will subtract the recorded angle from 180° for you. If the angle is acute, the recorded value is the bank angle and no subtraction is required.

Follow guidelines below for measuring angles on various types of banks.

Types of Banks:

Simple Banks: 1 angle >10 cm in height:

- Measure the angle from the base of the bank (where the streambed and bank meet) up to the first flat, floodplain-like surface located at or above the bankfull elevation.
- If a bankfull indicator / feature is not present, the upper limit of bank angle plot is 0.5 m above bankfull elevation.

Complex Banks: 2 angles (both ≥10 cm in height):

- When a bank has more than 1 angle, consider each angle with a vertical height of >10 cm.
- Measure the angle of the tallest section of bank
    - Lower portion of the bank if it is taller than the upper portion (Fig. 10 Left).
    - Upper portion of the bank if it is taller than the lower portion (Fig. 10 Right).

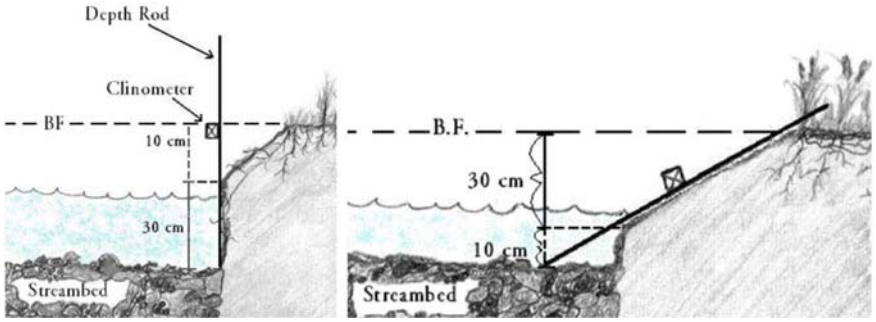

Fig. 10. (Left) The lower, vertical, portion of the bank is taller than the upper and is there for measured. (Right) The upper, slanted, portion of the bank is taller therefore it is measured.

Bank Angles: ≥3 angles (≥10cm in height):

- Measure the average angle by laying the depth rod along the outer corner of the steps (Fig. 11).
- Strive to represent the bank angle as accurately as possible with one rod placement.

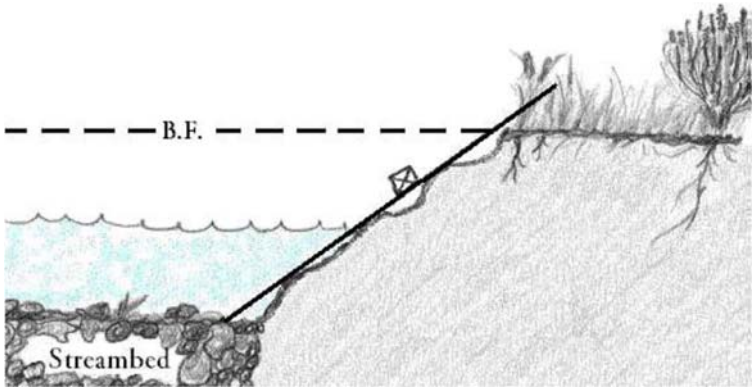

Fig. 11. Measure the angle of banks with 3 or more angles by laying the rod along outer edges.

Undercut Bank

- A qualifying undercut must be ≥ 5 cm deep, ≥ 10 cm in height and >10 cm in width.
    - The idea is that you could 'hide' a box of this size in the undercut, without being able to see it from above.
- For all transects with acute bank angles, including undercuts, record undercut depth as one of the following 3 categories:
    - <5 cm non-qualifying undercut
    - ≥5 cm qualifying undercut
    - NA ceiling above bankfull *(this is a non-qualifying undercut)*
- Undercut bank angles are measured from the deepest point of the undercut up to the ceiling of the overhang (Fig. 12).
    - Occasionally the back of the undercut will be a consistent depth, thereby lacking a deepest point (Fig. 13). Place the depth rod at the highest elevation, resulting in the smallest angle (angle B).

- Enter the angle as "1°" if the deepest part of the undercut is elevationally above the ceiling (Fig. 14).

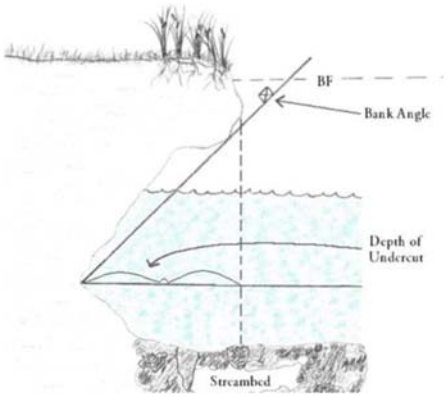

Fig. 12. Measure undercut bank angle from the deepest point to the ceiling of the undercut; determine if the undercut has a qualifying depth (≥5 cm) by lowering you depth rod until it is horizontal.

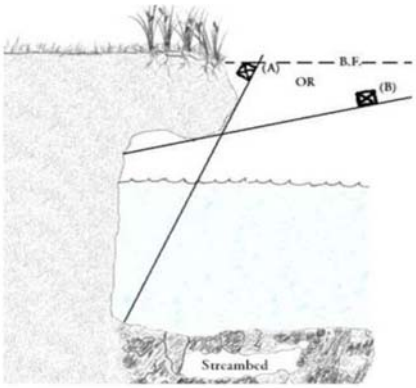

Fig. 13. Undercut banks with a constant depth are measured with the base of the depth rod at the highest elevation (angle B, not angle A).

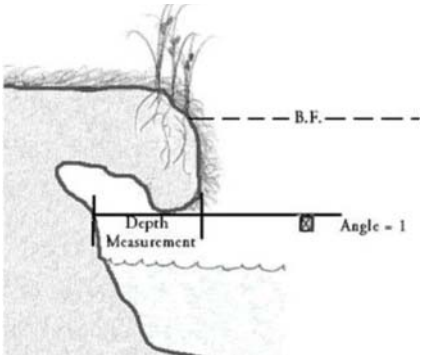

Fig.14. When the deepest point is elevationally above the ceiling of the undercut, determine if the undercut is 'qualifying' by holding the depth rod horizontal and directly underneath the ceiling. Record the angle as 1°

Depositional banks:

- Depositional features are not considered part of the bank. Start you bank angle measurement at the point where deposition ends.
- On un-vegetated depositional features such as point bars, start the measurement at the point where the top of the depositional feature and streambank meet (Fig. 15).

- If deposition ends at or above the first flat, floodplain-like feature (Fig. 16), record as a non-measureable angle (Flag code "K").
- Use the point where the depositional feature becomes >50% vegetated (perennial species) to define were the deposition ends and bank begins.

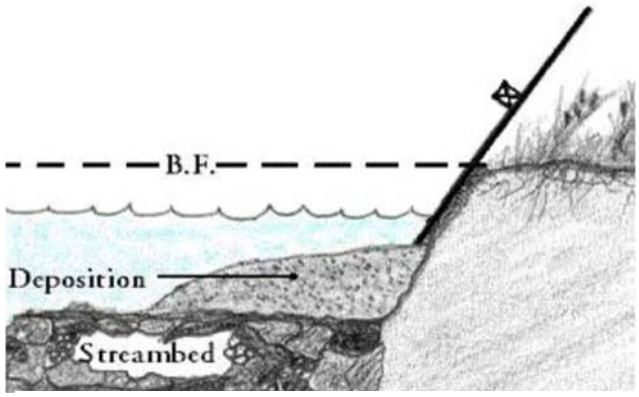

Fig. 15. Begin measuring the angle from the point where the deposition and bank meet.

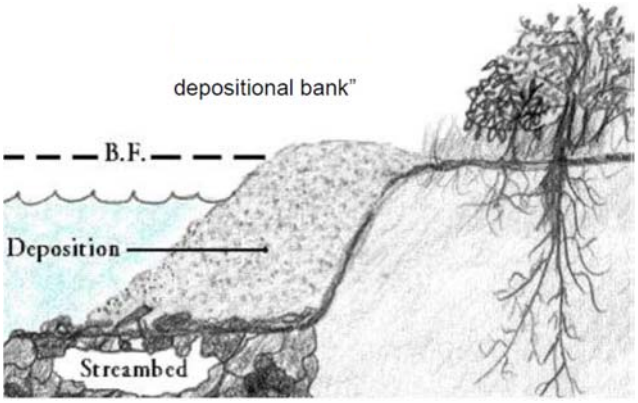

Fig. 16. Do not measure an angle when the deposit covers the first flat, floodplain like feature.

Slump Blocks:

- Slump block: piece of the bank that is detaching or has detached from the streambank.

- If the connection point (i.e. where the top of the slump block meets the bank) is below the scour line, the lower limit of your measurement is the connection point (Fig. 17 right).
- If the connection point is above the scour line, the lower limit of your measurement is where bed meets bank (Fig. 17 left).
- Do not consider slump blocks that are not attached to streambank.

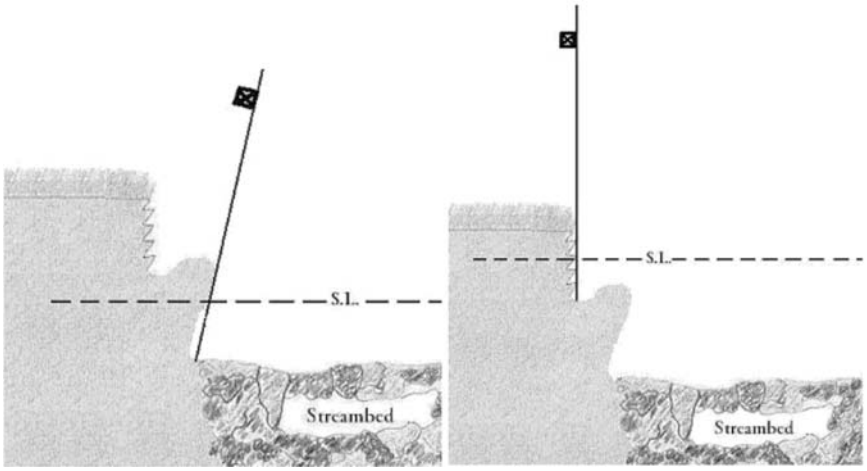

Fig. 17. Location of bank angle measurements with a slump block still attached and relative to the scour line.

Logs and Rocks:

- Consider logs (≥10 cm diameter) and rocks (≥15 cm b-axis diameter) as part of the bank if they are embedded within the bank.
- As with slump blocks, determine if the connection point (i.e. where the top of the log / rock meets the bank) is elevationally below the SL. If so, the lower limit of your measurement is the connection point.
- If the connection point is above the scour line, the lower limit of your measurement is where bed meets bank.

Special situations: Appendix B pg. 92

Side channels:

- See pg. 94

Bank Stability

Overview: Measured at all main (11) and intermediate (10) transects on the left and right banks.

Methods:

1. Define the plot area needed to estimate bank stability.
    a. Plot height extends perpendicular to the stream between the scour line and the first flat or depositional feature at or above bankfull.
    b. Plot width extends parallel to the stream 25 cm upstream and downstream of the transect flag.
2. Assess bank type, cover, and stability:

Bank Type

- **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", (i.e. cut banks, undercut banks, straight runs with no visible depositional features and outside edge of bends).

Bank cover

- **Covered (C)**: This applies to banks with at least 50% cover within the plot of the following types or combination thereof :
    a. Perennial vegetation (including roots)
    b. Cobbles 15 cm or larger
    c. Anchored large woody debris (LWD) with a diameter >10 cm
    d. Moss **does not** count as cover
- **Uncovered (U)**: This applies to all banks that do not meet the "Covered" criteria.

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 plot width or greater. Additionally, keep in mind that these features

(absent, fracture, slump, slough, and eroding) are on a continuum of stability where absent is the most stable and eroding is the least.

- **Fracture (F):** This applies to the top of the bank where a visible crack is observed (Fig. 18). The fracture has not separated into two separate components or blocks of a bank.
- **Slump (S)**: This applies to a stream bank that has obviously slipped down resulting in a separate block of soil/sod separated from the bank (Fig. 18-19). Slumps may be created by excessive animal trampling.
- **Slough (SL)**: 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. 20-21).
- **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. 22-23). 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.
- **Absent (A):** This applies in all other situations, if no feature meets the minimum criteria.

Special situations: Appendix B pg. 92

Side channels:

- See page 94

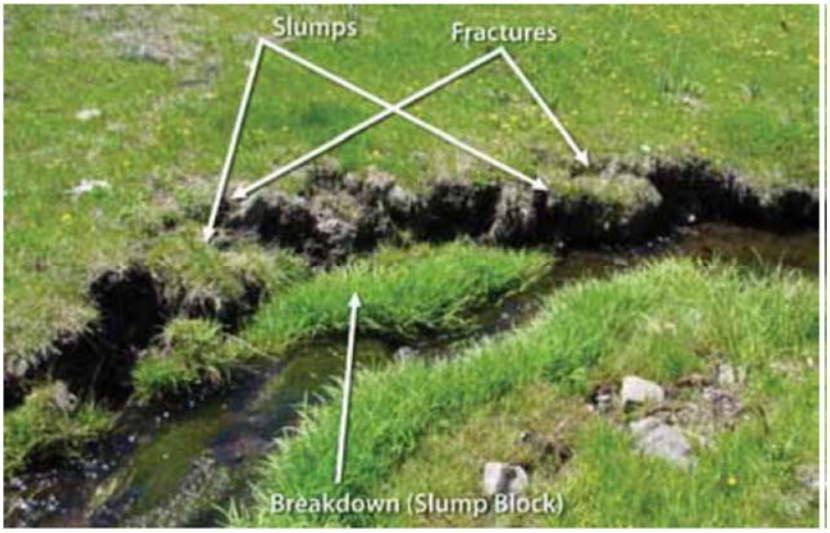

Fig. 18. Slump blocks that are detached from the streambank and now isolated to the channel are not considered part of the streambank. Slumps must be obviously sliding down but still attached as part of the streambank. Fractures must be obvious at the top of the bank or on the bench.

Fig. 19. 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). Photo - PIBO, U.S. Forest Service.

Fig. 20. Three different conditions are shown at this location. The left side is an outside bend that is erosional (E), with no vegetation, rock, or wood cover (U), and slough (SL) directly entering the stream. The upper middle section is an erosional (E) streambank, uncovered (U) with slump (S). The lower right streambank is a point bar that is depositional (D) and covered (C).

Fig. 21. The streambank is erosional (E) and not covered with vegetation, rock, or wood. It has a bank angle of more than 10 degrees (22 percent) from vertical with no bench to capture the sediment, and thus the sediment enters directly into the stream as slough; therefore, it is recorded as uncovered (U) and slough (SL).

Fig. 22. The streambank has an obvious scour line. The bank evaluated is above the scour line to the first bench and is recorded as erosional (E), uncovered (U), and eroding (E) or slough (SL).

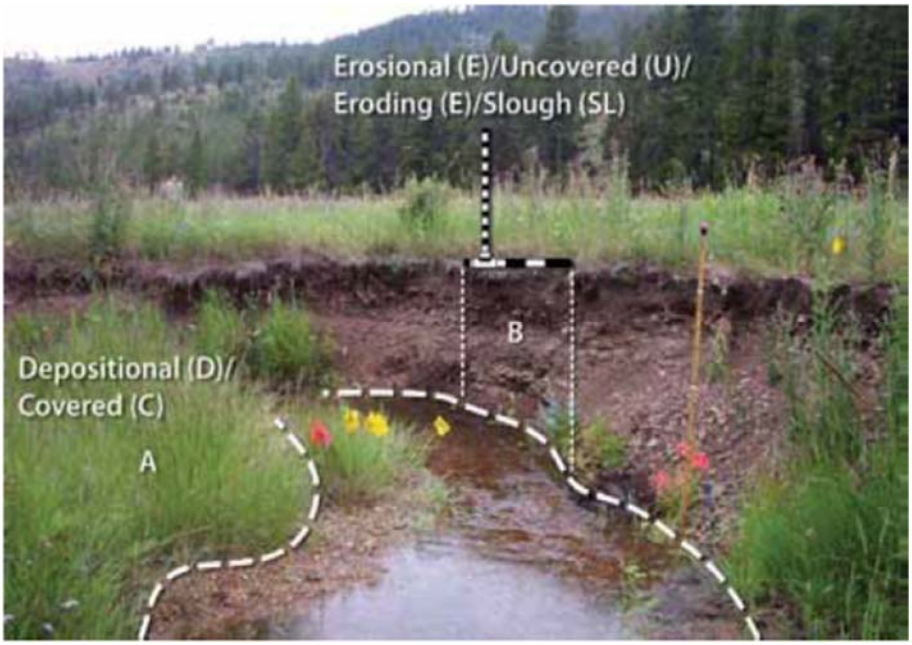

Fig. 23. The dotted line represents the scour line. "A" is a point bar, thus it is depositional (D) and covered (C). "B" shows the length of streambank evaluated. The streambank evaluated is erosional (E), uncovered (U), and eroding (E) or slough (SL).

Cross-Section Measurements

Overview: Substrate and embeddedness are measured at 10 points across the stream bed: 5%, 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85%, and 95% of the distance cross the stream bed. Substrate is measured at all main (11) transects and intermediate (10) transects but embeddedness is only measured on main transects.

Methods

1. Identify the stream bed by determining where bed meets bank on both the left and right banks.
2. At the left edge where bed meets bank, place depth rod down on substrate roughly 5% of the width from the edge of the scour line.
3. Pick up the first substrate particle the depth rod touches.
    - Avoid looking down when grabbing substrate particles to minimize bias against small or large particles.
    - If particles are too large to pick up or "cemented" into the streambed measure as best you can using the depth rod.
4. Measure the intermediate axis (B axis) of the particle and record in mm. (Fig. 24).
    - If not measurable (i.e., fines, bedrock, hardpan, organic matter), select one of the below categories and the app will automatically fill in the appropriate number.
        - For particles <2 mm, record as 1
        - For bedrock, record as 4097
        - For hardpan (consolidated fine substrate), record as 4098
        - For organic matter, record as other and provide comment.

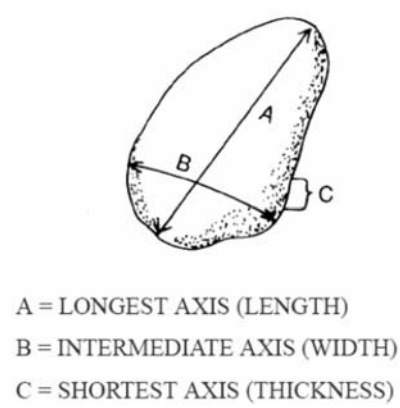

Fig. 24. Example of a particle's B or intermediate axis.

5. Denote whether the particle was picked form the wetted channel or if it was on a dry portion of the stream bed.
6. For particles larger than 2 mm, inspect the surface of the particle for signs of embeddedness; stains, markings and algae.
7. In a 10 cm circle around the point of contact from the depth rod, visually estimate the average % of the particle's volume that is surrounded by sand or fines and record it as the % embeddedness.
    - Sand and finer particles (≥2 mm) are considered 100% embedded.
    - Bedrock and hardpan are considered 0% embedded.
8. Repeat process for remaining locations; 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85% and finishing 95% of the way across the stream bed.
    - If you reach the last substrate measurement and have less than 5 particles from the wetted channel, take supplementary pebble measurements until a total of 5 particles from the wetted channel have been measured.

Special situations: Appendix B pg. 92
Side channel:

- See Page 94

Canopy Cover

Overview: Measured at all main (11) transects on the left bank, mid-channel, and right banks.

Methods:

1. Start by facing the left bank.
2. Hold the densiometer 0.3 m (1 ft.) above the surface of the stream. Level the densiometer and hold in front of you so your face is just below the apex of the taped "V" (Fig. 25).
3. Count the number of grid intersection points within the "V" (0-17) that are covered by a tree, a leaf, or a high branch.
4. Move to the stream at mid-channel and face upstream. Repeat steps 2-3.
5. Rotate a quarter turn and repeat steps 2-3 three times.
    - Will end up with four total measurements: center up, center right, center down, and center left.
6. Move to the right bank and while facing the right bank. Repeat steps 2-3.

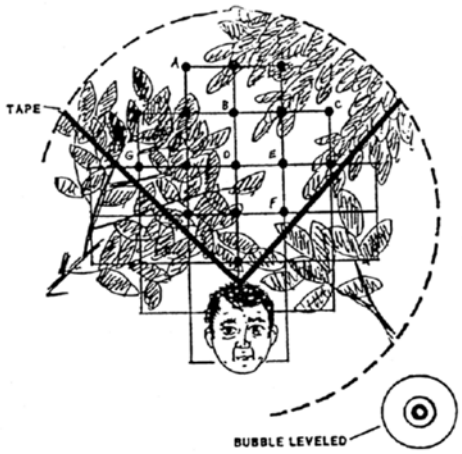

Fig. 25. Modified densitometer, count intersections in the V covered by vegetation.

Special situations: Appendix B pg. 92
Side channels:

- See page 94

Visual Estimates

Visual Riparian Estimates

Overview: Visually estimated at all main (11) transects on left and right banks.

Methods:

1. On the bank of each transect, visualize a 10 m x 10 m plot to estimate riparian vegetation cover.
    - Plot height starts at the scour line and extends 10 m back into the riparian vegetation.
    - Plot width extends 5 m upstream and downstream of the transect (Fig. 26).
        - On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.
2. Within this 10 m X 10 m area, conceptually divide the riparian vegetation into 3 layers:
    - Canopy layer (>5 m high)
    - Understory (0.5 to 5 m high)
    - Ground cover layer (<0.5 m high)
3. Categorize the dominant woody vegetation type for the canopy and understory layers as:
    - Deciduous (e.g., Russian olive, willow, cottonwood, tamarisk)
    - Coniferous (e.g., juniper, cedar, pine, fir)
    - Broadleaf evergreen (e.g., sagebrush, rhododendron, Manzanita)
    - Mixed- more than 10% of the areal coverage is made up of alternate type
    - None
4. Divide each layer into the below sub-categories
    - Canopy
        - Large trees (0.3 m [1 ft.] diameter at breast height [dbh])
        - Small trees (<0.3 m dbh)
    - Understory
        - Woody shrubs and saplings

        - Non-woody vegetation
    - Ground cover
        - Woody shrubs and saplings
        - Non-woody vegetation
        - Bare ground or duff
5. Estimate the % areal cover that each subcategory would make up of the total cover within the respective canopy, understory, or ground cover layer. Estimate the aerial cover as the amount of shadow that would be cast by a particular sub-category if the sun were directly over the plot area. Include standing dead trees as cover. Record the appropriate cover class:
    - 0=absent: zero cover
    - 1=sparse: <10%
    - 2=moderate: 10-40%
    - 3=heavy: 40-75%
    - 4=very heavy: >75%
6. 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%.
    - Ground cover is the only layer that must equal 100% coverage.
7. Repeat steps 1-6 for the opposite bank.

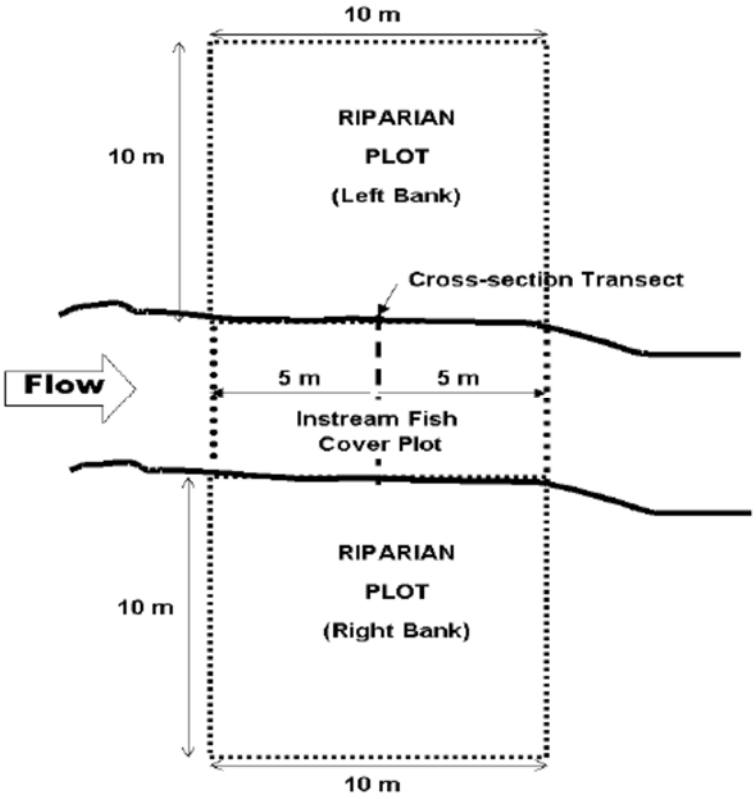

Fig. 26. 10 m X 10 m riparian plot for conducting visual riparian vegetative estimates, human impact assessments, and for conducting instream fish cover estimates.

Special situations: Appendix B pg. 92

Side channel:

- See page 94

Visual Fish Cover Estimates

Overview: Visually estimated at all main (11) transects within the wetted channel.

Methods:

1. For each main transect, visualize a plot that extends 5 m upstream and 5 m downstream of the transect and across the entire wetted width. (Fig. 26)
2. Estimate the following features and types of fish cover in the plot:
    a. ***Filamentous algae*:** long streaming algae that often occur in slow moving waters.
    b. ***Aquatic macrophyte*:** 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.
    c. ***Large woody debris:*** larger pieces of wood that can influence cover and stream morphology (i.e., those pieces that would be included in the large woody debris tally [> 1.5 m in length and 10 cm in diameter at the large end]).
    d. ***Brush and small woody debris:*** smaller wood pieces that primarily affect cover but not morphology.
    e. ***In-channel live trees or roots:*** living trees that are within the channel – estimate the areal cover provided by the parts of these trees or roots that are inundated.
    f. ***Overhanging vegetation*:** includes tree branches, brush, twigs, or other small debris that is not in the water but is close to the stream (within 1 m of the surface) and provides potential cover.
    g. ***Undercut banks:*** any bank that has an undercut > 5 cm deep.
    h. ***Boulders:*** basketball to car-sized particles.
    i. ***Artificial structures*:** designed for fish habitat enhancement, as well as in-channel structures that have been discarded (e.g., concrete, asphalt, cars, or tires) or deliberately placed for diversion, impoundment, channel stabilization, or other purposes.

3. For each cover type, estimate the **areal** cover. Record the appropriate cover class in fish cover*:*
    - 0=absent: zero cover,
    - 1=sparse: <10%,
    - 2=moderate: 10-40%,
    - 3=heavy: >40-75%, or
    - 4=very heavy: >75%).
4. Each kind of cover may equal 100%.

Special situations: Appendix B pg. 92
Interrupted flow:

- See page 92

Side channels:

- See page 94

Visual Estimates of Human Influence

Overview: Visually estimated at all main (11) transects on the left and right banks.

Methods:

1. At each transect visualize a 10 m x 10 m plot to estimate human influence (Fig. 27).
    a. Plot height starts at the active channel and extends 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.
    b. Plot width extends 5 m upstream and downstream of the transect.
2. Examine the channel, bank, and riparian plot area adjacent to the defined stream segment for the following human influences:
    - Walls, dikes, revetments, riprap, and dams
    - Buildings
    - Pavement/cleared lots (e.g., paved, graveled, dirt parking lot, foundation)
    - Roads or railroads
    - Inlet or outlet pipes
    - Landfills or trash (e.g., cans, bottles, trash heaps)
    - Parks or maintained lawns
    - Row crops
    - Pastures, rangeland, hay fields, or evidence of livestock
    - Logging
    - Mining (including gravel mining)
    - Hydrologic alterations (irrigation diversions, impoundments)
    - Grazing by livestock or wild horses & burros
    - Grazing exclosure
    - Recreation
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. The same human influence may be marked present at more than one transect but **do not include them if you**

have to sight through another transect or its 10 m x 10 m riparian plot.

4. For each type of influence, record the appropriate proximity class in the human influence tab. 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 m x 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 1-4 for the opposite bank.

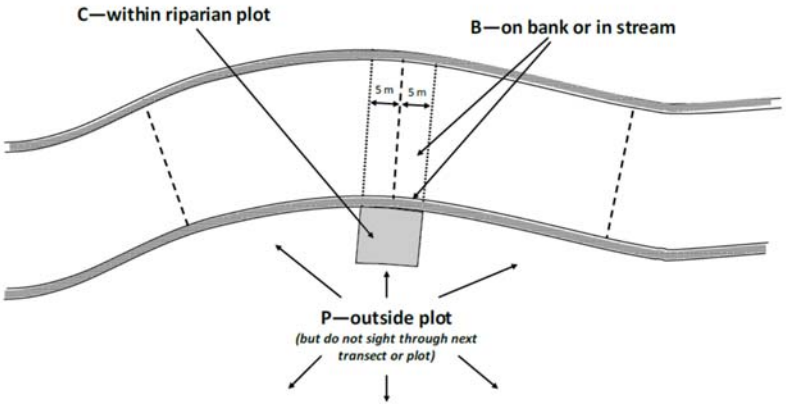

Fig. 27. Plot used for visual assessment of human influence at each of the 11 main transects.

Special situations: Appendix B pg. 92
Side channel:

- See page 94

Longitudinal Profile

Thalweg Profile

Overview: Measure depth and presence/absence of bars, side channels and backwater along the entire sampled reach of the main channel.

Method:

1. Using the following rules, verify the increment distance between measurements that the app calculates based on the wetted width used to determine the length of the reach.
    - For widths ≤ 1 m, establish stations every 0.5 m (30 per subsection).
    - For widths > 1 and ≤ 2.5 m, establish stations every 1 m (15 per subsection).
    - For widths > 2.5 and ≤ 3.5 m, establish stations every 1.5 m (10 per subsection).
    - For widths > 3.5 m, establish stations at increments equal to 0.01 times the reach length (10 per subsection).
        - e.g., a reach of 400 m would have stations every 4 m
2. Start at transect A, working your way upstream.
3. Record the wetted width of the transect as the wetted width at station 0. If a mid-channel bar is present, record the width of the bar as well. **Measure to the nearest 0.01 m.**
4. At each thalweg profile station, use a depth rod to locate the deepest point within the flow path (the thalweg), which may not always be found at mid-channel.
5. Measure the thalweg depth **to the nearest 1 cm** from the substrate surface to the water surface. Read the depth on the **side** of the rod to avoid inaccuracies due to the wave formed by the rod in moving water.
6. At each depth measurement note if there is a bar, side channel, or backwater present.
7. Use the depth rod, stadia rod or tape measure to approximately space each thalweg station.
8. Proceed upstream to the next thalweg station, repeating steps 5-7 until reaching the intermediate transect (station 5 for reaches ≥2.5 m, station 7 for reaches <2.5 m and > 1 m, station 14 for reaches ≤ 1 m).

9. At the intermediate transects, measure the wetted width (see wetted width pg. 43), classify the size of the bed substrate particles (see cross sections measurements pg. 63), and determine bank stability for both right and left bank (See bank stability pg. 56).
10. Proceed upstream to the next thalweg station, repeating steps 4-7 until reaching the next transect.
11. After all main transect measurements are completed, repeat steps 2-9 until all transects are completed.

Special situations: Appendix B pg. 92
If the thalweg is too deep to measure directly:

1. Stand in shallower water and extend the stadia's rod at an angle to reach the thalweg.
2. 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.
3. Record the water level on the rod and the rod angle in the comments section of the field data form.

Interrupted flow:

- See page 92

Side channels:

- See page 94

Large Woody Debris

Overview: Measured along the entire sample reach of the main channel.

Methods:

1. Scan the stream segment between the two cross-section transects where thalweg profile measurements are being made.
2. Talley all pieces of LWD that have a large end diameter of > 10 cm, a length >1.5 m, and are at least partially within or bridging the bankfull channel. Once the diameter is less than 10 cm, visually cut the log and do not use this portion for length estimates.
3. Keep talleys separate for each size class (based on the diameter of the large end **AND** the length) and for each location (pieces all/ part in bankfull channel or pieces bridge above bankfull channel). (Fig. 28)
    a. diameter of the large end:
        i. 0.1 m to <0.3 m
        ii. 0.3 m to <0.6 m
        iii. 0.6 m to <0.8 m
        iv. >0.8 m
    b. length of the piece (where diameter > 10 cm):
        i. 1.5 m to <3.0 m
        ii. 3 m to <5 m
        iii. 5 m to <15 m
        iv. >15 m

    Note: 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.
4. Repeat steps 1-4 for the next subreach.

Special situations: Appendix B pg. 92
Side channel:

- See page 94

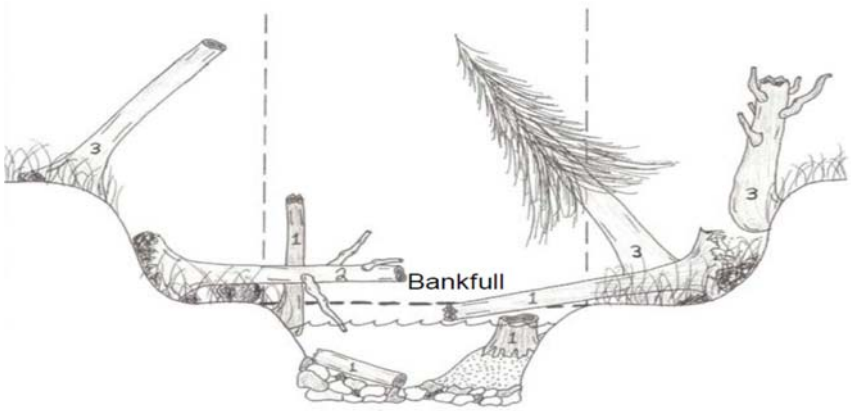

Fig.28. Pieces of wood labeled with a 1 are within the bankfull channel, pieces labeled with a 2 are spanning the bankfull channel and pieces labeled 3 are not counted.

Slope

Overview: Measure the change in elevation over the entire length of the sampled reach.

Methods:

Setting up the tripod and auto level

1. Determine a location to set up the auto level so that BR and TR will be visible from the same spot.
    - This is rarely possible at highly vegetated or steep reaches, so attempt to set up in a location where as much of the reach as possible is visible.
    - The most challenging part of slope is finding the best place to set up the level. Tips:
        - Sometimes vegetation removal is required but waving the rod around through vegetation can help see the rod through the level.
        - Sighting across land can be easier than trying to move up the stream.
        - It is ok to have a negative slope for a section as long as the total reach slope is positive.
2. Extend the tripod legs and firmly set into the ground. Adjust so the legs are in a regular triangle and are set so there is no wobble.
3. Place the auto level on the base plate and tighten the center screw.
4. Begin adjusting the legs of the tripod until the bubble is approximately in the center of the level.
5. Adjust the foot or fine screws until the bubble is exactly in the center of the circle.
6. Gently swivel the instrument to make sure it is level in all planes.

Taking measurements

1. Position the stadia rod at the BR, holding the bottom of the rod at the water's surface as vertical as possible with the numbers facing the auto level.
2. Sight the stadia rod through the auto level and record the reading **to the nearest 1 cm** (Fig. 29).
    a. Stadia rods are 5 m in length and alternate between black and red 1 m sections.

b. Each 1 m section is broken up into 10 cm increments designated by a large number on the right side and a line that stretches all the way across the stadia rod.
c. Each 10 cm section is divided in half with “E” symbols that are 5 cm in length.
d. The top or bottom of each block or line in the “E” is 1 cm.
e. For the image below (Fig. 29) the final measurement would be recorded as 142 cm.

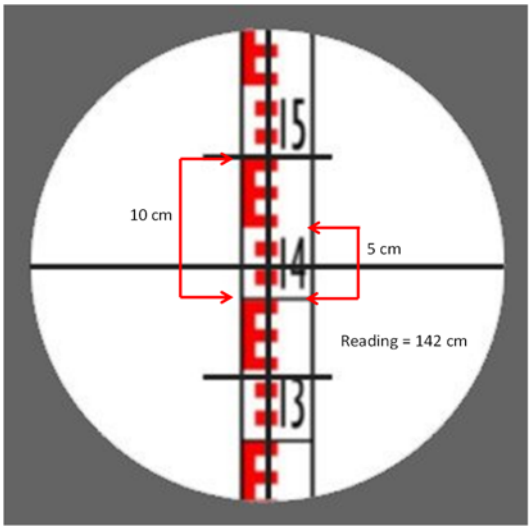

Fig. 29. Stadia rods are broken up into 10 cm sections, denoted by the large number on the right. Each 10 cm section has a large "E" that is 5 cm long. Each meter section is broken up by alternation red and black section colors.

3. Move the stadia to TR (or the farthest location that can still be seen through the level) and gently swivel the instrument (being careful to make sure the bubble stays inside the center of the level) to face the next reading.
4. Hold the stadia rod as before, vertically, with the bottom at the water level and the numbers facing the auto level.
5. Sight the stadia rod and record the reading **to the nearest 1 cm.**
6. If the TR is not visible from the first location that the level is set up at, hold the stadia rod at the last measured transect in the

exact position as the reading before (this serves as a reference point connecting the next line of shots).

7. Move the auto level to a new position where the stadia rod can be seen as well as a new portion of the reach. Set up as before making sure the equipment is level.
8. Back sight to the stadia rod, and start the new line of measurements from that point.
9. Continue and repeat until the stadia rod is sighted at TR.
10. Repeat steps 1-9 via a second pass to get a second total change in slope.
11. Calculate the % difference between the two readings. If it is greater than 10%, conduct a third pass.
    a. $Elevation\ of\ pass\ 1\ X\ .1 = 10\%\ of\ elevation$
    b. Add and subtract the 10% from the original elevation to get the acceptable range

Special situations: Appendix B pg. 92

Side channel:

- See page 94

Interrupted flow:

- See page 92

Overall Reach Assessment

Overview: Reach wide visual assessment of: Channel Constraint, Torrent Evidence, and Watershed Activities.

Channel Constraint

Overview: Visually assess the channel pattern and constraining features for the entire sampled reach.

Methods:

1. Fill out channel pattern
    - **One Channel:** may have occasional in-channel bars or side channels, but feature one dominate main channel.
    - **Anastomosing:** Relatively long major and minor channel but no predominate channel, diverging and converging around many vegetated islands (Fig. 30A).
    - **Braided Channel:** multiple branching and rejoining channels (no predominate channel) separated by unvegetated bars. During major floods, a single continuous channel may develop (Fig. 30B).
2. Determine the constraints of the channel
    - Channel very constrained in V-shaped valley.
    - Channel is in Broad Valley but channel movement by erosion during floods is constrained by incision.
    - Channel is in narrow valley but is not very constrained, but limited in movement by relatively narrow valley floor (<~10 X bankfull width).
    - Channel is unconstrained in broad valley.

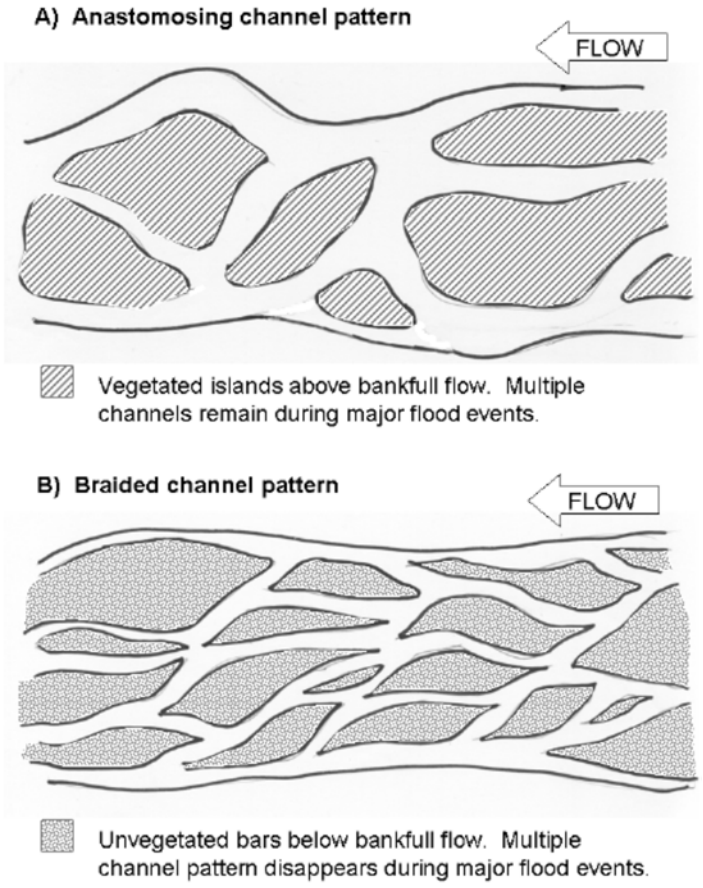

Fig. 30. (A) An anastomosing channel with vegetated islands. (B) a braided channel with numerous small unvegetated bars.

3. Determine what the constraining feature is.
    - Bedrock (Channel is a bedrock-dominated gorge.)
    - Hillslope (Channel is constrained in a narrow V-shaped valley.)
    - Terrace (Channel is constrained by its own incision.)
    - Human bank alterations (Constrained by rip-rap, landfill, dike, road, etc.)
    - No constraining features

4. Determine what percent of the reach is constrained by the dominant constraining feature (Fig. 31).

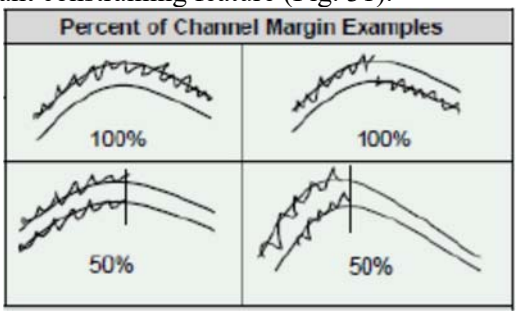

Fig. 31. Estimate the % of the reach that is constrained by the dominant constraining feature.

5. Estimate the average valley width throughout the reach.
    - If you cannot see the valley borders, estimate the distance you can see and make a note.

Torrent Evidence Assessment

Overview: Visually assess the evidence of torrents throughout the entire sampled reach.

Debris torrents: are larger than typical floods and are shorter in duration. Their flow consists of a dense mixture of water and debris. They are similar to landslides but they contain 50% water and 50% sediment. Their high flows of dense material exert tremendous scouring forces on stream beds, moving boulders and trees. In temperate regions, they occur primarily in steep drainages and are relatively infrequent occurring typically less than once in several centuries.

Evidence of torrents includes extreme scouring/disturbance and sediment deposits that do not appear to be fluvial. For example, deposits are NOT sorted, rounded, or stacked on top of each other, and/or deposits may form berms from the "bulldozing" of torrent sediment. (Figs. 32-35).

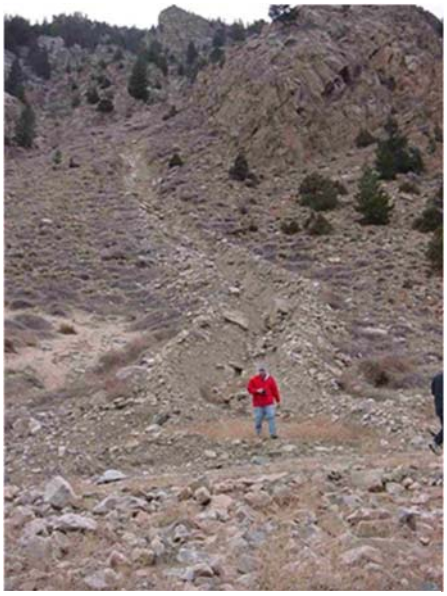

Fig. 32. Torrent "berm" deposits and scour from a small canyon.

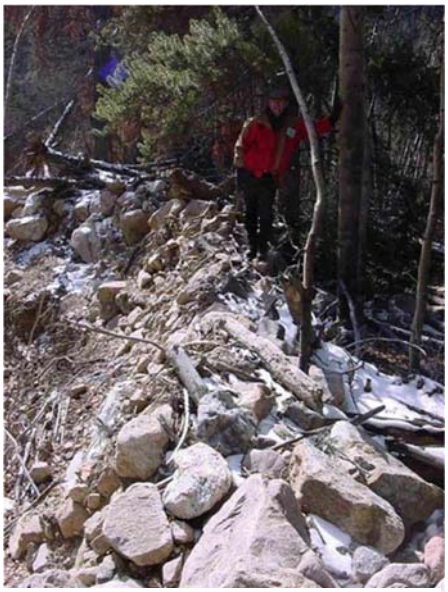

Fig. 33. Berms deposited high in the trees from "bulldozing" of torrents.

Fig. 34. Evidence of torrent through large rock scattered "every which way".

Fig. 35. Matrix supported angular rocks and boulders in a stream bank deposited by a debris flow.

Methods:

1. Survey the reach and upstream and downstream of the actual reach looking for:
    a. **Evidence of torrent scouring:**
        - Recently devegetated corridor, with expectations of fireweed, similar age class alder or cottonwood seedlings, grasses or other herbaceous plants.
        - Stream substrate cobbles or large gravels are lying in an unorganized pattern or "every which way". Particles are also often angular.
        - Little evidence of pool riffle structure.
        - Channel is scoured down to bedrock for substantial portions of the reach.
        - Gravel or cobble berms above the bankfull level.
        - Downstream, possibly several miles, there are large deposits of sediments, logs and other debris.
        - Riparian trees have fresh bark scars at seemingly unbelievable heights.
        - Riparian trees have fallen into the channel as a result of scouring.
    b. **Evidence of torrent deposits:**
        - Massive deposits of sediment and debris throughout the reach. These deposits could include logs and boulders that seemingly could not have been moved by the stream at even extreme flood stages.
        - The stream has begun to erode newly laid, matrix supported deposits. Large particles often having slit and fine sediments between them that are eroding away exposing the larger particles. Where as in a normal stream, fine sediments will normally "fill-in" interstices between coarser particles (Fig. 35).
    c. **No evidence of torrent**
        - No evidence of the previous indicators is present.

Assessment

Overview: Visually assess any watershed activities observed during sampling.

Methods

1. Fill out any of the watershed activities that were observed throughout the day for Residential, Recreational, Agricultural, Industrial and Stream Management as:
    - **Blank:** not observed
    - **L:** Low
    - **M:** Moderate
    - **H:** Heavy
2. Indicate the reach characteristics within a 200 m radius of the reach.
    a. Waterbody character
        i. Rate how pristine the system is (5 being very pristine and 1 being highly disturbed).
        ii. Rate how appealing the system is (5 being very appealing 1 being unappealing).
    b. Beaver activity
        i. Beaver signs: absent, rare or common.
        ii. Beaver flow modifications: none, minor or major.
    c. Dominate land use
        i. Dominate land use around X-site:
            - Forest
            - Agriculture
            - Range
            - Urban
            - Suburban/Town
        ii. If forest is the dominate land use what is dominate age class:
            - 0-25 years
            - 24-75 years
            - >75 years
3. After all the assessments have been made, note the weather conditions and local contacts, or other observations while at the stream (i.e. accessibility, boating, fishing, swimming or health concerns).

Decontaminating gear

Overview: Decontaminate equipment after every reach sampled, before you leave the reach.

Methods:

1. Use a scrub brush (attached to Surber net) to remove all visible mud / organic material from boots and waders before decontamination.
2. Use the large Rubbermaid Roughtote provided to make a solution of Sparquat that is at least 4.7%. To do this, fill the Roughtote with 6 gallons of water (1 full water jerry) and add 36oz. of Sparquat (or 6oz. of Sparquat for every gallon of water).
3. Soak any gear items that have been in contact with the water for at least 10 minutes. For example waders, boots and bug nets.
4. When decontamination is complete, put the used Sparquat solution back into the labeled 7 gal Aquatainer.
    a. If possible rinse the waders, boots, and other gear with water (not from the stream).
5. Before every decontamination session, determine if the Sparquat solution may be reused. To check for potency, use the "Quat Check 1000" test strips that have been provided. When the test strip reads below 600 ppm, you need to make a new solution.
6. Discard the Sparquat solution when it is no longer effective, it will need to be discarded down a drain that flows to a treatment facility.

Appendix A. Bankfull, Incision and Scour Line

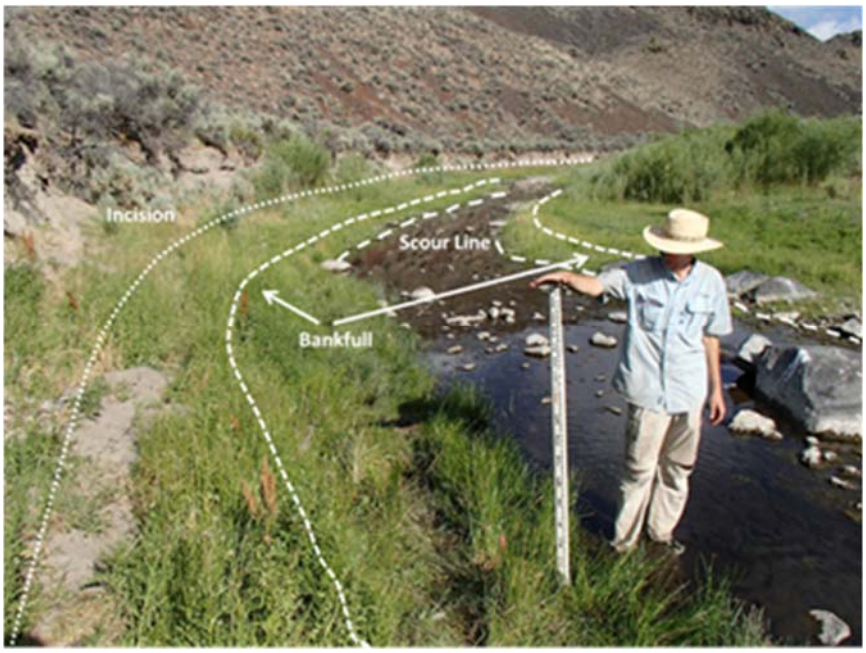

Fig. A1. Bankfull, incision, and scour line geomorphic features for a typical high desert system. Bankfull is noted by the break in slope at the lowest terrace.

Fig. A2. Incision height, bankfull, and scourline indicators for a small, high desert stream system. Bankfull height is indicated by the stainlines on rocks. Incision height is the first flat depositional feature above bankfull, where there is a drastic change in the vegetation type and a change in slope of the stream bank.

Fig. A3. Incision height, bankfull and scourline geomorphic surfaces for spring-fed systems. Incision height is marked by the change from green vegetation to bare dirt.

Fig. A4. Incision height, bankfull and scour line, geomorphic indicators for a southwest in desert system. Incision height is demarcated by the lower limit of flood intolerant vegetation (e.g. Sagebrush).

Appendix B. Special Situations

Interrupted Flow

Overview: For streams with interrupted flow, follow the guidelines below for what to measure on a qualifying stream.

Is the reach dry? A Dry reach is defined by >50% of transects are completely dry. If possible, try sliding the reach to gather more water (see sliding the reach pg. 24).

If reach is still dry even after sliding the reach:

- Do not sample the reach, but make appropriate notes on failed site (attempts) form:
    - Is a channel present?
    - Is there any riparian vegetation in or near the stream channel?
    - Are any other important features present in the reach (e.g. diversions, puddles, moist ground)?

Is the flow of the reach Interrupted? An interrupted reach is defined by > 50% of transects have at least puddles of water. If so, use the following guidance for setting up the reach and sampling:

- **Reach set up**- If the x-site or any of the five locations used for measurements of "typical" width are dry, use the width of the unvegetated portion of the stream bed in determining reach length.
- **Water quality-** Collect at the closest location to the x-site that has water > 10cm deep and > 1 m^2. If no location exists, do the best you can to take the measurements and record appropriate comments about the quality of the sample.
- **Macroinvertebrates-** Do not collect at dry transects, but if enough water is present to take a bug sample, collect it. Record any appropriate comments about the quality of the sample. Always record the altered sample area if for any reason an

invertebrate sample was not taken at a transect. (e.g., two transects were dry, bugs were taken at nine transects).

- **Pool delineation**- Measure only pools that have flow, even a trickle. Do not measure stagnant pools.
- **Wetted width**- At dry transects use the unvegetated portion of the stream bed to determine the wetted width, record the width as 0.
- **Bankfull and incision height**- At dry transects measure the height from the edge of the unvegetated (active channel) portion of the stream bed.
- **Thalweg**- Record depths and widths as 0 when dry.
- **Fish cover**- If the transect is dry, all fish cover is 0%.
- **Slope**- If multiple transects are dry, use the edge of the active channel (bankfull) for placement of the stadia rod instead of the water's surface.

Side Channel

Overview: Guidance for sampling a reach with a side channel present.

What is a side channel?

- **Side channel**: any channel separated directly from the main channel by an island (NOT a mid-channel bar).
    - **Island:** stream sediments within the channel with an elevation above bankfull; islands are almost always vegetated.
    - **Mid-channel bar:** stream sediments within the channel that are above current water level but below bankfull and are almost always unvegetated.
- **Minor side channel:** if the wetted channel is split by an island containing less than or equal to 15% of the total flow.
- **Major side channel:** if the wetted channel is split by an island with the side channel containing 16-49% of the total flow.

When and where to measure PHAB attributes when a side channel is present:

1. No measurements are needed on minor side channels; however, their presence will be noted in the thalweg profile measurements.
2. Take the following measurements on **major side channels only:**
    - Wetted width
    - Bank width and height
    - Incision height
        - Do not use the island for the incision height measurements; use the outside bank of the main channel.
    - Bank angle and undercut distance
    - Substrate size and embeddedness
    - Bank stability
    - Fish cover estimates
    - Riparian and human influence estimates

- There is a chance that side channel plots could contain water from the main channel. If there is water present, record as barren/bare dirt or duff.

- Pool delineation
  - When islands are present, only consider pools in the main channel; **don't** measure pools in side channels.
  - If a side channel is present, the pool must span at least 50% of the **main** channel's wetted width; disregard side channels width when making this determination.

Methods for setting up transects on qualifying side channels:

1. Visualize the main channel transect continuing over the island to the near bank of the side channel.
2. From the point that the transect would intersect the bank of the side channel, orient the transect so that it is perpendicular to the stream flow (Fig B1).

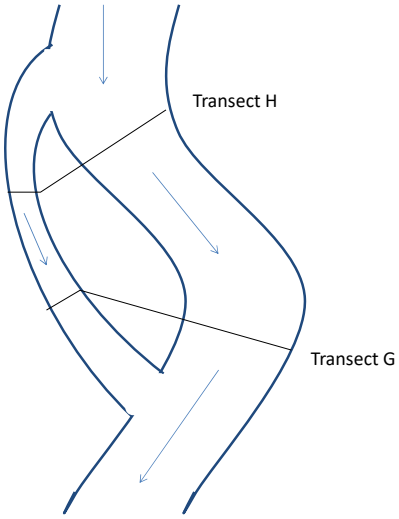

Fig. B1.. Transects are set up on side channels such that they are projected linearly across the island and turn perpendicular to the flow of the side channel.

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

Beaver Impacted Reaches

Overview: Guidance on sampling a reach that is impacted by beaver dams.

Methods:

1. Reach set up
    a. If >50% of the transects are inundated by beaver ponds, try to slide the reach to avoid the beaver pond.
    b. If large beaver ponds exist, place transects that fall in beaver ponds perpendicular to the thalweg of the beaver pond or the pool's center if no thalweg can be located. (Fig. B2).

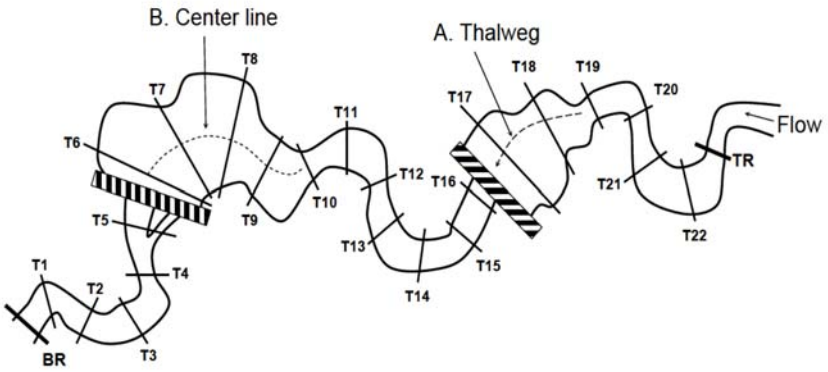

Fig. B2. (A) set up transects on a beaver impacted stream following the flow of the thalweg if visible. (B) Set up transects perpendicular to the center line of the beaver pool if the thalweg is not visible.

    c. Note which transects are impacted by beavers using the comments fields.
    d. If multiple side channels exist, follow side channel protocol above only if bed meets bank and bankfull indicators can be identified.
2. Photos
    a. Take photos of the following features such that you can see as much of the feature as possible.
        - Top of beaver pools, upstream and downstream
        - The beaver dam, upstream and downstream

- Overview of each beaver pool
- Take all other photos outlined in the photo section of the protocol (pg. 33)

3. Temp probe
   a. Place at BR instead of X-site.
4. Water chemistry
   a. Measure at BR, not the x-site.
   b. If there is a beaver dam / pool at BR, measure below the dam / pool even if it is downstream from the reach.
5. Macroinvertebrates
   a. Sample beaver dams that are safe to wade and do not have deep "bottom less" fine sediments.
   b. Kick nets will frequently be used in beaver ponds as they can be very deep and have low flow.
6. Pool delineation
   a. Measure pools using the crest of the beaver dam for the pool tail. Record all pool tail depth measurements as 0 m.
   b. To define the upstream boundary of the beaver pool, look for:
      - Flowing water
      - Normal wetted width
      - Elevationally above beaver dam height
      - Normal substrate
   c. Beaver dams do not have to be actively maintained to qualify as beaver pools.
7. PHAB and overall reach assessments
   a. Note which transects are impacted by beavers and how extensive the beaver impact is but collect all other measurements as normal to the best of your ability.

Appendix C. Calibration

Calibration of the YSI will be conducted on a weekly basis before or during a sampling hitch or if unusual/erratic values are observed. After calibration is complete, fill out the calibration form located in the lid of the pelican case. The information recorded should include: field technician, date, if pH 4, 7 and 10 were successful, the specific conductance value, if specific conductance calibration was successful and any notes on the calibration (i.e. if pH was unusually difficult to calibrate, if only two pH standards were calibrated, etc.)

pH calibration

pH calibration will be conducted using 3 different pH standards (pH 4, pH 7, and pH 10). In each YSI pelican case, there should be pH standards, a graduated cylinder needed for calibration, these instructions, and the user's manual. Calibration must always start with pH 7.

1. Fill the graduated cylinder with the pH 7 standard. Be sure the standard covers the black thermistor on the side of the gray probe bulkhead.
2. Press the UP ARROW and DOWN ARROW keys simultaneously to enter calibration menu.
3. Press ENTER. The pH value of the standard will be displayed. When the decimal point stops flashing press ENTER again. Hold the ENTER button until "SAVE" appears.
4. Clean the probe with DI or distilled water before switching to a new pH standard solution.
5. Continue calibrating the other two standards, fill graduated cylinder with appropriate standard, place probes in pH 4 and/or 10 buffer (order does not matter).
6. Press ENTER. The pH of the standard will be displayed and a decimal point will flash.
7. When decimal point stops flashing press and hold ENTER until the display reads "SAVE".
8. Repeat steps 4-6 for the third standard.
9. At the end of calibration, press MODE and rinse sensor to begin pH measurements.

Specific conductance calibration

Specific conductance calibration will be conducted using a one standard solution (1413 µS) according the YSI user's manual (provided in pelican case along with the YSI meter).

1. Turn the instrument on and allow it to complete its self-test procedure.
2. Place at least 7 inches of the 1413 µS standard solution in the plastic container or a clean glass beaker.
   NOTE: Do NOT use the 100 mL graduated cylinder. The diameter of the cylinder is too small for accurate conductivity measurements.
3. Use the MODE key to advance the instrument to display conductivity.
4. Insert the probe into the solution deep enough to completely cover the probe. Both conductivity ports must be submerged (see Fig. 6 on the following page).
5. Allow at least 60 seconds for the temperature reading to become stable.
6. Move the probe vigorously from side to side to dislodge any air bubbles from the electrodes.
7. Press and release the UP ARROW and DOWN ARROW keys at the same time.
8. The CAL symbol will appear at the bottom left of the display to indicate that the instrument is now in Calibration mode.
9. Use the UP ARROW or DOWN ARROW key to adjust the reading on the display until it matches the value of the calibration solution you are using.
10. Once the display reads the exact value of the calibration solution being used (the instrument will automatically make the appropriate compensation for temperature variation from 25 ° C), press the ENTER key. The word "SAVE" will flash across the display for a second indicating that the calibration has been accepted

Appendix D. Dry Ice Vendors and Locations

Regions with sparse dry ice

- Northern MT-no ice
- SE Oregon-only Baker's City
- SW Idaho-only Homedale

Known cities that have dry ice

- Moab and Price, Utah,
- Elko, NV
- Chico and Redding, CA
- Challis, Boise and Homedale, ID

Chains that carry it

- Pauls-in ID
- Most Albertsons (MT, SD and SW Oregon)
- Smiths, Safeways, and Fred Myers
- Penguin ice
- Most Associated Food stores
    - Generally mom and pop grocery stores throughout the west.
    - Also includes: Fresh Market, Macyes, Dan's, Lin's, Ridelys and Harmon's

Look up distribution centers on the list below to determine what towns in that proximity might have a higher chance of having it.

Call towns ahead of time!!

- Arizona
    - Phoenix, Airgas Dry Ice 602-723-3919
- California
    - San Carlos, Airgas Dry Ice 650-592-4212
    - Sacramento, Airgas Dry Ice 916-428-4700
    - Santa Fe Springs, Airgas Dry Ice 562-946-8394
    - Sylmar/Sun Valley, Airgas Dry Ice 818-367-3036
    - San Diego, Airgas Dry Ice 858-635-9432
- Colorado
    - Denver/Commerce City, Airgas Dry Ice 303-287-3469
- Idaho
    - Boise/Garden City, Airgas Dry Ice 208-336-2695
- New Mexico
    - Albuquerque/Amarillo Airgas Dry Ice 505-242-7750

- Oregon
    - Portland/Clakamas, Airgas Dry Ice 503-257-8890
- Utah
    - Salt Lake City, Airgas Dry Ice 801-977-9215
- Washington
    - Seattle/Kent, Airgas Dry Ice 253-854-6666
    - Spokane, Airgas Dry Ice 509-892-9224