Stream Condition Inventory (SCI) Technical Guide

Pacific Southwest Region

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Together they have completed the task of producing the Pacific Southwest Region Stream Condition Inventory Technical Guide.

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Frazier J.W.[1], K.B. Roby[2], J.A. Boberg[3], K. Kenfield[4], J.B. Reiner[5], D.L. Azuma[6], J.L. Furnish[7], B.P. Staab[8], S.L. Grant[9] 2005. Stream Condition Inventory Technical Guide. USDA Forest Service, Pacific Southwest Region - Ecosystem Conservation Staff. Vallejo, CA. 111 pp.

Current Job Title

[1] Forest Hydrologist, Stanislaus National Forest

[2] Fisheries Biologist, Lassen National Forest

[3] Fisheries and Watershed Program Leader, Six Rivers National Forest

[4] Fisheries Biologist, Six Rivers National Forest

[5] Ecosystem Restoration Supervisor, Lake Tahoe Basin Management Unit

[6] Research Forester, Pacific Northwest Research Station

[7] Regional Aquatic Ecologist, Pacific Southwest Region

[8] Regional Hydrologist, Pacific Southwest Region

[9] Hydrologic Technician, Stanislaus National Forest

Cover Photos

South Fork Stanislaus River at Fraser Flat, Stanislaus National Forest.

Illustrations

Jerry Boberg

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I. Overview

A. Introduction

The purpose of the Pacific Southwest Region Stream Condition Inventory (SCI) is to collect intensive and repeatable data from stream reaches to document existing stream condition and make reliable comparisons over time within or between stream reaches. SCI is therefore an inventory and monitoring program. It is designed to assess effectiveness of management actions on streams in managed watersheds (non-reference streams), as well as to document stream conditions over time in watersheds with little or no past management or that have recovered from historic management effects (reference streams).

SCI Objectives:

Inventory stream reaches using standard, measurable protocols to collect consistent region-wide existing stream condition data.

Monitor stream reaches over time to compare conditions within or between reaches at a reasonable level of statistical confidence (generally the detection of a 20% change with an 80% confidence level).

B. Background

The SCI technical guide was developed beginning in 1993 by a Pacific Southwest Region team of hydrologists, fisheries biologists, and a mathematical statistician from the regional research station. The intent was to select stream condition attributes and establish attribute measurement protocols that could be used across forest boundaries so that information could be shared across the region. Several criteria were established for selecting attributes:

- Attributes were demonstrated through research to be able to detect change resulting from management
- Attributes could be sampled by field crews
- Attributes had a small enough measurement error to be useful in describing differences with a moderate to high level of confidence (detecting a 20% change with a confidence of 80%)

A review of established attributes and protocols was conducted and a subset of the most promising was selected for pilot testing. Development of a protocol for streambank stability was conducted using several references.

Pilot testing was conducted in 1993 and 1994, during which a variety of channel lengths and protocols were evaluated at numerous sites in the region. Testing resulted in two preliminary SCI documents, Versions 1.0 and 2.0. An overview of the pilot testing preliminary results, plus a discussion of analysis and interpretation of the data, is included in Appendix A.

SCI became regionally operational in 1995 as Version 3.0. Minor changes in protocols occurred over the next three years and SCI Version 4.0 was published in 1998. Protocols, procedures and attributes remained the same until 2003 when a document review and revision was undertaken to update attributes, protocols, and procedures. The result is this technical guide, SCI Version 5.0.

C. Components of the SCI

Attributes

The SCI consists of stream features, or attributes, that are useful in classifying channels, evaluating the condition of stream morphology and aquatic habitat, and making inferences about water quality. Attributes are collected at selected reaches on streams of interest. Reaches are monumented to reduce variability when measurements are repeated.

Attributes are classified as either core or optional. Core attributes should be measured on every SCI reach to facilitate analysis at large scales. Local objectives and needs may necessitate collection of additional data. Because there is considerable variation over time and between sites with most stream attributes, it is recommended that all core attributes be collected at each site to provide a strong basis of comparison.

Protocols

Each attribute has a protocol for field measurement. The protocol describes the attribute's importance, objectives, and specific instructions on how and where to take measurements. The protocols are the keystone to the success of SCI since accurate data collection over time is essential.

Inventory Procedures

Procedures for conducting SCI in the field are the operational part of the technical guide. There are procedures that describe how to prepare for field work (watershed and stream reach identification), doing the field work (a pass sequence approach), and what to do after the fieldwork is completed (data check and data entry).

Quality Assurance/Quality Control

The QA/QC Plan in the technical guide is intended to improve quality of SCI data. It is essential for data to be collected accurately in order to be able to meet SCI objectives.

D. Inventory and Monitoring Design

Inventory

The SCI attributes and protocols are designed to measure a suite of characteristics for inventorying stream condition at a specific time and place. SCI consists of established and proven stream assessment techniques that are organized into a package that can be measured in the field in a complimentary and time-effective manner. SCI is thus designed to inventory many stream condition attributes in one visit to a stream reach.

SCI is primarily designed for use on wadable, perennial streams with gradients up to about 10%.

Establishing SCI reaches typically requires two to three days with a crew of two or three, depending on travel time and crew experience. Remeasurement of reaches requires slightly less time.

Monitoring

In recent years there have been numerous studies that have evaluated the repeatability of protocols, especially in relation to large-scale monitoring efforts (Archer et al. 2004). In setting up a monitoring location, it is important to understand the variability associated with stream reaches, as well as the variability in how observers take measurements. SCI is designed so that reliable repeat measurements can be made at desired intervals to detect change. Quantifiable, objective measurements in each protocol allow for remeasurement at the same location. It is critical that the Quality Assurance/Quality Control section of this document be understood to insure reliance on the data collected.

In addition, when remeasuring SCI reaches, consider any changes that may have been made to these protocols between sampling intervals. This may affect data collection and interpretation.

Data Management

SCI is compatible with NRIS. This national system will be used as the data storage and retrieval system when it is available in Region 5.

Limitations

The procedures provided in the SCI technical guide should be considered tools for stream inventory and monitoring. SCI is not intended to provide a complete list of inventory and monitoring attributes given the wide variety of channel and watershed types, beneficial uses of water, aquatic communities, and management activities in the Region. Additional data collection related to specific biota or stream characteristics may be needed to meet local inventory and monitoring objectives. Examples of such attributes include amphibians, stream longitudinal profile, chemical or physical water quality, range utilization, green-line, and fish spawning success.

Application of SCI to large rivers or very small streams should be undertaken with caution. In such cases, monitoring objectives and questions should be carefully evaluated before inventory is begun. Variables such as deep pools in large rivers make implementing some protocols problematic, and employee safety is an issue. Some SCI protocols are applicable to intermittent streams and some others are not. Selection of intermittent streams should consider the effects of a limited data set on the ability to interpret data. Likewise, several SCI attributes provide measures of channel morphology most applicable to low gradient channels. Application of SCI to high gradient streams should be undertaken with the knowledge that attributes sensitive to change may be different from low gradient streams; however, application of SCI in steeper, more resilient channels has been successful. Careful evaluation of inventory and monitoring objectives should be considered before conducting SCI on high gradient streams.

E. Relation to Other Inventories and Programs

Inventory and Monitoring Levels

SCI fits within a framework of inventory and monitoring tools available to Pacific Southwest Region watershed and aquatic specialists. Conceptually, these tools fit into four increasingly intensive levels of inventory and monitoring:

Level 1. Office Level – Maps, aerial photography, and other existing data are used to characterize watershed and stream attributes, such as area, geology, gradient, and valley width. This is a first step in designing plans for field inventory or monitoring.

Level 2. Field Extensive Level – A basin level field inventory is conducted to determine distribution of aquatic species, riparian condition, channel types and fish habitat, and location of stream improvement opportunities.

Level 3. Field Intensive Level – This is SCI, a field inventory and monitoring protocol intensive enough to provide reliable comparisons over time within or between streams across the region.

Level 4. Project Level – This is project/site specific monitoring, based on plans developed to address specific questions. It includes in-channel monitoring required by the R5 Best Management Practices Evaluation Program (BMPEP). In some cases, SCI protocols may be the appropriate tool to address Level 4 monitoring questions.

Related Assessment and Monitoring Programs

SCI is a portion of the larger task of ecosystem inventory, monitoring, and analysis. It has analytical application in conjunction with resource inventories that provide like data for other ecosystem components (i.e. Soil Surveys, Ecological Unit Inventory (EUI), Aquatic Ecological Unit Inventory (AEUI), Aquatic and riparian species surveys, Watershed Improvement Needs (WIN) Inventory, etc.). Assessment and evaluations where SCI data can be useful include:

Watershed Assessment/Analysis: The use of SCI as a tool for assessing condition should be spurred by identification of a question or data need posed during the large-scale analysis.

Watershed Condition Assessment: This regional protocol uses a range of objective and subjective indicators to rate the condition of watersheds. WCA may serve to highlight locations where data provided by SCI might be most useful. Existing data sources are used to support ratings made in the WCA. SCI data can provide a basis for the elements related to channel condition.

LRMP Monitoring: SCI data should be extremely useful in evaluating trends in condition over time. It therefore has utility in long-term monitoring associated with Forest Plans.

BMPEP In-Channel Monitoring: BMPEP directs each R5 forest to have at least one in-channel assessment of BMP effectiveness each year. SCI might be extremely useful for this purpose, dependent upon the specific questions associated with the project and stream selected.

Project Level Monitoring: The need for monitoring trends in channels before and after project implementation may be identified during project planning. Again, SCI might be an appropriate tool for such monitoring.

F. Relation to Forest Service Handbooks

The following is a list of current Regional and National handbooks that codify the agency's policy, practice, and procedures in relationship to aquatic systems:

Ecosystem Classification Handbook (FSH 2090.11): This handbook is reserved and is still to be developed, however it is anticipated that data collected through SCI would provide useful information for classification of aquatic ecological types.

Water Resource Inventory Handbook (FSH 2509.16): The SCI technical guide complements both Sections 1.2 (inventory) and 1.3 (evaluation and monitoring) of the Water Resource Inventory Handbook.

Water Information Management System Handbook (FSH 2509.17): The SCI technical guide provides useful information for managing water systems on National Forest lands. SCI procedures can help with floodplain delineation (Chapter 20). Applicable information collected through SCI inventory and monitoring includes, but is not limited to: channel cross-sections, percent fines, and residual pool depths.

Soil and Water Conservation Handbook (R5 FSH 2509.22): The SCI technical guide complements Chapters 10, 20, 30, and 40 of the Soil and Water Conservation Handbook. SCI inventory and monitoring helps with water quality management including best management practices evaluation (BMP) for National Forest lands in California (Chapter 10).

Specifically, SCI provides a means of completing in-channel evaluations required by the R5 BMPEP technical guide. Information collected through the SCI procedures assist with cumulative watershed effects analysis (CWE, Chapter 20). SCI information available for CWE analysis includes but is not limited to, stream channel processes, stream channel response, beneficial uses of water, water quality criteria necessary to protect specific beneficial uses, and channel attributes. Since SCI can be a monitoring tool, it is useful for determining effectiveness of stream management zones and land management activities in protecting riparian and aquatic resources (Chapter 30 & 40).

Water Resource Investigations (FSH 2531, R5 FSH 2531.3): There are three levels identified for water resource investigations. SCI is useful for providing information at all levels.

Water Quality Management (FSH 2532, R5 FSH 2532.04): The SCI technical guide procedures provide information relating to water quality and aquatic conditions. Specific data collected with SCI that could be used for water quality management include but are not limited to: sediment loading, water temperature, and stream channel stability.

Fisheries Habitat Evaluation Handbook (R5 FSH 2609.23): The inventory and monitoring procedures outlined in the Regional SCI technical guide supplements the existing fisheries habitat assessment procedures. SCI is intended to supplement the FSH 2609.23 Step II Habitat Inventory--Quality and Quantity. This provides an alternative tool for monitoring of streams with greater integration between fisheries and hydrology. SCI provides a greater sampling intensity than the existing FSH 2609.23 Step II procedures (220, 221, 221.1, 221.2, 221.3, 221.4, 221.5, 221.6). SCI Inventory and Monitoring procedures are also intended to supplement the FSH 2609.23 Step III Project Design and Evaluation (230, 231, 231.1, 231.2, 231.3, 231.4, 231.5, 231.6) by providing objective, measurable, repeatable protocols that can be used for monitoring or inventory with a greater level of statistical confidence than existing procedures. In actual application, forest aquatic specialists will choose procedures from both sources and additional procedures to address specific inventory and monitoring situations.

Investigating Water Quality in the Pacific Southwest Region: Best Management Practices Evaluation Program (BMPEP): SCI provides protocols useful in implementing BMPEP In-Channel Evaluation.

G. Data Quality

Recent evaluations of stream monitoring efforts (Roper et al. 2003), as well as experience with SCI during the pilot and draft periods continue to demonstrate the inherent variability of stream systems and the difficulty of monitoring them. The same efforts have reinforced the need for attention to quality control. Quality assurance and control procedures are discussed in Section IV.

H. Data Storage and Retrieval

An important component of having a standardized protocol is the use of a standardized database to facilitate storage and use of the data. SCI data is compatible with the National Resource and Information System (NRIS).

II. Stream Condition Inventory Attributes and Protocols

A. Stream Condition Inventory Attributes

The 18 stream condition attributes in this technical guide are shown in Table 1. Nine attributes are measured throughout the entire reach selected for SCI measurements, known as the sensitive reach, and nine are measured in the survey segment (the same length as the sensitive reach on reaches shorter than 1,000 m, or a randomly selected portion of sensitive reaches that are longer than 1,000 m). Section IIIA provides a definition and description of SCI stream reaches, and the rationale for attribute measurement locations.

SCI attribute measurement is described in this technical guide as a four-pass sequence along a stream reach although attributes can be measured in any sequence. See Section IIIB for a full description of the SCI pass procedure.

Table 1 - SCI Attributes

Location of Measurement	Attributes	Core/Optional	Pass Number
Sensitive Reach	Macroinvertebrates	Core	1
	Particle Size Distribution	Core	1
	Stream Temperature[1]	Core	1
	Large Woody Debris (LWD)	Core	1
	Bankfull Stage	Core	2
	Cross-section	Core	2
	Water Surface Gradient	Core	2
	Width-to-depth Ratio	Core	2
	Entrenchment	Core	2
Survey Segment	Habitat Type	Core	3
	Pools	Core	3
	Pool Tail Surface Fine Sediment	Core	3
	Streambank Stability	Core	4
	Stream Shading	Core	4
	Streamshore Water Depth[2]	Core	4
	Streambank Angle[2]	Core	4
	Aquatic Fauna	Core	4
	V^*_w[3]	Optional	N/A[2]

[1] Thermographs must be in streams prior to July 1st

[2] Measured only in low gradient stream reaches (<2%) with fine textured streambanks.

[3] V^*_w is a very intensive inventory and should be done after passes 1-4 are completed.

Of the 18 SCI attributes, 17 are core attributes and one is an optional attribute. Measurement priorities are described below:

Core Attributes – These should be measured on every SCI stream reach. Data for each attribute can be collected in a relatively short period and the data gathered strengthens each individual stream comparison, as well as interpretations at larger scales. Measurement of gradient is essential to facilitate comparison with other stream reaches in the regional database.

Optional Attribute – This should be included when it meets specific monitoring objectives.

V^*_w – This attribute has been shown to be a reliable measure of sediment deposition in pools in some geologic and channel types. It is an optional SCI attribute primarily because its application is limited to certain channel types and geology. V* requires a greater intensity of data collection than other SCI attributes. If monitoring questions focus on tracking fine sediment in appropriate geology and channel types then V^*_W should be considered.

B. Stream Condition Inventory Protocols

The protocols for the18 SCI attributes are described in the order in which they are recommended for surveying in the SCI pass sequence.

Macroinvertebrates

(Core Attribute)

Importance:

Macroinvertebrates have been demonstrated to be very useful as indicators of water quality and habitat condition (Rosenberg and Resh 1993). They are sensitive to changes in water chemistry, temperature, and their physical habitat. Most benthic macroinvertebrates have aquatic life stages lasting several months to several years, they are relatively abundant, and are easy to collect. These attributes contribute to the usefulness of macroinvertebrates as indicators of aquatic condition.

In recent years, the Pacific Southwest Region has developed the protocol described below to provide a consistent approach for collection of benthic macroinvertebrates. During this period a model was developed for use in the region utilizing data collected from numerous reference streams across the region (Hawkins, 2003). The model provides a consistent way to interpret macroinvertebrate data at the site, watershed, and regional scales. This model is one of several methods to analyze and interpret information from macroinvertebrate samples.

Objectives of This Measurement:

Gain a biological assessment of water quality and habitat condition. Bioassessment using macroinvertebrates provides a measure of biological integrity, as mandated by the Clean Water Act.

A secondary objective is to collect data to characterize the stream in terms of factors important to macroinvertebrates. This data improves the interpretative value of the macroinvertebrate data and facilitates comparison of data from reference streams with similar characteristics.

A key element in this characterization is water chemistry, as indicated by alkalinity and conductivity. Alkalinity primarily results from the presence of bicarbonates, carbonates, and hydroxides, which together shift the pH to the alkaline side of neutrality (i.e. pH> 7.0). Specific conductance is a measure of the resistance of a solution to electrical flow (resistance to electrical flow increases with the purity of water).

How Many Measurements to Take:

Macroinvertebrates:

Take two 0.1 square meter samples from four riffles (a total of eight samples composited into a single sample).

Particle Count:

Take four counts of 100 particles as described in the Particle Size Distribution protocol.

Water Chemistry:

Take two samples (conductivity and total alkalinity).

Where to Take the Measurements:

Macroinvertebrates:

Identify riffles during reach reconnaissance that are representative of the reach, using the riffle identification criteria described below.

Select the first four riffles upstream from the start of the sensitive reach that are representative of the reach, using the riffle selection criteria described below.

Riffle identification criteria:

- Flow: Turbulent
- Depth: Shallower than pools or runs (portions of substrate typically extend above the water surface).
- Morphology: Uniform to convex profile.
- Dimension*:* Riffles are often irregularly shaped, and vary in length and width. Some portion of the riffle is the dominant habitat across the channel width. Riffles may extend across the wetted width, but typically include features such as edgewater, bars and runs.
- Substrate: Varies from gravel to boulder depending on size of watershed and channel gradient. Typically coarser than that found in pools and runs.
- Gradient: Steeper than runs or pools. Some reaches may contain both low and high gradient riffles. High gradient riffles are relatively steeper and have larger substrate than low gradient riffles.

Riffle selection criteria:

- Length: Select riffles that are representative of the reach. For example, if the typical length is about 10 m with a range of 5 to 15 m, do not select a 2 m long riffle for sampling. In streams where riffles representative of the reach are very long, (i.e., greater than five times the wetted width) break the riffle into sample units that are two times estimated average wetted channel width, separated by one estimated average wetted channel width. Minimum riffle length and width is the size of 2 macroinvertebrate samples (2 square feet, or .62 m^2). This condition is usually only found in very small streams.
- Width: Select riffles that are representative of the reach, similar to the criteria for length.
- Substrate: Select riffles that are representative of the substrate size of riffles in the reach. For example, if nearly all riffles are mid-to-small gravels do not select a large cobble/small boulder riffle.
- Gradient: Select low gradient riffles if the reach has both low and high gradient riffles.

Water Chemistry:

Measure conductivity and total alkalinity at the furthest downstream riffle selected for macroinvertebrate sampling.

How to Take the Measurements:

Macroinvertebrates:

All samples are collected using a 500µm mesh net. Mesh size is critical, as it directly impacts the size and abundance of organisms collected.

Sampling begins at the first selected riffle at the downstream end of the sensitive reach. Remember that the area suitable for macroinvertebrate sample collection may not encompass the entire wetted riffle habitat unit. Include only those portions of the riffle that meet the sample criteria described above. Do not include edgewater, runs, or other areas that do not meet the criteria. Also, consider water depth. If riffles representative of the sensitive reach have depth less than the macroinvertebrate sampler, do not include areas deeper than the sampler in the sample area (sampler efficiency is reduced when depths exceed that of the sampler). Use Form 2 to sketch the selected riffle and the area within each riffle suitable for macroinvertebrate sample collection.

Use a ten-sided die, stopwatch, or random number table (see Appendix D) to randomly select two pairs of single digit numbers (1-9). To reduce edge effects, 0's are discarded if selected. The first number of each pair, multiplied by 10, is the percent upstream along the suitable area's length. The second number, multiplied by 10, is the percent of the stream width from the left edge of the sample area, looking downstream. The second pair of numbers is used in the same way to select the second macroinvertebrate sample location. The intent of this procedure is to randomize the selection of sample locations within the area of the riffle suitable for macroinvertebrate sampling.

Beginning at the most downstream site in the first riffle, place the opening of the net perpendicular to and facing the flow of water. Move substrate material as necessary to create a flush contact between channel substrate and the bottom of the sampler. Disturb the substrate in front of the opening of the net such that about .125 m^2 is disturbed; this is the width of the net by approximately .4 m (16”). Many samplers have a frame that lies in front of the net and outlines the sample area. Carefully remove, rub clean and inspect all large rocks in this area to ensure removal of all macroinvertebrates. After all of the larger rocks have been removed, rake or disturb the smaller rocks and sands to a depth of approximately .1 m (4”) for approximately 60 seconds.

If necessary, empty the contents of the net into a 14 L (five gallon) bucket. Repeat the sampling procedure above at the second randomly selected site for the first fast-water habitat. Empty the contents of the second sample into the bucket. Repeat the process for each of the three remaining riffles. A total of eight samples will be collected. All nets will be emptied into a single bucket, resulting in a single composite sample.

After all eight net samples are in the bucket, carefully remove large pieces of debris and rocks. Wash each piece of debris, inspect carefully and remove any invertebrates before disposal. Place remaining material from the bucket into one plastic jar. Sample material can be agitated (swirled) and dumped through a soil sieve with mesh size 500 um or less to remove organisms and reduce sample volume, as necessary. Carefully inspect material left in the bucket to see than no macroinvertebrates remain. Completely cover the sample material in the jar with 95% ethanol.

Samples must be mailed for laboratory analysis. Label samples and ship them to The BugLab at Utah State University. Note that two sample labels must be sent with each sample – one inside and one outside the sample jar. The inside label must be prepared in pencil on water resistant paper, and the outside label must be written in permanent marker. In addition, a sample form must be sent to the lab with each sample (Form 2, page 1), or the form available from the BugLab may be used). Detailed information on labeling and shipping is available from the BugLab, as follows:

The BugLab
Department of Aquatic, Watershed, and Earth Resources (AWER)
Utah State University
Logan, Utah 84322-5210
Phone: 435-797-3945
http://www.usu.edu/buglab/

Water Chemistry:

Measure conductivity at the center of the stream and record in µS/cm. Collect a sample at the same location and measure total alkalinity.

References

Rosenberg and Resh 1993

Karr and Chu 1998

Particle Size Distribution

(Core Attribute)

Importance:

Streambed materials are key elements in the formation and maintenance of channel morphology. These materials influence channel stability, resistance to scour during high flow events, and also act as a supply of sediment to be routed and sorted throughout the channel. The amount and frequency of bedload transport can be critically important to fish spawning and other aquatic organisms that use stream substrate for cover, breeding, or foraging.

Particle size distribution can change over time as a result of management activities and/or natural disturbances. Detecting change is important for making decisions related to managing aquatic communities and ecological processes.

Objective of This Measurement:

Detect status and change of streambed particle size distribution.

How Many Measurements to Take:

Conduct a particle count of 100 particles in each of the four riffles sampled for macroinvertebrates, for a total count of 400 particles in the sensitive reach.

Where to Take the Measurements:

Take the particle count in the four riffles sampled for macroinvertebrates (see Macroinvertebrate protocol). Measure and record the distance upstream from the start of the sensitive reach to the lower end of each riffle, and the length of each riffle.

Measurement is conducted on the stream bottom so that the streambed is sampled without incorporating bank materials. The stream bottom is the area of the stream that is practically bare of vegetation caused by the wash of waters of the stream from year to year. It is therefore at a level less than bankfull stage and excludes streambanks.

Riffles are the preferred sampling location for detecting change since they have a relatively homogenous particle size composition. This reduces sampling variability and makes it more likely to detect change than by sampling different habitat types (i.e. pools, runs). The objective of this procedure is to compare riffle particle size distribution over time and between reaches.

The riffle particle count may be suitable for reach characterization. Although the riffle D50 is likely to be different than a count across habitat types, it will usually be in the same particle category. Where a reach characterization across habitat types is desired, a different protocol should be employed.

How to Take the Measurements:

At each riffle, locate ten equally spaced transects perpendicular to the main axis of the channel. Proceed across the transect and count 10 particles at evenly spaced intervals. The minimum distance between sample points should not be less than the size of the largest particle in the riffle. (Note: where an anomalously large particle is present use the largest dominant particle size in the riffle. For example, if a riffle is 70% gravel and 30% cobble but has one very large boulder, use the largest cobble as the minimum spacing guide).

Record each particle on the data form in the “wet” or “dry” column to denote whether it is within or outside the wetted width of the channel at the time of the particle count. This allows analysis of the particle size distribution for the macroinvertebrate sample (in the wetted area) as well as the entire channel. To select an individual particle for measurement, reach down over the tip of the boot while averting the eyes. Collect the first particle touched by the tip of the index finger. Use a gravel template to measure the intermediate axis size class of the particle. A class-defined ruler may be used if a gravel template is unavailable but care should be taken to determine the correct size class. Sizes larger than 180 mm, or particles that cannot be extracted from the streambed, need to be measured with a ruler. For gravel-bed streams, tally particles smaller than 2 mm in size into a class defined as "<2 mm" because particles smaller than this are difficult to representatively sample. If a large proportion of the count (approximately more than 50%) is less than 2mm in size, volumetric sampling is suggested.

The particle count procedure varies for very small streams. Some reaches may be so narrow that 10 particles cannot be collected between streambanks while maintaining intervals greater than the largest particle size between sample points. In steeper, small stream systems, suitable riffle substrate for macroinvertebrate collections may be limited. Collection of macroinvertebrate samples may disturb (and remove) some or most of the substrate, making subsequent particle counts impossible. In these cases, the following technique will be employed. At each macroinvertebrate site (typically pool tails rather than true riffles) alternatively collect 12 or 13 particles for measurement using the following systematic approach. Within the macroinvertebrate sampler frame, superimpose an imaginary 3x4 grid. At each of the grid sample points, select a particle as per the "toe point" method. Wash the particle as per the macroinvertebrate collection procedure, then place the rock in a bucket for subsequent measurement. If 13 particles are to be collected, select the 13th particle from the center of the sample area. By collecting 12 particles from four samples and 13 particles from four samples, a total of 100 particles are collected from the eight macroinverterbate sample locations. Measure and record the length of the intermediate axis of all particles collected.

Vendor Information – Gravel Template

Federal Interagency Sedimentation Project (FISP)
US SAH-97 Gravelometer
Phone (601) 634-2721
www.stream.fs.fed.us (go to Stream Notes October 1997)

References:

Bunte and Abt 2001

Harrelson 1994

Potyondy 2003

Wolman 1954

Stream Temperature

(Core Attribute)

Importance:

Water temperature strongly influences the function of biological systems, and individual organisms and species. Stream temperature has impacts on health, behavior and survival of aquatic organisms. Manipulation of riparian vegetation that provides shade is a key management concern.

Objective of This Measurement:

Thermographs are used to collect and record stream temperatures during low-flow long day length periods, when maximum temperatures are likely. The objective of the measurement is to determine mean maximum temperature for the period July 1-August 31. Temperature range for this time period can also be derived. Maximum temperatures are determined for comparison with project or forest standards, or state water quality objectives.

Note: Forest or project standards may have objectives for temperatures other than this low flow period, including minimum (winter) temperatures. If such site-specific objectives for timing have been developed, they should be substituted for the July 1-August 31 sampling period.

Additional Note: Forests may also elect to collect "spot” temperature data with hand held thermometers or other means. This approach may be valuable, especially as a site-specific reference. This data does not lend itself to rigorous monitoring level comparisons between streams or over time, and therefore is not stored in the Regional database. Thermograph technology has developed to the point where they are very inexpensive relative to the amount of information acquired.

How Many Measurements to Take:

Take a minimum of 1, 468 measurements (hourly for 62 days).

Where to Take the Measurement:

At a run or riffle, anywhere where the flow is mixed (versus in a pool where stratification might occur).

How to Take the Measurement:

A recording thermograph is used for this measurement. Program the thermograph to take measurements at intervals of one hour (this is the minimum sampling intensity, most thermographs will take more frequent measurements over a 62 day time scale).

Install the thermograph prior to July 1, and retrieve it after August 31. Mean daily maximum temperatures (for the thermograph) are calculated for the 62 day period July 1-August 31. As with the measurement interval, the 62-day period is a minimum, most thermographs will record temperature over a much longer time period.

Note: If the thermograph is installed at the same time macroinvertebrate sampling is conducted, stay out of the water while setting the thermograph, or do the macroinvertebrate sampling first.

Large Woody Debris (LWD)

(Core Attribute)

Importance:

Large wood is important to the morphology of many streams. It influences channel width and meander patterns, provides for storage of sediment and bedload, and is often most important in pool formation in streams. Large wood is also an important component of instream cover for fish, as well as providing habitat for aquatic insects and amphibians. Large wood influences on stream ecology vary with size of the stream and size of the wood (small wood is easily transported in large systems).

Objective of This Measurement:

To characterize the woody debris in the sensitive reach that is influencing the stream channel. If the objective is to measure large woody debris (LWD) as a cover component, more extensive information should be collected although some inferences could be drawn from the tally in this protocol.

How Many Measurements to Take:

Conduct a count of all large woody debris and root wads within the sensitive reach that meet dimensions described below. Preliminary results from testing of these protocols confirmed the work of others demonstrating that LWD distribution is clumped, and that long reaches are necessary for an accurate description.

Where to Take the Measurement:

Count all pieces of wood lying within the sensitive reach that has any portion within the bankfull width of the channel. This includes logs suspended above the channel.

How to Take the Measurement:

Walk the sensitive reach counting wood longer than one-half bankfull width. Wood must be downed with a portion lying within bankfull stage.

Single Pieces – Tally each piece that meets the criteria in the paragraph above. There is no need to record the length or diameter of each piece. Sum the number of pieces on the form. Use the comment section to note if any of the large wood counted is part of stream enhancement structure.

Aggregates - Aggregates are defined as four or more pieces of woody debris in contact where each piece meets the minimum length requirement and has some portion occurring within bankfull width. Tally all the pieces in the aggregate meeting the minimum size criteria that can be feasibly and safely identified (some aggregates may be large enough to obscure individual pieces from view or safe access). Record the number of pieces in each aggregate on the aggregate line, and sum the total number of pieces.

Tally root wads as single pieces whether they occur alone or are within an LWD aggregate. A root wad is defined as the root mass of a tree whose trunk length is approximately equal to or shorter than the diameter of the root wad. Root masses with longer tree boles should be tallied as LWD.

Beaver dams should not be tallied with the LWD count. They should be noted as comments on the data form.

References:

Knopp 1993

Platts et al. 1987

Sedell et al. 1988

Bankfull Stage

(Core Attribute)

Importance:

The bankfull stage corresponds to the discharge at which channel maintenance is often the most effective. This discharge is a major factor in shaping channels sensitive to disturbance by management activities, such as gravel bed streams. The bankfull stage discharge is associated with a momentary maximum flow that has a recurrence interval of about 1.5 years (Dunne and Leopold, 1978).

Objective of this Attribute:

Identify bankfull stage in order to determine associated channel characteristics such as bankfull width, bankfull depth, and bankfull width-to-depth ratio. The location of bankfull stage is also important for stream classification.

How to Identify this Attribute:

The determination of bankfull stage should focus on the identification of the flat depositional surface adjacent to the stream channel that corresponds to the elevation of the floodplain. Depositional surfaces are most readily observed on low gradient streams but may be less evident in steep streams or in recently incised channels. When floodplains are not well defined, other indicators can serve as surrogates to identify bankfull stage. These include vegetation, changes in sizes of bank materials, and water stain or lichen lines on substrate. However, these must be used with care since specific indicators vary with stream type and geographical region. Vegetation, in particular, may exhibit regional differences. For example, the base of alders is an indicator of bankfull stage in some ecosystems, while willows indicate bankfull stage in others. Some perennial herbaceous plants that provide streambank stability, such as sedges, may extend below bankfull stage.

By using the presence of depositional surfaces as the conceptual underpinning, the identification of bankfull stage links directly back to the basic definition of bankfull discharge established by Leopold and Wolman (1964) which states, “Bankfull discharge is defined as that water discharge when stream water just begins to overflow into the active floodplain; the active floodplain is defined as a flat area adjacent to the channel constructed by the river and overflowed by the river at a recurrence interval of about two years or less.”

Note: It is important that bankfull stage is correctly identified. To do so, a length of approximately 20 channel widths should be selected in the sensitive reach where representative bankfull stage locations can be identified and marked with survey flags. Locating bankfull stage should be done in fastwater habitat units using field indicators and, when available, regional curves of bankfull dimensions.

The USDA video and DVD for identification of bankfull stage is a helpful reference (USDA 1995).

Where to Identify this Attribute:

Identify bankfull stage at the following sites:

1) Start of sensitive reach (to determine large woody debris minimum length tally)
2) Particle size distribution transects
3) Cross-section locations
4) Width-to-depth/entrenchment locations

References:

Dunne and Leopold 1978
Harrelson et al. 1994
Leopold and Wolman 1964
USDA 1995

Cross-section

(Core Attribute)

Importance:

Channel cross-section measurements express the physical dimensions of the stream perpendicular to flow. They provide fundamental understanding of the relationships of width and depth, streambed and streambank shape, bankfull stage and floodprone area, etc. All of these are important attributes of channel condition and indicators of the health of aquatic and riparian ecosystems. Cross-section measurements also serve as essential criteria for stream classification. Monumented cross-sections are used to determine channel condition and trend since they can be monitored repeatedly.

Objectives of This Measurement:

Measure channel cross-section to determine indicators of channel condition. These include width/depth ratio, bank angle, channel shape, floodprone area, etc.

Measure cross-sections to establish permanent monitoring sites to determine change in channel condition over time.

How Many Measurements to Take:

Measure up to three cross-sections per sensitive reach, each within fast water habitat units. If there are more than three candidate sites for cross-sections within the sensitive reach, randomly select three. If there are three or fewer candidate sites measure them all. (In reaches with more than three candidate sites, the ones not selected for cross-sections will become candidates for width-to-depth and entrenchment measurements).

Where to Take the Measurement:

Identify candidate sites during the first pass along the sensitive reach. Flag and number each candidate site and record its distance from the start of the sensitive reach. Candidate sites are fast water habitat units in straight sections typical of the sensitive reach. Candidate sites must have clear bankfull stage indicators. Do not use pools as candidate sites.

Measure the cross-section at the widest point in the selected candidate site.

How to Take the Measurement:

The standard SCI method is described below and shown in Figure 1. It is designed to use lightweight gear so that cross-sections can be easily measured at remote sites as well as more accessible sites. It utilizes permanent site marking stakes, a string line and level, a measuring tape, engineering survey flags, and a depth rod. Alternately, a survey level and rod can be used following standard surveying techniques such as described in Harrelson, 1994.

Establish a horizontal measuring line across the channel between permanent end-point markers of sufficient stability, elevation, and distance from water’s edge so they will not be washed out over time. End-point markers should be higher than two times maximum bankfull stage depth, preferably on a terrace or high bank (twice maximum bankfull stage depth approximates a 50-year flood). End-point markers are designated left pin (LP) and right pin (RP). The left pin is on the left bank facing downstream.

The horizontal measuring line must be a level, tight string line. The height of the string line on the end-point markers must be noted on the form so that future cross-section measurements are made at the same elevation. Place a measuring tape alongside the string line for reading distances at which depth measurements are taken across channel. Always start measurements at the left bank facing downstream.

Prior to taking depth readings, bankfull stage must be identified and marked. It must be the same elevation on both banks (the height from the string line down to bankfull stage must be identical). Bankfull stage cross-sectional area should be consistently similar at cross-section sites in the reach. If not, bankfull stage may not have been correctly identified. Compare the bankfull stage cross-sectional area measurements in the field as sites are measured to assure consistency.

Begin cross-section measurements at the left pin and end at the right pin. Take depth readings with rod at intervals representing 5-10 percent of total width measured, at all locations of significant slope changes across the channel, at bankfull stage, and at water's edge. Intervals may be at fixed widths where channel shape remains similar, but will be non-uniform across full width measured since certain points must be identified. As an example of the number of depth measurements to take, if a channel width is 10 m, 10% intervals yield 10 depth measurements and 5% intervals yield 20. Examples of significant slope changes in the channel include noticeable breaks between streambed and streambank, channel bars, terrace edges, large boulders, and undercut banks.

In the case of undercut banks, measure the depth at the top and bottom of the undercut and enough undercut widths to accurately depict the shape of undercut (see Figure 1). Record the depth and undercut widths on the datasheet. To determine the distance from the left bank, subtract the undercut width from the distance from left stake at the top of the undercut (TUC). It is important to record the cross-section point in the proper sequence so that the cross-section may be graphed. The sequence should be ordered so that a continuous line may be drawn from point to point depicting the cross-section profile. Plot the cross-section in the field and sketch the channel profile. Identify bankfull stage, water surface elevations, end-points, and undercut banks. Confirm the data accuracy and verify enough measurements were collected to provide a precise profile.

Make all measurements to the nearest 0.01 m.

Once depth measurements are completed, the measurements associated with cross-sections can be made. Gradient and entrenchment are measured using separate protocols. Width/depth ratio is calculated from data collected at the cross-section.

Permanent Identification:

- Cross-sections must be referenced with permanent monuments wherever monitoring change in stream morphology over time is desired. Permanent references include the following:
- Benchmarks – A benchmark should be a permanent feature near the cross-section and include a distance and bearing to the cross-section end-point markers. It should also include an elevation from the benchmark to the end-point markers. Refer to standard surveying protocol (Harrelson 1994). It is also helpful to take a bearing from one end-point marker to the other.
- Cross-section end-point markers – It is essential to install markers that will remain in place permanently. Rebar (about 1 m by 0.015 m sunk into the ground with only a short piece above ground) is a standard marker. Shorter rebar (i.e., 18”) can sink into the ground as time goes on, or can be pulled out. Other marker options include angle iron or T-stakes. Wilderness cross-section markers may have to be unobtrusive, but are still essential since remeasurement is impossible without a permanent marker. End-point markers must be of sufficient stability, sufficient elevation, and distance from water’s edge so they will not be washed out over time.
- Photographs – Photos are a key tool for relocating the cross-section site and showing change over time. Even with benchmarks and the cross-section’s known distance upstream from the start of the sensitive reach, they often provide the best clue to relocating cross-section markers. At a minimum, four photo angles should be used:

upstream, downstream, and left and right banks. Additional photos are recommended if there are important details of the site to display, such as the end-point pins and the bankfull stage flags. All photos of cross-sections should be taken with the string line and/or tape in place for better depiction of the location.

- Georeference – GPS units can be used to identify the cross-section location. However, GPS accuracy limitations are such that GPS will not find the precise spot where end-point pins are located. Georeferencing, however, is a good tool for locating the cross-sections so they can be mapped. If cross-sections are georeferenced, the start and end-points of the sensitive reach should also be georeferenced.

Cross-section Remeasurement:

Remeasurement of cross-sections should be done over time when it is expected there may be changes in channel morphology. Frequency of remeasurement depends on a number of environmental and management variables. These can include change in management practices in the watershed upstream of the cross-section, staffing, and changes in channel form due to large storm events. However, it is recommended that cross-sections be remeasured frequently enough to respond to the management questions for which they were established. As a guide, a range of 2-5 years is recommended. More frequent measurements may be considered if measurable annual change is expected, or a large natural event has affected the watershed.

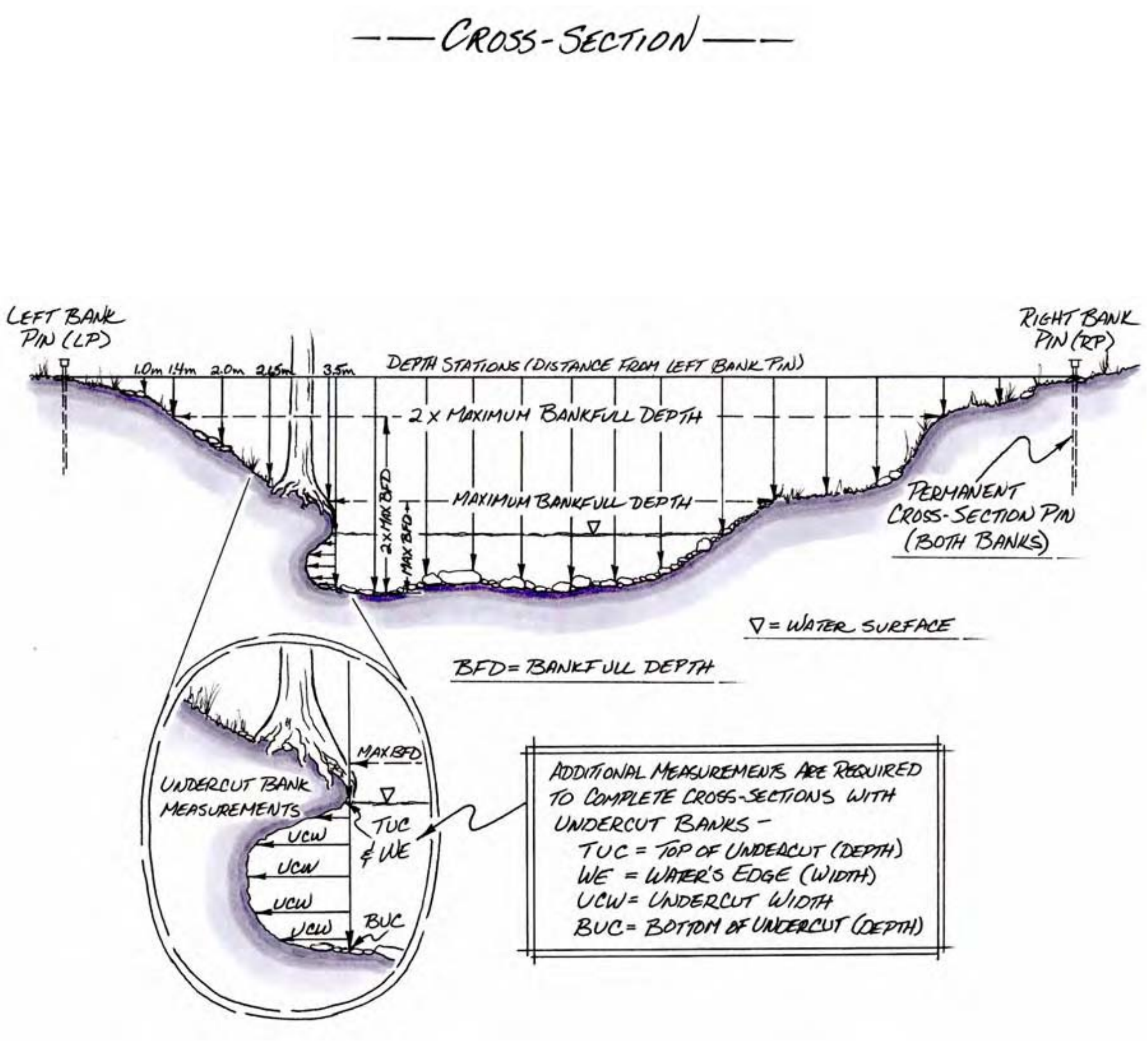
Procedure for remeasuring cross-sections is the same as for their establishment. However, the following points should be considered:

If the existing end-point markers are missing or appear to have been moved (i.e., bent or partially pulled up), establish new ones at the same site and consider it a new cross-section.

If the existing end-point markers were established lower than two times maximum bankfull depth, consider site factors to determine if they should be relocated higher (such as whether the present location appears to be subject to washing out). It is advisable to have the end-point markers above two-times maximum bankfull depth if practical to minimize them being dislodged or lost. When relocated higher, the original cross-section data are still usable if the existing end-point markers are in place. The only change is that additional height and width are added.

References:

Harrelson et al. 1994



ADDITIONAL MEASUREMENTS ARE REQUIRED TO COMPLETE CROSS-SECTIONS WITH UNDERCUT BANKS -

TUC = TOP OF UNDERCUT (DEPTH)
WE = WATER'S EDGE (WIDTH)
UCW = UNDERCUT WIDTH
BUC = BOTTOM OF UNDERCUT (DEPTH)

Figure 1 – Cross-section

Water Surface Gradient

(Core Attribute)

Importance:

Gradient of the stream surface is an essential element of many stream classification systems and a primary attribute for stratifying sensitive reaches in the R5 SCI database. In addition, knowledge of gradient helps provide understanding of the geomorphological processes shaping the channel.

Gradient must be measured in order to compare the reach with other reaches in the SCI database, and to help classify the reach stream type.

Objective of This Measurement:

To determine the water surface gradient in percent slope.

How Many Measurements to Take:

Three, one at each channel cross-section.

Where to Take the Measurement:

Gradient is measured at the channel cross-section location for a distance upstream and downstream that incorporates at least one pool-riffle or step-pool sequence. If such sequences are not present, measure the longest possible distance in order to represent the average gradient in the area of the cross-section*.*

How to Take the Measurement:

Distance between end-points upstream and downstream from the cross-section should be as long as practical. End-points should be located on the same channel feature (e.g. pool tail) and include as many pool-riffle or step-pool sequences as is practical. At least one pool-riffle or step-pool sequence must be included. In the case of streams where these sequences are not present or not easily identifiable, locate end-points that are as representative as possible of average gradient. Measure the distance, or “run,” between the gradient survey end-points along the thalweg. Determine the water surface elevation change, or “rise,” between the end-points. Divide rise by run and multiply by 100 to calculate gradient.

A hand level and tripod is the minimum tool for measuring gradient. More sophisticated surveying instrumentation such as a laser level may be used if available and practical. Do not use a monopod for mounting an instrument since it cannot be held steady. Lightweight camera tripods can be adapted to firmly hold a hand level. The lightweight tripod and hand level are often more practical in wilderness or other remote stream reaches.

If the end-point is difficult to see (i.e., vegetative obstructions, stream curvature, distance too far), the gradient measurement should be collected in increments. The gradient survey may be taken sighting upstream or downstream; if increments are needed to complete the survey, the instrument must be relocated or turned in place and sighted in the opposite direction.

There are two recommended general instrument locations for measuring gradient – In-stream and Off-stream:

<u>In-stream Sighting:</u>

To measure gradient with a single sighting (where the entire gradient “reach” can be observed without obstruction), the observer at the instrument places the tripod in the thalweg and attaches the level to the top of it (see Figure 2). The observer records the height of the instrument sight line and the height of the water surface above the streambed. The observer at the instrument sights through the level to an observer with a measuring rod at the other end-point of the survey. The observer at the rod notes the height on the rod that is level with the height of the instrument. The observer at the rod records this height and the height of the water surface above the streambed.

To calculate the gradient reach rise, first subtract the water-surface height from the height of the instrument. At the rod end, subtract the water-surface height from the level height observed from the instrument. For example, when sighting upstream, if the instrument height is 1.5 m above the streambed and the water-surface height is 0.2 m, the difference is 1.3 m. If the rod level height is 1.1 m and its water-surface height is 0.3 m, the difference is 0.8 m. The water-surface slope elevation change between the survey end-points is 0.5 m (1.3 m - 0.8 m), or the rise. Note: for single in-stream sightings, viewing upstream is usually easier because it is easier to read the rod end when level height is lower than at the instrument.

To complete the gradient calculation, divide the rise by the run (the distance along the thalweg between the downstream and upstream measuring points) and multiply by 100 to obtain percent gradient. Using the above example over a 50 m length between end-points, 0.5 m/50 m x 100 = 1% gradient.

To measure gradient with a double in-stream sighting (upstream and downstream), place the instrument in the gradient reach where both end-points can be viewed without obstruction. Point the instrument at one end-point (i.e., back sight) and record level height on the rod and water height at the rod. Turn the instrument to the other end-point (i.e., foresight) and, with the rod relocated at that end-point, record level height on the rod and water height at the rod. Calculate the gradient reach rise and run in the same manner as described above to complete the gradient measurement.

Off-Stream Sighting:

Gradient measurements and calculations are done in the same manner as double in-stream sighting. The difference is that the instrument is placed outside the stream, often on a nearby floodplain or terrace. This method is most commonly done with a survey level so it is not subject to falling in the water.

Common to both sighting locations and methods is obtaining rise and run measurements. In some cases the single in-stream sighting may be the quickest. In other cases in-stream or off-stream double sighting, or even a series of double sightings may be the most practical (such as where visual obstructions or a transit is already on site).

Reference:

Harrelson et al. 1994

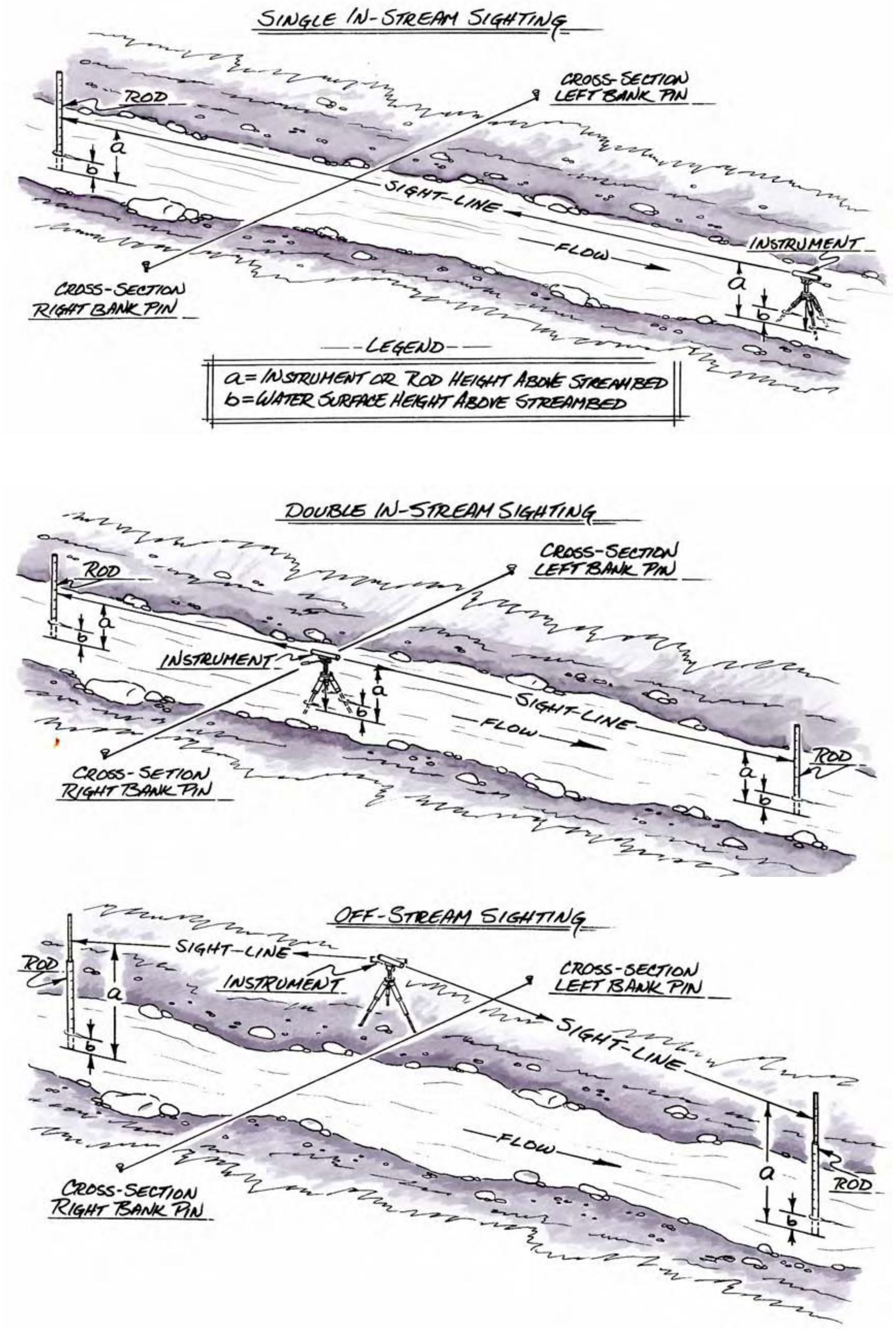


Figure 2 – Water Surface Gradient

Width-to-depth Ratio

(Core Attribute)

Importance:

Stream width-to-depth ratio is a key indicator of channel condition. A low width-to-depth ratio generally indicates good conditions for aquatic flora and fauna and riparian vegetation. Low width-to-depth ratios result in deeper water for aquatic species and a higher water table to support growth of riparian and meadow vegetation.

Objective of this Measurement:

Characterize stream morphology and aquatic habitat.

How Many Measurements to Take:

Take three measurements at the cross-sections and up to five additional measurements (depending on available candidate sites). For example, if there are seven remaining candidate sites after the cross-sections have been selected, randomly select five additional sites for width-to-depth measurements. If there are fewer than five remaining, measure them all.

Where to Take the Measurement:

Randomly select up to five sites from among the remaining cross-section candidate sites after the three cross-section sites have been selected. Candidate sites are in fast water habitat units in straight sections typical of the sensitive reach. Do not take width-to-depth measurements in other habitat types (i.e., pools).

How to Take the Measurement:

Width-to-depth measurements are taken at the same time as entrenchment measurements.

Once bankfull stage has been identified, stretch a measuring tape between bankfull stage flags. Starting at bankfull stage on the left bank, take a minimum of 10 depth measurements before reaching bankfull stage on the right bank. Include the thalweg, water's edge, and major slope changes in the channel cross-section. Take depth measurements at intervals that result in a representative sample of bankfull depths.

Make all measurements to the nearest 0.01 m.

Bankfull stage cross-sectional area should be consistently similar at width-to-depth sites in the reach. If not, bankfull stage may not have been correctly identified. Compare the bankfull stage cross-sectional area measurements in the field as sites are measured to assure consistency.

To calculate the mean depth, the total number of depth measurements should be divided by n+1, in order to account for the zero depths at the streamshore. For example, if 10 depth measurements are taken, divide the sum of those 10 depth measurements by 11.

Document the presence of undercut banks (UC) in the notes column on the data sheet but disregard computing undercuts when measuring width-to-depth ratio. It is beyond the scope of this attribute to assess undercut area and in, most cases, undercuts have a negligible effect on the width-to-depth ratio.

References:

Bauer and Burton 1993

Platts 1987

Rosgen 1996

Entrenchment Ratio

(Core Attribute)

Importance:

Stream discharges greater than bankfull strongly influence the character of the channel. The interaction of these flows with the channel floodplain plays a major role in sediment transport and storage, streambank stability, and channel morphology.

Entrenchment ratio is defined as the ratio of flood prone width to bankfull width as measured at twice the maximum bankfull depth. This measure is intended to quantify channel confinement.

Objective of this Measurement:

Characterize stream morphology and aquatic habitat.

How Many Measurements to Take:

Take three measurements at the cross-sections and up to five additional measurements (depending on available candidate sites). For example, if there are seven remaining candidate sites after the cross-sections have been selected, randomly select five additional sites for entrenchment measurements. If there are fewer than five remaining, measure them all.

Where to Take the Measurement:

At each cross-section and up to five sites randomly selected from among the remaining cross-section candidates.

How to Take the Measurement:

Entrenchment measurements are taken at the same time as width-to-depth measurements.

Double the maximum bankfull stage depth that was determined during the width-to-depth measurement, and measure flood prone width at this elevation using a level tape. Flood prone width may be nearly identical to bankfull width in gullied or very steep streams, or several hundred meters in low gradient streams in wide valleys. In wide valleys where tape measurements may be difficult, estimate the flood prone width by pacing. Avoid visual estimates over long distances since they can be substantially inaccurate. Once the flood prone width is measured, divide by bankfull width to derive the entrenchment ratio. Record the entrenchment ratio on the data form.

Make all measurements to the nearest .01 m.

References:

Rosgen 1996

Habitat Type

(Core Attribute)

Importance:

At the broadest resolution level, fluvial geomorphologists recognize fast water (riffles, runs, etc.) and slow water (pools) as the two primary stream habitat unit types. These units are an important core attribute because they are the base stratification of habitats that support aquatic life.

Forest management can alter the character of fast and slow water habitat units by changing the amount of sediment, water, and LWD contributed to streams. Excessive sediment can smooth channel gradient by filling pools. Removal or reduction in woody debris reduces sediment storage and eliminates local hydraulic variability that influences habitat unit development. Habitat types change throughout streams based on gradient and valley form. Over time these changes are based on stream flow or changes in hydrologic character.

Objective of This Measurement:

To describe the spatial distribution and characteristics of fast and slow water habitat units.

How Many Measurements to Take:

Take measurements equal to the number of fast and slow water habitat types in the survey segment.

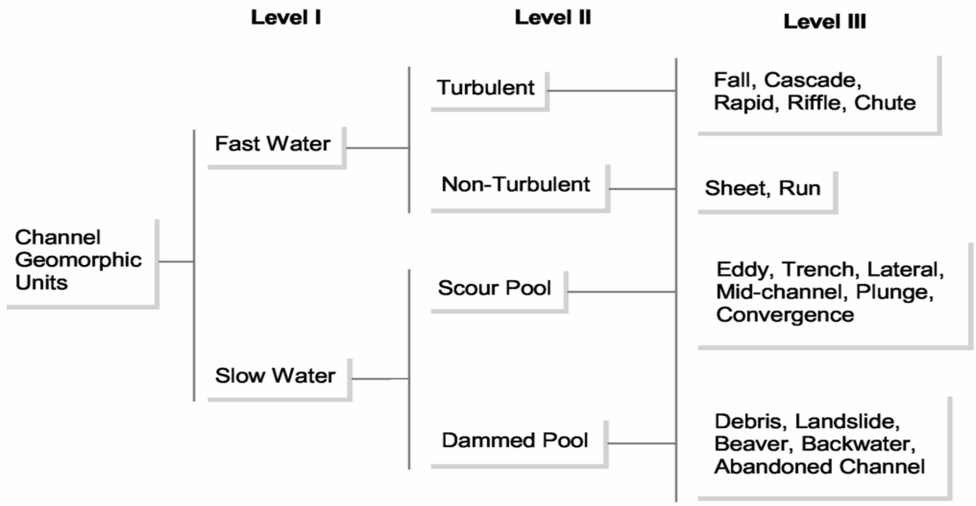
Where to Take the Measurement:

Measurement is taken continuously throughout survey segment.

How to Take the Measurement:

Using a string machine, begin measurement from the start of the survey segment noting lengths of slow and fast water. Record start and stop distance for each habitat unit. See Pools attribute for description of pools.

Finer levels of resolution can be used based on the following:



Reference:

Hawkins et al. 1993

Pools

(Core Attribute)

Importance:

Pools are an important component of habitat for aquatic organisms. They are important for different reasons to different aquatic species and may provide deep water and cool summer temperatures, winter refuge, and areas for rearing of fish and amphibians. They are also important components and indicators of channel morphology. Residual pool depth is measured to characterize pools in the survey segment because it reduces variability in pool depths that result from differences in stage.

Objectives of This Measurement:

Quantify the number of pools in the survey segment.

Determine range of residual pool depths within the survey segment. Residual pool depth is the difference between maximum pool depth and pool tail depth.

Document whether wood is a factor in pool formation.

How Many Measurements to Take:

Measure every pool in the survey segment.

Criteria for Determining Pools:

- Flow: Slow or no velocity during summer low flows.
- Morphology: Hydraulic control at pool tail, usually a concave longitudinal profile.
- Dimension: Dominant feature occupies most of stream width and includes thalweg (backwater and sidewater pools are not measured). Length is greater than wetted width. Depth is greater than non-pools. Maximum depth is more than twice pool tail depth. (Exceptions to these criteria can be found. These units should be considered pools if criteria described above are present).

Where to Take the Measurement:

Measure pool depth at the deepest point.

Measure pool tail crest depth. This is the deepest point in the channel cross-section at the downstream end of the pool where the water breaks from smooth to turbulent flow. See Figure 3.

How to Take the Measurements:

Use the staff rod to measure the pool at its deepest point, to the nearest .01 m. Use the tape or string machine (hip chain) to measure the length of the pool. Record this information on the data form.

Also note if the pool is formed by wood.

Reference:

Kershner et al. 2004

USDA 1994

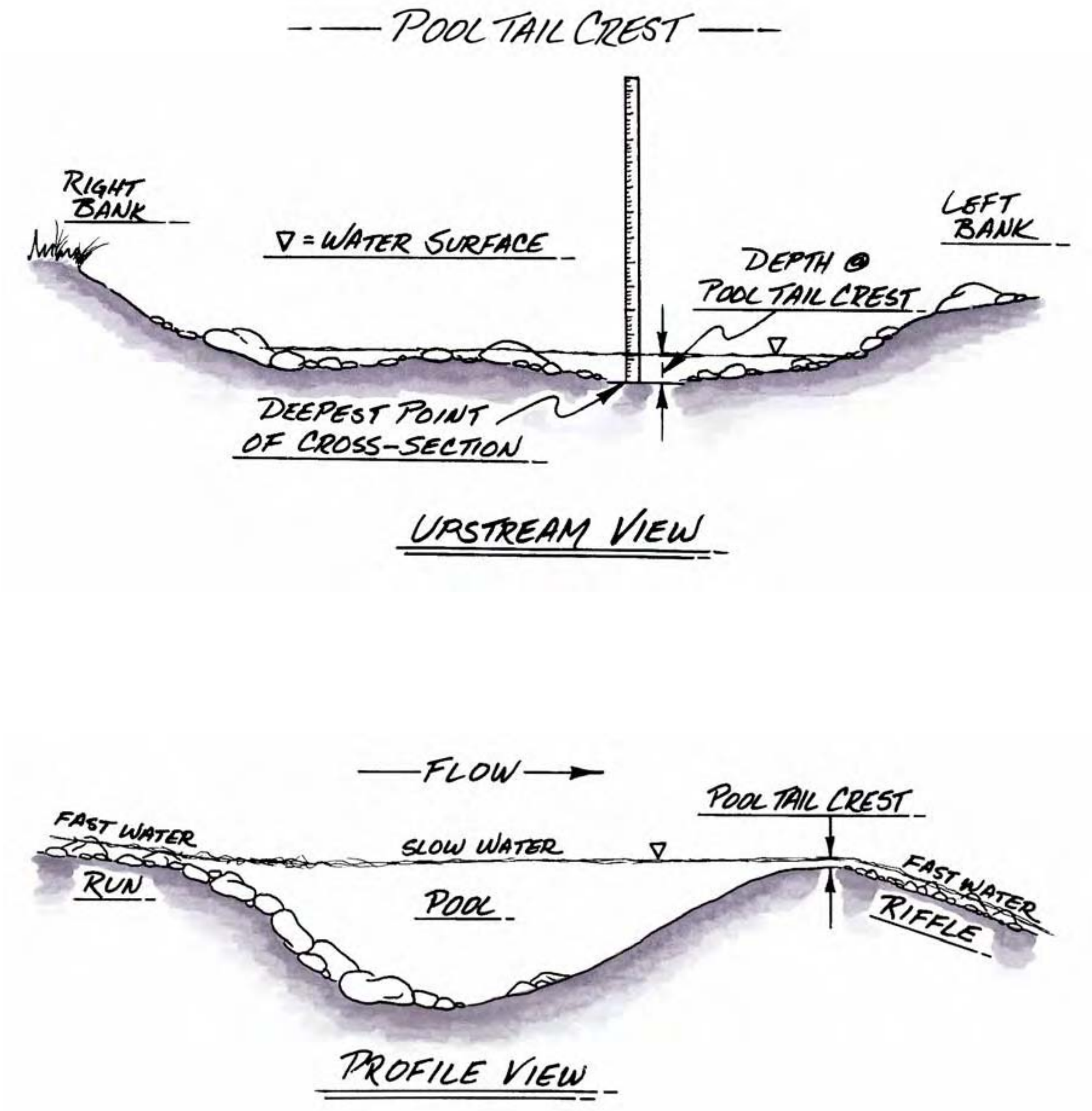


Figure 3 – Pool Tail Crest

Pool Tail Surface Fine Sediment

(Core Attribute)

Importance:

Watershed and streambank disturbance often result in increased sediment input to streams. Increased fine particles in the stream substrate can impair aquatic food production and decrease survival of young salmonids. Salmonid mortality is increased when water interchange between streams and redds is reduced by fine sediment and by filling interstitial spaces resulting in barriers to movement of alevins. Particles of 2 mm or less are the principal barriers, although particles up to 8mm have resulted in increased mortality.

Objective of This Measurement:

To quantify the percentage of fine sediment less than 2 mm on the pool tail substrate.

How Many Measurements to Take:

Three grid measurements are conducted at each pool tail within the survey segment. The grid is a 14-inch square frame with 49 line intersections and one corner (50 points total). Counts are made of percent fines at the intersections and one identified corner.

Where to Take the Measurement:

At each pool tail, stand on the pool tail crest. Define the extent of each pool tail unit by estimating a zone that incorporates the downstream 10% of the total pool length. It will lie within the wetted stream width. Within the area defined, make three random tosses of the grid. See Figure 4. The first measurement is in the thalweg within that 10% zone; the second measurement midway is upstream between thalweg and left wetted edge; and the third measurement is midway upstream between thalweg and right wetted edge.

Exception: Placing the sampling grid 10% of the distance upstream of some pool tail crests could result in measurements that may not be reasonably called pool tail substrate. Pool tails are usually a depositional feature, dominated by fine to cobbl-sized substrate. Where such conditions do not exist, avoid measuring pool tail surface fines.

How to Take the Measurement:

Count and record the number of intersections lying above substrate 2 mm or less. A viewing tube, dive mask, etc. can aid in viewing the grid by breaking the water surface turbulence.

Each point represents 2% fines. Multiply the points per toss by two and record on Form 8.

<u>Special Cases:</u>

Aquatic vegetation - In some streams, aquatic vegetation may be growing or otherwise cover parts of the area to be sampled by the grid, making its use difficult or impossible. If that is the case, an alternative procedure for that pool tail is employed. At such a location, the pool tail area is defined. Transects are then run across the area, with a particle selected at the toe point of each stride. If the particle falls into the <2 mm size class, it is tallied. This procedure is continued until 100 particles have been selected. Transects and strides should be staggered such that the entire pool tail area is sampled equally. The tallied number of particles under 2 mm represents the percent surface fines estimate for the pool tail.

- Small streams - If three tosses will not fit in the area defined by wetted width and the 10% pool length zone, take two tosses, or only one if possible. Do not overlap tosses.

References:

Bauer and Burton 1993

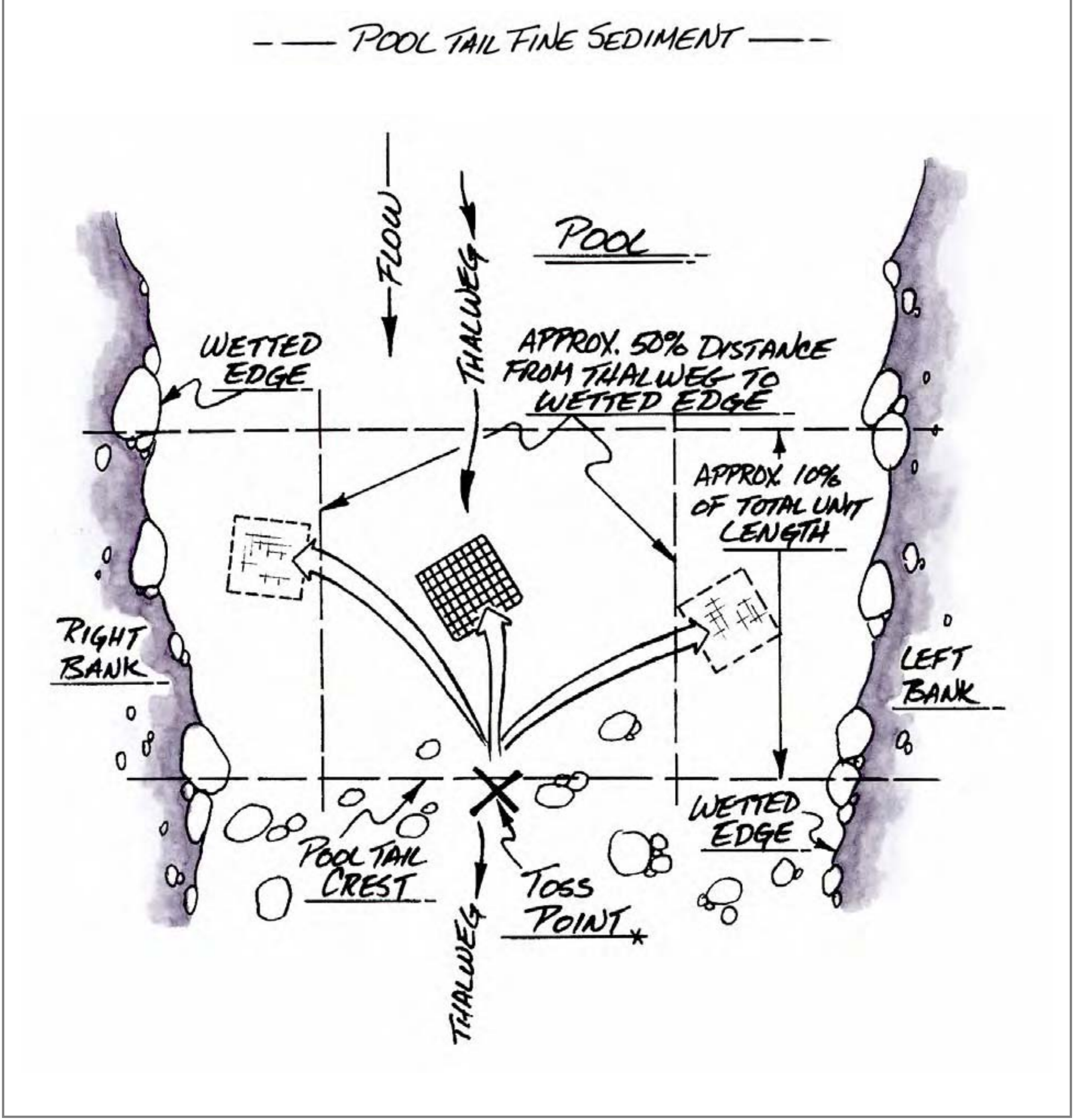


Figure 4 – Pool Tail Fine Sediment Measurement Area

Streambank Stability

(Core Attribute)

Importance:

Channel stability is a key indicator of channel condition. Stable streambanks are essential for achieving desired stream channel morphology. Stable banks maintain or help restore low width-depth ratio which in turn helps maintain a high water table, vegetative productivity and favorable habitat for aquatic and riparian dependent wildlife. In many low gradient channels, unstable banks are a major erosion source.

Objectives of This Measurement:

Calculate streambank stability of the sensitive reach.

How Many Observations to Make:

Make 100 observations (50 each bank). Sample points are located at each channel transect.

Where to Take the Measurement:

Streambank stability is a measure of cover that protects streambanks against erosion. Streambanks lie immediately adjacent to the edge of the streambed and are susceptible to the erosive force of water during high flows. Cover consists of perennial vegetation, rock, down wood, or similar erosion resistant material. Cover most commonly occurs above the bankfull stage of stream channels. However, vegetative cover can exist below this level. For example, live plants often grow slightly below bankfull stage along low gradient streams with fine textured streambanks. Where a cover component occurs below bankfull stage record it since it contributes to bank stability.

Streambank stability is measured by observing cover within a plot on the surface of the streambank (Figure 5). The plot is .30 m (12”) wide, perpendicular to flow and extends the length of the streambank as defined below.

How to Take the Measurement:

Identify the base of the streambank. It is the point of greatest slope change between the streambed and streambank.

Locate the point on the streambank where vegetative cover is first encountered above the streambed or at bankfull stage, whichever occurs first. Begin the stability plot at that point and extend it upwards as follows:

For channels less than 2% gradient with fine textured streambanks, to the crest of the first convex slope above bankfull stage. This is usually a terrace or an alluvial fan (see Figure 5).

For channels greater than 2% gradient with coarser textured streambanks, to the crest of the first convex slope above bankfull stage or twice maximum bankfull depth, whichever occurs first. Record the following streambank stability class for each plot:

- Stable - Stable streambank plots have 75% or more cover of living plants and/or other stability components that are not easily eroded, and have no indicator of instability.
- Vulnerable - Vulnerable streambank plots have 75% or more cover but have one or more instability indicators.
- Unstable - Unstable streambank plots have less than 75% cover and may have instability indicators. Unstable streambanks are often bare or nearly bare banks composed of particle sizes too small or uncohesive to resist erosion at high flows.

Remember that there are 100 plots that make up the average bank stability for the reach. Do not spend a lot of time determining individual plot condition. Once familiar with this rating system, streambank stability plots can be rated accurately and quickly. Record the numeric value (1 = stable, 2 = vulnerable or 3 = unstable) on Form 9 and move on to the next plot.

Cover Components:

Live Plants - (1) Perennial herbaceous species, such as grass-sedge-rush; (2) woody shrubs (willows, etc.); (3) broadleaf trees (cottonwood, aspen, alder, etc.); (4) conifer trees, and (5) plant roots that are on or near the surface of the streambank and provide substantial binding strength to the substrate beneath.

Rock - Boulders (>256mm), bedrock, and cobble/boulder aggregates when combined as a stabilizing mass.

Down Wood - Logs that are firmly embedded into stream banks.

Erosion Resistant Streambank Soil – In very limited cases, hardened conglomerate or highly cohesive clay/silt stream banks.

Instability Indicators:

Fracturing, blocking, or slumping – This includes cracks near the top of the streambank (often parallel with flow), slumping banks without cracks, and blocks of soil/plant material, which have fallen off or have been pushed down the bank. Usually associated with streams with gradients <2% and fine-textured banks.

Mass Movement - this includes stream bank failure from deep-seated landslides and gravity erosion of oversteepened slopes adjacent to the channel. Mass movement is usually associated with streams with >2% gradient.

Calculating Streambank Stability:

Tally the number of stable plots recorded. Divide the number of stable plots by the number of total plots and multiply by 100 to obtain percent streambank stability. For example, if a 100 plot survey segment has 85 stable plots, dividing by 100 and multiplying by 100 = 85% streambank stability. Vulnerable plots are not classified as stable because they have instability indicators.

References:

Bauer and Burton 1993

Rosgen 1996

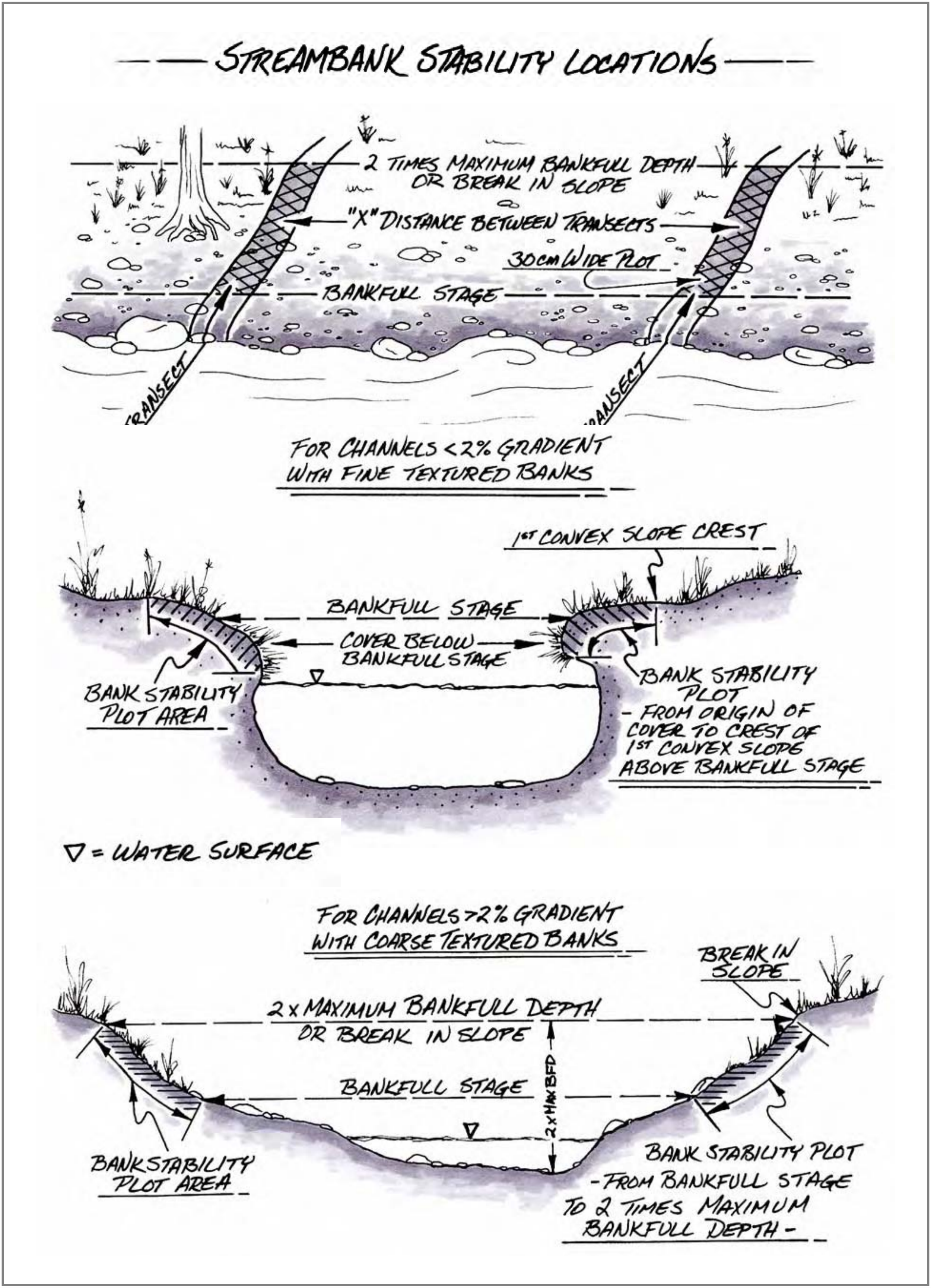


Figure 5 – Streambank Stability

Stream Shading

(Core Attribute)

Importance:

Stream temperature has impacts on the health, behavior, and survival of aquatic organisms and is strongly influenced by streamside shading. Streamside vegetation is a primary source of energy to most streams. Manipulation of riparian vegetation that affects shade to aquatic systems is a key Forest Service management concern.

Objective of This Measurement:

Determine the average canopy cover in the survey segment.

How Many Measurements to Take:

Fifty, one at each transect.

Where to Take the Measurement:

At mid-wetted width of the channel, approximately 0.3 m (12”) above water surface.

How to Take the Measurement:

Stream shading is measured using a Solar Pathfinder. At each sample location, level the instrument facing south at a height of approximately 0.3 m above the water surface. Before taking measurements, make sure that the declination on the pathfinder is correct, and that the path for the appropriate latitude is on the pathfinder. Look for the reflection of the sky and objects providing shade (trees, ridges, etc.) on the instrument dome, as viewed from no more than 15 degrees from vertical, at a distance between 0.3 (12”) and .45 m (18”).

Use the August sun path. Add the shaded sections along the sun path to yield the percent shade for each sample. When totaling the shade numbers, observe the portion of each section that is shaded. Consider fractions of individual sections, i.e. if half of a “6” section is shaded, record ”3”; if 2/3 of “3” section, record “2,” etc. Document the total number on Form 9. See Figure 6.

Tips for Using Pathfinder:

Glare from the sun can severely affect the observer's ability to read shade values. It may be helpful to hold a clipboard or hand above the pathfinder in a position that reduces glare while still allowing shade to be observed.

Vendor Information – Solar Pathfinder

Solar Pathfinder
3680 HWY 438
Centerville, TN 37033
(931) 593-3552
http://solarpathfinder.com

Reference:

Platts et al. 1987

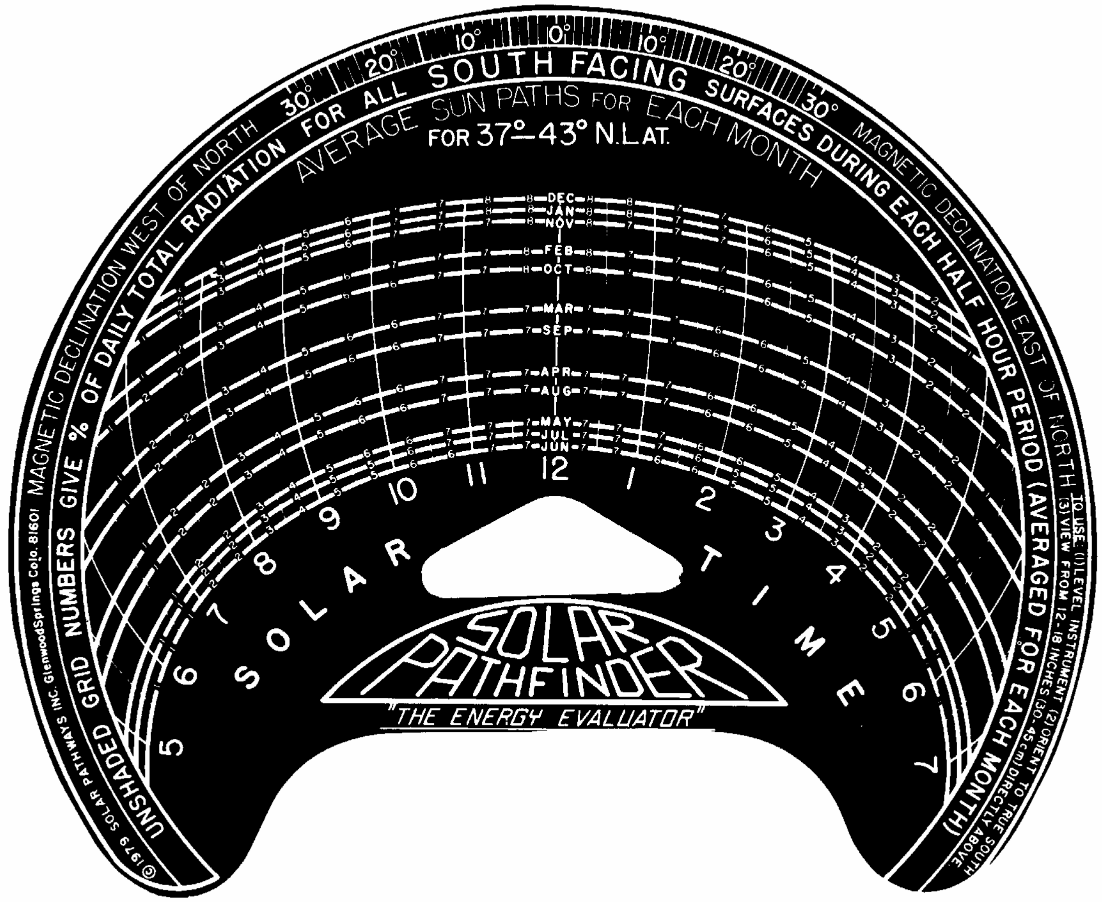


Figure 6 – Solar Pathfinder Sun Path

Streamshore Water Depth

(Core Attribute)

Importance:

This attribute is an important indicator of channel morphology in low gradient streams (<2%) with fine textured banks. Streamshore water depth is closely related to other indicators of channel conditions (bank angle and undercut bank) of channel conditions that provide cover and resting areas for aquatic species. Platts, et al. (1987) note that streamshore depth is critical for young-of-the-year salmonids.

Objective of This Measurement:

To quantify the average streamshore depth in the survey segment.

How Many Measurements to Take:

One hundred: one measurement at both shore edges on each of the fifty transects.

Where to Take the Measurement:

At the edge of water on each shore, at each of the fifty transects (two measurements per transect, one on each side of the stream).

Note: this attribute is measured only on streams where the gradient is less than 2% and the stream has fine textured streambanks.

How to Take the Measurement:

Measure the water depth at water's edge (see Figure 7).

If the bank angle is equal to or less than 90 degrees, the water depth will be greater than zero. The staff or rule should be held vertically, and water depth measured to the nearest .01 m.

If the bank angle is greater than 90 degrees, the water depth will be recorded as zero. For bank angles greater than 90 degrees, do not record water depths observed in micro-recesses at water's edge since they are not representative of the dominant bank angle.

References:

Platts et al. 1987

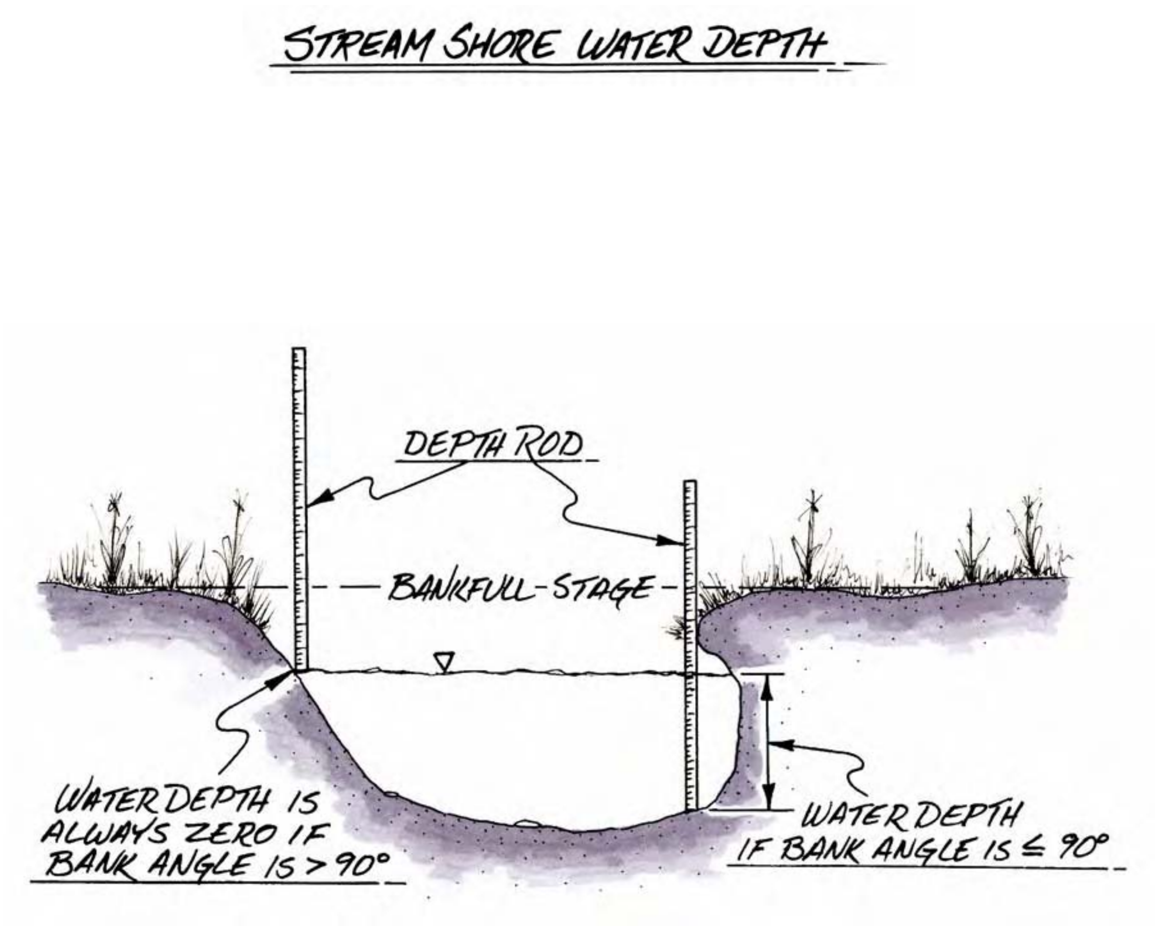


Figure 7 – Streamshore Water Depth

Streambank Angle

(Core Attribute)

Importance:

Bank angle is an important factor in aquatic habitat on many stream reaches. It influences shading, vegetation potential, bank stability, etc. Streambanks that are vertical or undercut provide more habitat value than banks sloping away from the streambed. Undercut banks provide excellent cover for fish, and are recognized as a component of healthy streams.

Objective of This Measurement:

To quantify bank angle and the frequency of vertical and undercut banks in the survey segment.

How Many Measurements to Take:

One hundred: one measurement at both shore edges on each of the fifty transects.

Where to Take the Measurements:

On the left and right bank at each channel transect.

Note: this attribute is measured only on streams where the gradient is less than 2% and the stream has fine textured streambanks.

How to Take the Measurement:

Bank angle is the measure of the dominant angle of the streambank between the bottom of the bank and bankfull stage. The bottom of the streambank is the point of greatest slope change between the streambed and the bank.

To measure bank angle, lay the depth rod on the streambank perpendicular to flow between the bottom of the streambank and bankfull stage (see Figure 8). Measure the angle that represents the greatest length between the bottom of the bank and bankfull stage (e.g., the dominant angle). Place a clinometer on the top of the depth rod and record the angle. If the bank slopes away from the streambed, the bank angle will be greater than 90 degrees. To obtain the actual bank angle for these banks, subtract the value on the clinometer from 180 (i.e., the clinometer reading is 30; 180 - 30 = 150). If the bank is vertical or undercut, the bank angle will be equal to or less than 90 degrees, respectively, and can be read directly from the clinometer.

If the bank is inaccessible at a transect (i.e. transect crosses a very deep pool with bedrock banks, extremely dense vegetation or a debris jam) estimate the bank angle. Circle estimated values on the data sheet and make a note in the comments why it was estimated.

Reference:

Platts et al. 1987

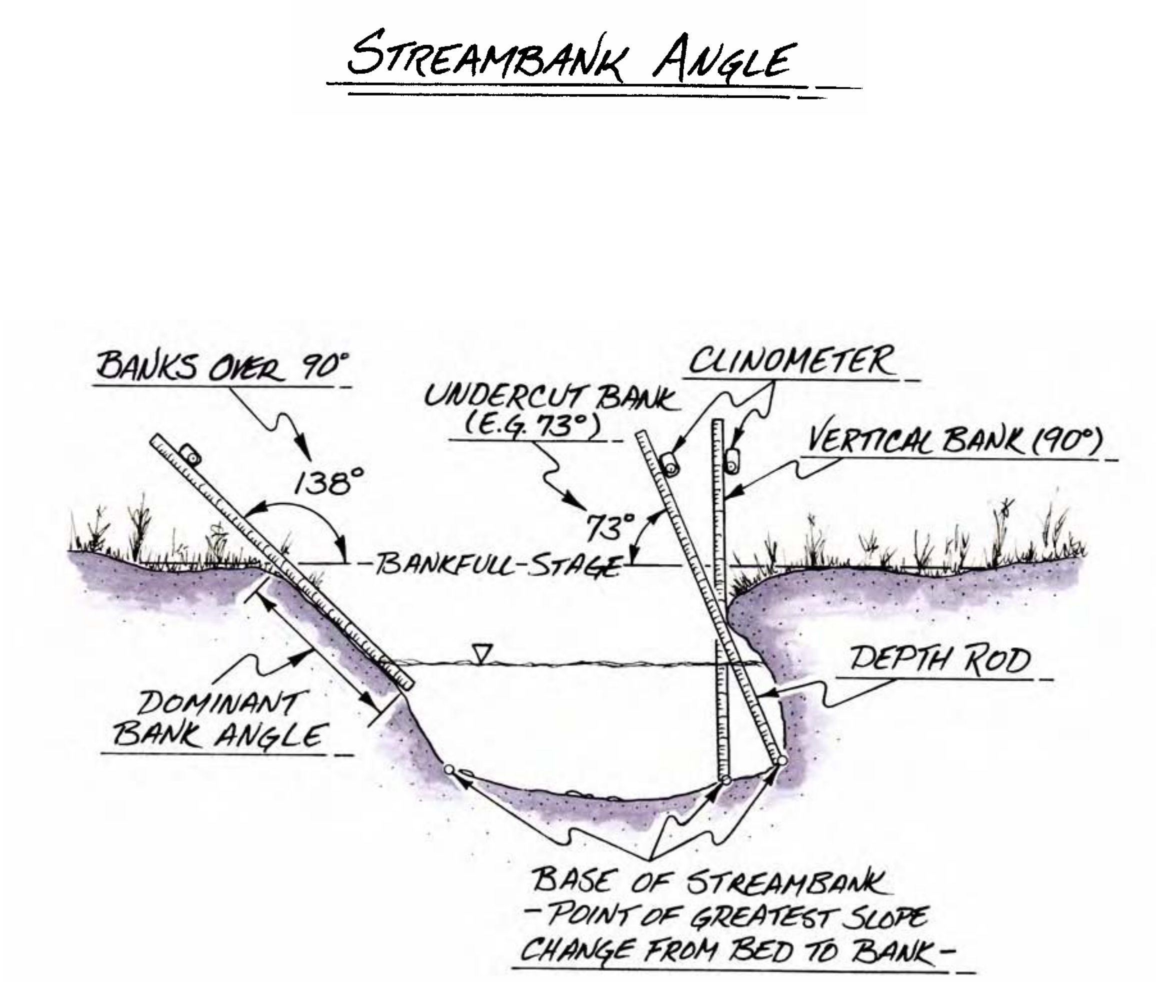


Figure 8 – Streambank Angle

Aquatic Fauna

(Core Attribute)

Importance:

Surveys such as SCI are sometimes the only record of the presence of aquatic species. With the increasing number of species of concern (TES species, mollusks, etc.) and increasing occurrences of exotic species (zebra mussel, mud snails, bullfrogs, etc.), having surveyors look for aquatic species and noting their presence is important in understanding frequency and distribution patterns.

This attribute is intended to identify the basic aquatic biota present in the stream, and may identify the need for more intensive biological surveys. Communication with other agencies is important in order to make surveyors aware of any key species that may be present, as well as make appropriate identification keys available.

Objective of This Measurement:

Document presence of aquatic fauna.

How Many Measurements to Take:

Take one at each transect. In addition, note any key species observed throughout the sensitive reach.

Where to Take the Measurements:

One at each transect in the survey segment, and throughout the sensitive reach.

How to Take the Measurement:

<u>At transects</u>: Note any species seen within eyesight of each transect. Carefully look around boulders and near the shore to cover all microhabitats at each transect. Record the four-letter species code for herptofauna (Appendix E) or the numeric code for fish species (Appendix F). Do not leave blank spaces on the form – use a dash or write “none.”

<u>Between transects</u>: Throughout the sensitive reach note any species observed during any of the survey passes. Record observations unrelated to transect measurements on Form 10. Note the location of the observation, the species name and relevant information, and take photos if possible.

V^*_W

(Optional Attribute)

Importance:

Pools are important habitat components for fishes and other aquatic organisms. Accelerated inputs of fine sediment are known to affect pools by reducing their volume, particularly during periods of low discharge. V* is a measure of the relative volume of fine sediment in a pool. The weighted mean value of V* for a reach, V^*_W, is a sensitive indicator of a channel's response to the volume of fine sediment delivered from its watershed.

Objectives of This Measurement:

For a given reach, determine the weighted mean value of the relative volume of fine sediment in pools (V^*_W). This can be used to assess stream condition, monitor trends over time, or detect and evaluate the effects of discrete sediment sources within a watershed.

Use and Limitations of V^*_W:

V^*_W is a very sensitive indicator of fine sediment in pools. However, its usefulness is limited to channels in which significant volumes of fine sediment can be deposited in pools. Therefore, it is not typically used in volcanic and metamorphic terrains.

V^*_W is an optional attribute because it is time consuming, typically requiring a three-person crew one to three days to characterize a single reach. Forests should therefore use discretion prior to measuring this attribute.

Hilton and Lisle (1993) should be consulted for additional information on uses and limitations.

Equipment:

The minimum equipment required is two tapes, chaining pins, and a graduated rod long enough to measure water depth plus fines depth in the deepest part of the pools to be measured. A palmtop computer with Excel is also highly recommended for selecting transect locations, entering data, calculating V*, calculating V^*_W, and computing the standard error for V*w in the field. This can be done quickly and easily using the "fips.xls" and "varv.xls" spreadsheets available at http://www.fs.fed.us/psw/topics/water

How Many Observations to Make:

The number of pools evaluated in a reach typically ranges from 6-20. If values in a given reach are relatively similar (V* for all pools differs from the mean by less than 20%), measurements should be taken in 6-10 pools. Where values vary moderately (V* for all pools is within 20-30% of the mean), measure 10-15 pools. Up to about 20 pools are needed in reaches where V* is highly variable (V* for some pools differs from the mean by more than 30%).

At each pool, measurements of water depth and fine sediment depth are taken at 4-10 cross-sections, depending on the complexity of the pool and the desired accuracy of the measurement. At each of cross-section, measurements are made at 7-16 locations.

Where to Take the Measurements:

Measurements of water and fine sediment depths are taken at various points at cross-sections in pools. For this attribute, measurable pools are defined as areas of the channel that have significant residual depths (i.e., the deepest part of the pools is greater than two times the depth of water flowing out of the pools), have relatively flat water surfaces during low flows, and occupy most of the channel (i.e., the thalweg and at least have the width of the low flow channel). These criteria can be modified, as long as they are repeatable and consistent across all reaches that are compared. Pools with unclear boundaries should be avoided.

How to Take the Measurements:

The following text is intended only to summarize the methods for measuring and calculating V^*_w. The more detailed protocol described in Hilton and Lisle (1993) should be consulted prior to taking these measurements.

Conduct a reconnaissance survey of the reach to identify pools that meet the definition provided above and number them while proceeding along the channel. During this survey, determine what constitutes fine sediment for this particular channel and the estimate the variability of V* between pools. Based on this variability and the desired accuracy, randomly select 6-20 pools for measurement[1].

The grain-sizes that constitute fine sediment for a particular channel is determined by evaluating the distribution of particle sizes and patterns of sediment deposition in the channel. Fine sediment in a reach is defined as material that is distinctly finer than the bed surface (median particle size of fine sediment is 10% of the median particle size of the bed surface) and can be distinguished from underlying coarser sediment by probing with a metal rod. For most channels, deposits with a median grain-size less than 11mm can be considered fine sediment, but this can increase to 16mm for channels with large surface particles and high transport capacity.

For each selected pool, measure riffle-crest depth and define the pool boundaries. Water depth at the riffle crest is measured at 5-20 evenly spaced locations across the thalweg. Water depths and fine-sediment depths are measured in the “scoured residual pool,” which is the residual pool that would result if all the fine sediment were removed.

Volumes of water and fine sediment are calculated from measurements of water and fine-sediment depths along a series of cross-sections in the pool. These measurements are made as follows:

Stretch a tape along the length of the pool, from the upstream end to the furthest point on the riffle crest or along the longest dimension of the pool. This tape must be straight, since bends will distort the volume calculations. If the pool is so irregular that a bend cannot be avoided, divide the pool into sections and measure each separately.

Draw a sketch map of the pool, showing the locations of the upstream end of the pool, riffle crest, areas of fine-sediment deposition, and major feature of the pools, such as logs and outcrops.

Decide on the number of cross-sections and the distance between depth measurements. The appropriate sampling intensity depends on the complexity of the pools and the desired accuracy. The number of cross-sections typically varies between 4 and 10 and the number of measurements at each cross-section ranges from 7-16, depending on the length of the cross-section.

Use the “fip.xls” spreadsheet to determine the locations of cross-sections and the depth measurements along each cross-section.

Run a tape perpendicular to the length-wise tape at each cross-section. Measure water depth and thickness of any fine sediment present at each measurement point with a graduate rod. Fine-sediment depth is determined by probing with the rod until a change in resistance is felt as it strikes coarse material. A small sledge is useful for probing deep deposits. The cross-section begins at the edge of the course pool where water depth plus fines depth becomes greater than riffle-crest depth. Enter the total water depth and fines

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[1] *The exact number of pools needed to obtain the desired accuracy will be quantitatively confirmed prior to leaving the field.*

depth data at both edges of the pool and at regular intervals across the pools into “fip.xls.” If a fines deposit deep enough to be included in the course pool extends above the water surface, record height above the water surface as a negative water depth.

After completing all measurements at the pool, use the spreadsheet to compute the total water volume, fine sediment volume, and V*. Copy the water volume and fine sediment volume into the “varv.xls” spreadsheet and move on to the next pool. Repeat the steps above.

When all pools have been measured, use “varv.xls” to estimate the total and mean pool water volumes for the reach, total and mean fine sediment volumes, V^*_W, and the standard error for V^*_W. Compare the standard error of V^*_W to the desired accuracy. If the error exceeds the desired accuracy, measure V* in additional pools until the desired accuracy is attained.

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Lisle and Hilton 1991

Lisle and Hilton 1992

Lisle and Hilton 1999

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III. Stream Condition Inventory Procedures

A. Pre-Field Procedures

Step 1. Determine What and Where to Inventory

Locating SCI reaches should consider the combination of management issues and anticipated management effects, stream sensitivity to those effects, and aquatic/riparian resource values of candidate watersheds and streams. Consideration of these factors may be a complex task. Two key steps need to be completed:

Determine Resource Values – Identify values most likely to be affected by management. This often requires an understanding of the resource values (i.e. fish stocks, amphibian populations) from large scales such as a river basin to small scales such as fish spawning sites, and edgewater pools for amphibian rearing.

Identify Sensitive Areas – Determine channel sensitivities relative to the resource values and anticipated management effects. For instance, a watershed might be stratified differently if the effect of concern is temperature (stratification by vegetation types), rather than sediment (where an erosion hazard based stratification might be used).

Resource values and sensitivity should be documented prior to fieldwork to help determine if SCI attributes or other stream attributes should be the focus of the effort. SCI is a set of protocols for measuring many attributes of channel and aquatic habitat conditions, but is not a complete list. SCI is a useful tool in many cases, but not all cases.

Step 2. Identify Watersheds to Inventory

Select watersheds for inventory that are of highest priority. Selection can be based on: (1) management activities of interest; (2) aquatic communities of interest; (3) watersheds of a particular type; (4) interest in establishing baseline or reference conditions; (5) a combination of these criteria.

Step 3. Characterize the Watershed

Collect existing watershed information including maps, aerial photos, past inventories (fish, watershed, soil, and vegetation surveys), and specialist knowledge on the watershed. This information is useful for describing basin history, stratifying or classifying streams and their basins, and describing existing information on stream and basin condition.

Step 4. Identify Stream Reaches to Inventory

Identify stream reaches that are most likely to display change based on analyses of channel morphology, biological communities and processes, and existing or proposed management activities. These are referred to as sensitive reaches and will be a high priority when determining stream condition inventory needs in a watershed. Also identify any stream reaches that may be considered reference reaches. These are streams or stream segments that are not noticeably disturbed by management activities, or may have recovered from historic management disturbances. This is an important stratification since the number of reference reaches is limited at both the forest and regional scale. Reference reaches are useful for comparison with non-reference reaches and in establishing a regional database of reference conditions for SCI attributes.

Reach Definitions:

- Reach – Any specified length of stream
- Sensitive reach – A reach that is likely to show change that relates to the inventory objective and is uniform in terms of channel and valley form characteristics.
- Survey segment –A section of a sensitive reach. Where sensitive reaches are shorter than 1,000 m, a subset of the SCI attributes is measured in this section. (Sample design

testing during protocol development showed that only some attributes need to be measured throughout long sensitive reaches).

- Reference reach – A reach that is undisturbed or is minimally disturbed by management activities, or may have recovered from historic management disturbances.
- Non-reference reach – A reach that shows evidence of current management disturbance or has not recovered from past management disturbances.

Step 5. Select Reaches

Select stream reaches that meet the inventory objectives. Selected reaches should meet two criteria: (1) likely to show change relative to question being asked and (2) uniform in terms of geomorphic characteristics (for example, gradient, flow, channel morphology and valley form). Selection should consider the availability of reference reaches with the same characteristics (watershed size, geology, etc.) that will strengthen data interpretation.

Most sensitive reaches selected are usually single thread channels. Reaches that are fully or partially braided should be selected with caution. However, where braiding occurs within a sensitive reach:

- Conduct measurements in the dominant channel (thalweg; most flow, etc.) for all attributes except LWD and cross-sections.
- Conduct LWD and cross-section measurements across all channels to the greatest bankfull width.

An example of sensitive reach selection is illustrated in Figure 9. In the example, vegetation management, road decommissioning, and fish habitat enhancement have all been implemented in the watershed. Managers are interested in both their effectiveness and their cumulative impact on channel condition. The stream increases in gradient as it ascends the watershed (moving from reach “A” to reach “H”). Downstream of reach “F,” lower gradient channel conditions are present. As lower gradient streams (and especially those with fine textured bank material) are most sensitive to changes in flow and sediment, these reaches are most likely to change as a result of management activity. Reach “E” is the closest lower gradient channel to the management activities, and therefore has the greatest potential for change in response to the activities. The upstream (lowest gradient) portion of reach “E,” a gravel bed channel type with a 1.5% gradient (e.g., C4 [Rosgen]; Response [Montgomery and Buffington]), is the likely candidate for sensitive reach designation.

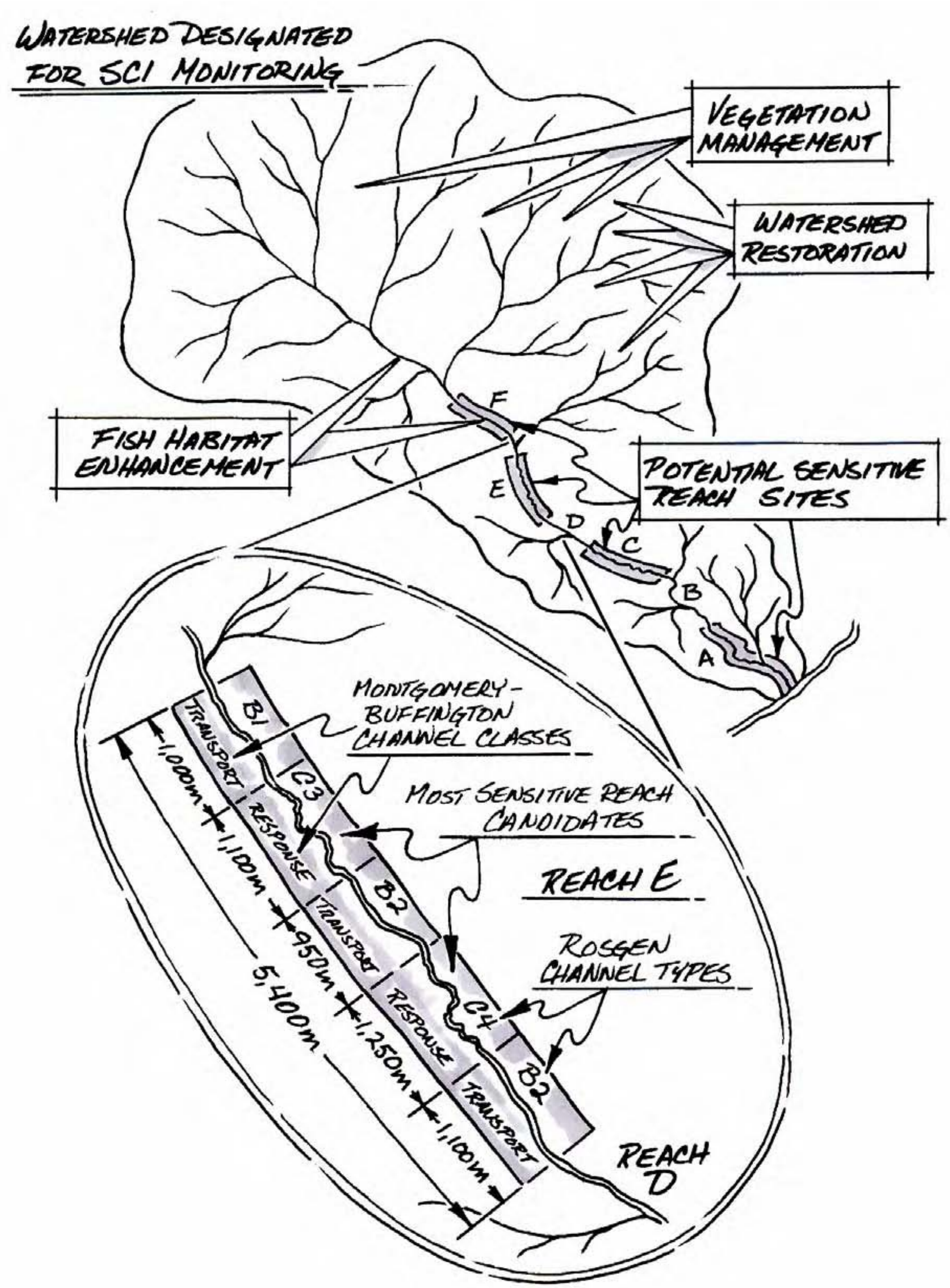


Figure 9 – Sensitive Reach Designation

Step 6. Determine the Length of the Sensitive Reach

Use GIS or other methods to estimate the length of the sensitive reach.

Maximum Length – While there is no maximum length, sensitive reaches greater than 2,500 m should be double-checked for uniformity of channel conditions. If uniformity is correct, sensitive reaches cannot be arbitrarily shortened.

Minimum Length – The recommended minimum length is 500 m if pools are key condition attributes of the sensitive reach. Reaches as short as 100 m are acceptable, provided LWD and pools are not key attributes.

Step 7. Survey Safety

Surveying streams can be hazardous at any flow. Survey locations are frequently in remote locations and caution should be taken to minimize the possibility of injuries. It is critical that surveyors have appropriate field gear and first aid equipment. A Job Hazard Analysis must be prepared prior to fieldwork and reviewed periodically during the survey.

B. Field Procedures

Collecting SCI Attribute data in the field is conducted by using a multiple pass sequence up and down the reach. This is often most efficiently done using the four-pass sequence recommended in Step 3 of this section. While the four-pass sequence is not mandatory, surveyors should first gain experience with it before using alternative methods of collecting the data. The overall objective is to conduct the most efficient and accurate inventory that the four-pass sequence or another alternative may provide. Alternatives to the recommended sequence may be employed depending on crew size, unique reach features, accessibility, etc.

General Notes regarding field procedures:

Protocols – SCI protocols should be carried in the field to help quality assurance.

Units of measure - All measurements are metric.

- Left and right bank - Streambanks are referenced looking downstream.
- Estimated data – Circle all estimated data (e.g., if pool depth cannot be accurately measured, estimate the depth as closely as possible and circle it on the data form).
- Photographs – Surveyors should be familiar with cameras and photo techniques (Hall 2001) since photos provide valuable supplemental information and context to SCI data.
- Cleaning equipment – Survey equipment should be cleaned between site visits. See Appendix C for a recommended cleaning protocol.
- To establish a new SCI reach follow steps 1-6 below. If the reach is being remeasured, proceed to step 3.

Step 1. Conduct Reach Reconnaissance

The reach reconnaissance is a preliminary walk-through of the sensitive reach before selecting the start of the sensitive reach and starting the pass sequence to collect data.

Make sure to stay out of the water on the reach reconnaissance so that attributes that will be measured later are not disturbed.

A reach reconnaissance should be conducted whenever the reach is unfamiliar or its validity is uncertain. It can even be a good idea to do a reconnaissance on a familiar reach when time permits.

Key observations to make on the reach reconnaissance are as follows:

- Reach validation – observe whether or not the sensitive reach delineated in the office is valid for inventory by considering the following:
- Stream type – if there are anomalies in geomorphic characteristics of the reach, apply the following rule:

  "10% Rule": If inclusions of different channel types or other anomalies are less than or equal to ten percent of the sensitive reach, include them in the Sensitive Reach. If they compose greater than ten percent of the reach length, break the channel into separate sensitive reaches. For example, a 1,300 m low gradient meadow stream channel has a moderate gradient bedrock section of 70 m midway in the reach. Since this is less than 10% of the reach length, include it as part of the reach.
- Stream tributaries – observe if there is an increase in stream order and/or substantial streamflow along the reach. If so, break it into separate reaches.
- Abnormalities – determine if there are any other unusual circumstances that would render the reach invalid. This could be a change in the character of the reach from some recent disturbance, a lack of suitable cross-section locations, or some other change in status of the reach.
- Reach overview – observe the character and condition of SCI attributes. This is often very useful when later measuring attributes. For example, what are the characteristics of pools and riffles in the reach (numbers, length, etc.), are there many candidate cross-section sites, are streambanks generally stable, and does the reach have a high or low width-to-depth ratio?
- Reach length estimation – if the reach length needs to be changed based on findings of the reach reconnaissance, estimate the length of the revised reach by pacing or GPS.
- Candidate cross-section locations – it may be useful to flag runs within fast water habitat types as candidate locations for cross-section, width-to-depth, and entrenchment measurements during the reach reconnaissance. Although this can be done on Pass 1, it may make that pass more efficient if done at this time.
- Bankfull width estimation – observe bankfull stage indicators in several locations along the reach. Visually estimate average bankfull width for the reach, or measure it where possible without entering the water (i.e., using log crossings). This will identify the minimum length of LWD to count (if large wood is counted), and provide an understanding of bankfull stage when later measuring cross-sections, width-to-depth, and entrenchment.
- Aquatic fauna – look for herptofauna and fish since they are often found during the first walk up a stream reach.

Step 2. Document the Start of the Sensitive Reach

Once the reconnaissance pass has been made the precise location of the start of the sensitive reach can be identified and documented (georeference, benchmark/bearing/distance, photographs and permanent monument). This will provide sufficient information for others to come back in subsequent years and find the start of the sensitive reach. Identification and documentation of this site is essential for long term monitoring.

Step 3. Collect Stream Data

The SCI four-pass sequence is described below. Each pass consists of a list of attributes to be measured, tasks, and equipment needed. In some cases, tasks conducted on one pass set up attribute measurements on the next pass.

There are 10 SCI Forms to be completed for each sensitive reach surveyed. Refer to Appendix G for sample forms and instructions. The form numbers applicable to each pass are identified below. Note that Form 1, Sensitive Reach Layout, is filled out when the survey is completed. Form 10, Photo Log and Comments, is filled out as the survey progresses. Photos are required when filling out forms 1, 2 and 5, and comments can be entered at any time.

Equipment required for each pass is described below. A complete equipment list for conducting SCI is provided in Appendix B.

Pass 1. (Upstream – Sensitive Reach)

Attributes to Measure:

1) Macroinvertebrates
2) Particle Size Distribution
3) Stream Temperature (optional attribute)
4) Large Woody Debris (LWD)

Forms Needed:

Form 1 – Sensitive Reach Layout (may be completed after reach inventory)

Form 2 – Macroinvertebrates

Form 3 – Particle Count

Form 4 – Cross-section and Width-to-depth Candidate Sites, and LWD

Form 10 – Sensitive Reach Photo Log (for Form 1 and 2 photos)

Tasks:

1) Conduct macroinvertebrate sampling in the first four riffles upstream of the start of the sensitive reach that meets the riffle identification criteria in the macroinvertebrate protocol. <u>In order to maintain an undisturbed streambed when sampling this attribute, stay out of the water until this attribute is measured</u>. Record macroinvertebrate information on Form 2.

2) Conduct particle count in the same four riffles where macroinvertebrate sampling occurred. Record data on Form 3.

3) Measure stream temperature (optional attribute) by installing a thermograph at the start of the sensitive reach. Note: there is no form for this attribute.

4) Measure the length of the sensitive reach along the thalweg using a hip chain.

5) While measuring the length of the sensitive reach, record the following information on Form 4:

   a. Candidate locations for cross-sections and width-to-depth/entrenchment measurements within fast water habitat units. Number these sites progressively and mark with survey flags.

   b. Large woody debris.

6) At the end of the sensitive reach, select sites for the cross-section and width-to-depth/entrenchment measurements. If more than three fast water habitat units are identified, randomly select three for cross-section measurements. From any remaining candidate sites, randomly select up to five for width-to-depth and entrenchment measurements. If three or fewer candidate sites have been identified measure them all as cross-sections (width-to-depth/entrenchment measurements are not taken).

7) At the end of the sensitive reach, select the survey segment if the sensitive reach is greater than 1,000 m. If the sensitive reach is longer than 1,000 m, randomly locate the survey segment within the sensitive reach. To do so, subtract 1,000 m from the length of the sensitive reach just measured (the survey segment is 1,000 m). For example, if the sensitive reach is 1,750 m long, subtracting 1,000 m equals 750 m. Use a random number table (Appendix D), or a calculator to generate a random number between 0 and 750. The selected number is the distance from the downstream end of the sensitive reach where the survey segment will begin. Thus, if the selected random number is 350 m, the survey segment begins at 350 m upstream from the start of the sensitive reach and ends at 1,350 m along the 1,750 m sensitive reach.

Equipment Needed:

- Metric tape
- Forms
- Gravel template
- Survey flags
- Pencils/markers
- Camera
- Depth rod
- Hip chain (string machine)
- Thermograph (optional)
- Macroinvertebrate sampling apparatus (separate equipment list)

Pass 2. (Downstream – Sensitive Reach)

Attributes to Measure:

1) Cross-section
2) Bankfull Stage
3) Water Surface Gradient
4) Width-to-depth Ratio
5) Entrenchment

Forms Needed:

Form 5 – Cross-section and Water Surface Gradient

Form 6 – Cross-section Diagram and Location Sketch

Form 7 – Width-to-depth Ratio and Entrenchment Ratio

Form 10 – Sensitive Reach Photo Log (for Form 5 photos)

Tasks:

1) Progressing along the pass, locate the cross-sections and the width-to-depth ratio/entrenchment sites that were randomly selected.

2) Identify bankfull stage in the immediate area of each cross-section and width-to-depth/ entrenchment sites so that it can be properly located when conducting measurements. Make sure to look for bankfull stage at several locations to increase the confidence that bankfull stage has been identified correctly.

3) Take cross-section and water surface gradient measurements at the selected cross-section sites. Record all data, plus calculations of width-to-depth and entrenchment ratios, on Form 5. Diagram and sketch each cross-section on Form 6.

4) Measure width-to-depth and entrenchment ratios at selected sites on reaches with more than three candidate sites. Record the data on Form 7.

Equipment Needed:

- Metric tape
- Two depth rods with levels
- Forms and pencils
- Permanent benchmark equipment (rebar and caps, etc.)
- Flagging or survey flags
- Hand level and tripod, or survey level and tripod
- String/string level
- Camera
- Bankfull identification survey flags or flagging
- Clamps

Pass 3. (Upstream – Survey Segment)

Note: Photograph the start and end of the survey segment on reaches greater than 1,000 m. It is important that these locations are documented for future measurements of the segment. Take photographs up and downstream, from both banks, and at any other location that will help relocate the sites.

Attributes to Measure:

1) Habitat Types

2) Pools

3) Pool Tail Surface Fine Sediment

Forms Needed:

Form 8 – Pools and Pool Tail Surface Fine Sediment

Tasks:

1) Continuously measure fast and slow water habitat units from the start to the end of the survey segment.

2) Record pool data at each pool (slow water habitat unit): maximum depth, pool tail crest depth, and if the pool is wood-formed.

3) Measure the percent of pool tail surface fine sediment at each pool.

4) Record all data on Form 8.

5) Flag the end of the survey segment to note the starting point for the start of Pass 4.

Equipment Needed:

- Metric tape
- Forms
- Pencils
- Depth rod

- Hip chain (string machine)
- Pool tail fine sediment grid
- 2 mm diameter pointer (engineering survey flag rod is 2 mm diameter)
- Viewing tube

Pass 4. (Downstream – Survey Segment)

Attributes to Measure:

6) Streambank Stability
7) Stream Shading
8) Streamshore Water Depth
9) Bank Angle
10) Aquatic Fauna

Forms Needed:

Form 9 – Streambank Stability, Stream Shading, Streamshore Water Depth, Streambank Angle, Aquatic Fauna

Tasks:

1) Measure the first four attributes listed above at each of 50 equally spaced transects in the survey segment. (Recall that streamshore water depth and streambank angle are measured only on low gradient reaches with fine textured streambanks).

Notes on delineating transect intervals:

- The interval between transects is determined by dividing the length of the survey segment by 50 (e.g., an 800 m survey segment would yield a 16 m interval).
- Transect intervals must always be at least bankfull width. Lesser intervals compromise the independence of the individual measurements. For example, if a survey segment is 150 m and the bankfull width is 5 m, the correct interval would be 5 m and 30 transects would be established. Spacing 50 transects at 3 m intervals is incorrect. Though the statistical confidence may decrease with fewer than 50 transects, the independence of the measurements is retained.

2) Record any aquatic fauna observed at each transect. Denote by species codes in Appendices C and D.

3) Record all data on Form 9.

Equipment Needed:

- Depth rod
- Pencil
- Form 9
- Solar pathfinder
- Metric tape
- Clinometer

Supplemental Pass (Upstream – Survey Segment)

This is the recommended time to do V* if this optional attribute is measured. It is very intensive and thus was not recommended for measurement during Pass 3 when pools were measured. V^*_W would be measured in the slow water habitat units that were measured in Pass 3. Refer to the V^*_W publication for instructions on measuring this attribute.

C. Post-Field Procedures

Step 1. Data Check

After data collection is completed, the crew leader should thoroughly check the data forms in the field. Make sure Form 1 has been completed before leaving the reach. Data entries should be complete and legible. There should be documentation of photographs taken at the start and end of the sensitive reach and survey segment, at channel cross-sections, and at the macroinvertebrate sample sites. If some data was not collected, adjustments to procedures had to be made for any reason, or if there were questions about the site or sampling during data collection, they should be noted on the data sheets.

An office review of all data shall be conducted. This review should include any comments or questions on the data sheets, as well as an initial review of the data to check for obvious errors, or results that might require follow up. Data should be checked to make sure it is complete and legible, and ready for electronic entry. Back-up documentation (maps, location notes, photographs) should also be checked for presence and accuracy.

Step 2. Data Entry

Data entry will be made into the Water Module of the NRIS database.

D. Remeasurement of SCI Reaches

One of the primary objectives of SCI is to assess changes in streams over time such as before and after implementation of management activities. SCI reaches are often established for this purpose. SCI reference reaches can also be remeasured to determine if change has occurred without the influence of management. Reference reaches can be compared for changes over time and/or with applicable non-reference reaches.

Remeasurement of SCI reaches requires some additional tasks and quality control considerations not involved when initially establishing a reach. The focus of these tasks is (1) to reduce, to the greatest degree possible, measurement error so that changes over time can be detected and (2) to document differences between repeat measurements that should be considered when evaluating data (i.e., flow conditions at the time initial and repeat measurements were conducted).

Consider the following when planning, taking the measurements, and evaluating data from remeasured reaches:

Review the reach file from previous measurements. This will provide information on the location of the sensitive reach and survey segment, riffles for bioassessment, particle counts, and monumented cross-sections. Comments should be reviewed to see if prior measurements were altered in any way, and to see what time of year and during what flow conditions the reach was measured. In addition, photos from previous surveys will usually be very helpful.

It is recommended that copies of the original and subsequent survey data sheets be taken to the field during the resurvey. That way, decisions about problems that may be encountered in the field can be informed with data from the prior surveys.

If the sensitive reach is longer than 1000 meters, use the survey segment randomly selected during the initial survey. Do not randomly select different survey segments during repeat measurements.

Prior to conducting the repeat measurements, compare the SCI protocols used in each previous survey. Most SCI protocols have remained constant since earlier versions of the protocol, but some protocols have changed. Primary among these is the particle count. Initially, a 100 count using a zig-zag traverse of the lower extent of the sensitive reach was used. The current protocol employs a count of 400 particles from four riffles at the downstream extent of the sensitive reach. If the monitoring plan indicates the particle counts are a primary attribute of interest for data analysis, then consideration should be given to supplementing the current protocol with a particle count using the zig-zag protocol. At the least, this change must be noted in comments to the repeat survey, so it will be recognized during data evaluation and analysis.

Pool data should also be evaluated during repeat measurements. In some stream systems, pools are difficult to consistently identify. In these cases they do not clearly meet (or differ from) the criteria provided in the SCI protocol, and substantial differences can occur in defining pools between crews and over time. Differences in the number of pools measured in a reach will influence not only estimates of pool frequency, but also residual pool depths, and pool tail fines (since different areas and amount of area will be measured). To reduce error, data from previous surveys can be reviewed to see where pools were identified. Obviously, these data will include pool lengths and depths. It is not necessary to duplicate pool “calls” made during previous surveys. It is necessary to recognize differences and note them, so that such differences can be taken into account during data analysis and interpretation.

In summary, remeasurement of SCI reaches is as important as the initial survey. In doing so, it is key to understand the history of the initial and any subsequent surveys. In addition, care must be given to conducting an accurate assessment of current conditions and evaluating differences between surveys over time and in any changes in protocols.

IV. Quality Assurance/Quality Control

A. Introduction

Quality assurance and control is an important part of this regional stream condition inventory. High quality data is essential for initial inventories and comparisons of the condition of a stream over time and between streams.

The goal of this Plan is to insure that high quality data are collected and recorded so that a valid inventory is achieved.

This QA/QC Plan consists of the following elements:

- Training (SCI procedures, field test)
- Pre-Survey Preparation (equipment, data forms, field gear, etc.)
- Field Oversight (crew evaluations during field season)
- Post-Survey Evaluation (review data, maps, photos, etc.)
- Data Entry (field data review, training, oversight, data entry check)
- Documentation of QA/QC

B. Training

QA/QC Form 1 – Training Documentation

Training of crews is the most important part of this plan. If crews are well trained, there is a high likelihood of successful data collection.

Training consists of both introductory and refresher sessions. Introductory sessions, for employees new to SCI work, consist of a combination of classroom discussion and field practice, often over a 3-day period. Refresher sessions are for personnel who have done SCI but who have not measured a reach in at least two years. Refresher sessions are usually one day in the field at an established SCI reach.

Introductory training includes office and fieldwork in SCI attribute measurement, sampling strategy (reaches, passes, and systematic and random selections), and data form management. Refresher training includes fieldwork only.

Training can be conducted on each forest or at locations where employees from several forests travel to a training site. Trainers usually consist of biologists and hydrologists well experienced in SCI measurements.

During or following training, a field test is conducted for introductory training. It is held at an established SCI reach, where new surveyors conduct SCI on part of the reach. All SCI attributes are measured on this test reach and compared with data for the reach that has been collected by experienced surveyors. New surveyors are evaluated on their performance so that any corrections can be made before conducting actual surveys.

C. Pre-Survey Preparation and Post-Survey Evaluation

QA/QC Form 2 – Survey Check List

This is a simple but necessary step to assure that fieldwork will begin and progress successfully. It consists of acquiring, organizing and checking serviceability of field equipment and data forms before starting fieldwork.

This step includes reviewing data sheets, maps, photos, etc. The Crew Leader should review all material at the completion of each reach so that data are accurate before starting a new reach.

D. Field Oversight

QA/QC Form 3 – Field Oversight

This is an essential phase of the QA/QC Plan because it tests if crews are conducting SCI properly. There are two periods of the field season that oversight should be conducted: during the first SCI reach and mid-season. Oversight by experienced surveyors during the first reach is important because field variables and questions may arise that were not discussed in training. It is best to address those issues as soon as possible. The mid-season oversight check is to assure the crew is successfully following procedures.

E. Data Entry

QA/QC Form 4 – Data Entry Check List

Data entry consists of training in the applicable database(s), oversight during data entry, and a spot check following completion of data entry. The spot check should be done as soon as possible when all or most of the data have been entered.

F. Documentation of QA/QC

QA/QC documentation forms are used to track QA/QC actions. This creates a record to help insure the goal of the QA/QC Plan has been accomplished. Forms are completed annually and stored on the Forest with SCI data.

G. Quality Assurance & Quality Control (QA/QC) Form Instructions and Sample Forms

QA/QC Form 1 – Training Documentation

Responsibility: SCI Field Trainer/Forest SCI Coordinator

This form provides documentation of formal crew training. Documentation of training is very important and serves as a record to show consistency of data collection.

Each participant in the training should enter their information on the form. In the Personnel Information block participants print their first and last name and forest name (3 letter abbreviation), and check the box for either trainee or trainer. In the Training Information block enter forest name, stream name where training occurred, and legal description. Also check either the Introductory (Intro) or Refresher (Refresh) training type.

QA/QC Form 2 – Survey Checklist

Responsibility: Crew Leader

This form documents field and field related activities for each crew, and is to be turned into the Forest SCI Coordinator at the end of the field season with all completed forms from each reach.

To complete the header block, print each crew member's first initial and last name and the forest they are conducting the survey on.

The Pre-survey Preparation block is a check list to be completed by the crew members involved in preparing the equipment and supplies needed for the survey. Print names and dates of preparation, and initial the field equipment and forms box for each activity accomplished. Add comments as necessary.

In the Post-survey Evaluation block the crew leader is to review all data sheets, maps, photos, etc. and document the review by initialing each section. Include the reach number, stream name, and date the review was completed. This form can be used for up to five reaches.

QA/QC Form 3 – Field Oversight

Responsibility: SCI Field Trainer/Forest SCI Coordinator

This form is essential for documentation of crew performance. The reviewer is to complete one form per crew for both the First Reach and the Mid-season Reach.

To complete the header block, print each crew leader/members and reviewers first initial and last name and the forest they are conducting the survey on.

The SCI Attributes and Protocol block is listed by form number. Review each form and check for accuracy. Indicate if the form was satisfactorily completed or not. If not, document the discrepancy and corrective measures in the Needs Improvement column (comments may be added for satisfactory work also). Include reach ID number, stream name and the date the review was completed.

The Field Procedures block is to be completed the same as above.

QA/QC Form 4 – Data Entry Checklist

Responsibility: Data Entry Person and Data Entry Trainer/Forest SCI Coordinator

The Data Entry Check List is to document SCI data entered into the NRIS database and the review of the data entered.

The Data Entry block is to be completed by the person entering the data. Print first initial and last name, stream name and reach ID number. Enter the form numbers and date completed (you can list more than one form number if they are completed on the same day).

USDA Forest Service Pacific Southwest Region **QA/QC Form #1**

Stream Condition Inventory (SCI)

Training Documentation

Personnel Information				Training Information			
Print Name	Forest	Trainee	Trainer	Date(s)	Location (forest/stream/legal)	Training Type	
						Intro	Refresh
A. DUMOS	STF	X		June 22, 04	STF/Clark Fork/ T6N, R20E, SEC 5		X
A. ANDAZOLA	STF	X		June 21-22, 04	STF/Clark Fork/ T6N, R20E, SEC 5	X	
A. BURNS	STF	X		June 21-22, 04	STF/Clark Fork/ T6N, R20E, SEC 5	X	
J. Frazier	STF		X	June 21-22, 04	STF/Clark Fork/ T6N, R20E, SEC 5	—	—

QA/QC Form #1 - Version 0.5 - July 2005

USDA Forest Service Pacific Southwest Region
Stream Condition Inventory (SCI)

QA/QC Form #2

Survey Checklist

Crew Leader: A.DUMOS

Crew Member(s): A. ANDAZOLA, A. BURNS

Forest: TAHOE N. F.

Pre-Survey Preparation (Crew/Crew Leader)

Name(s): A. ANDAZOLA, A. BURNS	Date(s): 7/6/04

Activity	Field Equipment	Forms	Comments
Acquire:	X	X	
Organize:	X	X	
Check Serviceability:	X		

Post-Survey Evaluation (Crew Leader)

Reach ID Number: 17025		Date: 7/9/04	
Stream Name: PACIFIC CREEK			
X	Data Sheets	X	Photos
X	Maps		Other:
Comments:			
Reach ID Number:		Date:	
Stream Name:			
	Data Sheets		Photos
	Maps		Other:
Comments:			
Reach ID Number:		Date:	
Stream Name:			
	Data Sheets		Photos
	Maps		Other:
Comments:			
Reach ID Number:		Date:	
Stream Name:			
	Data Sheets		Photos
	Maps		Other:
Comments:			
Reach ID Number:		Date:	
Stream Name:			
	Data Sheets		Photos
	Maps		Other:
Comments:			

QA/QC Form #2 - Version 0.5 - July 2005

Field Oversight

Crew Leader: A.DUMOS	
Crew Member(s): A. ANDAZOLA, A. BURNS	
Reviewer(s): J. FRAZIER	
Forest: TAHOE N. F.	

SCI Attributes & Protocols

Forms	First Reach		Mid-season Reach	
	Reach ID Number: 17025		Reach ID Number: 17027	
	Stream Name: PACIFIC CREEK		Stream Name: Mill Creek	
	Date: 7/9/04		Date: 8/5/04	
	Satisfactory Yes/No	Needs Improvement (comment required)	Satisfactory Yes/No	Needs Improvement (comment required)
Form 1: Sensitive Reach Layout	yes		yes	
Form 2: Macroinvertebrates Data/Sketches	yes		yes	
Form 3: Particle Count	no	remember to sum the data in each row	yes	
Form 4: Cross-section & Width-to-Depth Candidate Sites & LWD	yes		yes	
Form 5: Cross-section Data & Water Surface Gradient	no	re-check banfull locations. X-section areas inconsistent in reach	yes	very good, consistant x-section data
Form 6: Cross-section Diagram & Location Sketch	yes		yes	
Form 7: Width-to-Depth/Entrenchment Ratios	yes		yes	
Form 8: Pools/Pool Tail Fine Sediment	no	review pool definition criteria	yes	pool identification very good
Form 9: Streambank Attributes & Aquatic Fauna	yes	very good	yes	
Form 10: Photo Log & Comments	yes		yes	

Field Procedures

Step	First Reach		Mid-season Reach	
	Satisfactory Yes/No	Needs Improvement (comment required)	Satisfactory Yes/No	Needs Improvement (comment required)
Conduct Reach Reconnaissance	yes		yes	
Document start of the Sensitive Reach	yes	very good	yes	
Monumenting Cross-sections	yes		yes	

QA/QC Form #3 - Version 0.5 - July 2005

USDA Forest Service Pacific Southwest Region
Stream Condition Inventory (SCI)

QA/QC Form #4

Data Entry Checklist

Data Entry				Data Review	
Data Entered By	Stream Name & Reach ID #	Form #(s)	Date Completed	Reviewer Name	Date
A. BURNS	17025	1-3	9/3/04	J. Frazier	9/10/04
A. BURNS	17025	4-8	9/4/04	J. Frazier	9/10/04
A. BURNS	17025	8-10	9/7/04	J. Frazier	9/10/04
A. BURNS	17026	1-4	9/9/04		
A. BURNS	17026	5-10	9/10/04		

QA/QC Form #4 - Version 0.5 - July 2005

V. Appendices

Appendix A – Preliminary Results/Discussion of Analysis and Interpretation

Since pilot development, the protocol has been applied throughout R5, using the “final draft” protocols. Unpublished data from three applications are worthy of note. In the first, comparison of attributes from stream reaches in “reference” and “treated” watersheds was made. Streams were stratified into two stream types (response and transport). These comparisons found significant differences (p=.05) between the two treatment types in response streams for most attributes tested, and in transport streams for all attributes except bankfull width/depth. A summary of these comparisons is shown in Table 1.

Table 1

Attribute	Response		Significant Difference (.05)	Transport		Significant Difference (.05)
	Ref mean	Non Ref Mean		Ref mean	Non Ref Mean	
Surface Fines (mean %)	19.3	26.5	0.12	12.1	20.1	YES
Shade (mean %)	43.4	39.3	0.23	67.4	53.6	YES
Stability (% stable)	75.3	52.9	YES	80.9	55.5	YES
% <2mm	15.6	21.7	0.08	6.5	15.8	YES
W/D ratio	16.9	26.6	YES	19.4	20.1	0.43
Bank Angle (mean %)	112.4	131.4	YES	NA	NA	
Streamshore Water Depth (mean cm)	0.18	0.06	YES	NA	NA	

Table 1: Results of t-test comparisons of SCI data collected from SCI pilot development, Sierra Monitoring Development, and Forest Health Pilot Monitoring (Plumas, Lassen, and Tahoe NFs).

A similar approach was applied during pilot testing for the Sierra Province Aquatic Monitoring Plan developed in conjunction with the Sierra Framework. Forty-four treatment and reference streams were sampled in 1997. SCI has also been applied to monitoring of streams in conjunction with the Herger-Feinstein Quincy Library Group Plan (QLG) on the Tahoe, Plumas and Lassen National Forests. Preliminary work from this effort showed significant differences between streams from Westside, “Transition” and Eastside zones on the three forests for most channel attributes. Differences between QLG response streams and R5 reference streams were much greater than differences between transport streams. An example of results from this analysis is shown in Figure 1. This same program showed significant differences between streams burned by wildfire on the Tahoe NF and nearby reference streams. Results from comparison of pool tail fines are shown in Figure 2.

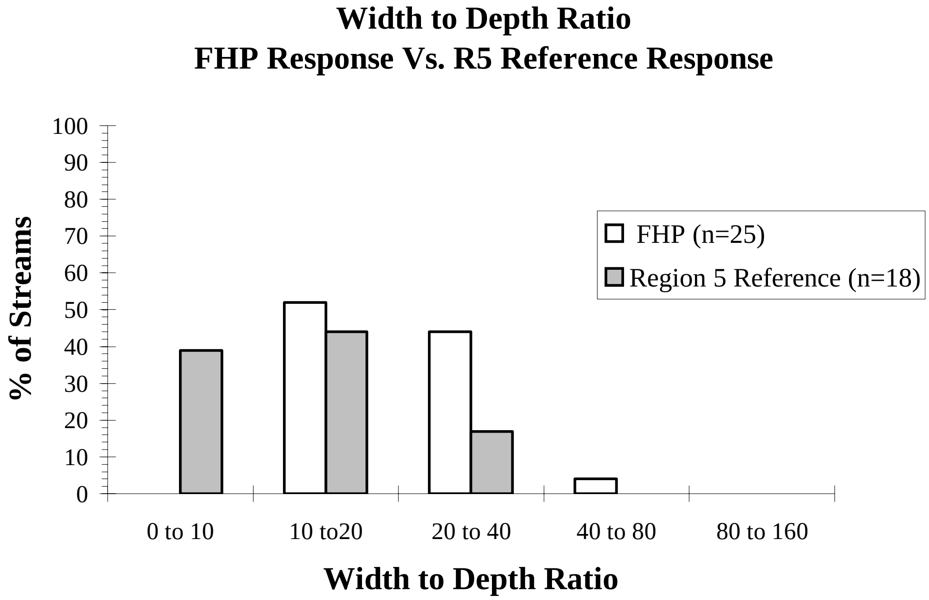


Figure 1 - Comparison of SCI data (Width-to-depth ratios) from Forest Health Pilot Response streams (Plumas, Lassen, and Tahoe NFs) and Region 5 Reference Response Streams

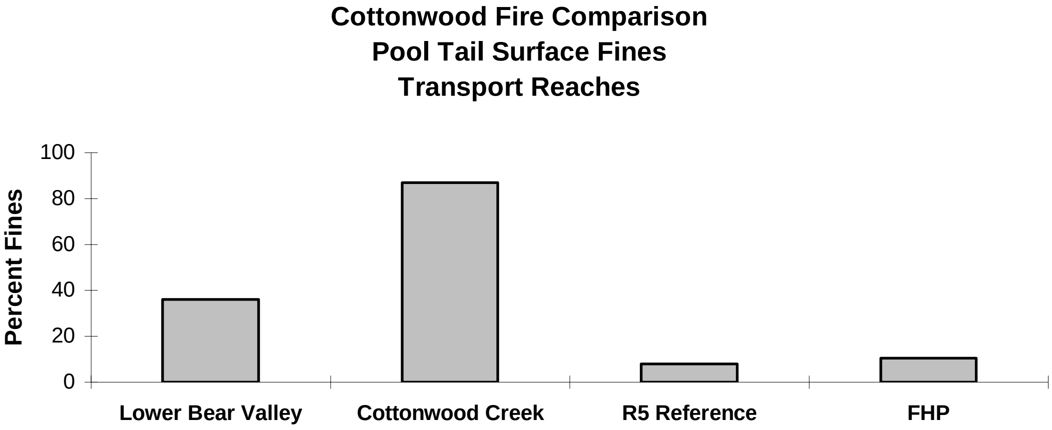


Figure 2 - SCI data comparison of Pool Tail Surface Fines for transport reaches within the Cottonwood Fire against R5 reference and FHP streams.

Data Analysis and Interpretation:

SCI data can be collected to meet a variety of objectives. Those objectives will determine the type of analysis. These questions can range from comparison data collected from a single site over time (before and after implementation of a management practice, for instance), to comparison of data from sites with different levels of management, to data collected from reference streams. In all cases, interpretation of data should consider both spatial and temporal variability. Stream systems are dynamic and change over time. For this reason, it is a good idea to evaluate changes in reference streams along with changes in any before and after comparisons. If the references are similar in terms of their ecological characteristics (catchment size, elevation, channel type, etc.) and have been sampled over the same time period as "treatment" streams, they provide a means of gauging what degree of change might be expected in the treatment streams, apart from any management affect.

In interpreting changes over time, it is also important to consider whether or not “triggering” events have occurred over the time period of the monitoring. For instance, if the objective of monitoring is to assess the impact of stream crossing improvements, the response from the crossings to the channels would probably not be expected until a large flow event had occurred.

Also, consider the degree to which attributes are influenced by environmental factors, and consider these in data interpretation. For instance, channel width-depth is strongly influenced by catchment size, so comparison of w/d rations for any two sites without consideration of drainage area is problematic. In this case, one approach might be to compare basin size versus w/d ratio for reference streams with similar ecological characteristics, and then see how well individual “treatment” streams follow the reference stream relationship. An example of this type of comparison is shown in Figure 3. Other attributes that are strongly influenced by catchment size are pool depth and substrate size.

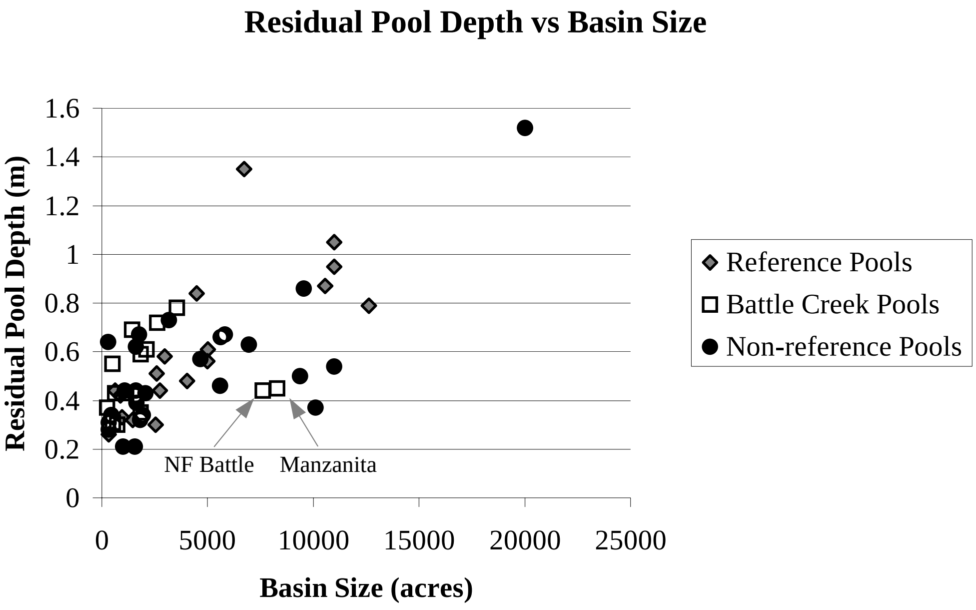


Figure 3 - Plot of residual pool depth against basin size for R5 reference transport channels, R5 non-reference transport channels, and transport channels in upper Battle Creek (Lassen NF).

Another consideration is to recognize the limitation of any single attribute. SCI collects data on numerous attributes, partly in recognition that each by itself is weak analytically. Interpretation then, should follow a weight of evidence type approach. The practical significance of findings should be evaluated in terms of the entire data set. It is likely that some attributes will show greater (or less) differences than others. Are differences trending in the same “direction”? For instance if width-to-depth ratios increase, one would also expect an increase in bank angle. If both trend in the same direction, there is more credence to the change than if they trended in “opposite” directions.

The key to interpretation is found back in plan design. Outline the expected responses and attributes to be used as indicators of those responses. For example, SCI is applied to monitor the effectiveness of a revised range management strategy in improving channel morphology and fish habitat. The expected outcomes might be decreased bank angle and width-to-depth ratio, increased bank stability and stream shade, and deeper pools. After implementation of the new strategy, data analysis should focus on these attributes.

Appendix B – Equipment List

Standard equipment (for most protocols)

- SCI Protocol and data forms
- Clipboard and field notebook
- Copy of prior SCI survey of same reach (if applicable)
- 7.5’ USGS Quadrangle Maps or other maps depicting survey area
- GPS unit to identify applicable survey locations
- Wading boots or waders
- 100m measurement tape
- 50m measurement tape
- Flagging
- Pencils/markers
- Camera (film if needed)
- Gravelometer, ruler
- Depth rods (m)
- Hip chain and string
- Tally whacker (LWD count)
- Fence posts or rebar (permanent x-section markers)
- Spray paint
- Level rod (m)
- Transit level with tripod
- Hand level
- String/string level
- Engineering survey flags (bankfull, x-section candidate sites, etc.)
- Clamps to connect measuring tape to stakes
- Pool tail fines grid
- View tube or mask
- Solar pathfinder
- Clinometer

Macroinvertebrate sampling equipment

General:

- Field data forms/ clipboard
- Field notebooks
- GPS unit to identify sampling location
- Permanent markers, pencils
- Wading boots/ waders
- Pump sprayer and wash bottles for washing insects and algae off rocks, pans, and nets
- 7.5’ USGS Quadrangle Maps or other maps depicting sampling location
- Camera

Invertebrates:

- 10-sided die or digital watch for generating random sample locations
- 0.09 m^2 Surber or D-frame sampler with 500µm mesh net (net should be ~ 1m)
- 14 liter bucket
- White plastic wash tub
- Two 500µl plastic sample jars
- Small spoons (2) for transferring samplings to jars
- Forceps (2 pairs)
- Labeling materials (preprinted Rite-in-the-Rain^{TM} labels)
- Buffered (CaCo3) Formalin or 95% EtOH
- Trowel

Water Chemistry and Temperature

- Conductivity meter
- Field alkalinity test kit

Physical Attributes:

- 100m measurement tape
- Gravelometer or ruler to measure substrate size

Appendix C – Cleaning Survey Equipment

Introduction

The purpose of this appendix is (1) to provide stream surveyors with awareness of invasive species and pathogens associated with stream surveys and (2) to introduce general protocols to manage the risks associated with introducing them to or transporting them within aquatic or terrestrial ecosystems.

The goal of this appendix is to help reduce the risk of introduction or spread of unwanted species or pathogens. The number of invasive species and pathogens may change over time and risk management protocols may vary by location within the region. It is beyond the scope of this appendix to describe or anticipate all problems and mitigations throughout the Pacific Southwest Region. Stream surveyors should check locally for specific problem identification and cleaning protocols.

Pathogens and Invasive Species

Several known pathogens in the region may be transported by stream surveyors. These include multiple fungi species that can lead to Port Orford cedar root rot, sudden oak death syndrome (SODS), and may lead to chytridiomycosis in certain amphibians. In addition, one aquatic invasive animal species and numerous terrestrial and aquatic plants are capable of being spread by stream surveyors. The New Zealand mud snail is expanding its range in the region and has become very problematic. Plant species are too numerous to mention and vary locally. One common invasive plant, Yellow starthistle, is currently widespread throughout the region.

Vectors

Stream surveyors, their equipment and vehicles can readily serve as vectors for pathogens and invasive species. Surveyors can transport fungus, plants, and insects on field equipment, clothing, boots and even by skin contact in some cases. Surveyor's vehicles can also introduce or spread invasive species or pathogens when traveling to or from field sites. Some pathogens and invasive species may be encountered outside of the stream environment and transported elsewhere. For example, some fungus species and many invasive plants are terrestrial and may be contacted while walking to a stream.

There may not be a risk of introduction or spread of pathogens or invasive species everywhere in the region. Check locally. Wherever a risk exists, stream surveyors should take appropriate risk management procedures.

General Cleaning Protocols

The guidelines below are intended as general recommendations for cleaning items that may introduce or spread pathogens or invasive species. Specific procedures such as cleaning frequency, duration, and washing chemicals should be determined by consulting local protocols.

See general cleaning protocols on the next page.

General Cleaning Protocols for Stream Survey Field Equipment

Cleaning Activity	Survey Equipment	Vehicles	Notes
What items to clean	• All survey gear that has been exposed to hazards – in and out of water • Clothing, skin, fingernails, etc. (when entering next watershed* without bathing)	All vehicles that have been used for ingress and egress	
When and where to clean items	• Upon return to the duty station, or • On site in the watershed if not returning to the duty station before surveying the next watershed	Same as survey equipment	Proper vehicle cleaning may not be feasible in remote field areas. Be aware that proper cleaning may be needed before entering the next watershed.
How to clean items	• Scrub gear that has gathered soil or organic debris • Disinfect gear to local protocol standard (bleach or Quat-128 solution are common treatments) • Dry gear sufficiently	• Inspect all parts of vehicles that may have collected mud, weed seeds, etc. • Wash thoroughly, preferably with a high pressure hose such as at a duty station or commercial car wash	

* The term “next watershed” is relative to the scale of surveys and the risk of introduction or transport of pathogens or invasive species. For example, cleaning needs may vary from between stream reaches to watersheds of ten or more thousands of hectares. Check locally for risk and scale.

References

USDA/USDI 2004

Appendix D – Random Number Table

13962	70992	65172	28053	02190	83634	66012	70305	66761	88344
43905	46941	72300	11641	43548	30455	07686	31840	03261	89139
00504	48658	38051	59408	16508	82979	92002	63606	41078	86326
61274	57238	47267	35303	29066	02140	60867	39847	50968	96719
43753	21159	16239	50595	62509	61207	86816	29902	23395	72640
83503	51662	21636	68192	84294	38754	84755	34053	94582	29215
36807	71420	35804	44862	23577	79551	42003	58684	09271	68396
19110	55680	18792	41487	16614	83053	00812	16749	45347	88199
82615	86984	93290	87971	60022	35415	20852	02909	99476	45568
05621	26584	36493	63013	68181	57702	49510	75304	38724	15712
06936	37293	55875	71213	83025	46063	74665	12178	10741	58362
84981	60458	16194	92403	80951	80068	47076	23310	74899	87929
66354	88441	96191	04794	14714	64749	43097	83976	83281	72038
49602	94109	36460	62353	00721	66980	82554	90270	12312	56299
78430	72391	96973	70437	97803	78683	04670	70667	58912	21883
33331	51803	15934	75807	46561	80188	78984	29317	27971	16440
62843	84445	56652	91797	45284	25842	96246	73504	21631	81223
19528	15445	77764	33446	41204	70067	33354	70680	66664	75486
16737	01887	50934	43306	75190	86997	56561	79018	34273	25196
99389	06685	45945	62000	76228	60645	87750	46329	46544	95665
36160	38196	77705	28891	12106	56281	86222	66116	39626	06080
05505	45420	44016	79662	92069	27628	50002	32540	19848	27319
85962	19758	92795	00458	71289	05884	37963	23322	73243	98185
28763	04900	54460	22083	89279	43492	00066	40857	86568	49336
42222	40446	82240	79159	44168	38213	46839	26598	29983	67645
43626	40039	51492	36488	70280	24218	14596	04744	89336	35630
97761	43444	95895	24102	07006	71923	04800	32062	41425	66862
49275	44270	52512	03951	21651	53867	73531	70073	45542	22831
15797	75134	39856	73527	78417	36208	59510	76913	22499	68467
04497	24853	43879	07613	26400	17180	18880	66083	02196	10638
95468	87411	30647	88711	01765	57688	60665	57636	36070	37285
01420	74218	71047	14401	74537	14820	45248	78007	65911	38583
74633	40171	97092	79137	30698	97915	36305	42613	87251	75608
46662	99688	59576	04887	02310	35508	69481	30300	94047	57096
10853	10393	03013	90372	89639	65800	88532	71789	59964	50681

Appendix E – California Herpetofauna Species Code

Compiled by: Don Ashton, Amy Lind, and Hart Welsh
USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Lab, 1700 Bayview Drive, Arcata, CA 95521 (707) 822-3691

The following is a code list for the native amphibian and reptile species in California. Common exotic species are also included and some recently described species may be excluded. Subspecies are included for some species of special concern in California (Jennings and Hayes 1994) and are indented below species name. The first two letters of each four-letter code represent the genus and the second two, the species. The list is ordered by four simple "bioregions": Northwestern, Sierra/Modoc, South Coast Ranges, and Southeastern Deserts. The National Forests included in each bioregion are listed at the beginning of each section. Within each bioregion section the species are ordered systematically. Recent taxonomic revisions are indicated as NEWNAME=OLDNAME for codes and old names in parentheses for scientific names. Where there is not consensus among herpetologists on common or scientific names, the less commonly used alternates are in []. An asterisk (*) following the species code indicates marginal distribution for that bioregion.

NORTHWESTERN (Klamath, Mendocino, Shasta-Trinity, Six Rivers)

AMPHIBIANS

Code	Common Name	Scientific Name
TAGR	Rough-skinned newt	*Taricha granulosa*
TARI	Red-bellied newt	*Taricha rivularis*
TATO	California newt	*Taricha torosa*
DITE=DIEN	Pacific giant salamander	*Dicamptodon tenebrosus (ensatus)*
RHVA=RHOL	Southern torrent salamander	*Rhyacotriton variegatus (olympicus)*
AMGR	Northwestern salamander	*Ambystoma gracile*
AMMA	Long-toed salamander	*Amybstoma macrodactylum*
AMTI	Tiger salamander	*Ambystoma tigrinum*
ANFE	Clouded salamander	*Aneides ferreus*
ANFL	Black salamander	*Aneides flavipunctatus*
ANLU	Arboreal salamander	*Aneides lugubris*
BAAT	California slender salamdr	*Batrachoseps attenuatus*
HYSH	Shasta salamander	*Hydromantes shastae*
ENES	Ensatina	*Ensatina eschscholtzi*
PLDU	Dunn's salamander	*Plethodon dunni*
PLEL	Del Norte salamander	*Plethodon elongatus*
PLAS	Scott Bar Salamander	*Plethodon asupak*
PLST	Siskyou mountains salamander	*Plethodon stormi*
SCHA	Western spadefoot toad	*Scaphiopus hammondii*
BUBO	Western toad	*Bufo boreas*
HYRE	Pacific treefrog [chorus frog]	*Hyla [Pseudaris] regilla*
ASTR	Tailed frog	*Ascaphus truei*
RAAU	Red-legged frog	*Rana aurora*
RAAA	Northern red-legged frog	*Rana aurora aurora*
RABO	Foothill yellow-legged frog	*Rana boylii*
RACT	Bullfrog - EXOTI	*Rana catesbeiana*
RACA	Cascades frog	*Rana cascadae*

NORTHWESTERN (Klamath, Mendocino, Shasta-Trinity, Six Rivers)

REPTILES

Code	Common Name	Scientific Name
CLMA	Western pond turtle	*Clemmys marmarota*
ELCO=GECO	Northern alligator lizard	*Elgaria (Gerrhonotus) coerulea*
ELMU=GEMU	Southern alligator lizard	*Elgaria (Gerrhonotus) multicarinata*
SCGR	Sagebrush lizard	*Sceloporus gracious*
SCOC	Western fence lizard	*Sceloporus occidentalis*
EUSK	Western skink	*Eumeces skiltonianus*
CNTI	Western whiptail	*Cnemidophorus tigris*
CHBO	Rubber boa	*Charina bottae*
COCO	Western racer	*Coluber constrictor*
COTE	Sharp-tailed snake	*Contia tenuis*
DIPU	Ringneck snake	*Diadophis punctatus*
LAGE	Common kingsnake	*Lampropeltis getulus*
LAZO	Mountain kingsnake	*Lampropeltis zonata*
MALA	Striped racer	*Masticophis lateralis*
PIME	Gopher snake	*Pituophis melanoleucus*
THSP	Garter snake (species unknown)	*Thamnophis spp.*
THAT=THCO	Santa Cruz garter snake	*Thamnophis atratus (couchii)*
THEL	Western terrestrial garter snake	*Thamnophis elegans*
THOR	Northwestern garter snake	*Thamnophis ordinoides*
THSI	Common garter snake	*Thamnophis sirtalis*
CRVI	Western rattlesnake	*Crotalus viridis*

SIERRA/MODOC (Eldorado, Inyo, Lake Tahoe Basin, Lassen, Modoc, Plumas, Sequoia, Sierra, Stanislaus, Tahoe)

AMPHIBIANS

Code	Common Name	Scientific Name
TAGR	Rough-skinned newt	*Taricha granulosa*
TATO	California newt	*Taricha torosa*
AMMA	Long-toed salamander	*Amybstoma macrodactylum*
AMTI*	Tiger salamander	*Ambystoma tigrinum*
AMCA	California tiger salamander	*Ambystoma californiense*
ANLU	Arboreal salamander	*Aneides lugubris*
BAAT	California slender salamander	*Batrachoseps attenuatus*
BANI	Black-bellied slender salamander	*Batrachoseps nigriventris*
BAPA	Pacific slender salamander	*Batrachoseps pacificus*
BASI	Kern Canyon slender salamande	*Batrachoseps simatus*
BARE	Relictual slender salamander	*Batrachoseps relictus*
BAST	Tehachapi slender salamander	*Batrachoseps stebbinsi*
BACA	Inyo Mountains salamander	*Batrachoseps campi*
HYPL	Mt. Lyell salamander	*Hydromantes platycephalus*
HYBR	Limestone salamander	*Hydromantes brunus*
ENES	Ensatina	*Ensatina eschscholtzi*
SCHA	Western spadefoot	*Scaphiopus hammondii*
SCIN	Great Basin spadefoot	*Scaphiopus intermontanus*
BUBO	Western toad	*Bufo boreas*

AMPHIBIANS

Code	Common Name	Scientific Name
BUEX	Black toad	*Bufo exsul*
BUCA	Yosemite toad	*Bufo canorus*
RUPU*	Red-spotted toad	*Bufo punctatus*
HYRE	Pacific treefrog [chorus frog]	*Hyla [Pseudacris] regilla*
RAAU	Red-legged frog	*Rana aurora*
RAAD	California red-legged frog	*Rana aurora draytonii*
RAPR	Spotted frog	*Rana pretiosa*
RABO	Foothill yellow-legged frog	*Rana boylii*
RAMU	Mountain yellow-legged frog	*Rana muscosa*
RAPI	Northern leopard frog	*Rana pipiens*
RACT	Bullfrog - EXOTIC	*Rana catesbeiana*
RACA	Cascades frog	*Rana cascadae*

REPTILES

Code	Common Name	Scientific Name
CLMA	Western pond turtle	*Clemmys marmarota*
COVA*	Western banded gecko	*Coleonyx variegatus*
DIDO*	Desert iguana	*Dipsosaurus dorsalis*
SAOB*	Chuckwalla	*Sauromalus obesus*
CADR*	Zebra-tailed lizard	*Callisaurus draconoides*
CRIN*	Desert collared lizard	*Crotaphytus insularis*
GAWI*	Long-nosed leopard lizard	*Gambelia wislizenii*
GASI*	Blunt-nosed leopard lizard	*Gambelia sila [silus]*
SCMA*	Desert spiny lizard	*Sceloporus magister*
SCGR	Sagebrush lizard	*Sceloporus gracious*
SCOC	Western fence lizard	*Sceloporus occidentalis*
UTST	Side-blotched lizard	*Uta stansburiana*
PHCO	Coast horned lizard	*Phrynosoma cornatum*
PHCF	California horned lizard	*Phrynosoma coronatum frontale*
PHPL	Desert horned lizard	*Phrynosoma platyrhinos*
PHDO	Short-horned lizard	*Phrynosoma douglassi*
XAVI*	Desert night lizard	*Xantusia vigilis*
EUSK	Western skink	*Eumeces skiltonianus*
EUGI	Gilbert's skink	*Eumeces gilberti*
CNTI	Western whiptail	*Cnemidophorus tigris*
ELCO=GECO	Northern alligator lizard	*Elgaria (Gerrhonotus) coerulea*
ELMU=GEMU	Southern alligator lizard	*Elgaria (Gerrhonotus)multicarinata*
ELPA=GEPA	Panamint alligator lizard	*Elgaria (Gerrhonotus) panamintina*
ANNI=ANPU*	California legless lizard	*Anniella nigra (pulchra)*
CHBO	Rubber boa	*Charina bottae*
LITR*	Rosy boa	*Lichanura trivirgata*
LEHU*	Western blind snake	*Leptotyphlops humilis*
MAFL	Coachwhip	*Masticophis flagellum*
MATA	Striped whipsnake	*Masticophis taeniatus*
MALA	California whipsnake	*Masticophis lateralis*
COCO	Racer	*Coluber constrictor*
SAHE	Western patch-nosed snake	*Salvadora hexalepis*
AREL	Glossy snake	*Arizona elegans*

REPTILES

Code	Common Name	Scientific Name
COTE	Sharp-tailed snake	*Contia tenuis*
DIPU	Ringneck snake	*Diadophis punctatus*
LAGE	Common kingsnake	*Lampropeltis getula [getulus]*
LAZO	California mountain kingsnake	*Lampropeltis zonata*
RHLE	Long-nosed snake	*Rhinocheilus lecontei*
PIME	Gopher snake	*Pituophis melanoleucus*
THSP	Garter snake (species unknown)	*Thamnophis spp.*
THAT=THCO*	Oregon garter snake	*Thamnophis atratus (couchii)*
THEL	Western terrestrial garter snake	*Thamnophis elegans*
THCO	Western aquatic garter snake	*Thamnophis couchi*
THSI	Common garter snake	*Thamnophis sirtalis*
SOSE	Ground snake	*Sonora semiannulata*
CHOC*	Western shovel-nosed snake	*Chionactis occipitalis*
TAHO	Southwestern black-headed snake	*Tantilla hobartsmithi*
TRBI*	Lyre snake	*Trimorphodon biscutatus*
HYTO	Night snake	*Hypsiglena torquata*
CRMI	Speckled rattlesnake	*Crotalus mitchelli*
CRVI	Western rattlesnake	*Crotalus viridis*

SOUTH COAST RANGES (Angeles, Cleveland, Los Padres, San Bernardino)

AMPHIBIANS

Code	Common Name	Scientific Name
TATO	California newt	*Taricha torosa*
TATT	Coast Range newt	*Taricha torosa torosa*
DITE=DIEN*	Pacific giant salamander	*Dicamptodon tenebrosus (ensatus)*
AMTI	Tiger salamander	*Ambystoma tigrinum*
AMCA	California tiger salamander	*Ambystoma californiense*
ANLU	Arboreal salamander	*Aneides lugubris*
ENES	Ensatin	*Ensatina eschscholtzi*
BAAR	Desert slender salamander	*Batrachoseps aridus*
BANI	Black-bellied slender salamander	*Batrachoseps nigriventris*
BAPA	Pacific slender salamander	*Batrachoseps pacificus*
BAST	Tehachapi slender salamander	*Batrachoseps stebbinsi*
SCHA	Western spadefoot toad	*Scaphiopus hammondii*
BUBO	Western toad	*Bufo boreas*
BUMI	Southwestern toad	*Bufo microscaphus*
BUMC	Arroyo toad	*Bufo microscaphus californicus*
BUPU*	Red-spotted toad	*Bufo punctatus*
HYCA	California treefrog[chorus frog]	*Hyla [Pseudacris] cadaverina*
HYRE	Pacific treefrog [chorus frog]	*Hyla [Pseudacris] regilla*
RAAU	Red-legged frog	*Rana aurora*
RAAD	California red-legged frog	*Rana aurora draytonii*
RABO	Foothill yellow-legged frog	*Rana boylii*
RAMU	Mountain yellow-legged frog	*Rana muscosa*
RAPI	Northern leopard frog	*Rana pipiens*
RACT	Bullfrog - EXOTIC	*Rana catesbeiana*

REPTILES

Code	Common Name	Scientific Name
CLMA	Western pond turtle	*Clemmys marmarota*
TRSC=PSSC	Slider - EXOTIC	*Trachemys (Pseudemys) scripta*
GOAG*	Desert tortoise	*Gopherus agassizi*
COSW*	Barefoot gecko	*Coleonyx switaki*
COVA*	Western banded gecko	*Coleonyx variegatus*
PHXA*	Leaf-toed gecko	*Phyllodactylus xanti*
DIDO*	Desert iguana	*Dipsosaurus dorsalis*
SAOB*	Chuckwalla	*Sauromalus obesus*
CADR*	Zebratail lizard	*Callisaurus draconoides*
CRIN*	Desert collared lizard	*Crotaphytus insularis*
GAWI*	Long-nosed leopard lizard	*Gambelia wislizenii*
GASI*	Blunt-nosed leopard lizard	*Gambelia sila [silus]*
SCMA*	Desert spiny lizard	*Sceloporus magister*
SCOR*	Granite spiny lizard	*Sceloporus orcutti*
SCGR	Sagebrush lizard	*Sceloporus gracious*
SCOC	Western fence lizard	*Sceloporus occidentalis*
UTST	Side-blotched lizard	*Uta stansburiana*
URGR*	Long-tailed brush lizard	*Urosaurus graciosus*
URMI*	Small-scaled lizard	*Urosaurus microscutatus*
PEME*	Banded rock lizard	*Petrosaurus mearnsi*
PHCO	Coast horned lizard	*Phrynosoma cornatum*
PHCB	San Diego horned lizard	*Phrynosoma cornatum blainvillii*
PHCF	California horned lizard	*Phrynosoma coroatum frontale*
PHPL*	Desert horned lizard	*Phrynosoma platyrhinos*
XAHE	Granite night lizard	*Xantusia henshawi*
XAHG	Sandstone night lizard	*Xantusia henshawi gracilis*
XAVI*	Desert night lizard	*Xantusia vigilis*
XAVS	Sierra night lizard	*Xantusia vigilis sierrae*
EUSK	Western skink	*Eumeces skiltonianus*
EUSI	Coronado skink	*E. skiltonianus interparietalis*
EUGI	Gilbert's skink	*Eumeces gilberti*
CNHY*	Orange-throated whiptail	*Cnemidophorus hyperythrus*
CNHB	Belding's orange-throated whiptail	*Cnemidophorus hyperythrus beldingi*
CNTI	Western whiptail	*Cnemidophorus tigris*
ELMU=GEMU	Southern alligator lizard	*Elgaria (Gerrhonotus) multicarinata*
ANNI=ANPU*	California legless lizard	*Anniella nigra (pulchra)*
CHBO	Rubber boa	*Charina bottae*
LITR	Rosy boa	*Lichanura trivirgata*
LEHU*	Western blind snake	*Leptotyphlops humilis*
PHDE*	Spotted leaf-nosed snake	*Phyllorhynchus decurtatus*
MAFL	Coachwhip	*Masticophis flagellum*
MAFR	San Joaquin coachwhip	*Masticophis flagellum ruddocki*
MALA	California whipsnake	*Masticophis lateralis*
COCO	Racer	*Coluber constrictor*
SAHE	Western patch-nosed snake	*Salvadora hexalepis*
SAHV	Coast patch-nosed snake	*Salvadora hexalepis virgultea*
AREL	Glossy snake	*Arizona elegans*
COTE	Sharp-tailed snake	*Contia tenuis*

REPTILES

Code	Common Name	Scientific Name
DIPU	Ringneck snake	*Diadophis punctatus*
LAGE	Common kingsnake	*Lampropeltis getula [getulus]*
LAZO	California mountain kingsnake	*Lampropeltis zonata*
LAZA	San Bernardino mnt kingsnake	*Lampropeltis zonata parivrubra*
LAZU	San Diego mountain kingsnake	*Lampropeltis zonata pulchra*
RHLE*	Long-nosed snake	*Rhinocheilus lecontei*
PIME	Gopher snake	*Pituophis melanoleucus*
THSP	Garter snake (species unknown)	*Thamnophis spp.*
THAT=THCO*	Santa Cruz garter snake	*Thamnophis atratus (couchii)*
THEL	Western terrestrial garter snake	*Thamnophis elegans*
THHA	Two-striped garter snake	*Thamnophis hammondii*
THSI	Common garter snake	*Thamnophis sirtalis*
TAPL*	Western black-headed snake	*Tantilla planiceps*
TAHO*	Southwestern black-headed snake	*Tantilla hobartsmithi*
TRBI*	Lyre snake	*Trimorphodon biscutatus*
HYTO	Night snake	*Hypsiglena torquata*
CRAT*	Western diamondback rattlesnake	*Crotalus atrox*
CRRU*	Red diamond rattlesnake	*Crotalus ruber*
CRMI	Speckled rattlesnake	*Crotalus mitchelli*
CRVI	Western rattlesnake	*Crotalus viridis*
CRSC*	Mojave rattlesnake	*Crotalus scutulatus*

SOUTH EASTERN DESERTS (no National Forests)

AMPHIBIANS

Code	Common Name	Scientific Name
BAAR	Desert slender salamander	*Batrachoseps aridus*
SCCO	Couch's spadefoot	*Scaphiopus couchi*
BUAL	Colorado River toad	*Scaphiopus alvarius*
BUBO*	Western toad	*Bufo boreas*
BUWO	Woodhouse's toad	*Bufo woodhousei*
BUPU	Red-spotted toad	*Bufo punctatus*
BUCO	Great plains toad	*Bufo cognatus*
HYCA*	California treefrog(chorus frog)	*Hyla [Pseudacris] cadaverina*
HYRE*	Pacific treefrog (chorus frog)	*Hyla [Pseudacris] regilla*
RAPI*	Northern leopard frog	*Rana pipiens*
RAYA	Lowland leopard frog	*Rana yavapaiensis*
RACT*	Bullfrog - EXOTIC	*Rana catesbeiana*

REPTILES

Code	Common Name	Scientific Name
CLMA*	Western pond turtle	*Clemmys marmarota*
TRSC=PSSC*	Slider - EXOTIC	*Trachemys (Pseudemys) scripta*
KISO	Sonoran mud turtle	*Kinosternon sonoriense*
GOAG	Desert tortoise	*Gopherus agassizi*
TRSP	Spiny softshell	*Trionyx spiniferus*
COVA	Western banded gecko	*Coleonyx variegatus*
PHXA	Leaf-toed gecko	*Phyllodactylus xanti*

REPTILES

Code	Common Name	Scientific Name
DIDO	Desert iguana	*Dipsosaurus dorsalis*
SAOB	Chuckwalla	*Sauromalus obesus*
CADR	Zebra-tailed lizard	*Callisaurus draconoides*
UMSC	Mojave fringe-toed lizard	*Uma scoparia*
UMNO	Colorado Desert fringe-toed liz.	*Uma notata*
UMIN	Coachella Valley fringe-toed	*Uma inornata*
CRIN	Desert collared lizard	*Crotaphytus insularis*
GAWI	Long-nosed leopard lizard	*Gambelia wislizenii*
SCMA	Desert spiny lizard	*Sceloporus magister*
SCOR*	Granite spiny lizard	*Sceloporus orcutti*
SCGR*	Sagebrush lizard	*Sceloporus gracious*
SCOC*	Western fence lizard	*Sceloporus occidentalis*
UTST	Side-blotched lizard	*Uta stansburiana*
URGR	Long-tailed brush lizard	*Urosaurus graciosus*
UROR	Tree lizard	*Urosaurus ornatus*
URMI	Small-scaled lizard	*Urosaurus microscutatus*
PEME	Banded rock lizard	*Petrosaurus mearnsi*
PHPL	Desert horned lizard	*Phrynosoma platyrhinos*
PHMC	Flat-tailed horned lizard	*Phrynosoma mcalli*
XAVI	Desert night lizard	*Xantusia vigilis*
EUSK*	Western skink	*Eumeces skiltonianus*
EUGI*	Gilbert's skink	*Eumeces gilberti*
CNTI	Western whiptail	*Cnemidophorus tigris*
ELMU=GEMU*	Southern alligator lizard	*Elgaria (Gerrhonotus) multicarinata*
ELPA=GEMU*	Panamint alligator lizard	*Elgaria (Gerrhonotus) panamintina*
ANNI=ANPU*	California legless lizard	*Anniella nigra (pulchra)*
HESU	Gila monster	*Helodermata suspectum*
HESC	Banded gila monster	*Helodermata suspectum cinctum*
LITR	Rosy boa	*Lichanura trivirgata*
LEHU	Western blind snake	*Leptotyphlops humilis*
PHDE	Spotted leaf-nosed snake	*Phyllorhynchus decurtatus*
MAFL	Coachwhip	*Masticophis flagellum*
MATA	Striped whipsnake	*Masticophis taeniatus*
MALA*	California whipsnake	*Masticophis lateralis*
COCO*	Racer	*Coluber constrictor*
SAHE	Western patch-nosed snake	*Salvadora hexalepis*
AREL	Glossy snake	*Arizona elegans*
DIPU*	Ringneck snake	*Diadophis punctatus*
LAGE	Common kingsnake	*Lampropeltis getula [getulus]*
RHLE	Long-nosed snake	*Rhinocheilus lecontei*
PIME	Gopher snake	*Pituophis melanoleucus*
THSP	Garter snake (species unknown)	*Thamnophis spp.*
THEL*	Western terrestrial garter snake	*Thamnophis elegans*
THCO*	Western aquatic garter snake	*Thamnophis couchi*
THMA*	Checkered garter snake	*Thamnophis marcianus*
SOSE	Ground snake	*Sonora semiannulata*
CHOC	Western shovel-nosed snake	*Chionactis occipitalis*
TAHO	Southwestern black-headed snake	*Tantilla hobartsmithi*
TRBI	Lyre snake	*Trimorphodon biscutatus*
HYTO	Night snake	*Hypsiglena torquata*

REPTILES

Code	Common Name	Scientific Name
CRAT	Western diamondback rattlesnake	*Crotalus atrox*
CRMI	Speckled rattlesnake	*Crotalus mitchellii*
CRCE	Sidewinder	*Crotalus cerastes*
CRVI*	Western rattlesnake	*Crotalus viridis*
CRSC	Mojave rattlesnake	*Crotalus scutulatus*

References for Scientific Names:

Collins, J.T. 1990. Standard Common and Current Scientific Names for North American Amphibians and Reptiles, 3rd ed. Herpetological Circular No. 19. Society for the Study of Amphibians and Reptiles.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and Reptile Species of SpecialConcern in California. California Department of Fish and Game. Rancho Cordova.

References for Range Information and Common Names:

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. California Department of Fish and Game. Rancho Cordova.

Stebbins, R.C. 1985. Western Reptiles and Amphibians. Houghton Mifflin Company Boston.

Zeiner, D.C., W.F. Laudenslayer Jr., and K.E. Mayer. 1988. California's Wildlife, Volume 1, Amphibians and Reptiles. California Statewide Wildlife Habitat Relationships System. The Resources Agency, Department of Fish and Game. Sacramento.

Appendix F – Fish Species Code

Code	Native or Introduced	Fish Range	Common Name	GIS Label	Alternate Name	Scientific Name
01	N	A	Pacific Lamprey	pacific lamprey	S01	*Lampetra tridentata*
02	N	R	River Lamprey	river lamprey	S02	*Lampetra ayresi*
03	N	R	Pacific brook lamprey	pac-brk-lamprey	S03	*Lampetra pacifica*
04	N	R	Pi-Klamath brook lamprey	pi-K-brk-lamprey	S04	*Lampetra lethophaga*
05	N	A	White sturgeon	white sturgeon	S05	*Acipenser transmontanus*
06	N	A	Green sturgeon	green sturgeon	S06	*Acipenser medirostris*
09	I	A	American shad	american shad	S09	*Alosa sapidissima*
10	I	A	Threadfin shad	threadfin shad	S10	*Doronmosa petenense*
11	N	A	Eulachon	eulachon	S11	*Thaleichthys pacificus*
15	I	R	Mountain whitefish	mtn whitefish	S15	*Prosopium williamsoni*
16	N	A	Pink salmon	pink salmon	S16	*Oncorhynchus gorbuscha*
17	N	A	Chum salmon	chum salmon	S17	*Oncorhynchus keta*
18	N	A	Coho salmon	coho salmon	S18	*Oncorhynchus kisutch*
18.5	N	A	Coho salmon-winter	coho winter	S18.5	*Oncorhynchus kisutch*
19	N	A	Chinook salmon all	chinook all	S19	*Oncorhynchus tshawytscha*
19.1	N	A	Chinook salmon spring	chinook spring	S19.l	*Oncorhynchus tshawytscha*
19.2	N	A	Chinook salmon summer	chinook summer	S19.2	*Oncorhynchus tshawytscha*
19.3	N	A	Chinook salmon fall	chinook fall	S19.3	*Oncorhynchus tshawytscha*
19.4	N	A	Chinook salmon late fall	chinook late fall	S19.4	*Oncorhynchus tshawytscha*
20	N	A	Sockeye salmon	sockeye salmon	S20	*Oncorhynchus nerka*
21	I	R	Kokanee	kokanee	S21	*Oncorhynchus nerka*
22	I	R	Brook trout	brook trout	S22	*Salvelinus fontinalis*
23	I	R	Lake trout	lake trout	S23	*Salvelinus namaycush*
24	I	R	Interior Dolly varden	int dolly varden	S24	*Salvelinus cortuentus*
25	N	A	Coast Dolly varden	cst dolly varden	S25	*Salvelinus malma*
26	N	R	Cuthroat trout resident	cuthroat resident	S26	*Oncorhynchus clarki*
26.5	N	A	Cuthroat trout winter	cuthroat winter	S26.5	*Oncorhynchus clarki*
27	N	B	Brown trout	brown trout	S27	*Salmo trutta*
28	N	R	Redband trout	redband trout	S28	*Oncorhynchus mykiss*
29	I	R	Volcano Creek golden trout	golden trout	S29	*Oncorhynchus aquabonita*
30	N	R	Rainbow trout resident	rainbow res	S30	*Oncorhynchus mykiss mongrel*
30.1	N	A	Steelhead all	rainbow all	S30.1	*Oncorhynchus mykiss irideus*
30.2	N	A	Steelhead summer	rainbow summer	S30.2	*Oncorhynchus mykiss irideus*
30.5	N	A	Steelhead winter	rainbow winter	S30.5	*Oncorhynchus mykiss irideus*
31	I	A	Arctic grayling	arctic grayling	S31	*Thymalius arcticus*
32	I	R	Carp	carp	S32	*Cyprinus carpio*

Code	Native or Introduced	Fish Range	Common Name	GIS Label	Alternate Name	Scientific Name
33	I	R	Goldfish	goldfish	S33	*Carassius auratus*
34	I	R	Tench	tench	S34	*Tinca tinca*
35	I	R	Golden Shiner	golden shiner	S35	*Notemigenus crysoleucas*
36	I	R	Sacramento blackfish	sac blackfish	S36	*Orthodon microlepidotus*
37	I	R	Hardhead	hardhead	S37	*Mylopharodon conocephalus*
38	I	R	Hitch	hitch	S38	*Lavinia exilicauda*
39	I	R	Sacramento pikeminnow	sac squawfish	S39	*Ptychocheilus grandis*
43	N	R	Tui chub	tui chub	S43	*Gila bicolor*
44	I	R	Arroyo chub	arroyo chub	S44	*Gila orcutti*
48	I	R	California roach	california roach	S48	*Lavinia symmetricus*
49	N	R	Speckled dace	speckled dace	S49	*Rhinicthys osculus*
50	R		Lahontan redside	lahontan redside	S50	*Richardsonius egregius*
51	R		Red shiner	red shiner	S51	*Cyprinella lutrensis*
52	I	R	Fathead minnow	fathead minnow	S52	*Pimephales promelas*
53	I	R	Bigmouth buffalo	bigmouth buffalo	S53	*Ictiobus cyprinellus*
62	I	R	Staghorn sculpin	staghorn sculpin	S62	*Leptocottus armatus*
63	I	R	Slender sculpin	slender sculpin	S63	*Cottus tenuis*
64		R	Prickly sculpin	prickly sculpin	S64	*Cottus asper*
65	N	R	Marbled sculpin	marbled sculpin	S65	*Cottus klamathensis*
66	N	R	Riffle sculpin	riffle sculpin	S66	*Cottus gulosus*
68	I	R	Santa Ana sucker	santa ana sucker	S68	*Catostomus santaanae*
69		R	Mountain sucker	mountain sucker	S69	*Catostomus platyrthynchus*
71	N	R	Klamath smallscale sucker	kla smcl sucker	S71	*Catostomus rimiculus*
73	I	R	Tahoe sucker	tahoe sucker	S73	*Catostomus tahoensis*
74	I	R	Owens sucker	owens sucker	S74	*Catostomus fimeiventris*
75	N	R	Klamath largescale sucker	kla lscl sucker	S75	*Catostomus snyderi*
76	I	R	Sacramento sucker	sac sucker	S76	*Catostomus occidentalis*
77	I	R	Blue catfish	blue catfish	S77	*Ictalurus furcatus*
78	I	R	Channel catfish	channel catfish	S78	*Ictalurus punctatus*
79	I	R	White catfish	white catfish	S79	*Ameiurus catus*
80	I	R	Yellow bullhead	yellow bullhead	S80	*Ameiurus natalis*
81	I	R	Brown bullhead	brown bullhead	S81	*Ameiurus nebulosus*
82	I	R	Black bullhead	black bullhead	S82	*Ameiurus melas*
83	I	R	Flathead catfish	flathead catfish	S83	*Pylodictis olivaris*
85	I	R	Rainwater killfish	rainwt killfish	S85	*Lucania parvu*
88	I	R	California killfish	cal killfish	S88	*Fundulus parvipinnis*
89	I	R	Desert pupfish	desert pupfish	S89	*Cyprinodon macularius*
90	I	R	Owens pupfish	owens pupfish	S90	*Cyprinodon radiosus*
91	I	R	Amargosa pupfish	amarg pupfish	S91	*Cyprinodon nevadensis*
92	I	R	Salt creek pupfish	salt ck pupfish	S92	*Cyprinodon salinus*
93	I	R	Cottonball marsh pupfish	ctn.mars. pupfish	S93	*Cyprinodon milleri*

Code	Native or Introduced	Fish Range	Common Name	GIS Label	Alternate Name	Scientific Name
94	H	R	Mosquito fish	mosquito fish	S94	*Gambusia affinis*
102	H	R	Mississippi silversides	miss silversides	S102	*Menidia audens*
103	N	R	Threespine stickleback	thrp stickleback	S103	*Gasterosteus aculeatus*
104	I	R	Striped bass	striped bass	S104	*Morane saxatilis*
105	I	R	White bass	white bass	S105	*Morane chrysops*
106	I	R	Sacramento perch	sacramento perch	S106	*Archoplites interruptus*
107	I	R	Black crappie	black crappie	Sl07	*Pomoxis nigromaculatus*
108	I	R	White crappie	white crappie	S108	*Pomoxis annularis*
109	I	R	Warmouth	warmouth	S109	*Leponis gulosus*
110	I	R	Green sunfish	green sunfish	S110	*Lepomis cyanellus*
111	I	R	Blue Gill	blue gill	S111	*Lepomis macrochirus*
112	I	R	Pumpkinseed	pumpkinseed	S112	*Lepomis gibbosus*
113	I	R	Redear sunfish	redear sunfish	S113	*Lepomis microlophus*
114	I	R	Largemouth bass	largemouth bass	S114	*Micropterus salmoides*
115	I	R	Spotted bass	spotted bass	S115	*Micropterus punctulatus*
116	I	R	Smallmouth bass	smallmouth bass	S116	*Micropterus dolomieu*
118	I	R	Yellow perch	yellow perch	S118	*Perca flavescens*
123	I	R	Tule perch	tule perch	S123	*Hysterocarpus traski*
128		R	Sharpnose sculpin	sharpnose sculpin	S128	*Clinocottus acuticeps*
129		R	Rough sculpin	rough sculpin	S129	*Cottus asperrimus*
131	N	R	Pit sculpin	pit sculpin	S131	*Cottus pitensis*
132		R	Paiute sculpin	paiute sculpin	S132	*Cottus beldingi*
133		R	Reticulate sculpin	retcula sculpin	S133	*Cottus perplexus*
134	N	R	Blue chub	blue chub	S134	*Gila coerulea*
135	N	R	Shortnose sucker	shortnose sucker	S135	*Chasmistes brevirostris*
136	N	R	Lost River sucker	lost rvr sucker	S136	*Catostomus luxatus*
137	N	R	Sculpin all species	sculpin sp	Sl37	*Cottus sp.*
138	I	R	Pond smelt	pond smelt	S138	*Hypomesus olidus*
139		R	Brook stickleback	brk stickleback	S139	*Culaea inconstans*
140	N	R	Modoc sucker	modoc sucker	S140	*Catostomus microps*
141	N	R	Klamath Lake sculpin	kla lake sculpin	S141	*Cottus princeps*
142	N	R	Klamath River lamprey	kla rvr lamprey	S142	*Lampreta similis*
143	N	R	Coast Range sculpin	cst range sculpin	S143	*Cottus aleuticus*
144	N	R	Kern River Rainbow trout	kern rvr rainbow	S144	*Oncorhynchus mykiss giberti*
145	N	R	Little Kern golden trout	little kern golden	S145	*Oncorhynchus mykiss whitei*
146	N	R	Lahontan cutthroat trout	lahontan cutthroat	Sl46	*Oncorhynchus clarki henshawi*
147			Delta smelt	delta smelt	S147	*Hypomesus transpacificus*
148			Surf smelt	surf smelt	S148	*Hypomesus pretiosus*
149			Topsmelt	topsmelt	S149	*Atherinops affinis*
150			Argentine pearlfish	arg pearlfish	S150	*Cynolebias bellotti*

Code	Native or Introduced	Fish Range	Common Name	GIS Label	Alternate Name	Scientific Name
151			Pacific Herring	pacific herring	S151	*Clupea harengus pallasi*
152			Guppy	guppy	Sl52	*Poecilia reticulata*
153			Green swordtail	grn swordtail	S153	*Xiphophorus helleri*
154			Redeye bass	redeye bass	S154	*Micropterus coosae*
155			Shiner perch	shiner perch	S155	*Cymatogaster aggregata*
156			Tidewater goby	tidewater goby	S156	*Eucyclogobius newberryi*
157			Longjaw mudsucker	longjaw mudsucker	S157	*Gillichthys mirabilis*
158			Arrow goby	arrow goby	S158	*Clevelandia ios*
159			Starry flounder	starry flounder	S159	*Platichthys stellatus*
160			Shortfin Corvina	shortfin corvina	S160	*Cynoscion parvipinnis*
161			Longtail goby	longtail goby	S161	*Ctenogobius sagittula*
162			Grass carp	grass carp	S162	*Ctenopharyngodon idella*
163			Lahontan tui chub	lahontan chub	S163	*Gila bicolor obesa*
164			Sacramento splittail	sac splittail	S164	*Pogonichthys macrolepidotus*
165			Inland silverside	inland silverside	Sl65	*Menidia beryllina*
166			Saltfin molly	saltfin molly	S166	*Poecilia latipinna*
167			Shortfin molly	shortfin molly	S167	*Poecilia mexicana*
168			Yellowfin goby	yellowfin goby	S168	*Acanthogobius flavimanus*
169			Chameleon goby	chameleon goby	S169	*Tridentiger trigonocephalus*
170			Unarmored 3 spine stickleback	unarmored 3 spine	S170	*Gasterosteus aculeatus williamsoni*
171			Barred pipefish	barred pipefish	S171	*Syngnathus auliscus*
172			California halibut	cal halibut	S172	*Syngnathus californicus*
173			Striped mullet	striped mullet	Sl73	*Mugil cephalus*
174			Diamond turbot	diamond turbot	S174	*Hypsopsetta guttulata*

Appendix G – Field Form Instructions and Sample Forms

All Forms

General Header Information:

- Ownership – Applicable land management agency
- District – Forest Ranger District; use applicable name for reaches on non-USFS land.
- Reach # - A five digit code. The first two digits are the forest number and the remaining three digits are sequential over time per forest, starting with 001 for the first reach surveyed.
- Observers – Enter each crew member's first initial and last name.
- Date: Record the single date or all dates each form was used.

Form 1 – Sensitive Reach Location and Layout

General Information:

Form 1 provides the sensitive reach overview. The required data may be recorded during or after the inventory. The sketch is drawn after all reach data have been collected. This form is numbered 1 because once the survey data are in a file it should be the first form to be viewed in order to provide the reader an understanding of the reach.

Take a full quad map along on the survey – it will help with required location features.

Header Information Unique to this Form:

- Stream Classification – Circle the appropriate stream classification that best represents the sensitive reach once the inventory is done. Record both of the classification systems whenever possible (see references).
- Directions to start of sensitive reach – Provide a short written narrative that will allow others to find the start of the sensitive reach. Include a supplemental map in the file if needed.

Data:

Sensitive Reach Layout Information

Record all applicable line items in a given reach using the abbreviation for the specific site (see list of abbreviations on the right side of the form). Record the distance from the start of the sensitive reach to each applicable line item. Record the GPS data for each applicable line item if the reach is being georeferenced.

SSR Data

Record the reference object (tree, boulder, etc.) and the benchmark type. Record the bearing and distance from the BM to the SSR (record bearing in degrees magnetic north. Be sure the compass is set to the correct declination (shown on quad map).

Sensitive reach sketch – Make sure to include all items in the instructions in the sketch box.

Photo Reminder

Photograph all applicable sites.

USDA Forest Service Pacific Southwest Region **Field Form #1**
Stream Condition Inventory (SCI)

Sensitive Reach Location and Layout

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA
Observers: A. DUMOS

Stream: PACIFIC CREEK
A. ANDAZOLA, A. BURNS

Reach #: 17025
Elevation (m) @ SSR: 2360
Date: 7/8-9/2004

Stream Classification:
Rosgen (circle 1 # and 1 letter) - A B [✓ C] D E F G 1 2 3 [✓ 4] 5 6
Montgomery & Buffington (circle 1) - [✓ Response] Transport

Directions to Start of Sensitive Reach (continue on reverse): Drive road 4N01 to trailhead of trail 20E01. Walk about 1/4 mile to stream crossing. SSR is about 150m downstream, near 36" DF on right bank about 25m from stream.

	SSR	0	001	758618	4233193	10
	R1	10	002	758648	4233164	10
	R2	35	003	758697	4233144	10
	R3	57	004	758747	4233147	10
	R4	82	005	758763	2333144	10
	WD1	107	006	758823	4233150	10
	SSS	120	007	758875	4233094	10
	WD2	453	008	758974	4233137	10
	XS1	502	009	759043	4233144	10
	WD3	710	010	759070	4233140	10
11	WD4	765	011	759178	4233177	10
12	XS2	839	012	759228	4233183	10
13	WD5	920	013	759274	4233199	10
14	ESS	1120	014	759333	4233706	10
15	XS3	1231	015	759445	4233216	10
16	ESR	1428	016	759501	4233229	10

SSR - Start of Sensitive Reach
ESR - End of Sensitive Reach
SSS - Start of Survey Segment
ESS - End of Survey Segment
R1 to R4 - Macroinvertebrate Riffles
XS1 - Cross-sections (up to XS3)
WD1 - Width to Depth (up to WD5)
WP# - Way point Number
BM - Benchmark

SSR Data
Reference Object: 36" Doug fir
Benchmark Type: rebar w/yellow cap
Bearing: BM to SSR 97°
Distance: BM to SSR 27.4 m

Note: record bearing in degrees magnetic north.

Sensitive Reach Sketch

Sketch stream pattern and indicate flow direction; show SSR benchmark, bearing and distance; show all applicable site locations and distances from SSR; show north arrow and adjacent location features (roads, trails etc.).

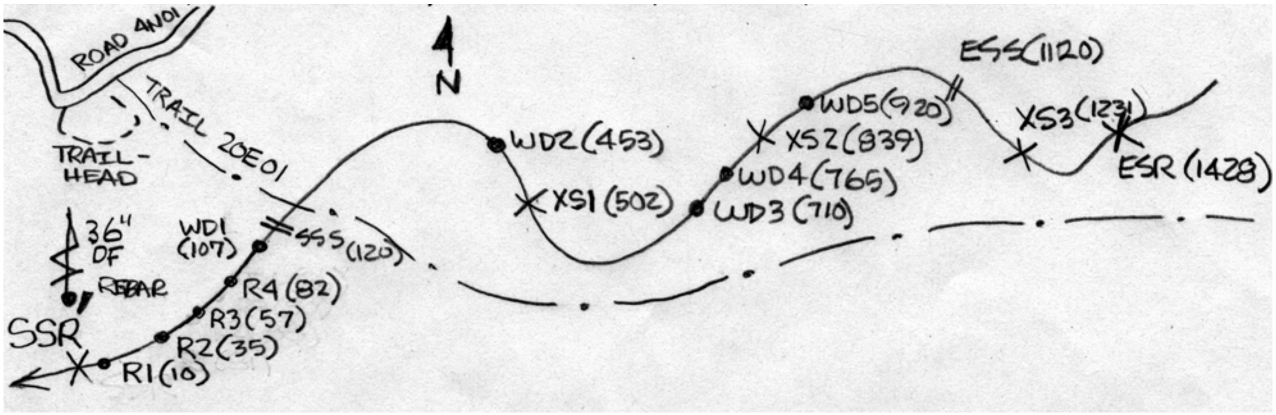


Photo Reminder! Photograph SSR and ESR (up and down stream, left and right bank), and SSS and ESS if there is a survey segment within the sensitive reach. Also photograph from SSR Benchmark to SSR and vice versa. Record on Photo Log (form #10)

Form 2 (Page 1) – Macroinvertebrate Data

General Information:

This form consists of two pages. The first page contains site measurement data and the second page contains sketches of each of the four sample riffles.

Header Information Unique to this Form:

- Type of site - circle either test site (i.e., moderately or heavily managed watershed upstream) or reference site (unmanaged, minimally managed, or recovered watershed).
- Flow regime – circle one. Most streams will be perennial (flowing year round in all or nearly all years). Intermittent streams will have some dry period each year.
- Record the elevation of the riffle sampling area, in meters. To convert feet to meters multiply by .3048.
- Record the latitude and longitude of the riffle areas (in decimals), derived from a GPS unit in the field or by GIS in the office.
- Record sampler mesh size (i.e., 500 microns) and total area sampled (i.e., 8 square feet)

Site Measurements:

Riffle Dimensions and Location:

Note: Riffle 1 is the furthest downstream of the four riffles. The remaining riffles are numbered consecutively progressing upstream.

Record the length of each of the four riffles, along the longest axis of the riffle in the main flow direction of the stream.

Record the width of each riffle along the short axis of the riffle perpendicular to the main flow direction of the stream.

Record the distance from the start of the sensitive reach to the downstream end of the riffle.

Location of Macroinvertebrate Samples:

Record % and distance up from riffle bottom and from left edge.

Water Chemistry:

Record the total alkalinity and conductivity.

Photo Reminder:

Photograph each of the four riffles, viewing upstream. Also photograph an overview of the four-riffle area – upstream from the first riffle and downstream from the fourth riffle. In reaches where the riffles in the four-riffle area are not intervisible (i.e., meanders or vegetation interrupts a continuous view), supplementary photos should be taken so that the entire riffle area can be pictorially depicted.

USDA Forest Service Pacific Southwest Region
Stream Condition Inventory (SCI)

Field Form #2
Page 1 of 2

Macroinvertebrate Data (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA

Observers: A. DUMOS

A. ANDAZOLA, A. BURNS

Stream: PACIFIC CREEK

Reach #: 17025

Date: 7/8-9/2004

Type of Site (circle one): **Test** or [✓ **Reference**] and [✓ **Perennial**] or **Intermittent**

Sampler Type: SURBER

Mesh Size (microns): 500

Total area sampled (ft.^{2}): 8

Site Measurements

Riffle Dimensions and Location	Riffle 1	Riffle 2	Riffle 3	Riffle 4
Length (m)	15	14	10	20
Width (m)	5	4	5	6
Distance form Start of Sensitive Reach	10	35	57	82

Location of Macroinvertebrate Samples	Riffle 1		Riffle 2		Riffle 3		Riffle 4	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
% Up from Riffle Bottom	20	50	30	60	20	70	30	40
Distance Up from Riffle Bottom	3	12	4.2	8.4	2	7	6	8
% from Riffle Left Edge	50	20	70	60	20	30	70	30
Distance from Riffle Left Edge	2.5	1	2.8	2.4	1	1.5	5.6	1.8

Water Chemistry

Total Alkalinity: 51.3 ppm CaC03

Conductivity: 18.6 uS/cm^2

Photo Reminder! Photograph each riffle, looking upstream. Photograph overview of riffle area **-** upstream from 1st riffle, downstream from 4th riffle and other overview photos as desired. Record on Photo Log (form #10).

Field Form #2 - Version 5.0 - July 2005

Form 2 (Page 2) – Macroinvertebrate Sketches

Sketches:

Sketch the following information for each of the four riffles.

- The shape of the riffle to the channel – sketch the location of wetted edge and bankfull in relation to the riffle. Note: the wetted edge should either be at or outside the sketched riffle since macroinvertebrate samples are collected only in the wetted portion of the riffle. For example, if a portion of a riffle is in the wetted width but the edges of the riffle habitat are dry, the sampled portion of the riffle is the wetted part. The wetted part is defined as having depth in the water column – moist substrate lacing water depth is not sampled.
- The main flow direction of the channel and flow across the riffle (flow across riffles is sometime diagonal to the main flow).
- The locations of both macroinvertebrate samples.
- Sidewater features such as runs, edgewater (definitions?)
- Distinguishing features in or near the riffle (large boulders, bedrock, large woody debris, etc.)

USDA Forest Service Pacific Southwest Region **Field Form #2**
Stream Condition Inventory (SCI) **Page 2 of 2**

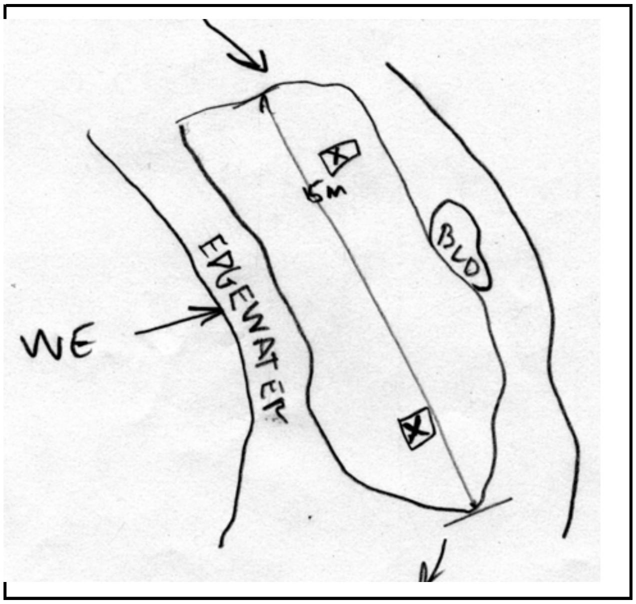
Macroinvertebrate Sketches (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.

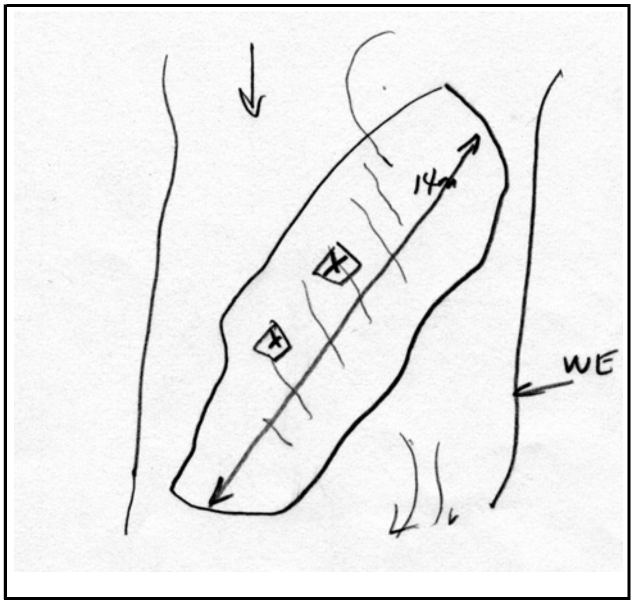
District: HIGH SIERRA	Observers: A. DUMOS
Stream: PACIFIC CREEK	A. ANDAZOLA, A. BURNS
Reach #: 17025	Date: 7/8-9/2004

Sketch each riffle (show shape relative to channel, location of sample points and any other key features).

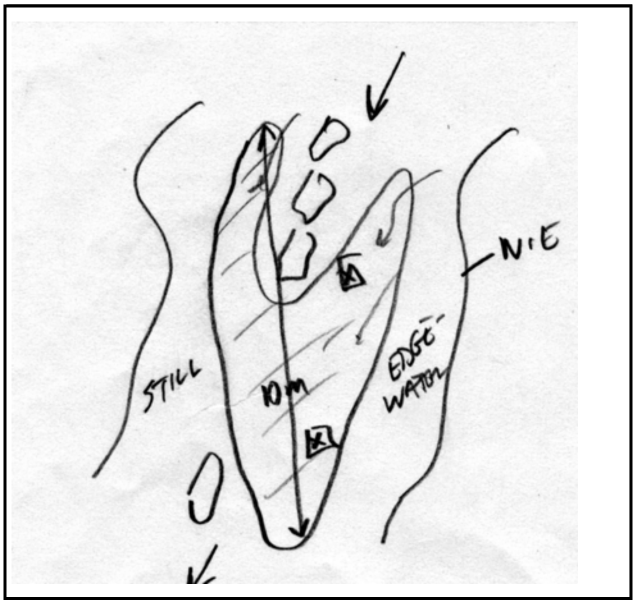
Riffle 1



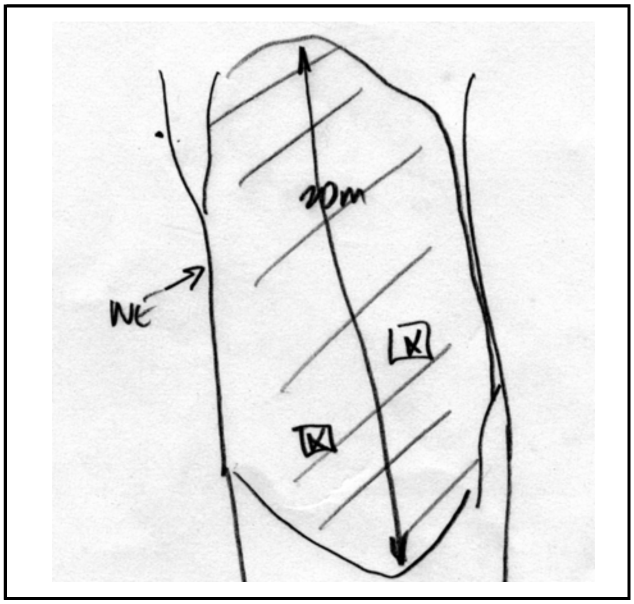
Riffle 2



Riffle 3



Riffle 4



Form 3 – Particle Count

Streambed Particle Count:

Record 100 particles in each of the four riffles sampled for macroinvertebrates. If macroinvertebrates are not sampled, riffles should still be selected per protocol instructions so that the particle count can be conducted.

Layout 10 systematically spread transects across each riffle between bankfull on both banks.

- Collect 10 evenly spaced particles along each transect. The minimum spacing between particles must be greater than the largest diameter particle in the riffle. (Note: where an anomalously large particle is present use the largest dominant particle size in the riffle. For example, if a riffle is 70% gravel and 30% cobble but has one very large boulder, use the largest cobble as the minimum spacing guide).
- Record each particle by size class shown on the form as either “wet” (within the wetted area) or “dry” (between wetted edge and bankfull stage). “Wet” is defined as the portion of the stream that has depth in the water column. “Dry” is defined as not having water column depth, (including moist substrate without water depth).

  It is strongly recommended that a gravel template be used. For particles larger than 180 mm or any particles that cannot be picked up, use the gravel template or a metric ruler to estimate the particle size class. Do not avoid particles than cannot be picked up – they must be included in the count if they are encountered along each transect. Circle all estimated particle sizes.
- On the bottom line of the form tally the count in each column to insure that 100 particles have been counted in each riffle.
- On the right two columns of the form sum the number of wet and dry particles for all four riffles for each particle size class.

USDA Forest Service Pacific Southwest Region **Field Form #3**
Stream Condition Inventory (SCI)

Particle Count (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.
District: HIGH SIERRA
Observers: A. DUMOS
A. ANDAZOLA, A. BURNS
Stream: PACIFIC CREEK
Reach #: 17025
Date: 7/8-9/2004

Particle Size Class			Streambed Particle Count									
			Riffle 1		Riffle 2		Riffle 3		Riffle 4		Row Sum	
	mm	Class	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Fines	< 2	1									4	15
Gravels	2 - 2.8	2									13	11
	2.8 - 4	3									18	7
	4 - 5.6	4									30	9
	5.6 - 8	5									38	8
	8.0 - 11	6									29	15
	11 - 16	7									29	6
	16 - 22.6	8									34	5
	22.6 - 32	9									18	8
	32 - 45	10									34	6
	45 - 64	11									18	3
Cobbles	64 - 90	12									13	0
	90 - 128	13									13	4
	128 - 180	14									6	3
	180 - 256	15									2	1
Boulders	256 - 512	16										
Bedrock	> 512	17										
Column Tally											Total Wet 299	Total Dry 101
											Total	400

Note: Circle all estimated values.

Field Form #3 - Version 5.0 - July 2005

Form 4 – Cross-section and Width-to-depth Candidate Sites and Large Woody Debris (LWD)

Candidate Sites:

Progressing along the sensitive reach, enter the number of the survey flag and the distance from the start of the sensitive reach for each candidate site (i.e., 1@78 m, 2@140 m). Record this information on lines 1 and 2. (Candidate sites are fast water habitat units in straight sections typical of the sensitive reach).

When all candidate sites have been identified at the end of the sensitive reach, randomly select three of the sites for cross-section locations. Record the selected sites on line three by placing a number for each selected site, starting with the site nearest the start of the sensitive reach (i.e., 1@502 m, 2@839 m, 3@1231 m).

If there are more than three candidate sites, select up to five for conducting width-to-depth and entrenchment ratio measurements. If there are more than five to choose from, select them randomly. If fewer than five, number them sequentially starting at the site nearest the start of the sensitive reach (i.e., 1@207 m, 2@453 m).

The designation of the selected sites establishes the order of measurements in the next survey pass.

Bankfull Width:

Enter the estimated bankfull width for the reach. The estimate should represent the average for the reach, with bankfull widths having been observed at several locations during the reconnaissance pass. Find a typical width site and measure it – do not visually estimate it because it can be different enough from a measured value to affect the length, and thus the amount, of the LWD tallied for the reach.

Minimum Debris Length:

Divide bankfull width by two to determine the minimum length to be counted.

Woody Debris Tally:

Single Pieces:

Progressing along the sensitive reach, dot or mark-tally each individual piece of woody debris that meets the minimum length of ½ bankfull width. Sum the total number of single pieces at the end of the sensitive reach.

Aggregate Tally:

Tally pieces that are part of an aggregate. (An aggregate is four or more pieces contacting one another with each piece meeting the minimum length). Remember to count only those pieces in an aggregate that are at least the minimum length – some pieces in aggregates are shorter and are not counted.

Record the number of pieces in each aggregate in the space provided (i.e., 5, 12). Sum the total number of pieces in aggregates at the end of the sensitive reach.

Root Wad Tally:

Enter a tally mark or dot for each root wad encountered in the sensitive reach.

Identification of Survey Segment:

Enter the sensitive reach length (A). If A > 1,000 m subtract 1,000 (B) and randomly select a number between 0 and B (C). Enter survey segment start and end-points (D).

USDA Forest Service Pacific Southwest Region **Field Form #4**
Stream Condition Inventory (SCI)

Cross-section and Width-to-depth Candidate Sites and Large Woody Debris (LWD) (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA	Observers: A. DUMOS
Stream: PACIFIC CREEK	A. ANDAZOLA, A. BURNS
Reach #: 17025	Date: 7/8-9/2004

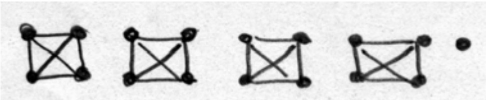
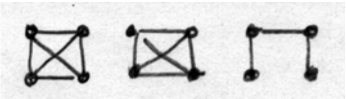
Candidate Sites (randomly select 3 x-section sites and up to 5 W/D sites)

Candidate Site #	1	2	3	4	5	6	7	8	9	10			
Distance from SR Start	82	107	211	453	502	710	765	839	920	1231			
Selected x-section #					1			2		3			
Selected W/D #		1		2		3	4		5				

Woody Debris Tally (Dead and Downed Wood)

Bankfull Stage Width: 8 m Min. Debris Length (=1/2 average bankfull width): 3 m

Number of Pieces

Single	**Aggregate**[1]
	
	Number of pieces in each aggregate: 8, 4, 15
Sum of Single Pieces: 41	Sum of Aggregate Pieces: 27

1 - An aggregate is 4 or more pieces of connected woody debris that are each greater than 1/2 bankfull width.

Number of Rootwads[2]	Tally: 	Sum: 4

2 - A root wad is the base of a tree whose bole is about the same length or shorter than the diameter of the root mass.

Identification of Survey Segment

A.	Sensitive Reach Length (m) 1428 B. A minus 1000m 428 (if A is greater than 1000m)
C.	Random # between 1 and B 120
D.	Survey Segment lies between C (Survey Segment Start) 120 and 1000+C (Survey Segment End) 1120

Comments:

Field Form #4 - Version 5.0 - July 2005

Form 5 – Cross-section Data and Water Surface Gradient

Note: bankfull stage cross-sectional area should be consistently similar at all cross-section and width-to-depth sites in the reach. If not, bankfull stage may not have been correctly identified at some sites. Compare the bankfull stage cross-sectional area measurements in the field as each site is measured to assure consistency. Width and mean depth will vary from site to site but the cross-sectional area should be similar.

Header Information Unique to this Form:

- Cross-section # - Record a 1, 2 or 3 as noted on Form 4.
- Distance from start of sensitive reach – Record distance as noted on Form 4.
- String Height (distance below top of pin) – record the distance below the top of the left and right pin that the level-string is attached, to the nearest .01 m. (It does not have to be the same on both pins). This data is essential for future cross-section remeasurement.

Cross-section Data:

Distance from Station Start

This is the horizontal distance from the left pin, facing downstream. The LP is always zero.

Total Depth

This is the vertical distance down from string height to ground surface (both in and out of water). Note that if the string line is established above ground level on the left or right pin the total depth will be greater than zero. (The total depth may be different on each pin).

Bankfull Depth

Enter the depth from bankfull stage to ground surface. It is the difference between total depth and bankfull depth.

Undercut Width

Record the depth at the top and bottom of undercut banks and measure enough undercut widths to depict the undercut shape. Record the undercut widths at each undercut depth measured. See cross-section diagram on sample Form 6 and SCI Figure 1 for illustrations.

Water Surface Gradient

Refer to the Water Surface Gradient protocol for instructions.

Width-to-depth Ratio

From cross-section data table, enter bankfull width in A. Calculate mean bankfull depth from bankfull depth column in the cross-section data table and enter in B. Calculate mean bankfull depth by summing all bankfull depth measurements and dividing by the number of measurements plus 1 to average both “0” depth end-points. Calculate the width-to-depth ratio by dividing A by B and record in the bottom line of the box.

Entrenchment Ratio

Record bankfull width and maximum bankfull depth (thalweg) in A and B. Calculate C. Measure the width at this depth (2x maximum bankfull depth) and enter in D. Measure using a tape, or by pacing in wide valleys where measurement is difficult. Do not visually estimate – it can be substantially inaccurate. Calculate entrenchment ratio by dividing D by A and record in the bottom line of the box.

Photo Reminder

Take photos as required on the bottom of this form. Log on Form 10.

USDA Forest Service Pacific Southwest Region **Field Form #5**
Stream Condition Inventory (SCI)

Cross-section Data and Water Surface Gradient (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA	Observers: A. DIMOS
Stream: PACIFIC CREEK	A. ANDAZOLZ, A. BURNS
Reach #: 17025	Date: 7/8-9/2004
Cross-section #: 1	Distance From Start of Sensitive Reach: 502 m

String height distance below top of: LP 0.05 RP 0.05 (cm)

Cross Section Data

Dist. From Station Start	Total Depth	Bankfull Depth	UCW	Notes*
0	0.04			LP
1.0	0.22			
2.0	0.50			
3.0	0.63			
4.0	0.80			
5.0	0.91			
6.0	0.93			
7.0	0.95			
8.0	1.00	0		BFL
8.2	1.10		0	TUC
8.0	1.20		0.20	
7.9	1.40		0.30	WEL
8.0	1.60		0.20	
8.2	1.70	0.70	0	BUC
9.0	1.80	0.80		T
10.0	1.75	0.75		
11.0	1.65	0.65		
12.0	1.60	0.60		
13.0	1.50	0.50		
14.0	1.40	0.40		WER
15.0	1.25	0.25		
16.0	1.00	0		BFR
17.0	0.95			
18.2	0.91			
19.5	0.83			
20.5	0.60			
22.0	0.20			
23.0	0.08			RP

Gradient

		Set Up	Set Up	Set Up
	Downstream End	1	2	3
a.	Instrument or Rod Height	2.25	1.50	
b.	Water Surface Height	0.25	0.10	
A.	a minus b	2.00	1.40	
	Upstream End	1	2	3
c.	Instrument or [✓ Rod Height]	1.55	1.00	
d.	Water Surface Height	0.20	0.20	
B.	c minus d	1.30	0.90	
C.	Elevation Change A to B	0.70	0.50	
	Length (downstream-upstream)	80	40	
	Total Elevation Change =		1.20	
	Total Length =		120	
	Gradient = Total Elevation Change/Total Length X 100 = %	1.00%		

Width to Depth Ratio

A.	Bankfull Width	8.0
B.	Mean Bankfull Depth	0.52

Width:Depth Ratio = A/B

Width: Depth Ratio = 15.4

Entrenchment

A.	Bankfull Width	8.0
B.	Maximum Bankfull Depth	0.8
C.	2 x Max Bankfull Depth	1.6
D.	Width at C	21.0

Entrenchment Ratio = D/A

Entrenchment Ratio = 2.6

*Notes: Enter These Only….

BFL = Bankfull Stage Left
BFR = Bankfull Stage Right
WEL = Water's Edge Left
WER = Water's Edge Right
LP = Left Pin
RP = Right Pin
T = Thalweg
TUC = Top of Undercut
BUC = Bottom of Undercut
UCW = Undercut Width

Photo Reminder! Photograph cross-section facing upstream, downstream, left and right bank. Photograph from BM to LP and RP, and LP and RP to BM. Photograph natural features that help site reference.

Field Form #5 - Version 5.0 - July 2005

Form 6 – Cross-section Diagram and Location Sketch

Header Information Unique to this Form:

- Cross-section # - Record a 1, 2, or 3 as noted on Form 4.
- Distance from start of sensitive reach – record distance as noted on Form 4.

Cross-section Diagram:

After recording the cross-section measurements on Form 5, diagram the cross-section on this form before removing the cross-section set-up in the field. If Form 5 data are not recorded accurately the sketch will appear incorrect. If so, this allows correction of cross-section measurements while the site is still set up.

The sketch template on this form allows scale flexibility for the vertical and horizontal axes. Note the left and right bank indicators above the template.

Cross-section Location Sketch:

Sketch the cross-section site area, recording all features noted in the top of the sketch template. In addition, record all requested information in the boxes below the sketch.

USDA Forest Service Pacific Southwest Region **Field Form #6**
Stream Condition Inventory (SCI)

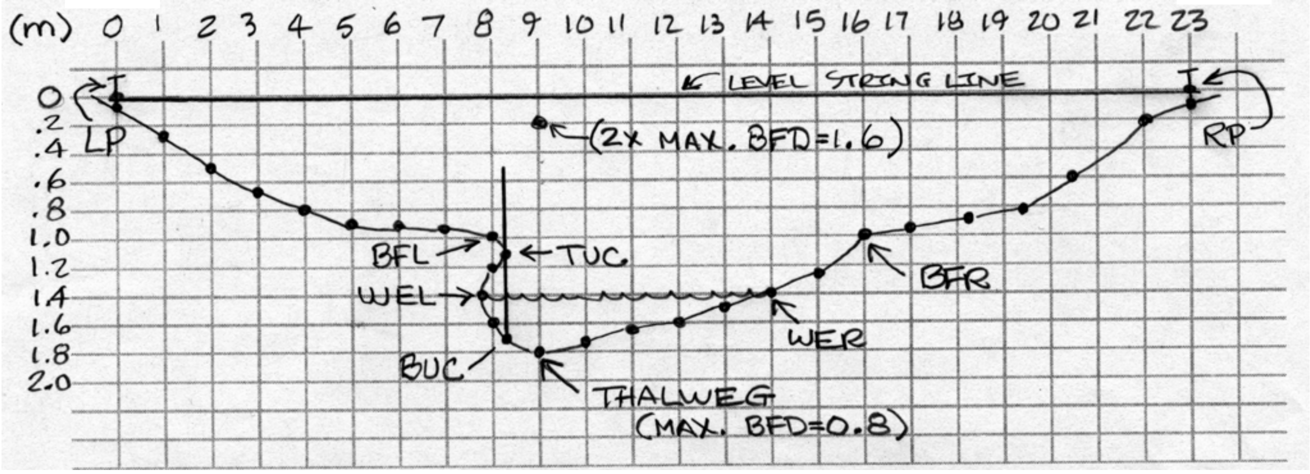
Cross-section Diagram and Location Sketch (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA	Observers: A. DUMOS
Stream: PACIFIC CREEK	A. ANDAZOLA, A. BURNS
Reach #: 17025	Date: 7/8-9/2004
Cross Section #: 1	Distance From Start of Sensitive Reach: 502 m

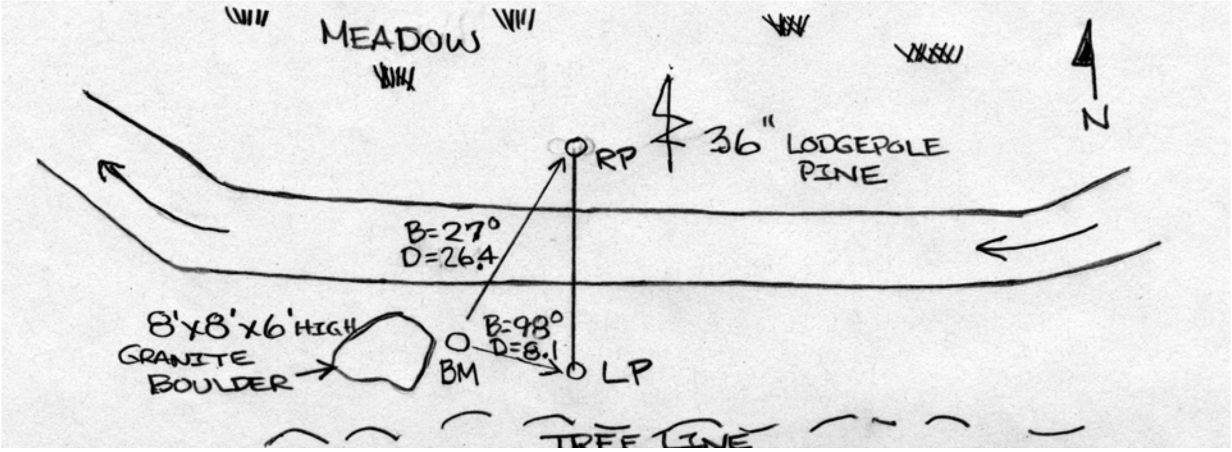
Cross-section Diagram

Left Bank Right Bank



Cross-section Location Sketch

Sketch stream channel and flow direction; benchmark location, left and right pin location, north arrow, and natural features that help ID site (i.e., large boulders or large trees). Record benchmark and pin data below sketch. Record bearings in degrees magnetic north.



BM Type: rebar w/yellow cap	Bearing: BM To LP 98^0	Distance: BM to RP 26.4 m	BM: UTME 759043
LP Type: rebar w/yellow cap	Distance: BM to LP 8.1 m	Distance: LP to RP 23.0 m	BM: UTMN 4233144
RP Type: rebar w/yellow cap	Bearing: BM To RP 27^0	BM: Way pt.# 009	BM: Zone 10

Measurements in Metric Units *Field Form #6 - Version 5.0 - July 2005*

Form 7 – Width-to-depth Ratio and Entrenchment Ratio

Note:

Bankfull stage cross-sectional area should be consistently similar at all cross-section and width-to-depth sites in the reach. If not, bankfull stage may not have been correctly identified at some sites. Compare the bankfull stage cross-sectional area measurements in the field as each site is measured to assure consistency. Width and mean depth will vary from site to site but the cross-sectional area should be similar.

Measurements:

<u>Width-to-depth #:</u>

Record the number of the site as noted on Form 4.

<u>Distance from SSR:</u>

Record the distance of this site from the start of the sensitive reach as noted on Form 4.

<u>Distance from BFL:</u>

Once bankfull stage has been located, begin measurements of width and bankfull depth starting at the left bank. Record these measurements to the nearest .01 m.

Be sure to record the locations of all the abbreviations in the notes below the measurement tables.

Calculations:

<u>Bankfull Width:</u>

Record the last number in the “Dist from BFL” in the measurement table.

<u>Mean Bankfull Depth:</u>

Sum all depth measurements and divide by the number of measurements plus 1. (The “plus 1” is to account for the depth between both end and next-to-end stations in the Bankfull depth column). Where multiple thread channels are encountered, sum the depths in all channels and divide by the number of measurements, plus the number of channels (e.g., two for double thread, three for triple thread).

<u>Floodprone Area Width:</u>

At a height twice the maximum bankfull stage depth, measure the valley width until ground surface is encountered. Take measurement with a level tape. Where the width is so great that a tape is not practical make a paced estimate. Avoid making a visual estimate since that is often substantially inaccurate.

<u>W/D Ratio:</u>

Calculate the ratio by dividing A by B.

<u>Entrenchment Ratio:</u>

Calculate the ratio by diving C by A.

USDA Forest Service Pacific Southwest Region **Field Form #7**
Stream Condition Inventory (SCI) **Page___of___**

Width-to-depth Ratio and Entrenchment Ratio (collected from sensitive reach)

Forest/National Park/Other Ownership: TAHOE N.F.
District: HIGH SIERRA Observers: A. DUMOS
Stream: PACIFIC CREEK A. ANDAZOLA, A. BURNS
Reach #: 17025 Date: 7/8-9/2004

Measurements

Width-to-Depth #: 1			Width-to-Depth #: 2			Width-to-Depth #:		
Distance From SSR: 107			Distance From SSR: 453			Distance From SSR:		
Dist from BFL	Bankfull Depth	Notes[1]	Dist from BFL	Bankfull Depth	Notes[1]	Dist from BFL	Bankfull Depth	Notes[1]
0	0	BFL	0	0	BFL			
0.10	0.46		0.15	0.46				
0.35	0.56	WEL	0.35	0.50	WEL			
1.00	0.70		1.10	0.60				
1.50	0.65		1.60	0.65				
2.00	0.71		2.00	0.61				
2.50	0.73		2.55	0.70				
3.00	0.69		3.10	0.59				
3.50	0.67		3.45	0.62				
4.00	0.69		4.10	0.63				
4.85	0.76	T	4.85	0.66				
5.00	0.74		5.30	0.71				
5.50	0.57		5.55	0.55	T			
6.00	0.66		6.15	0.60				
6.40	0.56	WER	6.40	0.56				
6.75	0.36		6.80	0.36	WER			
7.00	0.20		7.05	0.25				
7.30	0.15		7.50	0.22				
7.45	0	BFR	7.95	0.20				
			8.10	0.15				
			8.55	0.05				
			8.75	0	BFR			

Calculations

A Bankfull Width	7.45	A Bankfull Width	8.75	A Bankfull Width	
B Mean Bankfull Depth[2]	0.55	B Mean Bankfull Depth[2]	0.46	B Mean Bankfull Depth[2]	
C Floodprone Area Width[3]	18.5	C Floodprone Area Width[3]	23.5	C Floodprone Area Width[3]	
W/D Ratio = A/B	13.51	W/D Ratio = A/B	19.02	W/D Ratio = A/B	
Entr. Ratio = C/A	2.5	Entr. Ratio = C/A	2.7	Entr. Ratio = C/A	

[1] Notes: BFL= Bankfull Stage Left, BFR = Bankfull Stage Right, WE = Water's Edge, T = Thalweg, UC = Undercut Bank

[2] Mean Bankfull Stage Depth = Sum of Depths/Number of Depths + 1

[3] Total distance at 2 times maximum bankful stage depth.

Field Form #7 - Version 5.0 - July 2005

Form 8 – Pools and Pool Tail Surface Fine Sediment

Note:

Record all applicable measurements within the survey segment only. Do not record data for any portion of a fast or slow water habitat unit that extends upstream or downstream of the survey segment, whether the segment is shorter or longer than 1,000 m. For example, if a survey segment begins 15 m upstream from the start of a 30 m fast water unit, record only the 15 m length that is within the survey segment. If the survey segment begins 15 m upstream of the start of a 30 m slow water unit, record the 15 m of the pool that lies within the segment and record any of the other pool features that lie within the survey segment part of the pool. In this case, the pool tail crest would not be within the segment, and the maximum pool depth and, if present, a wood-formed feature may or may not lie within the survey segment. If a survey segment ends in a portion of a fast or slow water unit, again record only the data for the portion of the unit that lies within the survey segment.

Habitat Measurements:

Station Start, End and Unit Length:

Begin recording the first habitat unit as zero and measure the distance upstream to the end of the habitat type. Record that distance as well as the length of the unit. For example, 0 to 13.8 m is the start and end of the unit and thus the unit length is 13.8 m. The start of the next unit begins with the same number as the end of the previous unit (13.8 m in this case), and if the end of this second unit is 25.9 m then the unit length is 12.1 m. Continue measuring and recording habitat types until the end of the survey segment is reached. This will be 1,000 m if the sensitive reach exceeds that length, or less than 1,000 m if the sensitive reach is shorter than that length.

Pool Depth Measurements:

Locate the maximum depth of the pool with the depth rod and record it to the nearest .01 m (e.g., .97 m). Locate the deepest point across the crest of the pool tail (the thalweg) and record that depth as the pool tail crest depth to the nearest .01 m.

Wood formed?

Record a “Y” if wood is a factor in pool formation. This can be at the tail or head of the pool. Record an “N” if wood is not a factor in pool formation.

Pool Tail Fine Sediment Measurements:

Throw the grid at the three locations described and illustrated in the protocol. If the stream is too small for three throws, do two throws, or even one if only one will fit in the pool tail area. Do not overlap tosses in any case because it may recount particles. For each throw, count how many times fines (2 mm or less) are encountered at the 50 intersections on the grid. Multiply by 2 (”Points x2” as shown on the form) and enter that number in the column for that throw. Note that the fines count on the form must always be an even number.

If the grid toss is impossible due to vegetative or other obstructions at the pool tail, conduct a particle count in the pool tail area as described in the protocol. Enter the actual number of fines encountered in the Throw 1 column.

In any case where fewer than three columns are used to record pool tail substrate, enter an N/A in the remaining column(s) to verify that no data were collected. Do not leave a blank column.

USDA Forest Service Pacific Southwest Region **Field Form #8**
Stream Condition Inventory (SCI)

Pools and Pool Tail Surface Fine Sediment (collected from survey segment)

Forest/National Park/Other Ownership: TAHOE N.F.
District: HIGH SIERRA
Observers: A. DUMOS
A. ANDAZOLA, A. BURNS
Stream: PACIFIC CREEK
Reach #: 17025
Date: 7/8-9/2004

Habitat Measurements							Pool Tail Fine Sediment		
Habitat Type	Station Start[1]	Station End[1]	Habitat Unit Length	Max. Depth[2]	Pool Tail Crest Depth[2]	Wood Formed ?	Throw 1 Points x2	Throw 2 Points x2	Throw 3 Points x2
Fast	0	25.5							
Slow	25.5	36.5	11	0.61	0.11	N	12	4	6
Fast	36.5	70							
Slow	70	87	17	0.89	0.20	N	10	6	14
Fast	87	143.5							
Slow	143.5	165	21.5	1.12	0.22	Y	10	32	26
Fast	165	181							
Slow	181	190	9	0.78	0.13	N	14	18	14
Fast	190	199.5							
Slow	199.5	203	3.5	0.49	0.10	N	2	4	12
Fast	203	240							
Slow	240	254	14	0.83	0.14	N	4	2	10
Fast	254	281							
Slow	281	302.5	33.5	1.07	0.21	N	14	12	2
Fast	302.5	320							
Slow	320	330	10	0.94	0.17	Y	30	24	8
Fast	330	378							
Slow	378	386	8	0.45	0.12	N	44	20	8
Fast	386	429							
Slow	429	454	25	1.14	0.22	Y	4	14	0
Fast	454	515							
Slow	515	524	9	0.65	0.13	N	12	10	0
Fast	524	568.5							
Slow	568.5	576.5	8	0.63	0.13	N	6	0	10
Fast	576.5	630							
Slow	630	641	11	0.67	0.10	N	2	8	12
Fast	641	680							
Slow	680	703	25	1.52	0.20	N	32	22	24
Fast	703	763							
Slow	763	778.5	15.5	1.28	0.20	N	12	20	20
Fast	778.5	810							
Slow	810	828	18	0.81	0.15	N	20	8	0
Fast	828	879							
Slow	879	888	9	0.79	0.16	Y	4	10	18
Fast	888	925							
Slow	925	951	26.5	1.31	0.19	N	8	10	16
Fast	951	1000							

[1] Measurements are to the nearest 0.1 m (e.g. 3.6 m)

[2] Measurements are to the nearest 0.01 m (e.g. 3.65 m)

Note: Circle all estimated values.

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Form 9 – Streambank Stability, Stream Shading, Streamshore Water Depth, Streambank Angle and Aquatic Fauna

General Information:

Form 9 is a two-page form where all SCI “transect data” are measured and recorded in the survey segment only. All measurements are conducted at 50 evenly spaced transects within the survey segment. Note that streambank angle and streamshore water depth are measured only on streams where the gradient is less than 2% and the stream has fine textured streambanks.

Header Information Unique to this Form:

On the line provided, record the interval between transects to the nearest meter. The interval will be 20 m for all sensitive reaches 1,000 m or longer. The interval will be less if the sensitive reach is shorter than 1,000 m. For example, if the sensitive reach is 800 m the interval between transects will be16 m.

Transect Data

Streambank Stability:

Enter code 1, 2, or 3 for the left and right banks at each transect (see codes at the bottom of the form).

Stream Shading:

Enter percent shade using the August path on the Solar Pathfinder. Remember to take the measurement at mid-wetted width of the stream about 0.3 m above the water surface.

Streamshore Water Depth:

Measure the depth at the shoreline on the left and right banks. Record the depth as zero if the bank angle is greater than 90 degrees.

Streambank Angle:

Measure the dominant angle of both the left and right banks. See the protocol for definition of “dominant angle.”

Aquatic Fauna:

Be observant for aquatic fauna while approaching each transect. Note any fauna observed at or close to each transect. Record fauna by species code as listed in Appendices C (herptofauna) and D (fish). Aquatic fauna noted during other survey passes should be recorded on Form 10 under comments.

USDA Forest Service Pacific Southwest Region **Field Form #9**
Stream Condition Inventory (SCI) **Page 1 of 2**

Streambank Stability, Stream Shading, Streamshore Water Depth, Streambank Angle and Aquatic Fauna (collected from survey segment)

Forest/National Park/Other Ownership: TAHOE N.F.
District: HIGH SIERRA
Observers: A. DUMOS
A. ANDAZOLA, A. BURNS
Stream: PACIFIC CREEK
Reach #: 17025
Date: 7/8-9/2004
Transect Interval (m): 20

Bank	L	R	L	R	L	R	L	R	L	R
Transect #	1		2		3		4		5	
Stability Rating[1]	1	3	1	1	1	3	2	1	1	1
Shading[2]	24		17		38		19		16	
Shore Depth[3]	0.26	0	0	0.33	0	0	0	0.09	0.17	0
Bank Angle[4]	80	120	110	75	122	160	115	83	73	126
Aquatic Fauna[5]	RAMU-1 ADULT									
Transect #	6		7		8		9		10	
Stability Rating	1	1	1	1	1	1	1	1	1	1
Shading	10		6		5		5		5	
Shore Depth	0	0	0.41	0.03	0.17	0.25	0	0	0	0
Bank Angle	155	110	80	68	75	90	120	125	110	103
Aquatic Fauna			RAMU-12 TADS		THSI-1 ADULT					
Transect #	11		12		13		14		15	
Stability Rating	2	3	1	1	1	1	3	1	1	1
Shading	5		6		4		9		10	
Shore Depth	0.3	0	0.45	0	0	0	0	0	0	0
Bank Angle	85	140	55	150	120	103	93	117	103	91
Aquatic Fauna										
Transect #	16		17		18		19		20	
Stability Rating	1	1	1	1	2	3	1	1	1	1
Shading	6		7		17		8		9	
Shore Depth	0	0	0	0	0	0.26	0	0.17	0	0.31
Bank Angle	170	101	160	98	110	58	113	85	125	90
Aquatic Fauna									26-1 ADULT	
Transect #	21		22		23		24		25	
Stability Rating	1	1	3	3	1	1	1	1	1	1
Shading	14		28		35		17		10	
Shore Depth	0.07	0	0.24	0	0	0	0	0	0	0
Bank Angle	81	120	83	122	150	99	170	103	120	118
Aquatic Fauna										

1 - Stability Rating: #1 >75% cover, #2 >75% cover with instability elements (cracking, bank failure, etc.), #3 <75% cover.
2 - Record to nearest percent (i.e., 38)
3 - Record only on reaches with gradient < 2%, to nearest 0.01 m (i.e., 0.12). If bank angle is > 90 degrees, shore depth is zero.
4 - Record only on reaches with gradient < 2%, to nearest degree (i.e., 75, 120)
5 - Record 4-character code for herptofauna (Apx. E) and numeric code for fish (Apx. F). Put remarks on Form 10.

Note: circle all estimated values.

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Form 10 – Sensitive Reach Photo Log and Comments

General Information:

Record photos and comments sequentially throughout the survey. For example, the sample form lists and describes photos 1-6 at the start of the sensitive reach. The next item is a comment regarding an amphibian sighting where no photos could be taken before the individuals disappeared. Denote comments in the left column with either a “C” or “—“ to show no photo was taken. Where comments are made that are suitable for a non-required photo, record both the photo number and the comment.

Photo Log:

Record all the required, optional or additional photos taken along the sensitive reach. Photos are required while filling out forms 1, 2, and 5 (see the bottom of each of those forms). Optional photos may be taken while filling out these same forms as well. Additional photos that help characterize the reach are recommended.

Note the camera type (35 mm, digital, etc.) and the roll #, if applicable, in the spaces provided.

List and describe each photo taken. For example, the four required photos at the start of the sensitive reach could be listed as #1 – Upstream at SSR, #2 – Left bank at SSR, etc.

The objective is to record all photos taken so that they can be matched to the data file. This is both a field and office follow-up task requiring adequate attention to detail. Photos are a key element of the survey because they not only depict stream features but they can be retaken at intervals over time to denote changes in stream condition.

Digital cameras can make the job easier and more difficult at the same time. More photos are likely to be taken but careful description of the site at which each photo is taken must be carefully recorded in the field to match with the photo in the office after the survey. Make sure to catalog all photo sites as soon as possible after returning to the office.

While still photos are required, video recording of the reach may also be done. It has the advantage of audio if the recorder wishes to describe features along the reach.

Comments:

Observations may be made during the survey that cannot be recorded on Forms 1-9 due to space limits, etc. Other useful observations may not relate to forms but should be recorded. Use Form 10 for both cases. It is important to note as much as reasonably feasible.

Describe comments by noting location, date, applicable, form(s), etc. Make sure to clearly describe all observations.

USDA Forest Service Pacific Southwest Region
Stream Condition Inventory (SCI)

Field Form #10
Page___of___

Photo Log and Comments

Forest/National Park/Other Ownership: TAHOE N.F.

District: HIGH SIERRA

Observers: A. DUMOS
A. ANDAZOLA, A. BURNS

Stream: PACIFIC CREEK

Reach #: 17025

Date: 7/8-9/2004

Camera Type: DIGITAL

Roll # (optional): ~~

Photo #/ Comment	Description
1	SSR - FROM LEFT BANK
2	SSR - FROM RIGHT BANK
3	SSR - UPSTREAM VIEW
4	SSR - DOWNSTREAM VIEW
5	SSR - FROM BENCHMARK TO SSR
6	SSR - FROM SSR TO REFERENCE OBJECT & BENCHMARK
C	2 adult mountain yellow legged frogs observed
	15 meters upstream from SSR
7	R1 - UPSTREAM VIEW
8	R2 - UPSTREAM VIEW
9	R3 - UPSTREAM VIEW
10	R4 - UPSTREAM VIEW
11	OVERVIEW OF RIFFLE 1 & 2, LOOKING UPSTREAM
12	OVERVIEW OF RIFFLE 3 & 4, LOOKING UPSTREAM
13	SSS - UPSTREAM VIEW
14	SSS - FROM LEFT BANK
15	XS1 - UPSTREAM VIEW
16	XS1 - FROM LEFT BANK
17	XS1 - FROM RIGHT BANK
18	XS1 - DOWNSTREAM VIEW
19	Abandon car ('58 Ford) observed near right bank 20 meters
	upstream from cross-section 1

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