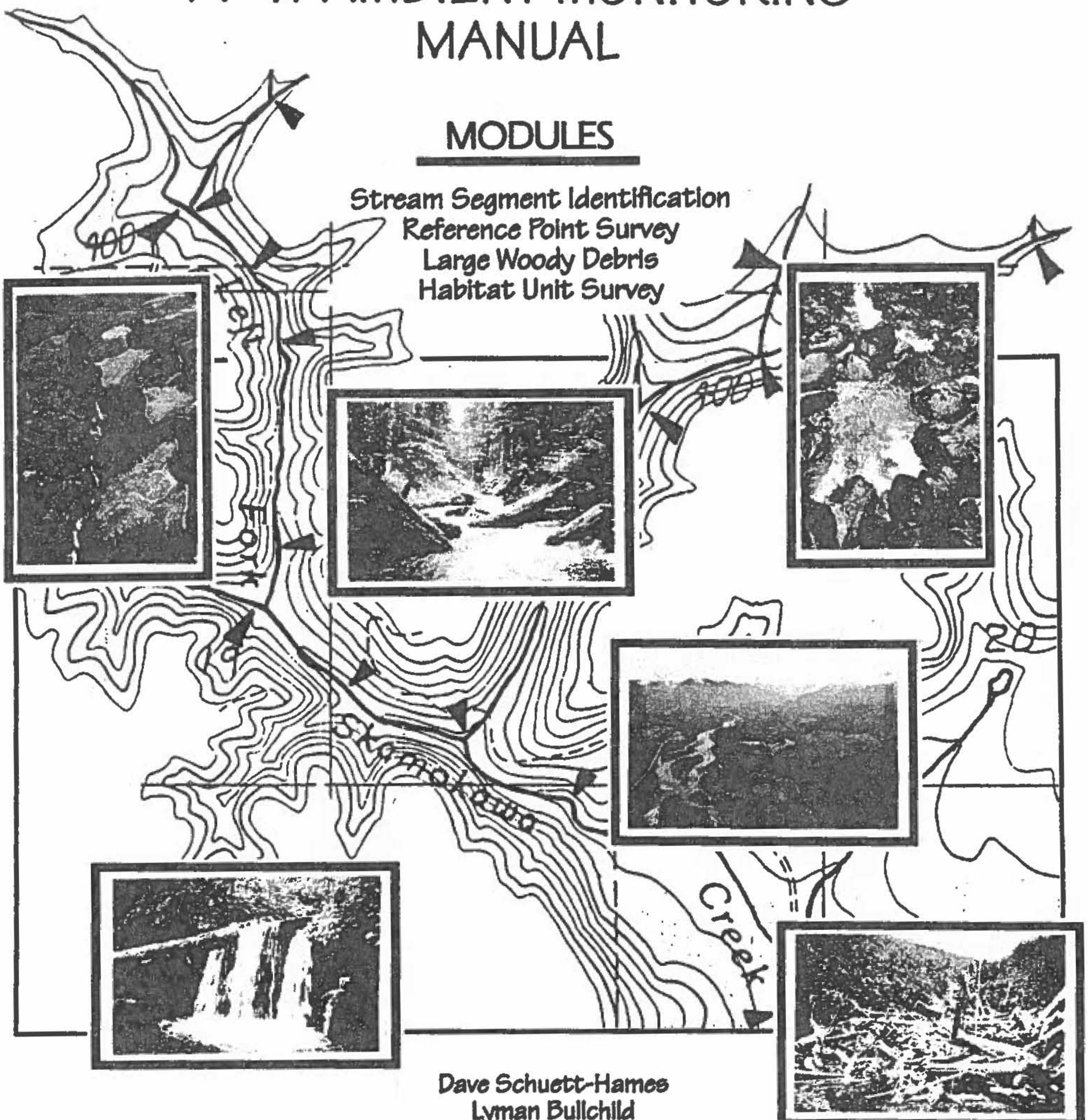
TFW-AM9-92-002

TIMBER - FISH - WILDLIFE

T-F-W AMBIENT MONITORING MANUAL

MODULES

Stream Segment Identification
Reference Point Survey
Large Woody Debris
Habitat Unit Survey



Dave Schuett-Hames
Lyman Bullchild
Scott Hall
Allen Pleus

Northwest Indian Fisheries Commission

August 1992

Northwest Indian Fisheries Commission

6730 Martin Way E., Olympia, Washington 98506

Phone (206) 438-1180
FAX #753-8659

Phone (206) 753-9010
FTS #434-9476

To: **Ambient Monitoring Cooperators**
From: Dave Schuett-Hames
Date: August 21, 1992
RE: Ambient Monitoring Manual

Enclosed is a copy of the final version of the 1992 TFW Ambient Monitoring Manual. The manual contains four modules, including stream segment identification, reference point survey, habitat unit survey and large woody debris survey.

Several changes have been made to improve and clarify the methodology since the draft version of the manual was distributed at the training session in late June. Some of the major changes are discussed below, but there have been many subtle changes in wording of criteria to necessitate another reading of the complete manual to avoid confusion.

Reference Point Survey Module

Additional information is provided on the use of the densiometer to determine **canopy closure**.

Habitat Unit Survey Module

1) Addition of another habitat unit- the **tailout**. We ran into difficulties with the simplified pool, riffle, cascade system when determining how to handle the tailout areas that often occur at the transitions between elongated pools and the downstream riffle. These areas are especially common in larger, low-gradient channels. They are distinct from either the pool or the riffle, having intermediate depth and velocity characteristics, and unique fish utilization patterns. In the micro-habitat classification system these areas were split out as glides. There appears to be disagreement over whether these areas should be included with the pools or riffles when percent pool area is calculated for watershed analysis. Because there was no satisfactory way to lump these areas with either pool or riffle without losing valuable information, we propose treating them as a distinct unit. That way they will be

preserved as a distinct category in the database. This will provide more resolution and flexibility in data analysis. See the manual for the criteria to identify tailout units.
2) Minimum **residual depth criteria** for pools. We received input that the original residual depth requirement was too deep. Additional field checks verified that some units that had the characteristics of pools did not meet the minimum pool depth requirement. Consequently, we have revised the depth criteria downwards to more accurately correspond with the observations of experienced surveyors. The minimum residual depth criteria does appear to be working as a tool for providing more consistent calls in the "gray area" between shallow pools and deep riffles. See the manual for details on the revised pool depth criteria.

Large Woody Debris Survey

1) We have included a **Level 1 Large Woody Debris** methodology for use by those interested in rapidly gathering limited information on the frequency, size class and channel location of large woody debris. This method is much more rapid than the more intensive Level 2 method, and provides information suitable for Level 1 Watershed Analysis. A Level 1 survey form is available.

2) After going out in the field and encountering many strange pieces of wood, we had additional consultations with Jim Ward on methodology. This resulted in further clarification of the **definition of large woody debris**. For the purposes of the ambient monitoring survey LWD must:

- **a)** be dead (or imminently dying with no chance of survival);
- **b)** have a root system that is wholly or partially detached and is not capable of supporting the weight of the log;
- **c)** have a diameter of at least 10 cm for at least 2 meters of its length; and
- **d)** intrude into the bankfull channel.

** Counting wood suspended above the bankfull channel is optional.

Finally, thanks for your patience as we work through the revisions to the methodology and production of the final version of the Ambient Monitoring Manual. It has been a larger undertaking than we imagined, however, I think it will be worthwhile because it will result in better monitoring information. Please call if you have questions or need assistance. Happy monitoring!

TABLE OF CONTENTS

Acknowledgements

The continued development of the TFW Ambient Monitoring project represents several years of on-going effort by many individuals too numerous to mention. We would like to begin by acknowledging the contributions of people involved in past program development and implementation activities, including present and former members of the Ambient Monitoring Steering Committee and the staff from the past ambient monitoring programs at the University of Washington Center for Streamside Studies and the Northwest Indian Fisheries Commission. We would also like to acknowledge past monitoring participants, including the Colville, Hoh, Lummi, Muckleshoot, Nisqually, Nooksack, Point-No-Point, Quileute, Quinault, Skagit System Coop, Squaxin Island, Yakima, and UCUT tribes, and ITT Rayonier, Inc.

Individuals who have contributed to the development of this manual with ideas, comments and field assistance include:
Bruce Baxter, Tim Beechie, Carol Bernthal, Linnea Cookson, Phil DeCillis, Larry Dominguez, Paul Faulds, Hugo Flores, Martin Fox, Brian Fransen, Jim Hatten, Jeff Light, Mark Mobbs, Ed Rashin, Mindy Rowse, Jim Ward and Sam Wright. Our thanks to these people and many others we have neglected to mention.

THE TFW AMBIENT MONITORING PROGRAM

Introduction to the TFW Ambient Monitoring Program

The TFW Agreement was initiated in 1988 as a result of negotiations between representatives of the timber industry, state resource agencies, Indian tribes and environmental groups. These negotiations resulted in agreement on a new forest practices management system which promotes management decisions and actions that result in mutual benefits to the timber, fish and wildlife resources.

A cornerstone of the TFW agreement is the emphasis on use of scientific information to improve management decisions. However, in many cases inadequate scientific information is available to provide certainty in decision-making. Consequently, TFW utilizes the concept of adaptive management, a process which combines scientific research with on-going evaluation of forest practices, and allows adjustment of the management system as new information becomes available.

To develop the scientific information necessary to implement adaptive management, the TFW participants established the Cooperative Monitoring, Evaluation and Research (CMER) program. The ambient monitoring project, charged with monitoring trends and changes in the condition of stream channels and instream habitat, has been part of the CMER program since its inception.

Goals of the Ambient Monitoring Stream Survey Project

The goals of the ambient monitoring stream survey project are:

1) to collect information on the current condition of stream channels in forested areas;

2) to monitor changes in stream channels over time, and identify trends occurring as a result of natural and management-induced disturbance and recovery; and,

3) to generate information which assists in identifying the cumulative effects of forest practices over time on a watershed scale.

This version of the ambient monitoring stream survey methodology has been revised to enhance its utility as an iterative monitoring tool. Monitoring parameters and methodologies have been evaluated and refined to improve accuracy and repeatability and minimize observer bias.This will enhance the capability of the methodology to detect and document changes in stream channel conditions over time.

The Ambient Monitoring Project Supports TFW and FPB Processes

The TFW ambient monitoring survey methodologies and products have been designed to dovetail with the information needs of "Watershed Analysis", the cumulative effects assessment procedure developed by CMER and approved by the Forest Practices Board. The stream segment identification module, the reference point survey, the habitat unit survey, the large woody debris survey, and the upcoming spawning gravel fine sediment module all provide information which is compatible with the habitat and channel assessment modules of Watershed Analysis.

Organization of the TFW Ambient Monitoring Program

The TFW Ambient Monitoring Program is designed to be a cooperative endeavor between CMER, TFW cooperators, and other interested parties. All TFW participants, as well as other interested parties, are encouraged to participate.

CMER encourages monitoring by providing funding for development and administration of the program, and by providing support services for monitoring cooperators.

Actual CMER oversight of the TFW Ambient Monitoring Program is accomplished by the Ambient Monitoring Steering Committee (AMSC), which prepares the workplan and oversees implementation of the program. Most implementation activities are accomplished by the Northwest Indian Fisheries Commission (NWIFC), under contract with CMER through the Washington Department of Natural Resources.

Products and Services Provided by the Ambient Monitoring Program

Some of the services provided by AMSC and the NWIFC to participants in the cooperative monitoring program include:

- **a.** development and evaluation of monitoring methodologies,
- **b.** training sessions in the use of monitoring methodologies,

c. follow-up field assistance and quality control,
d. development of data forms,
e. scanning of data forms,
f. data processing,
g. preparation of data summaries and reports.

In addition, summaries and evaluation of monitoring information are provided to CMER and TFW participants.

The Modular Structure of the Ambient Monitoring Program

The Ambient Monitoring Program consists of a modular system of standard methodologies organized around specific parameters or concerns, such as large woody debris. The modular system was developed in recognition that stream channel conditions and relevant concerns vary throughout the state. This system allows cooperators to identify watershed-specific concerns and information needs, and choose appropriate standard methodologies to develop a custom monitoring program for their watershed. The 1992 version of TFW ambient monitoring manual presents the following modules:

1. a stream segment identification module- which provides methods for identifying and labeling discrete stream segments for ambient monitoring and Watershed Analysis purposes;

2. a reference point survey module- which provides methods for establishing permanent reference locations along stream channels, and for taking photographs, bankfull width and depth measurements, and canopy closure readings at these locations;

3. a habitat unit survey module- which provides methods for identifying and measuring channel habitat units and determining the percent pools for Watershed Analysis; and

4. a large woody debris survey module- which provides methods of documenting information on the amount and characteristics of large woody debris and computing large woody debris loading rates for Watershed Analysis.

In addition, work is presently underway on development of a spawning gravel fine sediment module that will be compatible with the information needs of Watershed Analysis. Preliminary discussions have also been held with the Ambient Monitoring Steering Committee to establish priorities for additional modules. Potential topics being discussed for future module development include stream temperature, aquatic biota, and streambed scour.

Training, Field Assistance and Quality Control

This manual is intended as a reference for those collecting information using TFW ambient monitoring methods. In addition to the manual, the monitoring program offers (and encourages the use of) formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

The ambient monitoring program also provides a quality control service that involves having an experienced crew perform replicate surveys for cooperators. The purpose of quality control surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data being collected is replicable and consistent throughout the state. The quality control surveys will also help to identify problems with the methodologies that need to be addressed.

Data Processing and Outputs

The TFW ambient monitoring program provides field forms for recording monitoring data. Cooperators that use these forms can have their data scanned into a database and will receive both a hard copy data summary sheet for each segment surveyed and a copy of their database on floppy disk.

For More Information About Participating in the Program

We encourage cooperators to participate in the TFW ambient monitoring program and to utilize the services the program provides. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

TFW AMBIENT MONITORING
STREAM SEGMENT IDENTIFICATION MODULE

Table of Contents

Introduction to Stream Segments

In the TFW ambient monitoring system, survey reaches are stratified within a hierarchical framework (Frissell et al., 1986). The highest level of stratification occurs at the eco-region level, addressing factors that affect river systems on a watershed scale, such as precipitation, relief, and lithology. Typically, eco-regions are large areas, often incorporating several watersheds (or portions of watersheds) that share similar climatic, hydrologic, geologic, topographic and vegetational conditions.

The next level of stratification within the classification system occurs at the stream segment scale. Stratification at this level is based on the rationale that given similar watershed conditions and inputs to stream channels within an eco-region, the characteristics of the channels will vary in response to differences in physical factors such as gradient, channel confinement and stream size (Beechie and Sibley, 1990).

Purpose of the Stream Segment Identification Module

1. To identify discrete stream segments for conducting monitoring surveys using a system of channel and floodplain characteristics compatible with Watershed Analysis.

2. To identify characteristics of stream segments for use in analysis of monitoring information.

Stream Segment Identification Methodology

This section describes procedures for identifying and delineating stream segments for TFW ambient monitoring purposes. It also describes documentation of additional information on segment characteristics.

The stream segment classification procedure divides river systems into discrete survey segments based on stream gradient, the confinement of the channel (ratio of valley floodplain width:bankfull channel width), and the location of tributary junctions.

The procedure for delineating stream segments involves two steps: 1) an initial step using information from topographic maps and aerial photographs to identify major tributary junctions, determine stream gradient and estimate channel confinement, and; 2) field verification of mapping information, particularly the initial channel confinement estimate.

Equipment needed

* Segment summary forms (Form 1)
* USGS topographic maps (7.5 minute maps work best, if available)
* Aerial photos (helpful but not necessary)
* Map wheel & gradient template (for river miles and gradients)
* Architect scale ruler
* Colored pens or pencils
* Fiberglass tape or rangefinder (metric)

Determining Tributary Junctions

First, identify all significant tributary junctions in the river system. Tributaries supply additional water and sediment loads which result in changes in channel morphology. Consequently, channel characteristics often change below the confluence of significant tributaries (Richards, 1980).

Begin by making photocopies of the USGS 7.5 minute topographic maps for the watershed. Determine the stream order of the channels using the Strahler method described in Dunne and Leopold(1978; pages 498-499). In this system, small headwater streams that have no tributaries (depicted as blue lines on the map) are designated as first-order streams. When two first-order streams meet they form a second-order stream. Where two second-order streams join they form a third-order stream, and so forth. The stream order changes only when two streams of equal order meet, so the confluence of a lower order tributary does not alter the order of a larger stream (Figure 1).

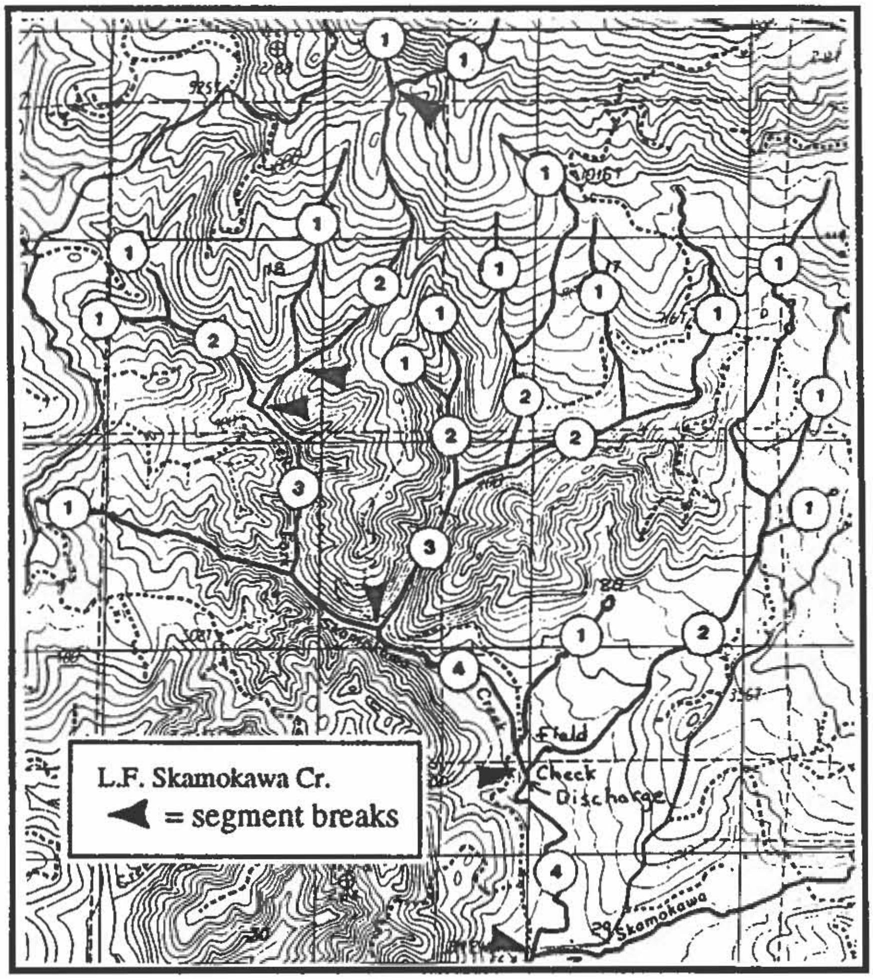


Fig. 1. Example of a stream system broken into segments based on stream order criteria.

Note all tributary junctions where the stream order of the tributary is the same, or the next smaller order, as the main channel. In addition, note any smaller tributary junctions where you are aware of changes in factors such as sediment load, channel width, or channel morphology. Mark all the appropriate tributary junctions on the working copy of your map.

Determining Stream Gradient

Next, determine stream gradients and break the stream system into smaller segments based on the following seven gradient categories:

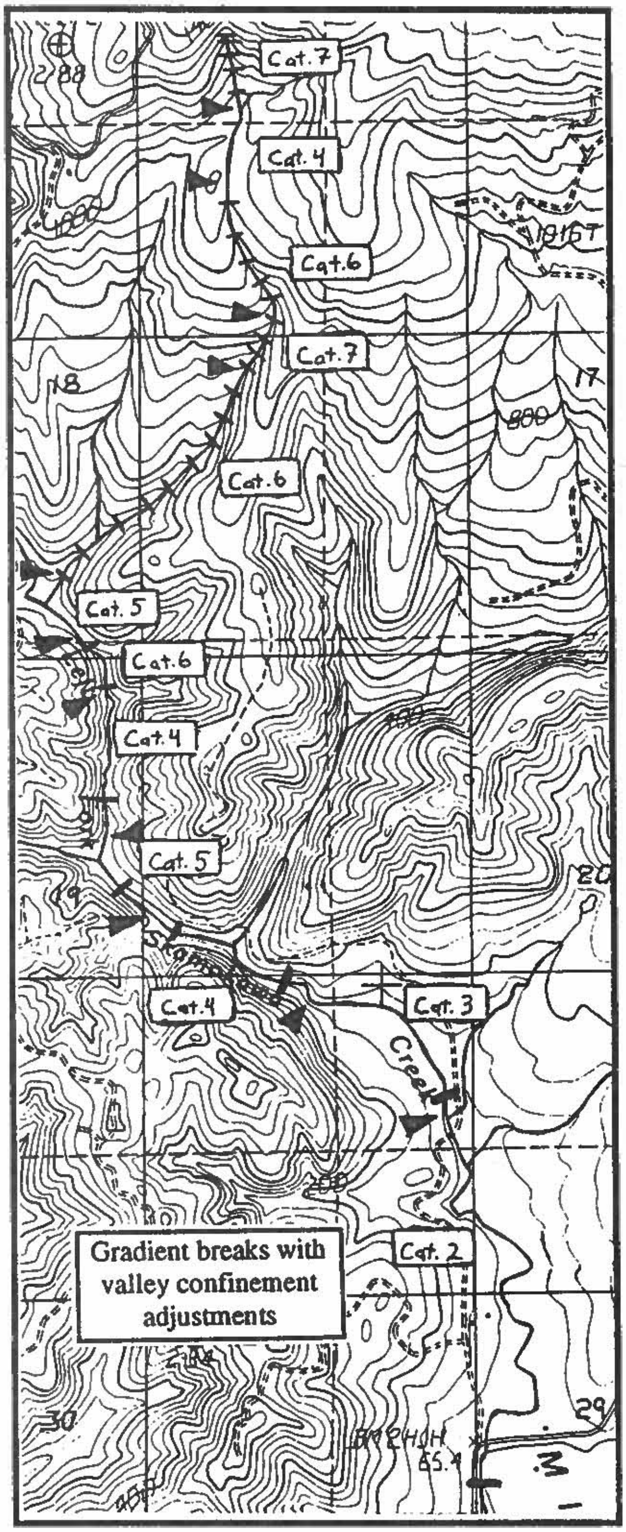


Fig. 2. Example of a stream system broken into segments based on gradient criteria.

Category **1** = less than 0.1%
Category **2** = 0.1% - 1%
Category **3** = 1% - 2%
Category **4** = 2% - 4%
Category **5** = 4% - 6%
Category **6** = 6% - 17%
Category **7** = greater than 17%

Highlight the stream channels and mark where each contour line crosses the stream channel with a colored pencil or pen (Figure 2).

Gradient is determined by dividing the difference in elevation (rise) over the horizonal distance (run). There are several ways to determine stream gradient from a topographic map.

In situations where the stream channel is relatively straight, the gradient category can be determined by using a clear plastic sheet marked at intervals corresponding with the breaks between the seven gradient categories. Overlay this template on the stream channel and compare the distance between the marks with the distance between the points where the contour lines cross the stream channel. The distance between the marks will depend upon the scale of the map and the elevation difference between contour lines (which often varies between adjacent USGS topographic maps). To calculate the distance between marks for each gradient break, divide the contour interval used on the map by the desired gradient (expressed as a decimal).

For example, on a USGS 7.5 minute topographic map with 40 foot contour intervals, the distance between contour lines at 1% gradient would be 40 feet / .01 = 4,000 feet. Then, from the map legend, determine the actual distance in inches corresponding to 4,000 feet and mark the template at that distance. A copy of the gradient template is provided in Appendix A.

A map wheel can be used to determine gradient in situations where the channel is sinuous. First, identify two places where elevation contour lines cross the stream channel. Then measure the distance between these two points by following the stream channel with the map wheel. Read the distance from the map wheel using the scale corresponding to the scale of the map. Finally, use a calculator to divide the rise (elevation difference between the two chosen contour lines) by the run (distance along the stream channel) to calculate stream gradient.

When the contour lines cross the stream at regularly spaced intervals, it is not necessary to do a calculation between each individual contour line. Separate calculations are required when the spacing of the contour lines crossing the stream changes, or where spacing is highly variable.

Finally, mark and label the boundaries between the seven gradient categories on the working copy of your map.

Determining Channel Confinement

Channel confinement is the ratio between the width of the valley floodplain and the bankfull channel width. Stream channels are placed in one of three channel confinement categories:

* Confined (**C**)- valley width less than 2 channel widths
* Mod. confined (**M**)- valley width 2-4 channel widths
* Unconfined (**U**)- valley width greater than 4 channel widths

Channel confinement is difficult to determine from maps or aerial photographs. Often the channel is obscured by vegetation, making it difficult to ascertain channel width. It is also difficult to differentiate valley floor floodplains from raised terraces that are not flooded (and are not included in the valley width measurement).

Make an initial estimation of channel confinement based on your personal knowledge of the river system and the surrounding landscape, and information from maps and photos. Mark and label the estimated break-points between the three channel confinement categories on the working copy of your map.

Then, spend some time in the field examining the stream channels and their floodplains. Take several measurements of channel width and valley floodplain width in representative locations. For this purpose, the valley width is the width of the "active" floodplain that receives waters during large flood events and is susceptible to channel-forming processes such as widening, meandering, braiding, and avulsion. It does not include elevated terraces that do not flood and act to confine an incised channel. Divide the total valley width (including the channel) by the channel width to compute channel confinement. Compare with your estimated values and mark and label any adjustments or corrections on the working copy of your map (see Figure 2).

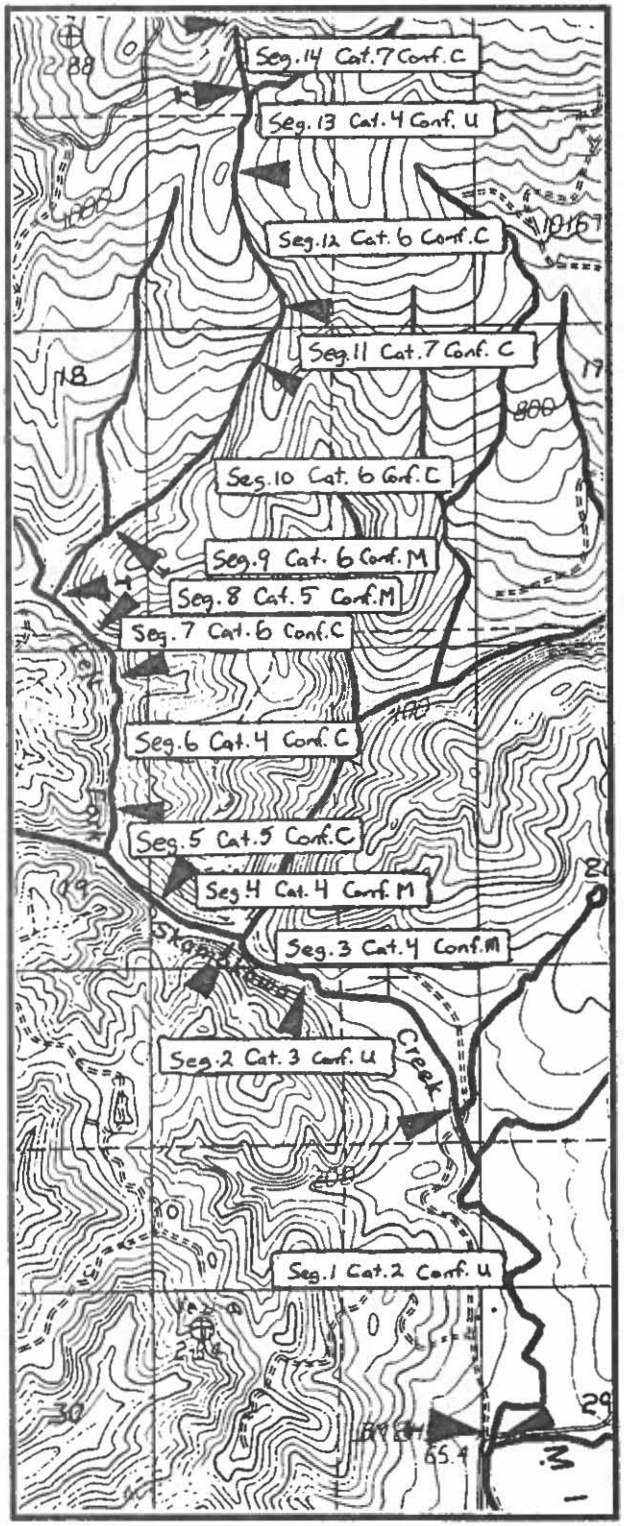


Fig. 3. Finalized segmenting according to tributary junctions, gradient, and confinement

Finalizing Stream Segment Delineation

Your working map should now be marked with break-points based on tributary junctions, the boundaries between stream gradient categories, and the boundaries between channel confinement categories (Figure 3). Each discrete segment on the map represents a reach with a unique combination of stream gradient, channel confinement and watershed area. These segments are the basic units for ambient monitoring stream surveys and the habitat module in watershed analysis.

In many cases, a stream segment that appears to be uniform according to information from the map may not actually prove to be of uniform gradient or channel confinement in the field. Often, there are short sections of greater or lesser gradient (or confinement) interspersed within a segment that appears homogenous on the map. This poses the question of whether to break out short, anomalous areas identified in the field (or on the map) as separate segments, or to include them in a larger segment. Combining them with a larger segment has the advantage of reducing the number of segments and simplifying record-keeping, but results in loss of resolution as data from small unique areas are blended in with those from larger areas. Splitting out smaller segments increases complexity, but documents the unique characteristics of each distinct area.

As a general guideline, anomalous stream reaches longer than 300 meters, should be treated as separate segments. The choice of whether to split or lump anomalous reaches shorter than 300 meters is left with the surveyor, and will depend on factors such as the degree of difference and the intended use of the information. For each segment that is surveyed, please describe the extent of variation in gradient and confinement within the section in the field notes section of the segment summary form.

Labeling Stream Segments with Unique Identification Numbers

Each segment should be assigned a unique identification number. Begin by determining the stream number from the WDF stream catalog (Williams et al., 1975).

The first two digits of the number represent the basin's Water Resource Inventory Area (WRIA) number. The next five spaces are provided for the four digit WRIA stream number. Use the fifth space to record a WRIA code letter if applicable.

The next four spaces are provided for un-numbered tributaries. In these cases, use the spaces provided for the WRIA number to record the WRIA number of the larger stream the un-numbered tributary flows into. Then use the first two spaces in the un-numbered tributary section to record RT for right bank (looking downstream) tributaries or LT for left bank tributaries. Use the next two spaces to assign a tributary number beginning with 01, 02, etc. Leave the four un-numbered tributary spaces blank if the stream has a WRIA number.

Finally, use the three segment identification spaces to assign each gradient/confinement segment a unique identification number, beginning with the number 001 at the downstream end of the basin.

WRIA basin number	WRIA stream number	Un-numbered tributary code	Segment identification number
9 9	0 0 3 8 A	R T 0 1	0 0 2
__ __	__ __ __ __ __	__ __ __ __	__ __ __

Whenever the WRIA stream number changes, begin with segment number 001 at the downstream end of the next stream. Mark the segment identification numbers on your map.

Using Stream Segments to Develop a Monitoring Strategy

The map should now display all the potential monitoring survey segments in the watershed. The choice of segments to monitor is up to the cooperator. Segments may be selected for a variety of reasons, depending on the needs and goals of the organization undertaking the survey.

Many surveys will be conducted in areas undergoing Watershed Analysis. See the Watershed Analysis manual for suggestion on selecting "response reaches" where the effects of processes such as sedimentation are best monitored (Appendix B).

To obtain a watershed-scale perspective on the current condition of your river system, select segments representing a variety of stream gradient/channel confinement categories. Include a variety of land-use categories, if present, such as areas where forest activities are planned, areas where forest practices have been completed and undisturbed "reference" segments.

You may also want to base your sampling strategy on instream resources of special interest (for example, habitat utilized by a specific salmonid stock). The Ambient Monitoring Program staff are available to assist you in developing a monitoring strategy to meet your needs.

Filling out the Segment Summary Form

The segment summary form (Appendix C) is used to record information used to identify and characterize each segment surveyed. One form should be filled out for each segment. This section discusses how to fill out the segment summary form (Figure 4).

DATE 8/18/92 STREAM NAME	CONFINEMENT/ GRADIENT		W.R.I.A. NUMBER			STREAM ORDER
● Creek ○ River	U/M/C	Cat.1-7	○ Unlisted	Trib.	Seg #	1 - 7
Left Fork Skamokawa	C	6	250224	○ ○ LB RB	10	2

Fig. 4. Header of Form 1

Date- Fill in the date that you began the survey.

Stream name- Fill in the name of the stream you are surveying.

WRIA and **Segment** identification number- Fill in the WRIA and seg ment identification number you have assigned to the segment being surveyed (see labeling stream segments with unique iden tification numbers, above).

Confinement- Record the confinement category using (**C**) for con fined, (**M**) for moderately confined, and (**U**) for unconfined.

Gradient- Record the appropriate code for the stream gradient cat egory of the segment, where; **1** = less than 0.1%; **2** = 0.1-1%; **3** = 1-2%; **4** = 2-4%; **5** = 4-6%; **6** = 6-17%; and **7** = greater than 17%.

Stream order-Record the stream order of the segment being surveyed from the working copy of the map.

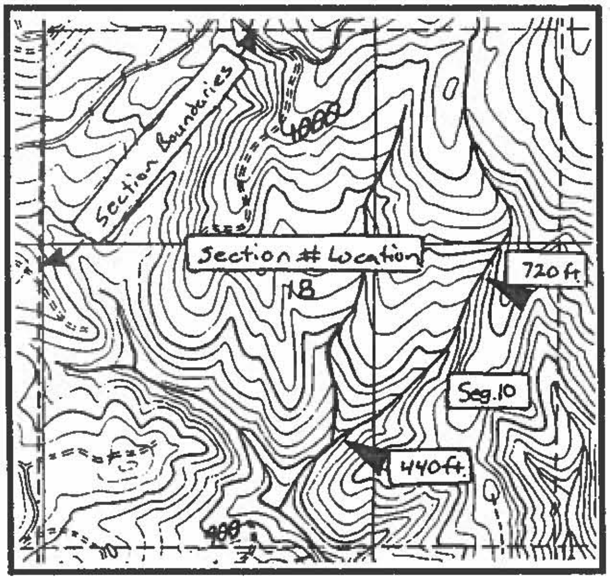
Surveyors and affiliation- Record the initials and affiliations of the surveyors who completed the survey.

LOWER BOUNDARY LOCATION (TOWN / RNG / SEC / 1/4 of 1/4)	ELEVATION (● feet ○ meters)	PHOTOGRAPHS (YR / ROLL / BEG FR. #)	REFERENCE POINT	RIVER MILE	LATITUDE / LONGITUDE
10N / 6W / 18 / SW of SE	440	92 / 001 / 01	0 ○ LB ● RB	2.5	
UPPER BOUNDARY LOCATION (TOWN / RNG / SEC / 1/4 of 1/4)	**ELEVATION (● feet ○ meters)**	**PHOTOGRAPHS (YR / ROLL / END FR. #)**	**REFERENCE POINT**	**RIVER MILE**	**LATITUDE / LONGITUDE**
10N / 6W / 18 / SE of NE	720	92 / 002 / 09	15 ● LB ○ RB	3	

Fig. 5. Segment location information on Form 1

Upper and lower boundary locations-

For this section, use the examples found in Figure 5 - Form 1 boxes - and Figure 6 - topographic elevation, township, range, and sec- tion identification. First, locate the upstream boundary of the segment. Record the township, range and section number in the appropriate spaces. In this case, The Upper Boundary Location of segment 10 is Township 10N, Range 6W, and Section 18. Next, divide the section into quarter-sections and decide if the boundary is in the NW, NE, SW or SE quarter-section. For segment 10, the upper segment break falls into the NE 1/4 of Section 18. Finally, divide the quarter-section into quarters and decide if the boundary is in the



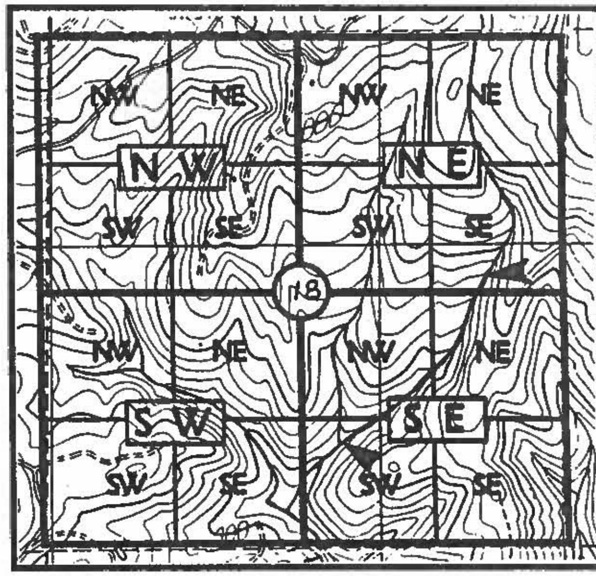
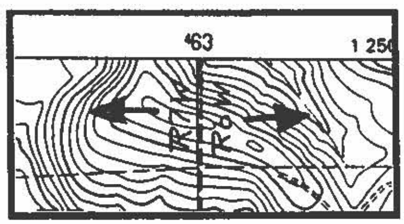
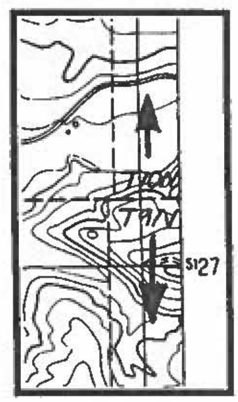


Fig. 6. Using Elevation, Township , Range, and Section information to locate Segment 10's boundaries



Range and Township markings on topo maps are located along the edges. Ranges are oriented parallel to the longitudinal line and Townships are oriented parallel to the latitudinal line.



NW, NE, SW or SE quarter of the quarter- section. This puts the upper segment break into the SE 1/4 of the NE 1/4 of Section 18. Record this information, using the first two spaces for the quarter of the quarter-section, and the second two spaces for the quarter-section. Follow the same procedure for the downstream boundary location.

Elevation of the upper and lower boundaries-

From the USGS topographic map, determine the elevation of the upper and lower boundaries of the segment being surveyed. Record the elevation of the contour line that crosses the stream closest to each respective boundary of the segment. For segment 10, each contour line represents a 40 ft. elevation interval (be sure to check each topographic map to find out the elevation scale). Each dark contour line represents a change of 5 X 40ft. or 200 ft. Count down the elevation contours from the 1000ft. line to find the upper boundary at 720ft. For the lower boundary, count up the contour lines to locate the segment break at 440ft.

River mile of the upper and lower boundaries-

From the WDF stream catalog for your area, determine and record the river mile (to the nearest tenth of a mile) of the upstream and downstream segment boundary.

Latitude and longitude of the upper and lower boundaries-

This field is provided to record location data from global positioning systems as it becomes available. If this information is not available, leave the spaces blank.

Photographs-

Record the roll and frame number of the first and last photographs taken in the segment.

Segment Location Maps and Access Information

Please provide the ambient monitoring program with a copy of the USGS map showing the boundaries of each segment surveyed. Also describe access to the segment for future reference.

Training and Field Assistance

This manual is intended as a reference for using the TFW Ambient Monitoring Stream Segment Identification Module. The TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the stream segment identification methodology.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Beechie, T.J. and T.H. Sibley. 1990. **Evaluation of the TFW stream classification system: stratification of physical habitat area and distribution.** Final Report; 1988-1990. Wash.Dept.of Natural Resources. Forest Regulation and Assistance Division. Olympia.

Dunne, T. and L.B. Leopold. 1978. **Water in environmental planning.** W.H. Freeman and Co. New York.

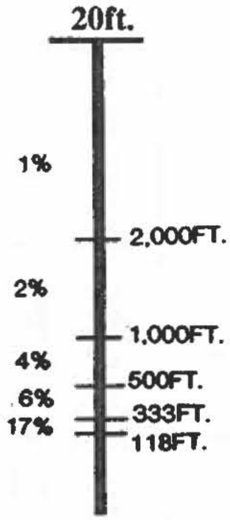
Frissell, C.A., W.J. Liss, C.E. Warren and M.D. Hurley. 1986. **A hierarchical framework for stream classification: viewing streams in a watershed context.** Env. Mngt. 10(2):199-214.

Richards, K.S. 1980. **A note on changes in channel geometry at tributary junctions.** Wat. Resour. Res. 16(1):241-244. Feb. 1980.

Williams, R.W., R.M. Laramie and J.J. Ames. 1975. **A catalog of Washington streams and salmon utilization. Vol. 1, Puget Sound Region; Volume 2, Coastal Washington.** Wash. Dept. of Fisheries. Olympia.

APPENDIX A.

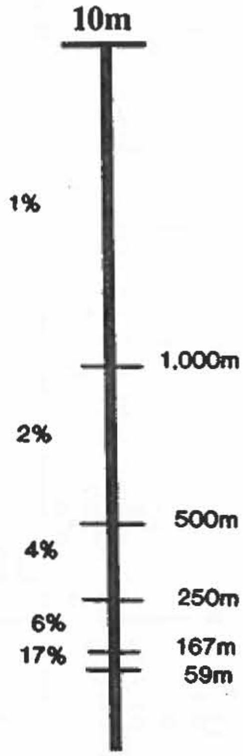
SCALE 1:24,000



Seg. Class

I.	<.01%
II.	.01>1%
III.	1>2%
IV.	2>4%
V.	4>6%
VI.	6>17%
VII.	17%>

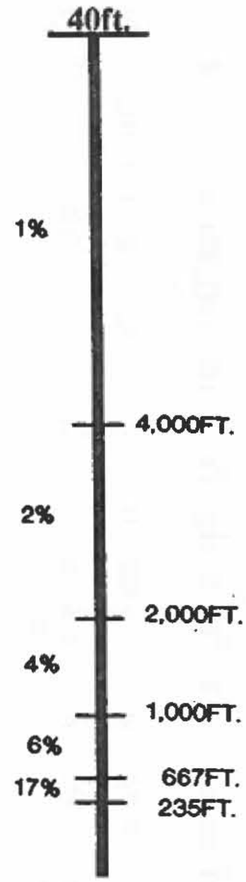
SCALE 1:24,000



Seg. Class

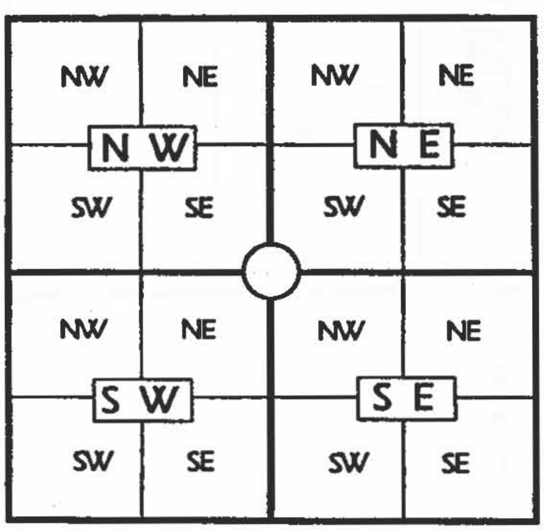
I.	<.01%
II.	.01>1%
III.	1>2%
IV.	2>4%
V.	4>6%
VI.	6>17%
VII.	17%>

SCALE 1:24,000



Seg. Class

I.	<.01%
II.	.01>1%
III.	1>2%
IV.	2>4%
V.	4>6%
VI.	6>17%
VII.	17%>



Template for topographical gradient categories on 7.5 minute USGS maps: 20ft., 40ft., & 10m contour intervals

Template for section of section and segment boundary location

TABLE E-2: CHANNEL RESPONSE BY GRADIENT/CONFINEMENT CLASS

SEDIMENT	PEAK FLOWS	WOOD	CATASTROPHIC EVENTS
FS - Fine Sediment Deposition MS - Mixed Sediment Deposition CS - Coarse Sediment Deposition	SD - Scour Depth SF - Scour Frequency BE - Bank Erosion	WL - Wood Loss WA - Wood Accumulation	DT - Debris Torrent

VALLEY CONFINEMENT OF CHANNEL

VW > 10 CW UC = UNCONFINED	FS WA	MS WL FS	CS WL MS			
4 CW < VW < 10 CW LC = LOOSELY CONFINED	FS WA	MS WL SF FS	DT CS SF WL MS	DT CS WL	DT WL	
2 CW < VW < 4 CW MC = MODERATELY CONFINED	FS WA	MS SD WL FS	CS BE SD DT SF MS WL	DT CS SF WL	DT WL	DT WL
1 CW < VS < 2 CW TC = TIGHTLY CONFINED		WL	CS SD WL BE DT	CS SF WL DT	DT WL	DT WL
	< 1.0 Dune/Ripple	1.0 - 2.0 Riffle/Pool (Meandering)	2 - 4 Riffle/Pool (Obstruction)	4 - 6 Cascade	6 - 17 Step/Pool	>17

VALLEY GRADIENT (PERCENT) AND CHANNEL BED MORPHOLOGY

APPENDIX B.

Version 7/10 AP

SEGMENT SUMMARY

FORM 1

TFW - N.W.I.F.C.
Ambient Stream Monitoring 1992

Page ____of____

DATE __/__/ 92 STREAM NAME ○ Creek ○ River	CONFINEMENT/ GRADIENT U / M / C Cat. 1-7	W.R.I.A. NUMBER ○ Unlisted Trib. ○ LB ○ RB Seg #	STREAM ORDER 1 - 7	SURVEYORS/ AFFILIATIONS Caller S1 A1 Recorder S2 A2	IMPORTANT ! Fill out FORM 1- 1ea. per segment. If additional FORM 2's (REF. PT. SURVEY) are necessary use same temp. form and fill in Form 1 categories: Page; Date; Stream Name; Conf/Grad; &W.R.I.A. #

LOWER BOUNDARY LOCATION TOWN RNG SEC 1/4 of 1/4	ELEVATION ○ feet ○ meters	PHOTOGRAPHS YR ROLL BEG FR. #	REFERENCE POINT	RIVER MILE	LATITUDE ° ' " LONGITUDE ° ' "	FIELD NOTES:
		9 2	○ LB ○ RB			
UPPER BOUNDARY LOCATION TOWN RNG SEC 1/4 of 1/4	**ELEVATION** ○ feet ○ meters	**PHOTOGRAPHS** YR ROLL END FR. #	**REFERENCE POINT**	**RIVER MILE**	**LATITUDE** ° ' " **LONGITUDE** ° ' "	
		9 2	○ LB ○ RB			

REFERENCE POINT SURVEY

FORM 2

TEMPORARY FORM

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL upstrm frame dwnstrm frame	BANKFULL (meters) WIDTH DEPTH	CANOPY CLOSURE	FIELD NOTES:
○ LB ○ RB				%	

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL upstrm frame dwnstrm frame	BANKFULL (meters) WIDTH DEPTH	CANOPY CLOSURE	FIELD NOTES:
○ LB ○ RB				%	

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL upstrm frame dwnstrm frame	BANKFULL (meters) WIDTH DEPTH	CANOPY CLOSURE	FIELD NOTES:
○ LB ○ RB				%	

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL upstrm frame dwnstrm frame	BANKFULL (meters) WIDTH DEPTH	CANOPY CLOSURE	FIELD NOTES:
○ LB ○ RB				%	

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL upstrm frame dwnstrm frame	BANKFULL (meters) WIDTH DEPTH	CANOPY CLOSURE	FIELD NOTES:
○ LB ○ RB				%	

APPENDIX C.

APPENDIX A.

Version 7/10 AP

Page ____ of ____

~~SEGMENT SUMMARY~~ FORM 1

TFW - N.W.I.F.C.
Ambient Stream Monitoring 1992

DATE __/__/ 92 STREAM NAME	CONFINEMENT/ GRADIENT	W.R.I.A. NUMBER	STREAM ORDER	SURVEYORS/ AFFILIATIONS	IMPORTANT ! Fill out FORM 1- 1ea. per segment. If additional FORM 2's (REF. PT. SURVEY) are necessary - use same temp. form and fill in Form 1 categories: Page; Date; Stream Name; Conf/Grad; &W.R.I.A. #
O Creek O River	U / M / C Cat.1-7	O Unlisted Trib. LB RB Seg #	1 - 7	Caller (S1, A1) Recorder (S2, A2)	

~~LOWER BOUNDARY LOCATION~~ TOWN, RNG, SEC, 1/4 of 1/4	~~ELEVATION~~ O feet O meters	~~PHOTOGRAPHS~~ YR ROLL BEG FR. #	~~REFERENCE POINT~~ LB RB	~~RIVER MILE~~	~~LATITUDE~~ ~~LONGITUDE~~	FIELD NOTES:
		9 2				
~~UPPER BOUNDARY LOCATION~~ TOWN, RNG, SEC, 1/4 of 1/4	~~ELEVATION~~ O feet O meters	~~PHOTOGRAPHS~~ YR ROLL END FR. #	~~REFERENCE POINT~~ LB RB	~~RIVER MILE~~	~~LATITUDE~~ ~~LONGITUDE~~	
		9 2				

REFERENCE POINT SURVEY

FORM 2

TEMPORARY FORM

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL (upstrm frame, dwnstrm frame)	BANKFULL (meters) WIDTH, DEPTH	CANOPY CLOSURE	FIELD NOTES:
	LB RB				%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL (upstrm frame, dwnstrm frame)	BANKFULL (meters) WIDTH, DEPTH	CANOPY CLOSURE	FIELD NOTES:
	LB RB				%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL (upstrm frame, dwnstrm frame)	BANKFULL (meters) WIDTH, DEPTH	CANOPY CLOSURE	FIELD NOTES:
	LB RB				%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL (upstrm frame, dwnstrm frame)	BANKFULL (meters) WIDTH, DEPTH	CANOPY CLOSURE	FIELD NOTES:
	LB RB				%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL (upstrm frame, dwnstrm frame)	BANKFULL (meters) WIDTH, DEPTH	CANOPY CLOSURE	FIELD NOTES:
	LB RB				%	

TFW AMBIENT MONITORING
REFERENCE POINT SURVEY MODULE

Table of Contents

Introduction to the Reference Point Survey

Reference points refer to a series of permanently marked points established along the edge of the stream channel. Channel and habitat features observed during stream surveys are located and described relative to these points. Reference points are also used as systematic sampling sites for data collected at specific points along the stream channel, such as canopy closure and bankfull channel width and depth. In addition, reference points provide permanent locations from which to photograph the stream channel over time.

Purpose of the Reference Point Survey Module

1. To establish permanent, marked locations along the channel to reference channel features and information from other modules.

2. To establish discrete 100 meter reaches used to characterize segment variation and allow future sub-sampling of stream reaches.

3. To establish permanent photo-points where photographs can be taken and compared over time.

4. To collect information on bankfull width and depth.

5. To collect canopy closure information.

Reference Point Survey Methodology

The following section describes how to establish reference points, take reference photographs, determine bankfull width and depth, and take optional canopy closure measurements.

Information and Equipment Needed

To undertake this module you must first identify a survey segment (see the TFW ambient monitoring stream segment identification module). We also suggest that you secure permission from landowners adjacent to the stream, and come to an agreement with them concerning appropriate techniques for marking reference points.

You will need the following equipment:

* Reference point survey forms
* Number 2 pencils
* Hip chain (metric)
* Steel (rebar) rods- 24" or longer
* Nails- 16d (use aluminum, if available)
* Masonry or rock nails
* Flagging
* Felt tip marker, permanent ink
* Hammer
* Tags, aluminum or durable plastic
* Camera (suitable for use under field conditions)
* Film

* Fiberglass tape measures (metric, 50 or 100 meter length, depending on channel width)
* Stadia rod or measuring stick (metric)
* Densiometer (for the optional canopy closure measurement)
* Calculator
* Field notebook
* Hip boots or waders
* Rain gear
* First aid supplies

FIELD NOTE: Make a copy of this list and use it each time before heading off to the stream. It can ruin your day if one piece was forgotten or one partner thought the other brought it.

Establishing Permanent Reference Points

Laying out Reference Points

To begin establishing reference points, first locate the boundary of the survey section, using information from the map produced during stream segment identification (see the stream segment identification module). In some cases, the map boundary may not correspond with actual field conditions. Adjust the boundary as necessary and mark the changes on the stream segment identification map.

Whenever possible, lay out and number the reference points beginning at the downstream boundary and working upstream. The first reference point, at the lower boundary of the segment, is assigned the reference point number 0. Attach one end of the tape measure, or hip chain line, in the center of the channel (midway between the banks). Proceed up the center of the channel, staying midway between the banks and following the curvature of the channel. You will not necessarily be at the thalweg or even in the wetted portion of the channel at all times. The idea is to measure the length along the middle of the bankfull channel (Figure 1) because this distance should remain most constant over time.

As you proceed up the channel, establish another reference point every 100 meters. The reference points should be numbered consecutively (0,1,2,3...) as you move upstream. The distance between reference points should be 100 meters, however the last one, which ends at the segment boundary, will vary in length.

Begin the numbering sequence over again at the boundary of each successive segment. Consequently, the reference point at the end of one segment and the beginning of another will have two numbers.

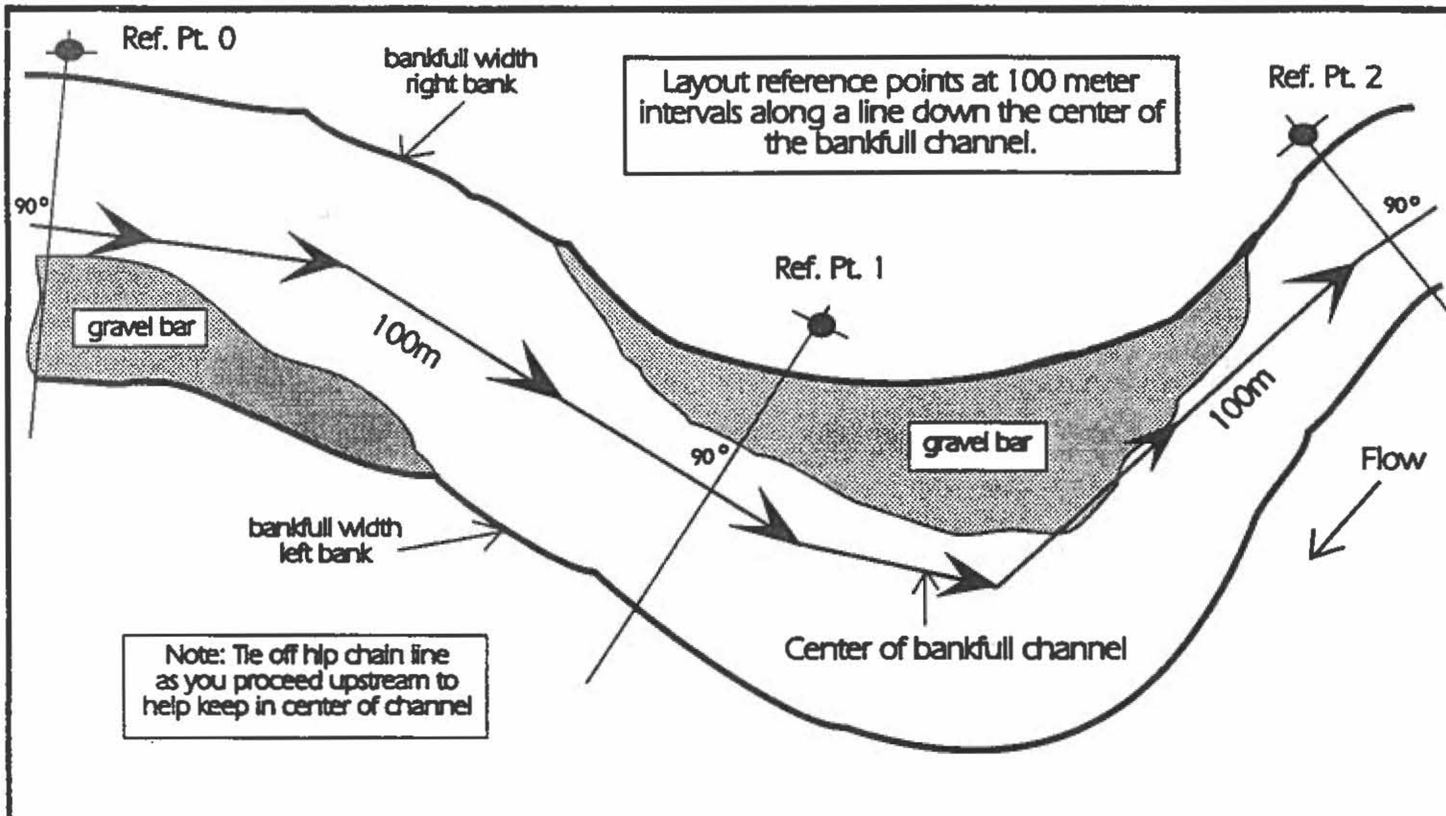


Figure 1. Measuring 100m intervals in the bankfull channel for reference point layout

One will correspond to the end of the sequence for the first segment, the other will be number 0 for the next segment.

<u>Tagging and Marking Reference Points</u>

The reference point markers should be placed far enough back from the edge of the channel so they will not be washed out by floods or bank erosion. Place them at least three meters from the bank. More distance may be necessary in locations where extensive bank erosion, braiding or channel migration is occurring.

Three methods are commonly used to permanently mark reference points: nailing a tag into a tree, pounding a steel 'rebar' rod into the ground and attaching a tag, or affixing a tag to a bedrock canyon wall with masonry nails. If there is a large, sturdy tree at the proper location, attaching the tag with a nail is the easiest option. You should have landowner permission to nail tags to trees. Use aluminum nails if possible to minimize potential hazards for loggers and sawyers in the future. The tags should be placed and flagged so they are readily visible from the stream. Trees should be stable and firmly rooted. Those leaning over, or being undercut by the stream are not good prospects for reference points.

Steel "rebar" rods make good reference points when there are no trees in the proper location, or where there are concerns about nailing tags in trees. Locate rebar rods at least three meters back from the bank; further back if the channel appears unstable. Rods should be at least 24 inches long and driven deep enough into the ground so they are difficult to pull out. They should protrude at least six inches (or more) from the ground to be visible and avoid burial, particularly in low-lying floodplain areas where active deposition occurs during floods. Rebar rods should have the tag attached with wire, and be marked with flagging. A plastic locking band would also work to attach a tag. Place flagging on nearby branches to make it easier to find the rods in the future. Finally, masonry or rock nails can be used to attach tags to the walls in bedrock canyons, or bridge abutments, where the other techniques are not possible.

Keep detailed notes on the type of marker, distance from the edge of the bank, and nearby trees to aid in locating reference points in the future.

Tags can be of either aluminum or durable plastic. Tags should identify the program (TFW ambient monitoring), the segment, and the reference point number.

Taking Photographs

Photographs should be taken from the center of the channel at each set of reference points. The first photograph should be taken looking downstream, the second looking upstream.

Note the roll and frame number for each shot. Use the first frame of each roll to photograph a sheet of paper with the roll number, segment and date.

Photo by Greg Poels

Allen Pleus with example of information sheet for film identification purposes. Big Beef Creek, 1991.

Streams with dense canopy cover have low light conditions. Film with an ASA of 400 works best in low light conditions.

Bankfull Width and Depth

The width and depth of a stream channel reflect the discharge and sediment load the channel receives, and must convey, from its drainage area. Channels are formed during peak flow events, and channel dimensions typically reflect hydraulic conditions during relatively frequent, bankfull (channel-forming) flows.

Bankfull width and bankfull depth refer to the width and average depth of the channel at bankfull flow. These dimensions are related to discharge at the channel-forming flow, and can be used to characterize the relative size of the stream channel. In addition, the ratio of bankfull width to bankfull depth (the width:depth ratio) of a stream channel provides information on channel morphology. Width:depth ratio is related to bankfull discharge, sediment load, and the resistance of the banks to erosion (Richards, 1982). For example, channels with large amounts of bedload and sandy, cohesion-less banks are typically wide and shallow, while channels with suspended sediment loads and silty erosion-resistant banks are usually deep and narrow. Changes in width:depth ratio indicate morphologic adjustment in response to alteration of one of the controlling factors (Schumm, 1977).

Identifying the Boundaries of the Bankfull Channel

To measure bankfull width and depth, you must first determine the edge of the bankfull channel. Bankfull flow occurs when water completely fills the channel and the surface of the water is level with the floodplain (Dunne and Leopold, 1978). Any additional flow would begin to overtop the banks and spread out over the floodplain. Unfortunately, the boundaries of the bankfull channel are not always easy to determine, particularly when a floodplain is absent. Geomorphologists use a variety of methods to identify the outer boundaries of the bankfull channel, however the most accurate methods require discharge records or the use of surveying techniques (Williams, 1978).

For ambient monitoring, use a combination of indicators including floodplain location, the shape of the bank, and changes in vegetation to identify the bankfull channel. In channels with a natural (un-diked) riparian area and a low, flat floodplain, the boundary of the bankfull channel corresponds with the top of the low bank between the active channel and the floodplain (Figure 2). The floodplain must be frequently flooded, i.e., during floods with a 1.5-2 year recurrence interval.

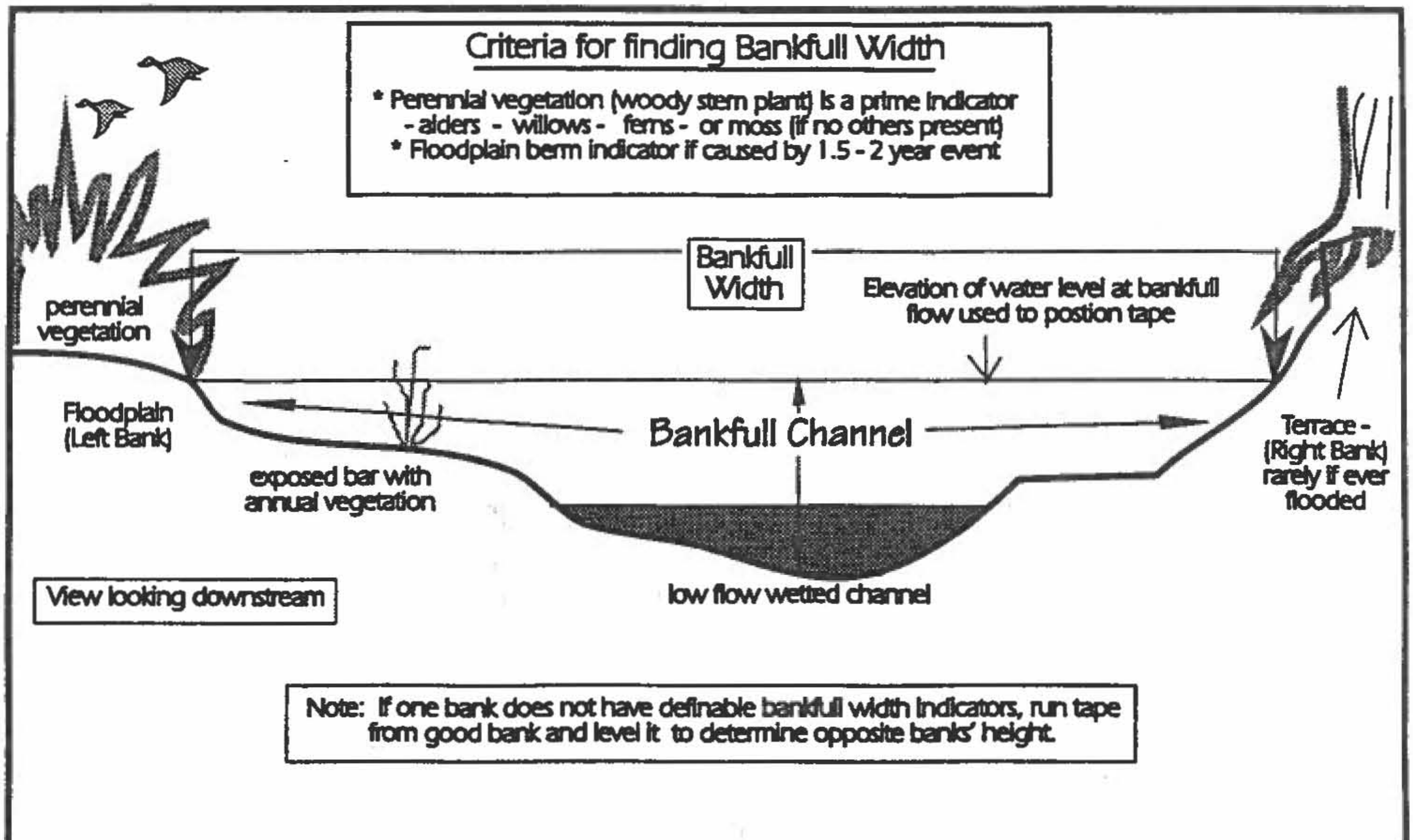


Figure 2. Determining the bankfull width of channels

Determining the boundary of the bankfull channel is more difficult in situations where there is not a floodplain. This occurs where streams have been artificially diked and channelized. It also occurs when the channel is confined between steep hillslopes or is incised into an elevated terrace deposit that is not frequently flooded.

In these cases, the bankfull channel boundary often is marked by a distinct demarcation line in the vegetation between lower areas that are either bare or have aquatic vegetation, and higher areas vegetated with shrubs, grasses or trees. In boulder or bedrock confined channels, it may be marked by the line between bare rock and moss. Unfortunately the vegetation line changes over time, retreating due to scouring during large peak flow events, and advancing during periods between floods.

Identifying the bankfull channel boundary using vegetational indicators requires caution. The vegetation line can be deceptively low when moisture-tolerant species are present. Reed canary-grass, willow and sedges are examples of plants that may actively invade and colonize areas within the bankfull channel. Often the vegetation line is disturbed along steep banks where bank sloughing or debris slides cause the bank to be bare far above the bankfull level. See Dunne and Leopold (1978; pages 612-613, 653-4) for a discussion on identifying the bankfull channel in the field.

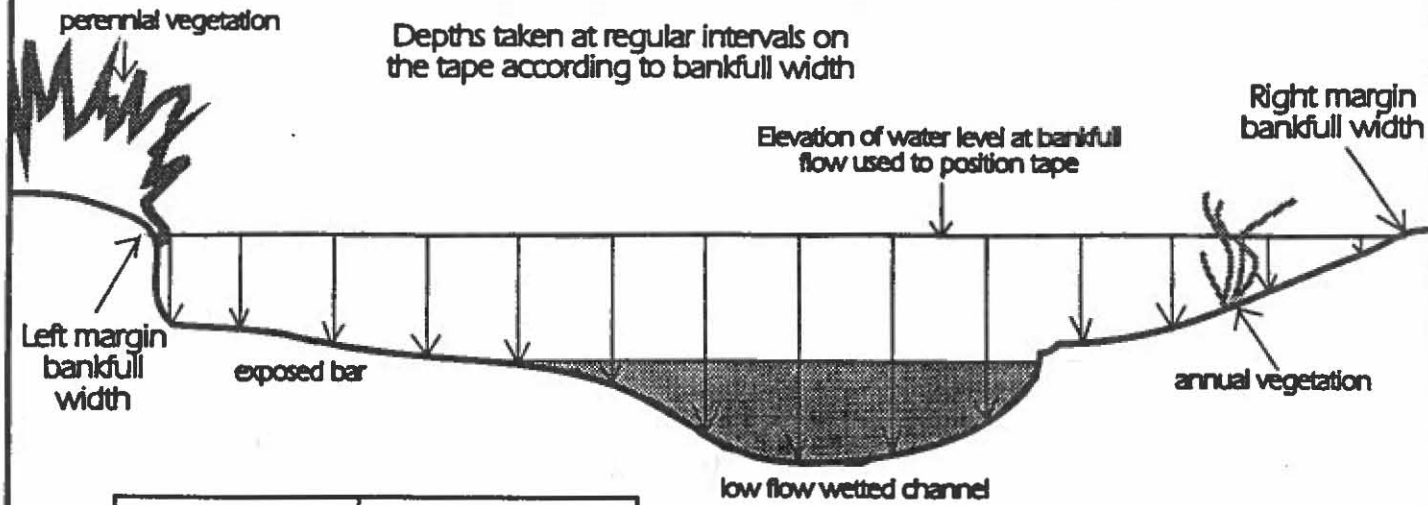
Sometimes it may be possible to identify the height of the bankfull channel on one side of the stream and not the other (for example if there is a low floodplain on one side and a steep, eroding bank on the other). In these cases, extend a level line horizontally across the channel to the other side to determine bankfull height on the side lacking adequate evidence. In other cases, physical obstructions such as debris jams, undercut banks, or complete lack of indicators may make determination or measurement of bankfull dimensions impossible at the reference point. In these cases, take the measurement at the nearest place where it is feasible.

Taking Bankfull Width and Depth Measurements

To measure bankfull width, securely attach the end of the fiberglass tape measure at one boundary of the bankfull channel. Extend the tape across the channel to the other boundary of the bankfull channel. This distance is the bankfull width. If a side-channel is present, add the bankfull width of the side- channel to that of the main channel.

With the tape stretched and fastened between these two points, you can now determine average bankfull depth. Bankfull depth measurements are taken at regular intervals across the stream channel. The number of measurements, and distance between them, depends on the width of the channel (Figure 3). Take measurements at 0.5 meter intervals in channels less than 5 meters in width, at 1 meter intervals in channels between 5 and 15 meters in width, at 2 meter intervals for channels between 15 and 25 meters, and every 4 meters in channels greater than 25 meters in width. In addition, take an initial measurement 0.1 meter out from the starting point, and 0.1 meter in from the endpoint.

Bankfull depth is the distance from the channel bed to the estimated water surface elevation at bankfull flow, represented by a tape stretched horizontally between the bankfull boundaries. The depth of water at the time of the survey, or its absence, does not affect this measurement (Figure 3). The sum of all depth measurements are then divided by the number of measurements taken to compute average bankfull depth.



Bankfull Width of:	Depths taken at:
< 5m	.5m intervals
5m > 15m	1.0m intervals
15m > 25m	2.0m intervals
25m >	4.0m intervals

Note: Take additional depth measurements at .1m from each end of the tape and average with all depths

Figure 3. Measuring bankful depth

8/11/92 AP

Canopy closure measurement

Cooperators interested in measuring the amount of canopy closure can make an optional canopy closure measurement at every reference point.

To do this, stand in the middle of the wetted portion of the channel and take four readings with the densiometer. Begin with a reading facing directly downstream. Turn clockwise 90 degrees and take a reading facing the right bank. Turn another 90 degrees clockwise and take a reading facing upstream, and finally turn clockwise another 90 degrees and take a reading facing the left bank.

To take a densiometer reading, hold the densiometer 12-18" in front of you at elbow height. Use the circular bubble-level to ensure that it is level. Look down on the surface of the densiometer, which has 24 squares etched into its reflective face. The reflection of your head should be just outside the grid. Imagine that each square is sub-divided into four additional squares. This makes a total of 96 smaller unit quarter-squares. Envision a dot in the center of each quarter-square. Next, count the total number of quarter-square dots covered by the reflection of vegetation (Figure 4). It is helpful to have your partner record the densiometer readings at each of the four positions.

When readings have been taken in all four directions, compute the average percentage of canopy closure at the reference point by: **1)** adding the four readings; **2)** dividing by four; and **3)** multiplying the result by 1.04. This number is recorded on Form 2.

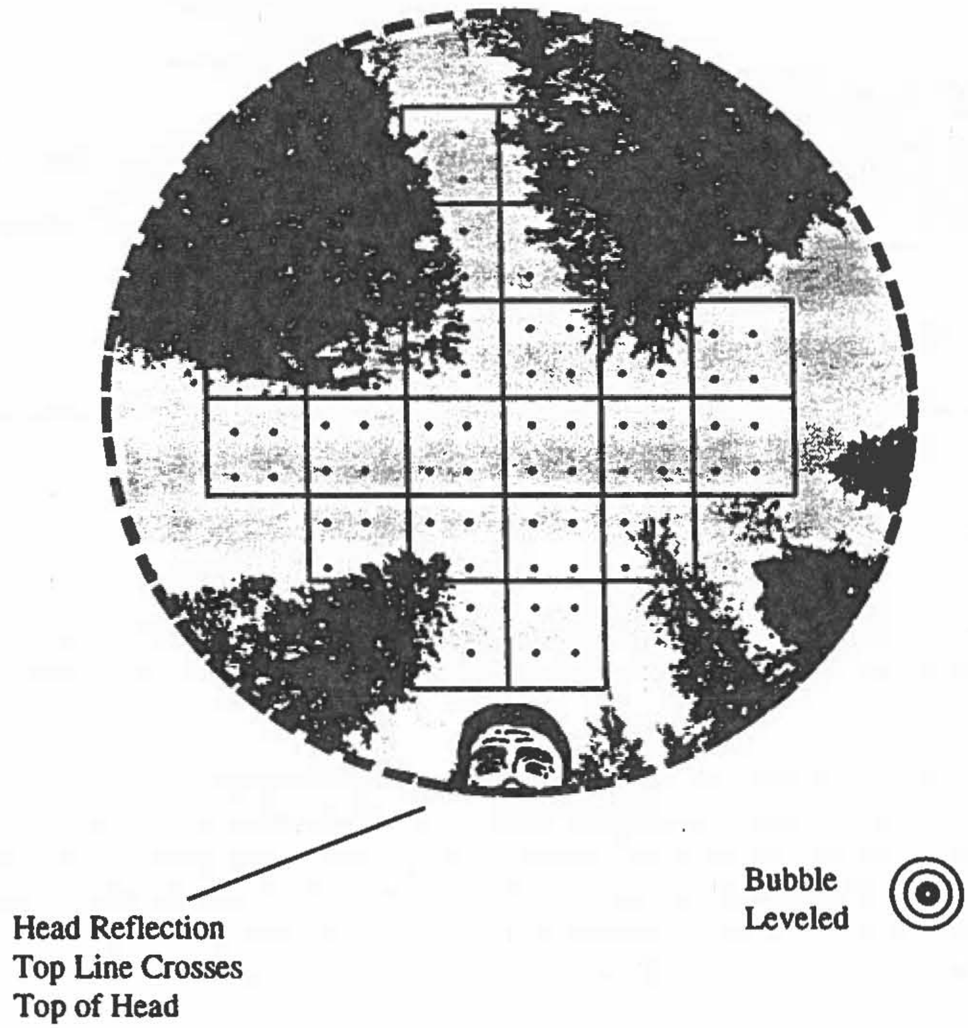


Figure 4. View into a convex spherical densiometer showing placement of head reflection and bubble level. Visualize four equi-spaced dots in each square and count the number covered by vegetation. Note: Concave densiometers are also available.

Filling Out the Reference Point Survey Form

The Reference Point Survey Form

Use the reference point survey form (Appendix A) to record information collected in the reference point survey. The following section describes how to record data on this form.

Background Information

Record the stream name, WRIA and segment number, gradient/confinement category and beginning and ending river miles. Note the date of the survey on each form. Begin a new form at the start of each day. Number the sheets sequentially for the entire segment, e.g., 1 of 10, 2 of 10 and so forth.

Reference Point Number

Record the number of each reference point in this column, beginning with reference point #0 at the lower boundary of the segment. Note if the tag was placed on the left bank, right bank or both (right and left bank are always determined looking downstream.)

Cumulative Distance

Record the cumulative distance (in meters) from the lower boundary to each successive reference point. For instance, when the reference points are laid out at 100 meter intervals, the cumulative distance to reference point #0 would be 0 meters, to reference point #1 would be 100 meters, to reference point #2 would be 200 meters, and so forth. If one or more of the reference points are not laid out at 100 meter intervals, record the actual cumulative distance.

Photographs

Record the roll and frame number for both the upstream and downstream photographs.

Bankfull Width

Record the bankfull width measurement at each reference point to the nearest tenth of a meter.

Bankfull Depth

Record the average bankfull depth, computed by adding together the individual bankfull depth measurements and dividing by the number of measurements taken (see measuring bankfull width and depth, above).

Canopy Closure

Record the average percentage of canopy closure (sky obscured by vegetation). This the average of the readings taken in each of four directions (see canopy closure measurement, above).

Training, Field Assistance and Data Processing

This manual is intended as a reference for those collecting monitoring information using the TFW Ambient Monitoring Program reference point survey module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that involves having an experienced crew perform replicate surveys for cooperators. The purpose of these surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data being collected is replicable and consistent throughout the state.

The TFW Ambient Monitoring Program also provides field forms for recording monitoring data. Cooperators that use these forms can have their data scanned into a database and will receive a hard copy data summary sheet and a copy of the database on floppy disk.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Dunne, T. and L.B. Leopold. 1978. **Water in environmental planning.** W.H. Freeman and Co. New York.

Richards, K. 1982. **Rivers: form and process in alluvial channels.** Methuen. New York.

Schumm, S.A. 1977. **The fluvial system.** Wiley-Interscience. New York.

~~SEGMENT SUMMARY~~ **FORM 1**

TFW - N.W.I.F.C.

Ambient Stream Monitoring 1992

Version 7/10 AP

Page ____ of ____

DATE __/__/ 92	CONFINEMENT/ GRADIENT		W.R.IA. NUMBER			STREAM ORDER	SURVEYORS/ AFFILIATIONS	
STREAM NAME								
O Creek O River	U / M / C	Cat. 1-7	O Unlisted	Trib. (LB / RB)	Seg #	1 - 7	Caller (S1 A1)	Recorder (S2 A2)

IMPORTANT ! Fill out FORM 1 - 1ea. per segment. If additional FORM 2's (REF. PT. SURVEY) are necessary use same temp. form and fill in Form 1 categories: Page; Date; Stream Name; Conf/Grad; &W.R.I.A. #

LOWER BOUNDARY LOCATION	ELEVATION	PHOTOGRAPHS	REFERENCE POINT	RIVER MILE	LATITUDE / LONGITUDE
TOWN / RNG / SEC / 1/4 of 1/4	O feet O meters	YR (9 2) / ROLL / BEG FR. #	LB / RB		
UPPER BOUNDARY LOCATION	**ELEVATION**	**PHOTOGRAPHS**	**REFERENCE POINT**	**RIVER MILE**	**LATITUDE / LONGITUDE**
TOWN / RNG / SEC / 1/4 of 1/4	O feet O meters	YR (9 2) / ROLL / END FR. #	LB / RB		

FIELD NOTES:

REFERENCE POINT SURVEY

FORM 2

TEMPORARY FORM

REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL: upstrm frame	PHOTOGRAPHS: dwnstrm frame	BANKFULL (meters) WIDTH	BANKFULL DEPTH	CANOPY CLOSURE
LB / RB						%
LB / RB						%
LB / RB						%
LB / RB						%
LB / RB						%

FIELD NOTES:

FIELD NOTES:

FIELD NOTES:

FIELD NOTES:

FIELD NOTES:

APPENDIX A.

REFERENCE POINT SURVEY FORM 2 (cont.)

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

	REFERENCE POINT	CUMULATIVE DISTANCE (meters)	PHOTOGRAPHS ROLL		BANKFULL (meters)		CANOPY CLOSURE	FIELD NOTES:
			upstrm frame	dwnstrm frame	WIDTH	DEPTH		
	LB RB						%	

N.W.I.F.C.
730 Martin Way E, Olympia, WA 98506
Contact:: Scott Hall (206)438-1180

TFW AMBIENT MONITORING
HABITAT UNIT SURVEY MODULE

Table of Contents

Introduction to Habitat Units

Hydraulic conditions such as water depth and velocity vary within stream channels. This variation often occurs in somewhat orderly patterns with distinct, alternating areas of deep water (pools) and shallow water (riffles). These distinct areas are referred to as "habitat units".

Various species and life history stages of aquatic organisms have adapted to the rigors and opportunities presented by particular hydraulic conditions. Consequently, they are more likely to be found in particular habitat units (Bisson et al., 1982). The type and amount of habitat units present can be used as an indicator of the suitability of a stream reach for a particular species or life history stage.

Intrinsic factors such as stream size, gradient and confinement influence the type and relative abundance of habitat units found in a particular reach (Beechie and Sibley, 1990). In addition, the relative abundance and characteristics of various habitat units is responsive to changes in local- and watershed-scale processes that determine sediment supply, runoff during storm events and recruitment of large woody debris. These processes and their inputs may be altered by human activities such as forest practices and by changing natural conditions.

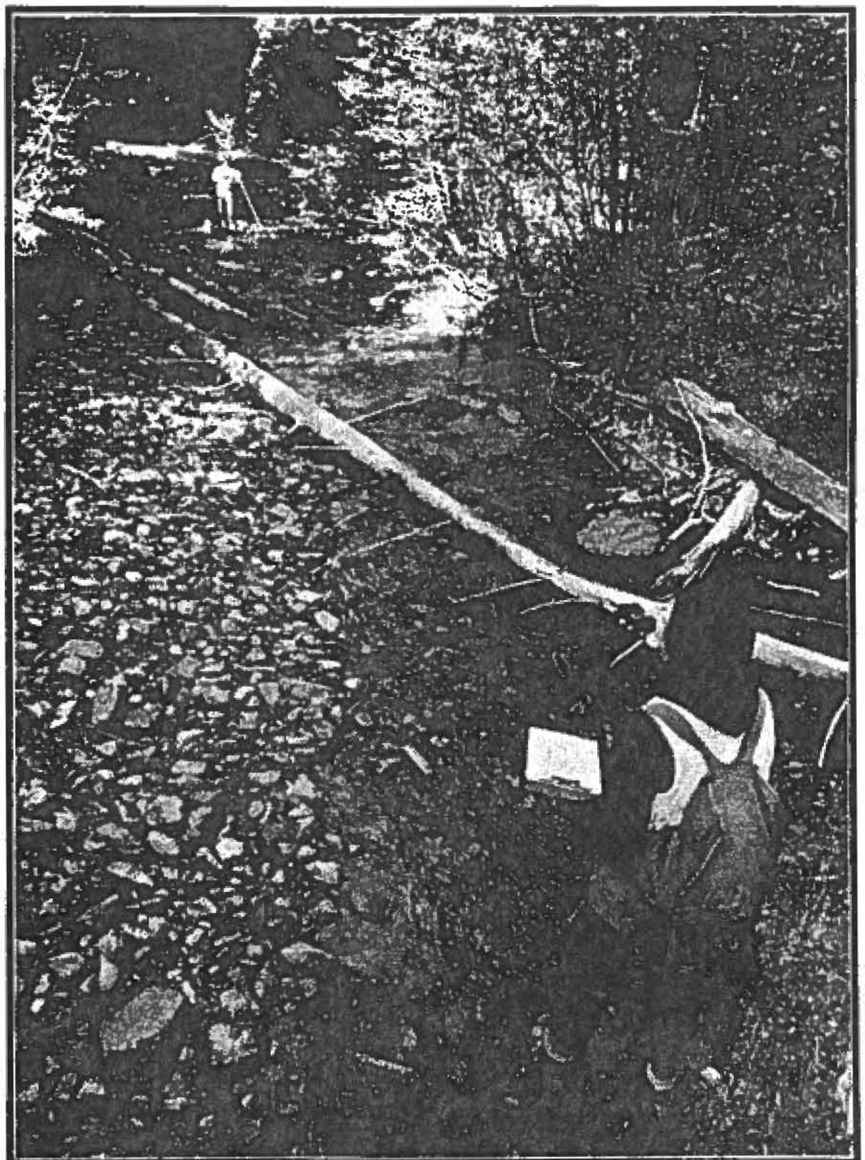


Photo by: A.E. Pleus

Lyman Bullchild (foreground) and Joe Apfel measuring the length of a riffle unit with a Sonin instrument. West Fork Taneum Creek. 1991.

Because the utilization of instream habitat varies by species, life history stage and physiographic region, no single habitat survey methodology can accurately characterize habitat conditions for all salmonids throughout the State of Washington. Instead, the habitat unit survey focuses on partitioning streams into basic morphologic features. The intent of the survey is to characterize current morphologic conditions, and to monitor changes in the size and frequency of these units in response to changing inputs of sediment, discharge and large woody debris associated with natural or management-induced disturbance and recovery.

Purpose of the Habitat Unit Survey Module

The purpose of the habitat unit module is to:

1. Provide a means of accurately characterizing the current status of basic channel morphology at a level of precision and detail suitable for use as a foundation for monitoring.

2. Provide a replicable methodology that can be repeated over time to document changes and trends in habitat unit distribution and abundance.

3. Provide information on the percentage of pools that is suitable for use in the Watershed Analysis cumulative effects assessment procedure.

The Habitat Unit Survey Methodology

This section describes procedures for identifying and measuring the characteristics of habitat units.

Those familiar with previous TFW ambient monitoring stream survey procedures will notice that the habitat unit classification system has been simplified from the numerous "micro" habitat units used in previous years to four "macro" habitat units (pools, tailouts, riffles, and cascades). This change was made to improve observer recognition of units and the ability to replicate surveys in the future. See Ralph et al. (1991) for a discussion of replication problems with the micro-habitat system.

Please record all measurements in metric units. Eliminating the need to separate and convert English and metric measurements will greatly reduce confusion and streamline data processing. The decision to use metric units was made because most scientific studies used for comparison and interpretation of monitoring data are reported in metric units.

Information and Equipment Needed

In order to complete the habitat unit survey, it is necessary to have previously identified a survey segment (see the TFW ambient monitoring stream segment identification module). It is also necessary to have established reference points (see the reference point survey module) so the habitat units can be associated with a permanent reference location. In addition, you will need to know the average bankfull width for the survey segment. To determine the average bankfull width, examine the completed reference point survey forms for the segment, sum the bankfull width measurements and divide by the number of measurements.

You will need the following equipment to conduct the survey:

* Habitat unit survey forms (3a and 3b)
* Number 2 pencils
* Clipboard or form holder
* Fiberglass tape and/or rangefinder (metric)
* Abney level or clinometer
* Stadia rod (metric)
* Flow meter
* Wading rod for flow meter
* Hip boots or waders
* Map
* First aid supplies
* Field notebook

Discharge

The surface areas of the wetted channel and individual habitat units change with discharge, so measured values are highly dependent on the amount of water flowing in the channel at the time of the survey. This methodology is designed to be applied during relatively stable flow conditions characteristic of the summer low flow period. Surveys should not be conducted during periods of high water associated with summer storms, during extreme low baseflow conditions when sections of typically perennial streams are dry, or during periods of rapidly fluctuating discharge.

Discharge should be measured at the time you begin to survey each segment and recorded on the habitat unit survey form. If discharge changes significantly during the time the segment is being surveyed, additional discharge measurements should be taken and recorded on subsequent survey forms.

In order to obtain comparable data, future surveys of the same segment should be conducted at a discharge similar to the discharge at the time of the original survey. At this time, the sensitivity of the methodology to changes in discharge has not been determined. Pending further analysis, we recommend that discharge at the time of repeat surveys be within 10% of the discharge during the original survey.

Discharge should be determined using standard streamflow measurement methods. First, select a suitable location (within the segment being surveyed) with adequate depth and smooth, laminar flow.

A suitable site should not have flow diversions, side-channels, or undercut banks. It should be relatively free of turbulence and flow obstructions such as large rocks, logs, and aquatic vegetation.

Stretch a fiberglass tape across the wetted portion of the stream channel and perpendicular to the direction of flow (Figure 1). Attach each side of the tape securely. Note the distance on the tape corresponding to the water's edge on each side of the stream. Assemble your flow meter, attach it to the wading rod, and test it to

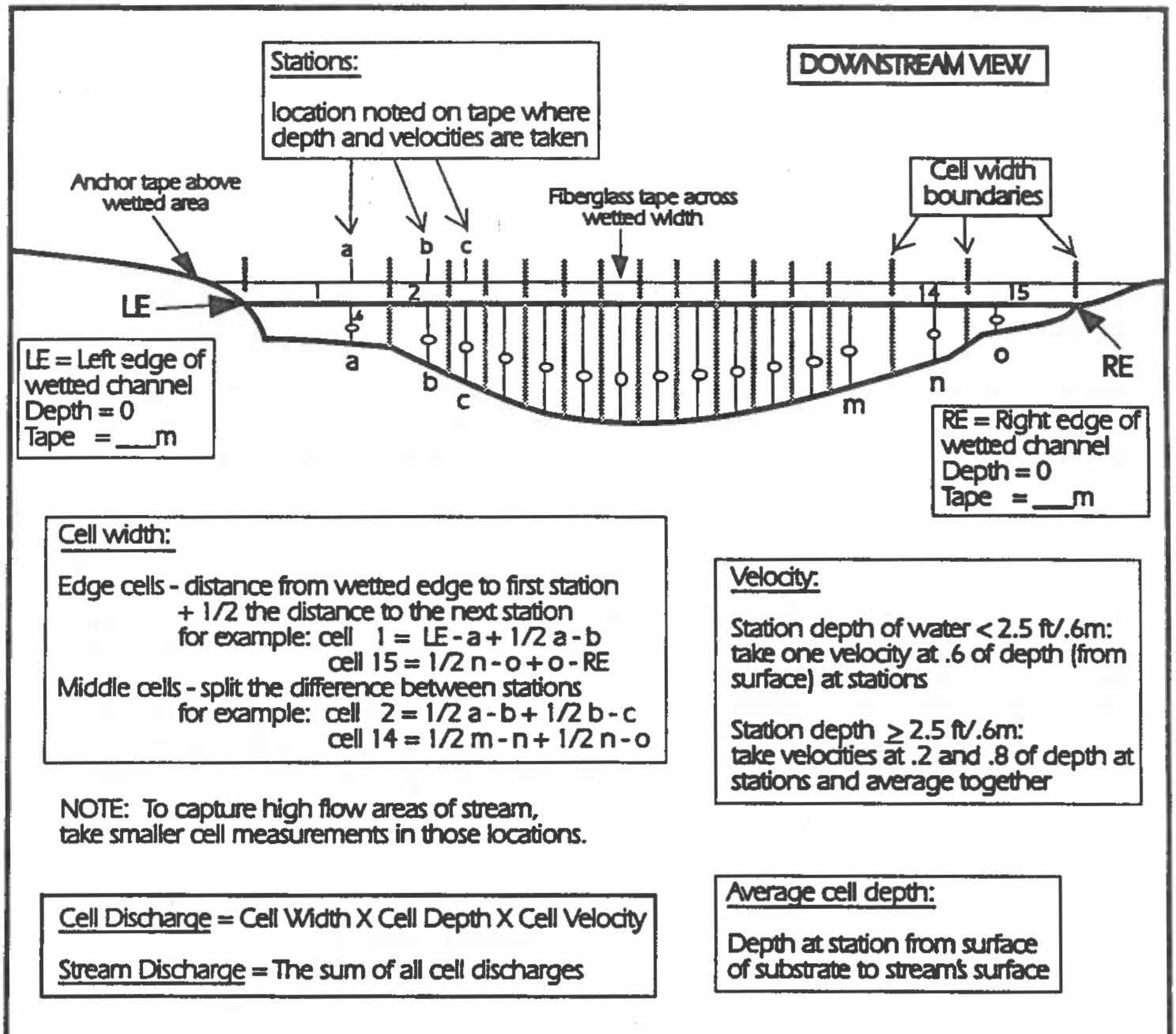


Figure 1. Discharge Measurement

8/92 AEP

ensure that it is working properly. A variety of flow meter designs are available that are suitable for this purpose. Operate your meter according to instructions provided by the manufacturer.

The next step is to divide the stream cross-section into cells and to measure water depth and velocity at the center of each cell . Cells can vary in width. The number and size of cells needed will vary depending upon the size and characteristics of the stream channel. Typically, 15-20 cells are necessary. Cells should be chosen so that the depth and velocity measurement taken at the center of the cell represents conditions throughout the cell. Cell boundaries should be placed wherever noticeable breaks or discontinuities in velocity and depth occur. No cell should have more than 10% of the total discharge. If this appears to be the case, the cell should be divided into two or more smaller cells.

Place the wading rod/flow meter assembly in the center of each cell. Record the distance along the tape at each station where measurements are taken and the width of each cell. Read the water depth from the wading rod and record. Adjust the wading rod so the flow meter is at the proper depth. Water velocities typically vary with depth. If the water depth is less than 2.5 feet, the meter should be placed 0.6 of the distance from the water surface to the stream bottom to properly characterize average velocity. For depths greater than 2.5 feet, two velocity measurements should be taken and averaged. These should be taken at 0.2 and 0.8 of the total depth. Use the meter to measure velocity and record for each cell.

To determine the total discharge, calculate the discharge for each cell by multiplying the cell width and water depth to find cross-sectional area. Then multiply cross-sectional area by velocity to get discharge. Sum the discharge measurements for all cells to calculate the total discharge. An example of a completed discharge measurement form is shown in Appendix A. A blank discharge measurement form that can be copied for field use is included in Appendix B. The form also contains a formula for converting cubic feet/second to cubic meters/second.

Identification of Habitat Units

The first step in this procedure is to determine the type of habitat units present.

Wetted portions of the main channel and side channels where water is present are assigned to one of four habitat unit types, pool (**P**), tailout (**T**), riffle (**R**) or cascade (**C**). When portions of the channel are not visible, for example when it passes under a massive debris jam or through a long culvert, it is designated obscured (**O**). If it dissipates into a wetland without a distinct channel, it should be designated as a wetland (**W**). If the main channel is dry it should be designated as sub-surface flow (**S**).

To qualify as a pool, tailout, riffle or cascade, a potential unit must meet a minimum size criteria. The minimum size requirement for a habitat unit varies with channel size, expressed as bankfull width (see Table 1, below). Areas that do not meet the minimum size criteria should be combined with the most similar adjacent unit.

The purpose of the minimum unit size criteria is to provide guidance on when it is appropriate to lump or split small units, in order to improve consistency between observers who tend to lump units and those who tend to split.

Table 1. Minimum unit size by channel bankfull width.

Channel Bankfull width (meters)	Minimum unit size (square meters)
0 - 2.5 meters	0.5
2.5 - 5 meters	1.0
5 - 10 meters	2.0
10 - 15 meters	3.0
15 - 20 meters	4.0
> 20 meters	5.0

<u>Characteristics of Habitat Units</u>

Once the minimum size criteria is met, pools, tailouts, riffles and cascades are distinguished on the basis of depth and gradient characteristics.

Pools- Pools are areas of low gradient (typically less than 1 %), deep water. They are typically created by scour adjacent to obstructions or impoundment of water behind channel blockages and hydraulic controls such as logjams, bedforms or beaver dams. To qualify as a pool, a unit must meet a minimum residual depth requirement that increases with increasing channel width.

Tailouts- Tailouts are areas of moderately shallow water with an even, laminar flow and a lack of pronounced surface turbulence. They are situated on the downstream end of pools, in the transitional area between the pool and the head of the downstream riffle. They have a flat, smooth bottom, lacking the scour typically associated with the pool. Because they are located on the upstream side of the riffle crest, they lack the velocity and surface turbulence associated with riffles or cascades located on the downstream slope of the riffle crest. Tailouts are most commonly found in low-gradient channels associated with elongated pools with well-sorted substrate. They are uncommon in small, high-gradient streams with coarse substrate.

Riffles- Riffles are shallow, low gradient areas that do not meet the residual pool depth requirement. They are distinguished from cascades by having a water surface gradient of less than 3.5 percent. Although many riffles exhibit surface turbulence associated with increased velocity and shallow water depth over gravel or cobble beds, the riffle classification also includes shallow areas without surface turbulence such as glides and very shallow pools that do not meet the minimum pool depth requirement.

Cascades- Cascades are steep areas with a water surface gradient exceeding 3.5 percent. Some cascades are very short and smooth, such as slip-face cascades located on the downstream faces of channel bars or bedrock outcrops. Step-pool cascades occur where boulder or cobble substrate forms stair-steps. They often are very turbulent and have numerous small pools associated with the cobble/ boulder steps.

Using Minimum Residual Pool Depth to Distinguish Pools

Although some pools are quite distinct, in many cases it is difficult to differentiate shallow pools from deep glides or riffles. Considerable divergence occurs in habitat calls made by experienced observers in these situations. To eliminate this problem and provide consistent, replicable survey results, a criteria for minimum residual pool depth has been established. A pool must exceed a minimum residual pool depth criteria that corresponds with channel size, expressed as bankfull width (Table 2).

To determine if a potential unit qualifies as a pool, take a residual depth measurement (see section on determining residual pool depth, below), and compare with the minimum value for the appropriate channel size using the average bankfull width computed from the reference point survey form.

If the minimum residual depth requirement is met, the next step is to establish the boundaries of the pool unit and determine if the potential pool meets the minimum unit size requirement.

Table 2. Minimum residual depth criteria for pools by channel bankfull width.

Channel Bankfull Width	Minimum Residual Pool Depth (meters)
0 - 2.5 meters	0.10
2.5 - 5 meters	0.20
5 - 10 meters	0.25
10 - 15 meters	0.30
15 - 20 meters	0.35
> 20 meters	0.40

In most cases, pool boundaries extend laterally to the waters edge. However, if there is a distinct riffle or cascade unit adjacent to the pool that meets the minimum unit size criteria, it should be treated as a separate, adjacent secondary unit.

Delineating the upstream and downstream boundaries of pools can be difficult. The variety of situations encountered make a single criteria impractical. Often, the upstream or downstream boundary of a pool is distinguished by a change in water surface gradient. Look for a distinct break between the steeper adjoining riffle or cascade and the nearly flat water surface of the pool.

Distinguishing Tailouts

In other cases, there is no distinct gradient break between a pool and the adjacent downstream area. Often, a gradual increase in velocity and decrease in depth occurs in a transitional tailout area below larger, elongated pools. In these situations, the boundary between the pool and the tailout is delineated by examining the bedform of the channel and determining the downstream extent of distinct streambed scour. Where the cross-sectional profile of the bed becomes even and flat, the downstream boundary of the pool has been reached. The area below this boundary is designated as a tailout (Figure 2). The tailout extends downstream to the riffle crest, where the water shallows increases in velocity as it flows down the downstream slope of the bar. This boundary is typically distinguished by surface turbulence associated with the riffle or cascade.

Many pools, particularly smaller pools in moderate to high gradient channels, do not have distinct tailouts because the zone of scour extends to the riffle crest. In these cases, extend the pool unit to the riffle crest and do not delineate a tailout unit.

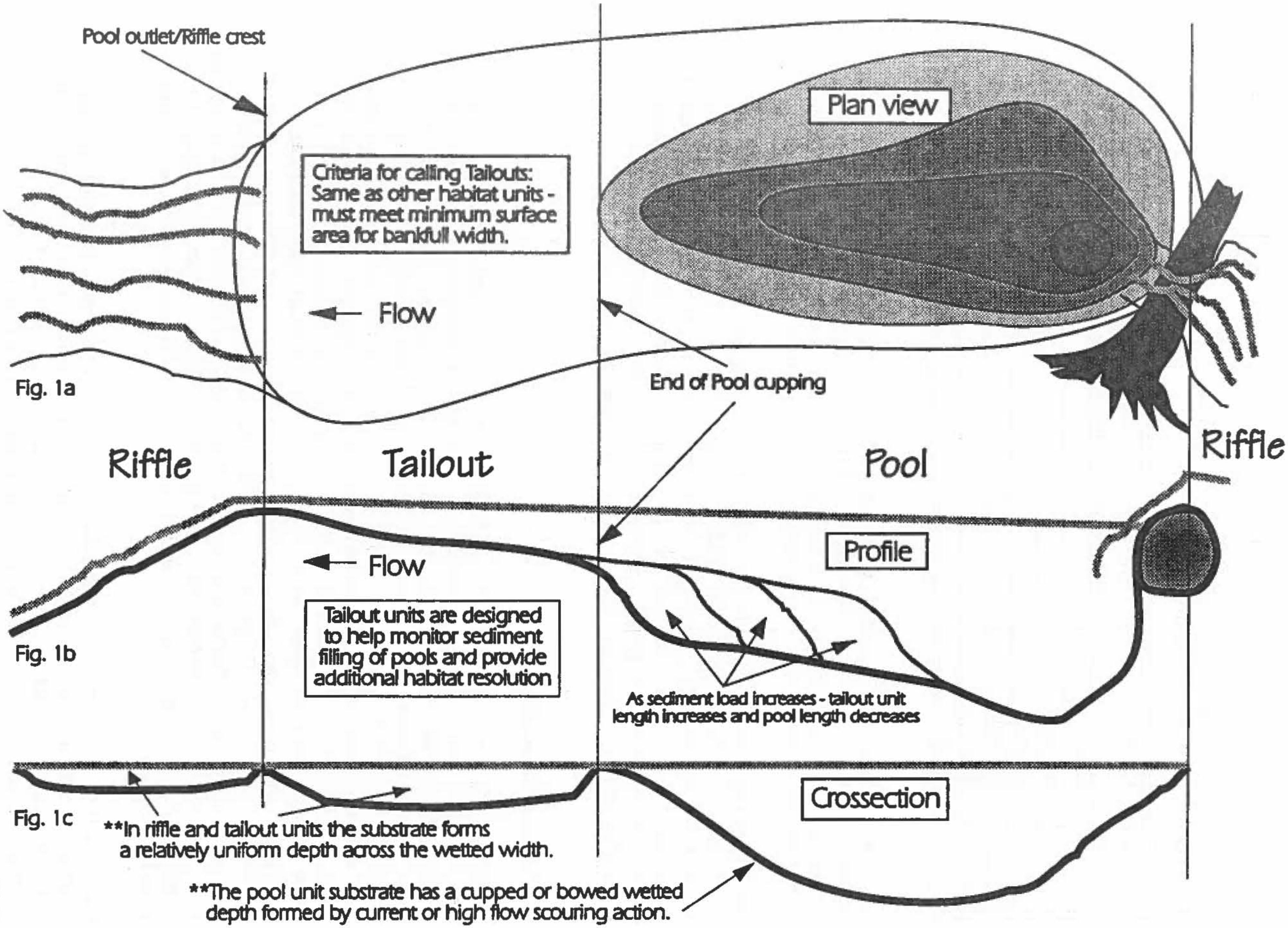


FIGURE 2. Criteria for Pools and Tailouts

Distinguishing Riffles from Cascades

For the purposes of this survey, areas that do not meet the criteria for pools or tailouts are classified as either riffles or cascades. Riffles and cascades are distinguished on the basis of water surface gradient. Riffles are areas with water surface gradients less than 3.5 percent; cascades have gradients greater than 3.5 percent.

To measure the water surface gradient of a potential riffle or cascade, observers are positioned at the upstream and downstream boundaries of the potential habitat unit. One person stands at water's edge, with the bottom of their boots at the water surface level, and sights through a hand-held Abney level or clinometer at a stadia rod held with its base at the water surface by the person at the other end of the unit. The Abney level or clinometer is sighted at a point on the stadia rod equal to the observers eye-level, and the gradient is read from the instrument (follow the instructions for your instrument).

To identify the boundary between a riffle and cascade, look for a distinct gradient break, where one side is less than 3.5 percent water surface gradient and the other is 3.5 percent or greater.

Distinguishing Small Pools and Riffles within Cascades

Cascades with boulder/cobble stair-steps (step-pool cascades) often contain numerous small pools and occasional riffles, posing the question of whether to split them out as separate units. These small pools and riffles should be examined and classified as separate units if they meet the appropriate minimum unit size requirements and residual pool depth requirement (see Tables 1 & 2.) Small pools that occur within riffle areas should be treated in the same manner. Although the minimum unit size requirement occasionally forces the observer to combine small, distinct areas with adjacent units, using these criteria will improve the repeatability of surveys performed by different observers over time.

Photo by: A.E. Pleus

Example of small pool unit within a cascade on Willaby Creek

Sub-Surface Flow, Obscured and Wetland Units

Occasionally, stream reaches will alternate between wet and dry areas, or be completely dry. If the stream is dry because of extreme low flow associated with drought, it probably is not an appropriate time to conduct a habitat unit survey because the information generated will not be useful for comparative purposes. On the other hand, if intermittent flow is a typical low flow condition, or if it appears to be resulting from changing conditions such as coarse sediment aggradation, then documenting its occurrence is useful.

When intermittent dry areas are encountered in the main channel, they are recorded as sub-surface flow units. Only main channel sub-surface flow areas are counted and recorded, dry side-channels and dry secondary units are not recorded.

Channel Location of Habitat Units

Habitat units are classified in one of three categories, depending on their location and relative significance within the stream channel (Figure 3).

The three categories are:

Category 1- Primary units. These are the dominant units in the main channel. They occupy over 50% of the wetted channel width. At any given point along the length of the channel, there can be only one primary channel unit.

Category 2- Secondary units. These are subdominant units in the main channel that occupy less than 50% of the wetted channel width. They may be either adjacent to a primary unit or lie embedded within and surrounded by a primary unit.

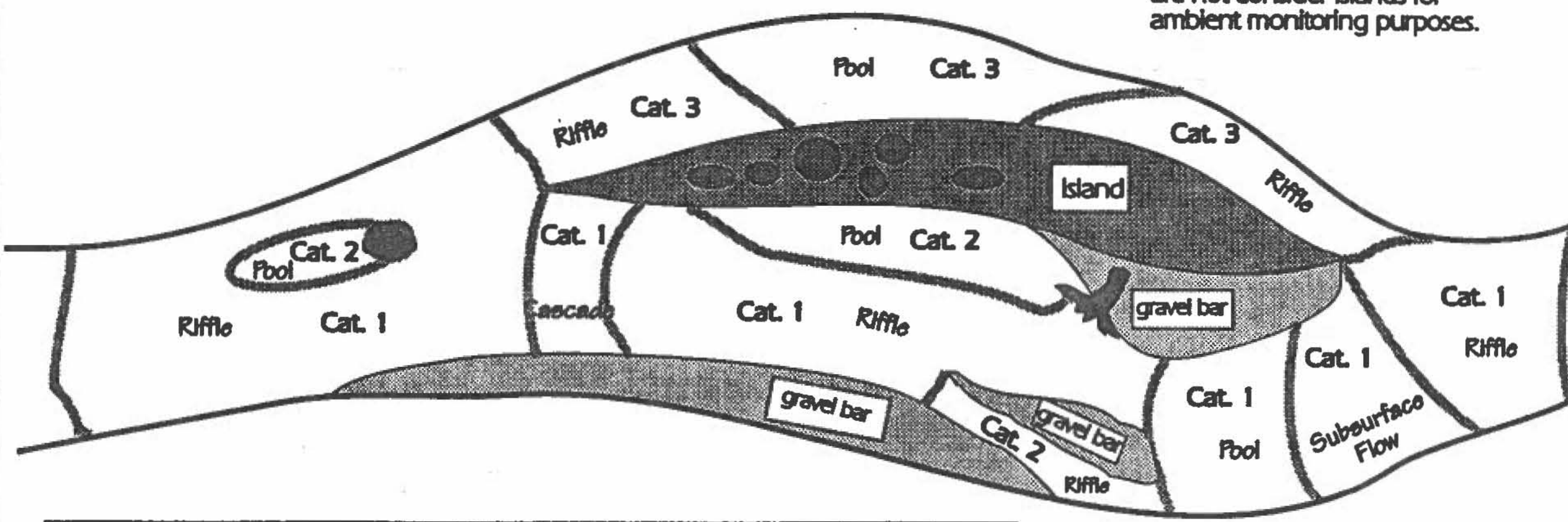
Category 3- Side-channel units. These are found in side-channels that are isolated from the main channel by islands. An island must: a) have a length equal to at least two bankfull widths, and b) be colonized by perennial vegetation. Units separated only by bare gravel bars are treated as adjacent units.

Information on habitat unit location allows determination of the relative abundance of side-channels and main channel habitat during summer low flow conditions. In addition, by summing the length of primary units, the total thalweg length of the survey segment can be calculated.

Criteria for an island:

1) Must have perennial vegetation growing on it (e.g., plants which survive overwinter such as alders, willows, cottonwood, ferns, etc.)
2) Must have a length equal to at least two bankful widths (e.g., for a segment with an average bankfull of 13m, an island must be 26m in length or greater.)

Note: Gravel bars of any length with or without annual vegetation are not consider islands for ambient monitoring purposes.



Catagory 1 - Primary unit: width covers greater than 50% of wetted channel width.

Catagory 2 - Adjacent unit: width covers less than 50% of wetted channel width May be separated from primary unit by a gravel bar.

Catagory 3 - Side-channel unit: channels which are separated from primary channel by a island.

Figure 3. Habitat unit catagories

8/92 AEP

Measuring Lengths and Widths of Habitat Units

The lengths and widths of habitat units are measured in order to compute the surface area of each habitat unit. During data analysis, the total surface area and relative percentage of each habitat type is calculated.

Measuring Lengths of Pools, Tailouts, Riffles and Cascades

Habitat unit lengths can be measured with a fiberglass tape measure, hip chain, or rangefinder. Habitat unit lengths should be measured from the boundary with the adjacent downstream unit to the boundary with the adjacent upstream unit (Figure 4).

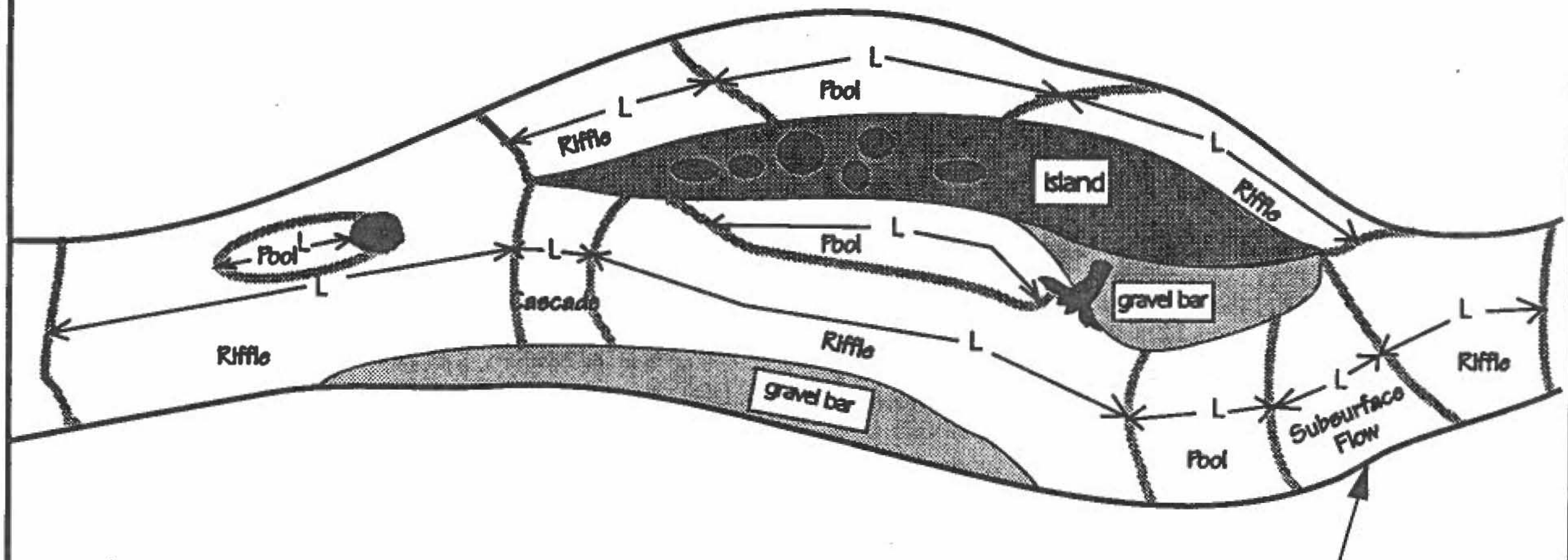
Measurements should follow the shape of the unit (the thalweg in the case of primary units). For instance, if the unit curves around a bend, the measurement should follow the curve, rather than taking the shortest distance between the upper and lower boundary. The sum of the lengths of all the primary units should represent the thalweg distance for the segment.

When the boundary between adjacent upstream and downstream units is a straight line perpendicular to the direction of flow, establishing the beginning and ending points for the length measurement is straightforward. Often the boundaries are not perpendicular to the angle of flow. In these cases, measure from a point midway along boundary between the units.

Measuring Lengths of Sub-Surface Flow, Obscured and Wetland Units

In areas where the main channel goes dry (sub-surface flow units), length is recorded as the distance between upper end of the adjacent downstream wetted unit and the lower end of the next wetted unit upstream. Follow the curvature of the channel thalweg if it can be determined.

Lengths of obscured units should be measured from the point at which the channel is no longer visible to where it re-emerges into view. The length of wetland units is taken from where the channel becomes indistinguishable as it spreads out in the wetland area to where it re-emerges again.



Measure lengths only on Category 1 subsurface flow units

Length measurements are made along the thalweg of each unit.

The thalweg is along the deepest part of the unit or the center if depth is uniform.

Note: It may be necessary to take several consecutive lengths to capture the curvature of the unit's thalweg.

Figure 4. Measuring habitat unit lengths

8/92 AEP

Measuring Average Widths

Average widths are calculated for pool, tailout, riffle and cascade units. Average widths are not measured in sub-surface flow, obscured or wetland units.

The width of units is measured from the waters edge on one side of the stream to the waters edge on the other side, unless there are two adjacent units. Where there are two adjacent units side-by-side, measure from the edge of the stream to the boundary between the adjacent units (Figure 5). When an adjacent unit is embedded within a larger unit, subtract the width of the embedded unit from the total width to calculate the width of the larger unit.

Determining the edge of the wetted channel may be difficult, particularly on the margin of gravel bars where there is water between the particles. In these cases, extend the wetted width measurement shore-ward to the point where the particles are no longer completely surrounded by water and the water is restricted to isolated pockets. If a dry bar or island is present within the unit, subtract the width of the dry area when measuring width. Protruding objects such as logs or boulders are included in the width measurement.

Determine the average width of the unit. In units with a consistent width, one measurement may suffice to determine average width. Often the width of a habitat unit will vary considerably along its length. In these cases it is necessary to take multiple width measurements and compute the average width. To do this, divide the unit along its length into two or more cells of equal distance, depending on the length of the unit and the amount of variation. Take a width measurement at a representative place in each cell and record the measurements in a field notebook. Sum the width measurements and divide by the number of measurements to compute average width.

Splitting Units at Reference Points

We want to be able to separate habitat unit data into discrete 100 meter reaches separated by the reference points. This will provide an opportunity to randomly or systematically sub-sample 100 meter reaches for future monitoring, instead of re-surveying entire segments. It will also provide the opportunity to document and display variation in conditions throughout the segment in 100 meter increments.

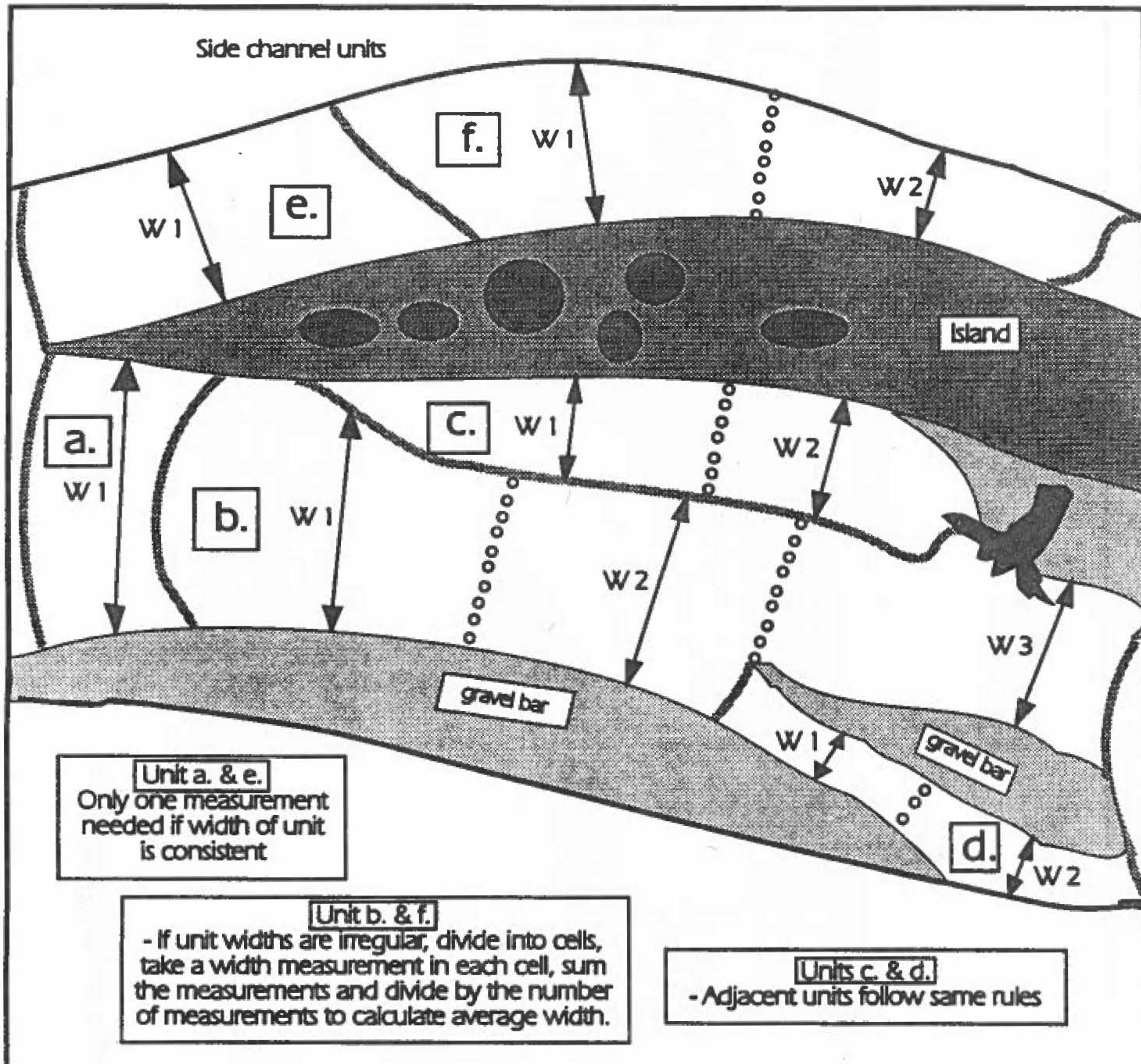


Figure 5. Measuring average habitat unit widths

All types of categories of habitat units, primary, secondary, side-channel and subsurface flow, should be split at reference points.

To separate the habitat unit data into 100 meter reaches, identify the units that cross reference points and split them where the reference point intersects the unit. Record separate lengths and average widths for each portion of the unit above and below the reference point boundary (Figure 6). Split units require a separate

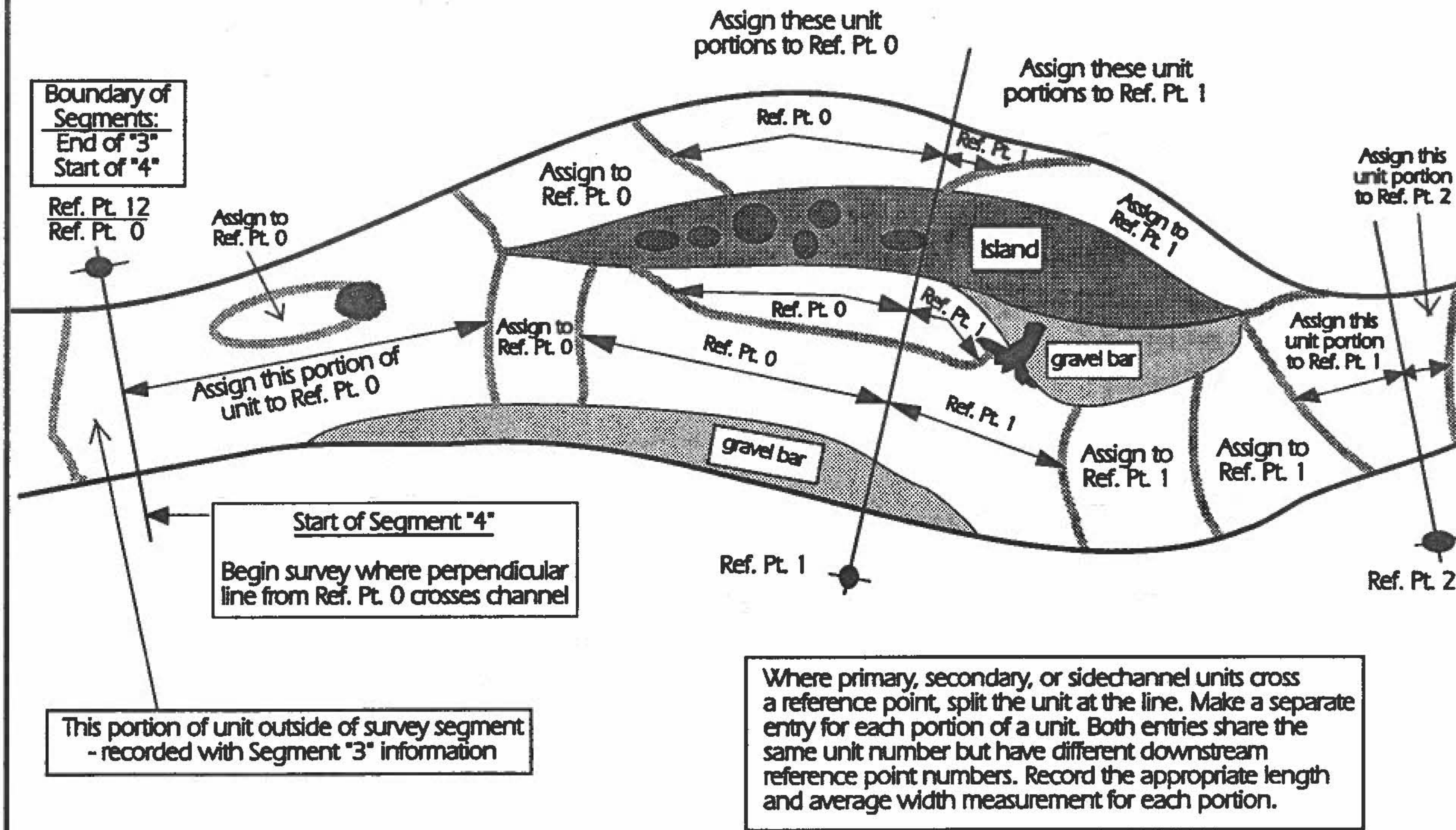


Figure 6. Splitting habitat units at reference points

8/92 AEP

entry on the form for each portion of the habitat unit. Both entries will share the same habitat unit number, but will have different downstream reference point numbers, indicating that they are in different 100 meter reaches.

Separate lengths and average widths should be recorded for each portion of a split unit. If the unit is a pool, only one entry for maximum depth, outlet depth, and pool forming obstruction should be recorded for the entire unit.

Determining Residual Pool Depth

Residual pool depth is a discharge-independent measurement of the depth of a pool relative to the height of the adjacent downstream hydraulic control structure that controls the water depth in the pool, such as a gravel bar or a log. It is only measured in pool units. Residual pool depth is used as a criteria for identifying pools, and as a means of monitoring the filling of pools with sediment over time.

Residual pool depth represents the difference between the elevation of the deepest point in the pool and the elevation of the crest of the bar immediately downstream. This is determined by calculating the difference between the water depth at the deepest point and the water depth on top of the downstream bar or control structure. To visualize the concept of residual pool depth, imagine what would happen if the water level dropped until it was no longer flowing over the downstream riffle, isolating the pool. The depth of the water that would remain in the pool at its deepest point would be the residual pool depth. See Lisle (1987) for a detailed discussion of residual pool depth.

To determine residual pool depth, two depth measurements are required (Figure 7). First, locate the deepest spot in the pool and measure the distance from the deepest point to the surface of the water. This measurement is the maximum pool depth.

Next, locate the downstream riffle crest, the point at the outlet of the pool that forms the dam and controls the release of water from the pool. This spot can be tricky to locate. It is often located below the downstream boundary of the pool unit. The correct location to make the measurement is where the thalweg (deepest part) of the channel crosses the top of the bar. It can be visualized as the summit of a mountain pass. The water depth at this location is the pool outlet depth. In some cases, the downstream hydraulic control may be an obstruction that impounds water, such

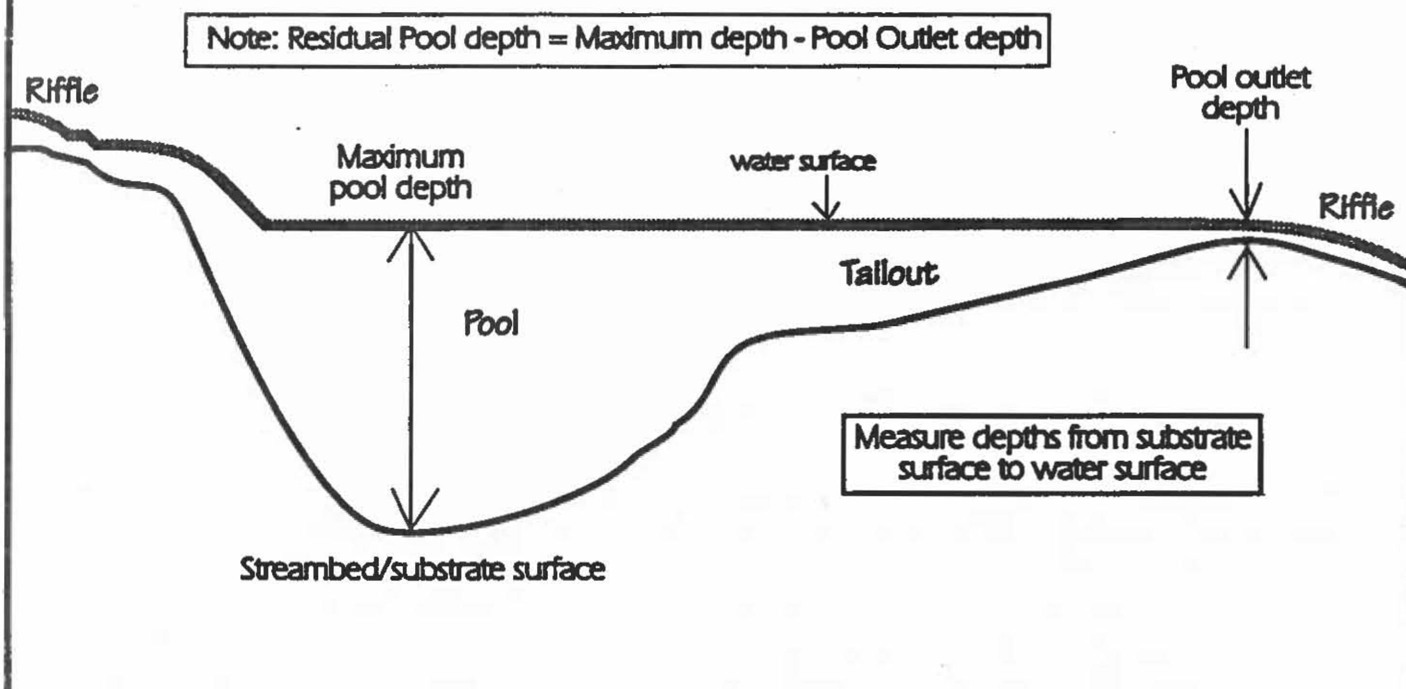


Figure 7. Measuring maximum pool depth and depth of pool outlet

as a log or a beaver dam, rather than a gravel bar.

In these cases, the depth of water flowing over the obstruction would be the pool outlet depth. If the water is not flowing over the downstream hydraulic control or if the water is filtering through (not over) a beaver dam, then the pool outlet depth would be zero.

During data analysis, residual pool depth will be calculated by subtracting the pool outlet depth from the maximum pool depth.

Identifying Factors Contributing to Pool Formation

Pools typically form as a result of scour adjacent to channel obstructions or due to impoundment of water behind blockages. Information on the factors contributing to pool formation is collected in order to document changes over time and to provide interpretive information related to current conditions such as percentage of pools and residual pool depth.

Table 3 lists a number of factors that often contribute to pool formation. Record any that appear to be contributing to the scour and/or damming effect forming the pool you are observing. Imagine the pool-forming processes at bankfull flow in order to make this determination. Select more than one factor, if applicable. When you observe a factor contributing to pool formation that is not on the list, select "other" and describe the feature in the field notes section. See the TFW ambient monitoring Large Woody Debris survey module to identify a log, rootwad or debris jam.

Table 3. List of potential factors contributing to pool formation and their field form codes.

Factors contributing to pool formation	**Code**
Log(s)	1
Rootwad(s)	2
Debris Jam	3
Roots of standing tree(s)or stump(s)	4
Rock or Boulder(s)	5
Bedrock outcrop	6
Channel bedform	7
Scour associated with resistant banks	8
Artificial bank	9
Beaver dam	10
Other	11

Filling Out the Habitat Unit Survey Form

Use the habitat unit survey form (Appendix C) to record information collected during the habitat unit survey. Start with a fresh form 3a at the start of each segment and on each consecutive day. During the course of the day, use form 3b to record additional data collected after the initial form 3a is full. Please record data in metric units. A conversion chart is provided in Appendix D.

Background Information

Begin by recording the date, the stream name, WRIA and segment number, rivermile and the confinement/gradient category. Record the discharge at the time of the survey. If the discharge is similar on subsequent days, record the same discharge on form 3a for subsequent days. If the discharge changes, take a new discharge measurement and record this measurement on subsequent forms. Number each page sequentially for the entire segment. For example, if twelve forms are used in a segment, the first one would be 1 of 12, the second would be 2 of 12, and so forth.

Unit Number

Each habitat unit should be given a discrete number, beginning with one. Units should be numbered sequentially through the stream **segment** as they are encountered. Begin the numbering sequence over again for each segment surveyed.

Downstream Reference Point Number

Record the number of the nearest downstream reference point for each unit. Remember to split habitat units at reference points.

Recording Information for Units Split at Reference Points

When a habitat unit is split at a reference point, make two separate entries. Make one entry for the portion of the unit above the reference point and one for the portion below the reference point. Record the same habitat unit number for each entry, since both portions are part of the same unit. Each entry will have a different downstream reference point number, since the upper portion of the unit has crossed a reference point. Record the appropriate unit type and unit category for each portion of the split unit (they should be the same). Record different lengths and average widths for each portion of the unit. Make only one maximum pool depth, pool outlet depth and pool forming obstruction entry for each pool unit, even if the unit is split. Record this information on the first entry for split pool units. See 'splitting units at reference points', above, for more information on this topic.

Unit Type

Note the type of unit as a pool (**P**), tailout (**T**), riffle (**R**), cascade (**C**), sub-surface flow (**S**), obscured (**O**), or wetland (**W**).

Unit Category

Record the unit category as primary (**1**), secondary (**2**) or side-channel (**3**). Primary units are over 50% of the wetted width, secondary units are less than 50%, and side-channels are separated from the main channel by an island (over two bankfull widths in length with perennial vegetation).

Length

Record the length of the habitat unit to the nearest tenth of a meter.

Width

Record the average width of the unit to the nearest tenth of a meter.

Maximum Pool Depth

Record the maximum water depth of each pool to the nearest centimeter. Maximum depth measurements are recorded only for pool units.

Pool Outlet Depth

Record the pool outlet depth of each pool unit to the nearest centimeter. Outlet depth measurements are recorded only for pool units.

Pool Forming Obstruction

Record the code number for any factors that are acting to form the pool. See Table 3 or the field code sheet (Appendix C) for the appropriate codes. If the factor causing the pool is not listed, enter #11 and describe the pool forming factor in the field notes section.

Field Code Sheet

All the codes for the habitat unit survey (and the level 2 large woody debris survey) have been compiled on the field code sheet in Appendix E. Copy this sheet on to weather-proof paper and carry it in the field with you for easy reference.

Training, Field Assistance and Data Processing

This manual is intended as a reference for those collecting monitoring information using the TFW Ambient Monitoring Program habitat unit survey module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that involves having an experienced crew perform replicate surveys for cooperators. The purpose of these surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data being collected is replicable and consistent throughout the state.

The TFW Ambient Monitoring Program also provides field forms for recording monitoring data. Cooperators that use these forms can have their data scanned into a database and will receive a hard copy data summary sheet and a copy of the database on floppy disk.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Beechie, T.J. and T.H. Sibley. 1990. **Evaluation of the TFW stream classification system: stratification of physical habitat area and distribution. Final Report; 1988-1990.** State of Washington Dept. of Natural Resources. Forest Regulation and Assistance Division. Olympia.

Bisson, P.A., J.L. Nielsen, R.A. Palmason and L.E. Grove. 1982. **A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow.** Pages 62-73 IN: N.B. Armantrout (ed.). Acquisition and utilization of aquatic habitat inventory information: proceedings of a symposium. Western Div. Amer. Fish. Soc.

Lisle,T.E. 1987. **Using residual depths to monitor pool depths independently of discharge.** USDA For.Serv.Res.Note PSW-394. Pac. Southwest Range and Exp. Stat. Berkeley.

Ralph, S.C., T. Cardoso, G.C. Poole, L.L. Conquest and R.J. Naiman. 1991. **Status and trends of instream habitat in forested lands of Washington: the Timber-Fish-Wildlife Ambient Monitoring Project, 1989-1991 Biennial Progress Report.** CSS. Univ.of Wash.Seattle.

Discharge Measurement Form

Dist. from initial point on tape	Cell Width	Depth	Velocity at point	Cell Discharge
0.5 (wetted perimter)				
1	1.	.3	.05	.015
2	1.	.4	.11	.044
3	.75	.6	.22	.099
3.5	.5	.8	.35	.14
4	.5	1	.40	.2
4.5	.5	1.2	.45	.27
5	.5	1.4	.54	.378
5.5	.5	1.4	.66	.462
6	.5	1.3	.69	.449
6.5	.5	1.2	.56	.336
7	.5	1.1	.48	.264
7.5	.5	1.	.42	.21
8	.75	.6	.22	.099
9	1.	.5	.12	.06
10	1.5	.2	.06	.018
11 (wetted perimeter)				

CONVERSION: Cubic Feet/Second - Cubic Meters/Second CFS CMS 3.044 X .0283 = .086	Cell Discharge Total	3.044

Segment Number 01

Stream Name Deschutes River

Date 7/10, 19 92 Surveyors Smith/Wesson

Discharge Measurement Form

Dist. from initial point on tape	Cell Width	Depth	Velocity at point	Cell Discharge

CONVERSION: Cubic Feet/Second - Cubic Meters/Second CFS CMS X .0283 =	Cell Discharge Total	

Segment Number____________________

Stream Name ____

Date __________, 19___ Surveyors ____

HABITAT UNIT SURVEY

FORM 3A & 3B

TFW - N.W.I.F.C.
Ambient Stream Monitoring 1992

TEMPORARY FORM

Page ____of____

DATE __/__/ 92 STREAM NAME ○ Creek ○ River	CONFINMENT/ GRADIENT U / M / C Cat. 1-7	W.R.I.A. NUMBER ○ Unlisted	Trib. ○ ○ LB RB	Seg #	RIVER MILE Beg End	DISCHARGE (cubic meters/sec)

START NEW SHEET AT BEGINNING OF EACH DAY

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE P/R/C/S/O/W	UNIT CAT. 1-3	LENGTH (meters)	WIDTH (meters)	MAX DEPTH (POOL) (meters)	OUTLET DEPTH (POOL) (meters)	POOL OBS. 1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE P/R/C/S/O/W	UNIT CAT. 1-3	LENGTH (meters)	WIDTH (meters)	MAX DEPTH (POOL) (meters)	OUTLET DEPTH (POOL) (meters)	POOL OBS. 1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE P/R/C/S/O/W	UNIT CAT. 1-3	LENGTH (meters)	WIDTH (meters)	MAX DEPTH (POOL) (meters)	OUTLET DEPTH (POOL) (meters)	POOL OBS. 1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE P/R/C/S/O/W	UNIT CAT. 1-3	LENGTH (meters)	WIDTH (meters)	MAX DEPTH (POOL) (meters)	OUTLET DEPTH (POOL) (meters)	POOL OBS. 1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE P/R/C/S/O/W	UNIT CAT. 1-3	LENGTH (meters)	WIDTH (meters)	MAX DEPTH (POOL) (meters)	OUTLET DEPTH (POOL) (meters)	POOL OBS. 1 - 12

FIELD NOTES:

HABITAT UNIT SURVEY

FORM 3A & 3B (cont.)

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

UNIT NUMBER	DOWNSTREAM REF. PT. #	UNIT TYPE	UNIT CAT.	LENGTH	WIDTH	MAX DEPTH (POOL)	OUTLET DEPTH (POOL)	POOL OBS.
		P/R/C/S/O/W	1-3	(meters)	(meters)	(meters)	(meters)	1 - 12

FIELD NOTES:

N.W.I.F.C. 730 Martin Way E, Olympia, WA 98506
Contact:: Scott Hall (206)438-1180

Metric Conversion Chart

Symbol	When You Know	Multiply By	To Find	Symbol
		Length		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		Area		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000m2)	2.5	acres	
		Temperature (exact)		
°C	Celsius temp.	9/5 (+32)	Fahrenheit temp.	°F
		Temperature (exact) to Metric		
°F	Fahrenheit temp.	−32 5/9 of remainder	Celsius temp.	°C
		Length		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		Area		
in^2	square inches	6.5	sq. centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	sq. kilometers	km^2
	acres	0.4	hectares	ha

APPENDIX E.

TFW AMBIENT MONITORING CODE SHEET

HABITAT UNIT CODES

Unit type

P = pool
T = tailout
R = riffle
C = cascade
S = sub-surface flow
O = obscured
W = wetland

Unit Category

1 = primary unit
2 = secondary unit
3 = side-channel unit

Factors contributing to pool formation

Log(s)	1
Rootwad(s)	2
Debris Jam	3
Roots of standing trees or stumps	4
Rock(s)/boulder(s)	5
Bedrock outcrop	6
Channel bedform	7
Erosion-resistant banks	8
Artificial bank protection	9
Beaver dam	10
Other	11

LARGE WOODY DEBRIS CODES

Piece type

L = log
R = rootwad

Wood Type

C = conifer
D = deciduous
U = unknown

Stability

R = rootwad
B = buried
P = pinned

Pool forming function

Y = yes
N = No

Wood location zone

1 = Zone 1
2 = Zone 2
3 = Zone 3
4 = Zone 4

Pool forming function

Y = Yes
N = No

Bankfull width (meters)	Minimum unit size (square meters)	Minimum residual pool depth (meters)
0 - 2.5 m	0.5	0.10
2.5 - 5.0 m	1.0	0.20
5 - 10 m	2.0	0.25
10 - 15 m	3.0	0.30
15 - 20 m	4.0	0.35
> 20 m	5.0	0.40

TFW AMBIENT MONITORING
LARGE WOODY DEBRIS SURVEY MODULE

Table of Contents

Introduction to Large Woody Debris

Large woody debris (LWD) is an important component of stream channels in the Pacific Northwest. It plays an integral role in the formation of channel morphology and fish habitat. Logs and rootwads enter stream channels due to bank cutting, blowdown, and mass wasting. Once in the channel, the effect of large woody debris is related to the size, stability and longevity of the individual pieces, and to the tendency of wood to collect in large accumulations known as debris jams.

Large woody debris influences channel morphology in several ways. Pools often form in association with large woody debris, due to adjacent scouring or impoundment of water behind channel-spanning pieces. Large woody debris often traps and stores sediment, having a moderating affect on sediment transport rates. In steeper, smaller channels, it often forms distinct steps that capture sediment on the upstream side and dissipate energy as the flow drops over the step.

Large woody debris plays an important biological role in Pacific Northwest streams, creating and enhancing fish habitat in streams of all sizes (Bisson et al., 1987). Pools formed in association with large woody debris often provide deep, low velocity habitat with cover. This habitat is beneficial for a variety of salmonid species and life history stages, particularly those that over-winter in stream channels. Large woody debris also functions to retain spawning gravel in high energy channels and provides thermal and physical cover.

The nature and abundance of large woody debris in a stream channel reflects past and present recruitment rates. This is largely determined by the age and composition of past and present adjacent riparian stands. Activities that disturb riparian vegetation, including timber removal in riparian areas, can reduce LWD recruitment. In addition, current conditions also reflect the past history of both natural and management-related channel disturbances, such as flood events, debris flows, splash damming, and stream cleanout.

Our understanding of the function of large woody debris in stream channels is still developing. To help increase the state of knowledge regarding LWD distribution and characteristics in Washington streams, Peterson et al. (1992), recommend expanding the type and amount of information collected in LWD monitoring and inventory surveys.

Purpose of the Large Woody Debris Survey Module

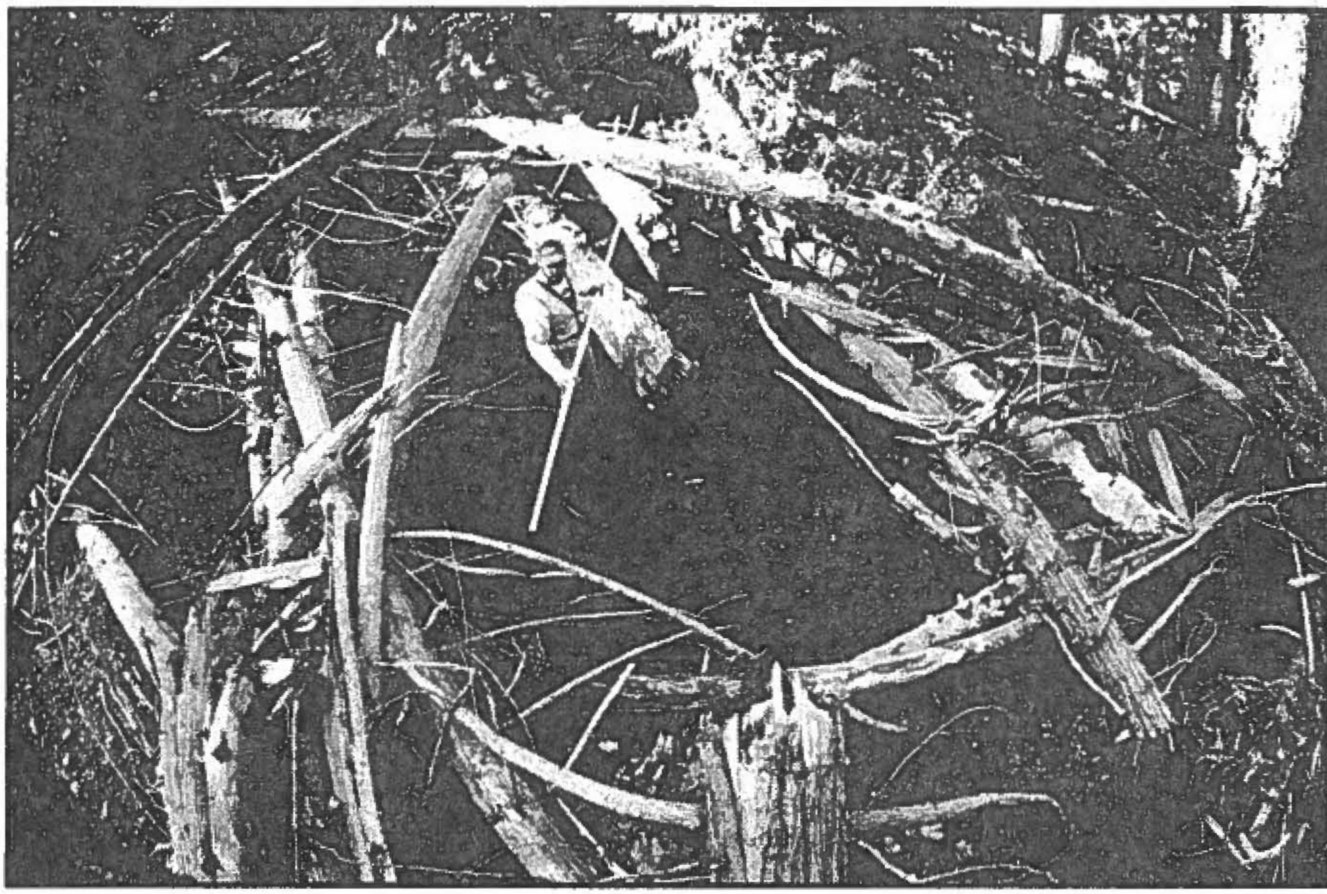
The purpose of the large woody debris survey module is to:

1. Provide a means of accurately documenting the current abundance and characteristics of large woody debris in stream channels.

2. To provide a repeatable methodology that can be used to monitor changes in the status of large woody debris over time.

3. To provide information on the frequency and size of large woody debris that is suitable for use in the Watershed Analysis cumulative effects assessment procedure.

4. To improve our knowledge of the distribution and characteristics of large woody debris in Pacific Northwest streams.



Joe Apfel on West Fork Taneum Creek.is surrounded by a large debris jam.

Photo by: A.E. Pleus

Large Woody Debris Survey Methodology

This section describes procedures for identifying and measuring large woody debris and large debris jams. Two options are provided. The less intensive Level 1 option does not require measurement of individual pieces of wood and provides information on frequency and size class suitable for Watershed Analysis Level 1. The more intensive Level 2 method requires measurement of each piece of wood and provides detailed information on diameter, length, volume and channel location suitable for Watershed Analysis Level 2. Please record all measurements in metric units to reduce confusion and streamline data processing.

Information and Equipment Needed

In order to complete the ambient monitoring large woody debris survey, it is necessary to have previously identified a survey segment (see stream segment identification module). It is also desirable to have established reference points (see the reference point survey module) so that large woody debris and debris jams can be associated with permanent reference locations.

You will need the following equipment:

Large Woody Debris survey forms (separate forms are provided for the Level 1 and Level 2 methods)
Large Debris Jam survey forms
Number 2 pencils
Clip board or form holder
Fiberglass tape (metric)
Rangefinder (metric)
Calipers (metric)
Stadia rod or measuring stick (metric)
Field notebook
Field guide to tree identification (to help distinguish coniferous and deciduous species)
Hip boots or waders
First aid supplies

FIELD NOTE: Again, it is important to make a copy of this list and use it before each daily survey.

Identifying large woody debris

For the purposes of the large woody debris survey module, there are three types of LWD: logs, rootwads and large debris jams. Somewhat different information is collected for each type, so the first step is to identify the type of piece being observed.

How to Identify a **Log**

To qualify as a log, a piece of wood must:

1) be dead (or imminently dying with no chance of survival);
2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight;
3) have a diameter of at least 10 cm for at least 2 meters of its length, and;
4) intrude into the bankfull channel (see Figure 1a).

This criteria is based on the definition of LWD used by Bilby and Ward (1989; 1991), and is compatible with the Watershed Analysis LWD assessment procedure.

Pieces that meet the minimum length and diameter criteria above are classified as logs regardless of whether or not they have roots attached.

Individual stems that have grown in a cluster and meet at the base may be counted as separate pieces if they meet the minimum length and diameter criteria. Branches that are attached to the trunk of the tree should not be counted regardless of their size.

How to Identify a **Rootwad**

Rootwads are pieces of wood with a root system that do not meet the minimum length criteria for a log. To qualify as a rootwad, a piece;

1) must be less than 2 meters long (except for old-growth stumps) and have a root system attached;
2) must be at least 20 cm diameter at the base of the stem where it meets the roots;
3) must have roots that are either wholly or partially detached from the soil so the rootwad has the ability to fall over, and;
4) must intrude into the bankfull channel (Figure 1b).

Old stumps are often found along the banks of stream channels running through areas that were harvested in the past. Often the stream has cut into the bank, exposing the roots of these standing stumps. The exposed roots are within the bankfull channel, and may have an influence on channel morphology. However, to maintain consistency, stumps with root systems that are still anchored in the ground are not counted as rootwads unless the stem (above the roots) has fallen into the bankfull channel (see section on length and channel location, below).

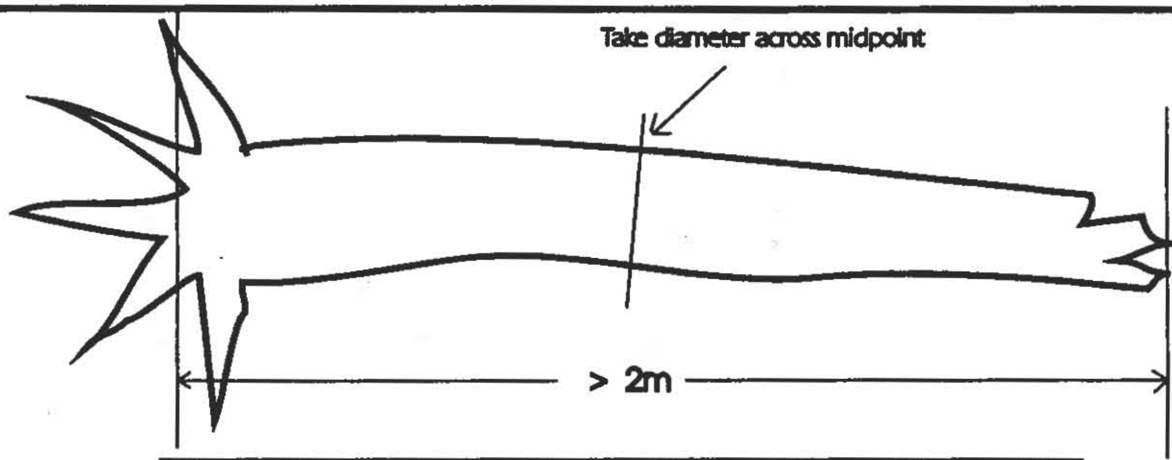


Fig. 1a

LOG

Criteria:
1) must be dead or death is immenant [NO chance of survival]
2) roots must no longer support the weight of the log
3) 10cm diameter for at least 2m length
Note: measure log length to bottom of rootwad if attatched
4) must intrude on bankfull channel

ROOTWAD

Criteria:
1) roots must be detatched: either it has fallen over or it has the ability to fall over
2) length less than 2 meters
3) diameter where stem meets roots greater than 20 cm
4) must intrude on bankfull channel

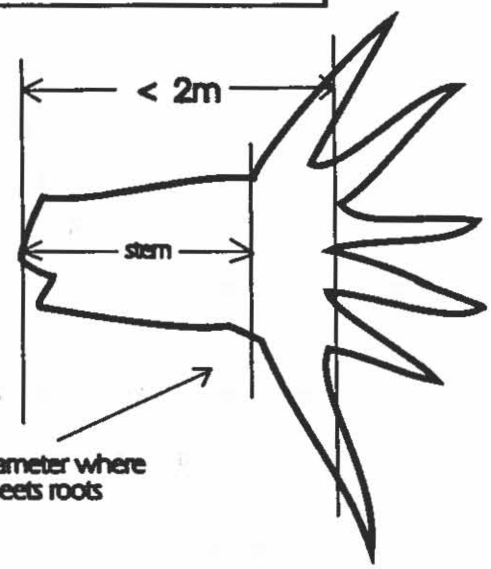


Fig. 1b

Level 1 Survey Sizes:

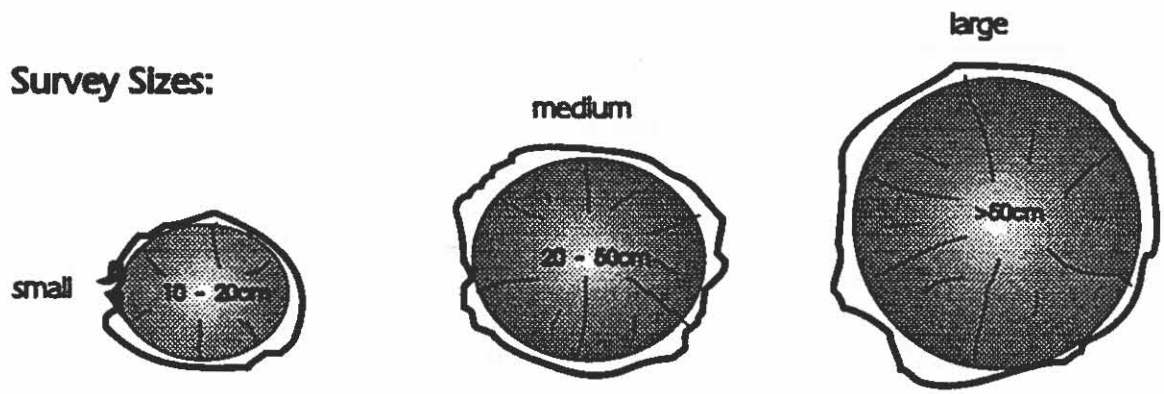


Fig. 1c

FIGURE 1. Criteria for large woody debris.

8/92 AEP

How to Identify a **Large Debris Jam**

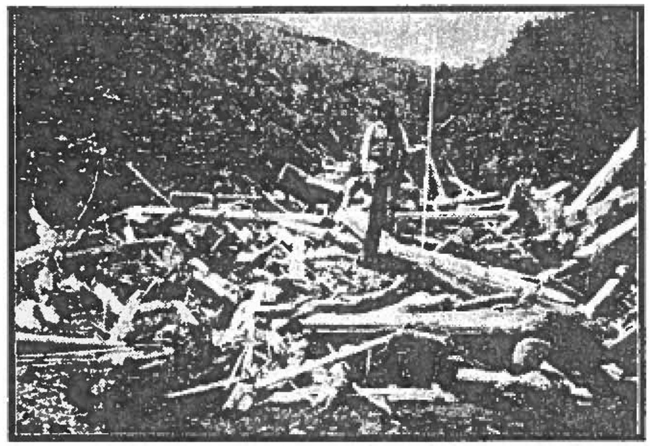


Photo by: A.E. Pleus

Lyman Bullchild on top of a large debris jam on the headwaters of Charley Creek. 1991.

Large debris jams are defined as accumulations of 10 or more qualifying logs or rootwads that are in contact with one another. Each qualifying piece must meet the minimum size criteria (defined above) and must intrude into Zone 1, 2 or 3. While smaller accumulations may sometimes function as debris jams, for our purposes they are not counted as "large debris jams". Only limited information is collected on individual pieces of wood in large debris jams (see section on large debris jams, below).

Collecting Information on Logs, Rootwads and Large Debris Jams

Two options are provided for collecting information on logs and rootwads. The Level 1 method is least intensive and does not require measurement of individual pieces of wood. It is designed to collect a minimal amount of information on LWD rather rapidly and generates information on the frequency and size class of LWD suitable for Watershed Analysis Level 1. The more intensive Level 2 method involves taking measurements on individual pieces of wood. This method is more time consuming, however it provides detailed information on attributes such as diameter, length, volume, channel location, wood type and stability that is suitable for Watershed Analysis Level 2.

The Level 1 Large Woody Debris Method

Use the Level 1 Large Woody Debris Survey Form (Appendix A) to record information collected using the Level 1 LWD survey method. Fill out the survey date, stream name, WRIA and segment identification numbers, and beginning and ending rivermiles.

Begin the survey at the start of the stream segment (see the TFW ambient monitoring stream segment identification module). If reference points have been established in the segment, determine the segment length from the reference point survey form. If you are not planning on establishing reference points prior to the Level 1 LWD survey, then you will need to measure the length of the survey segment by running a tape or hip chain down the center of the bankfull channel. This can be done before or during the Level 1 LWD survey.

Walk the channel, counting the number of qualifying pieces encountered (see identifying large woody debris, above). In the Level 1 LWD survey, qualifying pieces are assigned to one of the following four categories (Figure 1c):

* log: 10-20 cm diameter at midpoint
* log: 20-50 cm diameter at midpoint
* log: greater than 50 cm diameter at midpoint
* rootwad: 20 cm or greater at base of stem

Next, determine the maximum extent to which the piece intrudes into the channel and assign the piece to either channel location zone 1 or 2. If a portion of the piece intrudes into the water at low flow, it is assigned to Zone 1. If it does not intrude into the water at low flow but would be partially submerged at bankfull flow, it would be assigned to Zone 2. See discussion of length and channel location in the Level 2 LWD method (below) for a detailed discussion of the channel location zones.

Once the size category and channel location have been determined, tally the piece in the appropriate column (size category) and row (channel location zone) in the matrix on the Level 1 form. Each piece should only be tallied once. At the end of the survey add up all the tally marks in each cell of the matrix and record the total at the bottom of each cell. The sum of the totals for all cells equals the total count for the segment.

The Level 2 Large Woody Debris Method

The following information is collected on qualifying logs and rootwads during the Level 2 survey and is recorded on the Level 2 large woody debris survey form (Appendix B). This type of information is not collected for logs or rootwads that occur in accumulations of 10 or more pieces; they are treated separately as large debris jams (see large debris jams, below).

Association with Reference Points

Each log or rootwad should be assigned to a 100 meter reach delineated by established reference points (see reference point survey module). Locate the mid-point along the log or rootwad, and record the number of the nearest downstream reference point (Figure 2).

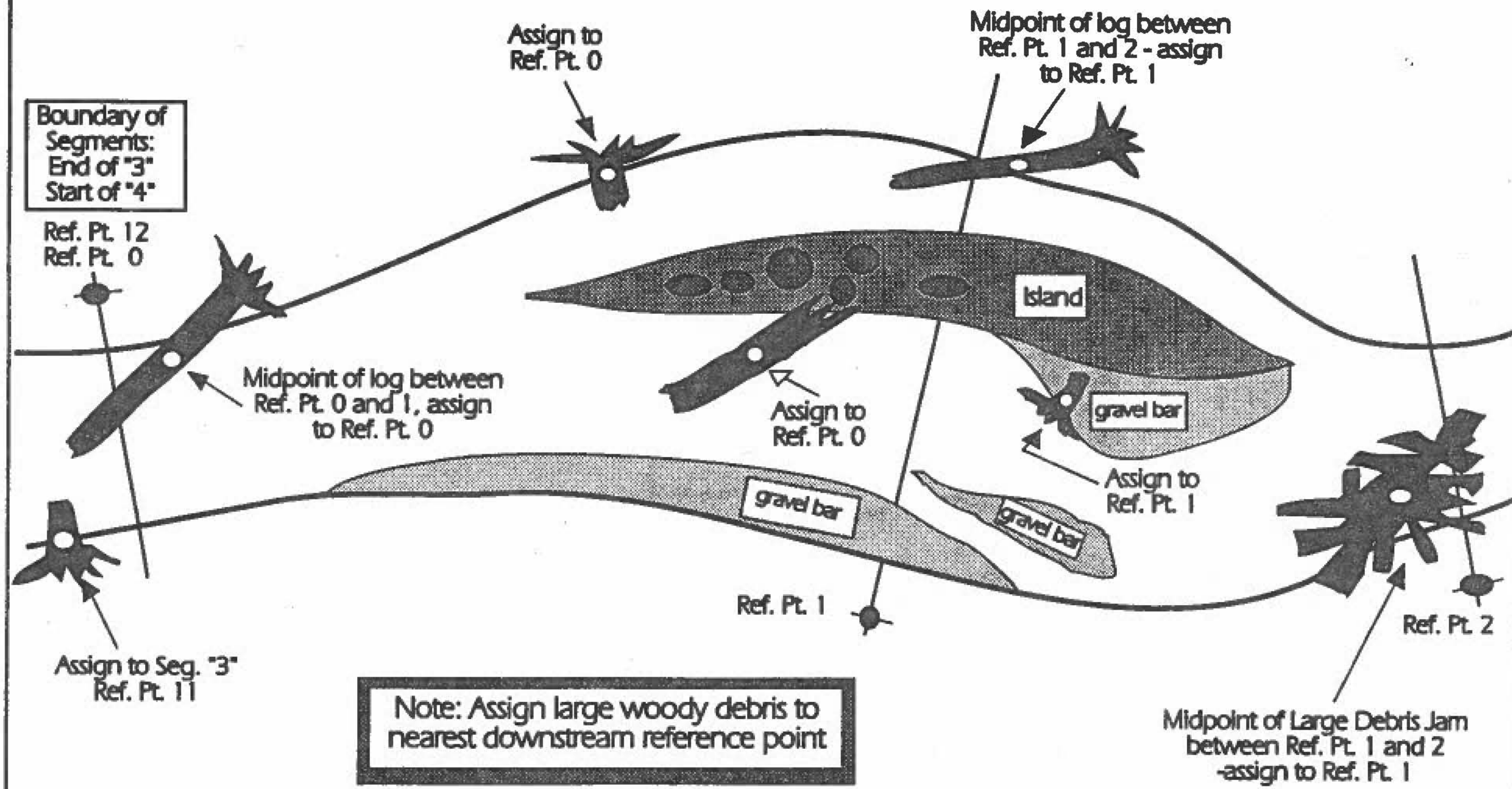


Figure 2. Assigning large woody debris to reference points

8/92 AEP

Diameter

Diameter information is useful in determining the relative size and volume of individual logs. Diameter (to the nearest centimeter) is measured at the mid-point along the length of each log with a caliper or measuring stick. If a log cannot be measured, for example if the water is too deep or part of the log is suspended above the channel, estimate the diameter. If the log is divided into several large branches at the mid-point, making an accurate diameter measurement impossible at that location, measure the diameter immediately below the point where the branches fork. The diameter of rootwads is measured on the stem just above where the roots begin.

Length and channel location

Information on the length of logs and rootwads is useful in determining their relative size and volume. In conjunction with the length measurement, information on the channel location of the piece is collected. The system used to describe channel location (based on Robison and Beschta, 1991) consists of four location zones or categories (Figure 3a).

Zone 1 is the wetted low flow channel, defined as the area under water at the time of surveys done during the low flow period.

Zone 2 is an area within the influence of the bankfull flow. This zone is within the perimeter of the bankfull channel and below the elevation of the water at bankfull flow (excluding areas defined as Zone 1). Zone 2 includes areas such as gravel bars that are exposed at low flow.

Zone 3 is an area within the perimeter of the bankfull channel but above the water line at bankfull flow. This zone includes pieces that extend out over the channel but are suspended above the elevation of the water at bankfull flow.

Zone 4 is the area outside of the bankfull channel perimeter. This zone includes the upper banks and riparian areas.

To measure length and channel location, first determine which zones the log or rootwad passes through. To define the location of the zones, it is necessary to determine the point on each bank that represents the high water mark at bankfull flow.

A variety of methods have been used by geomorphologists to establish the outer boundaries of the bankfull channel, however many require discharge records or surveying techniques.

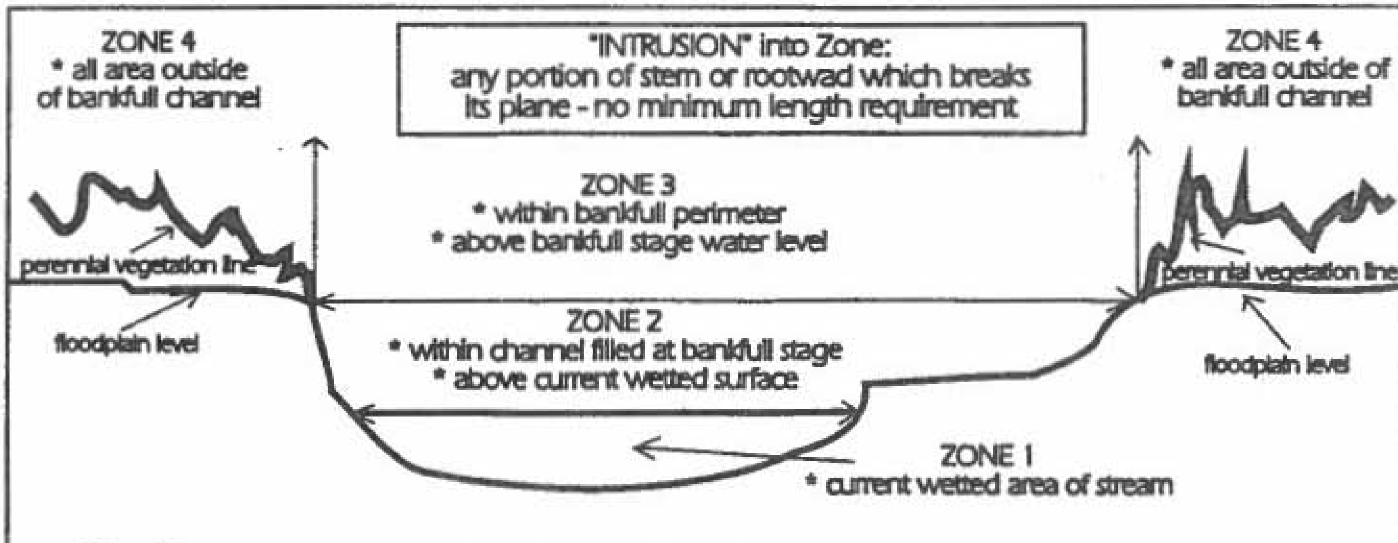


Fig. 3a. Description of LWD zones in channel

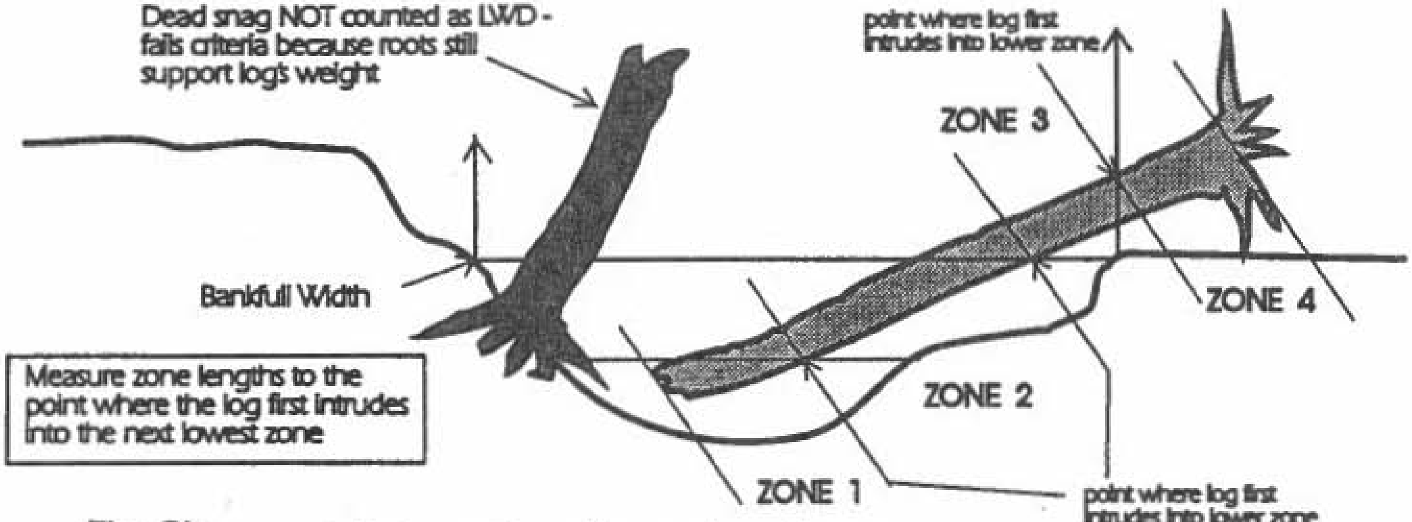


Fig. 3b. Assigning portions of logs to channel zones

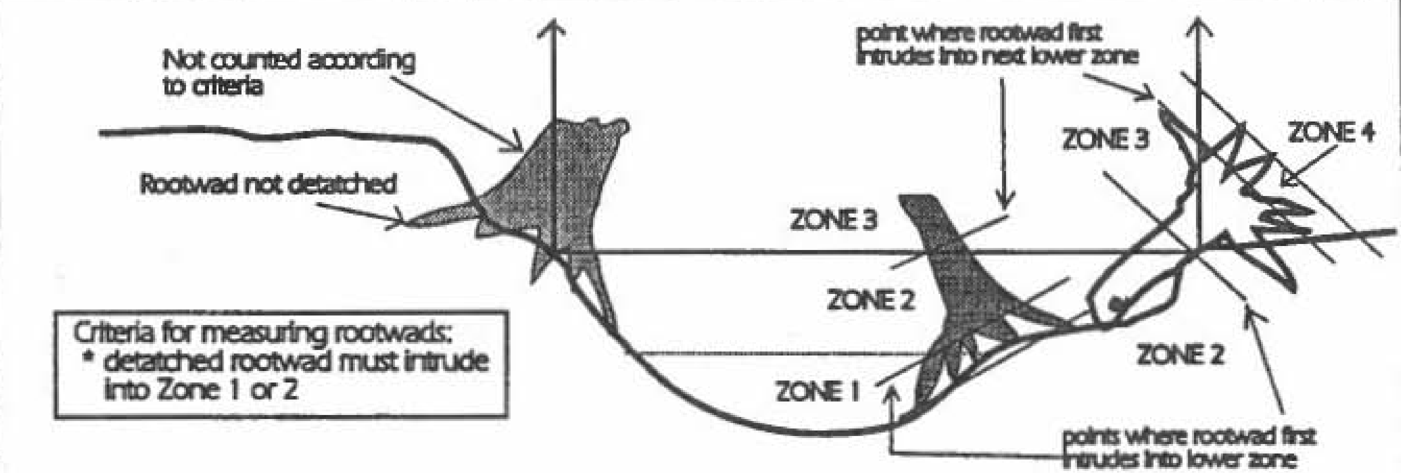


Fig 3c. Assigning Rootwads to channel zones

FIGURE 3. Measuring length of LWD by channel location

8/92 AEP

For ambient monitoring purposes, use bank form and vegetation indicators to identify the perimeter of the bankfull channel. See the reference point survey module for a detailed discussion on determining bankfull channel dimensions. In channels with natural (undiked) riparian areas and frequently inundated floodplains, the boundary of the bankfull channel corresponds with the top of the low banks between the active channel and the floodplain. For confined channels without a floodplain, channels that have been artificially diked and channelized, or channels that are incised into terrace deposits that are not regularly inundated, the line of perennial non-aquatic vegetation is the best indicator of the bankfull channel boundary.

The outer boundary of the bankfull channel can be used to separate Zone 4 from Zones 2 and 3. Zone 4 lies outside the bankfull channel. To separate Zones 2 and 3, extend an imaginary horizontal line across the channel connecting the bankfull boundary points, representing the estimated water surface when the channel is at bankfull stage.

Once the zones have been determined, measure the length of the log or rootwad (along its main stem) in each of the four zones (Figure 3b & c). The boundary line between two zones often passes through the log at an angle. In these situations, start with the lowest zone and measure to the furthest extent that the log influences that zone. At the point where the entire log has left the first zone, measure to the furthest extent that the log influences the second zone. Often the bottom of a log is the last portion to leave Zone 1 or 2.

If part of a piece that is within Zone 1 or 2 also extends into zone 3 or 4, measure and record the length in Zone 3 or 4. If a piece lies entirely within Zone 3 and/or 4 it is not counted in the survey.

Extend the length measurement from the base of the attached rootball, if present, to the end of the log, even if the end is less than the minimum diameter. If a portion of a log is buried and the entire length cannot be determined, measure only the exposed portion of the log. When a piece of wood forks into numerous small branches, such as the branches at the top of a tree, measure to the point where the main stem is no longer distinctly larger than the branches forking off of it.

Recruitment Option

Cooperators interested in documenting wood that may be recruited into the channel in the near future may also want to count and measure pieces of debris that are suspended or bridged over the channel in Zone 3. To do this, also enter data for qualifying pieces that intrude into Zone 3 but do not enter Zone 1 or 2. These pieces will not be included in the regular wood count but will be recorded in a separate "recruitment" category.

Type of Wood

Logs are classified in one of three categories based on the species of tree. The three categories are coniferous (C), deciduous (D) or unknown (U). This provides information on the type of material that is entering the channel and its potential longevity, since conifers resist rot and persist longer than deciduous pieces. Characteristics of the bark, wood fiber, and branching pattern can often be used to identify the type of wood. A tree identification guide may be useful to help identify various species. If unsure about the type of wood, enter unknown (U).

Stabilizing Factors

Note if the piece has a root system (R), is partially buried (B), or is pinned (P). Buried is defined as having increased stability at bankfull flow due to complete burial of either end or lateral burial of 50% or more of the piece. Pinned is defined as having increased stability at bankfull flows due to having another piece on top of it, or due to being wedged between other logs, standing trees or bedrock.

Pool Forming Function

Note if the log or rootwad is associated with pool formation, contributing to either scour or impoundment of water. Imagine the pool-forming processes at bankfull flow to make this determination, because pieces outside of the wetted perimeter at low flow may contribute to pool formation at bankfull flows.

Large Debris Jams

Large debris jams consist of accumulations of ten or more qualifying pieces (either logs or rootwads) that are touching. Pieces must be wholly or partially within Zones 1, 2 or 3 to be counted in debris jams.

In the Level 2 LWD method, the following information is collected on logs and rootwads that are found in large debris jams and is recorded on the Large Debris Jam survey form (Appendix C). Walking on top of large debris jams can be difficult and dangerous, so this information is intended to be collected while walking around the outside of the debris jam and does not involve actual measurements on individual pieces of wood.

Associating Large Debris Jams with Reference Points

Each debris jam should be associated with a 100 meter reach delineated by established reference points (see reference point survey module). Locate the mid-point along the length of the debris jam, and record the number of the nearest downstream reference point (see Figure 2).

Number and Size of Visible Pieces

Walk around the debris jam and count the visible pieces that meet the minimum size criteria for logs and rootwads. Because it is often not possible to see both ends of logs that go through the middle of large jams, it may be difficult to know if you are counting the same piece twice. Take your time and do your best! Assign each piece that you count to one of four categories, based on a visual estimate of the diameter. The categories are:

* log: 10-20 cm diameter at midpoint
* log: 20-50 cm diameter at midpoint
* log: greater than 50 cm diameter at midpoint
* rootwad: 20 cm or greater at base of stem

Determining the Size of the Debris Jam

The purpose of this information is to obtain an estimate of the dimensions of the debris jam as a means of characterizing its relative size. Determining the dimensions of a debris jam may be difficult because debris jams often have irregular shapes with individual logs that protrude from the pile. Imagine the debris jam as a rectangular shape with the smaller protruding pieces pushed into the pile or trimmed off, and record the average length, width and height measurements.

Channel Location

Use the system of channel location zones described in the section on collecting information on logs (above). Note the furthest channel location zone into which the debris jam intrudes. To determine this, imagine the debris jam with the protruding individual pieces trimmed off, as when determining the size of the debris jam.

Pool Forming Function

Note if the debris jam is associated with pool formation, contributing to either scour or impoundment of water. Imagine the pool-forming processes at bankfull flow to make this determination. It is possible that debris jams outside of the wetted perimeter at low flow contribute to pool formation at bankfull flows.

Filling out the Level 2 Large Woody Debris Survey Form

The Level 2 LWD Field Form

Use the Level 2 LWD field form (Appendix B) to record information collected using the Level 2 methodology. This section describes how to enter information on the form.

Background Information

Begin by recording the **date** the survey was done. Begin a new sheet on each subsequent day if the segment takes more than one day to survey. Record the **stream name**, **WRIA** and **segment ID number**, and the beginning and ending **rivermile**. This information can be taken from the segment summary form.

Piece Number

Make one entry on the Level 2 form for each qualifying piece of wood (except those in large debris jams). Assign each piece a unique piece number, beginning with 001 and continuing in sequence to the last piece in the stream segment. Record this in the piece number column.

Downstream Reference Point Number

Record the number of the nearest downstream reference point from the mid-point of the log or rootwad in the downstream reference point column.

Piece Type

Determine if the piece is a log (greater than 2 meters, with or without roots) or a rootwad (less than 2 meters with roots attached). Record (L) for log or (R) for rootwad in the piece type column.

Diameter

Record the diameter measurement (to the nearest centimeter) in the diameter column.

Length

The form has separate columns for each of the channel location zones. Record the length of the portion of the log or rootwad assigned to each zone in the appropriate column. Lengths are measured to the nearest 0.1 meter. Total length will be computed during data processing by adding the lengths in each of the individual zones.

Wood type

Record the type of wood in this column using (**C**) for conifer, (**D**) for deciduous or (**U**) for unknown.

Stability

Use this column to record all of the applicable stability factors for the piece using (**R**) for root system, (**B**) for buried, and (**P**) for pinned.

Pool Forming Function

After determining if the log or rootwad is associated with a pool, use this column to record (**Y**) for yes and (**N**) for no.

Filling out the Large Debris Jam Survey Form

The Large Debris Jam Survey Form

Use the large debris jam survey form (Appendix C) to record information collected using the large debris jam methodology.

Background Information

Begin by recording the date the survey was done. Begin a new sheet on each subsequent day if the segment takes more than one day to survey. Record the stream name, WRIA and segment ID number, and the beginning and ending rivermile. This information can be taken from the segment summary form.

Large Debris Jam Number

Make one entry on the Large Debris Jam survey form for each qualifying large debris jam (10 or more interconnected qualifying pieces of wood). Assign each large debris jam in the segment a unique number beginning with 1, and record in this column.

Downstream Reference Point Number

Record the number of the nearest downstream reference point from the mid-point along the length of the debris jam.

Visible Pieces

Record the total number of visible pieces in each of the size categories in the appropriate column.

Length, Width and Height

Record the length, width and height (in meters) of the debris jam in these columns.

Channel Location Zone

Record the zone number (**1** or **2**) corresponding with the greatest intrusion of the debris jam into the channel.

Pool Forming Function

After determining if the debris jam is associated with a pool, use this column to record (**Y**) for yes or (**N**) for no.

Training, Field Assistance and Data Processing

This manual is intended as a reference for those collecting information using the TFW Ambient Monitoring Program large woody debris survey module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW ambient monitoring program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that involves having an experienced crew perform replicate surveys for cooperators. The purpose of these surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data being collected is replicable and consistent throughout the state.

The TFW Ambient Monitoring Program also provides field forms for recording monitoring data. Cooperators that use these forms can have their data scanned into a database and will receive a hard copy data summary sheet and a copy of the database on floppy disk.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Bilby, R.E. and J.W. Ward. 1989. **Changes in characteristics and function of woody debris with increasing size of streams in western Washington.** Trans. Amer. Fish. Soc. 118:368-378.

Bilby, R.E. and J.W. Ward. 1991. **Characteristics and function of large woody debris in streams draining old-growth, clear- cut and second growth forests in southwestern Washington.** Can. J. Fish. Aquat. Sci. 48:2499-2508.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski and J.R. Sedell. 1987. **Large woody debris in forested streams in the Pacific Northwest: past, present and future.** Pages 143-190 IN: E.O. Salo and T. Cundy (eds.). Streamside management: forestry and fishery interactions. College of For. Res. Univ. of Wash. Seattle.

Peterson, N.P., A. Hendry and T.P. Quinn. 1992. **Assessment of cumulative effects on salmonid habitat: some suggested parameters and target conditions.** Center for Streamside studies. Univ. of Wash. Seattle.

Robison, E.G. and R.L. Beschta. 1991. **Characteristics of coarse woody debris for several coastal streams of southeast Alaska, USA.** Can. J. Fish. Aquat. Sci. 47:1684-1693.

LARGE WOODY DEBRIS SURVEY

FORM 4 | **LEVEL 1**

TFW - N.W.I.F.C.
Ambient Stream Monitoring 1992

TEMPORARY FORM

Page ___ of ___

DATE __/__/ 92 STREAM NAME	CONFINMENT/ GRADIENT		W.R.I.A. NUMBER			RIVER MILE		DISCHARGE (Optional)	START NEW SHEET AT BEGINNING OF EACH SEGMENT
○ Creek ○ River	U / M / C	Cat.1-7	○ Unlisted	Trib. ○ LB ○ RB	Seg #	Beg	End	(cubic meters/sec)	FIELD NOTES:

Beg. Ref Pt.	
End Ref Pt.	

TOTALS PER SEGMENT

	ROOTWAD >20cm	LOG 10-20cm	LOG 20-50cm	LOG >50cm
ZONE 1	Total	Total	Total	Total
ZONE 2	Total	Total	Total	Total
~~ZONE 3~~	~~Total~~	~~Total~~	~~Total~~	~~Total~~

N.W.I.F.C. 730 Martin Way E. Olympia, WA 98506
Contact: Scott Hall (206) 438-1180

LARGE WOODY DEBRIS SURVEY

FORM 4 LEVEL 1

TFW - N.W.I.F.C.

Ambient Stream Monitoring 1992

TEMPORARY FORM

Page ____ of ____

APPENDIX A.

DATE __/__/ 92 STREAM NAME	CONFINMENT/ GRADIENT		W.R.I.A. NUMBER			RIVER MILE		DISCHARGE (Optional)	START NEW SHEET AT BEGINNING OF EACH SEGMENT
○ Creek ○ River	U / M / C	Cat.1-7	○ Unlisted	Trib. ○ LB ○ RB	Seg #	Beg	End	(cubic meters/sec)	FIELD NOTES:

Beg. Ref Pt.	
End Ref Pt.	

TOTALS PER SEGMENT

	ROOTWAD >20cm	LOG 10-20cm	LOG 20-50cm	LOG >50cm
ZONE 1	Total	Total	Total	Total
ZONE 2	Total	Total	Total	Total
~~ZONE 3~~	~~Total~~	~~Total~~	~~Total~~	~~Total~~

APPENDIX A.

N.W.I.F.C. 730 Martin Way E. Olympia, WA 98506
Contact: Scott Hall (206) 438-1180

LARGE WOODY DEBRIS SURVEY

FORM 4 **LEVEL 2**

TFW - N.W.I.F.C.

Ambient Stream Monitoring 1992

TEMPORARY FORM

Page ____of____

APPENDIX B.

DATE __/__/ 92 STREAM NAME	CONFINMENT/ GRADIENT		W.R.I.A. NUMBER			RIVER MILE		DISCHARGE (Optional)	*START NEW SHEET AT BEGINNING OF EACH DAY*
O Creek O River	U / M / C	Cat.1-7	O Unlisted	Trib. O O LB RB	Seg #	Beg	End	(cubic meters/sec)	FIELD NOTES:

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH (in meters) ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

APPENDIX B.

LARGE WOODY DEBRIS SURVEY

FORM 4 (cont.) LEVEL 2

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

PIECE No.	DWNSTRM REF. PT.	PIECE TYPE R/L	LOG DIA. (CM)	LENGTH [in meters] ZONE (circle for rootwad) 1 2 3 4	WOOD TYPE C/D/U	STAB. R/B/P/U	POOL FORM FUNC.
							O Y O N

N.W.I.F.C. 730 Martin Way E, Olympia, WA 98506
Contact:: Scott Hall (206)438-1180

LARGE LOG JAM SURVEY

FORM 5 — LEVEL 2

TFW - N.W.I.F.C.

Ambient Stream Monitoring 1992

TEMPORARY FORM

Page ___ of ___

DATE ___/___/ 92	CONFINMENT/ GRADIENT		W.R.I.A. NUMBER			RIVER MILE		DISCHARGE (Optional)	START NEW SHEET AT BEGINNING OF EACH DAY
STREAM NAME									FIELD NOTES:
O Creek O River	U / M / C	Cat.1-7	O Unlisted	Trib. O LB O RB	Seg #	Beg	End	(cubic meters/sec)	

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

APPENDIX C.

LARGE LOG JAM SURVEY

FORM 5 (cont.)

Version 7/17 AP

N.W.I.F.C.
730 Martin Way E. Olympia, WA 98506
Contact: Scott Hall (206) 438-1180

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N

LOG JAM No.	DOWNSTRM REF.PT.	VISIBLE PIECES		RTWD >20CM	LENGTH	WIDTH	HEIGHT	ZONE	POOL FORM FUNC
		10-20cm	20-50cm	>50 cm	meters	meters	meters	1-4	
									O Y O N