

PHYSICAL HABITAT SURVEY AND MONITORING PROTOCOL FOR WADABLE STREAMS VERSION 6.0

SNOHOMISH COUNTY SURFACE WATER MANAGEMENT
(6/26/01)

Reaches

Delineation and Selection

Stream reaches in selected sub-basins were delineated according to Level I stream classification methods (Rosgen 1996). Physical habitat surveys will be conducted over a randomly selected 25 percent of the total length of each reach type (A, B, C, D, DA, E, F, or G) within wadable, fish-bearing waters during the low flow period of the year. A ditch category has also been added to Snohomish County SWM's modified Rosgen reach classification scheme. A subset (10%) of surveyed reaches will be resurveyed for data quality and assurance.

In future years, using a rotational panel design, Snohomish County fish habitat analysis staff (FHAS) intend to sample the remaining sub-basins, expand to non-fish-bearing waters and non-wadable streams, and resample previously sampled reaches for trend analysis and effectiveness monitoring.

Field Reconnaissance

FHAS will conduct field reconnaissance prior to the survey season to improve the accuracy of reach delineation. Efforts will be targeted at distinguishing between G and B channels and C and F channels, as well as transitional zones between reaches. A Rosgen level II analysis will be conducted when it is necessary to make a reach determination.

Unit Reach Length

Using Rosgen (1996) as a guide, a standard survey reach length of 30 bankfull channel widths was selected. Bankfull width measured at the beginning of each unit reach is used to calculate the unit reach length. Less than a length of 30 channel widths will only be measured if the reach type changes before a length of 30 channel widths is obtained. The minimum acceptable reach length is 20 channel widths. If less than 20 is obtained, the data that have been collected will be lumped with the adjacent downstream reach, if it is of the same channel type.

Field Equipment

Field computer	Stadia rod
Measuring tape	Hip chain
Wire grid	Tallywacker
Aqua scope™ (for deeper channels)	Plexiglass viewer (for shallower channels)
Flagging tape	Pea gun level w/ stand (QA/QC)

Two way radios (optional)
Biltmore stick (optional)
Hand-held calculator (optional)

Range Finder (optional)
Logger tape (optional)

Field Computers and File Management

During the survey, data will be entered into a spreadsheet database contained on a Juniper Systems' Allegro™ Field PC. Detailed operating instructions for both hardware and software are contained in the Allegro Field PC Owner's manual, available to all surveyors. The following section describes the procedure each survey team should follow to ensure all data are stored in a useful and organized format.

Activate the Field PC by pressing the On/Off button (as long as the batteries remain charged, the field computers will revert to suspended mode when turned "off" or not used for a predetermined amount of time). Once activated, most of the subsequent functions are most easily achieved using the touch screen. If for any reason during the survey the touch screen becomes inoperable, most necessary functions can be accessed using the keypad in much the same way as on a desktop PC.

At the beginning of each unit reach, open (double tap) the shortcut to **PHabFSV6.pt**, the main database file. The file contains six worksheets: one header sheet containing the information about the reach to be surveyed, five sheets for habitat parameter data entry and a compilation sheet that organizes data from each of the previous sheets into a single spreadsheet (for data management purposes only). Before entering any data, use the **Save As** command in the **File** menu to save the file as the designated reach identification number. Make sure the file saves to the C drive, as this is the solid state hard drive that stores data even in the event power is lost. A backup copy of the blank spreadsheet is located in **C_MyDocs** in case the original is saved over.

Once the file is saved as the reach identification number, check to make sure the caps lock is engaged and begin filling all known reach information into the spaces provided in the header sheet (Figure 1). Begin surveying the stream, switching back and forth between habitat parameter sheets by tapping on the tab at the bottom of the screen and filling in appropriate information. Save the file periodically to ensure a minimal loss of data in the event of a computer lockup. At no time should data be entered into the compilation sheet (while the sheet is protected, some data entries are still possible). If data is entered inadvertently into the compilation spreadsheet, use the **Undo** function under the **Edit** pull down menu to remove entries (deleting the entry may also delete equations built into the sheet). At the end of the reach, fill in all remaining blanks in the header sheet and perform a final save before closing the file.

Completed reach files should be transferred to an office PC after each day of survey and checked for invalid or missing data. Any anomalies should be recorded and communicated to the data manager.

Figure 1 Example data entry for unit reach header sheet.

Field	Value	Unit
Rosgen Reach #	501.13	
Unit Reach #	2	
Sub Basin	BEAR CREEK DRAINAGE	
Stream Name	CAT CREEK	
Rosgen Class	F	
Hip Chain Start	0	m
Hip Chain End	403.4	m
SWD Tally	79	
Date/Time	6/20/01 13:15	
Party	PTL, RDM	
Weather	LIGHT RAIN	
General Reach		
Comments		
1st BFW Meas	13.5	m
BFW & Fines @	202.5	m
&	405.0	m = Unit Length

General Procedure

Comment Field

Invariably there will be times when this protocol does not fully capture a situation encountered during a survey. Comment fields are included as part of each spreadsheet in the database and are intended as a means to document instances when a measurement or classification of a habitat parameter is not completely clear. When these situations occur, surveyors are encouraged to make calls based on their best professional judgment. A brief explanation of the decision should be recorded in the comment field associated with the parameter in question.

Station

At the start of each reach, tie off and zero the hip chain. Record a station for each piece of information gathered in the reach. The station designation provides an organizational record for data entry into an extensive field computer database. Where survey measurements are made in the main channel, enter MC in the channel type field within the database. If survey measurements are made in secondary channel habitat enter SC1 or SC2 (see below). While the hip chain station reading is fairly arbitrary on a subbasin scale, it allows the physical habitat information recorded to be analyzed, if need be, on a site-specific level. The station designation also provides the opportunity for quality control surveys.

Protocol for Dry Channels

Fish bearing (type 1, 2 and 3) channels that are dry at the time of the survey will be surveyed for bankfull width, wood and bank instability. If these channels have standing water in pools, and these pools meet the survey criteria, they will also be recorded.

Habitat Parameters

Bankfull Width

Purpose: Bankfull width is the primary measure of channel size and is used to determine the minimum size of functioning pools and woody debris along the reach (explained below), as well as the unit reach length.

Definition: Bankfull width is the width of a stream channel at the point where over-bank flow begins during a flood event. In entrenched channels with disconnected or undeveloped floodplains, bankfull indicators may include: the top of deposited bedload (gravel bars), stain lines, the lower limit of perennial vegetation, moss or lichen, a change in slope or particle size on the stream bank and undercut banks (USFS 1999).

Procedure: Measure bankfull width at the crest of the first riffle, crest of the riffle nearest the midpoint (15 channel widths), and at the crest of the last riffle within the reach (generally 30 channel widths). Straight, low-gradient riffles with uniform banks are best for identifying bankfull stage and therefore, bankfull width. Locate bankfull stage using any of the above indicators on at least one of the stream banks. Measure the width of the channel at the indicated point and record it in the handheld computer database (Figure 2).

Figure 2 Example data entry for Start, Midpoint and End BFW measurements.

Station	Channel Type	Riffle Measure BFW	Riffle Vetter Width	Comments
0	MC	13.5	10.2	
200.6	MC	12.7	10.0	
5				

Stream Bank Instability

Purpose: To assess channel stability and response to watershed conditions.

Definitions: This protocol will follow the definitions used by Bauer and Burton (1993):

Banks are unstable if they show indications of any of the following features at or above bankfull:

Breakdown: obvious blocks of bank broken away and lying adjacent to the bank breakage.

Slumping or False bank: bank has obviously slipped down, cracks may or may not be obvious, but the slump feature is obvious.

Fracture: a crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream.

Vertical & Eroding: The bank is mostly uncovered as defined below *and* the bank angle is steeper than 80° from the horizontal.

Otherwise, Banks are stable.

Banks are covered if they show any of the following features:

Perennial vegetation ground cover > 50%.

Roots of vegetation cover > 50% of the bank.

≥ Rocks of cobble size protect 50% of the bank surfaces or larger

≥ 50% of the bank surfaces are protected by logs of ≥10-cm diameter.

Otherwise, banks are considered uncovered.

Procedure: Stream bank instability will be continuously measured along both banks. When a portion of unstable bank is encountered, identify whether it is on the right or left bank (facing downstream) and record the hip chain reading in the field computer database. Continue with the survey while monitoring the instability and collecting data on any and all other required stream features. When the end point of the instability is reached, record the hip chain reading in the database. The length of the instability will be calculated automatically. In instances when the instability is small and more easily measured with a stadia rod or tape, do so and enter the length in the end point column. If the channel is braided, then measure bank instability along the banks furthest to the right and left only.

Bank segments that have been hydromodified will be considered unstable for the purpose of this survey. Inclusion of these features in the bank instability class is based on an assumption that they were installed at points where bank erosion was occurring.

For hydromodified banks, record the type of modification in four categories: dike/levee/berm (built up), revetment (armored only), bulkhead (vertical feature), bridge footing. Also record the material composition of the toe of the feature (at and below the bankfull elevation) in four categories: riprap, rubble, structural and earth. Bank material greater than 256mm (10 in) in diameter is considered *Riprap*. Bank material less than 256mm will be considered *Rubble* (Beamer & Henderson, 1998). Other classes such as wood, concrete, and gabion are lumped into the *Structural* toe class. *Earth* includes soil as well as other “natural” toe materials.

Figure 3 Example data entry for stream bank instability.

Station	Channel Type	R or L Bank	Stream Bank Instability			Hydro Modification	Armor Toe Class	Comments
			Start Pt.	End Pt.	Calc. Inst.			
186.9	MC	L	186.9	199.0	12.1	None	None	
188.6	MC	R	188.6	194.3	5.7	Revetment	RIPRAP	
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			
					0.0			

Data entry for stream bank instability:

Required Values: Station (hip chain reading), start point, end point and type (erosional or hydromodified). For hydromodified banks, also record the material composition.

Automatically Calculated Values: Bank instability length.

Secondary Channel Habitat

Purpose: To quantify habitat in secondary channels and identify significant off-channel features.

Definition: Secondary channels are defined as channels that are separated from the main channel by a stable island and contain the smaller portion of the total flow. A stable island in a forested stream is defined by USFS (1999) as supporting woody vegetation (excluding willow) which is estimated to be at least 5 years old (and covers at least 50% of the island surface). Off-channel habitats include marshes, ponds and oxbow lakes that are outside the bankfull channel.

Procedure: Identify whether or not a potential secondary channel feature is separated from the main channel by a stable island. If the feature is not separated by a stable island, then lump it in with the main channel measurements. If the feature is located outside the bankfull channel, then describe the off-channel feature in the comments.

For all secondary channels identified, record the station at the first point encountered where the channel connects to the main channel. Determine whether the secondary channel is dry but within the bankfull channel, connected at one end (channel type SC1), or connected at both ends (channel type SC2) at the time of the survey, and record the

corresponding code in the database. Remove the hip chain and leave it next to the main channel. Measure with a stadia rod or tape, the length and mean wetted width, and the mean bankfull width of the secondary channel. Record these values in the field computer database.

Figure 4 Example of data entry for secondary channel habitat.

Station	Channel Type:	Unit Wetted Length	Unit Total Length	Mean Wet Width	Mean Total Width	Calc. Wet Area	Calc. Total Area	Comments
15.5	SC1	9.7	15.4	4.0	4.8	38.8	73.9	
145.3	SC2	20.3	20.3	4.2	6.3	85.3	127.9	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	
						0.0	0.0	

Survey the secondary channel following the same protocol for mainstem channels. Enter any new lines of data at the original side channel hip chain station (i.e. two pools in the same side channel require two lines in the database). Each line should be recorded with the identical station numbers (the first point encountered where the side channel enters the stream). See figures 4 and 5. When all values for the secondary channels are collected, return to the point where the hip chain was placed and continue the main channel survey.

Significant off channel habitat features, which are outside the bankfull flow should be noted in the comments but not measured.

Data Entry for secondary channel measurements:

Required Values: Station (hip chain reading where side channel enters the main channel), channel type (SC1 or SC2), length and average wetted width of side channel and the required values for any woody debris and pools which meet survey criteria.

Automatically Calculated Values: Wetted area, bankfull channel area

Woody Debris

Purpose: To measure the characteristics and quantity of wood debris providing habitat complexity, cover and hydraulic roughness.

Definitions: Woody debris is partitioned into four length classes, the first three of which are reported for individual pieces encountered: large woody debris (LWD - length class 1

or 2), stumps/sticks with rootwads (SSR - length class 3), and small woody debris (SWD) according to the following definitions:

LWD (Length class 1 or 2) - Following the forest service definition, LWD is defined as downed wood that intercepts bankfull flow (trunk not branches) in a substantial fashion and is large enough to influence the formation of habitats (USFS, 1999). To be counted as LWD, a piece of wood must be of a length greater than or equal to 7.6 m (length class 1) or greater than twice the bankfull width of the stream reach being surveyed (length class 2), whichever is less. For both classes, the minimum diameter of the wood must be 30 cm at a distance of 7.6 m or twice bankfull width, whichever is less. These length classes need not have a rootwad attached. Wood that is suspended above and directly adjacent to the bankfull channel that meets the above criteria is counted in the survey. Buried wood, if it can not be determined whether or not it meets the length criteria, is not included in this length class, but may be reported as another class as described below.

Procedure: Record station number (w/ hipchain) for individual pieces of LWD. Measure debris diameter (must be at least 30 cm) at 7.6 m or 2 times the bankfull width, whichever is less. If diameter is less than 30 cm and piece has a root wad, go to length class 3.

SSR (Length Class 3) – Any piece of wood debris that does not meet the LWD definition, but has a rootwad with a mean diameter greater than or equal to one meter, and that is located within the bankfull channel. Pieces in this class must be at least 10 cm in diameter for at least 2 meters length (Pleus *et al.*, 1999). These pieces may be greater than 7.6 m in length, but would not meet the minimum diameter of 30 cm specified for LWD. If pieces are greater than 7.6 m in length, do not meet the minimum diameter of 30 cm, and do not have a rootwad, they are classified as SWD and tallied as indicated below.

Note: Stumps supporting their own weight by root attachment are not counted. Stumps standing vertically and partially within the bankfull area are not counted if they are located where originally rooted. If this cannot be determined and the stump is creating a qualifying pool, then count the stump. Otherwise do not count the stump.

Procedure: Record station number (w/ hipchain) for individual pieces of LWD. Measure length and diameter at end of bole of stump or at 7.6 m length of stick if piece is longer than 7.6 m. For all woody debris pieces, length will only be measured and reported for SSR pieces less than 7.6 m in length.

SWD – All wood that is not classified in the LWD or SSR class, but is at least 10 cm diameter for at least 2 meters length (Pleus *et al.*, 1999). This class of woody debris does not have a rootwad.

Procedure: Count SWD pieces over the length of the unit reach using a Tallywacker™. SWD piece measurements are not reported, but may be necessary to determine length class association. The length class 4 is not reported along unit reach stations.

Individual LWD and SSR pieces (length classes 1-3) are further characterized by collecting data on, rootwad presence, wood type, decay class and association with a jam. These debris characteristics and procedures for reporting data are defined as:

Rootwad presence (relevant to LWD only) - for a rootwad to be counted on a piece of woody debris, the mean rootwad diameter must be greater than or equal to one meter. Report Y or N for rootwad presence.

Wood type - Deciduous (D), evergreen/conifer (C), or unknown (U). Report wood type (D,C,U) for LWD and SSR pieces. Pieces within decay class 5 will automatically be classified as wood type unknown.

Decay class - characterizes each piece based on the condition of the wood from natural decay. Table 1 from Schuett-Hames et al. (1994) lists the criteria for decay class. The five classes have been simplified into three : “recent” (1), “intermediate” (3) and “old” (5) (Collins et al., 2001). Report decay class for LWD and SSR pieces. Pieces within decay class 5 will automatically be classified as wood type unknown.

Table 1: Decay Class Criteria

Decay Class (Collins et al., 2001)	Decay Class (Schuett-Hames et al. 1994)	Bark	Twigs	Texture	Shape	Wood Color
1	1	Intact	Present	Intact	Round	Original Color
1	2	Intact	Absent	Intact	Round	Original Color
3	3	Trace	Absent	Smooth	Round	Darkening
5	4	Absent	Absent	Abrasion	Round/Oval	Dark
5	5	Absent	Absent	Vesicular	Irregular	Dark

Jam- 3 or more touching pieces of LWD (defined above) together producing a single structure significantly intercepting bankfull flow. Report Y or N if piece is part of a jam.

Data Entry for wood debris:

Required Values: Station (hip chain reading), channel type, length class, diameter, length (SSR only), wood type, decay class, rootwad presence or absence, and debris jam association.

Automatically Calculated Values: None

Figure 5 Example data entry for wood structure.

Station	Channel Type	Length Class	Diameter	Measured @	Decay Class	Wood Type	Rootwad Present	Part of Jam	Comments
8	MC	2	0.34	7.6	1	D	N	N	
9	SC1	3	0.32	5.4	3	C	Y	N	
10	MC	2	0.40	7.6	3	C	Y	N	
11	MC	2	0.42	7.6	1	D	N	Y	
12	MC	1	0.33	7.6	1	C	N	Y	
13	MC	1	0.31	7.6	5	U	N	Y	
14	MC	1	0.34	7.6	3	D	Y	N	
15	MC	2	0.40	7.6	3	D	N	N	
16	MC	2	0.32	7.6	1	D	Y	N	
17	SC2	3	0.24	7.6	3	D	Y	N	
18	MC	1	0.50	7.6	3	C	N	N	

Pool Habitat

Purpose: To measure habitat area available for holding and rearing.

Definition:

Pool – a section of stream channel where water is impounded within a closed topographical depression (Abbe and Montgomery, 1996). For a habitat unit to qualify as a pool in this survey, it must meet the minimum area and depth requirements in Table 2.

Procedure: Pool parameters will be recorded for pools meeting the bankfull width, residual depth and surface area criteria described in Pleus *et al.* (1999). See Table 2.

Table 2: Minimum pool size requirements

Bank Full Width (m)	Area (m ²)	Residual Pool Depth (m)
0 – 2.	0.5	0.10
2.5 – 4.9	1.0	0.20
5.0 – 9.9	2.0	0.25
10.0 – 14.9	3.0	0.30
15.0 – 19.9	4.0	0.35
>20	5.0	0.40

Pleus *et al.*, 1999

When a pool is encountered, measure the maximum depth and tailout depth using a stadia rod. Maximum depths of more than 2 meters may be entered into the spreadsheet as 2.0 with “over 2 m” entered in the comment field. Calculate the residual pool depth

(maximum depth minus pool tailout) manually with a calculator or automatically by entering the depth values into the appropriate database fields. If the calculated residual depth value falls within the criteria for the established bankfull width (see BFW section above), measure the mean wetted width and length of the pool, and the mean *functional* width and length. The functional area is the area of the pool most likely to be used by adult salmonids for holding, and is defined by a depth greater than or equal to 0.2 m or the pool tailout depth, whichever is greater. This definition captures the deeper areas of the pool and excludes the shallow margins as the pool tapers toward the banks. If the functional area meets the area requirements in Table 2 the pool is of acceptable size. If it does not, remove the entered measurements from the record and continue surveying.

When two or more pools occur in sequence they should be split and measured separately whenever there is a clear division (tailout) between them.

Calculate the *functional* pool surface area (length * width) manually with a calculator or automatically by entering the functional pool length and width values into the field computer database. If the calculated area falls within the criteria for the BFW, enter all of the remaining required information for the pool unit into the field computer database. If any of these calculated values do not meet the pool criteria for the given bankfull width, delete all entered information for the pool.

Data Entry for pools meeting minimum size criteria:

Required Values: Station (hip chain reading), channel type, maximum and tailout pool depths, wetted and functional pool length and mean wetted and functional pool width.

Automatically Calculated Values: Pool residual depth and functional pool area.

Percent Surface Fines

Purpose: To measure the percent surface fines in potential spawning locations and thereby the risk to eggs and juveniles from entombment, oxygen depletion, gill abrasion and foraging difficulty.

Definitions:

Surface fines – fine sediment particles that are < 6.3mm (Bauer and Burton 1993, Rhodes and Purser, 1998.)

Procedure: Measure surface fines at the riffle crest/pool tailout directly downstream of the first four pools which meet the criteria for measurable pools and have a D_{50} bed surface particle size (ocular estimation) less than or equal to 128 mm within the riffle crest/pool tailout.

First, record the riffle wetted width at an appropriate location downstream from the riffle crest/pool tailout channel. Next, at the riffle crest/pool tailout and within 2 m upstream or downstream of the most likely redd position, establish a cross-sectional transect perpendicular to flow. Excluding the slackwater margin and backwater features, divide

the transect into 5 equal sections (Table 3). Using a grid method adapted from Bauer and Burton (1993), Lisle (1989), Lisle and Eads (1991) and Rhodes and Purser (1998), measure the percentage of fines at each of the dividing points between the equal segments (4 samples per site).

Place the 100 cross-section grid at the first point along the transect described above. Using an Aqua scope or a plexiglass viewer to reduce surface glare, count the number of grid points directly underlain by fine substrate < 6.3mm (Bauer and Burton 1993, Rhodes and Purser, 1998). If the grid point falls on larger substrate (cobble, boulder, bedrock, etc.) at a point where the substrate is covered with fines, count the point. If the grid point falls on dark interstitial areas between gravels, cobbles, etc., assume there are no fines and do not count.

Repeat this procedure at each established point along the transect. Record the number of points underlain by fines for each grid position along the transect in the handheld computer database (Figure 5).

Figure 6 Example Field Computer data entry for pools and surface fines.

Station	Channel Type	Pool Habitat						Substrate	Percent Surface Fines					Comments			
		Max D	Tail D	Calc. Red D	Wetted W	Funct. W	Wetted L		Funct. L	Calc. Area Fines	Pt 1	Pt 2	Pt 3		Pt 4	Calc. % Fines	
7																	
8	12.4 MC	10.2	8.4	14.3	13.4	112.6	1.0	0.2	0.8	Y	9.8	15	6	6	10	9	
9	54.2 MC	9.4	9.0	12.1	10.0	90.0	1.5	0.3	1.2	Y	10.3	8	4	9	0	5	
10	74.0 MC	9.6	8.2	8.6	8.1	66.4	0.6	0.2	0.3	Y	10.9	12	13	45	3	18	
11	125.4 MC	11.4	11.4	15.4	14.0	159.6	1.4	0.4	1.0	N						###	DAM POOL NO TAIL OUT
12	145.3 SC2	2.6	1.9	4.5	4.3	8.2	0.7	0.3	0.4	Y	9.7	5	14	7	7	8	
13	198.1 MC	5.6	4.8	14.3	12.5	60.0	0.8	0.3	0.5							###	
14				0.0					0.0							###	
15				0.0					0.0							###	
16				0.0					0.0							###	
17				0.0					0.0							###	
18				0.0					0.0							###	
19				0.0					0.0							###	
20				0.0					0.0							###	
21				0.0					0.0							###	

Data Entry for percent surface fines measurement:

Required Values: Station (hip chain reading of second and third transect if necessary), channel type, riffle wetted width, number of grid points underlain by fines for each measured point.

Automatically Calculated Values: Total Percent Fines for each transect in redd position

References

Abbe, T.B, and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. *Regulated Rivers: Research & Management*, Vol. 12, 201-221.

Bauer, S.B., and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency Region 10, Seattle, WA.

Beamer, E.M., and R.A. Henderson. 1998. Juvenile salmonid use of natural and hydromodified stream bank habitat in the mainstem Skagit River, Northwest Washington. Skagit System Cooperative. La Conner, WA. 51 p.

Collins, B. D., D.R. Montgomery, and A. D. Haas. 2001. Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers, submitted to *Canadian Journal of Fisheries and Aquatic Science*.

Johnston, N.T. and P.A. Slaney. 1996. *Fish Habitat Assessment Procedures*. British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests, Watershed Restoration Program, Tech. Circ. No. 8. 97 p.

Lisle, T. 1989. Sediment transport, and resulting deposition in spawning gravels channels, north coastal California. *Water Resources Research* 25: 1303-1319.

Lisle, T., and R.E. Eads. 1991. Methods to measure sedimentation of spawning gravels. USDA-FS Pacific Southwest Research Station, *Research Note* PSW-411.

National Marine Fisheries Service. 1996a. *Coastal Salmon Conservation: Working Guidance For Comprehensive Salmon Restoration Initiatives on the Pacific Coast*. USDC-NOAA, NMFS, Portland, OR. Report dated September 15, 1996.

National Marine Fisheries Service. 1996. *Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale*. NMFS, Portland, Oregon. 31 p.

Overton, C.K., S.P. Wollrab, B.C. Roberts and M.A. Radko. 1997. *R1/R4 (Northern/Intermountain Regional) Fish and Fish Habitat Standard Inventory Procedures Handbook*. Gen. Tech. Rep. INT-GTR-346. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 73 p.

Pleus, A. E., D. Schuett-Hames, and L. Bullchild. 1999. TFW Monitoring Program method manual for the habitat unit survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-003. DNR #105. June.

Rhodes, J.J., and M.D. Purser. 1998. Overwinter sedimentation of clean gravels in simulated redds in the upper Grande Ronde River and nearby streams in northeastern

Oregon, USA: Implications for the survival of threatened spring chinook salmon. Pages 403-412 in M.K. Brewin and D.M.A. Monita, tech. Coords. *Forest-fish conference: land management practices affecting aquatic ecosystems*. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Inf. Rep. NOR-X-356.

Rosgen, D. L. 1996. *Applied River Morphology*. Wildland Hydrology Books, Pagosa Springs, CO.

Scholz, J.G. and D.B. Booth. 1999. *Stream Habitat Assessment Protocols: An evaluation of urbanizing watersheds in the Puget Sound Lowlands*. Center for Urban Water Resources Management, Dept. of Civil and Environmental Engineering, Univ. Washington, Seattle, WA.

Schuett-Hames, D., A. Pleas, L. Bullchild, S. Hall. [eds.] 1994. *Ambient Monitoring Program Manual*. Timber-Fish-Wildlife, TFW-AM9-94-001. Northwest Indian Fisheries Commission, Olympia, WA.

Snohomish Salmonid Recovery Technical Committee (SRTC). 2000. *Snohomish Basin Interim Habitat Recovery Goals and Performance Criteria*. Working paper developed under direction from the Snohomish Basin Forum.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R. P. Novitzki, 1996. *An Ecosystem Approach to Salmonid Conservation*. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR.

United States Forest Service. 1999. *Stream inventory handbook: Level I & II*. USDA, Region 6, Version 9.9.