PROTOCOL
FOR
MONITORING EFFECTIVENESS
OF
HABITAT PROTECTION PROJECTS

(Land Parcel Biodiversity Health)

MC-10

Washington Salmon Recovery Funding Board

July 2011

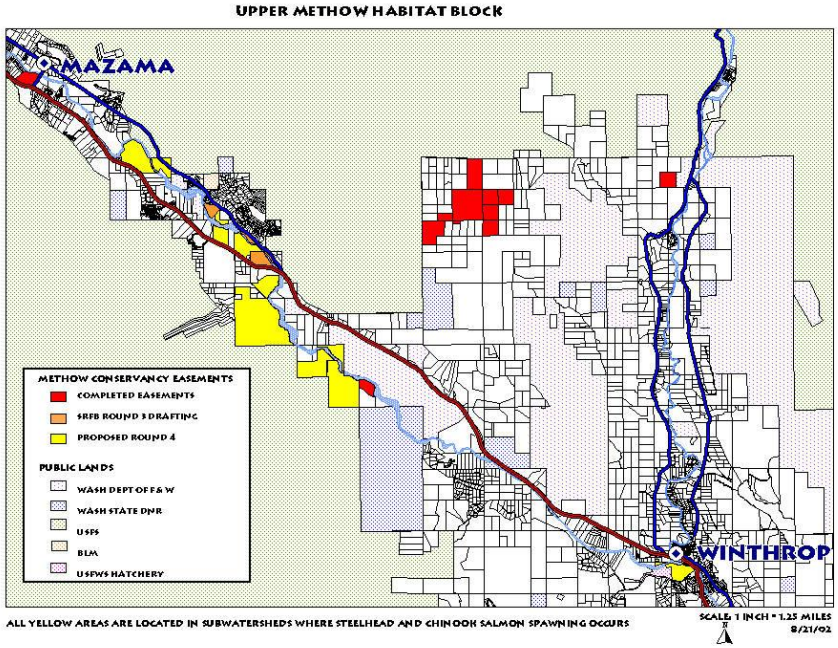

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TABLE OF CONTENTS

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ORGANIZATION

This document details the monitoring design, procedures, and quality assurance steps necessary to document and report the effectiveness of Habitat Protection Projects at the parcel scale.

This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002).

SRFB objectives for protecting property for salmon recovery through purchases or easements include the following:

1. Protect identified blocks of critical habitat within an ESU, which provide protection from further decline for the species at risk (a conservation area identified for conservancy – a refugia).
2. Protect property providing key linkages between fragmented habitats (a parcel that contributes to maintaining key ecological processes).
3. Protect property used to enhance habitat and to offset poor habitat elsewhere in the watershed (habitat enhancement/restoration).

The Board funds two categories of projects related to land acquisition, Restoration/Protection projects and Protection projects. Restoration/Protection projects are specific parcels of land acquired with habitat restoration activities in mind. Protection Projects include lands that the project proponent has prioritized as a high need for acquisition because it meets one of the protection goals already discussed.

A Protection Project is a property acquired either in fee title or a property protected by a restrictive use agreement or easement. Habitat protection, or acquisition, effectiveness monitoring is limited to Protection Projects because the effects of restoration activities upon the land parcel will confound baseline data.

There are two scales for assessing the effectiveness of habitat acquisitions -- the parcel scale and the watershed scale. Monitoring at the parcel scale determines whether the desirable attributes of the property, in terms of habitat and fish populations, have continued at original levels or improved over time. This is purely a local evaluation and is blind to the overall watershed needs and existing conditions. It only answers the questions: ***What is the status of the habitat and fish on acquired lands? Is it improving, remaining the same, or declining?*** The assumption behind this form of effectiveness monitoring is that acquired habitat that remains unchanged or is improving reflects an effective acquisition. If the habitat is declining, the causes may or may not be directly attributable to changes occurring on the sampled land parcel. For example, there could be activities occurring upstream that affect instream morphology or stream bank structure within the acquisition boundaries.

The watershed scale is more complex but also more directly answers the questions of interest. However, this document does not address those larger questions, such as: How do SRFB acquisitions fit into the overall critical habitat protection needs identified for each watershed? ***Have SRFB acquisitions been effective in addressing watershed habitat protection goals?*** The assumption behind these questions is that we know what needs to occur in a watershed in terms of restoring habitat, providing refuges, and halting habitat destruction. Furthermore, these questions also assume that the needs have been prioritized and have broad support.

This "Effectiveness Monitoring Procedure for Habitat Protection Projects" addresses only the characteristics of the parcels as separate and independent entities (parcel scale). It does not attempt to answer land protection effectiveness monitoring questions at watershed or regional scale.

MONITORING GOAL

Determine whether habitat protection parcels as a whole and individually are effective in maintaining and/or improving salmon habitat and fish and invertebrate species assemblages within the parcel boundaries.

QUESTIONS TO BE ANSWERED

Have the protected properties maintained or improved the riparian habitat benefits for which they were purchased?

Have the protected properties maintained or improved the upland habitat benefits for which they were purchased?

Has the biological condition of the macroinvertebrate and fish species assemblages improved, declined or stayed the same within the protected properties?

NULL HYPOTHESES

Protected property over a 12-year period has had no significant adverse change upon:

- The amount or quality of riparian vegetation and cover.
- The amount or quality of upland vegetation and cover.
- The amount or quality of instream structure and morphology.
- The amount or quality of intertidal vegetation and substrate.
- The macroinvertebrate species assemblages and multi-metric index.
- The native fish species assemblages and index.

OBJECTIVES

BASELINE (YEAR 0)

Determine status of instream, riparian, and upland habitat within each randomly selected parcel.

Determine the biological condition of macroinvertebrate and fish species assemblages using a multi-metric index for each randomly selected parcel.

POST-PURCHASE OBJECTIVES (YEARS 3, 6, 9, AND 12)

Determine trends in instream, riparian, and upland habitat within each randomly selected parcel compared to the baseline year.

Determine status of macroinvertebrate and fish species assemblages using a multi-metric index for each randomly selected parcel.

RESPONSE INDICATORS

LEVEL 2 INSTREAM MORPHOLOGY

Thalweg Profile. The Thalweg profile characterizes pool-riffle relationships, sediment deposits, wetted width substrate characteristics, and channel unit-pool forming categories. Stream morphology sampling methods are taken from EMAP (Peck et al. 2003), Section 7.4.

Stream morphology response variables

Indicator Abbreviation	Description
AREASUM	Mean Thalweg vertical profile area for the study reach
RP100	Mean Thalweg residual depth within the study reach
Log10V1WM100	Volume of large woody debris of all sizes within the study reach
CHANL	Study reach bankfull channel capacity
PCT_FN	Mean percent of the study substrate in fines
XEMBED	Mean percentage of the substrate that is embedded within the study reach

LEVEL 2 INTERTIDAL ZONE TRANSECT

Intertidal Zone Transect. Transects will be surveyed to quantify vegetation characteristics and bottom substrate of the intertidal zone for Estuary Habitat Protection Projects. Parameters monitored are taken from the NOAA document, "Science based Restoration Monitoring of Coastal Habitats," and Transects are adapted from grassland Transects devised by Joe Arnett, Tetra Tech FW, Inc.

Intertidal zone response variables

Indicator Abbreviation	Description
ALGAE_M	Percent of the length of the intertidal Transect with marine algae
ALGAE_LN	Linear extent of algae along the intertidal Transect
VASCULAR_M	Percent of the length of the intertidal Transect with vascular plants
VASCULAR _LN	Linear extent of vascular plants along the intertidal Transect
SLOPE_M	Percent slope from mean high tide to mean low tide or low water
PCT_FNM	Percent of the length of the intertidal Transect with fine sediment
FN_LN	Linear extent of fine sediment along the intertidal Transect

LEVEL 2 RIPARIAN PLANTS

Riparian condition is determined by measuring the plant density and species composition within the study reach. It is also important to measure stream bank erosion. Streamside riparian habitat sampling methods are taken from EMAP (Peck et al. Unpubl.), Section 7.4.

Riparian vegetation response variables

Indicator Abbreviation	Description
XCDENBK	Mean percent shading at the bank (using a densiometer)
XPCMG	Proportion of the reach containing all 3 layers of riparian vegetation, canopy cover, under-story, and ground cover
BANK	Proportion of the reach containing actively eroding stream banks

LEVEL 2 UPLAND PLANTS

Upland habitat can be important to salmon recovery in providing a buffer area between other upland activities and processes and the riparian corridor and stream. Depending upon topography and slope, buffers along streams may need to be much wider than in other areas to protect the stream from erosion and temperature effects. Upland plant community sampling methods are taken from the National Park Service "Fire Monitoring Handbook (FMH)" 2003, and Joe Arnett of Tetra Tech FW, Inc.

Upland vegetation response variables

Indicator Abbreviation	Description
HERB_NN_ABS	Absolute percent cover of non-native herbaceous vascular plant species as measured along randomly chosen Transect segments, each consisting of ten one-meter line intercept plots.
HERB_NN_REL	Relative percent cover of non-native herbaceous vascular plant species as measured along randomly chosen Transect segments, each consisting of ten one-meter line intercept plots.
SHRUB_NN_ABS	Absolute percent cover of non-native shrub species as measured along randomly chosen Transect segments, each consisting of ten one-meter line intercept plots.

Indicator Abbreviation	Description
SHRUB_NN_REL	Relative percent cover of non-native shrub species as measured along randomly chosen Transect segments, each consisting of ten one-meter line intercept plots.
BA_CONIF	Basal area of conifers per acre (square feet/acre) as measured within 1/10 acre circular forest plots. Each plot is centered over a randomly selected point along the Transect.
SA_CONIF	Stem count of conifers per acre (number/acre) as measured within 1/10 acre circular forest plots. Each plot is centered over a randomly selected point along the Transect.
BA_DECID	Basal area of deciduous trees per acre (square feet/acre) as measured within 1/10 acre circular forest plots. Each plot is centered over a randomly selected point along the Transect.
SA_DECID	Stem count of deciduous trees per acre (number/acre) as measured within 1/10 acre circular forest plots. Each plot is centered over a randomly selected point along the Transect.

LEVEL 3 FISH SPECIES ASSEMBLAGES

Total abundance of salmon can be determined using both adult counts and juvenile counts. Both adults and juveniles can be monitored using protocols developed by Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. However, annual variations of salmon abundance located on a particular parcel of land may be the result of changes in variables unrelated to the property monitored. Such things as harvest, ocean conditions, downstream passage, and random preferences of the fish may all contribute to annual changes in fish abundance not directly attributable to the property.

Therefore, fish populations in this Procedure are evaluated using an index of biological integrity (IBI) as described by Mebane et al. (2003). Fish species diversity sampling methods are taken from EMAP (Peck et al. 2003), Section 7.4. Procedures summarizing EMAP Table 12-3 and 7-4 are found on page 47. The IBI includes the following indicators of fish assemblage, health and ecosystem quality:

1. Number of native coldwater species
2. Percentage of sensitive native individuals
3. Percentage of coldwater individuals
4. Percentage of tolerant individuals
5. Number of alien species
6. Percentage of common carp
7. Catch per unit effort of coldwater individuals (not applicable to snorkel surveys
8. Percentage of individuals with selected anomalies

Fish assemblage response variable

Indicator Abbreviation	Description
FISHINDEX	Index of Biological Integrity

LEVEL 3 MACROINVERTEBRATE ASSEMBLAGES

Stream macroinvertebrate species composition and relative abundance of particular groups show strong correlations with water quality and watershed health factors. Changes in macroinvertebrates would indicate that water quality conditions within the parcel have changed over time. Macroinvertebrate sampling methods are taken from EMAP (Peck et al. 2003) Section 11. Protocols summarizing EMAP Table 11-2, 11-3, and 11-4 are found on page 55 and in the Department of Ecology's "Benthic Macro-Invertebrate Biological Monitoring Protocols for Rivers and Streams", Publ No. 01-03-028. Indicators considered most sensitive to regional change are compared using a multi-metric index (Karr and Chu, 1999; Wiseman, 2003). The MMI includes the following indicators of stream health based upon invertebrate species composition and relative abundance:

1. Percent of the family Chironomidae of the total sample count
2. Percent of the Orders Ephemeroptera, Plecoptera, and Trichoptera of the total sample count
3. Percent of the Order Ephemeroptera of the total sample count
4. Hilsenhoff Biotic Index (HBI) which is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals
5. Total number of taxa
6. Number of highly intolerant taxa, as defined by Wiseman (2003)
7. Percent of clinger taxa of the total sample count
8. Number of clinger taxa
9. Number of intolerant taxa with a tolerance value less than 3 (TV3)
10. Percent of the tolerant taxa of the total sample count with a tolerance value greater than 7(TV7)
11. Percent of the top 3 abundant taxa of the total sample count
12. Percent of the filter taxa of the total sample count
13. Percent of the predator taxa of the total sample count
14. Percent of the scraper taxa of the total sample count
15. Number of long-lived taxa

Macroinvertebrate assemblage response variable

Indicator Abbreviation	Description
MMI_INVERT	Macroinvertebrate indicators considered most sensitive to regional change are compared using a multi-metric index (Wiseman, 2003).

SAMPLING PROCEDURE

Elements of the design are as follows:

- Identify the response indicators most sensitive to change and that reflect the attributes that support salmon recovery.
- Establish a randomly selected sub-sample of acquisition projects such that they are representative of the total number of projects completed.
- Insure that enough projects are selected that a significant change is likely to be detected for the response indicators selected.
- Collect a baseline year of sampling to determine status at or near the time of purchase.
- Conduct periodic re-sampling at the same site to determine if significant change occurs for the monitored properties.

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: ***Peck et al. (2003), pp. 63-65, Table 4-4; Mebane et al. (2003)***

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar, orange and blue spray paint or plastic rebar caps, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" reaches have been matched with "control" reaches of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of Transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas (see Figure 1). The Transects are then averaged to obtain an average representation of the stream reach.

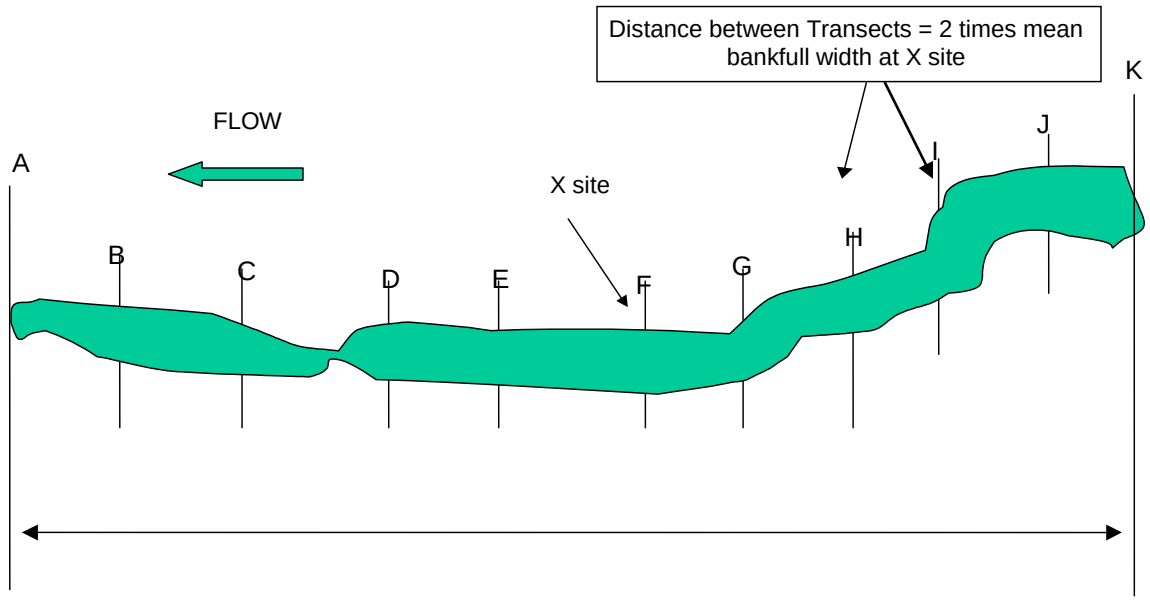


Figure 1. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the X site and record latitude and longitude on the stream verification form. The X site should be considered the center of the impact or control study reach. The impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the length of the impact reach. It will be located in the center of the control reach, which will measure the same as the length of the impact reach whenever possible. Mark the X site on the bank above the high water mark with one of the rebar stakes and a colored plastic cap so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the bankfull width of the channel at five places considered to be of "typical" width within approximately five channel widths distance upstream and downstream of the X site location. Average those five bankfull widths, then multiply that average bankfull width by 20 to determine the reach length. For streams less than 7.5 m in average bankfull width, the reach length should be at minimum 150 m, and for streams greater than 25 m in width, the maximum reach length shall be 500 m. If the impact reach is less than 150 m, measure and include the entire impact area in the sampling reach. Determine the impact reach length based upon the above, and set the control site reach length equal to the impact reach length.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 10 times the bankfull width (equal to one half the sampling reach length) determined in Step 1.

For example, if the reach length is determined to be 150 meters, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 20 times bankfull width, the entire project's length should be sampled and a control reach of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankin and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area. To adjust the stream reach, simply add or subtract additional length to Transects A or K, as appropriate (i.e. do not shift the entire reach upstream or downstream to encompass an entire pool). In the case where the treatment site is dry in Year 0, reach lengths should still be based upon 20 times the bankfull width.

Step 4: Starting back at the X site, measure a distance of 10 average bankfull widths down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as Transect "A".

Step 5: Using the tape, measure 1/10th (2 average bankfull widths in big streams or 15 m in small streams) of the reach length upstream from the start point (Transect A). Flag this spot as the next cross section or Transect (Transect B).

For example, if the reach length is determined to be 200 meters, a Transect will be located every 20 meters, which is equivalent to 1/10th the total reach length.

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional Transects (labeled "C" through "K" as you move upstream) at intervals equal to 1/10th of the reach length. At the reach end points (Transects A and K) and the middle of the reach (X site or Transect F), install a rebar stake as described in Step 1.

METHOD FOR CHARACTERIZING RIPARIAN VEGETATION STRUCTURE

Protocol taken from: ***Peck et al. (2003), Table 7-10; Kauffman et al. (1999)***

PURPOSE

This protocol is designed to determine the changes in riparian vegetation due to a restoration project where riparian vegetation has been planted.

EQUIPMENT

Convex spherical densiometer, field waterproof forms, hip boots or waders

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Sampling should occur during June-August when vegetation is at its maximum growth, or when feasible at each project site.

PROCEDURES FOR MEASURING RIPARIAN VEGETATION AND STRUCTURE

Following are taken from Table 7-10 of EMAP protocols:

Step 1: Standing in mid-channel at a Transect (A-K), estimate a 5m distance upstream and downstream (10m length total).

Step 2: Facing the left bank (left as you face downstream), estimate a distance of 10m back into the riparian vegetation or until an exclosure is encountered. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.

Step 3: Within this 10 m X 10 m area, conceptually divide the riparian vegetation into three layers: a canopy layer (>5 m [16ft] high), an understory (0.5 to 5 m [20 inches to 16ft.] high), and a ground cover layer (<0.5 m high).

Step 4: Within this 10 m X 10 m area, determine the dominant vegetation type for the canopy layer as Deciduous, Coniferous, Broadleaf Evergreen, Mixed, or None. Consider the layer mixed if more than 10% of the aerial coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the "Visual Riparian Estimates" section of the Channel/Riparian Cross Section Form (Figure 2).

Step 5: Determine separately the aerial cover class of large trees (>0.3 m [1ft] diameter breast height [DBH]) and small trees (<0.3m DBH) within the canopy layer. Estimate aerial cover as the amount of

shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form ("0"= absent: zero cover, "1"= sparse: <10%, "2"= moderate: 10-40%, "3"=heavy: 40-75%, or "4"= very heavy: >75%).

Step 6: Look at the understory layer. Determine the dominant vegetation type for the understory layer as described in Step 4.

Step 7: Determine the aerial cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in Step 5 for large trees.

Step 8: Look at the ground cover layer. Determine the aerial cover class for woody shrubs and seedlings, non-woody vegetation as described in Step 5 for large canopy trees, and the amount of bare ground present. Note that Reed's canary grass often meets the height requirements for the understory layer, but should always be counted as ground cover.

Step 9: Repeat steps 1 through 8 for the right bank.

Riparian Vegetation Cover	Left Bank					Right bank					Flag
	Canopy (> 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Big trees (trunk > 0.3m DBH) XCL	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Small trees (trunk ,0.3m DBH) XCS	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Understory (0.5 to 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Woody shrubs and saplings XMW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XMH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Ground Cover (0.5m high)										
Woody shrubs & saplings XGW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XGH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Barren dirt or duff XGB	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	

Figure 2. Form for recording visual riparian estimates

Step 10: Repeat steps 1 through 9 for all Transects, using a separate field data form for each Transect. Once vegetation has been accounted for in a layer, it should not be included in subsequent layers as they are evaluated.

Note: Use one form for each Transect (A – K)

The following table taken from Kauffman et al. (1999) details the parameter codes and precision metrics of EMAP procedures conducted in Oregon (Table 1). Parameters in bold type are the most precise. This table is provided for information purposes only.

Table 1. Parameter codes and precision metrics of EMAP procedures conducted in Oregon.

Code	Variable name and description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCL	Large diameter tree canopy cover (proportion of riparian)	0.057	38	4.6
XCS	Small diameter tree canopy cover (proportion of riparian)	0.12	55	1.4
XC	**Tree canopy cover (proportion of riparian)**	**0.12**	**33**	**2.4**
XPCAN	**Tree canopy presence (proportion of riparian)**	**0.08**	**8.7**	**10**
XMW	Mid-layer woody vegetation cover (proportion of riparian)	0.12	41	0.9
XMH	Mid-layer herbaceous vegetation cover (proportion of riparian)	0.13	100	0.9
XM	**Mid-layer vegetation cover (proportion of riparian)**	**0.19**	**44**	**0.6**
XPMID	**Mid-layer vegetation presence (proportion of riparian)**	**0.03**	**3.5**	**2.1**
XGW	Ground layer woody vegetation cover (proportion of riparian)	0.17	77	0.1
XGH	Ground layer herbaceous vegetation cover (proportion of riparian)	0.16	40	1.1
XGB	Ground layer barren or duff cover (proportion of riparian)	0.07	47	2.0
XG	Ground layer vegetation cover (proportion of riparian)	0.22	36	0
PCAN_C	Conifer riparian canopy (proportion of riparian)	0.11	58	8.5
PCAN_D	Broadleaf deciduous riparian canopy (proportion of riparian)	0.13	31	7.4
PCAN_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.16	65	2.9
PMID_C	Conifer riparian mid-layer (proportion of riparian)	0.02	55	37
PMID_D	Broadleaf deciduous riparian mid-layer (proportion of riparian)	0.33	58	0.7
PMID_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.32	87	0.6

PROCEDURES FOR MEASURING CANOPY COVER

Canopy cover is determined for the stream reach in the treatment and control areas at each of the 11 cross-section Transects. A convex spherical densiometer (Model B) is used. Six measurements are obtained at each cross section Transect at mid-channel.

Step 1: At each cross-section Transect, stand in the stream at mid-channel and face upstream.

Step 2: Hold the densiometer 0.3 m (1 ft.) above the stream. Hold the densiometer level using the bubble level. Move the densiometer in front of you so that your face is just below the apex of the taped "V".

Step 3: Count the number of grid intersection points within the "V" that are covered by either a tree, a leaf, a high branch, or other shade providing feature (Reed's canary grass, bridge or other fixed structure, stream bank, etc.). Record the value (0-17) in the CENUP field of the canopy cover measurement section of the form.

Step 4: Face toward the left bank (left as you face downstream). Repeat steps 2 and 3, recording the value in CENL field of the data form.

Step 5: Repeat steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the CENDWN and CENR fields of the field data form.

Step 6: Repeat steps 2 and 3 again, this time facing the bank while standing first at the left bank, then the right bank, while holding the densiometer approximately 0.3 m (1 ft.) above the water surface and at the wetted edge. Record the value in the LFT and RGT fields of the data form.

Step 7: Repeat steps 1-6 for each cross-section Transect (A-K). Record data for each Transect on a separate data form.

Step 8: If for some reason a measure cannot be taken, indicate in the "Flag" column. This situation would occur if there is no access to one side of the channel, or if the channel is too wide or deep to cross, so middle measurements cannot be taken. If measurements cannot be taken they will not be estimated.

Location	1-17	Flag
CENUP		
CENL		
CENDWN		
CENR		
LFT		
RGT		

Figure 3. Form for tallying canopy density

Each of the measures taken at the center of the stream are summed for all 11 Transects and converted to a percentage based upon a maximum score of 17 per Transect. The results are then averaged to produce a mean % canopy density at mid-stream (XCDENMID).

Each of the measures taken at the banks of the stream are summed for all 11 Transects and converted to a percentage based upon a maximum score of 17 per Transect. The results are then averaged to produce a mean % canopy density at the stream bank (XCDENBK).

Each of the measures are totaled and averaged to produce the following table of riparian vegetative cover.

Table 2. The shaded composite variables are considered the most important in terms of their precision and are the ones that will be used to determine effectiveness of riparian plantings. RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement. CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement. S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep} is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. This table is provided to demonstrate the best indicators for testing significance.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	Mean % canopy density at bank (Densiometer reading)	3.9	4.4	17
XC DENMID	**Mean % canopy density mid-stream (densiometer reading)**	**5.8**	**8.1**	**15**
XCM	Mean riparian canopy + mean mid-layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid-layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

METHOD FOR MEASURING SUBSTRATE

Protocol taken from: ***Peck et al. (2003), Table 7-7 modified Wolman pebble count***

PURPOSE

Determining the changes in the percentage of fines and embeddedness within the impact and control areas pre- and post-project in order to determine any significant changes.

EQUIPMENT

Meter stick, surveyor's rod, metric tape

SITE SELECTION

The sample reaches should be laid out according to page 13-15.

SAMPLING DURATION

Counts should be taken during summer low flow period when turbidity and visibility is normally at its best. This may not be true for glacial streams.

PROCEDURE

Step 1: Substrate size class is estimated for a total of 105 particles taken at 5 equally-spaced points along each of 21 cross sections, located at 11 regular transects (A through K) and 10 intermediate transects. Depth is measured and embeddedness estimated for the 55 particles located along the 11 regular transects also. Cross sections are defined by laying the surveyor's rod or tape to span the wetted channel.

Step 2: Fill in the header information on the Substrate Form. Indicate the cross-section Transect. At the Transect, extend the surveyor's rod across the channel perpendicular to the flow, with the zero end at the left bank (facing downstream). If the channel is too wide for the rod, stretch the metric tape in the same manner. For dry and intermittent streams, where no water is in the channel, use the bankfull width to determine where to collect substrate information (record the wetted width depths as zeros).

Step 3: Divide the wetted channel by 4 to locate substrate measurement points on the cross section to get locations corresponding to 0% (LFT), 25% (LCTR), 50% (CTR), 75% (RCTR), and 100% (RGT) of the measured wetted width.

Step 4: Place your sharp-ended meter stick or calibrated pole at the LFT location (0 m). Measure the depth and record it on the field data form. Cross section depths are measured only at regular Transects A through K, not at the 10 mid-way cross sections (A-B, B-C, etc.).

Step 5: Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder), and visually estimate its particle size, according to the following table (Table 3). Classify the particle according to its median diameter (the middle dimension of its length, width, and depth). Record the size class code on the Substrate Form (Figure 4). (Cross section side of form for Transects A-K; special entry boxes on Thalweg Profile side of form for mid-way cross-sections.)

Table 3. Substrate particle classification

Code	Size class	Size range (mm)	Description
RS	Bedrock (smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan		Firm, consolidated fine substrate
BL	Boulders	>250 to 4000	Basketball to car size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (coarse)	>16 to 64	Marble to tennis ball size
GF	Gravel (fine)	>2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size, but visible as particles – gritty between fingers
FN	Fines	<0.06	Silt, Clay, Muck, (not gritty between fingers)
WD	Wood	Regardless of size	Wood and other organic particles
OT	Other	Regardless of size	Concrete, metal, tires, car bodies, etc.

Step 6: Evaluate substrate embeddedness as follows at 11 Transects A-K. For particles larger than sand, examine the surface for stains, markings, and algae. Estimate the average percentage embeddedness of particles in the 10 cm circle around the measuring rod. Record this value on the field data form. By definition, sand and fines are embedded 100 percent, bedrock and hardpan are embedded 0 percent.

Step 7: Move successively to the next location along the cross section. Repeat steps 4 through 6 at each location. Repeat steps 1 through 6 at each new cross section Transect.

SUBSTRATE FORM

Site: _____ Date: _____ Reach: _____ Surveyors: _____

Main Transect Substrate

Transect	Substrate Size Code					FLAG
	LFT	LCTR	CTR	RCTR	RGT	
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						

Intermediate Transect Substrate

Intermediate Transect	LFT			LCTR			CTR			RCTR			RGT		
	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)
A[1]															
B[1]															
C[1]															
D[1]															
E[1]															
F[1]															
G[1]															
H[1]															
I[1]															
J[1]															

Figure 4. Gravel form

METHOD FOR MEASURING POOL ATTRIBUTES

Modified Protocol taken from: ***Heitke et al. (2010) pp. 44-46***

PURPOSE

Determining the changes in the percentage of fines and embeddedness within the impact and control areas pre- and post-project in order to determine any significant changes.

EQUIPMENT

Meter stick, surveyor's rod, metric tape

SITE SELECTION

The sample reaches should be laid out according to page 13-15.

SAMPLE DURATION

Counts should be taken during summer low flow period when turbidity and visibility is normally at its best. This may not be true for glacial streams.

PROCEDURE

Step 1: Fill out header information on Pool Attribute Form (Figure 5). Then, while working from downstream to upstream, locate each pool. For each pool encountered, complete steps 2-4 as described below.

Pools are defined as the following:

- Pools are depressions in the streambed that are concave in profile, laterally and longitudinally.
- Pools are bound by a 'head' crest (upstream break in streambed slope) and a 'tail' crest (downstream break in streambed slope).
- Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
- Pools span at least 50% of the wetted channel width at any location within the pool. So a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool.
- Side channels - when islands are present only consider pools in the main channel; don't measure pools in side channels.

Step 2: For each pool encountered, measure pool-tail crest depth to the nearest centimeter (cm) and record. Pool-tail depth is measured at the maximum depth along the pool tail crest, which is normally, but not always, the thalweg. To find this point, imagine that the water in the stream is 'turned off'. You want to measure the depth of the last spot that would have flowing water before the stream stopped flowing.

Step 3: Measure maximum depth of each pool encountered and record. Maximum depth is the deepest point in the pool. Locate it by probing the pool with a meter stick or surveyors rod. If unsafe to measure maximum pool depth, estimate the maximum depth.

Step 4: Measure pool width at the widest point of each pool encountered and record.

Pool Attributes Form

Site ID _____ Station _____ Date _____ Year _____

Surveyors _____

Pool #	Max Width (m)	Max Depth (cm)	PTC Depth (cm)	Comments

Figure 5. Pool Attribute Form

METHOD FOR MEASURING POOL TAIL FINES

Protocol taken from: ***Heitke et al (2010), pp. 49-50.***

PURPOSE

This protocol is designed to determine the percentage of fine sediments on the pool tail surface of plunge pools and scour pools.

EQUIPMENT

Grid (14"x14", with 49 evenly distributed intersections), measuring stick, electrical tape, field forms, waders

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Sampling should occur during June - August at low flow levels, or when feasible at each project site.

PROCEDURE

For the purposes of this method, the following criteria must be met for a feature to be considered a pool:

- Pools are depressions in the streambed that are concave in profile, laterally and longitudinally.
- Pools are bound by a 'head' crest (upstream break in streambed slope) and a 'tail' crest (downstream break in streambed slope).
- Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
- Pools span at least 50% of the wetted channel width at any location within the pool. So a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool.
- When islands are present only consider pools in the main channel; don't measure pools in side channels.
- If a side channel is present, the pool must span at least 50% of the main channel's wetted width; disregard side channels width when making this determination.
- Maximum pool depth is at least 1.5 times the pool tail depth.

Step 1: Collect measurements in the first ten scour and plunge pools of each reach beginning at the downstream end (Transect A). Exclude dam pools (and beaver pools). If there are fewer than 10 pools within the reach, sample all pools that meet the criteria listed above.

- Sample within the wetted area of the channel.

- Take measurements at 25, 50, and 75% of the distance across the wetted channel, following the shape of the pool tail.

- Take measurements upstream from the pool tail crest a distance equal to 10% of the pool's length or one meter, whichever is less.

For example, if the pool length is 7 meters, measurements would be taken 0.7 meters upstream of the pool tail crest, which is 10% of the pool length.

If the pool length is 12 meters, measurements would be taken at 1 meter upstream from the pool tail crest because it is less than 10% of the pool's length, which would be 1.2 meters.

- Locations are estimated visually.

Step 2: Assess surface fines using a 14 x 14 inch grid with 49 evenly distributed intersections. Include the top right corner of the grid and there are a total of 50 intersections.

Step 3: Using the grid, take measurements in each pool by completing the following steps:

1. Place the bottom edge of the grid upstream from the pool tail crest a distance equal to 10% of the pool's length or one meter, whichever is less (Figure 6).

2. Place the center of the grid at 25% of the distance across the wetted channel, making sure the grid is parallel to and following the shape of the pool tail crest.

3. If a portion of the fines grid lands on substrate 512 mm (approx. 20 inches) or larger in size (b-axis), record the intersections affected as non-measurable intersections (Figure 7).

Step 4: Record the number of intersections that are underlain with fine sediment < 2 mm in diameter at the b-axis in the Pool Tail Fines Form (Figure 7). Place a 2 mm wide piece of electrical tape on the grid and use this to assess the particle size at each intersection.

Step 5: Record the number of intersections that are underlain with fine sediment < 6 mm in diameter at the b-axis in the Pool Tail Fines Form (Figure 8). Place a 6 mm wide piece of electrical tape on the grid and use this to assess the particle size at each intersection.

Step 6: Aquatic vegetation, organic debris, roots, or wood may be covering the substrate. First attempt to identify the particle size under each intersection. If this is not possible due to debris, then record the number of non-measurable intersections. Do not attempt to move the obstructing debris

Notes:

- Your number of fines < 2mm cannot exceed the number of fines < 6mm.
- In small streams you can have grid placements overlap.

Step 7: Repeat steps 2 – 6 at 50% and 75% of the distance across the wetted channel, for a total of three measurements per pool

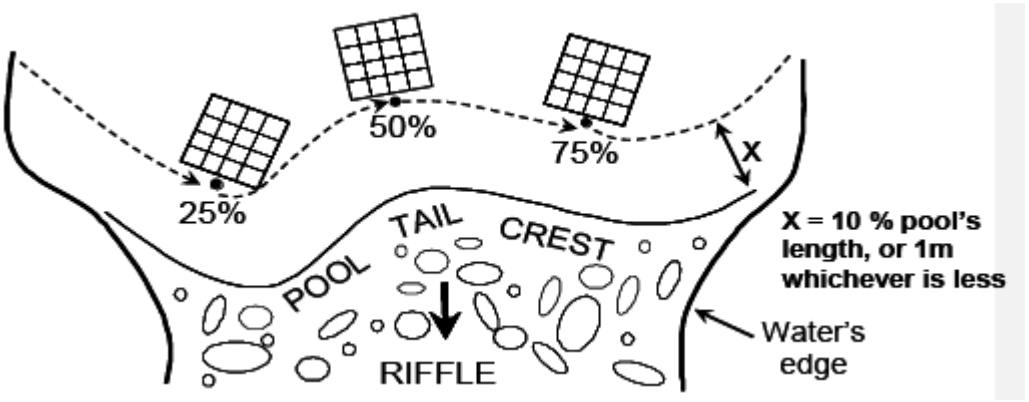


Figure 6. Orientation and location of grid placement (from Heitke et al (2010)).

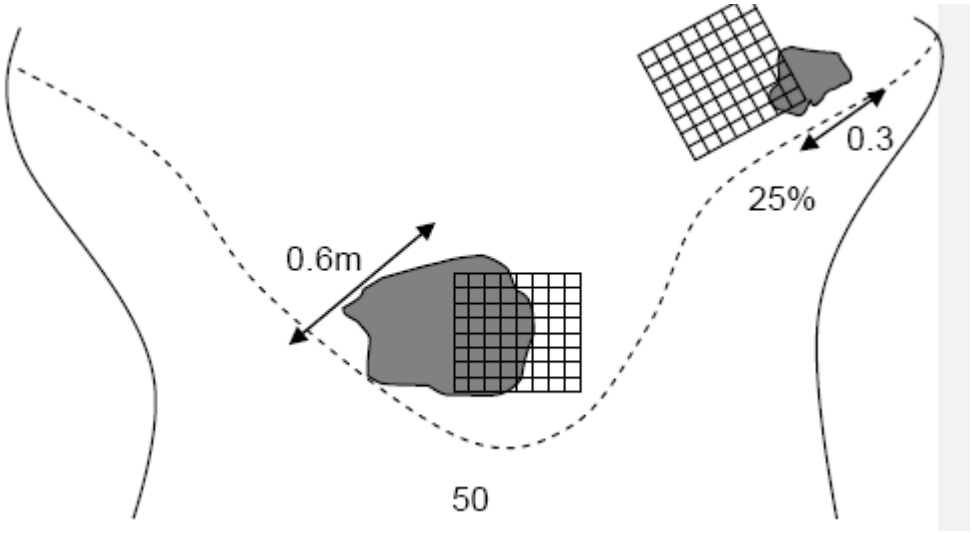


Figure 7. This figure illustrates non-measureable substrate at the 50% placement (from Heitke et al (2010)).

Pool Tail Fines Data Sheet

Site: _____ Reach: Control Impact Surveyors: _____

Date: _____ Visit #: _____

Transect (A-B, B-C, etc.)	**Pool #** (1-10)*	**# Intersections with Fine Sediment** (out of 50 at each location)								
		25%			***50%***			***75%***		
		<2mm	***<6mm***	***Non-measurable***	***<2mm***	***<6mm***	***Non-measurable***	***<2mm***	***<6mm***	***Non-measurable***

Comments:

*Pools should be numbered from 1-10 sequentially beginning at downstream end of reach.

Note: The number of intersections listed as < 2 mm cannot exceed the number that is listed as < 6 mm

Figure 8. Pool Tail Fines Form

METHOD FOR MEASURING LARGE WOODY DEBRIS (LWD)

Modified Protocol taken from: ***Heitke et al (2010) pp. 83-87; Peck et al. (2003), pp. 115-117; Table 7-5; Kauffman et al. (1999)***

PURPOSE

These methods are used to tally "large woody debris" (LWD). The tally includes all LWD that are in the bankfull channel (the active channel), or spanning above the active channel. The active, or bankfull, channel is defined as the channel that is filled by moderate-sized flood events that typically occur every one or two years. LWD in the active channel is tallied over the entire length of the reach, including between the channel cross-section Transects.

EQUIPMENT

Measuring tape, meter stick, waterproof sampling forms

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Counts should be taken during summer low flow in conjunction with other instream measurements such as Thalweg profile.

PROCEDURE

Note: *Measure pieces of LWD within each segment of stream at the same time the Thalweg profile is being determined. Include all pieces whose large end is located within the segment in the tally.*

In order to be counted, each piece must meet the following criteria. Also refer to Figures 9 and 10 below, which are adopted from Heitke et al (2010).

a. Each piece must be greater than 1 meter in length and at least 10 cm in diameter one-third of the way up from the base. For pieces that are not evenly round, measure the widest axis.

b. The stem of the large wood piece must extend below the bankfull elevation. Imagine the stream is flowing at bankfull, any piece whose stem is wet would count.

c. Only count dead pieces

- Can be fallen or standing trees.
- Dead trees are defined as being devoid of needles or leaves, or where all of the needles and leaves have turned brown.

- Consider it living if the leaves or needles are green.

- Use caution when assessing the condition of a tree or fallen log. Nurse logs can appear to have living branches when seedlings or saplings are growing on them.

d. Wood embedded in the streambank is counted if the exposed portion meets the length and width requirements (see Figure 10 below, adopted from Heitke et al (2010)).

e. Do not count a piece if only the roots (but not the stem/bole) extend within the bankfull channel.

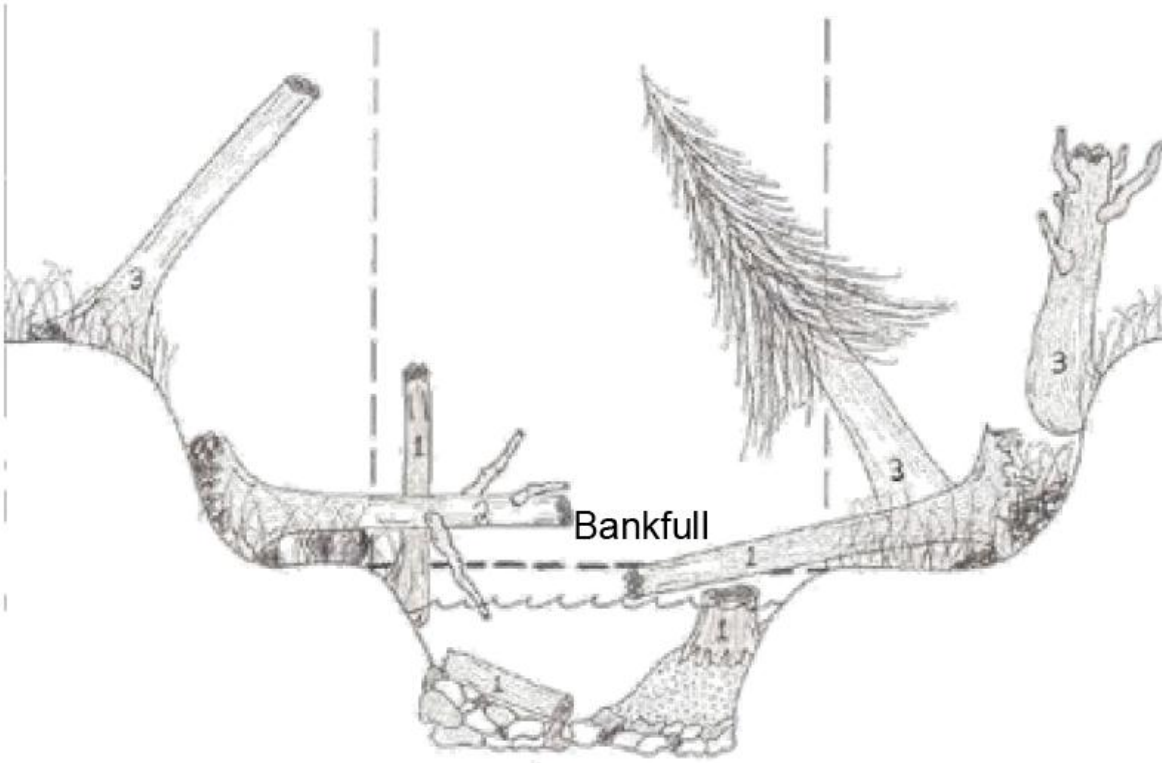


Figure 9. Pieces numbered "1" are counted; pieces numbered "2" or "3" are not.

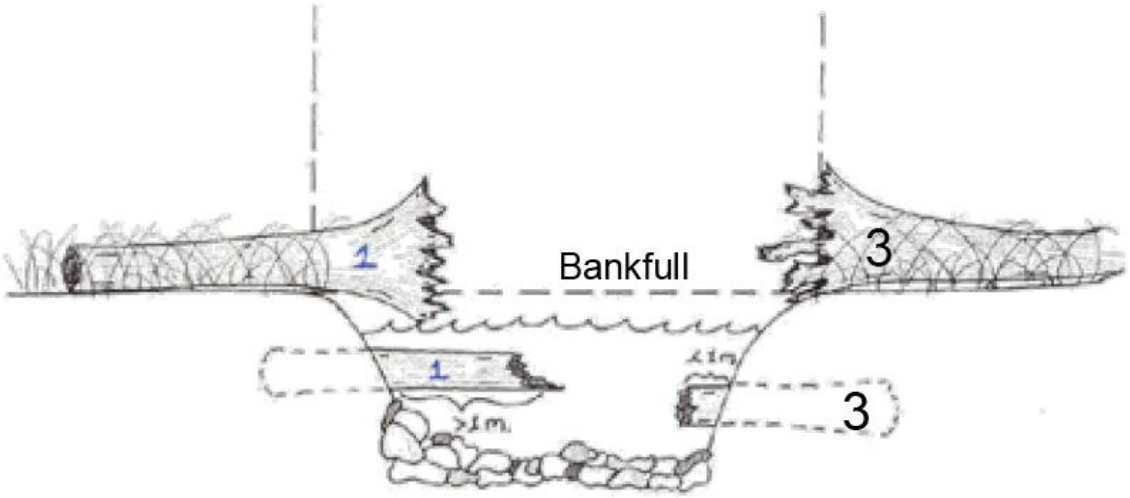


Figure 10. Examples of qualifying large wood, numbered a "1". The pieces numbered as "3" are not counted because either only the roots extend over the bankfull channel (upper piece) or the exposed section is less than 1 meter in length (lower piece).

f. Some pieces crack or break when they fall. Include the entire length when the two pieces are still touching at any point along the break. Treat them separately if they are no longer touching along the break (see Figures 11 and 12 below, adopted from Heitke et al (2010)).

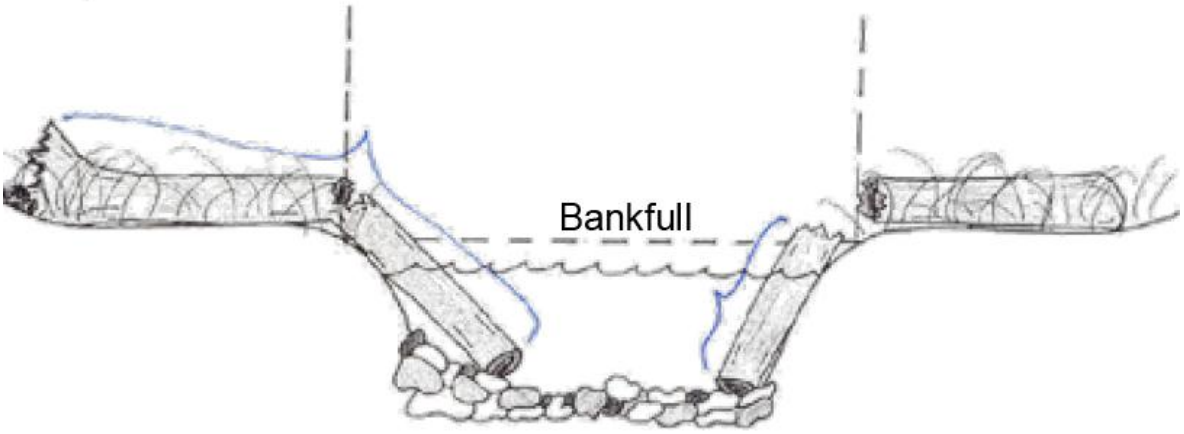


Figure 11. Example of how to measure the lengths of broken pieces. Measure length of entire piece shown on the left (pieces are still connected) and only measure the piece within bankfull channel of the pieces shown on the right (pieces disconnected).

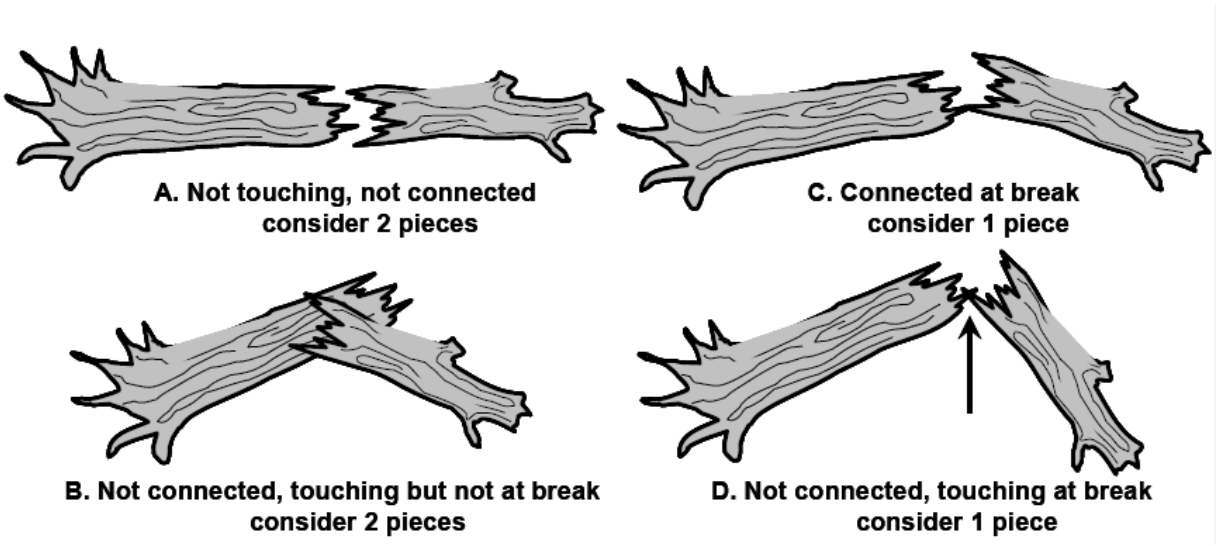


Figure 12. Variations that may be seen in how pieces may be touching vs. not touching along a break.

Step 1: Scan the stream segment between the two cross section Transects where Thalweg profile measurements are being made.

Step 2: Record the number of LWD pieces within the segment that meet the criteria above, and record the estimated length (nearest 10 cm) and estimated diameter (nearest cm) of all qualifying pieces in the reach. The same person will make all estimates for a given reach. Record the name of the estimator in the data form.

For each piece of LWD, determine the size class based on the diameter of the large end:

• 0.1 m < 0.3 m	[4 in < 12 in]	Small
• 0.3 m < 0.6 m	[12 in < 24 in]	Medium
• 0.6 m < 0.8 m	[24 in < 32 in]	Large
• > 0.8 m	[> 32 in]	X-Large

For each piece of LWD, also determine the size class based on the length of the piece:

• 1 m < 5.0 m	[5 ft. < 17 ft.]	Small
• 5.0 m < 15 m	[17 ft. < 50 ft.]	Medium
• > 15 m	[> 50 ft.]	Large

If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with circular cross section that would have the same volume.

When estimating length, include only the part of the LWD piece that has a diameter greater than 10 cm (4 in.).

Step 3: Measure the length (nearest 10 cm) and diameter (nearest cm) of the first 10 pieces beginning at the downstream end of the reach (Transect A). The person estimating should not be made aware of the measured value.

An additional subset of pieces will be measured at sites with more than 10 pieces.

a. For sites estimated to have between 11 and 100 pieces, measure the first ten pieces, then starting at the 11th piece only measure every 5th piece.

b. For sites estimated to have over 100 pieces, measure the first ten pieces, then starting at the 11th piece only measure every 10th piece.

Notes:

Measure the length of the main stem and not branches or roots. Begin measurements where the roots attach to the base of the stem when the roots are still connected.

Do not measure the length and/or diameter of standing dead trees, pieces buried in log jams, or other pieces that are unsafe to measure. If that piece was one that required measuring, record the estimated length/diameter and leave the measured length and/or diameter blank. Then measure the next required piece, maintaining established interval.

Begin counting from the bottom of the reach to the top of the reach, and from the bottom up when pieces are stacked on each other.

Large wood in isolated side channels, pools or depressions below bankfull elevation is not measured.

Step 4: Place a tally mark in the appropriate diameter X length class tally box in the "PIECES ALL/PART IN BANKFULL CHANNEL" section of the Thalweg Profile and Woody Debris Form.

Step 5: After all pieces within the segment have been tallied, write the total number of pieces for each diameter X length class in the small box at the lower right hand corner of each tally box.

Step 6: Repeat Steps 1 through 5 for the next stream segment, using the Large Woody Debris Measurement Form (Figure 13).

Large Woody Debris Measurement Form

Site ID _____ Station _____ Date _____ Year _____

Surveyors _____

LWD #	Length (m)	Diameter (m)	Estimated size class (diameter/length)
1			/
2			/
3			/
4			/
5			/
6			/
7			/
8			/
9			/
10			/
Every 5 or 10?			

Size Class – Diameter:

0.1 m < 0.3 m	[4 in < 12 in]	Small
0.3 m < 0.6 m	[12 in < 24 in]	Medium
0.6 m < 0.8 m	[24 in < 32 in]	Large
> 0.8 m	[> 32 in]	X-Large

Size Class – Length:

1 m < 5.0 m	[5 ft. < 17 ft.]	Small
5.0 m < 15 m	[17 ft. < 50 ft.]	Medium
> 15 m	[> 50 ft.]	Large

Comments:

Figure 13. Large Woody Debris Measurement Form

METHOD FOR CHARACTERIZING STREAM MORPHOLOGY, THALWEG PROFILE

Protocol taken from*: Peck et al. (2003), Table 7-3; Kauffman et al. (1999)*

PURPOSE

The Thalweg profile can detect changes in the stream morphology associated with habitat restoration projects designed to improve pool-riffle relationships, provide velocity changes and other structure that is beneficial as hiding and holding habitat for salmonids.

EQUIPMENT

Surveyor's telescoping rod (2-3 m long), 50 m measuring tape, laser range finder, meter stick, surveyor tape, bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms or digital data collection device

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

PROCEDURE

The Thalweg Profile is a longitudinal survey of depth, habitat class, presence of soft/small sediment deposits, and off-channel habitat at 100 equally spaced intervals (150 in streams less than 2.5 m wide) along the centerline between the two ends of the sampling reach. "Thalweg" refers to the flow path of the deepest water in a stream channel. Wetted width and bankfull width are measured and substrate size is evaluated at 21 equally spaced cross-sections (at 11 regular Transects A through K, plus 10 supplemental cross-sections spaced mid-way between each of these).

Step 1: Determine the interval between measurement stations based on the bankfull width used to determine the length of the sampling reach. For bankfull widths < 7.5 m, establish stations every 1 m. For bankfull widths of 7.5 m or greater, establish stations at increments equal to 0.01 times the sampling reach length.

For example, if the reach length is determined to be 300 meters, a measurement station will be located every 3 meters, which is equivalent to 0.01 times the total reach length.

Step 2: Complete the header information on the Thalweg Profile Form (Figure 14), noting the Transect pair (downstream to upstream). Record the interval distance determined in Step 1 in the "INCREMENT" field on the field data form.

NOTE: *If a side channel is present and contains between 16 and 49% of the total flow, establish secondary cross-section Transects as necessary. Use separate field data forms to record data for the*

side channel, designating each secondary Transect by checking both "X" and the associated primary Transect letter (e.g., XA, XB, etc.). Collect all channel and riparian cross-section measurements from the side channel.

Step 3: Begin at the downstream end (station "0") of the first Transect (Transect A).

Step 4: Measure the wetted width if you are at station 0, station 5 (if the stream width defining the reach length is 7.5 m or greater), or station 7 (if the stream width defining the reach length is < 7.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the wetted width on the field data form to the nearest 0.1 m for widths up to about 3 meters, and to the nearest 5% for widths > 3 m. This is 0.2 m for widths of 4 to 6 m, 0.3 m for widths of 7 to 8 m, and 0.5 m for widths of 9 or 10 m, and so on. For dry and intermittent streams, where no water is in the channel, record zero for wetted width.

NOTE: *If a mid-channel bar is present at a station where wetted width is measured, measure the bar width and record it on the field data form.*

Step 5: Measure bankfull width if you are at station 0, station 5 (if the stream width defining the reach length is 7.5 m or greater), or station 7 (if the stream width defining the reach length is < 7.5 m). Bankfull width is measured perpendicular to the stream channel and is measured to the nearest 0.1 meter. When local bankfull indicators are not present use the bankfull height to approximate bankfull. Bankfull height can be determined by measuring the vertical distance from the water's surface to the dominant bankfull elevation throughout the reach. When side channels are present, record the bankfull width of each channel individually. Record bankfull widths in the Bankfull Width Form (Figure 15).

Step 6: At station 5 or 7 (see above) classify the substrate particle size at the tip of your depth measuring rod at the left wetted margin and at positions 25%, 50%, 75%, and 100% (right wetted margin) of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections A through K, except that for these mid-way supplemental cross-sections, substrate size is entered on the Thalweg Profile side of the field form. For dry and intermittent streams, where no water is in the channel, use the bankfull width to determine locations at which to collect substrate information.

NOTE: *Collection of substrate data as described in Step 5 above is to be completed in conjunction with the "Method for Measuring Substrate" protocol. Together, these two data collection procedures produce the desired 105 particles used to evaluate substrate composition. Step 5 above should be implemented only if substrate is listed as an evaluation metric for the specified project class where the "Method for Measuring Substrate" protocol is also to be implemented (Channel Connectivity, Constrained Channel).*

Step 7: Identify bankfull using the following indicators:

1. Examine streambanks for an active floodplain. This is a relatively flat, depositional area that is commonly vegetated and above the current water level unless there is a large amount of spring runoff or there has been a substantial rain event (i.e. stream running at bankfull stage).

2. Examine depositional features such as point bars. The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage. However, depositional features can

form both above and below the bankfull elevation when unusual flows occur during years preceding the survey. Large floods can form bars that extend above bankfull whereas several years of low flows can result in bars forming below bankfull elevation.

3. A break in slope of the banks and/or change in the particle size distribution from coarser bed load particles to finer particles deposited during bank overflow conditions.

4. Define an elevation where mature key riparian woody vegetation exists. The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.

5. Examine the ceiling of undercut banks. This elevation is normally below the bankfull elevation.

6. Stream channels actively attempt to reform bankfull features such as floodplains after shifts or down cutting in the channel. Be careful not to confuse old floodplains and terraces with the present indicators.

Note that all six indicators may *not* be present. After you identify bankfull, measure the vertical distance from the water's surface to the dominant bankfull elevation measured throughout the reach. This vertical distance can be used when bankfull indicators are not present at a particular point along the streambank. Bankfull height is needed for streambank measurements, bankfull widths, pebble counts, large wood, and cross-sections.

Step 8: At each Thalweg Profile station, use a meter ruler or a calibrated pole or rod to locate the deepest point (the "thalweg"), which may not always be located at mid-channel. Measure the thalweg depth to the nearest cm, and record it on the Thalweg Profile form. Read the depth on the side of the ruler, rod, or pole to avoid inaccuracies due to the wave formed by the rod in moving water.

NOTE: *For dry and intermittent streams where no water is in the channel, record zero for depth.*

NOTE: *At stations where the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor's rod, calibrated rod, or pole at an angle to reach the thalweg. Determine the rod angle by resting the laser range finder on the upper surface of the rod and reading the angle on the external scale of the laser range finder. Leave the depth reading for the station blank, and record a "U" flag. Record the water level on the rod and the rod angle in the comments section of the field data form. For even deeper depths, it is possible to use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line and then toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the laser range finder exactly as done for the surveyor's rod.*

Step 9: At the point where the thalweg depth is determined, observe whether unconsolidated, loose ("soft") deposits of small diameter (<16 mm), sediments are present directly beneath your ruler, rod, or pole. Soft/small sediments are defined here as fine gravel, sand, silt, clay or muck readily apparent by "feeling" the bottom with the staff. Record the presence or absence in the "SOFT/SMALL SEDIMENT" field on the field data form.

NOTE: A thin coating of fine sediment or silty algae coating the surface of cobbles should not be considered soft/small sediment for this assessment. However, fine sediment coatings should be identified in the comments section of the field form when determining substrate size and type.

Step 10: Determine the channel unit code and pool forming element codes for the station. Record these on the field data form using the standard codes provided in Table 4. For dry and intermittent streams where no water is in the channel, record habitat type as dry channel (DR).

Table 4. Thalweg Channel and Pool Codes

POOL FORMING CODES		CHANNEL UNIT CODES	
N	Not a pool	PP	Pool, Plunge
W	Large Woody Debris	PT	Pool, Trench
R	Rootwad	PL	Pool, Lateral Scour
B	Boulder or Bedrock	PB	Pool, Backwater
F	Unknown, Fluvial	PD	Pool, Impoundment
		GL	Glide
	Combinations eg. WR, BR, WRB	RI	Riffle
		RA	Rapid
		CA	Cascade
		FA	Falls
		DR	Dry Channel

Source: Peck et. al (2003)

Step 11: If the station cross-section intersects a mid-channel bar, indicate the presence of the bar in the "BAR WIDTH" field on the field data form.

Step 12: Record the presence or absence of a side channel at the station's cross-section in the "SIDE CHANNEL" field on the field data form.

Step 13: Record the presence or absence of quiescent off-channel aquatic habitats, including sloughs, alcoves and backwater pools in the "BACKWATER" column of the field form.

Step 14: Proceed upstream to the next station and repeat Steps 4 through 13.

Step 15: Repeat Steps 4 through 14 until you reach the next Transect. At this point, complete Channel/Riparian measurements at the new Transect. Then prepare a new Thalweg Profile Form and repeat Steps 2 through 12 for each of the reach segments, until you reach the upstream end of the sampling reach (Transect "K").

THALWEG PROFILE FORM										
SITE NAME:						DATE:	VISIT: 1 2			
SITE ID:						TEAM ID:				
TRANSECT (X) A-B B-C C-D D-E E-F F-G G-H H-I I-J J-K										
THALWEG PROFILE							Increment (m)			
Station	Thalweg Depth cm (XXX)	Wetted Width (XX.X)	Bar Width		Soft/Small sediment (X for yes)	Channel Unit Code	Pool Form Code	Side Channel (X for yes)	Flag	Comments
			Y/N	(XX.X)						
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
TOTAL										
MEAN										
VAR										
SE										

Figure 14. Thalweg Profile Form

Bankfull Width Form			
Site ID _____ Station _____ Date _____ Year _____ Surveyors _____			
Transect	Station	Bankfull Width (m)	Comments
A	0		
A[1]	5		
B	0		
B[1]	5		
C	0		
C[1]	5		
D	0		
D[1]	5		
E	0		
E[1]	5		
F	0		
F[1]	5		
G	0		
G[1]	5		
H	0		
H[1]	5		
I	0		
I[1]	5		
J	0		
J[1]	5		
K	0		

Figure 15. Bankfull Width Form

METHOD FOR MEASURING SLOPE AND BEARING

Protocol taken from: ***Peck et al. (2003), Table 7-6; Kauffman et al. (1999)***

PURPOSE

Using the following methods, the water surface slope and bearing can be determined. These measures can be used to calculate residual pool depth. Residual pool volume is the amount of water that would remain in the pools if there were not flow and the pools were impermeable basins. The intent of measuring this parameter is to show the changes in cross sectional stream complexity typified by pools and riffles.

Slope and bearing are measured using two people by back-sighting downstream between Transects.

EQUIPMENT

Two surveyor's telescoping stadia rods, 50 m measuring tape, laser range finder, Abney hand level or clinometer, bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

PROCEDURE

Step 1: Stand in the center of the channel at the downstream cross-section Transect. Determine if you can see the center of the channel at the next cross-section Transect upstream without sighting across land, (i.e. do not short circuit a meander bend). If not, you will have to take supplementary slope and bearing measurements.

Step 2: Have one surveyor position a stadia rod at the water's edge (water surface level) at the downstream Transect (A). Level the stadia rod. The second surveyor shall proceed upstream to the next Transect (B) and similarly position the second stadia rod along the same bank at the waters edge. The second surveyor shall hold and level the Abney hand level (or clinometer) at a known elevation (instrument height) along the upstream stadia rod and shoot back to the downstream stadia rod (Figure 16). Determine the elevation change (cm) by reading the downstream stadia rod and subtracting the instrument height. Record numbers on Slope Measurement Form (Figure 17).

Step 3: Walk upstream to the next cross-section Transect and repeat Step 2. Continue this process through Transect K.

Step 4: With the laser range finder, site back downstream on your flagging at the downstream Transect. Read and record the percent slope in the Slope Measurement Form (Figure 17). Record the "PROPORTION" as 100%. In some cases where full line of sight is not available between Transects, it

may be necessary to measure elevation changes incrementally as line of sight allows within a given Transect. Incremental elevations should be summed for each Transect and recorded as indicated above.

Step 5: Stand in the middle of the channel at upstream Transect, and site back with your compass to the middle of the channel at the downstream Transect. Record the bearing (degrees) in the Slope Measurement Form (Figure 17). Note that bearing measurements should be taken at each primary Transect (A, B, C, etc) and at the supplemental measurement points.

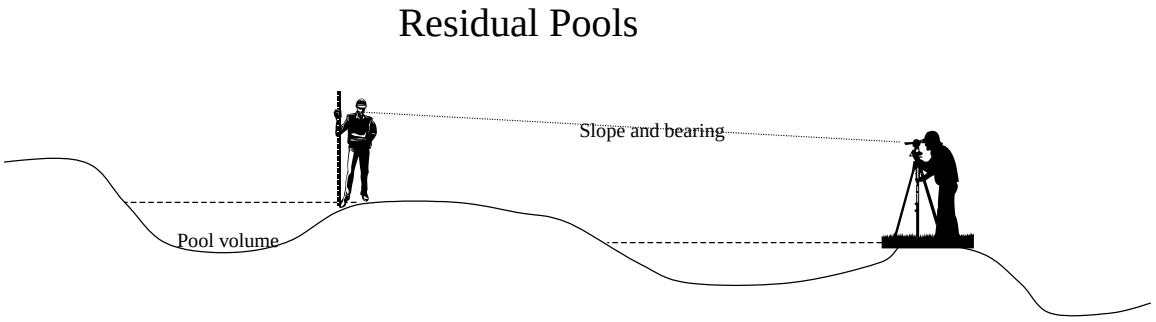


Figure 16. Measurement of Slope and Bearing

SLOPE MEASUREMENT FORM						
Site:		Station:				
Visit #:		Date:				
Transect	Direction	Upstream	Downstream	Distance (m)	Slope (%)	Comments
A-B Main						
A-B 1st Sup						
A-B 2nd Sup						
B-C Main						
B-C 1st Sup						
B-C 2nd Sup						
C-D Main						
C-D 1st Sup						
C-D 2nd Sup						
D-E Main						
D-E 1st Sup						
D-E 2nd Sup						
E-F Main						
E-F 1st Sup						
E-F 2nd Sup						
F-G Main						
F-G 1st Sup						
F-G 2nd Sup						
G-H Main						
G-H 1st Sup						
G-H 2nd Sup						
H-I Main						
H-I 1st Sup						
H-I 2nd Sup						
I-J Main						
I-J 1st Sup						
I-J 2nd Sup						
J-K Main						
J-K 1st Sup						
J-K 2nd Sup						

Figure 17. Slope Measurement Form

METHOD FOR MEASURING ACTIVELY ERODING STREAMBANKS

Protocol taken from: ***Moore et al. (1998)***

PURPOSE

This protocol will allow us to determine if the stream banks within the habitat restoration area have improved and thereby reduced siltation and erosion by reducing the percentage of the streambank that is actively eroding.

EQUIPMENT

Appropriate waterproof sampling form, waders or hip boots

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 13-15.

SAMPLING DURATION

Sampling should occur during summer low flow conditions, or when feasible at each project site.

PROCEDURE

Step 1: Estimate the percent of the lineal distance between each Transect (A – B, B – C, etc.) that is actively eroding at the active channel height. Active erosion is defined as recently actively eroding or collapsing banks and may have the following characteristics: exposed soils and inorganic material, evidence of tension cracks, active sloughing, or superficial vegetation that does not contribute to bank stability.

Step 2: Record estimated percent on the bank erosion form (Figure 18)

Transect	Left Bank	Right Bank
A-B		
B-C		
C-D		
D-E		
E-F		
F-G		
G-H		
H-I		
I-J		
J-K		
Total (sum left & right bank)		
Mean Percent erosion (total/20)		
Variance		

Figure 18. Bank erosion form (percent erosion)

METHOD FOR DETECTING FISH SPECIES ASSEMBLAGES USING BACKPACK ELECTROFISHING OR SNORKELING

Modified Protocol taken from: ***Peck et al. (2003) Table 12-2 and 12-5.***

PURPOSE

This protocol is designed to calculate an Index of Biological Integrity (IBI) for fish species found within the sampled study reach. The health of a stream in terms of fish can be determined by species composition and age class structures. The IBI will be used to compare the changes, if any, in the fish population structure over time.

EQUIPMENT

Use a backpack electrofisher consisting of an anode and cathode pole and capable of producing adjustable pulsed D.C. voltage up to 300 volts and an amp meter allowing adjustable amperage up to 1.5 amps. Determine that all team members are wearing waders and gloves, polarized sunglasses, and capture nets. The electrofisher should have automatic current switches in case the operator falls. The electrofisher should be equipped with an audio indicator when the unit is turned on and warning devices when voltage or current exceeds 300 volts or 1.5 amps. Appropriate capture nets and buckets should be available to capture and hold fish, watch or stopwatch, sample bottles, 10% formalin, labels, digital camera, appropriate waterproof field forms or electronic forms.

Persons conducting snorkel counts should be equipped with dry suits or wet suits, masks, snorkels, and rubber soled boots. Additional equipment such as hand counters, dive lights, and underwater white boards are helpful for enumerating fish. A 30 X 30 PVC quadrat, fish identification book/chart(s), measuring device, clear box (at least 3 inches tall), camera, and two aquarium nets are needed for the demersal fish survey. Waterproof forms or electronic forms are necessary for recording all fish counts.

SITE SELECTION

The sample reach is laid out according to procedures described on pages 13-15.

SAMPLING DURATION

Sampling for fish species should occur during the low flow period in late summer.

ELECTROFISHING SAMPLING PROCEDURES

Step 1: Be sure that all required collectors' permits and ESA clearances have been obtained before proceeding.

Step 2: Allocate the fishing time between all sampled A-K Transects within the stream reaches based on stream size and complexity.

Step 3: If conductivity, turbidity, or depth precludes backpack electrofishing, sample by snorkeling, seining, or otherwise, do not sample.

Step 4: Once the settings on the electrofisher have been set properly, begin sampling the reach and fish in an upstream direction. Sample available cut-bank and snag habitat as well. Be sure that deep, shallow, fast, slow, complex, and simple habitats are all sampled.

Step 5: Continue upstream until the next Transect is reached. Process fish and change water after each Transect to reduce mortality and track sampling effort.

Step 6: Complete Fish Index Form.

Step 7: Repeat steps 2-6 until Transect J-K is finished.

Step 8: Determine the species.

SNORKELING SAMPLING PROCEDURES

Step 1: Measure the water temperature and record the temperature in the Juvenile Fish Survey Form (Figure 19). Estimate visibility as low, medium, or high and record it in the field form. Begin at the downstream boundary of the control reach (Transect A) and proceed upstream through each Transect, ending at Transect K. In many smaller streams the riffle areas will be too shallow to snorkel and will contain mostly smaller young of the year trout species.

Step 2: A two person snorkeling crew can conduct snorkel surveys in wadeable stream control and impact study reaches. In areas where the stream is not wadeable, up to four snorkelers may be needed. In wadeable stream reaches, one crew member should snorkel each pool-riffle area while the other crew member records the counts as they are given by the snorkeler. In non-wadeable areas, crew members should snorkel side by side and sum their individual counts. Each snorkeler counts the fish to the immediate front and to the sides opposite the other snorkeler or as designated by the team leader to avoid duplication of counts.

Step 3: In all wadeable and most non-wadeable stream reaches, snorkeling should involve only a single pass through each Transect.

Step 4: All species of fish observed from one Transect to the next (A to B, B to C, etc.) should be enumerated, identified, and recorded (Fish Survey Form, Figure 9). Forklengths should be estimated to the nearest 5 mm. Continue proceeding upstream until the survey is completed at Transect K. Forklengths should be estimated to the nearest 5 mm.

Step 5: After snorkeling, the underwater visibility of each study reach is ranked on a scale of 0 to 3 where 0 = not snorkelable due to an extremely high amount of hiding cover or zero water visibility; 1 = high amount of hiding cover or poor water clarity; 2 = moderate amount of hiding cover or moderate water clarity, neither of which were thought to impede accurate fish counts; and 3 = little hiding cover and good water clarity.

Step 6: Only reaches with a visibility rank of two or three should be used in data analysis. Where possible, the proportion of trout estimated by sample snorkeling/electrofishing that was cutthroat and steelhead should be used to reclassify unknown trout as underwater determination of species is often impossible.

Step 7: Determine the reach area (m^2) by utilizing the data collected for each reach in Steps 1-6 of the Method for Measuring Wetted Width. Reach area is determined by multiplying the averaged wetted width by the reach length.

Step 8: For each study reach, the number of fish/m^2 can be calculated for each salmonid species by dividing the total number of fish counted for each species (Step 4). This would result in fish/m^2 for each species in the control reach and in the impact reach.

Step 9: Consult Thurow (1994) and Johnson et al. (2007) for additional information.

DEMERSAL FISH SURVEY PROCEDURES

Step 1: Begin at the downstream end of the stream reach, Transect A. Choose the left, right or center of the stream along the Transect. Randomly drop the quadrat at the chosen side of the Transect and have one person (data recorder) hold down the quadrat under water while the other person (snorkeler) places their head underwater to look in the area inside of the quadrat. The snorkeler looks for demersal fish inside of the quadrat, slowly turning over rocks as needed.

Step 2: When demersal fish are observed, the snorkeler uses the two aquarium nets to collect the demersal fish. The individual recording observations should fill the clear box with stream water, holding the container in near the water surface where the snorkeler can place the demersal fish from the nets into the container safely. The snorkeler and observation recorder continue this process of looking for demersal fish inside the quadrat and placing them safely, each in a separate container until no more demersal fish are found inside the quadrat.

Step 3: After no additional demersal fish are found inside of the quadrat, the snorkeler and observer should go to a stream bank to identify the demersal fish in the containers. Demersal fish should be identified, measured, enumerated, and photos taken (as needed), recording the information in a field form.

Step 4: Once all of the demersal fish have been identified and measured, they should be released in the same general area as collected.

Step 5: Repeat steps 1 through 4 until Transect K is complete.

FISH ID AND TALLY PROCEDURE

Step 1: Complete all header information accurately and completely. If no fish were collected, write "NONE COLLECTED" in the species column.

Step 2: Identify and process each individual completely, ideally handling it only once. Record the common name on the field form. If a species is unknown, assign it as "UNKNOWN" followed by its family name if known. Note the Transect where each species is collected.

Step 3: Process species listed as threatened and endangered first and return individuals immediately to the stream.

Step 4: Keep voucher specimens of unknown species for future identification. Using a digital camera photograph all other species as a voucher.

Step 5: Tally the number of individuals of each species collected in the "TALLY" box and record the total number in the TOTAL COUNT field.

Step 6: Measure the total body length of the largest and smallest individuals to provide a size range for the species. For salmon, trout, char, and sculpin measure all specimens and record in the "AGE CLASS FREQUENCY DISTRIBUTION" part of the field form.

Step 7: Examine each individual for external anomalies and tally those observed. Readily identified anomalies include missing organs (eye, fin), skeletal deformities, shortened operculum, eroded fins, irregular fin rays or scales, tumors, lesions, etc. After all species have been processed, record the total number of individuals with anomalies in the "ANOMALY COUNT" area of the form.

Step 8: Record the total number of mortalities due to electrofishing or handling on the form.

Step 9: Follow the appropriate procedure to prepare voucher specimens. Release all remaining individuals.

Step 10: For any line with a fish name, ensure that all spaces on that line are filled in with a number, even if it is zero.

Step 11: Repeat steps 2-10 for all other species.

JUVENILE FISH SURVEY FORM

Fish Survey	**Fish Species**				**Widths** (fish passage projects only):		
Project Type:	Chinook	CH	Rainbow	RB	1:	8:	15:
Site #:	Coho	CO	Bulltrout	BT	2:	9:	16:
Station:	Sockeye	SK	Brooktrout	BK	3:	10:	17:
Date:	Chum	CM	Sculpin	SC	4:	11:	18:
H_2O temp:	Steelhead	ST	Lamprey	LP	5:	12:	19:
Team:	Pink	PK	Dace	DC	6:	13:	20:
Visit:	Cutthroat	CT	Stickleback	SB	7:	14:	21:
Visibility:							

Transect	Bank	Snorkeler	Species	Number	Size	Comments

Figure 19. Juvenile Fish Survey Form

FISH IBI CALCULATION PROCEDURES

Step 1: Calculate the total number of fish species present and enter the number into the Fish IBI calculation table. Determine the score from the formulas provided below from Mebane et al. (2003) and enter it on the appropriate line.

Step 2: Repeat for each of the parameters measured.

Table 5. Fish IBI calculation table

IBI Parameter	*Total*	*IBI Score*
# native CW species		
% of sculpin individuals		
% of sensitive native individuals		
% of coldwater individuals		
% of tolerant individuals		
# of alien species		
% of common carp individuals		
CPUE of coldwater individuals		
% of individuals with anomalies		
# of selected salmonid age classes		
Total IBI Score		

SCORING CHARTS AND FORMULAS

Percent Coldwater Individuals

The score for percent coldwater species is calculated from the formula **y = 0.0143x** where y is the score and x is the percent coldwater individuals calculated from the field data. Coldwater species are those species normally occupying coldwater and will include non-native trouts, chars, and other species.

Percent Sensitive Native Individuals

The score for percent sensitive native individuals is calculated from the formula **$y = 0.014 + 0.039x – 5.38E – 4x^2 + 2.47E –6x^3$** where y is the score, x is the percent sensitive native individuals, and E is the natural log.

Percent Individuals with Anomalies

The score for percent individuals with anomalies is calculated from the formula **$y = e^{-0.69x}$** where y is the score, x is the percent individuals with anomalies expressed as a whole number not a decimal, and e is the natural log.

Number of Coldwater Native Species

The score for number of coldwater species is calculated from the formula **y = 0.33x** where y is the score and x is the percent coldwater individuals calculated from the field data. Coldwater species are those species normally occupying coldwater and will not include non-native trouts, chars, and other species.

Number of Selected Salmonid Age Classes

Ages	0	1	2	3	>3
Score	0	0.1	0.5	0.875	1

Percent Tolerant Individuals
The score for the percent of tolerant individuals is calculated from the formula

$$Y = (0.987 – 0.0065)/ 1 + (x/40.3)^{7.23} + 0.0065$$

Where y is the score and x is the percent tolerant individuals. Tolerant individuals are the proportion of fish that thrive in or tolerate poor quality physical and chemical habitat

Number of Alien Species

Number	0	1	2	3	>3
Score	1	0.5	0.25	0.0625	0

Percent Carp
The score for percent carp is calculated from the formula $y = e^{-0.69x}$ where y is the score, x is the percent carp expressed as a whole number not a decimal, and e is the natural log.

Catch Per Unit Effort (CPUE) of Coldwater Individuals
To calculate the score for the number of coldwater individuals captured per minute, the formula $Y = 0.0225 + 0.642x – 0.155x^2 + 0.0147x^3$ where y is the score and x is the CPUE.

PROCEDURES FOR PREPARING FISH VOUCHER SPECIMENS

Protocol taken from: *Peck et al., Table 12-6 (Only used if species cannot be identified)*

Step 1: Determine the voucher class of a species and the number of specimens to include in the voucher sample based upon the following guidelines. Process Class 1 species first.

Class 1 - State or federally listed species. Photograph and release immediately. Photographs should include (1) a card with the stream ID and (2) an object of known length with the specimen. If specimens have died, proceed to Step 2 and include them in the voucher sample. Flag the species with an “Fn” on the Collection Form and note it is a listed species in the comments section of the form.

Class 2 – Large, easily identified species or adults that are difficult to identify or species that are uncommon in that region. Preserve 1-2 small (<150mm total length) adult individuals per site plus 2-5 juveniles. If only large adults are collected, reserve smallest individuals until voucher procedure is complete and preserve only if space is available. Individuals with a total length > 160mm should be slit on the lower abdomen of the right side before placing them in the container. Photograph if considered too large for the jar or place in a bag on ice for freezing.

Class 3 - Small to moderate size fish or difficult to identify species (e.g. lampreys, juvenile salmonids, minnows, sculpin). Preserve up to 20 adults and juveniles (several per Transect). If fewer than 20 individuals are collected, voucher them all.

Step 2: Anesthetize voucher specimens in a bucket with two carbon dioxide tablets and a small volume of water, then transfer them to a nylon mesh bag. Tally, then record the number of individuals

included in the voucher sample in the “VOUCHERED COUNT” field for the species on the Collection form.

Step 3: Select a “FISH BAG” tag with the same ID number as the voucher sample jar. Record the tag number in the “TAG NO” field on the corresponding line for the species on the Collection Form. Place the tag into the mesh bag and seal. **This bagging, tagging, and recording is crucial, as it enables us to estimate species proportionate abundances in the assemblages even when one suspected species turns out to be multiple species.**

Step 4: Immediately place the bag into a container large enough to hold the voucher specimens loosely and half filled with 10% formalin. **Use additional jars if necessary to avoid close packing and bending of voucher specimens**.

Step 5: Repeat steps 1 through 4 for all species collected.

METHOD FOR DETERMINING MACROINVERTEBRATE SPECIES ASSEMBLAGES

PURPOSE

The health of a stream can be determined from the species of macroinvertebrates present. Some species of aquatic insects are very sensitive to water quality problems and others are affected by sedimentation or temperature. The purpose of this protocol is to provide for a standard method of measuring changes in the macroinvertebrate assemblages of streams acquired by the SRFB. A macro-invertebrate index (MMI) is calculated based upon previous studies and used to compare results against future measures at the same site and other sites.

EQUIPMENT

Modified kick net (D-Frame with 500 micro meter mesh) and 4 ft handle (Wildco # 425-C50), stop watch, plastic buckets (8-10 qt), sieve with 500 micro meter mesh openings. Forceps, wash bottle, spatula, spoon or scoop, funnel with large bore spout, sample jars, ethanol (95%), rubber gloves, cooler, composite benthic sample labels with preprinted ID numbers (barcodes), blank labels on waterproof paper for inside of jars, sample collection form, clear packing tape for sealing jars, plastic electrical tape, scissors, appropriate field forms.

SITE SELECTION

The sample reaches should be laid out according to on pages 13-15.

SAMPLING DURATION

Sampling should occur at the same time that other samples are taken from the stream reach for fish assemblages and for habitat measures.

PROCEDURE TO COLLECT KICK NET SAMPLES

Protocol modified from: *Peck et al. (2001) Table 11-3 and 11-4 Targeted Riffle Sample*

Step 1: Before sampling, survey the stream reach to estimate the total number (and area) of riffle habitat units contained in the defined stream reach. To be considered as a unit the area must be greater than 1 square foot.

A. Do not sample poorly represented habitats. If the reach contains less than 8 ft^2 of riffle macrohabitat, then do not collect a targeted riffle sample.

B. If the reach contains more than one distinct riffle macrohabitat unit but less than eight, allocate the eight sampling points among the units so as to spread the effort throughout the reach as much as possible. You may need to collect more than one kick sample from a given riffle unit.

C. If the number of riffle macrohabitat units is greater than eight, skip one or more habitat units at random as you work upstream, again attempting to spread the sampling points throughout the reach.

Step 2: Begin sampling at the most downstream riffle unit, and sample units as they are encountered to minimize instream disturbance.

Step 3: At each unit exclude "margin" habitats by constraining the potential sampling area. Margin habitats are edges, along the channel margins or upstream or downstream edges of the riffle macrohabitat unit. Define a core area for each riffle unit as the central portion, visually estimating a "buffer" strip circumscribing the identified unit. In some cases, the macrohabitat unit may be so small that it will not be feasible to define a core area and avoid and edge.

Step 4: Visually lay out the core area of the unit sampled into 9 equal quadrants (i.e., 3 x 3 grid). For each macrohabitat type, select a quadrant for sampling at random from the following list of locations (right and left are determined as you look downstream):

Lower right quadrant
Lower center quadrant
Lower left quadrant
Right center quadrant
Center quadrant
Left center quadrant
Upper right quadrant
Upper center quadrant
Upper left quadrant

Step 5: Beginning at the most downstream riffle unit within the sampling reach, locate the sampling point within the microhabitat as described in Steps 3 and 4.

Step 6: Attach the 4 ft handle to the kick net. Make sure that the handle is on tight or the net may become twisted in a strong current, causing the loss of part of the sample.

Step 7: With the net opening facing upstream, position the net quickly and securely on the stream bottom to eliminate gaps under the frame. Avoid large rocks that prevent the sampler from sealing properly on the stream bottom.

Step 8: Holding the net in position on the substrate, visually define a rectangular quadrant that is one net width wide and one net width long upstream of the net opening. The area within this quadrant is 0.09 m^2 (1 $ft.^2$). Alternatively place a wire frame of the correct dimensions in front of the net to help delineate the quadrant to be sampled.

Step 9: Hold the net in place with your knees. Check the quadrant for heavy organisms, such as mussels and snails. Remove these organisms from the substrate by hand and place them into the net. Pick up any loose rocks or other larger substrate particles in the quadrant. Use your hands or a small scrub brush to dislodge organisms so that they are washed into the net. Scrub all rocks that are golf ball

sized or larger and which are over halfway into the quadrant. Large rocks that are less than halfway into the quadrant are pushed aside. After scrubbing, place the substrate particles outside the quadrant.

Step 10: Keep holding the sampler securely in position. Start at the upstream end of the quadrant, vigorously kick the remaining finer substrate within the quadrant for 30 seconds (use a stopwatch).

Step 11: Pull the net out of the water. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. Avoid having any water or material enter the mouth of the net during this operation.

Step 12: Invert the net into a plastic bucket marked "TARGETED RIFFLE" and transfer the sample. Inspect the net for any residual organisms clinging to the net and deposit them into the bucket as well. Use forceps if necessary to remove organisms from the net. Carefully inspect any large objects (such as rocks, sticks, and leaves) in the bucket and wash any organisms found off the objects and into the bucket before discarding the object. Remove as much detritus as possible without losing organisms.

Step 13: Record the nearest Transect location in the box for the sample on the Sample Collection Form. Place an "X" in the appropriate substrate type box for the Transect on the Collection Form.

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

Step 14: Thoroughly rinse the net before proceeding to the next sampling location.

Step 15: Repeat steps 1-14 at subsequent riffle sampling points until 8 kick samples have been collected and placed in the "TARGETED RIFFLE" BUCKET.

PROCEDURE FOR PREPARING COMPOSITE SAMPLES FOR IDENTIFICATION

Protocol modified from: *Peck et al. (2001), Table 11-5*

Step 1: Pour the entire contents of the "TARGETED RIFFLE" bucket through a sieve with 500 micro-meter mesh. Remove any large objects and wash any clinging organisms back into the sieve before discarding.

Step 2: Using a wash bottle filled with stream water, rinse all organisms from the bucket into the sieve. This is the composite reach-wide sample for the site.

Step 3: Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample. Avoid using more than one jar for each composite sample.

Step 4: Fill in a "TARGETED RIFFLE" sample label with the stream ID and date of collection. Attach the completed label to the jar and cover it with a strip of clear packing tape.

Step 5: Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into the jar, using as little water from the wash bottle as possible. Use a large bore funnel if necessary. If the jar is too full, pour off some water through the sieve until the jar is not more than ¼ full, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use forceps to place them into the sample jar.

Step 6: Place a waterproof label with the following information inside each jar:

- Project number
- Worksite description
- Type of sampler and mesh size used
- Name of stream
- Date of collection
- Collector's name
- Number of Transects sampled composited

Step 7: Completely fill the jar with the 96% ethanol (no headspace) so that the final concentration of ethanol is between 75 and 90%. It is very important that sufficient ethanol be used, or the organisms will not be properly preserved.

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

Step 9: Store labeled composite samples in a container until transport to the laboratory.

MULTI-METRIC INDEX DEVELOPMENT

Protocol taken from: *Wiseman (2003), Tables 1, 8, and 9*

Step 1: Obtain results from laboratory analysis of species present in the REACHWIDE composite sample and their relative abundance.

Step 2: Determine the following metrics from the laboratory sample:

- Percent of the family Chironomidae of the total sample count
- Percent of the Orders Ephemeroptera, Plecoptera, and Trichoptera of the total sample count
- Percent of the Order Ephemeroptera of the total sample count
- Hilsenhoff Biotic Index (HBI) which is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals
- Total number of taxa
- Number of highly intolerant taxa, as defined by Wiseman (1998)

- Percent of clinger taxa of the total sample count
- Number of clinger taxa
- Number of intolerant taxa with a tolerance value less than 3 (TV3)
- Percent of the tolerant taxa of the total sample count with a tolerance value greater than 7 (TV7)
- Percent of the top 3 abundant taxa of the total sample count
- Percent of the filter taxa of the total sample count
- Percent of the predator taxa of the total sample count
- Percent of the scraper taxa of the total sample count
- Number of long-lived taxa

Step 3: Score each indicator based upon the following tables taken from Wiseman (2003).

Table 6. Scoring criteria for Puget lowland area MMI

		Scoring Criteria		
Category	**Metric**	**1**	**3**	**5**
Richness	Total richness	<24	24-33	>33
Richness	Ephemeroptera richness	<4	4-6	>6
Richness	Plecoptera richness	<3	3-5	>5
Richness	Trichoptera richness	<4	4-6	>6
Tolerance	Intolerant richness (bi)	<2	2	>2
Tolerance	% tolerant (TV7)	>19	11-19	<11
Tolerance	% top 3 abundant	>70	54-70	<54
Trophic/habitat	% predators	<11	11-19	>19
Trophic/habitat	% clingers	<26	26-47	>47
Voltinism	Long lived richness	<3	3-5	>5

Table 7. Scoring criteria for Cascade MMI

		Scoring Criteria		
Category	**Metric**	**1**	**3**	**5**
Composition	% Ephemeroptera	<35	35-57	>57
Richness	Total richness	<37	37-52	>52
Richness	Plecoptera richness	<5	5-9	>9
Richness	Trichoptera richness	<9	9-12	>12
Richness	Clinger richness	<12	12-16	>16
Tolerance	Intolerant richness (bi)	<6	6-9	>9
Tolerance	% tolerant (bi)	>23	12-23	<12
Tolerance	HBI	>3.8	2.8-3.8	<2.8
Trophic/habitat	% filterers	>28	15-28	<15
Trophic/habitat	% clingers	<36	36-54	>54

Scoring criteria for eastern Washington are under development by the Department of Ecology.

METHOD FOR DETERMINING UPLAND VEGETATION SPECIES DIVERSITY AND DENSITIES

Protocol provided by Joseph Arnett of Tetra Tech FW, Inc. with some procedures taken from: *USDI National Park Service Fire Monitoring Handbook (2003) Chapter 4 Monitoring Program Design Table 3, Table 4 and Figures 9-14; and Chapter 5 Vegetation Monitoring Protocols Tables 5-10 and Figures 15-20.*

PURPOSE

Many SRFB acquired lands contain significant areas of upland habitat that either were acquired in fee title or by easement to protect the downslope portion of the salmon bearing stream, or they were part of a parcel of land having significant riparian and instream habitat and the uplands were acquired as part of the parcel requirements. In either event, health of upland habitat should be maintained or improved where stream and riparian protection is a high priority. Upland areas contribute to erosion, landslides, high runoff and high stream temperatures. These protocols are intended to track forest cover, brush and grasslands species diversity, and density as a measure of their health and changes since the base year when purchased.

EQUIPMENT

Topographic maps, ESRI Arc View or ArcMap software with appropriate laptop or desktop computer, aerial orthophotographs, digital camera, compass, hand held GPS unit, engineering flagging tape, 2 ft. rebar stakes, hammer, numbered metal tags for plot identification, wire, wire cutters, clipboard and pencils, plastic bags for plant samples, plant identification guides, 50 meter tape, 10 meter DBH tape, aluminum nails, small gardening trowel, and appropriate waterproof field forms.

SITE SELECTION

Within acquisition project areas, plot locations in upland areas will be randomly located on Transects established within vegetation polygons that have been delineated on orthophotos in GIS format. While plots will be randomly located, Transects will be positioned to facilitate their relocation and to sample the range of vegetation present on the site. Data will be collected in these plots in accordance with the procedures described below.

SAMPLING DURATION

Sampling should occur during the late spring or summer when the majority of flowers are in bloom and when it is easiest to identify grasses and other kinds of ground cover. This time period may vary slightly from year to year depending on climatic factors. Sampling in succeeding years should occur at approximately the same stage of vegetation development.

PROCEDURE FOR DELINEATING VEGETATION POLYGONS

Step 1: Obtain orthophotographs of all acquisitions to be sampled.

Step 2: For each acquisition, delineate major vegetation polygons by visual inspection of the orthophotos in GIS format (Arc View or ArcMap). The level of resolution of this delineation depends on

the type of vegetation, but would, at a minimum, distinguish between forested, shrub steppe, and grassland communities, and within these vegetation types distinguish between stands that are visually distinct due to differences in stand age, level of disturbance, and dominant species. Forested polygons would not generally be expected to be smaller than five acres; herbaceous polygons might be much smaller, especially in emergent wetlands where boundaries between vegetation types may be distinguished at a much finer scale. Vegetation polygons in emergent wetlands are often distinct and based on dominance of a single species.

PROCEDURE FOR EVALUATING VEGETATION POLYGONS IN THE FIELD

Protocol adapted from: *Washington Natural Heritage Program*

Note: This procedure was originally developed to be applied to assessment of acquisitions for wildlife habitat, but is being used here to assess upland habitat conditions of acquisition projects.

Step 1: During the field survey, verify the boundaries of the vegetation polygons as delineated in GIS.

Step 2: Visually classify and assess the vegetation within the polygon using the Ecological Conditions Rating Table (Table 8) and the Polygon Condition form (Figure 20). Plant associations will be based on the best available classifications, including those developed by the Washington Natural Heritage Program or National Forests. If existing classifications are not applicable, the vegetation will be characterized by the dominant species in each vegetation layer. The source of the classification will be included in the data.

Step 3: During field examination, each polygon will be examined for its vegetation history, based on conditions in the field and augmented with information obtained from local land managers. Notes should be taken on:

- General character of the vegetation such as size (diameter at breast height (DBH)), height, dominant species, etc.,
- Remarks about the polygon as a whole, including information on the presence of noxious weeds, incidental observations of rare plants, wetlands, or other sensitive or unique features, and preliminary management recommendations.
- Information on management activities that have occurred.

Subjective ecological conditions will be assigned to plant associations based on the following table. The intent is to be able to compare conditions in each polygon over time (i.e., Are invasive species becoming dominant? Are native shrubs and grasses reestablishing?)

Table 8. Ecological Conditions Rating Table (Source: Washington Natural Heritage Program)

Rating	Description
A Excellent	Plant association is pristine, appears to have experienced little or no present or past disturbance by post-industrial humans, is a large stand, or exhibits exceptional species diversity.
B Good	Plant association is in good to very good condition. Species composition and diversity are within the range expected for the type.
C Moderate	Plant association is somewhat degraded or recovering. While species diversity is typically low, environment and species composition are similar to published source.
D Poor	Plant association is degraded by logging, grazing, development, or by non-native species, although it is still recognizable as a described community.
E Extirpated	Plant association is completely altered and unrecognizable. Non-natives dominate.

Polygon Condition Form		
Project:	Date:	Surveyors:
Polygon	Condition Class	Description

Figure 20. Polygon Condition Form

PROCEDURE FOR ESTABLISHING TRANSECT AND PLOT LOCATIONS

Step 1: In GIS format, or in the field using aerial photographs for reference, establish Transects within the acquisition parcel and determine geographical coordinates of the endpoints of each Transect. These Transects will be termed **"**baseline Transects" and their positioning and length will be determined on a site-by-site basis. The precise location of these Transects may be adjusted as they are established in the field, based on the characteristics of the terrain and vegetation. Transects need not be established in all vegetation polygons, but must be established in all major vegetation types. Install a steel rebar stake at the Transect origin. To facilitate relocating the origin stake, metal identification tags may be attached with aluminum nails at eye level to adjacent trees, if such trees are present, facing the origin stake. The origin stake will be permanently labeled with a metal or plastic cap on the upper end of the rebar. Ability to relocate Transect origins is of primary importance, and the location of endpoints may be modified based on landmarks in the field to facilitate relocation. For example, prominent outcrops of trees may be used to mark endpoints. Record GPS coordinates of origin stakes and end points of Transects, along with datum used, and include notes and a sketch map on the data sheets to facilitate relocation in the field.
`

After the first field visit, modify the Transects in GIS to conform with Transects as they are actually established on the ground, and include a sketch map of the Transect layout on the Transect Plot Data Sheet. Sampling plots will be randomly located on these Transects. Prior to collecting plot data, record the locations of boundaries between major vegetation types by GPS coordinates and in distance along the Transect from the Transect origin.

For the purpose of characterizing vegetation within polygons, locate plots in homogeneous areas, away from ecotones. If the **baseline Transect** is located entirely within a vegetation polygon, select plots from the entire Transect. See Transect A in Figure 21. If the baseline Transect extends across polygon boundaries, select plots from the portion of the Transect within an individual polygon. If the baseline Transect crosses narrow vegetation bands, as in Transect B in Figure 21, in some cases it may be necessary to establish lateral Transects extending off the baseline in order to obtain the required number of random plots. If lateral Transects are required, stake and record them in the same manner as the baseline Transects. Establish plots by first randomly locating **Transect segment starting points** at a minimum interval of 10 meters along the baseline Transects. Select five Transect segment starting points in each major vegetation type (grassland, shrubland, forest). If there are pronounced differences within a major vegetation type, additional segments may be selected to sample the range of vegetation. Locate Transect segment starting points by distance from the origin point along the baseline or lateral Transect. On uneven ground it may help to permanently mark segment starting points in the same manner as Transect origin points, with rebar stakes and metal tags, but generally distance along the Transect will give a precise location. Locate plots in reference to these Transect segment starting points, depending on the type of vegetation, as described below.

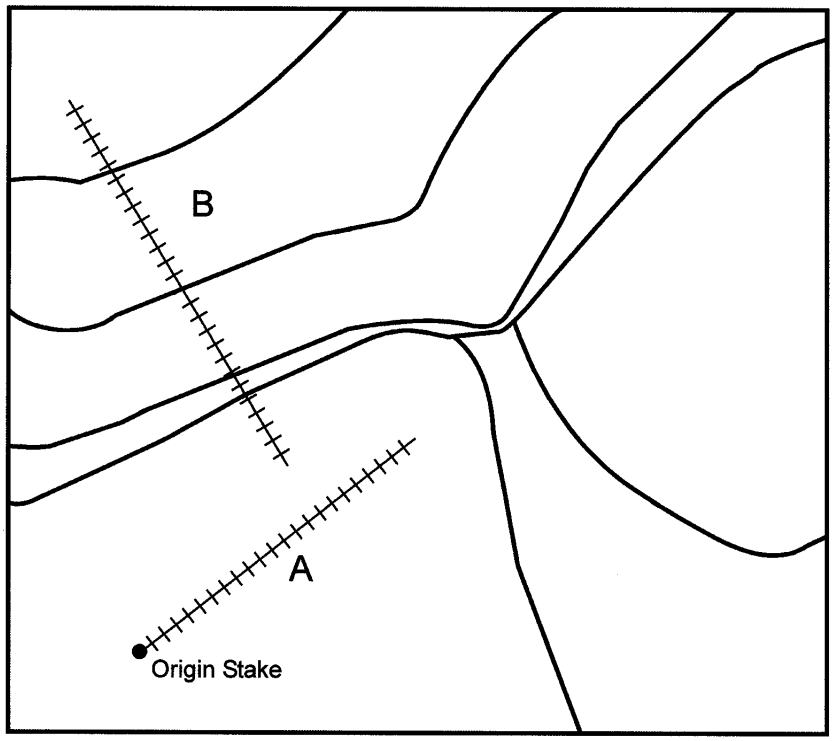


Figure 21. Diagrammatic Vegetation Polygons Showing Transect Locations.

Step 2: If the area surveyed is grassland, proceed with Step 3. If the area surveyed is sagebrush, steppe, or other shrubland, proceed to Step 8. If the area surveyed is forested, proceed to Step 12. If a project area includes two or more vegetative types, locate each Transect segment to lie within a single vegetation type.

GRASSLAND PLOTS

Step 3: Establish plots as ten 1-meter segments of the baseline Transect extending beyond each designated Transect segment starting point (Figure 22).

Step 4: Measure the outer boundary of the Transect segment using the meter tape. The Transect segment starting point has been established and marked in Step 1 above.

Step 5: Depending on the visibility and the vegetation, take a photo of the Transect segment from a lateral view, or other feasible point of view, to obtain a community-wide view of change over time.

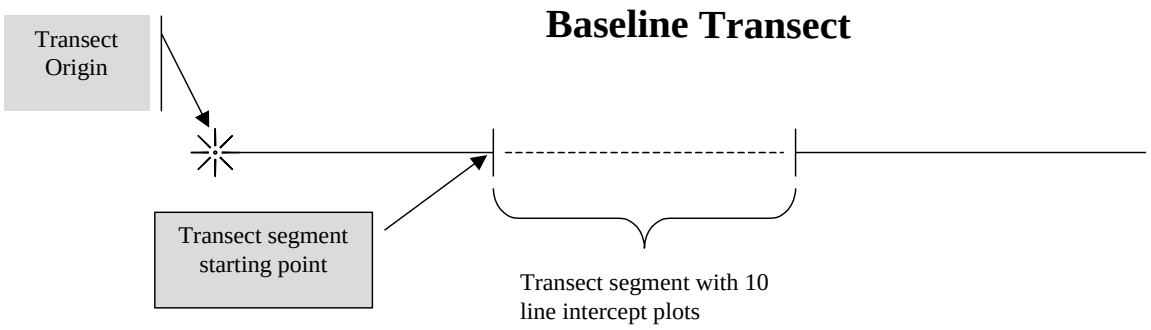


Figure 22. Establishing a Transect Segment

Step 6: On the Transect plot data sheet (Figure 23), record each species that touches the line and measure in centimeters the extent of the species intersection with the line. Record the substrate (bare soil, mosses, lichens, rock, forest litter, basal area, etc.). These values should add up to 100 percent. Basal area is the area of the cross section of living plants (i.e., if all plants were compressed together, how many centimeters that would cover). Record average height by vegetation type within each plot.

Step 7: Repeat Steps 3-6 for each grassland Transect segment sampled.

SHRUB PLOTS

Step 8: Establish Transect segment starting points (Figure 22). As described above for grassland plots, each Transect segment starting point will be a random point that has been established along the baseline Transect, at minimum intervals of 10 meters. Establish ten 1-meter plots on each Transect segment, extending for 10 meters beyond each designated Transect segment starting point. If practical, run the tape along the ground. However, if the shrubs are tall and fairly continuous, it may be necessary

to string the tape at an elevated location through the stems. Record the method of stringing the tape so future monitors can replicate your work.

Step 9: Depending on the visibility and the vegetation, take a photo of the Transect segment from a lateral view, or other feasible point of view, to obtain a community-wide view of the vegetation, with the intention of recording change over time.

Step 10: On the Transect plot data sheet (Figure 23), record each species that touches each 1-meter Transect segment plot and measure in centimeters the extent of the species intersection with the line. Large overstory trees should be included in this (i.e., look up at each Transect plot and estimate coverage by trees). Record the substrate (bare soil, rock, mosses, lichens, forest litter, basal area, etc.). These values should add up to 100 percent. Basal area is the area of the cross section of living plants (i.e., if all plants were compressed together, how many centimeters that would cover). Record average height by vegetation type within each plot.

Step 11: Repeat Steps 8-10 for each shrubland Transect segment sampled.

TRANSECT PLOT DATA SHEET		Date:							
Surveyors:		Project:		Transect Bearing:					
Site-ID:		Transect #		Deg	Min	Sec			
Origin Stake GPS Coordinates or Forested Plot Centerpoint , Latitude):									
Origin Stake GPS Coordinates or Forested Plot Centerpoint , Latitude):									
Transect Segment Starting Point GPS Latitude (dms):									
Transect Segment Starting Point GPS Longitude (dms):									
Transect Segment Starting Point (in meters from the Origin Stake):									
species	Plot Number								
	1	2	3	4	5	6	7	8	9	10
Basal Area										
Litter										
Bare ground										
Moss/lichen cover										
Avg height shrubs (cm)										
Avg height herbs (cm)										

Note: Basal Area, Litter, Bare Ground, and Moss/Lichen should add to 100 percent.

Notes:

Figure 23. Herbaceous and Shrub Transect data sheet

Forest Plots

Protocol adapted from: ***New Zealand National Vegetation Survey (2004); Greening Australia Federation (2004); Wishnie et al. (1999)***

Step 12: Establish a 1/10 acre circular plot centered over each Transect segment starting point. These points have been established and marked in Step 1 above. Permanently mark the center of each forested plot by installing a 0.5" rebar stake, and marking it with a metal identification tag.

Step 13: Measure out 37.2 feet in all directions from the center stake. For each plot, record the following data on the Forest Plot Data Sheet (Figure 24):

a. Project site, plot number, and date.
b. Tree species.
c. Height or diameter at-breast height (DBH), 4.5 feet from the ground, of each tree by the following size classes. Basal area (square feet per acre) and stem density (number per acre) will be calculated from this plot data. Trees less than 4.5 feet tall will be recorded as seedlings and will not be included in the calculation of stems per acre.

DBH

1) 0.0" – 2.5"
2) 2.6" – 5.0"
3) 5.1" – 10.0"
4) 10.1" – 15.0"
5) 15.1" – 20.0"
6) 20.1" – 30.0"

Step 14: Record on the Transect Plot Datasheet (Figure 23) shrub and herbaceous species in each of the ten one-meter plots following the Transect segment starting point, as described above in the protocol for grasslands, Steps 3-7.

Step 15: Repeat Steps 3-7 (for grasslands), 8-11 (for shrublands), and 12-14 (for forested stands) in year 3, 6, 9, and 12.

Forest Plot Data Sheet					Plot Number: (transect/plot center)		
Project:					Date:		
Surveyors:					Transect #:	Transect Heading:	
GPS Datum:					Center Stake GPS Coordinates:		
Plot Center (meters from the Origin):					Slope (%):	Aspect (degrees):	
Tree Species	seedlings (< 4.5' tall)	tree size class (dbh in inches)					
		< 2.5	2.6 - 5.0	5.1 - 10.0	10.1 - 15.0	15.1 - 20.0	20.1 - 30.0

Figure 24. Forest Plot Data Sheet

METHOD FOR DETERMINING INTERTIDAL CONDITIONS

Protocol provided by: ***Joseph Arnett of Tetra Tech FW, Inc. with parameters taken from NOAA Coastal Ocean Program "Science Based Restoration Monitoring Of Coastal Habitats"***

PURPOSE

Many SRFB acquired lands contain significant areas of intertidal habitat that either were acquired in fee title or by easement to protect the marine portion of the estuary where juvenile salmon reside. These protocols are intended to track marine vegetation in the form of marine algae and rooted vascular plants in terms of species diversity, and density as a measure of their health and changes since the base year when purchased. Beach slope and percent fines will also be monitored as indicators of changes in beach physical conditions.

EQUIPMENT

Topographic maps, ESRI Arc View or ArcMap software with appropriate laptop or desktop computer, aerial orthophotographs (taken at low tide, if available) digital camera, tripod, compass, hand held GPS unit, engineering flagging tape, 2 ft. rebar stakes, forestry marking paint, magnetic field locator for surveys in years subsequent to the initial layout, plot identification tags, wire, clipboard and pencils, standard plant press, containers for plant samples, plant identification guides, 50 meter tape, small gardening trowel, tally meter, 2 stadia rods, clinometer or Abney hand level, and appropriate waterproof field forms.

SAMPLING DURATION

Sampling should occur during the summer when the majority of estuarine and marine rooted vascular plants are in full growth and when the tide is at a minus stage. This time period may change from year to year depending on tides. Surveys should be timed to be conducted during low tide.

PROCEDURE FOR DELINEATING INTERTIDAL VEGETATION POLYGONS

Step 1: Obtain orthophotographs of all marine acquisitions to be sampled.

Step 2: For each acquisition delineate major vegetation polygons in the intertidal zone by visual inspection of the orthophotos in GIS format (Arc View or ArcMap). The level of resolution of this delineation depends on the type of vegetation, but would, at a minimum, distinguish between algae, cordgrass, kelp, and eelgrass communities. Vegetation polygons in the estuarine environment are often distinct and based on dominance of a single species.

PROCEDURE FOR EVALUATING INTERTIDAL VEGETATION POLYGONS IN THE FIELD

Step 1: During the field survey verify the boundaries of the intertidal polygons as delineated in GIS.

Step 2: Classify and assess the vegetation within the polygon using the Ecological Conditions Rating Table (Table 7) and the Polygon Condition form (Figure 20).

Step 3: During field examination intertidal polygons will be examined for vegetation and intertidal habitat history, based on conditions in the field and augmented with information obtained from local land managers, if available.

Step 4: The following information will be recorded for intertidal polygons on Polygon Condition Forms (Figure 20) for each of the identified polygons:

- General character of the vegetation/habitats such as cover of algae, kelp, and eel grass; dominant species, etc.
- Substrate conditions (i.e. fines, cobbles)
- Remarks about the polygon as a whole, including information on the presence of noxious weeds, incidental observations of rare plants or other sensitive or unique features
- Information on management activities that have occurred if known

PROCEDURE FOR ESTABLISHING TRANSECT AND PLOT LOCATIONS

Step 1: In GIS format, establish Transects perpendicular to the slope, extending from the upper limits of vegetation influenced by extreme high water across the intertidal zone to the level of mean low tide or low water. Determine geographical coordinates of the Transect origin and endpoint of each Transect. Measure slope between origin and endpoint of Transect. These Transects will be termed **"intertidal Transects"** and their positioning will be determined on a site-by-site basis.
On the Transect Record Form for Intertidal Transects (Figure 26) record the:

- Length of the intertidal transect
- Slope of the intertidal zone
- Linear extent of vascular plants along the intertidal Transect
- Linear extent of algae, kelp, cordgrass, and eelgrass along the intertidal Transect
- Linear extent and type of substrate (i.e. fines, gravel etc.) present along the intertidal Transect.

Step 2: For the purpose of characterizing intertidal vegetation within the area of influence of extreme high water, **"Transect segments"** will be randomly located in homogenous vegetation polygons along the Intertidal Transects. If vegetation polygons are too narrow to allow an adequate number of 10-meter Transect segments within homogenous areas, **"lateral Transects"** may be established parallel to the polygon boundaries, as illustrated in Figure 25. Install a steel rebar stake at the Transect origin. To facilitate relocating the origin stake metal identification tags may be attached with aluminum nails to adjacent trees, if such trees are present, facing the origin stake. The origin stake will be permanently labeled with a metal or plastic cap on the upper end of the stake and a metal identification tag at ground level. Ability to relocate Transect origins is of primary importance. GPS coordinates of Transect origin and Transect segment starting points will be recorded, along with datum used. The number of segments along the baseline Transects will depend on the variation within the vegetation, but an average of 5 Transect segments within each major vegetation type at each project area is anticipated. Prior to sampling within Transect segments, record the locations of boundaries of major changes in vegetation

along baseline Transects. Include boundaries between vegetation and bare ground and between substrate classes. Record boundaries by distance along the Transect from the origin point and by recording GPS coordinates.

Step 2: Each Transect segment starting point will be a random point that has been established along the baseline Transect, at minimum intervals of 10 meters (Figure 25). Ten plots will be established on each Transect segment, extending for 10 meters beyond each designated Transect segment starting point.

Step 3: Mark the Transect segment dimensions by installing 0.5 inch rebar stakes at the segment starting point and at 10 meters along each Transect segment (end point). Burial of the origin stake is recommended to avoid vandalism.

Step 4: Color code Transect segment beginning and ending stakes (orange for origin point and blue for end point) with forestry marking paints. Install permanent Transect segment identification tags on each stake.

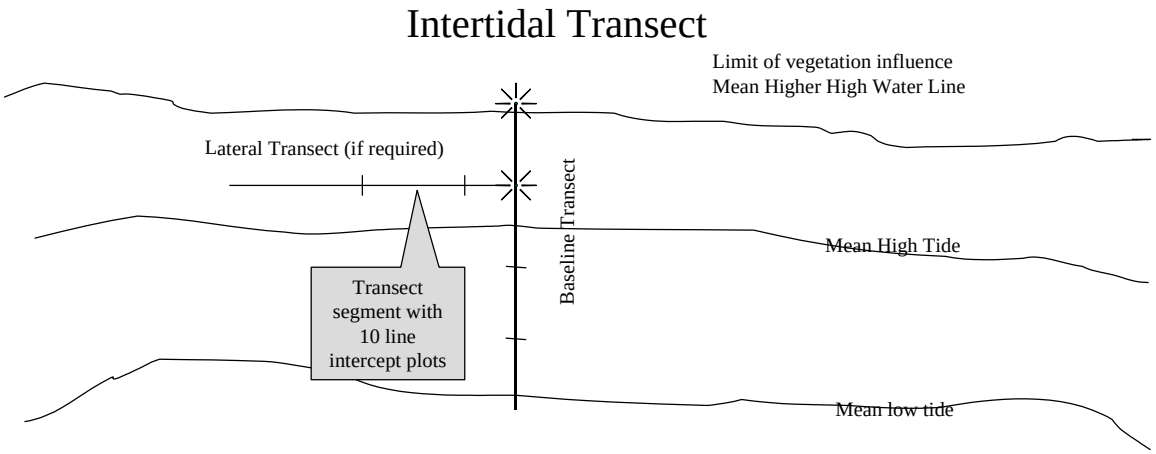


Figure 25. Establishing an Intertidal Transect

Step 5: Within each 1-meter plot, record each species that touches the Transect segment line and enter the information on the Transect Plot Data Sheet (Figure 23). Record the species from the tallest to the shortest. For portions of plots devoid of vegetation, record the substrate as fines, sand, or gravel. Average height by vegetation type will be recorded within each plot.

TRANSECT RECORD FORM FOR INTERTIDAL TRANSECTS

Project:	**Transect #**	**Date:**
The purpose of this form is to document the extent of major vegetation types or substrates along a transect and to spatially locate the boundaries between them. Other pronounced features (such as fences, streams, or trails) may also recorded here as reference points. GPS coordinates need not be recorded for each boundary. For estuarine sites include substrates and the locations of the mean high and low tide lines.		
Surveyors:		**GPS Datum:**
Origin GPS Coordinates:		
Transect Bearing:		**Origin Tag #**
Percent slope between mean high tide and mean low tide or low water:		
Length of Intertidal Transect:		
Starting point (i.e. distance from the transect origin in meters) of vegetation type, substrate or other feature	Vegetation type, substrate, or other feature (i.e. herbaceous, algae, fines)	Total length along transect of vegetation type, substrate or other feature
Make a diagram of the transect here, including a north arrow and prominent reference features:		

Figure 26. Transect Record Form for Intertidal Transects

SUMMARY STATISTICS

After field data collection, the data are uploaded into an MS Access® database which then computes summary statistics to reflect habitat conditions at the reach scale. These summary statistics were generally developed as part of the EPA EMAP and were selected for this program based on their high signal to noise ratios as compared to other potential summary variables. The following variables are reported for Habitat Protection Projects.

GPS Coordinates
The GPS coordinates taken at Transect A and Transect K in each reach. These response variables are the GPS coordinates in Degrees, Minutes, Seconds, which are entered into the stream verification form onsite.

Sample Date
This is the date that the reach was surveyed, which is entered into the stream verification form onsite.

Reach Length
Reach length is measured onsite as the distance between the start and end of a reach, or calculated as forty times the average wetted width of the stream. The reach length is determined for both the impact and control reaches, as described in the Method For Laying Out Control And Impact Stream Reaches For Wadeable Streams. The Reach Length variable is simply reported as this measurement or calculated distance.

Reach Width
Reach width is calculated as the average wetted width of the reach. A measurement of wetted with is taken at each Transect in meters and entered into the Physical Habitat form. Wetted width and bar width are measured at station 5, between each Transect, in meters during the thalweg profile. Each of the 11 wetted width measurements from the physical habitat form and the 10 measurements of wetted width from the thalweg profile (the width used from the thalweg profile is defined as the wetted width minus the bar width) are summed and divided by the number of measurements to come up with the average wetted width, which is Reach Width, in meters.

Log10 of Volume of LWD
This is a measure of the volume of large woody debris (LWD) of all sizes within the study reach. At each Transect a count of LWD that fall into various classes of diameter and length is taken. The are four classes of diameter and three of length, and each class is assigned a minimum value in meters to use in calculating a nominal volume. The classes and values are:

Diameter class	Class minimum diameter (Meters)
Small	0.1
Medium	0.3
Large	0.6
Extra Large	0.8

Length Class	Class minimum length (meters)
Small	1.5
Medium	5
Large	15

The volume of each piece of LWD is estimated by the standard formula for volume of a cylinder, which is the area of the base (pi times the radius squared) times the length. The values used for radius and length are the class minimum diameter and class minimum length from the tables above. In addition the calculated area of the base and length are multiplied by 1.33 to account for the average piece of LWD falling somewhere between the minimum length and diameter of its class and the next largest class. For example the volume of a piece of LWD that was determined to be Large Diameter, Medium Length would be:

PI * (1.33 * (cmd/2)^2) * (1.33 * cml) = 2.5 cubic meters where cmd = 0.6 and cml = 5 from the above tables.

The nominal volume of each piece of LWD is calculated in this way and then the total nominal volume is the sum of all the pieces, which is called VIW. V1WM100 is VIW times 100, divided by the reach length (Reach Length from above). The final response indicator, Log10 of Volume of LWD is the base 10 logarithm of V1WM100.

Mean Residual Pool Vertical Profile Area

The mean residual pool vertical profile area is the calculation of an accumulation of areas over the course of the reach. The input data includes the thalweg depths of the channel, taken at 10 stations dived equally between Transects, the slope of the reach, and the increment which is the distance between stations. At each station we calculate a residual pool profile area, and we accumulate those areas to determine Mean Residual Pool Vertical Profile Area in meters squared per reach. The calculations used to determine Mean Residual Pool Vertical Profile Area are derived from the EPA EMAP program and additional information may be obtained from Phil Kauffman of the EPA.

Mean Residual Pool Area

Mean Residual Pool Area is also referred to as the mean residual depth, and is derived directly from the Mean Residual Pool Vertical Profile Area calculation performed above. It is simply the Mean Residual Pool Vertical Profile Area divided by the total length in meters of the reach, and then multiplied by 100 to get a residual depth in centimeters. The calculations used to determine Mean Residual Pool Area are derived from the EPA EMAP program and additional information may be obtained from Phil Kauffman of the EPA.

Percent Fines

Percent fines is calculated using the 105 measurements of substrate class that are collected at each main transect and intermediate transect through the reach. The total number of classes for with the code FN (fine sediment) is selected is divided by the total number of sediment class measurements made. The proportion is converted to a percentage and is reported as percent fines.

Percent Embeddedness

Percent embeddedness is calculated as the average of all the embeddedness estimates for the entire reach

Canopy Cover

This is the mean percent canopy density at the bank, based on densiometer readings at the left and right banks. We collect a measurement from a densiometer at locations near the right and left banks of each transect in the reach. The reading is a value between 0 and 17, with 0 indicating no canopy density

whatsoever and 17 reading 100 percent canopy density. The final variable takes each measurement read from each transect, both left and right, and calculates the mean.

Riparian Vegetation Structure

Riparian Vegetation Structure is the proportion of the reach containing all 3 layers of riparian vegetation: canopy cover, understory and ground cover. Each of the three layers of riparian vegetation is defined by two constituent layers, and we count a layer as containing riparian vegetation if either of its two constituents are present. The constituents for canopy cover are small trees and big trees. Understory is broken into woody understory, and non-woody understory, and ground cover is broken into woody ground cover and non-woody ground cover. At each transect a value is recorded for all six constituents at each bank, so for instance a value is recorded for big trees on the left bank and big trees on the right bank at each transect. The values are integers from 0 to 4, representing percentage ranges. A 0 means no presence whatsoever, 1 means less than 10 percent, 2 means 10-40 percent, 3 is 40-75 percent, and 4 is greater than 75 percent.

The calculation is the percentage of the 22 possible locations in the reach that have each of the three layers of riparian vegetation present. We treat the right and left banks separately to come up with the 22 possible locations (the right and left banks for each of the 11 transects.) Since presence of a layer is shown if either of its constituents are present, we start the calculation by looking at the canopy cover, and if the value for big trees OR the value for small trees is 1 or greater, then we count that location to have canopy cover present. In a similar way we judge understory and ground cover and if the location has all 3 layers present we contribute that location to the percentage of the full 22 locations in the reach.

Bank Erosion

Bank erosion is a measure of the proportion of the reach containing actively eroding stream banks. At each transect we collect an estimation in percent (0-100) at the left and right banks. The variable Bank Erosion is the mean of all the measurements, right and left banks combined.

Non-native Shrub Cover

Non-native shrub cover is a measure of the percent cover of non-native shrub species present in upland habitats. Cover of non-native shrubs is measured in plots located along permanent baseline Transects established in upland habitat. Along each Transect there are five randomly located transect segments each consisting of ten one meter linear plots (See Figures 21 and 22, p. 63 -64). During sampling, the length of all vascular plant species observed in each linear one meter plot is recorded in centimeters. This represents the percent cover of each species in each plot. To calculate absolute percent cover of non-native shrub species, the lengths of all non-native shrub species in all plots along a Transect are summed. This sum is then divided by the total distance (length) covered by all plots along a Transect.

$$\text{Average \% cover} = \frac{\text{Total length of all non-native shrub species in all plots along a Transect}}{\text{Total length of ground covered by all plots along a Transect}}$$

Relative percent cover represents the proportion of cover of non-native shrub species in relation to cover of all vascular plant species. To calculate relative percent cover of non-native shrubs, the lengths of all non-native shrubs in all plots along a Transect are summed. This number is then divided by the sum of the length of all vascular plant species in all plots along this Transect.

$$\text{Relative \% cover} = \text{Total length of all non-native shrub species in all plots along a Transect}$$

Total length of all vascular plant species in all plots along a Transect

If a site has more than one upland Transect, the absolute and relative percent cover of non-native shrub species are calculated separately for each transect. A single reporting value for each parameter is derived by averaging the absolute and relative percent cover of non-native shrub species in each Transect. Values reported, beginning in the 2008 report, are absolute percent cover of non-native shrubs (SHRUB_NN_ABS) and relative percent cover of non-native shrubs (SHRUB_NN_REL).

Coniferous Basal Area

This is the basal area per acre (square feet/acre) of conifers present in upland habitats. This statistic is calculated by measuring the diameter at breast height (DBH) of each conifer present in forest plots. There are typically five 1/10 acre circular forest plots per Transect (thus forest plots along each Transect typically cover ½ acre). Each forest plot is centered over a randomly selected point along the Transect. Each tree observed in forest plots is placed into a size class based on DBH measurement:

0.0" – 2.5"
2.6" – 5.0"
5.1" – 10.0"
10.1" – 15.0"
15.1" – 20.0"
20.1" – 25.0"
>25.0"

The number of coniferous trees in each DBH size class is then summed. To convert from DBH to basal area, the sum of the number of coniferous trees in each DBH size class is multiplied by the following conversion factors:

0.0" – 2.5" = 0.0085
2.6" – 5.0" = 0.079
5.1" – 10.0" = 0.311
10.1" – 15.0" = 0.859
15.0" – 20.0" = 1.680
20.1" – 30.0" = 3.422

The conversion factor represents the basal area associated with the mean value in the size class. The total basal area for each size class in each plot per Transect is then summed to provide the total basal area of conifers in forest plots along a Transect. This number is then converted to square feet per acre based on the number of forest plots surveyed. For example, if a site has one Transect with five forest plots the sum of basal area in forest plots will represent basal area (in square feet) per ½ acre and this number will be multiplied by 2 to determine the basal area (in square feet) per acre. If a site has two Transects with five forest plots each the summation of basal areas in all plots along the two Transects will already represent square feet/acre. If there are three transects with five plots each, the sum would need to be divided by 1.5 acres (the total area of all the transects) to get basal area per acre.

Coniferous Density

Coniferous density is the stem count of coniferous trees per acre. This variable is measured by counting the number of coniferous trees present in permanent forest plots located along Transects in upland habitat. Each circular forest plot is 1/10 acre and each Transect typically has five forest plots (thus, forest plots along a Transect would cover ½ acre). The number of conifers found in all forest plots along each

Transect is summed. This number is then converted to square feet per acre based on the number of forest plots surveyed. For example, if a project site has two Transects with five forest plots each a simple count of the number of coniferous trees found in the ten plots along these two Transects is an estimate of coniferous trees per acre. If there is only one Transect with five plots at a site; however, the number of coniferous trees found in the five 1/10 acre plots is an estimate of the number of coniferous trees found in a half acre. The number of coniferous trees found in these five plots is then doubled to give in an estimate of the number of coniferous trees per acre. Thus, stem counts need to be converted to stems per acre based on the total area covered by all forest plots, converted to one acre equivalents.

Deciduous Basal Area

This is a measure of the basal area (square feet/acre) of deciduous trees present in upland habitats. This statistic is calculated as described for coniferous basal area; except that deciduous trees (vs. conifer trees) present in forest plots are used for the calculations.

Deciduous Density

This is a measure of the number of deciduous trees per acre. This statistic is calculated as described for coniferous density; except that deciduous trees (vs. conifer trees) present in forest plots are used for the calculations.

Fish Species Assemblage Index

The fish species assemblage score is calculated using the Index of Biotic Integrity (IBI) for coldwater rivers in Idaho and surrounding states. This index is available from Chris Mebane (cmebane@usgs.gov, 208-373-0173). The model calculates the index score based on data entry of the number of each species observed in the survey. The species of sculpin and other fish observed must be identified (using a quadrat survey or other method) to properly calculate the index.

Macroinvertebrate Multimetric Index

The macroinvertebrate multimetric index is calculated using output from Aquatic Biology Associates (ABA) in Corvallis Oregon. ABA identifies each species in a subsample of 500 invertebrates from a surber sample collected at each project site. Based on the taxonomy of each species, and the abundance of each taxa, metrics are calculated that reflect the health, or ecological integrity, of the aquatic system. Using those metrics, indices are calculated based on the metrics most appropriate for the system in which the project is located. The index score relates to a health rating for each project site.

TESTING FOR SIGNIFICANCE

A random sample will be drawn without replacement from completed SRFB habitat protection projects and monitored for the above response indicators to test the null hypotheses. We must be sure that the sample size is large enough to detect significant changes in the response indicators over a relatively short period of time. The number of projects that must be sampled is dependent upon the amount of variation from year to year and among projects, the signal to noise ratio, and the power of the test. Existing data from EMAP sampling conducted by the USEPA and Oregon Department of Fish and Wildlife were used to estimate minimum sample sizes needed to detect change.

A simple linear regression model was used to estimate the number of sites needed to determine whether stream locations improve or decline in condition through time. For this model, each habitat variable would be regressed against year. A slope significantly different from zero would indicate a change in resource condition, with improvement indicated by a positive slope and decline by a negative slope. The linear model assumes that the response variable is normally distributed.

For each variable, the model can be expressed in terms of an equation =M. In the case of RP100 where

$$RP100_{sy} = M + S_s + Y_y + E_{sy}$$

and RP100 for a particular site-visit differs from the mean of all site-visits (M) based on the site location, S (indexed from 1 to the total number of sites), and year, Y (with *y* indexed by year). E_{sy} represents the residual, or unexplained, variance due to measurement error.

The significance of the trend, or slope of the line, depends on its associated variance (Larsen et al. 1995; Urquhart et al. 1998). If the response variable is extremely variable, only very large changes in the slope will be statistically significant. The smaller the variance associated with the slope of the trend line, the more likely we are to detect significant changes. To estimate the variance of the slope, the following equation was used:

$$\text{var}(\hat{C}) = \frac{s^2_{year} + (s^2_{site*year} + s^2_{error})/s}{\sum (Y_y - \ddot{Y})^2}$$

where $\hat{C}$ represents the slope, s^2 refers to an estimate of variance, *s* equals the number of sites, and *r* equals the number of repeat visits to each site. In the denominator, *Y* represents the year value indexed according to the number of years sampled. Data from Oregon Department of Fish and Wildlife and the EPA's Regional Environmental Monitoring and Assessment Program (REMAP) in Washington and Oregon was used to estimate variance components for this model (D. P. Larsen, personal communication).

Slope estimators are assumed to be normally distributed. We used the estimate of the slope's variance above in the following equation to estimate the statistical power of a habitat variable to detect changes through time:

$$\text{Power} = \Phi \left[z_\alpha - \hat{C} / \text{s.e.}(\hat{C}) \right]$$

Power was set to equal to 0.8, Φ is the cumulative normal distribution function, z_α was equal to 0.10 for a 1-sided test, and the standard error of the slope [*s.e.* ($\hat{C}$)] was derived from the equation above. The equation was solved for $\hat{C}$, the slope, to determine the minimum amount of change a habitat variable could detect.

Different sampling scenarios were evaluated using this approach by varying the number of sites and years sampled. This process was completed for all habitat variables to determine the best overall sampling strategy for each variable. Statistical testing for a slope different from zero will determine whether the projects improved, declined, or showed no change through time. After three years of data collection, individual sites can also be tested for improvement, decline, or no change in biological condition.

An example regression may look similar to Figure 27.

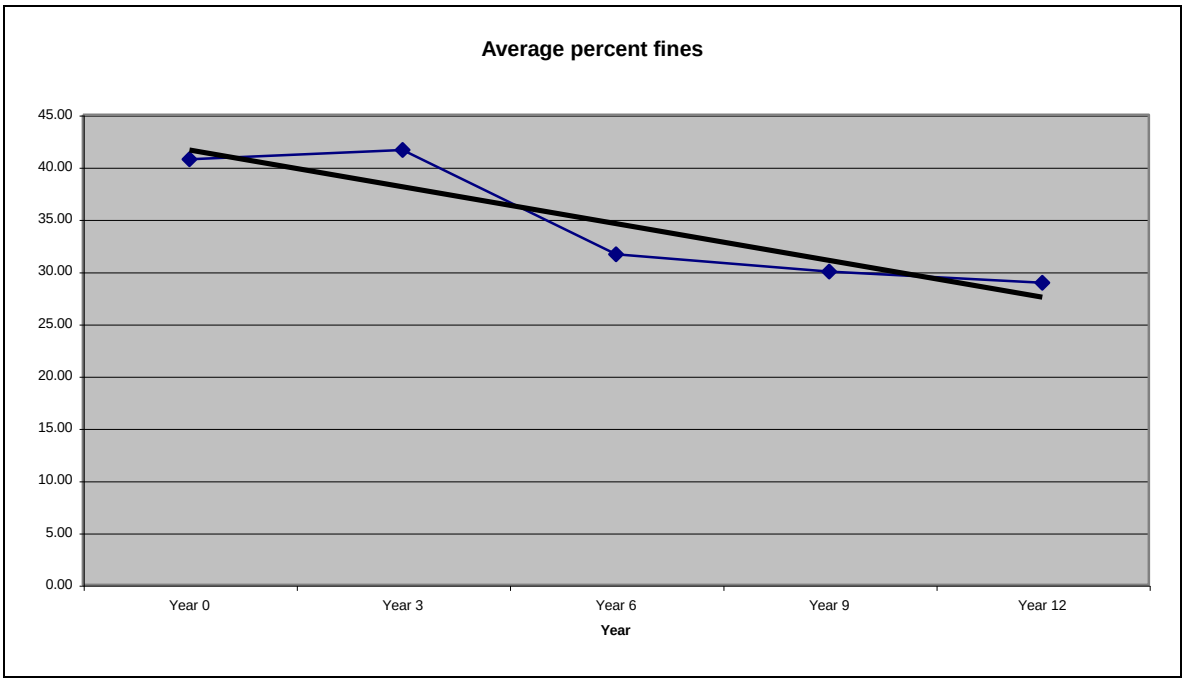


Figure 27. Sample regression chart of percent fines (each data point represents average of 10 projects)

Table 9. Sample size (sites) and years needed to detect 10% and 20% change in selected indicators. Table provided to demonstrate why a sample size of ten was chosen for various project categories.

Indicator	# Sites	10% Change	20% Change
XEMBD	10	6-9 years	3-6 years
	20	6-9 years	3-6 years
PCTFN	10	6-9 years	3-6 years
	20	6-9 years	3-6 years
XCDENBK	10	6-9 years	3-6 years
	20	6-9 years	3-6 years
	30	3-6 years	3-6 years
RP100	10	12-20 years	9-12 years
	20	12-20 years	9-12 years
LWD	10	6-9 years	3-6 years
	20	6-9 years	3-6 years
	30	3-6 years	3-6 years
XDEPTH	10	>20 years	12-20 years
	20	>20 years	12-20 years

Based upon the results shown in Table 9, ten acquisition projects will be sampled five times over 12 years (Years 1, 3, 6, 9, and 12) in order to detect a 20% change in the variables. For nearly all variables, increasing the number of sites from 10 to 20 had no effect upon the ability to detect change in a shorter period of time or in increasing the amount of change that could be detected.

REFERENCE YEAR

Studies designed to compare the quality of habitat sometimes use reference locations. Reference locations contain habitat considered ideal, or representative of, natural conditions. They are used as a point of reference for comparing changes in the habitat for the lands being monitored. Because the lands sampled are so varied, and because most available reference areas in Washington are higher elevation sites, a baseline year will be used for reference for each of the sampled properties. Change will be measured against the baseline year. Baseline years will be established as soon as a property is acquired, whenever possible, in order to reflect the status of the property at the time it was acquired.

EVALUATION OF CHANGE AT INDIVIDUAL SITES

Although the above information has value in testing whether acquisitions in general have or have not maintained their habitat characteristics as measured by the indicators, it is of minimal value in evaluating effectiveness of individual parcels in maintaining their habitat characteristics over time. However, after three or more years of sampling, a regression may be performed to provide additional information.

GOAL

The goal is to test for changes in individual parcels through time using 15 habitat variables measured at a site. In order to compare all variables simultaneously for two sampling occasions at one site, a single statistical test is needed.

METHOD

One approach would compare each of the 15 variables for the initial sampling time with the most recent sampling time (that is, only the first and last samples would be compared). If the variables are independent (see below), we would conclude no change if about half the variables indicated improved conditions while the other half indicated a decline. Thus, we would like to test if the probability of change is significantly different from 50% (p = 0.5). A two-tailed binomial test will test whether the number of variables that changed is different from what we would expect due to chance alone.

The sign test is a robust nonparametric test that is an alternative to the paired *t*-test. This test makes the basic assumption that there is information only in the signs of the differences between paired observations, not in their sizes. If the value represents a positive change to the better or no change for habitat or fish and invertebrate assemblages, a + is given, and for the opposite case where there is an observed decline in the variable, a – is given. The null hypothesis is that the probability of a variable being + or – is 0.5. In cases where data are not normally distributed, a sign test can also be used. Data from paired samples will be evaluated for normal distribution. If the distribution is not normal, the Wilcoxon paired-sample test will be used instead of a paired t-test to determine if there is a significant difference in values between the baseline year and the current year.

We will take the paired observations, calculate the differences, and count the number of +s n_+ and –s $n\_$, where $N = n_+ + n\_$ is the sample size. We will use tables provided by Zar (1985) which gives the $n\_$, probability of getting exactly this many +s and -s if positive and negative values are equally likely.

Table values from Zar (1984) illustrate the changes that would be significant for 12, 13, 14 or 15 habitat variables (Table 1).

ASSUMPTIONS

Habitat measures at a site are not necessarily independent. Residual pool depth may be related to bankfull depth. While it is probably not possible to select a set of completely independent habitat measures, a reasonable effort should be made to eliminate those that depend directly on each other to make this a fair test. The test is equivalent to a coin toss for each variable. If an increase in one variable predicates an increase in another, they are not independent and the "coin toss" is biased.

Table 10. Table values for testing whether the number of variables is statistically significant (two-tailed binomial test, P = 0.5). Shown are the number of habitat variables measured at a site, the number of variables that improved vs. declined (or declined vs. improved) when the first year of sampling was compared to the last year, and the *p*-value associated with that level of change. Example: "For 12 measured habitat variables at a site, if 10 of 12 variables improve (or 10 of 12 variables *decline*), we conclude that site condition has improved (or *declined*) with a confidence of p < 0.10." Values are from Table B.26 in Zar (1984).

Number of variables	Ratio of change	p
12	10 vs. 2	< 0.05
12	11 vs. 1	< 0.01
12	12 vs. 0	< 0.001
13	11 vs. 2	< 0.05
13	12 vs. 1	< 0.005

Number of variables	Ratio of change	p
13	13 vs. 0	< 0.001
14	12 vs. 2	< 0.02
14	13 vs. 1	< 0.002
14	14 vs. 0	< 0.001
15	12 vs. 3	< 0.05
15	13 vs. 2	< 0.01
15	14 vs. 1	< 0.001
15	15 vs. 0	< 0.001

Table 11. Example table for testing overall percent positive change in measured indicators at a freshwater parcel

Project #1	Year 1 2003	Year 3 2005	Plus or Minus
	Baseline	After	
AREASUM	51	49	-
RP100	1.5	1.4	-
Log10(V1WM)	29	19	-
XCDENBK	13	15	+
XPCMG	78	76	-
MMI INVERT	3	3.2	+
FISH INDEX	4.4	4.8	+
XEMBD	18	17	+
PCT_FN	12	13	-
BANK	8	9	-
HERB_NN_ABS	12	16	-
HERB_NN_REL	10	7	+
SHRUB_NN_ABS	30	40	-
SHRUB_NN_REL	25	22	+
BA_CONIF	56.8	64.9	+
SA_CONIF	115	145	+
BA_DECID	84.3	88.7	+
SA_DECID	20	18	-
Total +			9
N			18
P Value			0.81
Reject Null Hypothesis			No

DECISION CRITERIA

Table 12. Response variable decision criteria

Habitat	Indicators	Metric	Test Type	Decision Criteria
Riparian Condition	Mean percent canopy density at the bank densiometer reading (XCDENBK)	1-17 score	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3, 6, 9, or 12
	3-layer riparian vegetation presence (proportion of reach) (XPCMG)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Actively eroding banks (BANK)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% decrease between Base Year 0 and Year 3
Stream Morphology	Mean residual pool vertical profile area (AREASUM)	m^2	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Mean residual depth (RP100)	cm	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Percent substrate embedded (XEMBED)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% decrease between Base Year 0 and Year 3
	Percent substrate as fines (PCT_FN)	%t	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% decrease between Base Year 0 and Year 3
	Large Wood (Log10(V1WM100)	m^3	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
Stream Animal Assemblages	Macroinvertebrate Multimetric Index (MMI INVERT)	MMI score	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Fish species Assemblages (FISH INDEX)	FI score	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3

Habitat	Indicators	Metric	Test Type	Decision Criteria
Upland habitat	Absolute percent cover of non-native herbaceous vascular plant species (HERB_NN_ABS)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Relative percent cover of non-native herbaceous vascular plant species (HERB_NN_REL)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Absolute percent cover of non-native shrub species (SHRUB_NN_ABS)	%	non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Relative percent cover of non-native shrub species (SHRUB_NN)	%	Linear Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Basal area of conifers per acre (BA_CONIF)	ft^2/acre	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Stem count of conifers per acre (SA_CONIF)	#/acre	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Basal area of deciduous trees per acre (BA_DECID)	ft^2/acre	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Stem count of deciduous trees per acre (SA_DECID)	#/acre	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
Intertidal Habitat	Percent cover of algae per Transect (ALGAE_M)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Linear extent of algae along the intertidal Transect. (ALGAE_LN)	#	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Percent cover of vascular plants (VASCULAR_M)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Linear extent of vascular plants along the intertidal Transect. (VASCULAR_LN)	#	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3

Habitat	Indicators	Metric	Test Type	Decision Criteria
	Percent slope from mean high tide to mean low tide (SLOPE_M)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Mean percent of the substrate Transect in fines (PCT_FNM)	%	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3
	Linear extent of fine sediment along the intertidal Transect. (FN_LN)	#	Linear Regression or non-parametric test	Alpha =0.10 Detect a minimum 20% increase between Base Year 0 and Year 3

AFTER-PROJECT DELIVERABLES

The monitoring entity will deliver to the SRFB on Year 3, 5, and 10:

- A completed copy of all monitoring data
- A completed metadata form
- Percent change in upland vegetation composition
- Percent change in riparian vegetation composition
- Percent change in intertidal vegetation and substrate composition
- Percent change in amount of stream shaded
- Percent change in stream gravel fines
- Percent change in stream Thalweg profile measures
- Percent change in actively eroding streambanks
- Percent change in macroinvertebrate MMI
- Percent change in fish MMI
- A statement as to whether Decision Criteria were met as effective habitat protection projects

QUALITY CONTROL

For 5% of the monitored parcels, a different sampling entity will collect the same data to verify results.

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from project analysis will be downloaded to the PRISM database. The PRISM database shall contain fields for the response variables associated with these objectives.

AUDITS AND REPORTS

TECHNICAL SYSTEMS AUDIT (TSA)

The SRFB will employ a consultant to randomly audit 5% of ongoing acquisition monitoring to determine if quality assurance protocols and procedures are followed. This audit should be completed annually, shortly after the monitoring of parcels begins.

PROGRESS REPORT

A progress report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 1 and Year 5.

FINAL REPORT

A final report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 10. It shall include:

- Estimates of precision and variance
- Confidence limits for data
- Summarized data required for PRISM database
- Determination whether project met decision criteria for effectiveness
- Analysis of completeness of data, sources of bias

Results will be reported to the SRFB during a regular meeting after 3, 6, 9, and 12 years of sampling. Results will be entered in the PRISM database and will be reported and available over the Interagency Committee for Outdoor Recreation web site and the Natural Resources Data Portal.

ESTIMATED COST

It is estimated that between 157 and 210 hours would be required for each acquisition project, depending on size and location of the parcel. Costs for each project range from $12,000 to $19,000.

REFERENCES CITED

Arnett, Joseph. Tetra Tech FW, Inc. Personal communication.

Crawford, B.A., C. Drivdahl, S. Leider, C. Richmond, and S. Butkus (2002). The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery. Vol. 2. Olympia, WA. 377p.

Fore, Leska. Evaluation of Alternative Sampling Designs for Biological Monitoring of Streams. (May 2001). Statistical Designs, Seattle, WA. Final report submitted to WA Dept. of Ecology. 13p.

Greening Australia Federation. 2004. Website. Monitoring regeneration. www.greeningaustralia.org.au/GA/NAT/TipsAndTools/library/monitoringregeneration.htm

Henderson, J. and R. Lesher (2003). Draft survey protocols for benchmark plots (permanent intensive ecoplots) for Western Washington. Western Washington Ecology Program. USDA Forest Service, Region 6.

Karr, J.R. and E.W. Chu (1999). Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, D.C.

Kauffman, P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck (1999). Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

Larsen, D. P., N. S. Urquhart, and D. L. Kugler (1995). Regional scale trend monitoring of indicators of trophic condition of lakes. Water Resources Bulletin 31: 117-140.

Mebane, C., T.R. Maret, R.M. Hughes (2003). An index of biological integrity (IBI) for Pacific Northwest rivers. Trans. Amer. Fish. Soc. 132:239-261.

Moore, K., K. Jones and J. Dambacher (1998). Methods for stream habitat surveys aquatic inventory project. Oregon Department of Fish and Wildlife. Corvallis, OR. 36p.

New Zealand National Vegetation Survey. (2004). Website. Frequently asked questions, field methodologies. http:nvs.landcareresearch.co.nz/html/nvsfaq.html

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft (2003). Environmental Monitoring and Assessment Program - Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.

Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. U.S. Forest Service. Gen Tech Rept. INT-GTR-307. 29 p.

Urquhart, N. S., S. G. Paulsen, and D. P. Larsen. 1998. Monitoring for policy-relevant regional trends over time. Ecological Applications 8:246-257.

USDI National Park Service (2003). Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center. 274 p.

Wiseman, C. 2003. Multi-metric index development for biological monitoring in Washington State streams. Publ. No. 03-03-035. WA Dept. Ecology. Olympia, WA. 28p.

Wishnie, M., A. McClinick, J. Hansen, and F. Bob (1999). Riparian conversion monitoring data collection protocols (Fact sheet). Lummi Natural Resources Riparian Zone Restoration Project (RZRP), Lummi Natural Resources, Lummi Indian Nation and Center For Streamside Studies. University of Washington. Seattle. 3 pages.

Zar J.H. 1984. Biostatistical Analysis, 2nd ed. Prentice-Hall, Inc., Englewood Cliffs, NJ.

APPENDIX A

Variance estimates provided by Phil Larson for EMAP sampling in Oregon and Washington

Variance estimates provided by Phil Larson for EMAP sampling in Oregon and Washington

Indicator	site	year	interaction	residual
NorthCoast				
GRADIENT (%)	18.355	0.158	0.000	1.456
WIDTH (meters)	16.290	0.000	0.587	0.474
ACW (meters)	54.023	2.241	2.968	1.768
ACH (meters)	0.215	0.001	0.003	0.014
UNITS100 (#/100 meters)	3.133	0.215	0.000	1.451
NOPOOLS (per surveyed reach)	33.074	0.346	0.000	61.724
POOLS100 (#/100 meters)	0.748	0.095	0.000	0.739
PCTPOOL (%)	547.034	33.415	134.101	79.949
PCTSNDOR (%)	639.270	13.579	0.000	65.795
PCTGRAVEL (%)	124.711	5.676	0.000	62.562
RIFSNDOR (%)	565.694	14.888	0.000	109.893
RIFGRAV (%)	163.597	28.215	0.000	129.284
SHADE (%)	218.243	1.317	27.478	68.804
LOG(PIECESLWD + 0.01) (#/100m)	0.763	0.000	0.184	0.157
LOG(VOLUMELWD +0.01) (m^3/100m)	0.782	0.014	0.110	0.343
RESIDPD (meters)	0.041	0.000	0.007	0.009
MidCoast				
GRADIENT	29.113	0.013	0.000	0.268
WIDTH	23.326	0.044	0.002	0.240
ACW	36.874	0.000	0.000	1.536
ACH	0.030	0.005	0.002	0.009
UNITS100	3.241	0.394	0.194	1.790
NOPOOLS	79.058	6.550	2.245	42.350
POOLS100	0.594	0.155	0.277	0.703
PCTPOOL	523.901	7.683	45.339	58.514
PCTSNDOR	273.350	6.282	61.548	40.020
PCTGRAVEL	118.169	0.000	72.143	43.067
RIFSNDOR	122.774	9.892	122.051	20.380
RIFGRAV	147.421	16.788	111.854	103.025
SHADE	101.627	0.000	0.000	72.149
LOG(PIECESLWD + 0.01)	0.576	0.000	0.053	0.071
LOG(VOLUMELWD +0.01)	1.179	0.082	0.019	0.137
RESIDPD	0.024	0.002	0.002	0.003
MidSouth Coast				
GRADIENT	39.323	0.000	0.668	1.127

Indicator	site	year	interaction	residual
WIDTH	11.787	0.140	0.265	0.445
ACW	127.226	0.284	13.844	1.469
ACH	0.067	0.008	0.041	0.010
UNITS100	3.617	0.000	0.000	2.757
NOPOOLS	40.158	7.783	0.000	39.949
POOLS100	0.994	0.130	0.000	0.936
PCTPOOL	2302.291	66.942	0.000	133.292
PCTSNDOR	745.841	0.000	50.251	38.813
PCTGRAVEL	154.449	14.949	99.921	42.448
RIFSNDOR	596.811	0.000	0.000	97.845
RIFGRAV	245.749	57.324	121.386	143.471
SHADE	359.391	0.000	36.755	36.033
LOG(PIECESLWD + 0.01)	1.841	0.053	0.061	0.144
LOG(VOLUMELWD +0.01)	2.526	0.000	0.130	0.142
RESIDPD	0.060	0.001	0.000	0.057
South Coast				
GRADIENT	48.931	0.009	0.000	0.819
WIDTH	5.861	0.000	0.148	0.320
ACW	0.925	0.152	1.323	1.178
ACH	0.034	0.000	0.000	0.024
UNITS100	3.966	0.228	0.276	2.114
NOPOOLS	23.026	5.504	17.710	7.287
POOLS100	0.465	0.169	0.535	0.169
PCTPOOL	134.038	3.604	63.489	14.255
PCTSNDOR	310.631	1.362	50.100	31.698
PCTGRAVEL	98.312	1.365	3.740	59.004
RIFSNDOR	239.329	3.144	27.204	26.771
RIFGRAV	141.190	1.956	0.000	147.734
SHADE	242.543	0.099	0.004	34.122
LOG(PIECESLWD + 0.01)	1.266	0.013	0.000	0.113
LOG(VOLUMELWD +0.01)	2.560	0.012	0.488	0.128
RESIDPD	0.076	0.001	0.000	0.009
Umpqua				
GRADIENT	38.669	1.468	1.028	0.707
WIDTH	5.371	0.027	0.200	0.181
ACW	14.712	0.109	0.000	1.415
ACH	0.009	0.000	0.000	0.019
UNITS100	4.328	0.305	1.019	1.939
NOPOOLS	42.423	4.043	4.984	15.272
POOLS100	0.787	0.181	0.574	0.460

Indicator	site	year	interaction	residual
PCTPOOL	370.002	11.894	37.765	28.533
PCTSNDOR	390.854	5.954	0.000	52.316
PCTGRAVEL	133.923	17.369	0.000	69.735
RIFSNDOR	419.849	3.834	0.000	102.846
RIFGRAV	184.520	32.025	0.000	191.116
SHADE	43.049	52.844	70.674	117.949
LOG(PIECESLWD + 0.01)	0.636	0.006	0.000	0.404
LOG(VOLUMELWD +0.01)	1.579	0.000	0.994	0.152
RESIDPD	0.040	0.003	0.004	0.004
All				
GRADIENT	35.043	0.141	0.782	2.673
WIDTH	12.729	0.011	0.412	0.664
ACW	53.292	0.024	0.000	6.488
ACH	0.075	0.000	0.011	0.016
UNITS100	3.512	0.196	0.109	2.407
NOPOOLS	46.746	2.061	0.000	43.968
POOLS100	0.758	0.104	0.011	0.878
PCTPOOL	766.630	7.196	50.633	138.567
PCTSNDOR	445.890	0.648	36.730	100.554
PCTGRAVEL	129.336	1.087	28.487	68.083
RIFSNDOR	349.322	2.656	14.741	143.852
RIFGRAV	183.849	7.594	55.597	156.896
SHADE	195.289	3.425	16.858	80.223
LOG(PIECESLWD + 0.01)	1.048	0.012	0.000	0.258
LOG(VOLUMELWD +0.01)	1.722	0.003	0.202	0.429
RESIDPD	0.049	0.001	0.000	0.019
Relative variances for All				
GRADIENT	0.906944	0.00364	0.02024	0.069176
WIDTH	0.92134	0.000765	0.029812	0.048083
ACW	0.891119	0.000394	1.87E-10	0.108487
ACH	0.733491	4.23E-06	0.108201	0.158303
UNITS100	0.564281	0.031513	0.017529	0.386676
NOPOOLS	0.503861	0.02222	2.14E-07	0.473918
POOLS100	0.432636	0.059638	0.006326	0.501401
PCTPOOL	0.796064	0.007472	0.052577	0.143887
PCTSNDOR	0.763743	0.001111	0.062912	0.172234
/..PCTGRAVEL	0.569778	0.004791	0.125497	0.299935
RIFSNDOR	0.684179	0.005202	0.028872	0.281747
RIFGRAV	0.455143	0.018801	0.137639	0.388418

Indicator	site	year	interaction	residual
SHADE	0.660218	0.011578	0.056992	0.271211
LOG(PIECESLWD + 0.01)	0.795269	0.008767	3.88E-13	0.195964
LOG(VOLUMELWD +0.01)	0.730982	0.00115	0.085641	0.182227
RESIDPD	0.703577	0.01681	3.78E-14	0.279613

APPENDIX B
Stream Measurement and Densiometer Reading Locations

TRANSECT MEASUREMENTS AND DENSIOMETER READING LOCATIONS

Figure 1

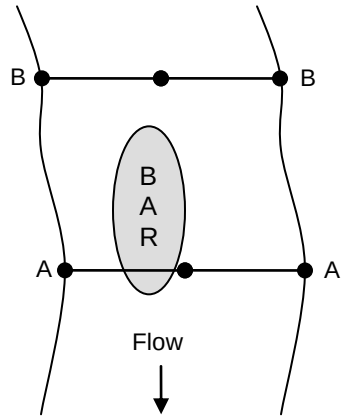


Figure 2

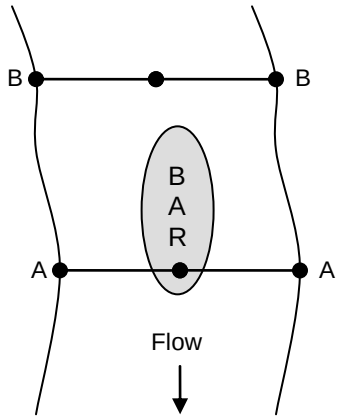


Figure 3

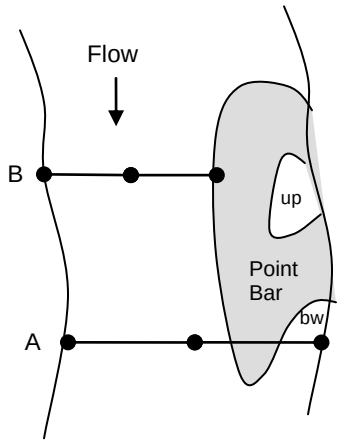


Figure 4

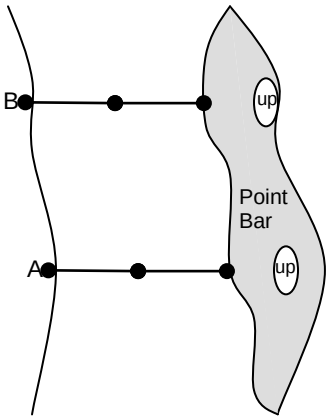


Figure 5

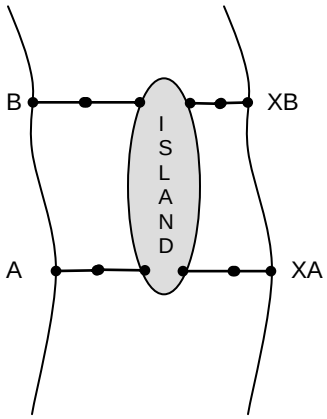


Figure 6

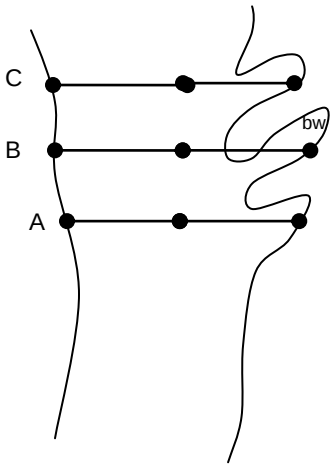


Figure 7

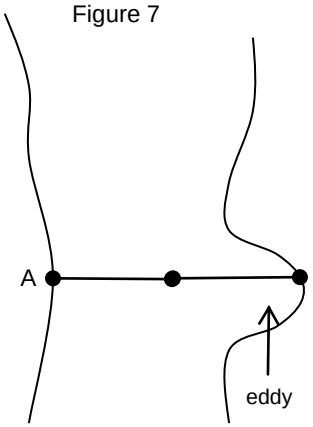


Figure 8

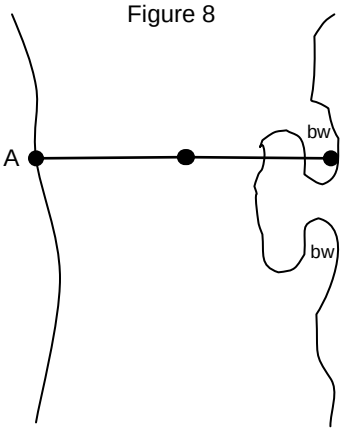
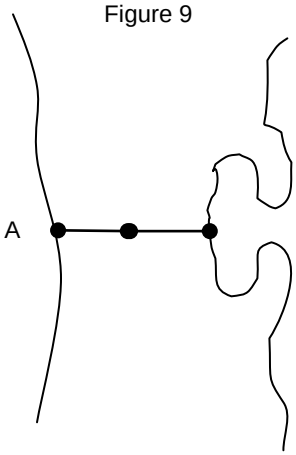


Figure 9



Notes:

- up = unconnected puddle; bw = backwater
- In all figures, flow is from the top of the figure to the bottom of the figure.
- In all figures, each line across the channel represents a Transect and the dots represent the locations of densiometer measurements.
- Measurement locations within the reach are determined based on the conditions present at the time of the survey.
- Substrate measurements (not illustrated in the figures) are made at five equal distance locations across each Transect and each secondary/mid-Transect (e.g., between Transect A and B).
- Right bank is on the right side of the stream when facing downstream; left bank is on the left side of the stream when facing downstream.
- Regardless if a bar is present, densiometer readings occur at the right bank, in the center of the channel, and at the left bank (Figures 1 and 2).
- Wetted width is measured across bars from the right edge of water to the left edge of water (Figures 1 and 2). The bar width is also measured and is independent of the wetted width measurement.
- If a point bar is present (e.g., gray areas in Figures 3 and 4), the edge of water is where the point bar and water meet (i.e., the bank). In Figures 3 and 4, the left bank measurements occur where the point bar and water meet (i.e., the left edge of the water). However, in the case of Transect A, in Figure 3, backwater is present and, therefore, the left edge of water (i.e., the left bank) would be on the left bank of the backwater. Unconnected puddles are never included in any measurements.
- Bars are mid-channel features below the bankfull flow mark that are dry during baseflow conditions. Islands are mid-channel features that are dry even when the stream is experiencing a bankfull flow. Both bars and islands cause the stream to split into side channels. When a mid-channel bar is encountered along the thalweg profile, it is noted on the field form and the active channel is considered to include the bar. Therefore, the wetted width is measured as the distance between the wetted left and right banks. It is measured across and over mid-channel bars and boulders. If mid-channel bars are present, record the bar width in the space provided in the form.
- If a mid-channel feature is as high as the surrounding flood plain, it is considered an island (Figure 5). Treat side channels resulting from islands different from mid-channel bars. Manage the ensuing side channel based on visual estimates of the percent of total flow within the side channel as follows:

  Flow less than 15% - Indicate the presence of a side channel on the thalweg field data form.

  Flow 16 to 49% - Indicate the presence of a side channel on the thalweg field data form.

  Establish a secondary Transect across the side channel (Figure 5) designated as “X” plus the primary Transect letter; (e.g., XA), by creating a new record in the physical habitat form and selecting “X” and the appropriate Transect letter (e.g., A through K) in the new record on the field data form. Complete the physical habitat and riparian cross-section measurements for the side channel on this form. No thalweg measurements are made in the side channel. When doing width measurements within a side channel separated by an island, include only the width measurements of the main channel in main channel form, and then measure the side channel width separately, recording these width measurements in the physical habitat side channel form. Refer to Peck et al. (2003) for detailed instructions on side channel measurements.
- When multiple backwaters and eddies are encountered (Figure 6), measurements are made across the entire channel, over depositional areas (e.g., Figure 6, Transect B) to the edge of water.
- When eddies are encountered (Figure 7), measurements are still made from the right bank to the left bank.

- In instances where a depositional area has become a peninsula and the Transect falls in a location where backwater is present (Figure 8), measure from the right bank across the depositional area to the left bank (e.g., Figure 8, Transect A). When the Transect falls in a location where backwater is not present (e.g., Figure 9, Transect A), only measure to where the water meets the edge of the depositional area/peninsula.