A Field Manual of Scientific Protocols for Fine Sediment Sampling within the Upper Columbia Monitoring Strategy

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This protocol is largely based upon the methods that the U.S. Forest Service has been implementing for the long-term monitoring of fine sediment levels in spawning gravels within the Upper Columbia River Basin. These Forest Service methods are based upon the monitoring protocols developed by Schuett-Hames et al. (1993) and Schuett-Hames et al. (1999). A draft of this protocol was reviewed by USFS experts monitoring fine sediment within the Upper Columbia River Basin. I would like to acknowledge the contributions of Phil Archibald (USFS) and Matt Karrer (USFS) who provided recommendations which improved this protocol and its application to watersheds within the Upper Columbia River Basin.

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Section 1: Introduction

Columbia River Basin anadromous salmonids have exhibited precipitous declines over the past 30 years, with several populations now protected under the Endangered Species Act (ESA) (Schaller et al. 1999; McClure et al. 2002). A comprehensive monitoring strategy needs to be implemented to reduce the uncertainties surrounding the declines, and the strategies required to reverse this trend. Data collected from current and historical monitoring programs are generally not adequate or reliable enough for the purposes of ESA assessments and recovery planning (Tear et al. 1995; Campbell et al. 2002; Morris et al. 2002). In addition, monitoring programs for anadromous salmonids in the Columbia River Basin have typically been initiated to evaluate the effects of specific management actions, such as the demographic effects of hatcheries. As such, data are most appropriately viewed at the scale of the subpopulations and populations for which they were derived. However, the ESA requires assessments of species and their habitat at multiple spatial scales – from specific reaches, to subpopulations, populations, and the ESA management unit of Pacific salmon, the Evolutionary Significant Unit (ESU), which is a distinct population or group of populations that is an important component of the evolutionary legacy of the species.

Current monitoring programs for Pacific salmon did not develop as a cohesive design, thus aggregating existing data from a myriad of independent projects creates challenges in addressing these spatially complex questions. These problems arise because information is often not collected in a randomized fashion (Larsen et al. 2004), sampling techniques and protocols are not standardized across programs, and abundance, distribution, population dynamic, and demographic data for species and their habitat is often not available (Tear et al. 1995; Campbell et al. 2002; McClure et al. 2002). As recovery planning has focused more effort on tributary habitat restoration to mitigate for the mortality resulting from the Federal Columbia River Power System (FCRPS) the limitations of historic and current sampling programs have become increasingly apparent.

The Integrated Status and Effectiveness Monitoring Program (ISEMP – BPA project #2003-0017) has been created as a cost effective means of developing protocols and new technologies, novel indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments. These tools are designed to support the development of a region-wide Research, Monitoring and Evaluation (RME) program to assess the status of anadromous salmonid populations, their tributary habitat, and restoration and management actions.

The ISEMP has been initiated in three subbasins: Wenatchee/Entiat, WA, John Day, OR, and Salmon River, ID, with the intent of designing monitoring programs that can efficiently collect information to address multiple management objectives over a broad range of scales. This includes:

• Evaluating the status of anadromous salmonids and their habitat;

• Identifying opportunities to restore habitat function and fish performance, and

• Evaluating the benefits of the actions to the fish populations across the Columbia River Basin.

The multi-scale nature of this goal requires the standardization of protocols and sampling designs that are statistically valid and powerful, properties that are currently inconsistent across the multiple monitoring programs in the region. This fine sediment monitoring protocol is a component of the overall ISEMP, and while it stands alone as an important contribution to the management of anadromous salmonids and their habitat, it also plays a key role within ISEMP as it is built on a standardized format following Oakley et al. (2003) that all of the ISEMP protocols adhere to. This protocol will be revised and updated over time.

This protocol was designed to provide standardization for the implementation of the fine sediment monitoring component the Monitoring Strategy for the Upper Columbia Basin as described by the Upper Columbia Monitoring Strategy (UCMS; Hillman 2006). This region includes five major subbasins: Wenatchee; Entiat; Chelan; Methow; and Okanogan (Hillman 2006). The field methods of this protocol are based primarily on the Salmonid Spawning Gravel Composition Survey methods of the TFW Monitoring Program (Schuett-Hames et al. 1999), the protocol that is recommended by the UCMS. This protocol also incorporates some modifications made by the U. S. Forest Service (USFS) in implementing the TFW fine sediment monitoring methods in the Upper Columbia River Basin. The U. S. Forest Service (USFS) has been monitoring fine sediments within spawning gravels in the Entiat and Wenatchee subbasins for the last 15 years using the methods of the TFW Monitoring Program (i.e. Schuett-Hames et al. 1993, Schuett-Hames et al. 1999).

However, the use of the TFW protocol within the Wenatchee and Entiat subbasins has resulted in some changes in language which are addressed in this document. Monitoring and sampling related language has been standardized within this protocol to insure that monitoring related terminology is internally consistent within ISEMP and ISEMP data management structure. Changes in terminology are noted where preferred ISEMP terminology differs from that used by the USFS or the TFW programs. The sampling design and sample site selection process described in this protocol follows that of Schuett-Hames et al. (1999), which differs from the sampling design recommended by the UCMS (Hillman 2006).

This protocol was primarily designed for fine sediment monitoring programs being implemented in the Upper Columbia River Basin which rely on McNeil core sediment sampling. This protocol may provide general guidance broadly applicable to other Columbia River sub-basins; however, prior to implementation it would benefit from review by monitoring practitioners in specific subbasins to incorporate local needs and environmental conditions, and possibly the addition of alternative fine sediment sampling techniques where necessary.

Section 2: Sampling Design

This protocol is designed to standardize methods for monitoring fine sediment levels in salmonid spawning gravels in the Upper Columbia River Basin. The Monitoring Strategy for the Upper Columbia Basin (UCMS; Hillman 2006) serves as the general framework and reference for the statistical and sampling designs at the basin and subbasin scale, such as the selection of index populations or subpopulations for monitoring. Fine sediment levels within spawning

gravels, referred to as "depth fines" in the UCMS, is but one attribute of a suite of physical and biological indicators suggested for monitoring at selected monitoring sites.

This protocol recommends the sampling of fine sediments within spawning gravels at, or upstream of,[1] integrator sites. Integrator monitoring sites are located at the downstream end of the distribution of each population or subpopulation of salmonid that is the target of monitoring efforts (Jordan 2003). To characterize spawning gravel composition within sites near integrator sites this protocol largely follows the methods established by the TFW Monitoring Program in their Salmonid Spawning Gravel Composition Survey (Schuett-Hames et al. 1999), the fine sediment monitoring protocol recommended by the UCMS (Hillman 2006). Any deviations from UCMS (Hillman 2006) recommendations or the methods of Schuett-Hames et al. (1999) are described.

The use of three sampling-related terms is standardized to avoid confusion and provide consistency within the ISEMP program and ISEMP data management. These include: sampling site; sampling transect; and sampling point. The sampling site or "site" refers to a delineation of stream length within which sampling transects and sampling points are identified. The TFW (i.e. Schuett-Hames et al.1999) refers to this as a "stream segment" and the USFS refers to this as a "reach". The sampling transect or "transect" is a latitudinal transect across the stream channel along which sampling points are identified. The USFS refers to transects as "riffles" or "sites"(1 through 4) as they employ the riffle crest sampling method and consistently take four McNeil core samples along riffle transects. The sampling point or "point" is a precise location along a sampling transect where a McNeil core sample is taken.

Sampling Site Selection

Consistent with Schuett-Hames et al. (1999) the sampling site, or "stream segment" in TFW terminology is used as the fundamental unit for analysis. Sampling sites are defined as stream reaches that share similar gradient, valley confinement and flow (Schuett-Hames et al. 1999). For streams with integrator sites, a site used for spawning above the integrator site is identified and then assessed for compatibility with McNeil core fine sediment sampling methods.

If sites have not previously been delineated, the TFW Monitoring Stream Segment Identification method (Pleus and Scheutt-Hames 1998) can be used. However, the locations of spawning areas and sites have often been previously delineated by state and/or federal resource management agencies. The selected sites are then classified down to the Channel Segment Level as described in the UCMS (Hillman 2006) that includes a minimum Level I geomorphic characterization of the Rosgen (1996) channel type.

A selected site must be suitable for spawning gravel composition sampling. Schuett-Hames et al. (1999) provide a method to rate site suitability. The McNeil core sample method requires that water depths at spawning areas to be less than 0.3 meters and dominated by

[1] Sampling methodologies associated with other protocols conducted at integrator sites (e.g. smolt trapping, water quality sampling) necessitate that integrator sites are not located in spawning riffles. For example, smolt traps are established downstream of spawning areas. Therefore, fine sediment sampling in spawning gravels "at integrator sites" must be done at spawning riffles that are nearby (and in our case, upstream of) integrator sites.

spawning gravels between 8 and <100 millimeters (b-axis) (Schuett-Hames et al. 1999). Typically, sites with less than 2% gradient are best and sites with gradients greater than 6% are typically unsuitable (Schuett-Hames et al. 1999). Sites may be inappropriate for sampling if they are inaccessible or access is restricted by landowners.

The Schuett-Hames et al. (1999) sampling site selection approach adopted here differs from the fine sediment sampling design of the UCMS (Hillman 2006). For example, the UCMS recommends that the sampling site selection design for status/trend monitoring follow the methods established by EMAP, which selects spatially balanced sample sites with the generalized random tessellation stratified design (GRTS) (Stevens 1997; Stevens and Olsen 1999; Stevens and Urquhart 2000; Stevens 2002). This approach was deemed impractical for characterizing the fine sediment levels encountered by spawning salmonids since GRTS randomly selected monitoring sites often do not fall within sites where McNeil core sampling is practical or feasible and do not adequately represent areas of salmonid spawning. The Schuett-Hames et al. (1999) sampling design that is recommended here is the same protocol being implemented in the Entiat and Wenatchee River subbasins by the USFS for effectiveness and status/trend monitoring.

Sampling Frequency and Timing

An annual sampling frequency is adopted here for fine sediment status and trend monitoring consistent with recommendations of the UCMS (Hillman 2006). Schuett-Hames et al. (1999) suggest the ideal timing for annual McNeil core fine sediment sampling is late summer/early fall as: 1) stream conditions and substrate composition are relatively stable; and 2) stream conditions are similar to those that salmon will encounter when spawning. Collecting fine sediment samples should be avoided during periods of spawning or when eggs are still present within gravels (Schuett-Hames et al. 1999). Additionally, collecting fine sediment samples during extremely low flows should be avoided to limit the potential bias in site selection that may result from the sampling of a smaller proportion of potential spawning habitat (Schuett-Hames et al. 1999).

Personnel Requirements and Training

Each monitoring agency is responsible for training the personnel who will be performing fine sediment field sampling, entering and uploading the data to ATM's and performing data analyses.

Section 3: Sample Inventory

References:

Schuett-Hames et al. (1999)

Equipment:

Maps of sites, topographic maps, spawning gravel survey forms, stadia rod, hip chain and measuring tapes, gps, standard personal field gear.

Concept:

A site selected for gravel composition monitoring will first need to be inventoried to enable the random selection of sampling transects. The sample inventory procedure identifies suitable spawning gravel transects within sites and documents other areas that are not suitable for sampling. Sample inventories identify reference points, landmarks, candidate riffle crests or gravel patches, and the suitability of candidate gravel occurrences. There are two inventory methods that are tailored to the characteristics of spawning gravels distributions within sites: 1) the riffle crest method; and 2) the gravel patch method (Schuett-Hames et al. 1999). The sample inventory phase establishes the distribution of spawning gravels within sites from which McNeil core sub-sampling is then performed.

Procedure:

Step 1: Determine which sampling inventory method is most appropriate for the site to be monitored. This step may require some preliminary field reconnaissance of sites where field conditions are not well known.

a) Riffle Crest Method: The riffle crest sample inventory method is the preferred sampling method and is most appropriate within sites less than 2% gradient where gravel size and well defined pool/riffle morphology are favorable (Schuett-Hames et al. 1999).

b) Gravel Patch Method: Useful where spawning gravel occurrence is patchy and the riffle crest method would perform poorly in characterizing available spawning habitats (Schuett-Hames et al. 1999). Often useful in sites that exceed 2% gradient.

Step 2: Verify the downstream end of the site and begin the sample inventory at this location.

Step 3: Use a hip chain to track cumulative distance upstream for identification of reference points, landmarks and riffles/gravel patches.

Step 4: Record the location of candidate riffle crests and gravel patches. Riffle crest or gravel patches can be rejected if they are inaccessible, dangerous to sample or in cases where landowners deny access.

Step 5: Determine the suitability of candidate gravel occurrences. Riffle crests and gravel patches are suitable if they meet the following criteria established by Schuett-Hames et al. (1999):

1) Dominated by spawning gravels between 8 and <100 millimeters (b-axis);
2) Minimum surface area of 1 square meter and 0.5 meter width (2.0 m length);
3) In the wetted channel under flowing water;
4) Water depth less than 0.3 meters; and
5) Obstructions do not affect criteria #2.

Step 6: Estimate the number of potential McNeil core samples at riffle crest or gravel patch transects:

a) Riffle Crest Method: Determine the number of potential samples at a riffle crest transect by measuring the width of suitable spawning gravel across the riffle crest. Record one sample for each meter of width across the riffle crest, up to a maximum of four (modified from Schuett-Hames et al. 1999). Mark riffle crest transects with flagging labeled with transect number.

b) Gravel Patch Method:

   i) Measure gravel patch length.

   ii) Based upon patch length, identify the number and location of transects for patches (Table 1, Schuett-Hames et al. 1999). Mark Patch transects with flagging labeled with patch and patch transect number.

   iii) Estimate the number of potential samples for each patch transect using the same methodology as for riffles. Record one sample for each meter of width across the transect, up to a maximum of four (modified from Schuett-Hames et al. 1999). Insure all transects are labeled with patch and transect number.

Table 1. Criteria for determining the number and locations of patch sampling transects (taken from Schuett-Hames et al. 1999).

Patch Length (m)	Number Transects	Transect Location (Patch length multiplied by:)
≥ 1 and < 2	1	0.50
≥ 2 and < 4	2	0.25 and 0.75
≥ 4 and < 20	3	0.17, 0.50, and 0.83
≥ 20	4	0.13, 0.38, 0.63, and 0.88

Section 4: Sampling Point Selection

References:

Schuett-Hames et al. (1999)

Equipment:

Random number generator/ table.

Concept:

Based upon the results of the sample inventory, a systematic random sampling strategy is used to select a subpopulation of 12 spawning gravel sample points for McNeil core sampling (Schuett-Hames et al. 1999). The two sampling methods 1) the riffle crest method; and 2) the gravel patch method (Schuett-Hames et al. 1999) that can used to select appropriate locations for gravel composition core samples are described in Section 3. Both of these methods begin with performing an inventory of all spawning habitats within a site, and then a systematic random sample of sub-sampling points are selected from the available spawning habitat.

Procedure:

Step 1: For the site of interest, count the total number of estimated samples from all riffle crests or gravel patch transects identified in the Sample Inventory.

Step 2: If the total number of estimated samples is between 12 and 18, then no systematic sub-sampling is required (Schuett-Hames et al. 1999). Randomly select either riffle transects or gravel patch transects and add the sample points within those transects until 12 McNeil core sample points have been identified. Each transects will contain from 1 to 4 sample points based upon transect width. McNeil core sampling is then performed at these transects and sample points.

Step 3: If the total number of estimated samples is greater than 18, then a systematic sub-sample of transects needs to be performed. Schuett-Hames et al. (1999) recommend the following systematic sub-sampling methodology, which has two phases:

a) Count the total number of riffle crests or patch transects identified in the Sample Inventory. Apply this number to column one in Table 2 to achieve recommended sub-sample size and random number.

Table 2. Sub-sample proportion and random number selection based upon total number of riffle crests (RC) or patch transects (T) found within a site (from Schuett-Hames et al. 1999).

Total Number RC or T	Subsample	Choose a random number between
7-12	50%	1 and 2
13-18	33%	1 and 3
19-24	25%	1 and 4
25-30	20%	1 and 5
>30	12.5%	1 and 8

b) Use Table 3 to determine which riffle crests or gravel patches to sample based upon the random number and sub-sample proportion results from Table 2.

c) Cross-check the resulting riffle crest or gravel patch transects with field data forms to insure that the number of samples within the selected transects is at least 12. If this process resulted in fewer than 12 samples, then additional transect(s) will need to be randomly selected from the un-selected sample population (Schuett-Hames et al. 1999).

Table 3. Determining a systematic sub-sample of riffle crest or gravel patch transects from the sub-sample proportion and random number attained from Table 2. (from Schuett-Hames et al. 1999).

Random No.	50%	33%	25%	20%	12.5%
1	1, 3, 5, 7, 9, 11	1, 4, 7, 10, 13, 16	1, 5, 9, 13, 17, 21	1, 6, 11, 16, 21, 26	1, 9, 17, 25, 33, 41, etc
2	2, 4, 6, 8, 10, 12	2, 5, 8, 11, 14, 17	2,6, 10, 14, 18, 22	2, 7, 12, 17, 22, 27	2, 10, 18, 26, 34, 42, etc
3		3, 6, 9, 12, 15, 18	3, 7, 11, 15, 19, 23	3, 8, 13, 18, 23, 28	3, 11, 19, 27, 35, 43, etc
4			4, 8,12, 16, 20, 24	4, 9, 14, 19, 24, 29	4, 12, 20, 28, 36, 44, etc.
5				5, 10, 15, 20, 25, 30	5, 13, 21, 29, 37, 45, etc.
6					6, 14, 22, 30, 38, 46, etc.
7					7, 15, 23, 31, 39, 47, etc.
8					8, 16, 24, 32, 40, 48, etc.

Step 4: If the total number of estimated samples is less than 12, Schuett-Hames et al. (1999) recommend considering several alternatives:

a) If the Riffle Crest Method was used, either simply collect samples at the identified riffle crests or resurvey the site using the Gravel Patch Method.

b) If the Gravel Patch Method was used, and all patch lengths are less than 4m, sample the identified patch transects as the sample size represents the condition of the site.

c) If the Gravel Patch Method was used, and one or more patch lengths are greater than 4m, increase the sample size by using a smaller transect interval criteria.

Section 5: McNeil Sediment Core Sampling

References:

Schuett-Hames et al. (1999)

Equipment:

McNeil core sampler with plunger; 5-gal plastic buckets with lids; wash bottles; 150 mm ruler; sample tracking labels; sample collection forms; maps of sites and locations of riffles/gravel patches to be sampled; copies of completed Sample Inventory and Sampling Site Selection forms; hip chain and measuring tapes, gps, standard personal field gear including waders with traction soles.

Concept:

Once sampling transects and points have been selected, McNeil core samples can then be collected. The precise location for McNeil core sampling points along transects largely follows the recommendations of Schuett-Hames et al. (1999) though slightly modified to enable the identification of up to four sampling points along a single transect if it is sufficiently wide (4m or greater). The sampling of four McNeil core samples per riffle crest is currently being successfully implemented by the USFS in the Upper Columbia River Basin. McNeil core samples are taken at all selected sample points, transferred to buckets for transport and storage, and documented for effective sample tracking (Schuett-Hames et al. 1999).

Procedure:

Step 1: Begin spawning gravel sample collections at transects that are furthest downstream within the site and proceed upstream. Verify the locations and suitability of transects and points that have been selected for sampling.

Step 2: Establish the precise sampling point locations along the riffle crest or gravel patch transects that have been selected for sampling.

a) Establish a measurement line along the selected transect with a measuring tape. For riffle crest transects, allow the measuring tape to follow the shape of the riffle crest (Schuett-Hames et al. 1999). At gravel patch transects the measuring tape should be straight and perpendicular to the centerline of the bankful channel (Schuett-Hames et al. 1999). In

some cases excessive mid-channel depths at riffle transects will prohibit the establishment of a single transect compatible with McNeil core sampling that spans the entire channel. In these cases it is appropriate to establish two transects, one from each bank, to identify all sample points at a single riffle crest..

b) Establish up to four sampling points along transects based upon the width of the sample transect. At transects less than 2m in width, a single sample point will be established in the center of the transect (Table 4). For transects 2 to < 3m in width two sample points are established, and for transects 3m to < 4m three sample points will be established. For transects 4m or greater in width, 4 sample points will be identified (modified from Schuett-Hames et al. 1999).

c) Establish the precise location of the sample points along transects. Sample point locations can be calculated as a function of transect width with the aid of Table 4.

Table 4. Identifying the precise location of sampling points of randomly selected McNeil core samples along transects. This procedure has been modified from Schuett-Hames et al. (1999) to enable the collection of up to 4 samples if transects are 4 or more meters in width.

		Locating Randomly Selected Sample Sites (multiply by total width by:)			
Sample Area Width (m)	Number of Candidate Samples in Transect	Sample Site 1	Sample Site 2	Sample Site 3	Sample Site 4
≥ 1 to< 2.0	1	0.5			
2.0 to < 3.0	2	0.25	0.75		
3.0 to <4.0	3	0.17	0.5	0.83	
≥ 4.0	4	0.13	0.38	0.63	0.87

Step 3: Collect spawning gravel samples at each randomly selected sample point with the McNeil core sampler.

a) Prior to taking sample, remove plunger and rinse sampler to ensure it is free of sediment and debris (Schuett-Hames et al. 1999).

b) Insert the McNeil Core sampler perpendicular to the streambed. Apply downward pressure and a rotating technique to work the sampler into the stream bed until the bottom of the cylinder is resting on top of the stream bed (Schuett-Hames et al. 1999).

c) If a successful core sample was not possible due to unseen obstructions, select another nearby sampling point, but insure it is 1m away from the failed or other selected sample points.

d) Excavate the McNeil core sample: Using bare hands or lightweight gloves (e.g. Atlas brand with rubberized gripping surfaces and mesh backs), excavate the McNeil sample into the sampler's donut shaped basin. Excavate spawning gravels down to the level of the stop ring. When excavating the sample follow the three recommendations of Schuett-Hames et al. (1999) to prevent fine sediment loss and bias in sample collection:

   (1) Keep fingers tightly closed when removing handfuls of sediment from the coring cylinder.

   (2) Scoop out rather than pluck out larger sediment particles.

   (3) Always rinse the excavating hand in the collection basin water between each excavation.

e) In cases where a larger particle extends above the stop ring, the particle can be removed and included on the sample (along with surrounding material) if it does not extend below the top of the coring teeth (Figure 1; Schuett-Hames et al. 1999). Where the particle extends past the top of the coring teeth, the sample must be discarded and another sample taken at a nearby sample point (Figure 1; Schuett-Hames et al. 1999).

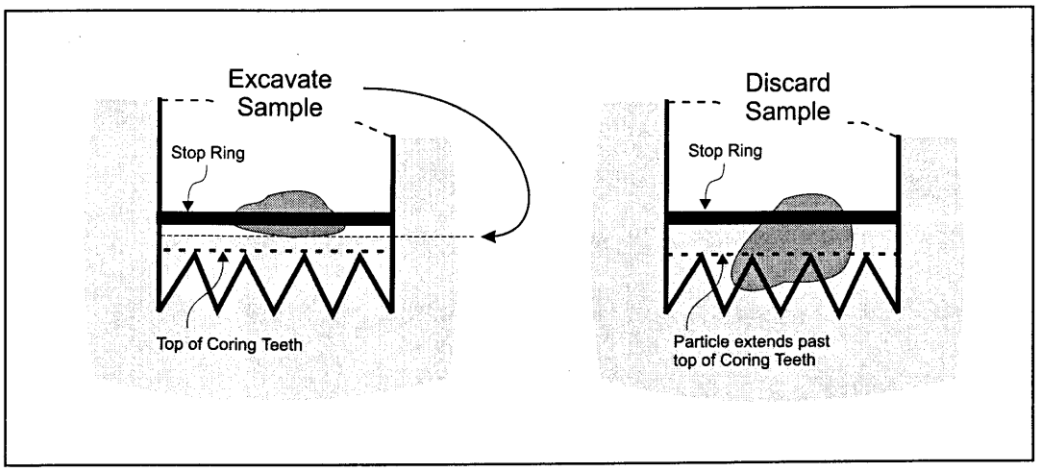

Figure 1. Protocol for treating large particles that extend below the stop ring (from Schuett-Hames et al. 1999).

f) Insert the Koski plunger into the coring cylinder, SLOWLY pushing it down until it comes to rest on the stop ring (Schuett-Hames et al. 1999).

Step 4: Transfer excavated sample to two 5 gallon buckets.

a) Ensure the 5 gallon bucket is clean of debris and sediment.

b) Transfer the water and sediment sample from the McNeil coring device by pouring the sample into the 5 gallon buckets.

c) Use wash bottles to rinse all particles on the inside of the sampler into the bucket that contains the sample. Take care to not include any sediment or debris from the outside of the sampler.

Step 5: Document and label sample, insert a sample tracking slip into the spawning gravel sample and tightly cover the sample bucket with a lid.

Section 6: Sample Processing

References:

Schuett-Hames et al. (1999).

Equipment:

Sieve processing station; sieves (12" diameter; minimum stack of 9 different sieve sizes) modified graduated cylinders; Imhoff cones; displacement flask; brushes; wide-mouth canning jar funnels; turkey baster; pressurized water supply and hose; rain gear; sediment sample data forms.

Concept:

There are two primary methods for processing McNeil core sediment samples, the volumetric processing method and the gravimetric processing method (Schuett-Hames et al. 1999). The UCMS (Hillman 2006) recommends that fine sediment monitoring programs in the Upper Columbia use the volumetric processing method which is also employed by the USFS in the Upper Columbia. This protocol therefore adopts the volumetric processing method that begins with the sorting of a McNeil sediment core sample into its respective size categories through the use of a series of stacked sieves oriented on a sieve processing station. The volume for each sediment size category is then determined through the use of a displacement flask. The total volume of fine sediment smaller than the sieve sizes used is established by the settling these sediments in a modified graduated cylinder or Imhoff cone.

Procedure:

Step 1: Ensure the sieve processing station and sieves are clean of all sediment and debris prior to use.

Step 2: A minimum of 9 sieves of the following sizes are to be used for sorting: 75.0 mm, 25.0 mm, 19.0 mm, 9.5 mm, 6.3 mm, 4.0 mm, 2.36 mm, 1.7, mm 1.0 mm, 0.85 mm, 0.50 mm.

Step 3: Stack the sieves in descending order so as the smallest sieve size is on the bottom and the largest sieve size in on the top. Place the nested sieve stack in the sieve holder of the sieve processing station (Schuett-Hames et al. 1999).

Step 4: Transfer the sediment sample and water from the 5 gallon storage buckets into the top sieve on the processing station. Do not dump the entire contents of a bucket into the sieve stack at once. Some shaking of the sieve stack may be required to transfer the entire sample.

Step 5: Process each sieve in order beginning with the largest mesh sized sieve on top of the sieve stack:

a) Gently shake and use pressurized water to pass sediment smaller than the sieve mesh size to the next sieve. Attempt to minimize the amount of water used to effectively process sediments as this adds to the total amount of water that must be processed to identify the volume of silts.

b) Once a sieve has been processed, remove it and the sediment it contains from the stack. Rinse any sediment on the bottom of the sieve, into the next sieve on the stack. Set the sieve and its contents aside to dry for a minimum of 15 minutes before using the sieve sample for volumetric measurements.

Step 6: After the last sieve is processed, allow 20 minutes for the finest sediment sizes to settle out of the catch basin and into the modified graduated cylinder (Schuett-Hames et al. 1999) or Imhoff cone. After 20 minutes, remove the modified cylinder or set aside, wait 60 minutes and then record the volume based upon the sediment line level (Schuett-Hames et al. 1999). Imhoff cones can alternatively be used to measure the volume of fine sediments from the catch basin. Record the size of this sediment sample as less than the size of the smallest sieve used in sediment processing.

Step 7: While sieved samples are drying, determine the largest particle in the sample and measure its intermediate diameter in millimeters and record the value on the data sheet for that sample. After a minimum of 15 minutes drying time for each sieve sample, determine the volume that each sieve sediment sample displaces using a displacement flask (Schuett-Hames et al. 1999). Ensure that all sediment in each sieve gets captured in the displacement flask. Transferring sediments from sieves to flask may benefit from the use of brushes, funnels and/or rinsing the sieve with water from the flask with the aid of a turkey baster. Ensure that volumes displaced are recorded and the displacement flask is zeroed out after each sieve sample is processed.

Section 7: Data Management

Data management framework

The ISEMP Data Management effort is designed to develop standardized tools and procedures for the organization, reduction, and communication of monitoring data and methods within ISEMP pilot basins located in the Wenatchee and Entiat subbasins, WA, John Day, OR, and Salmon River, ID. Beginning in 2004, a pilot project has been under development aimed at integrating four primary data management tools: Automated Template Modules (ATMs), the Status Trend and Effectiveness Monitoring Databank (STEM databank), Protocol Editor (PE), and the Aquatic Resources Schema (ARS). The STEM Databank is the central data repository

for the ISEMP project. It was developed by the Scientific Data Management Team at NOAA-Fisheries to: (1) accommodate large volumes of data from multiple agencies and projects; (2) summarize data based on how, when, and where data were collected; (3) support a range of analytical methods; (4) develop a web-based data query and retrieval system, and (5) adapt to changing requirements. This fully-normalized database structure allows the incorporation of new attributes or removal of obsolete attributes without modification of the database structure. Data can be summarized in a variety of formats to meet most reporting and analytical requirements.

Successful data management systems require a user interface that is intuitive to the user and that increase the efficiency of the user's workflow. The ATMs are a collection of forms that allow users to enter and view data in a format that is familiar to biologists. Each ATM has forms for entering new data, reviewing existing data, and updating existing data. Additionally, each ATM has a switchboard to help guide the user to the correct forms.

The general layout of the forms includes a header section to display information about the data collection event and a series of tabs that display detailed observational data. The header section describes the general characteristics about when, where, and how the data was collected or observed. The header section always includes the site, the start date and time, and the protocol. Additionally, the header section may include general characteristics about the sampling reach or unit, environmental conditions, weather conditions, water temperature and visibility, presence of fish, and protocol deviations. A series of tabs below the header section display detailed observations that occurred during the data collection event in spreadsheet format. Tabs vary between the different ATMs, but typically include a tab for crew and for equipment.

Data entry forms perform the critical function of validating data at the time of data entry. For categorical attributes, users are only allowed to select from acceptable categories as defined by the protocol. Similarly, values entered for continuous attributes are checked to ensure values are within the expected range. Data entry forms are "protocol aware". The database includes tabular data that specifies details about the protocol. All categorical fields on data entry forms have pull-down lists that limit the values a user can enter for the field. The pull-down lists reference the protocol documentation tables and only display values that are defined for the active protocol. Similarly, for continuous values, the forms check the expected range as defined in the protocol and warn the user if the entered value falls outside of the expected range. Users can choose to modify the value or accept the value as it was entered. The use of "soft" bounds on continuous values is an effective validation strategy for ecological data, where data often follows a normal distribution with long tails as opposite to a discrete distribution common to financial data.

The ATMs also apply an innovative approach to solving the species code issue. Short species code abbreviations are often used by field biologist to speed data recording in the field. However, every agency or program uses a uniquely defined set of species codes that are appropriate for their geographic location and data gathering requirements. When data containing these idiosyncratic species codes are submitted to regional data warehouses, the codes often become meaningless or indecipherable. A simple solution requires field biologist to define their species codes as tabular data in the database. The definition for each species code includes the

scientific name, life stage, age class, run, and origin. Scientific name is the only required field and the name must be recognized by a taxonomic authority. Forms in the ATMs allow users to select from the list of defined species codes. When a species code is selected, the forms store all five fields in the data table. This ensures that the definition of the code is never separated from the raw data and facilitates efficient analysis by allowing users to select or aggregate on any one of the five fields that make up a species code.

Protocol Editor is a data dictionary, user-friendly tool for describing the list of all attributes collected by a given protocol that includes a description of the data type, units of measure, number of characters or digits, number of decimal places, and list of acceptable values for all attributes collected by a protocol. Protocol Editor allows the ATM to be calibrated to a given protocol and allows the ATM to ensure consistency between the protocol and the data entered for that protocol. Protocol Editor follows the same rules established by Protocol Manager (a protocol documenting tool being developed by U.S. Bureau of Reclamation). A protocol is defined as a collection of methods, where each method consists of the list of attributes to be recorded by the data collector. The name of attributes is restricted to attributes defined by the ARS; however, users are allowed to create an alias name for the attributes. Metadata entered into Protocol Editor can easy be exported in a tabular format for importing into Protocol Manager.

The ARS is the collection of database tables that store data entered into the ATM forms. The ARS was developed to support agencies within the Columbia River Basin manage, document, and analyze aquatic resources data. The ARS aims to define a standardized data structure for storing and processing water quality, fish abundance, and stream habitat data. The ARS is robust against variations between data collection protocols, supports procedures for increasing data integrity at the time of data entry, and supports proper analysis and summarization of aquatic resources data.

Data handling

The field practitioners should be careful to avoid transposing errors when writing and entering data, and should be sure that all data is clearly legible. Practitioners should be in the practice of making photocopies of data sheets, and designating a copy as the Master Copy. The Master Copy can be edited by reviewers using red ink who should initialize and date any edits. Future copies of the Master Copy should either be made in color or clearly show these post-survey edits.

Data should be entered into the ATM provided by ISEMP on a regular basis by the data collectors and should undergo QA/QC before being sent to the ISEMP coordinator, and the Upper Columbia Data Steward for uploading into the STEM Databank.

Data Analysis

This section is under development by the ISEMP data analysis team and will be included in the next revision of the working draft.

Data Reporting

The data collection agencies are responsible for preparing an annual report that will follow the outline below covering the fine sediment monitoring period:

1. Brief abstract (limit 600 words).

2. Standard introduction provided by ISEMP plus brief description of specific project(s) covered in report.

3. Concise description of project area/map.

4. Description of methods and materials used to perform tasks.

5. Summary of results, including:

   a) Percent fines (and confidence intervals), geometric mean particle size, and fredle index by monitoring site / reach for the current year.

   b) Trends in mean percent fines by site/reach.

   c) Brief discussion of results by task (problems encountered, suggestions for future work).

6. If necessary, supplemental electronic copies of summarized field data in spreadsheet or GIS format.

The annual report shall be submitted to the BPA Project Manager/COTR and ISEMP coordinator. Guidelines for preparing the report can be found at http://www.efw.bpa.gov/Integrated_Fish_and_Wildlife_Program/ReportingGuidelines.pdf. The Upper Columbia Data Steward is responsible for generating an annual report to the Watershed Action Teams, Project Sponsors and monitoring agencies that will include a summary of the fine sediment monitoring efforts by tributary and subbasin. Reporting procedures are provided in SOP #6 Data Analysis and Reporting.

Section 8: References

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Appendix A: Attribute Table

This section is under development and will be included in the document in the next revision of the working version.

Appendix B: Datasheets

Sample Processing Dataforms

(Modified from dataforms used by the USFS in the Wenatchee and Entiat Rivers)

OBSERVERS_____

DATE CORED_____DATE SCREENED_____DATE ENTERED_____

STREAM_____SAMPLE LOCATION_____

SITE #

TRANSECT #

SAMPLE #

SIEVE DIAMETER	**SIEVE NUMBER**	VOLUME DISPLACED (mL)	TOTAL DISPLACED (mL)
75.0 mm	**1**		
25.0 mm	**2**		
19.0 mm	**3**		
9.5 mm	**4**		
6.3 mm	**5**		
4.0 mm	**6**		
2.36 mm	**7**		
1.7 mm	**8**		
1.0 mm	**9**		
0.85 mm	**10**		
0.50 mm	**11**		
silts			
DIAMETER OF LARGEST PARTICLE IN SAMPLE (mm)			

SITE #

TRANSECT #

SAMPLE #

SIEVE DIAMETER	**SIEVE NUMBER**	VOLUME DISPLACED (mL)	TOTAL DISPLACED (mL)
75.0 mm	**1**		
25.0 mm	**2**		
19.0 mm	**3**		
9.5 mm	**4**		
6.3 mm	**5**		
4.0 mm	**6**		
2.36 mm	**7**		
1.7 mm	**8**		
1.0 mm	**9**		
0.85 mm	**10**		
0.50 mm	**11**		
silts			
DIAMETER OF LARGEST PARTICLE IN SAMPLE (mm)			

SEDIMENT CORE SAMPLING RECORDS SHEET

RIVER	SITE #	TRANSECT #	SAMPLE #	DATE CORED	DATE SIEVED	DATA ENTRY	COMMENTS

Appendix C: Revising the Protocol

As new information becomes available and fine sediment monitoring efforts are refined, the protocol will be revised. Effectively tracking past and current protocol versions are important for data summaries and analyses that utilize data collected under different protocol versions. Protocol Editor will house previous and current protocol versions and the dates of their implementation. Reviews will be performed for all proposed changes to the protocol and the Upper Columbia Data Steward notified so the version number can be recorded in the project metadata and any necessary changes can be made to database structure (Peitz et al. 2002).

Consistent with the recommendations of Oakley et al. (2003) this protocol includes a log of its revision history. The revision history log (adapted from Peitz et al. 2002) will track the protocol version number, revision dates, changes made, the rationale for the changes, and the author that made the changes. Revisions or additions to existing methods will be reviewed by ISEMP staff prior to implementation. Major revisions such as a complete change in methods will necessitate a broader review by outside technical experts. When the protocol warrants significant changes the protocol version and date on the title page should be updated to reflect the new version. Version numbers should increase incrementally by hundreths (e.g., Version 1.01, 1.02 etc.) for minor changes and by the next whole number (e.g., version 2.0, 3.0 etc.) for major changes (Peitz et al. 2002).

Protocol Revision History Log

Previous Version #	New Version #	Revision Date	Author	Changes Made	Reason for Change