



Fisheries and Habitat Monitoring Plan



Henry M. Jackson
Hydroelectric Project
(FERC No. P-2157)



September 2010

**Updated per September 2, 2011
License Article 410**

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ACRONYMS

A-LA	Aquatic License Article
ARC	Aquatic Resource Committee
FERC	Federal Energy Regulatory Commission
HEA	Habitat Enhancement Account
MCS	Marsh Creek Slide
PM&E	Protection, mitigation and enhancement
RM	River mile
RSP	Revised Study Plan
USFS	United States Forest Service

1. INTRODUCTION

1.1. Background

The Public Utility District No. 1 of Snohomish County (District) is seeking from the Federal Energy Regulatory Commission (FERC) a new license for the existing 111.8-megawatt (MW) Henry M. Jackson Hydroelectric Project (FERC No. 2157) (Project). The original license expires May 31, 2011. The Project is located on the Sultan River in Snohomish County, Washington, near the City of Sultan. The Project was originally licensed in 1961 and amended in 1981. In 1964, construction of Culmback Dam was completed to create Spada Lake Reservoir – the source of 80% of the drinking water supplied to Snohomish County by the City of Everett. In 1984, construction of the hydroelectric portion of the Project as it exists today was completed. The Project includes a 262-foot high rock-fill dam (Culmback Dam); a 1,870-acre reservoir (Spada Lake or Spada Reservoir) operated for the City of Everett’s water supply, fisheries habitat enhancement, hydroelectric power generation, and incidental flood control; a Powerhouse and various other facilities; wildlife mitigation lands; and several developed and undeveloped recreation and river access sites.

On October 14, 2009, the District filed a comprehensive settlement agreement (Settlement Agreement) on behalf of itself, National Marine Fisheries Service, United States Forest Service, United States Fish and Wildlife Service, United States National Parks Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, the Tulalip Tribes of Washington, the City of Everett, Snohomish County, the City of Sultan and American Whitewater (collectively referred to as “Settlement Parties”). The Settlement Agreement resolved among the signatories all issues associated with issuance of a new license for the Project, including reservoir operation, minimum instream flows, process flows, whitewater boating flows, ramping rates, fish passage, fish habitat improvements, wildlife habitat management, marbled murrelet protection measures, recreation, historic properties and license term.

The Settlement Agreement requests that the Commission adopt, without material modification, a set of Proposed License Articles. These Proposed License Articles will implement a complex and interrelated suite of protection, mitigation and enhancement measures that will result in improved resource conditions and ecological processes in the Sultan River over the term of a new license. The Proposed License Articles mainly address flows, fish passage, fish and wildlife habitat enhancement and protection, water quality, municipal water supply, rule curves for reservoir operation, fish supplementation, recreation, historic properties, and noxious weeds.

Proposed Aquatic License Article (A-LA 17) provides for the development of this Fisheries and Habitat Monitoring Plan (“FHM Plan” or “Plan”) (see Appendix 1). The Plan was developed with the Aquatic Resources Committee (ARC) in consideration of the following guidelines: (a) monitoring and studies will be relevant to the License, (b) monitoring and studies will be chosen and conducted so that they provide useful information for Project management decisions or establishing compliance with License conditions, and (c) monitoring and studies will be cost-effective in meeting the specific purpose of the monitoring activity.

On September 2, 2011, the FERC issued a 45-year license for the Jackson Project (License). Article 410 of the License approves the FHM Plan submitted to the FERC on September 2, 2010 with modifications to Section 4.1 and Section 4.2 (see Appendix 1B); this version of the FHM Plan reflects those required modifications.

1.2. Purpose

The purpose of the FHM Plan is to inform the implementation of other aquatic License Articles and addresses fishery and aquatic habitat monitoring requirements not identified in other management plans. The FHM Plan includes provisions that address:

1. periodic monitoring and characterization of riverine habitat in the Sultan River to assess the performance of restoration and enhancement efforts and the affect of Project operations on fish habitat conditions;
2. monitoring of water temperature in the Sultan River basin consistent with the protocols outlined in the Water Quality Protection Plan (WQPP) to inform the biological data collected through separate monitoring efforts (i.e., date of initiation of spawning, incubation rates, emergence timing, juvenile size / growth rates, habitat utilization, and fish distribution);
3. the conducting of annual spawning surveys (spring and fall) using standard methods employed in the region (see Appendix 3) to assess species presence, abundance, distribution, timing, and run composition;
4. the installation and operation of a juvenile fish (smolt) trap in the lower Sultan River to assess juvenile salmonid production and timing of outmigration in the Sultan River; and
5. supplemental site specific assessments of juvenile fish distribution, abundance, and habitat utilization relative to habitat restoration and enhancement projects and project operations.

Monitoring long-term changes in fish habitat, water temperatures, adult salmon and steelhead distribution and abundance, and juvenile salmonid production, distribution and habitat utilization over the term of a new License will enable the District and the ARC to evaluate the effectiveness of habitat modifications and/or alterations in Project operations outlined in the aquatic resource License Articles. In addition, information resulting from monitoring will likely generate a library of data that can be used to inform decisions about Project operations throughout the new License period, and to evaluate the need for future habitat enhancements or modifications.

For purposes of implementing the FHM Plan, each year is defined on a calendar year basis (i.e., January through December). Where years are specified, Year 1 is the first year after this Plan is approved.

Supplemental site specific assessments of juvenile fish distribution, abundance, and habitat utilization relative to habitat restoration and enhancement projects and project operations will be conducted under project-specific management plans. Monitoring of Fish Habitat Enhancement Plan Habitat Enhancement Account-funded projects will be addressed within the individual plan for such projects. Such surveys will use techniques such as snorkeling and/or backpack electrofishing surveys. The surveys will be subject to obtaining appropriate permits, and conducted to evaluate such things as fish distribution, utilization and relative abundance in side channel habitats. The specifics regarding these surveys will be included in the monitoring section of the Large Woody Debris/Side Channel Enhancement Plan.

1.3. Coordination and Integration

1.3.1. District's Role

Upon issuance of the new license and approval of the FHM Plan, the District will be responsible to implement the FHM Plan. This responsibility will include:

- providing the funding to carry out the measures as described herein;

- coordinating with surrounding landowners regarding land management in or near the Project boundary that may affect or be affected by the measures provided;
- consulting with the ARC;
- monitoring resource effects; and
- reporting to the FERC.

The District's resource specialists and consultants will be involved as needed.

1.3.2. ARC Involvement

The District will meet quarterly with the ARC on license implementation measures. As necessary, these meetings will address outstanding issues associated with the implementation of this Plan. Where this Plan requires consultation with or review by the ARC, such involvement will typically occur during these quarterly meetings. The District may consult or seek input from the ARC on an as-needed, issue-specific basis as well.

2. MONITORING OF FISH HABITAT IN THE SULTAN RIVER

2.1. Riverine Habitat Monitoring

2.1.1. Purpose

The purpose of the riverine fish habitat monitoring program is to characterize and quantify habitat types (including side channel, riparian, and flood plain) in the Sultan River to determine how habitat restoration efforts and Project operations affect fish habitat conditions over the life of the License. Because the majority of the restoration efforts are focused in the alluvial portion of Reach 1, the comprehensive habitat monitoring program will focus primarily on habitat changes in the Sultan River downstream of River Mile (RM) 2.7. Surveys of habitat upstream of RM 2.7 will rely on aerial photography and discrete site specific characterizations (as described in the Process Flow Plan section 4.1).

2.1.2. Method

The District will assess the quantity and quality of fish habitat in the lower Sultan River (downstream of River Mile (RM) 2.7) by employing standard Timber, Fish and Wildlife (TFW) Agreement (*Pleus et al 1999*) or comparable methods, consistent with the recent assessment of the Sultan River conducted under relicensing Revised Study Plan 18 (see Appendix 3). The District will assess habitat units, such as pools, riffles and glides, substrate composition, gradient, channel exposure, woody debris, bank stability, and riparian vegetation content. The District will use a statistically-valid approach consistent with the TFW methods in assessing both the quantity and quality of habitat, and in enabling detection of changes to habitat condition between sampling events. The District will conduct surveys during late summer to assess conditions under low flows and for consistency between surveys.

The existing baseline habitat information for the river channel downstream of Culmback Dam is already divided into distinct process reaches based on channel morphology and habitat types. Analysis and data summarization will be performed consistent with these reach boundaries, as appropriate with survey methods employed.

2.1.3. Frequency

The initial habitat survey conducted as part of the relicensing studies (Study Plan 18, Stillwater 2008) will constitute the baseline for all subsequent surveys including the lower river comprehensive surveys and the site specific surveys in the remainder of the river.

During Year 1 through Year 10, if there is a high flow event or other major event causing change, the District will perform a subsequent habitat survey of the lower river. From Year 11 throughout the term of the License, the District will perform habitat surveys once every five years (starting in Year 16) unless the frequency of such surveys is modified by the ARC.

2.2. Water Temperature Monitoring

2.2.1. Purpose

The purpose of water temperature monitoring is to document temperature regimes in the Sultan River basin, within each reach, and in the receiving waters downstream. This data is needed to help analyze the biological information collected through separate monitoring efforts (i.e., date of initiation of spawning, incubation rates, emergence timing, juvenile size / growth rates, habitat utilization, and fish distribution).

2.2.2. Method

Consistent with protocols outlined in the Water Quality Protection Plan, the District will monitor water temperatures on 30-minute intervals in the Sultan River at the South Fork Sultan River, the base of Culmbach Dam, upstream and downstream of the Diversion Dam, upstream and downstream of the Powerhouse, at the confluence with the Skykomish River, and in the Skykomish River immediately upstream and downstream of the confluence with the Sultan River (Figure 1). The District will use the existing USGS gaging stations in the South Fork Sultan River (12137290) and downstream of the Diversion Dam (12137800) for collecting temperature data; the District will install and maintain thermographs at all other locations identified above.

2.2.3. Frequency

The District will monitor the thermographs and USGS gaging stations at the above-listed locations in the Sultan River continuously throughout the term of the License, unless the frequency or locations of monitoring are modified by the ARC.

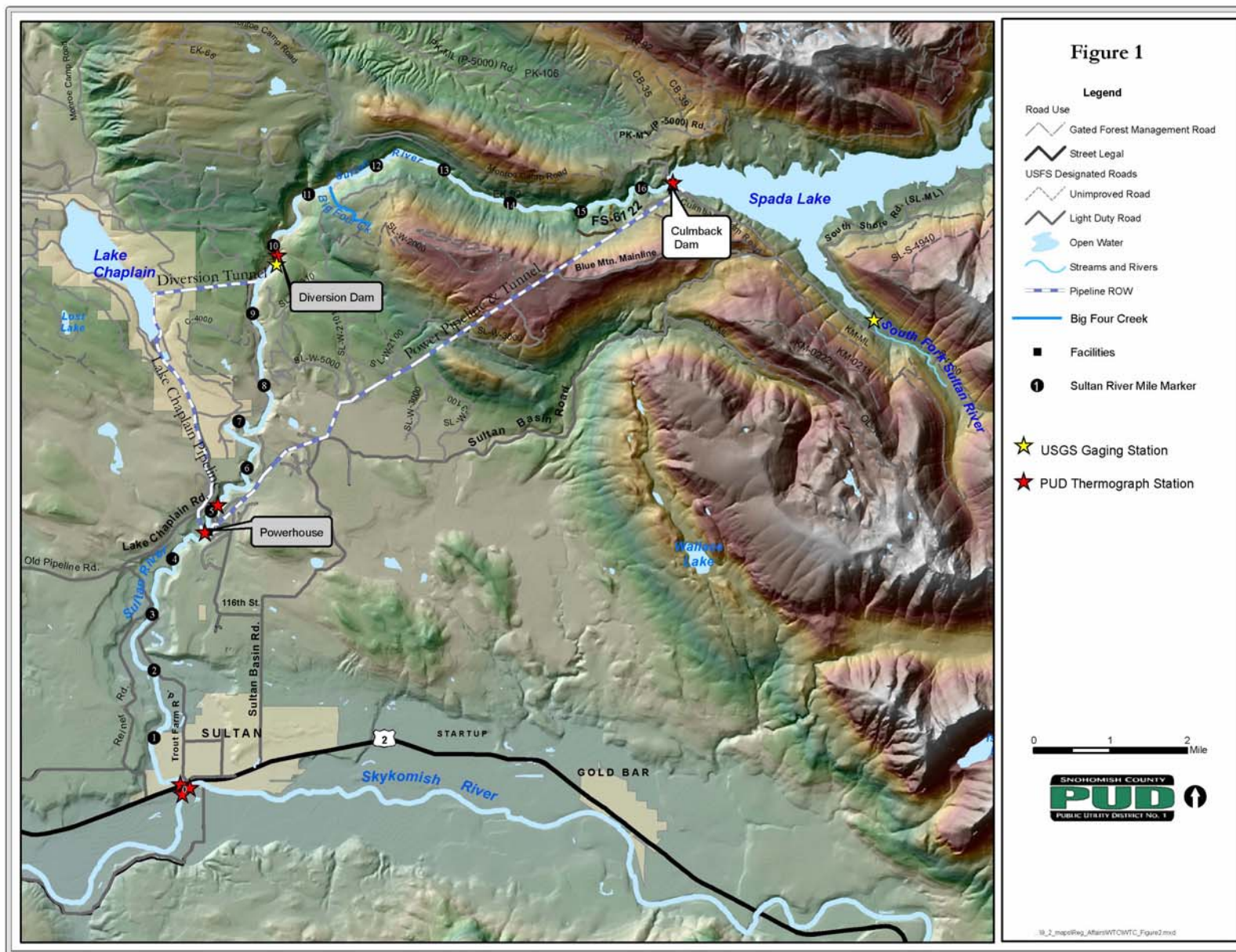


Figure 1. Water temperature monitoring locations.

3. MONITORING OF FISH POPULATIONS IN THE SULTAN RIVER

3.1. Spawner Abundance, Distribution, and Timing in the Sultan River

3.1.1. Purpose

The purpose of assessing spawner abundance, distribution, and timing is to evaluate trends in adult salmon and steelhead escapement and habitat utilization over the term of the License.

3.1.2. Method

The District will conduct surveys consistent with methods employed in the State of Washington to assess species presence, abundance, distribution, timing, and run composition. These methods will be locally modified and adapted for conditions in the Sultan River, survey needs and resource objectives. These methods will be applied consistently over the term of the License, unless modified by the ARC. See Appendix 3.

Such surveys will enumerate redds and/or fish (live and dead) depending on species and location within the river. Such surveys will be conducted using one or more of the following techniques depending on species and location within the river: foot surveys, raft surveys, and helicopter surveys. Where possible and for data consistency and compatibility, these surveys will use the same index areas and procedures used under the original license and in place since 1991 (Figure 2). An additional index area will be established upstream of the Diversion Dam when fish passage is instituted.

The District will collect, compile, analyze and report the following: (1) spawner abundance by species, production origin (hatchery versus wild), and location; (2) species distribution; and (3) spawning timing. The District will share data and the development of final escapement numbers in cooperation with WDFW and the Tulalip Tribes.

3.1.3. Frequency

The District will conduct assessments annually during the spawning seasons for each species throughout the term of the License.

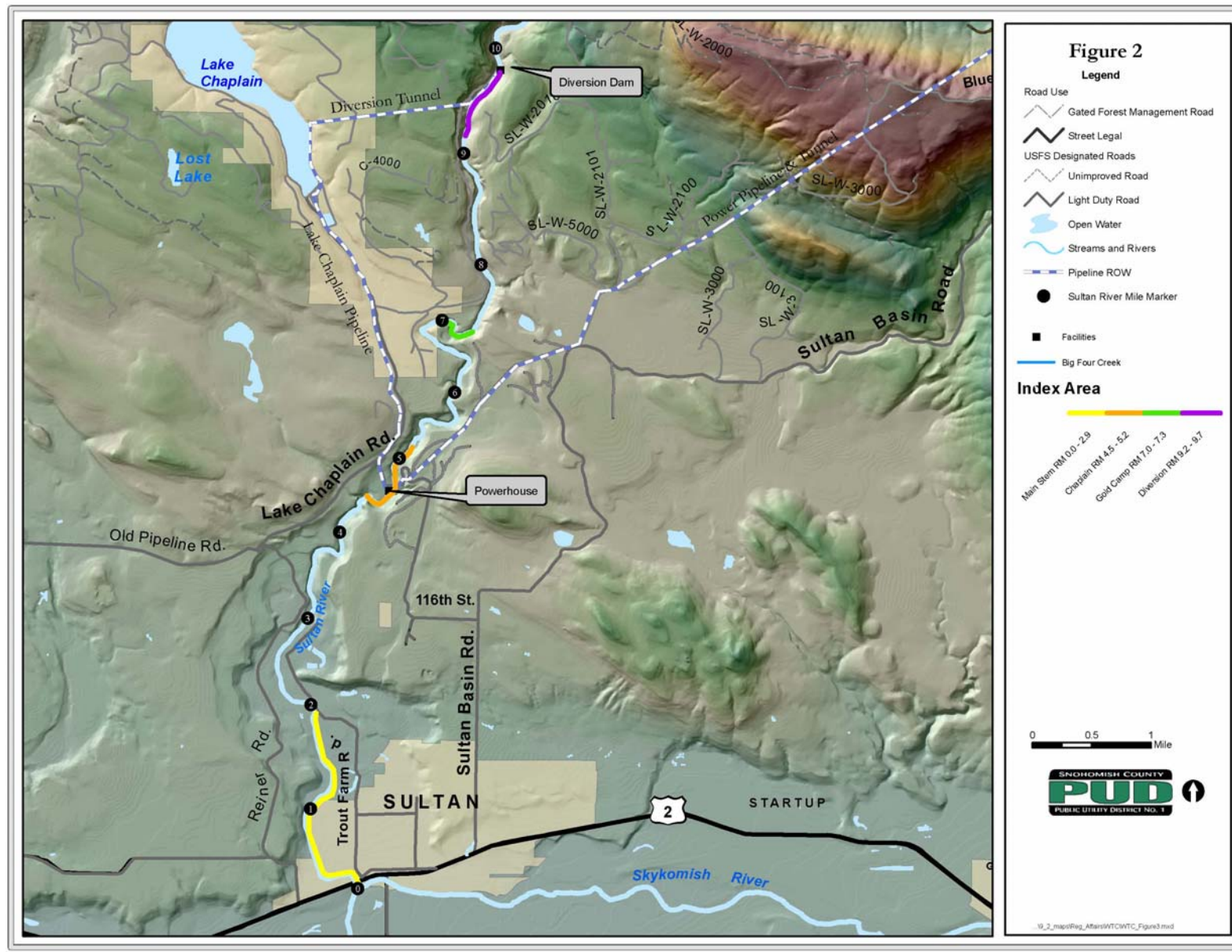


Figure 2. Index area locations for spawning surveys.

3.2. Juvenile Production in the Sultan River

3.2.1. Purpose

The purpose of assessing juvenile production in the Sultan River is to evaluate reproductive success relative to habitat restoration and enhancement efforts and to Project operations over the term of the License. The distribution and habitat utilization by juvenile salmonids will be assessed as part of the monitoring tied to the side channel and large woody debris enhancement projects.

3.2.2. Method

The District will install and operate a juvenile (smolt) trap in the lower mile of the Sultan River to assess natural salmonid production in the Sultan River.

The District will collect, compile, analyze and report the following trap data by species and life stage: number captured, size distribution, timing (diel and seasonal), fish population estimates and trap efficiency.

3.2.3. Frequency

The District will operate the juvenile trap to assess juvenile production annually in the Sultan River for the first six years after License issuance and then two out of every six years thereafter for the term of the License.

The District will operate the trap during the period that juveniles are expected to emigrate from the Sultan River. During Years 1 and 2, the District will operate the trap beginning February 1 through June 30. Based upon the results obtained during Years 1 and 2, thresholds to reduce sampling days and periods will be developed by the ARC for subsequent years. The goal is to have sampling sufficient to encompass at least 90 percent of the out-migration period.

The District will operate the trap between 30 and 40 percent of the hours in any given week and follow standard procedures employed by WDFW and the Tulalip Tribes (see Appendix 5), except that the trap will not be operated during severe flow events. During Years 1 and 2, such operations will include weekends. After such time, unless the sampling results indicate such operations are necessary, the trap will not be operated on weekends. Traps will be scheduled to fish for four day and four night periods per week. Each fishing period will last a minimum of six hours. This operation schedule may be adjusted by the ARC if an alternative sampling schedule produces acceptable data for assessing juvenile production. Also, during periods when few fish are emigrating, trapping frequency can be reduced to fewer days per week. Exact scheduling will be determined by the ARC.

With respect to the juvenile fish trap, the District will operate the trap during the juvenile outmigration process flow component and any associated whitewater boating event during the survey window between February and June.

4. REPORTING

4.1. Schedule and Contents

The District will file with the FERC, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year. **Per Article 410, the annual report will include:**

- a. documentation of compliance with the monitoring and maintenance requirements of the side channel enhancement measures implemented pursuant to License Appendix A, condition 5.2 (A-LA 7);
- b. a description of any deviations from the 550-cfs Chinook salmon spawning flow ceiling required by License Appendix A, condition 5.2 (A-LA 5);
- c. a description of any documented dewatering of Chinook salmon redds during the September through January Chinook salmon spawning and fry emergence period;
- d. a description of any proposed corrective actions if any flow-ceiling exceedances occur; and
- e. documentation of consultation with the National Marine Fisheries Service, the Forest Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Tulalip Tribes, Snohomish County, City of Everett, City of Sultan, and American Whitewater (Aquatic Resource Committee, as it may be revised in accordance with License Appendix B, condition 2 (A-LA 1)), including copies of comments and recommendations on the report after it has been prepared and provided to the Aquatic Resource Committee, and specific descriptions of how the Aquatic Resource Committee's comments are accommodated by the report. If the District does not adopt a recommendation, the filing will include the District's reasons based on project-specific information.

The ARC will have at least 30 days to review and comment on the draft report prior to the District filing it with the FERC. The District will provide copies of the annual report to the ARC.

By December 1 of each year, the District will file with the FERC a notice describing the monitoring activities required under the Plan for the following year.

4.2. Plan Review and Updates

The ARC may modify the monitoring program methods and frequencies of data collection to more effectively meet the specific purpose of a monitoring activity. The District will review and update this Plan at least every five years to reflect these modifications. The ARC will have at least 30 days to review and comment on the draft Plan prior to the District filing it with the FERC.

Per Article 410 of the License, for any plan update developed in accordance with this Section the District will include:

- a. documentation of consultation with the Aquatic Resource Committee;
- b. copies of comments and recommendations on the updated plan after it has been prepared and provided to the Aquatic Resource Committee; and
- c. specific descriptions of how the Aquatic Resource Committee's comments are accommodated by the plan. If the District does not adopt a recommendation, the filing will include the District's reasons based on project-specific information.

In Article 410, the FERC also reserved the right to require changes to the plan. Implementation of an updated plan will not begin until the plan is approved by the FERC. Upon FERC approval, the District will implement the plan, including any changes required by the FERC.

5. SCHEDULE

Task	Timing
Annual Report of previous year data (see section 4.1)	by June 30 each year
Annual Report of following year plans (see section 4.1)	by December 1 each year
Riverine habitat monitoring (see section 2.1.3)	Years 1 through 10 after each high flow or habitat changing event; then Years 16 and every 5 years thereafter through term of license
Water temperature monitoring (see section 2.2.3)	Annually Years 1 through term of license
Spawner abundance, distribution, and timing monitoring (see section 3.1.3)	Annually during spawning season starting Year 1 through term of license
Juvenile production monitoring (see section 3.2.3)	Annually during first six years starting Year 1 then two out of every six years thereafter for the term of the license

6. REFERENCES

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

Stillwater Sciences and Meridian Environmental. 2008. Study Plan 18: Riverine, Riparian, and Wetland Habitat Assessment Technical Report. Prepared for Public Utility District No. 1 of Snohomish County. March.

Appendix 1

Proposed License Article

A-LA 17: Fisheries and Habitat Monitoring Plan

Within one (1) year after License issuance, the Licensee shall file with the Commission, for approval, a Fisheries and Habitat Monitoring Plan (FHM Plan) for the Sultan River. The Licensee shall implement the FHM Plan throughout the term of the License, in consultation with Aquatic Resource Committee (ARC).

The Licensee shall develop the FHM Plan in consultation with the ARC. The Licensee shall allow a minimum of thirty (30) days for members of the ARC to comment and make recommendations before submitting the FHM Plan to the Commission. When filing the FHM Plan with the Commission, the Licensee shall include documentation of consultation, copies of comments and recommendations, and specific descriptions of how comments and recommendations from the ARC are accommodated by the Licensee's plan. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons based upon Project-specific information.

The purpose of the FHM Plan is to inform the implementation of other aquatic License Articles. The FHM Plan shall include a schedule for the Licensee's: (1) implementation of the plan consistent with this License Article; (2) consultation with the ARC regarding the results of the monitoring and a schedule for providing preliminary monitoring data; and (3) filing of results, comments, and the Licensee's response to these comments with the Commission.

Implementation of the plan shall not commence until the Licensee is notified by the Commission that the filing is approved. Upon Commission approval, the Licensee shall implement the plan.

The Licensee shall file with the Commission, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year. By December 1 of each year, the Licensee shall file with the Commission a notice describing the monitoring activities required under the plan for the following year. The ARC shall have at least thirty (30) days to review and comment on the draft report prior to filing with the Commission. The Licensee shall provide copies of the annual report to the ARC.

As provided below, the ARC may modify the monitoring program methods and frequencies of data collection and reporting requirements to more effectively meet the specific purpose of a monitoring activity.

The following guidelines shall be used in developing and implementing the FHM Plan: (a) monitoring and studies shall be relevant to the License, (b) monitoring and studies shall be chosen and conducted so that they provide useful information for Project management decisions or establishing compliance with License conditions, and (c) monitoring and studies shall be cost-effective in meeting the specific purpose of the monitoring activity.

For purposes of implementing the FHM Plan, each year is defined on a calendar year basis (i.e., January through December). Except as provided in other License Articles, this Plan covers monitoring and studies to be conducted by the Licensee during all years through the term of the License. Monitoring of A-LA 12 habitat projects shall be addressed within the Plan for such projects. Where years are specified, Year 1 is the first year after the Plan is approved.

The FHM Plan shall consist of monitoring the following:

7. Fish Habitat in the Sultan River

7.1. Riverine Habitat

7.1.1. Purpose

The purpose of the riverine fish habitat monitoring program is to characterize and quantify habitat types (including side channel, riparian, and flood plain) in the Sultan River to determine how habitat restoration efforts and Project operations affect fish habitat conditions over the life of the License. Because the majority of the restoration efforts are focused in the alluvial portion of Reach 1, the habitat monitoring program shall focus primarily on habitat changes in the Sultan River downstream of River Mile (RM) 2.7.

7.1.2. Method

The Licensee shall assess the quantity and quality of fish habitat in the lower Sultan River by employing standard Timber, Fish and Wildlife (TFW) Agreement (*Pleus et al 1999*) or comparable methods, consistent with the recent assessment of the Sultan River conducted under relicensing Study Plan 18. The Licensee shall assess habitat units, such as pools, riffles and glides, substrate composition, gradient, channel exposure, woody debris, bank stability, and riparian vegetation content. The Licensee shall use a statistically-valid approach consistent with the TFW methods in assessing both the quantity and quality of habitat, and in enabling detection of changes to habitat condition between sampling events. The Licensee shall also use digital photography to document conditions at a series of fixed permanent photo points. The Licensee shall conduct surveys during late summer to assess conditions under low flows and for consistency between surveys.

The river channel of interest is already divided into distinct process reaches based on channel morphology and habitat types consistent with existing baseline habitat information. Analysis and data summarization shall be performed consistent with these reach boundaries.

7.1.3. Frequency

The initial habitat survey as part of the relicensing studies (Study Plan 18) shall constitute the initial baseline for all subsequent surveys.

During Year 1 through Year 10, if there is a high flow event or other major event causing change, the Licensee shall perform a subsequent habitat survey. From Year 11 throughout the term of the License, the Licensee shall perform habitat surveys once every five (5) years (starting in Year 16) unless the frequency of such surveys is modified by the ARC.

1.2. Water Temperature

1.2.1. Purpose

The purpose of water temperature monitoring is to document temperature regimes in the Sultan River. This data is needed to help analyze the biological information collected through separate monitoring efforts (i.e., spawning timing, emergence timing, juvenile size or growth rates, distribution, habitat utilization, and species interactions).

1.2.2. Method

The Licensee shall install thermographs to monitor water temperatures on an hourly basis in the Sultan River at the South Fork Sultan River, the base of Culmback Dam, upstream and downstream of the Diversion Dam, upstream and downstream of the Powerhouse, at the

confluence with the Skykomish River, and in the Skykomish River immediately upstream and downstream of the confluence with the Sultan River.

1.2.3. Frequency

The Licensee shall deploy, operate and maintain thermographs at the above-listed locations in the Sultan River continuously throughout the term of the License, unless the frequency of monitoring or locations are modified by the ARC.

8. Fish Populations in the Sultan River

8.1. Spawner Abundance, Distribution, and Timing in the Sultan River

8.1.1. Purpose

The purpose of assessing spawner abundance, distribution, and timing is to evaluate trends in adult salmon and steelhead escapement and habitat utilization over the term of the License.

8.1.2. Method

The Licensee shall conduct surveys using standard methods employed in the region to assess spawner abundance, spawner distribution, spawning timing, and species composition.

Such surveys shall enumerate redds and/or fish (live and dead) depending on species and location within the river. Such surveys shall be conducted using one or more of the following techniques depending on species and location within the river: foot surveys, raft surveys, and snorkel surveys. Where possible and for data consistency and compatibility, these surveys shall use the same index areas and procedures used under the current License and in place since 1991. It is expected that methods and procedures that work best to achieve the purpose shall be evaluated during the first several years of the License. Once the methods have been evaluated and the most appropriate ones selected, they shall be applied consistently over the term of the License, unless modified by the ARC.

The Licensee shall collect, compile, and report the following: (1) spawner abundance by species, production origin (hatchery versus wild), and location; (2) species distribution; and (3) spawning timing.

The Licensee shall include in the FHM Plan provisions for appropriate and reasonable analysis of data from the above surveys. The Licensee shall implement such provisions.

8.1.3. Frequency

The Licensee shall conduct assessments annually during the spawning seasons for each species throughout the term of the License.

8.2. Juvenile Production, Distribution, and Habitat Utilization in the Sultan River

8.2.1. Purpose

The purpose of assessing juvenile production, distribution, and habitat utilization in the Sultan River is to evaluate reproductive success and species behavior over the term of the License.

8.2.2. Method

The Licensee shall install and operate a juvenile trap in the lower Sultan River to assess natural salmonid production in the Sultan River.

The Licensee shall collect, compile, analyze and report the following juvenile trap data by species and life stages: numbers of fish caught, timing, fish population estimates, hatchery and wild composition, size distribution, and trap efficiency.

Under circumstances defined in the monitoring plan, the Licensee shall conduct supplemental assessments using snorkeling and/or backpack electrofishing surveys, subject to obtaining appropriate permits, to evaluate such things as rearing, fish distributions, relative abundance, habitat utilization, size, and life stage survival.

8.2.3.Frequency

The Licensee shall operate the juvenile trap to assess juvenile production annually in the Sultan River for the first six (6) years after License issuance and then two (2) out of every six (6) years thereafter for the term of the License.

The Licensee shall operate the trap during the period that juveniles are expected to emigrate from the Sultan River. During Years 1 and 2, the Licensee shall operate the trap beginning February 1 through June 30. Based upon the results obtained during Years 1 and 2, thresholds to reduce sampling days and periods shall be developed by the ARC for subsequent years. The goal is to have sampling sufficient to encompass at least 90 percent of the out-migration period.

The Licensee shall operate the trap between 30 and 40 percent of the hours in any given week and follow standard procedures employed by WDFW and the Tulalip Tribes, except that the trap shall not be operated during severe flow events. During Years 1 and 2, such operations shall include weekends. After such time, unless the sampling results indicate such operations are necessary, the trap shall not be operated on weekends. Traps shall be scheduled to fish for four (4) day and four (4) night periods per week. Each fishing period shall last a minimum of six (6) hours. This operation schedule may be adjusted by the ARC if an alternative sampling schedule produces acceptable data for assessing juvenile production. Also, during periods when few fish are emigrating, trapping frequency can be reduced to fewer days per week. Exact scheduling shall be determined by the ARC.

The following text is an excerpt of the Joint Explanatory Statement regarding the Proposed License Article above:

P. Article A-LA 17: Fisheries and Habitat Monitoring Plan

The Fisheries and Habitat Monitoring Plan ("FHM Plan") (A-LA 17) was not included in the License Application; however, it does incorporate several monitoring PM&Es that were proposed in the License Application (e.g., annual salmon and steelhead spawning surveys and water temperature monitoring). Specifically, the FHM Plan will include provisions to (1) periodically monitor and characterize riverine fish habitat (including side channel, riparian, and floodplain habitats) in the Sultan River to determine how habitat restoration efforts and Project operations affect fish habitat conditions; (2) monitor water temperature in the Sultan River to help analyze the biological information collected through separate monitoring efforts (i.e., spawning timing, emergence timing, juvenile size or growth rates, distribution, habitat utilization, and species interactions); (3) conduct annual surveys using standard methods

employed in the region to assess spawner abundance, spawner distribution, spawning timing, and species composition; and (4) install and operate a juvenile fish trap in the lower Sultan River to assess juvenile salmonid production, distribution, and habitat utilization in the Sultan River.

With respect to the juvenile fish trap, the Settlement Parties anticipate that the District will operate the trap during the juvenile outmigration process flow component (and any associated whitewater boating event).

The monitoring pursuant to this License Article will be in addition to any monitoring required by other License Articles. For example, as a component of its monitoring pursuant to the Recreation Plan, the District will post the Spada Lake Reservoir elevation data on its website. The posting of this data will not only inform the use of the reservoir's boat ramps, but also provide important information for flood (spill) awareness and whitewater boaters.

The District will file with the Commission, by June 30 of each year, an annual report fully describing the monitoring efforts of the previous calendar year. By December 1 of each year, the District will file an annual plan with the Commission describing the monitoring activities required for the following year. The District will also provide copies of the annual report and annual plan to the ARC.

Monitoring long-term changes in fish habitat, water temperatures, adult salmon and steelhead distribution and abundance, and juvenile salmonids production, distribution and habitat utilization over the term of a new License will enable the District and the ARC to evaluate the effectiveness of habitat modifications and/or alterations in Project operations outlined in the aquatic resource License Articles. In addition, information resulting from monitoring will likely generate a library of data that can be used to inform decisions about Project operations throughout the new License period, and to evaluate the need for future habitat enhancements or modifications.

Appendix 1B
License Article 410
per the FERC-Issued License on September 2, 2011

Article 410. Fisheries and Habitat Monitoring Plan. The Fisheries and Habitat Monitoring Plan, filed on September 2, 2010, as referenced by Appendix A, condition 5.2 (A-LA 17), and Appendix B, condition 5.2 (A-LA 17), is approved and shall be implemented with the following modifications:

(1) the annual report described in section 4.1 of the plan shall include (a) documentation of compliance with the monitoring and maintenance requirements of the side channel enhancement measures implemented pursuant to Appendix A, condition 5.2 (A-LA 7); (b) a description of any deviations from the 550-cfs Chinook salmon spawning flow ceiling required by Appendix A, condition 5.2 (A-LA 5); (c) a description of any documented dewatering of Chinook salmon redds during the September through January Chinook salmon spawning and fry emergence period; (d) a description of any proposed corrective actions if any flow-ceiling exceedances occur; and (e) documentation of consultation with the National Marine Fisheries Service, the Forest Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Tulalip Tribes, Snohomish County, City of Everett, City of Sultan, and American Whitewater (Aquatic Resource Committee, as it may be revised in accordance with Appendix B, condition 2 (A-LA 1)), including copies of comments and recommendations on the report after it has been prepared and provided to the Aquatic Resource Committee, and specific descriptions of how the Aquatic Resource Committee's comments are accommodated by the report. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons based on project-specific information; and

(2) any plan update developed in accordance with Section 4.2 shall include documentation of consultation with the Aquatic Resource Committee; copies of comments and recommendations on the updated plan after it has been prepared and provided to the Aquatic Resource Committee; and specific descriptions of how the Aquatic Resource Committee's comments are accommodated by the plan. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons based on project-specific information. The Commission reserves the right to require changes to the plan. Implementation of the updated plan shall not begin until the plan is approved by the Commission. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Appendix 2

Documentation of Consultation Opportunities

Appendix 3
General Protocols for Spawning Ground Surveys
Conducted in Washington State and Specific
Protocols Used by the PUD on the Sultan River

Field Procedures to Determine Salmon and Steelhead Escapement in Washington State

(Adapted from procedures originally developed by
Quinault Department of Natural Resources)

1. INTRODUCTION

Fisheries staffs on the Washington Coast have developed a technique to estimate spawning escapement using the numbers of redds, (excavation into which a female salmon or steelhead deposits her entire complement of eggs) as the basic unit of estimation. Although redd counts form the backbone of estimated escapements, other biological data are also collected. These data include numbers of fish by species (identified by jacks, adults and sex), scales or otoliths, length samples and numbers of marked fish. Surveys are conducted primarily by foot and out of boats, while larger mainstems are surveyed by helicopter.

The procedure for conducting spawner surveys has evolved over time from a relatively simple process of recording the number of fish and redds observed on a ten to fourteen day basis, to the present fairly complex methodology. Currently, we record cumulative redd counts for the season within established index "intensive" areas.

Additionally, "extensive" data, from stream sections outside of these index areas, are collected. The increasing complexity of this process has mandated a set of specific instructions to maintain a consistent database. This manual should address most of the questions that surveyors will have about conducting the surveys. However, if questions (not covered here) arise, consult your supervisor for clarification.

2. SURVEY TYPES

Two types of spawner surveys are conducted by the Regional Fisheries staff. All survey areas will be listed under one of these categories. They are:

1. Intensive
2. Extensive

INTENSIVE SURVEYS (Index):

Intensive or Index surveys are conducted set intervals of no later than ten days apart for salmon, and every fourteen days for steelhead. This type of survey has the highest priority. Dates for the first and last surveys will include the earliest and latest spawning activity for the target species.

Data collected on critical and intermediate surveys will include new and visible redd

counts by species as well as live and dead fish counts (also by species). However, in the case of chum and sockeye, only fish counts are made except where the redds could be misinterpreted on future surveys or are superimposing on other species redds.

EXTENSIVE SURVEYS (Supplemental):

Extensive or Supplemental surveys are usually conducted at least once during the peak of the spawning period for each species as well as each run within species (i.e. hatchery/wild and early/late runs). Field personnel will be assigned to conduct these surveys on sections outside the boundaries of intensive surveys or on streams that have no regular index area.

The data to be collected on these surveys is the same as for intensive surveys except that redds are ONLY classified as visible (no new or cumulative categories). Spawning escapement estimates are made by pooling the information collected on both types of surveys (intensive and extensive).

3. GENERAL PROCEDURES

Each survey area will be measured for total survey distance. Within each survey section, quarter mile markers are, or will be, installed and surveyors will note each marker as they come to them on a separate line of the survey form. These markers will provide a better picture of redd distribution in the stream as well as providing uniform subdivisions in the data.

Keep in mind that you can **NEVER** take too much data, but quality is still more important than quantity. Take the time, record your data, and check previous notes carefully.

Each successive survey should be conducted in the same direction, but the surveyors should try not to follow the same path each time. Remember to survey all side channels and braids as these are part of the index areas. The digging activity in these areas should be identified as such. In other words, indicate if a redd is in a side channel or a braid because this will help others follow your notes in subsequent surveys.

REDD AND NEST COUNTS:

Interpreting redds by species can be difficult, especially with the overlap of chinook to coho, and coho to steelhead (see section on Redd Identification). When making the determinations, keep in mind your live and dead fish counts, and the condition of these fish. In other words, if you are seeing only chinook in your live/dead counts, then more than likely, most of the redds are chinook so your calls should be made accordingly. However, additional care should be taken during the transition from coho to steelhead because you will not see steelhead on redds as often as you will salmon.

Another useful aid to improve your skill at redd differentiation is to approach riffles carefully to identify fish on redds. These positive redd identifications will provide a gauge by which to judge redds without fish.

It is important to be conservative in making a decision about a redd because we would rather underestimate than overestimate the number of redds. Bear in mind, that steelhead frequently dig more than one nest per redd, while salmon typically dig only one.

Nests are differentiated from redds by their size and shape (smaller), proximity to one another (generally on the same riffle), and age (similar algae growth and/or formation).

When several nests are determined to be part of a particular redd, each nest is flagged with the same flag code and sequence number but an "A", "B", "C", etc. is also added to the end. For example: 4-46-3A and 4-46-3B indicate that the third coho redd seen in week 46 was determined to be made up of two separate (unconnected) nests.

FLAGGING OF REDDS:

When a redd is encountered, the pertinent information is recorded on the survey form and the redd marked. This marking consists of hanging a flag on a branch as close to the redd as possible. If there are no branches in the area, the flag can be tied to a stick driven into the ground on the riverbank.

The surveyor is to write the redd number (or other identification), as well as the location of the redd in relation to the flag, on all flags hung. A redd number consists of three parts (separated by hyphens), the species code, the week number and a sequential redd number for that species on that survey. A different color flagging will be used each week according to the schedule listed in **Table 1**. The different flag colors helps the surveyor keep track of old flags by eliminating the need to have to read the numbers on each flag in order to identify it. Additionally, if part of the flag is missing, chances are that it will be identifiable and the flag replaced with the new one. This replacement flag does not have to be the same color as the original but it must have the same identification number.

QDNR FLAGGING COLOR BY WEEK #	
WEEK #	FLAG COLOR
40	BLUE GLO
41	ORANGE GLO
42	YELLOW GLO
43	PINK GLO
44	GREEN GLO
45	RED
46	BLUE
47	ORANGE
48	YELLOW
49	PINK
50	WHITE
51	BLUE/WHITE
52	ORANGE/WHITE
53/1	YELLOW/WHITE
2	BLUE GLO
3	ORANGE GLO
4	YELLOW GLO
5	PINK GLO
6	GREEN GLO
7	RED
8	BLUE
9	ORANGE
10	YELLOW
11	PINK
12	WHITE
13	BLUE/WHITE
14	ORANGE/WHITE
15	YELLOW/WHITE
16	BLUE GLO
17	ORANGE GLO
18	YELLOW GLO
19	PINK GLO
20	GREEN GLO
21	RED
22	BLUE
23	ORANGE
24	YELLOW

Table 1. List of flag colors to be used by statistical week #.

The location of the redd should be pinpointed by distance (in feet) and direction to the center of the redd, from the flag (i.e. 2 ft. out, 5 ft. down). The following list indicates the terminology to be used:

1. UP (upstream), DOWN (downstream)
2. IN (towards the bank)
3. OUT (towards the center of the river)
4. BELOW (under the flag)

Surveyors will sometimes encounter areas of intense spawning activity where it is impossible to accurately flag locations due to the absence of overhanging vegetation. This typically occurs in chinook indexes on larger tributaries or mainstem indexes where redds may be scattered across a riffle or pool tailout. Flag each digging activity with a railroad spike or rock and place it in the middle of the redd. Surveyors should also map these areas, showing redd locations in relation to obvious landmarks. Identify maps and corresponding stream sections in a manner that will be clearly understood by future surveyors. Attach these maps to the survey forms.

4. LIVE AND DEAD COUNTS

Record all fish observed, by species and sex or under SPND if the species cannot be determined. NOTE: No sex breakdown is needed for chum, sockeye, or pink salmon, record only as SND. Define the live counts as either spawners or pre-spawners. Spawners can be identified by their condition (i.e. flag-tailed) or by their association with redds or riffle areas (i.e. steelhead hanging out on riffles). Pre-spawners tend to be in groups in pools.

As with redd identification, approach riffles carefully in order to get an accurate count of fish on redds. Throw a rock or two into pools in order to scare fish out into the open to facilitate counting them, but don't spend a lot of time doing it.

DEAD FISH COUNTS:

Counting - All carcasses will be counted during the course of a survey regardless of whether they had been counted on previous surveys. In order to be counted as a dead fish, the carcass may contain a whole fish or a portion thereof.

Make every reasonable effort to determine the species and sex of all carcasses, but do not spend a lot of time trying to retrieve them from hard to reach areas such as deep pools. A surveyor may stumble upon carcasses away from the stream margins. Include these incidental observations in the carcass count but make no special effort to sample these areas.

Mark Sampling: - (Chinook, Coho, and Steelhead only) In addition to counting carcasses you should also be mark sampling them. Mark sampling means that you check the carcass for marks such as a fin clip (the most common of which is an adipose fin clip). Such fin clips indicate that the fish should have a coded wire tag in its snout identifying the fish's origin.

In contrast to counting you should only mark sample a fish once. To prevent double sampling of carcasses, a piece of ribbon is to be tied around the tail of a carcass that has been mark sampled. The surveyor should continue to count this carcass each time it is observed and record it as a Previously Mark Sampled fish (PMS).

For the purpose of sampling, a carcass must have at least a tail section (including the adipose fin region). However, this may vary depending on what type of mark is used in that area. If a carcass is in too bad a shape, or if it is inaccessible, it is recorded as a Did Not Sample (DNS) carcass, but indicate the species and sex if possible. The mark sampling procedure is as follows:

1. Check each carcass for fin clips or tags. Write "DNS" (did not sample) in the fish sampling section of the form if the carcass is not checked, on the same line as the other information about the fish.
2. Take a length measurement if a measuring device is available. Length should be taken from the middle of the eye (or eye socket) to the hypural plate (**Fig. 1**). An easy way to do this is to lift the tail and jab your knife into the caudal peduncle where the natural bend occurs. Then measure from the eye to the puncture. Also estimate the pre-spawning weight of the fish.
3. Remove heads from adipose clipped or otherwise marked carcasses. Write the pertinent information on the sampling tag (**Fig. 2**) Place the tag and the head in a plastic bag. Scales will be placed in scale envelope (**Fig. 3**). This will be discussed in greater detail in the next section of this manual (Scale Collection).

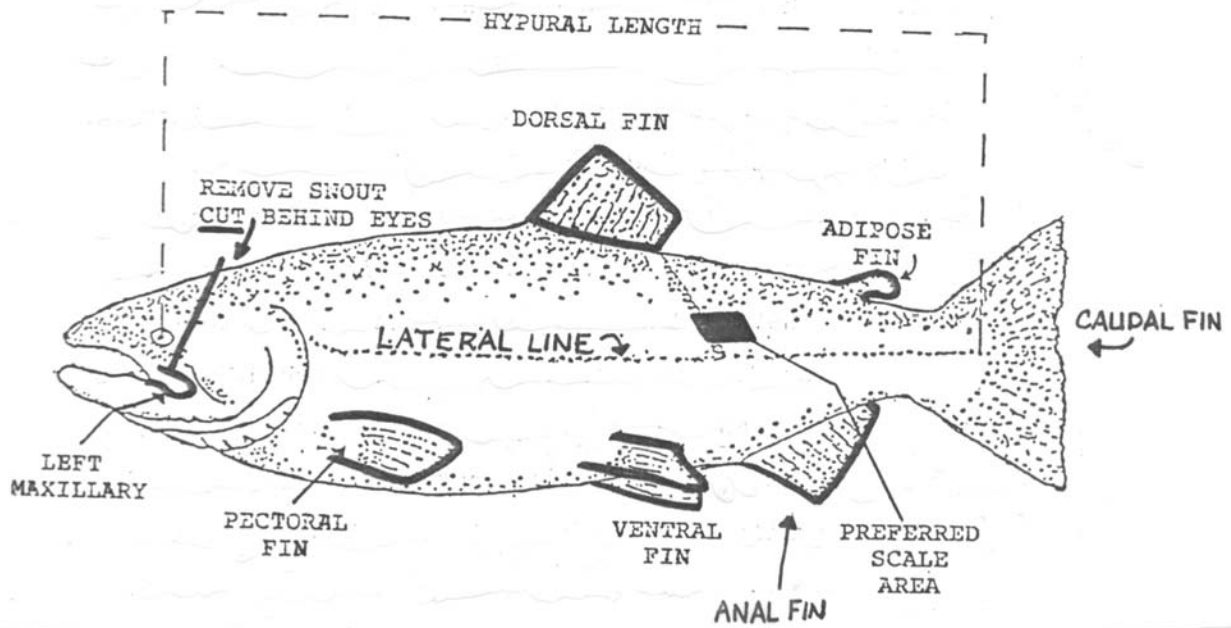


Figure 1. Location of the preferred scale collection area and the hypural length measurement.

Locating the preferred area – follow the imaginary line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (on either side of fish). The preferred area begins 2 scales up from the lateral line and several scales back from the imaginary line.

DATE _____		FISH # _____	
CC _____	PR _____	OTHER _____	
CHIN _____	COHO _____	STHD _____	OTHER _____
L _____	W _____	M	F J
MARK:			
Partial	Complete	SD	Other _____
Adipose	Adipose	Not Taken	
Scales: Taken		Not Taken	
CWT # _____	AGENCY _____		
TAG RECOVERED BY QUINULT DEPT. OF NATURAL RESOURCES			

Figure 2. Example of a blank head label.

DATE _____	LENGTH _____
SEX _____	WEIGHT _____
SPECIES _____	STREAM _____
MATURITY _____	LOCATION _____
COLLECTOR _____	

Figure 3. Example of a blank scale envelop.

4. Record AD under fish sampling and then the sequential number of AD samples on that stream section on that day under "HEAD #".
5. If a head of an adipose clipped fish is missing from natural causes or for some reason the surveyor could not take the head, fill out a tag as if the head was taken but record on the tag and the survey form that the head was not taken and the reason for not taking it. Make sure that the head was not taken on a previous survey before it is counted as a new marked fish.
6. A ribbon should be tied around the caudal peduncle of all fish mark sampled.
7. Examine the dorsal fin on steelhead for stubbed or missing fin rays. Wild steelhead (W) usually have 11 or 12 straight fin rays. Hatchery fish (H) usually have bent, crooked, stubbed or missing rays (see **Fig. 4**). Indicate this on the survey form under "SCALE #" separation from scale sequence by a hyphen. Record either hatchery (H), wild (W), or did not sample (DNS).

Scale Collection:

Scales should be taken whenever possible to provide age class breakdowns of the spawning population. They are to be taken from the "preferred area" on either side of the carcass (See Fig. 1). This area contains the first scales to develop on a fish so they have the most complete and accurate information. If for some reason scales must be taken from a different area it should be indicated on the scale envelope (Fig. 3) with the code NP (not preferred) written in the corner.

Whenever possible examine salmon scales for regeneration. This is done by holding the scale up to the light with tweezers or hemostats and check for a clear center

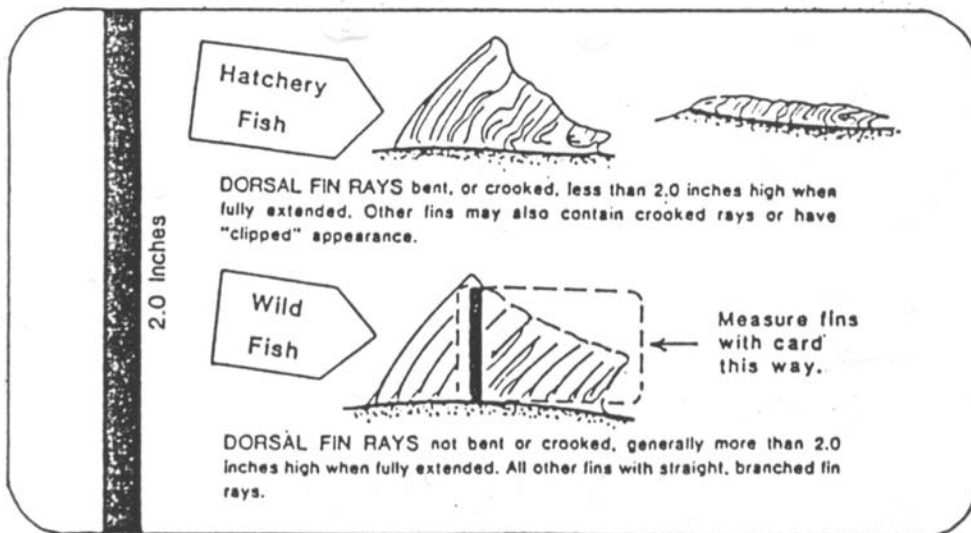
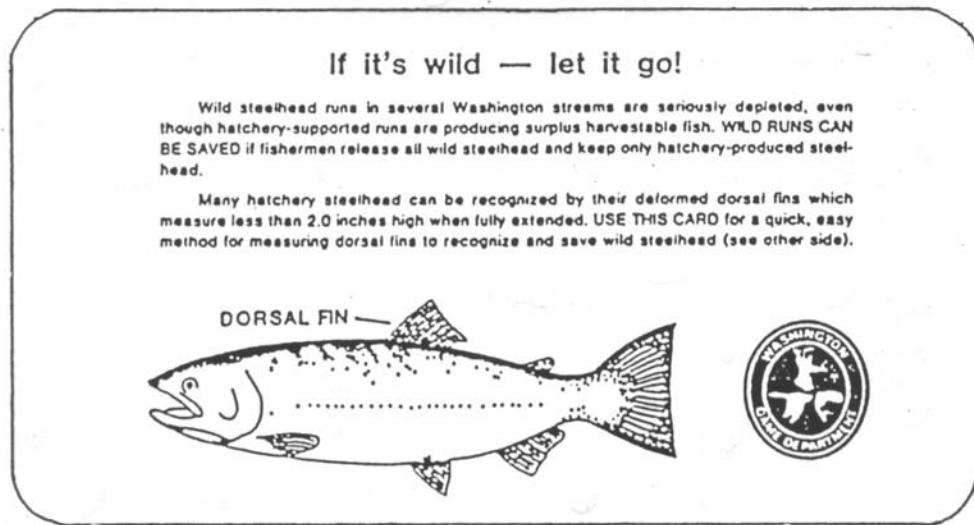


Figure 4. Reproduction of a sampling card issued by the Dept. of Game explaining stubbed dorsal fin.

with all circuli present as compared to a fuzzy center which indicates previous scale loss (**Fig. 5**).

Remove at least 3 scales from all fish, except when you are SURE that you have taken at least 3 good (non-regenerated) ones. For all survey areas, collect as many chinook and steelhead scale samples as possible, especially spring chinook. For chum salmon, collect only 2 good scales per fish. Depending upon carcass availability and allotted survey time remaining, a minimum of 10 scale samples per species survey section and survey day, is needed. Unless requested, no samples will be taken on sockeye, coho, or pink salmon.

Pre-printed scale envelopes (Fig. 3) should be used whenever available to insure that all necessary information is taken (Fig. 2). If these envelopes are not available the following information is to be filled out on a blank one:

- | | |
|--|-------------------------------|
| 1. Date | 5. Species |
| 2. Length (in cm) | 6. Stream name or number |
| 3. Sex | 7. Maturity (bright, or dark) |
| 4. (PS) weight est. | 8. Surveyors Name (Initials) |
| 9. Sequential number of scale samples taken on that stream on that day. This number should be recorded under "SCALE #" of the survey form as well. | |



Figure 5: Example of a good Chinook scale that has a clear center (not regenerated).

SPAWNING GROUND SURVEY FORM

The following instructions explain the type of information that is needed in completing the survey form (**Fig. 6**):

Stream: Name and/or stream number (water resource inventory area stream code). If the stream has no number, enter "unnumbered" and then describe its location in relation to the nearest numbered stream.

Species: Circle the species code for each fish that you expect to see on the survey.

Date: Month, Day and Year the survey was conducted.

Location: Description of the upper and lower points of the section being surveyed. If either of these points are at a tributary, give the name or number of the tributary. Put down the river mile points if they are known.

Method: Circle the survey method (foot, boat, or helicopter).

Flow: Describe the stream's volume of flow in relation to the average flow expected throughout the course of the season in that stream. Circle one of the following:

- | | |
|---------------|----------------|
| 1. Low | 4. Medium High |
| 2. Medium Low | 5. High |
| 3. Medium | |

Record any flow changes that occur during the survey in the "Comments" section of the form.

Examples: No flow a R.M. 7.4. Not surveyable at R.M. 11.6 due to high water.

Riffle Visibility and Pool Visibility: Take into account the water clarity, flow, glare, wind, rain, etc. Circle one of the following:

- | | | |
|--------------|--------------|---------|
| 1. Excellent | 2. Very Good | |
| 3. Good | 4. Fair | 5. Poor |

These descriptions should be filled out after the survey is completed since viewing conditions often change as a survey progresses. The most predominant condition is used. Record any changes affecting viewing conditions during the survey, even as weather or tributaries change the water clarity.

Time Start – Finish: Record the time you start and finish the survey.

Upstream or Downstream: Check the box indicating the direction that the survey was conducted.

Weather: A description of the weather conditions, which predominated throughout the survey.

Example: cloudy and light rain. Fill this section out after the survey is completed because changes may occur during the survey.

Ribbon Color (Wk #): Indicate the color being used for the survey. Follow the color schedule for each week (Table 1). Note the statistical week number in parenthesis.

Crew: Identify the person or persons conducting the survey. If more than one person is in the crew, the scribe's (note taker's) name is entered first.

Time: Record the time for each entry. If you are at one location for an unusually long time (for example if there are a number of redds on the same riffle) put down the time that you first got there on the first line and no other time entries for the other lines describing that riffle.

Unmarked: New or unmarked digging activity which includes nests, redds and test digs. The flag code should be entered in the box. The flag code consists of a species code, the week number and the sequence number for that species. **Example:** 4-10-3 indicates that the redd is the third coho redd observed on the survey conducted in week 10. For a test dig, the flag code consists of the week number, "T/D", and the sequence number of test digs on the survey. **Example:** 9-T/D-4 indicates the fourth test dig observed on the survey in week 9

Species Identification Codes:

- | | |
|------------|--------------|
| 1. Chinook | 6. Steelhead |
| 2. Chum | 7. Cutthroat |
| 3. Pink | 8. SPND |
| 4. Coho | |
| 5. Sockeye | |

Marked: Digging activity that has been flagged on a previous survey. The flag identification number should be entered in the box anytime the surveyor comes across a flag regardless of whether the redd is still visible or not.

Percent Algae: This is a comparison between the coloration of the digging site and the surrounding substrate and is an indication of how old the redd is. It should be recorded as New (N), 50, 100 or Absent (A). (N) means that the redd is fresh; (50) is between N and 100%; whereas, (100) means that there is no discernable difference in coloration, but that the form of the redd is still visible (i.e. it would be called a redd if this was the first survey). Absent (A)

means that the redd would not have been detected had the flag not been there to indicate that a redd was once there, or if the surveyor did not have any knowledge of the redd from a previous survey.

The flags should be left up until the last survey of the season, unless there are too many redds in the area to easily keep track of. In that case, the supervisor should make the decision to take the flag down. If a flag is taken down, it should be noted on the survey form by entering the number of the flag in the "Marked" column as usual and then circle it.

Location: Using initials, describe the location of the redd in the stream. **Example:** RB or LB indicates the redd is on the right or left bank (one side of the redd is cut into the bank), RS or LS would be on the right or left side of the stream and MS would be mid-stream. It should also be indicated if the site is in a braid or a side channel (i.e. RS/LB would mean the right side of the left braid). Left and right is determined by the direction the survey is conducted.

Size: The physical dimensions of the digging site should be listed as the length followed by the width. **Example:** 10 x 5 means the redd is 10 feet long and 5 feet wide. Take a little extra time and care to be as accurate as possible on these measurements without actually measuring it with tape measure. The reason for this accuracy is that it will help on future surveys to determine if a redd has been enlarged since the last survey, or if superimposition is occurring on an older redd.

Species through **Snd:** These boxes are used to keep track of the fish activity in the stream. When fish are associated with a particular digging site, the information should be entered on the same line as the redd information, otherwise they should be listed on a separate line. Fish listed on a separate line will be considered pre-spawners unless otherwise indicated in the comments column (i.e. flag-tailed females).

Species: Enter the species code of the fish that are observed. If more than one species are present at the same location, use a separate line for each species. Make every effort to determine the species, but if this is not possible, enter the counts as SPND's. This is done by putting a 0 in the species column and the number of fish in the SND column.

Live/Dead: Enter an L for live and D for dead. If both are present use separate lines for each.

Males, Females, SND and Jacks: Enter the number of each in the appropriate box.

Spawner(S) or Pre-Spawner(PS): Enter condition of fish (see glossary for detailed description).

Comments: Enter additional information about redds, fish or landmarks on separate line(s). It is important to record any obvious landmarks such as bridges, tributaries, survey markers etc. so future surveyors will be able to follow your notes easier. You should record the same landmarks on each successive survey in case a future survey is not completed for some reason the data can be broken down into a smaller index section that has the most complete data.

EXPLANATION OF COMPLETED SPAWNING GROUND SURVEY FORM

Figure 7 is a sample of a completed Spawning Ground Survey Form. An explanation of these entries is as follows:

Stream - Big Creek. This could also have been the WRIA stream number or an exact description of the stream location. The creek is in the Humptulips River System.

Species - This should include all the species that would be expected for the survey (not just the ones that were actually observed).

Location - The surveyor walked from tributary 0198 (this is the WRIA stream number for the tributary) which is located at river mile 2.5 of Big Creek to Highway 101 at river mile 1.5.

Method - This was a foot survey. **Water condition** - There was medium flow (3) and the visibility was good (3) on the riffles, and fair (4) in the pools. This description was filled in at the end of the survey.

Time - The time began at 8:00 and ended at 10:00.

Direction - The surveyor walked downstream.

Weather - It was cloudy and raining. This description was taken at the end of the survey and it represents the most predominant condition during the survey.

Ribbon color - Green glo flagging was used on statistical week #44.

Crew - Joe Pro was the scribe and Bob Cando helped.

STREAM: BIG CR. (HUMP.) SPECIES 1 2 4 5 6 DATE: 10/24/88 PAGE 1 OF 1
 LOCATION: FROM Trib. 0198 (R.M. 2.5) TO HWY 101 (R.M. 1.5)
 METHOD: FOOT BOAT HELI FLOW: 1 2 3 4 5 RIFFLE VIS. 1 2 3 4 5
 TIME: Start 8:00 Finish 10:00 UPSTREAM DOWNSTREAM POOL VIS. 1 2 3 4 5
 WEATHER: Cloudy, Rain RIBBON COLOR (WV #): GREEN GLO (44) CREW: J. Pro, B. Cando

	Range (Meters) Or Time	Unmarked	Marked	RECD DESCRIPTION			FISH ACTIVITY							FISH SAMPLING			
				Alga	Location	Size	Spaced	Live Dred	Male	Female	SND	Jack	S-PS	DNS-PS	NM-AD	Head #	Scale #
(1)	8:05	1-44-1		N	M	8x4	1	L	1	1		2	S				
(2)	8:07						Logging Bridge										
(3)	8:17		1-43-1	A													
							Trib. L. S.										
(4)	8:19						Survey Marker 1										
(5)	8:20						1	D			1			DNS	--	----	
(6)	8:22		1-43-2	50													
(7)	8:39						0	D			1			DNS	--	----	
							Survey Marker 2										
(8)	8:47	1-44-2		N	L	15x7											
(9)			4-43-1	50												SI by 1-44-2	

↑ FRONT SIDE

"Durante"

	Range (Meters) Or Time	Unmarked	Marked	RECD DESCRIPTION			FISH ACTIVITY							FISH SAMPLING				
				Alga	Location	Size	Spaced	Live Dred	Male	Female	SND	Jack	S-PS	DNS-PS	NM-AD	Head #	Scale #	
(10)	8:55		1-42-1	A														
							Survey Marker 3											
(11)	9:03	44-TD-1		N	M	2x2												
(12)	9:07						0	L			3		PS					
(13)	9:12	4-44-1		N	RB	4x2	4	L		1			S					
(14)	9:22						1	D	1					NM	--	1		
(15)	9:23	4-44-2A		N	R	6x3												
		4-44-2B		N	R	6x4												
			1-43-3	50			No Flag -- Replaced with GREEN GLO											
			1-42-2	100														
(16)	9:45	2-44-Mass		N	LB	20x6	2	L			14		S					
(17)	9:50						2	D			6			DNS	--	1-5		
(18)	10:00						END SURVEY											
							----- HWY 101											
							=====											
			2 (2) Chinook	1	N.M.	O.A.D.												
			2 (3) Ccho	0	N.M.	O.A.D.												

↑ BACK SIDE

Figure 7: Completed Spawn Survey Form

- 1) An unmarked chinook redd was observed at 8:05, it was 8 feet long and 4 feet wide. It was new (no algae growth on it) so % algae is (N) and it was in the middle of the stream (MS). There were 4 live chinook (species code 1) on or near the redd: 1 male, 1 female, and 2 jacks.
- 2) The surveyors came to a logging bridge at 8:07. This logging bridge should be noted in all future surveys.
- 3) At 8:17 an old ribbon was observed (1-43-1) but the redd was absent - not visible (i.e. it would not have been detected by the surveyors if the flag was not there to indicate that a redd had been there). Therefore % algae is (A). There is also a tributary that enters Big Creek at this location on the left side.
- 4) The first survey marker is noted (at 8:19) which means the surveyors have walked 1/4 mile.
- 5) A chinook carcass is observed in a pool that couldn't be reached to sample (DNS) and the sex could not be determined (SND).
- 6) An old (previously flagged) chinook redd (1-43-2) is observed and is 50% algae and the size is still 18' X 10'.
- 7) A carcass of unknown species is found therefore the species code is 0 and it is tallied under SND. This carcass was not sampled so write DNS under mark sampling. The second survey marker is observed in the same location.
- 8) A second unmarked chinook redd is observed. It is 15 feet long and 7 feet wide. It is (N)ew (no algae growth). It's on the left side of the stream and there are no fish in the area.
- 9) An old coho redd (4-43-1) has been superimposed upon by the new chinook redd (1-44-2) but it is still detectable and it is only 50% algaed. The size is not necessary since it is being superimposed upon but this should be noted instead. The time is left blank because it is at the same location as the new chinook redd (1-44-2).
- 10) An old flag is seen but the chinook redd is (A)bsent. The third survey marker is seen (3/4 mile point).
- 11) The first test-dig is observed. The area is small (2 feet by 2 feet) and the observer feels that no eggs have been deposited. This could be upgraded to a redd, during a subsequent survey, if it enlarges. In that case the T-dig flag would be taken down and a new flag labeled with the week number that it was determined to be a redd and/or nest. This change would be written down in the notes.
- 12) 3 fish of unknown species are seen in a pool. They are listed as pre-spawners (PS) because they are not associated with a redd and do not appear to have been spawning.
- 13) A coho redd is found with a flag-tailed female actively digging. It is 4 feet long and 2 feet wide and located next to the right bank.
- 14) A male chinook carcass is sampled, it has no marks (NM) and scales were taken. The scale envelope is labeled number 1.
- 15) Another coho redd is found which has 2 distinct and separate nests. 1 is 6 X 3 (nest A) and the other is 6 X 4 (nest B). They are both on the right side of the stream and there is no detectable algae growth. The location time is listed as 9:23 - which means that the redds and activity noted at that time were all on the same riffle which the surveyor first got to at 9:23.

An old chinook redd (1-43-3) is on the same riffle as the 2 new coho nests and it is 50% algaed and it's 15' X 8'. From the previous notes the surveyor determines that this is the same redd as the one marked on the last survey but the flag is missing. Therefore a new flag is hung with the old number written on it.

Another old chinook redd (1-42-2) was also located on the same riffle. The shape of the redd is still visible but it has the same coloration (100%) as the surrounding substrate the size is 12 X 10.

- 16) An area of mass chum spawning is observed at 9:45. It is 20 feet long and 6 feet wide on the left bank and it is composed of 6 interconnected pockets within the 20 X 6 foot area. There were 14 live chum of unknown sex in the general area.
- 17) At 9:50, 6 dead chum were found. Scales were taken from 5 of these fish (3 males and 2 females) and the scale envelopes were labeled with the numbers 1 through 5. The 6th fish was too badly decomposed to determine the sex or to take scales.
- 18) The surveyors reach the end of the survey at Hwy 101 (10:00).

SUMMARY SHEET

A summary sheet shall be filled out on the day of the survey or the next day before going out in the field again. The survey data shall be entered according to the "Washington Coastal Spawning Ground Summary Report System" on pages 48-51.

All boxes shall be filled for all species available even if they are zero counts (see **Fig. 8**). An arrow may be used to indicate duplicate information for each line such as stream number, date, and etc. The following defines both mark and scale sampling columns, which are located on the back side of the summary form.

STREAM: Big Creek (Hump.) DATE: 10 / 24 / 88

STREAM NUMBER (WRLA)	SPECIES 9	RACE 10	AGENCY 11	CARD TYPE 12	DATE			RMS COUNT 18	RIVER MILES		METHOD 31	FLOW 32	VISIBILITY 33	TYPE COUNT 34	REDD COUNTS			VISIBLE NESTS 74	OTHER SPECIES 77	COMMENTS
					YEAR 14	MONTH 15	DAY 16		BEGIN 24	END 25					NEW 65	VISIBLE 68	CUMULATIVE 71			
22.0042	1	1	8	18	8	10	24	1	1.5	2.5	1	3	1	2	5	7	5	3	4	
	2																		14	
	4													2	2	2	3	1	2	

FRONT SIDE

CREW: Joe Pro , Bob Cando

SPECIES	LIVE COUNTS				DEAD COUNTS			
	MALES 26	FEMALES 39	SND 43	JACKS 47	MALES 50	FEMALES 54	SND 58	JACKS 62
1	1	1	0	2	1	0	1	0
2	--	--	14	--	--	--	6	--
4	0	1	0	0	0	0	0	0
0	0	0	3	0	0	0	1	0

BACK SIDE

MARK SAMPLING			
New Checked	1	0	0
Now Ad Clip	0	0	0
Cum Checked	4	1	0
Cum Ad Clip	1	0	0
	Chim.	Coho	Stk.

SCALE COLLECTION			
NEW	1	5	0
CUM	4	5	0
	Chim.	Coho	Stk.

Figure 8. Sample of summary form using data from Figure 7.

MARK SAMPLING

New Checked: The number of fish that were mark sampled on this survey.

New Ad Clipped: The number of adipose clipped (marked) fish observed on this survey.

New Checked The number of fish that were marked sampled on this survey.

Cum Checked and Cum Ad Clipped: The totals of new (this survey) and the cumulative from the previous surveys summary sheet.

SCALE COLLECTION

New The number of fish that were sampled for scales on this survey.

Cum The total number of new sampled and the cumulative from the previous surveys summary sheet.

GLOSSARY

Artificial Redd - A disturbance in the substrate dug by Fisheries Personnel to imitate a fish redd. They are used to determine how long redds remain visible and to help determine the age of actual fish redds in the river.

Carcass - A dead fish which is generally comprised of a major portion of the fish.

Flag Tail - Characteristic of a spawning or spawned-out female where she has a white tail caused by the digging process.

Freshet - A large increase in the height of a river caused by heavy rains.

Hypural Length - A standard method of measuring a fish that has undergone physical changes during spawning. It consists of a measurement from the middle of the eye (or eye socket) to the hypural plate (the place where the tail bends when the tail is folded back)

Mass Spawn - Area where more than one female has spawned and the redds are all run together or superimposed on one another making it impossible to differentiate individual redds. If the redds are those of the target species a conservative estimate of the number of redds should be made but for non-target species (i.e. chum) it can be labeled mass spawning and the overall dimensions of the disturbance noted.

Nest - Separate depressions in the stream substrate that make up the redd of one female. A redd can be made up of more than one nest, which happens more often in the case of steelhead than salmon. The surveyor interprets the number of nests to a single redd by nest size, configuration, relative age (gauged by the algae growth) and proximity to one another.

Percent Algae - Relative gauge used to judge the age of a redd by comparing the coloration of the redd to that of the surrounding substrate. Estimates are made in 50% increments (New, 50, 100, and Absent).

Pocket - The portion of a redd which is characterized by a depression in the substrate. A nest or a redd can have more than one pocket. Pockets differ from nests in that they are connected to one another while nests or redds are separated by undisturbed substrate.

Pool - Section of stream that is deep and has slow water flow

Pre-Spawner - (pooled fish) Adult fish that has not begun to spawn. They tend to be found in small schools in pool areas.

Redd - One or more depressions in the stream substrate where the full complement of one female's eggs is deposited. They are usually characterized as having a depression and a tailspill which are lighter in color (less algae growth) than the surrounding substrate. A redd may be comprised of more than one nest.

Redd Life - The length of time that a redd is able to be detected by a surveyor.

Redd Size - The dimensions of a redd measured in feet and noted as length by width.

Riffle - Opposite of pool areas (shallow with fast moving water).

Spawner - Adult fish either in the process of digging or spawning or which has completed spawning. Females are generally characterized by having a white caudal fin (flag-tail) or other obvious spawning injuries.

Substrate - Material that makes up the streambed.

Superimpose- When a fish digs a redd on top of an older redd.

Tailspill - Downstream portion of a redd characterized by a buildup of substrate and is often in the shape of a cone when viewed from above.

Test Dig - A disturbance in the stream substrate caused by fish digging that does not contain eggs. It is identified by its small size and shallow pocket.

ABBREVIATIONS

<u>A</u>	= Absent (or redd no longer detectable)
<u>AD</u>	= Adipose clipped
<u>B-LAMP</u>	= Brook lamprey
<u>CHIN</u>	= Chinook
<u>CUTT</u>	= Cutthroat
<u>D</u>	= Dead fish
<u>DNS</u>	= Did not sample (didn't check a carcass for adipose fin clipped other marks)
<u>F</u>	= Female
<u>FTF</u>	= Flag-tail female
<u>J</u>	= Jack (male under 18" in length)
<u>L</u>	= Live fish
<u>L</u>	= Left (as in left bank-LB, left side-LS)
<u>LAMP</u>	= Lamprey
<u>M</u>	= Mid (as in mid stream)
<u>N</u>	= New redd (0% algae growth)
<u>NP</u>	= Non-preferred scales
<u>NM</u>	= No marks
<u>PS</u>	= Pre-spawner
<u>PMS</u>	= Previously mark sampled fish
<u>R</u>	= Right (see left)
<u>S</u>	= Spawner
<u>SI</u>	= Superimposed
<u>SND</u>	= Sex not determined
<u>SOCK</u>	= Sockeye
<u>SPND</u>	= Species not determined
<u>STHD</u>	= Steelhead

ERRORS TO AVOID

The following is a list of errors to watch for:

1. Failure to carry the needed materials and equipment necessary to adequately perform the duties of a spawner ground surveyor.
2. Failure to properly complete field data forms with the following information: Date (month/day/year), River mile section, Viewing conditions, Noting landmarks.
3. Miscalculating visible and cumulative redd counts. Visible redds include the new redds plus the old redds still visible. The cumulative redd count is the total of new redds and the previous cumulative count.
4. Failure to keep track of the redd (#'s). Redds that are no longer visible (until the flag has been pulled).
5. Recording visible redds on an extensive survey as new redds in the summary form. On extensive surveys there are no new redds or cumulative redds ONLY visible redds.
6. Failure to identify the proper location of the starting and ending points of the survey particularly for extensive surveys on small tributaries, (i.e. unnamed R.S. tributary to E. Fk. Hoquiam at R.M. 10.0)
7. Failure to record data legibly using the accepted abbreviations.
8. Carelessness in marking redd numbers on flagging and in the notes. These can be confusing so don't rush.
9. Interpreting superimposed redds as old visible redds. Noting the redd size each survey should minimize this problem.
10. Failure to move flags with continued construction. The location on the flag should indicate the distance to the center of the redd.
11. Inconsistent methodology in conducting intensive and extensive surveys (speed of survey, method of redd identification, etc). All surveys should be conducted in the same manner.

SPAWNING GROUND SURVEY SUPPLY CHECKLIST

- 1) Rain gear (if needed)
- 2) Hip boots, waders, neoprenes (optional)
- 3) Spawner survey forms
- 4) Polarized glasses
- 5) Watch (water-resistant)
- 6) Boot socks
- 7) Appropriate ribbon color
- 8) Sharp knife
- 9) Sandwich bags (for heads)
- 10) C.W.T. head labels
- 11) Scale envelopes (pre-printed)
- 12) Tweezers or hemostats
- 13) Pencils, markers
- 14) QFiD cap, visor
- 15) Stream maps
- 16) Portable radio
- 17) Yellow notebook
- 18) Orange surveyors vest

- 19) List of QFiD radio call codes

Keep in mind that you can **never** take enough required materials and necessary equipment.

REDD IDENTIFICATION

Interpreting redds in stream bottoms is no simple task. Mixed species, mass spawning, stream flow, vehicle and animal tracks have even confused the most experienced surveyor.

The following redd descriptions indicate the differences and similarities between fish species. It is used to generate the same ideas amongst all of our surveyors to establish consistency in the data. These are general descriptions and not as precise as one would like because species redd descriptions overlap (i.e. interpreting between late coho and hatchery steelhead or early wild steelhead).

Fish counts, both live and dead, and observing fish on redds will greatly improve one's ability to identify redds where there is no fish activity.

CHINOOK:

- * Largest redd of all species.
- * Spawn primarily in mainstems and the lower sections of tributaries.
- * Not common above obstacles (i.e. E. Fk. Hoquiam falls).
- * Redds are located above the heads of riffles, generally located in mid-stream as opposed to bank spawning.
- * Large redds, deep pockets and large rocks moved.
- * Mass spawning with superimposition is not common.

COHO:

- * Variety of spawning locations (mainstems to upper reaches of small tributaries).
- * Spawning occurs in both medium fast to slow moving water. Generally found at the head end of riffles.

- * Redds are usually shaped like an ice cream cone with uniform well defined margins. Classic redd shape: medium depth, round pocket flowing back to a V-shaped tailspill.
- * Medium sized redds.

CHINOOK -vs- COHO:

Redd size is important. Chinook dig deeper redds (Noted by depth of pocket and height of tailspill) and move more substrate. Redds are longer and wider. Larger rocks are moved or turned over (coho do not generally move large rocks within the pocket). Chinook redds are built in deeper water and towards mid-stream whereas coho are in shallower water and smaller substrate.

CHUM:

- * Found in slower water than chinook or coho.
- * Usually located next to stream banks above the head of riffles or below tail-out on the slack side.
- * Spawning occurs in mainstem and lower ends of tributaries.
- * Mass spawning is very common. Redds appear as if a rototiller churned up the substrate.
- * Found in both deep and shallow waters.
- * Fish generally associated with redds due to short spawning season.
- * Prefer smaller substrate, the digging area is shallow and not uniform or defined.
- * Individual redds are determined by site locations and mid-depth pocket with high short stacked tailspill. Redd size is smaller than a coho redd and more oblong than cone shaped.

SOCKEYE:

- * Substrate consists of small to medium rock, coarse sand can also be found.
- * Prefer deeper and somewhat slower water compared to other species.
- * Mass spawning is very common. Redds very similar to coho and chum except they prefer smaller substrate and dig shallower and more spread out redds.

STEELHEAD:

- * Found in both mainstem and upper sections of streams. Also, found above areas that are impassable to salmon (i.e. W. Fk. Humptulips Gorge, and Kilkelly Rapids (Queets River)).
- * Redds above head of riffle but can also be found in riffles.
- * Prefer mid-stream areas. Bank spawning is not common.
- * Typical shape is cone (12 feet) and narrow (3-4 feet), depth of redd is similar to salmon but height of tailspill is flatter.
- * Common to see more than one pocket within a nest (i.e. adjoining pockets and tailspills). It is common to see more than one nest dug by a steelhead (separate digging sites) whereas salmon generally build only one nest.
- * When a female builds two nests, the shapes closely resemble coho redds as opposed to a redd consisting of only one nest.

COHO -vs- STEELHEAD:

Of all the species, coho and steelhead overlap the most in both redd description and site selection. In shape, coho redds are more cone shaped compared to oblong for steelhead. Tailspills are flatter for steelhead. Steelhead prefer faster water and the redds tend to be closer to the head of riffles. Both spawn throughout the watershed, but the coho range would include smaller streams whereas steelhead prefer larger areas.

Steelhead build redds in areas with continued flow, even during low flows while it is not uncommon to see redd stranding with salmon, especially chum.

LAMPREY (Pacific):

- * Found throughout the watershed.
- * Spawning starts in late March through early summer.
- * Redds are small (<4 feet), round pocket with most smaller rocks removed. Large rocks are not moved and found in the bottom of the pocket.
- * Redd shape is irregular with the tailspill facing in any direction but mainly downstream.
- * Tailspill composed of rocks "placed", not dug up as with salmon and steelhead. Lamprey suck onto rocks and move them one at a time. Therefore, there is very little silt in the tailspill.
- * Redds located in the same areas as steelhead, but also common in slow moving deeper areas as well.
- * Eggs can be seen settled amongst the gravel or by stirring the pocket or tailspill with a stick. Eggs are small and white in color.
- * Mass spawning is common.
- * Brook lamprey redds are typically 1' X 1' and look like elk footprints.
- * Lamprey redds are shallow.
- * Superimposition onto steelhead redds is not uncommon. When this occurs they prefer to build in the pocket of steelhead redds.

STEELHEAD -vs- LAMPREY:

Lamprey redds are smaller and irregular in shape. Shallow depth and the tailspill contains very little silt. Mass spawning areas are determined by the shallowness and the numerous pockets within the digging area. Eggs tend not to be as deep so when in doubt poke the redd carefully with a stick and look for the eggs.

CUTTHROAT:

- * Small cone shaped redd (looks like a small coho redd)
- * Generally found in streams and small tributaries.
- * Tend to be found on the sides of the stream.
- * Size is generally about 4' X 2'.
- * Can be confused with a test dig.

DATA APPLICATION

Most surveyors will not be involved in analyzing the spawning ground survey data but it is necessary to understand the way that it is used in order to appreciate the need for complete and accurate data. The following simplified example should give you a basic understanding of the process.

The map in **Figure 9** illustrates the situation. Tributary "A" has three miles of accessible spawning habitat because of a barrier at river mile 3.0 that blocks the passage of fish. One mile down the mainstem is another tributary which happens to have 2.8 miles of accessible habitat (barrier at R.M. 2.8). Both streams are similar in size, gradient and substrate therefore the data collected on one tributary can be used to estimate the escapement in the other. This transfer of data is important because it is impossible to survey an entire watershed throughout the spawning season. Index areas have to be chosen that best represent the habitat in the rest of the system.

In this case the index area is in tributary "A" between river miles 1.0 and 2.0. This index area is walked intensively (at least once a week) throughout the coho season. In addition, extensive surveys were conducted near the peak of the season (December 13th) in the areas outside of the index area. During these extensive surveys 10 redds were visible between R.M. 0.0-1.0 and 3 redds were visible between mile 2.0 and 3.0 in tributary "A". While 6 redds were found in tributary "B" between mile 1.0-2.0.

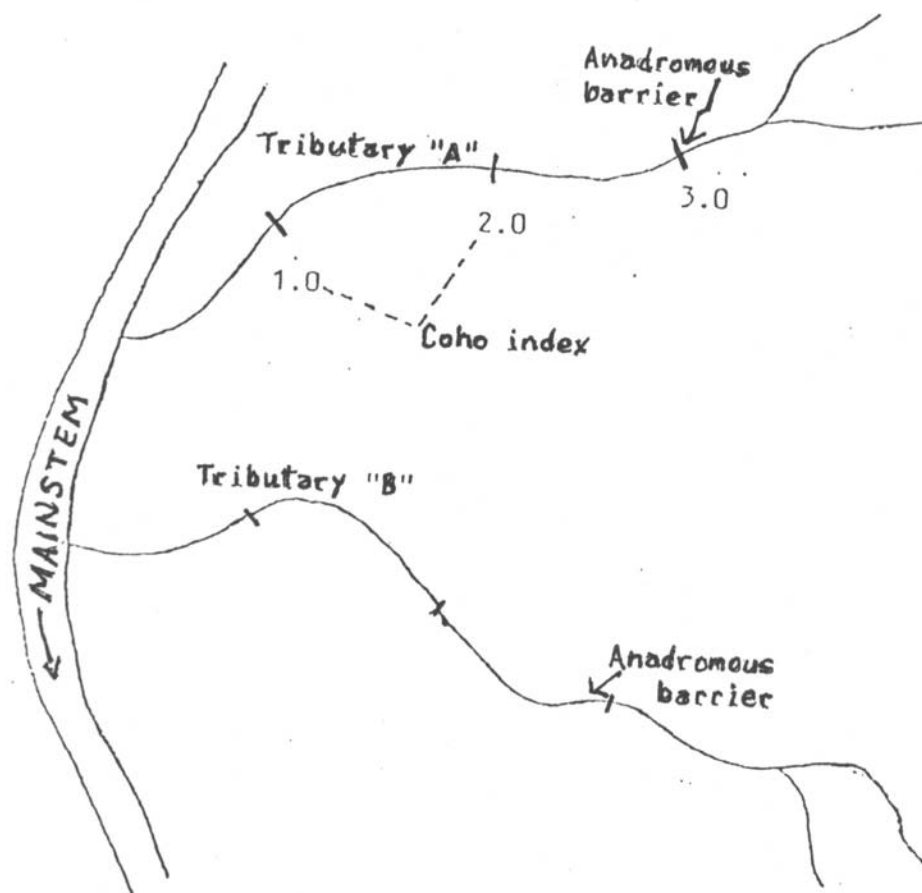


Figure 9. Map showing tributaries "A" and "B" used in the data application section.

Using the intensive data (from the index area) a spawning timing curve can be developed using the number of visible redds on each survey divided by the total number of redds in the index area for the season (**Table 2**). This indicates the percentage of the total redds that were visible during any one survey.

(Table 2). Summary of new, visible, and cumulative redd counts for tributary "A" fall coho index.

Survey No.	Survey Date	Redd Counts		Proportion of Visible	
		New	Visible	Cumulative	to season cumulative
1	10/31	0	0	0	0
2	11/07	0	0	0	0
3	11/09	2	2	2	.143
4	11/13	0	1	2	.071
5	11/18	1	2	3	.143
6	11/30	4	6	7	.429
7	12/06	1	3	8	.214
8	12/13	4	7	12	.50
9	12/20	2	7	14	.50
10	12/27	0	5	14	.357
11	1/05	0	2	14	.143

From the table you can see that on the December 13th survey, 50% of the season's total redds were visible. This means that approximately half of the total number of redds (for the season), in the extensive areas of tributary "A", should also have been visible on that day. Therefore, to get an estimate of the total in these area you would divide the number of redds seen by .50 (**Table 3**). The result is an estimate of 20 redds for the season between R.M. 0.0 and 1.0 and 6 redds between 2.0 and 3.0.

(Table 3). This brings the estimated season total for tributary "A" to 40 redds.

Survey Date	River Mile Section	Visible Redd Count	Expansion Factor	Est. Season Cumulative Redd
12/13	0.0-1.0	10	0.50	20
12/13	2.0-3.0	3	0.50	6
Season	1.0-2.0	14	-	14
Total =				40

Since tributary "B" is similar to tributary "A" this 50 percent figure is used to estimate the seasons total in the surveyed area of "B" (R.M. 1.0-2.0). This is converted into an estimate of redds/mile which is multiplied by the total number of miles accessible in "B" (2.8 miles). The result is an estimate of 33.6 (rounded to 34) redds constructed in tributary "B" over the entire season.

The estimate of total redds is converted to numbers of fish by simply multiplying the number of redds by 2 for coho or steelhead and by 2.5 for chinook. The resulting escapement estimate of coho in tributary "A" is 80 and the estimate in "B" is 68.

In this example, if there were no extensive surveys conducted in tributary "A", the expansion would have been similar to that done in tributary "B". In other words, a redd/mile number (14) would have been estimated from the index area and then multiplied by the accessible miles in "A" (3.0) for an estimate of 42 redds or 84 fish.

The amount of expansion that is performed on the original numbers can be quite extensive, depending on the situation, which illustrates the need for those original numbers to be as accurate as possible. Therefore, keep in mind that each redd in your survey area, can represent many redds in the final analysis so take the time to make the best determination possible in every situation. If you have doubts about anything that you see or think you see. "Don't hesitate to discuss it with your supervisor as soon as possible".

APPENDIX A

Beginning Day of Statistical Weeks For the Years 1975-2010

APPENDIX B

Washington Coastal Spawning Ground Survey Summary Report System

Washington Coastal Spawning Ground Survey Summary Report System

The Washington Coastal Spawning Ground Survey Summary Report System is designed as a repository for the results of all the spawning ground surveys performed on Coastal Washington Streams. With the number of agencies working on these streams it is important that we improve the communication of data. This will help minimize duplication of effort, and achieve a higher level of benefit from the data. It is designed to compliment the methods used on Coastal Washington Streams and has several unique features. The system is patterned after the "soft data" system presently being used for Washington catch data, though it is a post-season summary, rather than an in-season report. Anyone with access to the University of Washington Academic Computer System and a very limited knowledge of how it works should be able to use the system.

CODING THE DATA

Data should be entered according to the following data format. Two types of cards can be used for each survey. The first is the data card which includes the basic spawning ground information. The second is a comment card for written comments, if any, concerning unique features of the survey.

It is important to note that:

1. Data not collected on a survey should be left blank while the absence of an observed piece of data should be noted with a O.
2. Decimal points (i.e., for river mile information) should be coded on the data form.

Column Data Description 1/

1-7	WRIA = Stream number <u>2/</u> Cols. 1-2 = Water Resource Basin number. Col. 3 = Decimal Point Col. 4 = Stream Number
-----	--

Some streams were left out of the initial stream cataloging system and are not numbered. In that case the WRIA number should be the basin number followed by .0000. For a stream in the lower Chehalis River Basin this would be 22.0000. A written description of the stream location should then be included on a comment card(s). A system for numbering additional streams has been developed. For further information call Ron Egan (206) 753-0195.

 1/ See the attached coding sheet for examples.

2/ A complete listing of WRIA stream numbers is found in: Phinney, L.A. and P. Bucknell 1975. A catalog of Washington streams and salmon utilization; Vol. 2 Coastal Region. Wash. Dept. Fish. R.W. Williams Ed.

<u>Column</u>	<u>Species</u>
9	1 = Chinook 2 = Chum 3 = Pink 4 = Coho 5 = Sockeye 6 = Steelhead
10	<u>Race</u>
11-12	<u>Agency</u> 0 = WDF 02 = Chehalis Tribe 07 = Hoh Tribe 10 = Makah Tribe 17 = Quileute Tribe 18 = Quinault Tribe FW = U.S. Fish and Wildlife Service NP = Olympic National Park NR = Department of National Resources UW = University of Washington DG = Washington Department of Game FS = U.S. Forest Service
13	<u>Card Type</u> 1 = Data Card 2 = Comment Card (see discussion on comments, page 4)
14-19	<u>Date</u> = sequence is Year (last two digits), Month, Day (numbers only)
20	<u>Multiple</u> <u>Survey</u> <u>Count</u> = when more than one survey is done on the same stream on the same day, they should be numbered sequentially, 1-9 and then A-Z.
21-30	<u>Survey</u> <u>Location</u> = River Mile to nearest .1 for the downstream (20-24) and upstream (25-29) points of the survey.

Column

31

Method

1 = Foot 6 = Scuba
 2 = Boat 7 = Weir
 3 = Helicopter 8 = Tagging Study
 4 = Fixed Wing 9 = Ladder
 5 = Snorkel

32

Flow

1 = Low 4 = Moderate high
 2 = Moderate low 5 = High
 3 = Moderate

33

Visibility

1 = Excellent 4 = Fair
 2 = Very good 5 = Poor
 3 = Good 6 = Not surveyable

34

Type Count

1 = Intensive counts made in an area on a routine basis with a specific target species.
 2 = Extensive counts made in areas that are not surveyed on a routine basis or for counts of incidental species seen in an index survey.
 3 = Spot checks are for areas counted on a very infrequent basis, usually for less than 1/10 mile in distance.
 4 = Total used for areas where counting programs provide a total count (i.e., weir, towers, fishways, tagging studies).

35-49

Live Fish Counts

Adult - male (35-38)
 Adult - female (39-42)
 Adult - sex not determined (43-46)
 Jacks - (47-49)

50-64

Dead Fish Counts

Adult - male (50-53)
 Adult - female (54-57)
 Adult - sex not determined (43-46)
 Jacks - (62-64)

Column

65-76

Redd Counts 1/

New redds - Numbers of new redds seen on this survey; used in conjunction with Intensive surveys only. (65-67)

Visible Redds - Number of redds seen on this survey. (68-70)

Cumulative Redd - Total number of redds constructed during this spawning season; used in conjunction with Intensive surveys only. (71-73)

Visible Nests - Number of spawning nests observed on this survey. (74-76) Discussion of the term nest has produced various opinions. At a meeting of State and Tribal Biologists on October 11, 1979 the following definitions were discussed and generally agreed upon:

Redd - That amount of spawning activity which when summed represents one female's complement of eggs.

Nest - That portion of a redd which consists of one depression with one or more pockets. One nest may equal one redd.

77-79

Other Species - The code number (1-6) for other species seen on the survey should be entered here to provide a crosscheck. A separate survey entry should then be filled out for each species seen, see Type Count category of previous page.

80

Continuation - If additional written comments are to be included concerning this survey enter 1; otherwise leave this blank.

1/ See page 4 for a description of redds and nests

COMMENT CODING

If comments are to be assigned to a survey, use the following procedure:

1. Code column 80 = 1 (on survey data card, type 1)
2. Enter data in columns 1/20 as usual on next line, except code column 13 = 2 denoting a comment card.
3. Code column 21 = 1 denoting the first line of comments.
4. Enter comments using alpha and numeric characters in cols. 22-79.
5. If no additional comments are needed, leave column 80 blank. If additional comments are required, code column 80 = 1 and proceed as before, except: column 21 should be increased by one for each additional comment card, up to a total of 9 cards.

**ADDENDUM – SITE SPECIFIC PROCEDURES
FOR MONITORING OF
SALMON AND STEELHEAD ESCAPEMENT
IN THE SULTAN RIVER**

Prepared For
Snohomish County Public Utility District No. 1
July 2010

Salmonid Escapement Monitoring

The Sultan River freshwater production population estimates for winter-run steelhead trout and salmon follow prescribed procedures used in Washington state and are performed cooperatively with WDFW biologists for steelhead. The Sultan River index areas surveyed for all salmonid species are the following:

Main Stem RM 0.0 – 2.9

Chaplain RM 4.5 – 5.2

Gold Camp RM 7.0 – 7.3

Diversion RM 9.2 –9.7

The Main Stem index is a float survey, the others are foot surveys. Detailed maps of all the index areas denote the names of specific river reaches and are used to note the location of fish and redds. The specific location of steelhead trout and chinook salmon redds shall be noted in the data book and the redds will be individually marked by tying flagging tape around an oblong rock and placing it near the upstream end of the redd. Weather conditions are noted and the “percent seen” for the live counts shall be judged at the completion of each index area survey. If high flows or turbidity preclude surveys in the specified time frame, the conditions shall be monitored and the survey performed as soon as conditions allow. Photo copying of the data book after each survey completion is prudent.

The abbreviated field notes and estimation methodology basis for the species are:

STHD = steelhead trout - estimate based on redd counts

CHIN = chinook salmon - estimate based on redd counts

COHO = coho salmon – estimate based on live counts

CHUM = chum salmon – estimate based on live counts

PINK = pink salmon – estimate based on live counts

The abbreviated field notes for the data are:

New = new redd(s)

S/V = old redd(s), still visible

L = live

D = dead

R = redds (used in totals)

The equipment required to perform the surveys is the following:

Raft- rowing frame, oars, cooler, life vests, and air pump.

Survey gear- chest waders, pugh, polarized glasses, flagging tape, hand counters, data

book and pencil. Extras of all the survey gear are essential.

Steelhead trout

Surveys for winter-run steelhead trout begin on or around March 15, as this is WDFW's cutoff date for the spawning of hatchery origin fish. The surveys are a full day's work and personnel should be on-site by 9 am. The escapement estimate is based on redd counts and surveys are performed on fourteen-day intervals with the assistance of a WDFW biologist. The number of live and dead fish is also recorded. The run peaks in late May, however, this may vary from year to year depending on river conditions. When the peak is judged to have occurred, the river shall be flown by helicopter at noon and the all redds will be counted, breaking the index area redd counts from those in the unsurveyed reaches. The index areas shall then continue to be surveyed until the redd counts zero out in late June.

After completion of the surveys, the data shall be summarized by the number of new redds recorded in each of the index areas and the number of cumulative redds in these areas totaled. Jennifer Whitney, WDFW Region IV District Fish Biologist (Mill Creek) is the agency contact (425.775.1311 ex.107) and the steelhead escapement estimate is calculated cooperatively with her staff.

Salmon

Salmon surveys should begin by September 1. The surveys are a full day's work and personnel should be on-site by 9 am. The salmon surveys continue on ten-day intervals through January as the various species return to spawn and will require assistance. The schedule for salmon surveys is much more likely to be altered due to freshet conditions than the steelhead surveys and the situation requires constant monitoring so that surveys can be rescheduled and completed.

For chinook salmon the survey procedures are the same as outlined above for steelhead trout, however, the surveys are performed on ten-day intervals. The escapement estimate is based on redd counts and the historical peak of the run is October 1. The helicopter flight should be scheduled at noon as close to this date as possible depending on weather, particularly fog. Chinook salmon have been documented to spawn through November. Again, the agency contact is Jennifer Whitney, and the escapement estimate will require the same data summary.

Sultan River pink salmon, returning on odd years only, have identical run timing as the chinook salmon. The estimate is based on live count data and the numbers of returning

adults can be large. In order to achieve the best possible count, hand counters shall be used and the individuals are not enumerated until they are upstream of the counter. Large schools of adult pink salmon will preclude the use of the hand counters and these schools must be estimated as they pass upstream of the counter. Accuracy of these estimated schools will improve with experience and may also be verified by the dead counts of the following survey. Chum and coho salmon escapement estimates are also based on live count data and performed with the same procedure as the pink salmon surveys (Note: data for coho salmon is sporadic due to poor water visibility).

Appendix 4
Timber, Fish, and Wildlife (TFW) Methodology
Employed by Stillwater Sciences During Baseline
Habitat Survey of Sultan River

RIVERINE / RIPARIAN HABITAT SURVEY

The primary objectives are to provide quantitative information describing the amount and distribution of habitat available for fish species within and adjacent to the Sultan River (including riparian and side channel habitat), to map the quantitative information using GIS mapping tools, and to link these geographic data to associated data tables. The map-based format and display of results should aid subsequent analyses and interpretation of the significance of aquatic and riparian habitat features.

Overview

The general methods used to generate the required habitat delineations and produce the initial GIS maps and data layers involved four key steps, as described below. More detailed methods of field data collection and habitat verification for mapping of aquatic, riparian, and wetland features are described below.

The first-order identification and mapping of aquatic and riparian areas follow standard aerial photo interpretation and mapping procedures. A classification system was defined to include all types of habitats expected to be encountered. This higher-order classification scheme was used to nest all habitat types encountered (see Sub-Appendix A). Cover/habitat types are defined so that each type is unique and that the types provide the information that is necessary for the analyses.

Aerial photos were acquired that cover the extent of the mapping area. Cover/habitat types were identified and delineated within the effective area of the aerial photos. The scale, color, contrast, flight date, and flight line orientation of existing photography, in addition to landscape and terrain features, control the scale of information that can be interpreted and mapped from aerial photography. A minimum mapping unit defines the smallest cover/habitat feature that can be identified and delineated on the photography. Field identification and mapping were required for any features smaller than this minimum.

Photo mapping results were transferred to a georeferenced base map. This was completed by transferring mapped polygons from an aerial photo to an orthophoto image. This process removes the non-uniform scale distortion that is inherent in aerial photography. The new information added to the georeferenced base map was then digitized and assigned classification attributes to create the GIS databases.

Following the initial mapping procedure, the accuracy and consistency of the mapping was field-checked. Field visits were used to verify initial interpretation and to conduct additional mapping of features that were smaller than the minimum unit feasibly mapped by aerial photo interpretation.

This procedure worked well for the identification and mapping of riparian and wetland features. However, the resolution of air photo imagery and the prevalent shadow cast within the canyon made in-river habitat unit identification and boundary delineation relying solely on air photo imagery impossible. A full in-river habitat census was therefore required to identify riverine habitat features. Base maps of the channel were constructed from georeferenced aerial

orthophotos and were used by the field survey crews to record the location and dimensions of instream habitats and LWD.

The data available from remote sensing tools (existing digital elevation models and analyses of LiDAR data) were used to further refine the spatial alignment of habitat units to increase the accuracy of GIS maps. A digital elevation model (DEM) was used to increase the spatial accuracy of positions of identified riverine habitat units within the GIS database. The DEM was derived from LiDAR imagery data from several separate surveys (2004-2006) that were merged to form a single "bare earth" elevation model for the river corridor. The resulting DEM was used to construct contour lines at vertical intervals as fine as one foot. The model was used to calculate channel gradients and to identify the positions of river channel margins. The riverine unit field mapping data were digitized and spatially adjusted to reflect a best-fit with the field measurements and with the LiDAR-derived terrain and channel margins.

Study Area Description and River Reach Delineation

The Study Area includes approximately 16.5 miles of the Sultan River from Culmback Dam to its confluence with the Skykomish River. The lateral extent of the riverine habitat mapping is limited to the bankfull width area. The area outside of this zone is included in the riparian habitat mapping. Mapping of riparian habitat areas extend laterally in the upper confined reach (above approximately RM 3) to the top of the first prominent break in the hillside adjacent to the river. The lateral extent of the riparian habitat mapping in the lower unconfined reach (below approximately RM 3) of the Sultan River extends to the width of the flood plain terrace. The use of the terms "riparian" or "riparian area" throughout this study refers to the general extent of the Study Area as described above.

Within the Study Area, the river can be divided into sub-reaches based on both Project operational structures (operational reaches) and physical and geomorphic characteristics (process reaches). A description of designated operational reaches (herein referred to as OR) and process reaches (PR) are provided below. Figure 1 illustrates the geographic location and overlap by river mile. Because the beginning and ending points for the process reaches (PR) are not precise, they are not easily identified in the field, and so we used the operational reaches to reference discrete boundaries during the field surveys.

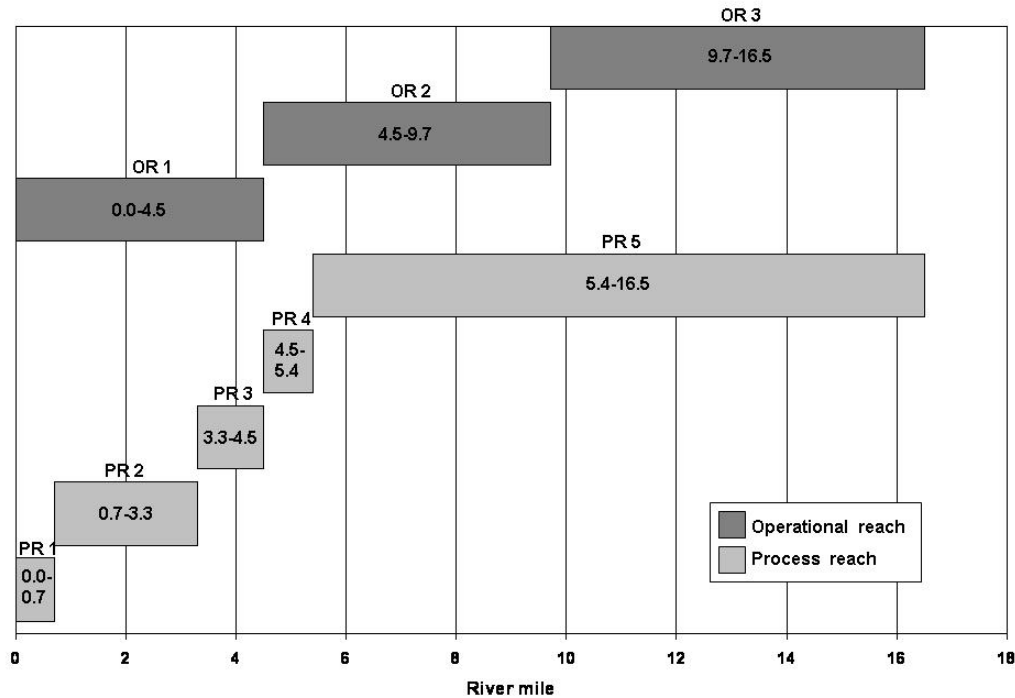


Figure 1. Operational and process reach juxtaposition in the Sultan River below Culmback Dam. River miles are noted in the horizontal bars.

The uppermost operational reach (OR 3) extends from Culmback Dam at RM 16.5 downstream to the Diversion Dam (RM 9.7) and is wholly contained in the uppermost process reach (PR 5 [RM 16.5–5.4]). OR 3 is best described as a high gradient, highly confined bedrock gorge characterized by higher rates of sediment transport as compared to subsequent downstream reaches.

The middle operational reach (OR 2) extends from the Diversion Dam (RM 9.7) downstream to the powerhouse (RM 4.5) and contains two process reaches: (1) PR 5 (RM 16.5 to RM 5.4), best described as a bedrock gorge, and (2) PR 4 (approximately RM 5.4 to RM 4.5) above the powerhouse. Channel confinement and slope are moderated in comparison to PR 5, and gravel patches, LWD, and sediment deposition are more evident.

The lowermost operational reach (OR 1) extends from the powerhouse (RM 4.5) to the Sultan River's confluence with the Skykomish River (RM 0) and contains three process reaches: (1) PR 3 (RM 4.5 to 3.3), defined as the lowermost extent of bedrock gorge; (2) PR 2 (RM 3.3 to RM 0.7), which is predominately a low gradient, unconfined alluvial reach; and (3) PR 1 (RM 0.7 to RM 0), which is also a low-gradient, unconfined alluvial reach.

Operational reach designations were used to stratify the survey field effort and data for quantifying in-river habitat and LWD. This approach was chosen due to the unambiguous field identification of river reach breaks.

Channel gradient and confinement by canyon walls is relatively consistent through ~ 13 miles of the river channel below Culmback Dam, except for the lower ~ 3.3 miles (PR 2 & 1) to its confluence with the Skykomish River.

A plot of channel gradient (Figure 2) within the Study Area suggests that the channel has relatively consistent gradients of 1-2% through most of its length below Culmback Dam, with average gradients decreasing to less than 1% in the lower ~ 3.3 miles (PR 2 & 1) to its confluence with the Skykomish River. In terms of the mid-scale v. fine-scale gradient variability, the steepest mile is below the diversion dam (RM 9-10), while at a finer scale local slopes can average up to 3-5% over 100s-1000s of feet, in OR 2-3 for example.

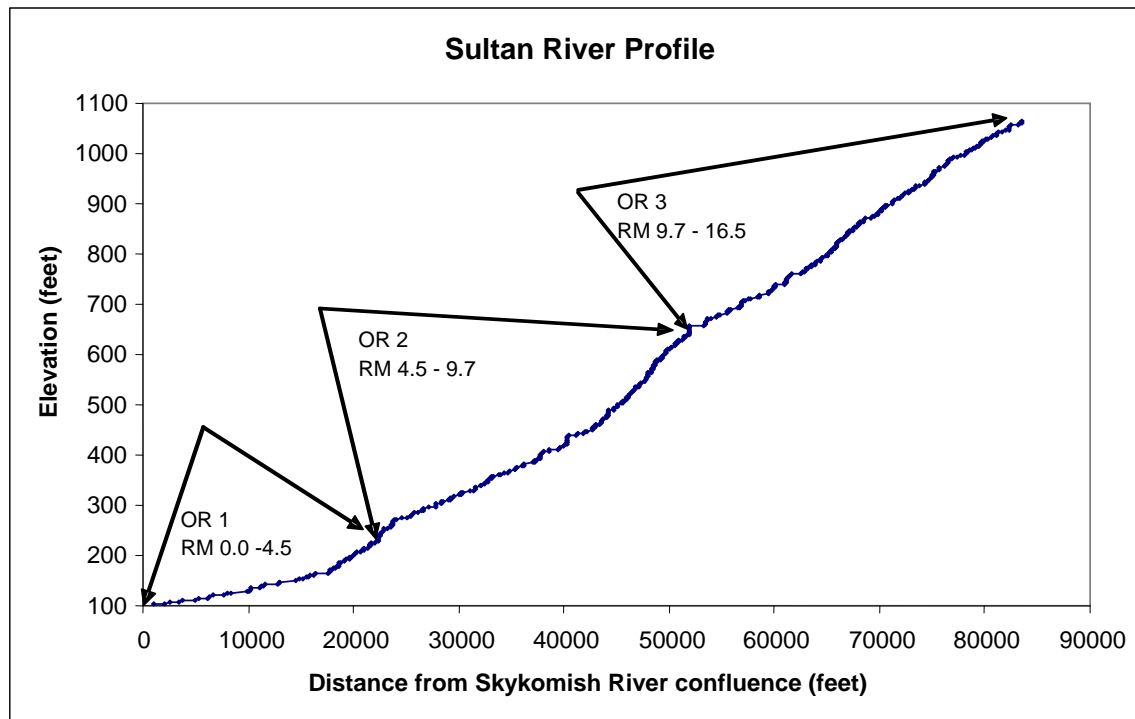


Figure 2. Profile of Sultan River channel gradient from the confluence with the Skykomish River upstream to Culmback Dam (RM 0-16.8) (OR = “operational reaches”; vertical exaggeration 50x).

Riverine Habitat Mapping and Large Woody Debris Survey

The use of recent aerial photographs and a helicopter flight survey in May 2007 were helpful for identifying broad riverine habitat characteristics and providing an initial survey of LWD distribution. These survey data have been captured as a data layer in the GIS database. A subsequent field census of the complete Study Area was necessary, given the required level of detail for identification of habitat attributes and the limited resolution of aerial photographs available. Aerial photographs were used to develop initial base maps onto which instream habitat attributes and LWD data were recorded during field surveys.

Light detection and ranging (LiDAR) remote sensing data and post-processing techniques were used to provide refinement and discrimination of terrain features in the river canyon corridor.

LiDAR data and post-processing ultimately provided enhanced detail for topographic mapping of both the channel and the adjacent hillslope, and allowed a more accurate representation of the juxtaposition of in-river habitat features and associated LWD.

As called for in the RSP 18, methods used to quantify in-river habitat units and associated large woody debris (LWD) were selected to provide repeatable identification of habitat types, dimensions, and locations, as well as documentation of associated LWD and sediment characteristics. All information has been catalogued within a GIS database framework. The classification schemes used to identify specific habitat unit types, substrate sizes, and LWD attributes are given in Table 1 and Table 2.

Table 1 Riverine (instream) habitat type and substrate attributes

Reach Delineation	
	Operational Reach (3)
	Process Reach (5)
Habitat Types	
	Pool
	Riffle
	Cascade
	Rapid
	Glide
	Side Channel
	Undercut Banks
	Backwater Areas
	Bar Edges
Substrate Category	
	Mud
	Silt
	Sand
	Gravel
	Cobble
	Small Boulder
	Large Boulder
	Bedrock

Table 2. Large woody debris attributes (LWD)

LWD JAM	
	Number of pieces

	Dimension (length, width, height)
	Channel Position (bank, mid-channel, bar)
	Percent of Channel Width
	Largest Piece Size
LWD Piece	
	Length
	Diameter
	Decay Class
	Species Class (conifer, deciduous)
	Rootwad (yes, no)
	Anchoring (bed bank)
	Channel Position (bank, mid-channel, bar)

Delineation of In-River Habitat Units

In-river habitat unit classification system and field methods were adapted from those commonly used in Washington State (Pleus et al. 1999 and Schuett-Hames et al. 1999). They provide consistency for unit type identification and for recording unit dimensions. Habitat attributes recorded include unit type (e.g., pools, riffles, etc.), measurements of wetted unit surface area dimensions (length and width), average unit depths, unit margin features (lengths of undercut banks and bar edges), and LWD characteristics. Example field data collection forms and criteria are provided in Sub-Appendix B.

The habitat and large woody debris (LWD) assessment was conducted in June and July 2007 within the designated Study Area of the Sultan River. The habitat assessment involved a field survey (or census) of the Study Area by a three-person crew, and was conducted in three stages corresponding to the three operational reaches. Each reach presented unique challenges, including access, turbidity, and the controlled release of high flows for the purpose of other studies associated with Project relicensing. OR 3 was surveyed first, moving upstream beginning at the Diversion Dam. OR 2 and OR 1 were subsequently surveyed in that order, moving downstream from the Diversion Dam and the powerhouse, respectively.

The field crew surveyed each OR sequentially to identify habitat unit boundaries and associated attributes. Data were collected in a hierarchical manner to first identify habitat unit locations within each OR, assign a core unit-type designation, and indicate a category to define the unit position within the lateral channel. These first-order reach-unit scale data were recorded using an alphanumeric coding system that assigned (a) a unique numeric data identifier (Natural Sequence Order or NSO unit number); (b) a core unit type (riffle, pool, sub-surface flow, obscured, or other [Pleus et al. 1999]); and (c) a ranking that defined the degree to which the unit occupied the wetted channel. The latter included primary main channel units (category 1),

secondary main channel habitat units (category 2), and side channel habitat units separated from the main channel by an island (category 3). Islands were identified according to Schuett-Hames et al. (1999) where the length of such island units is at least two times the bankfull channel width and the terrestrial area is vegetated by perennial plants two meters or greater in height. The sum of all Category 1 habitat units is equivalent to the actual linear river length of the OR surveyed.

Subsequent data, including unit subtype and dimension measurements, were recorded for NSO. Length, average depth (except in pool habitat units), and three wetted width measurements were recorded for each delineated habitat unit. Habitat unit subtypes were designated for pool and riffle core units according to the criteria given in Table 3-3. Additional information was recorded for pools, including maximum depth, residual pool depth, and the dominant factor forming the pool according to the criteria given in Table 3-4 (Pleus et al. 1999).

Table 3. Criteria and their definition used to identify core and sub-unit habitat types (with associated field code acronyms). Sub-unit designations and definitions are adapted from Flosi et al. 1998.

Core Habitat Unit Type	Sub-Habitat Unit Type	Criteria Definition
Riffle (R)	Low Gradient Riffle (LGR)	Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient <4% is usually cobble dominated.
	Rapid (RPD)	Steep sections of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively high. Gradient is >4%, and substrate is boulder dominated. In Flosi et al. (1998), these are 'high gradient riffles'.
	Glide (GLD)	Wide uniform channel bottom. Flow with low to moderate velocities, lacking pronounced turbulence. Substrate usually consists of cobble, gravel, and sand.
	Cascade (CAS)	The steepest riffle habitat, consisting of alternating small waterfalls and small shallow pools. Substrate is usually bedrock and boulders.
Pool (P)	Main Channel Pool (MCP)	Large pools formed by mid-channel scour. Water velocity is slow, and the substrate is highly variable.
	Lateral Scour Pool (SCP)	Formed by flow impinging against a partial channel-bank obstruction.

	Backwater Pool (BKW)	Formed along channel margins and caused by eddies around a bank obstruction. These pools are usually shallow and are dominated by fine-grained substrate. Current velocities are quite low.
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Table 4. List of pool forming factors and associated field codes (Pleus, et al. 1999). Definitions for individual large woody debris (LWD) pieces versus debris jams are according to Schuett-Hames et al. (1999)

Field Code	Pool Forming Factor
1	LWD Log(s)
2	LWD Rootwad(s)
3	LWD Jam
4	Roots of standing tree(s) or stump(s)
5	Boulder(s)
6	Bedrock
7	Channel bedform
8	Resistant bank
9	Artificial bank
10	Beaver dam
11	Other / Unknown

In-River LWD Inventory

Survey methods to characterize and enumerate LWD within the Sultan River followed methods refined for the Timber Fish and Wildlife Monitoring Program (Schuett-Hames et al. 1999). Deviations from survey methods included lumping LWD into size categories and characterizing LWD in debris jams by tallying individual pieces and rootwads. Example field data collection forms and criteria are provided in Appendix B.

For the field survey, large woody debris (LWD) was defined as dead logs, limbs, or rootwads partially or entirely located within the bankfull channel. LWD was enumerated according to a minimum size and length criteria. Individual downed logs and rootwads tallied had a minimum length of two meters and a mid-point diameter of twenty centimeters or greater. Total length for each piece was recorded, and a diameter class was assigned. Diameter classes were defined as (a) ≥ 20 cm to < 40 cm, (b) ≥ 40 cm to < 60 cm, or ≥ 60 cm. The location of LWD either within the

wetted channel (zone 1) or within the bankfull channel width (zone 2) was also recorded based on present wetted channel conditions. Additional LWD data attributes recorded were:

- anchor feature (root system, boulder, pinned or unstable [Schuett-Hames et al. 1999])
- species class (conifer, deciduous or unknown)
- decay class (1-5, [Robison and Beschta 1990 cited in Schuett-Hames et al. 1999]),
- the presence or absence of an intact rootwad

In addition to individual pieces of LWD, debris jams were mapped on base maps and measured. The criteria for identifying debris jams was the accumulation of ten or more pieces of interlocked LWD (including rootwads) where at least ten pieces were ≥ 20 cm in diameter, ≥ 6 feet in length, and the majority of the debris jam was located within the bankfull channel (Schuett-Hames et al. 1999). Attribute data recorded for debris jams included a tally of all pieces and rootwads meeting the criteria described above, and approximate length, width, and height dimensions. Specific diameter and length measurements were recorded for the most prominent individual piece within each jam.

Exceptionally large LWD (whether individual pieces or within a debris jam) were recorded according to key piece criteria used in Schuett-Hames et al. (1999). Key pieces are of interest given their potential longevity, stability, and influences on river geomorphology. Key piece criteria varied throughout the river corridor based on the relationship between the width of the bankfull channel and dimensions of the LWD piece in question.

All LWD was geographically referenced by recording the associated habitat unit NSO in addition to other data described above.

Characterization of River Channel Substrate

A modified Wolman (1954) approach similar to the method described in GeoEngineers (1984) report was used to characterize the surface size distribution of discrete patches of spawning-sized gravel. Patches of gravel deposited along channel margins, pool tail-outs, or on the lee of large mid-channel obstructions were identified as sample sites. One hundred particles were chosen at random throughout the selected patch, and the diameter of the secondary axis was measured to the nearest millimeter with a ruler. Sampled substrate represents gravels and cobbles within the size range of salmonid spawning habitat. The underlying particles represent the subtending bed surface. See *Study 22: Sultan River Physical Processes Studies* for a more detailed discussion of particle size distribution in the Sultan River.

Riparian Habitat Mapping

The general identification and interpretation of cover types was conducted using aerial photos taken during August 2001 (1:12,000 scale natural color). Photos appear to have been taken mid-day, thus producing minimal shadowing. Color balance of photos was heavy skewed toward a green tint which made the distinction of some cover types difficult, particularly conifer versus cottonwood. Initial photo interpretation from 2001 photos was supplemented by reviewing digital versions of the 1997 aerial photos (non-stereo) taken in April 1997 during leaf-off conditions for deciduous trees.

Photo interpretation was conducted in several stages. The first stage identified all distinct polygons on the aerial photos composed of forest types and large wetland types. Polygons were labeled with a unique ID number corresponding to attributes in a linked spreadsheet of attribute data. Polygons delineated in the first stage of photo interpretation were digitized using a 2006 orthophoto base map (Department of Agriculture NAIP) to create a shapefile linked to unique attribute data. Field verification of forested cover types was conducted between first stage and second stage photo interpretation to identify and rectify errors.

Second-stage photo interpretation was conducted to identify small wetland types difficult to delineate in the aerial photos. Second-stage photo interpretation allowed the small wetland polygons to be accurately integrated and geographically referenced with the digital output from first-stage photo interpretation. Second-stage photo interpretation was conducted using a combination of aerial images including stereo photo pairs of 2001 aerial photos, the 2006 orthophoto image, an elevation shaded image from the 2006 LiDAR flight, and multiple series of historical aerial photos taken during the winter to clarify location of deciduous versus conifer species.

Second-stage photo interpretation also enabled updating cover type information to reflect 2006 conditions. The orthophoto base map was used to identify recent changes in cover types (e.g., timber harvest areas). Cover type polygons and attribute codes were updated to reflect recent observed changes.

Field verification of wetland cover types was conducted to verify the presence or absence of a hydrological connection between the wetland areas and the Sultan River, as well as to confirm that wetlands were in fact present where interpreted.

Cover type codes served as the anchor for all other attribute data. Riparian shapefiles were merged with the results of riverine habitat mapping and checked to ensure proper joining of map layers.

Forest and wetland attribute categories are shown in Tables 5 and 6. Riparian cover type descriptions and density descriptions are provided in Sub-Appendix C.

Table 5. Forest type attributes

Plant Association		
	Western Hemlock / Alaska Huckleberry	TSHE / VAAL
	Western Hemlock / Swordfern-Oregon Grape	TSHE / POMU-BENE
	Western Hemlock / Swordfern-Salal	TSHE / POMU-GASH
	Western Hemlock / Swordfern-Foamflower	TSHE / POMU-TITR
	Western Hemlock / Devil's Club-Ladyfern	TSHE / OPHO-ATFI
	Western Hemlock / Skunkcabbage	TSHE / LYAM
Seral Stage		
	Seedling / Sapling (< 1" dbh)	SS
	Pole (1 - 9" dbh)	P
	Mid-Successional (10 - 20" dbh)	MS
	Mature (> 20" dbh)	M
	Old-Growth (> 24" dbh)	OG
Density		
	Low (< 30% canopy cover)	L
	Medium (30 - 60% canopy cover)	M
	High (> 60% canopy cover)	H

Geo-referenced Habitat Mapping

Aerial photographs were used to guide field efforts. Large-format air photos were assembled into a folio for use in the field. In deeply shaded areas of the Sultan River canyon, aerial photograph series from 1997 and 1983 were orthorectified within ArcMap and used to supplement the 2003 coverage. These photos served as the template onto which measurements of habitat unit boundaries were recorded. Information recorded on the photos was digitized and used to create geographically referenced map layers with GIS tools.

In order to create corresponding digital map data layers using GIS tools, a variety of techniques and tools were employed. First, a digital elevation model (DEM) was used to increase the spatial accuracy of positions of field identified riverine habitat units within the GIS database. Rather than relying on existing USGS 1:24,000 elevation datasets, the DEM was customized by derivation from available (LiDAR) imagery data from several separate surveys (2003-2006) that were merged to form a single "bare earth" elevation model for the river corridor. The DEM has horizontal resolution of six foot grid cells, resulting in contour lines at vertical intervals as fine as one foot. The model was used to calculate channel gradients and to identify the positions of river channel margins. The riverine unit field-mapping data have been digitized and spatially adjusted to reflect a best-fit with the field measurements and with the LiDAR-derived terrain and channel margins.

GIS feature data containing the riparian and wetlands habitat was integrated with the riverine habitat feature data.

SUB-APPENDIX A

Comprehensive Mapping Classification

The maps of aquatic, riparian, and wetland habitats required by the revised study plan are integrated into a hierarchical classification system (Appendix A Public Utility District No. 1 of Snohomish County and City of Everett 1988)) and described in RSP 18. The mapping of aquatic, riparian, and wetland habitat within the same classification system ensures that no gaps exist between features within the extent of the mapping area, and that each cover/habitat type is uniquely defined without overlap.

Table 1 . Comprehensive mapping classification system

Land Code	Develop Code	Forest Code	Upland Code	Wetland Class	Cover Type	Code
Water				Riverine	see aquatic habitat types in Table 3-3 of this report	
Water			Wetland	Palustrine	Palustrine Open Water	POW
Water			Wetland	Lacustrine	Lacustrine Open Water	LOW
Land	Developed	Non-Forested	Upland		Project Facilities	FAC
Land	Developed	Non-Forested	Upland		Commercial	COM
Land	Developed	Non-Forested	Upland		Residential	RES
Land	Developed	Non-Forested	Upland		Agricultural	AG
Land	Developed	Non-Forested	Upland		Recreational	REC
Land	Developed	Non-Forested	Upland		Rock Pit	RP
Land	Undeveloped	Non-Forested	Wetland	Riverine	Riverine Unconsolidated Shore	RUS
Land	Undeveloped	Non-Forested	Wetland	Lacustrine	Lacustrine Unconsolidated Shore	LUS
Land	Undeveloped	Non-Forested	Wetland	Palustrine	Palustrine Emergent	PEM
Land	Undeveloped	Non-Forested	Wetland	Palustrine	Palustrine Shrub / Scrub	PSS
Land	Undeveloped	Non-Forested	Upland		Rock Outcrop	RO
Land	Undeveloped	Non-	Upland		Rock Talus	RT

		Forested				
Land	Undeveloped	Non-Forested	Upland		Shrubland	SH
Land	Undeveloped	Non-Forested	Upland		Grass / Meadow	MD
Land	Undeveloped	Forested	Wetland	Palustrine	Palustrine Forested	PFO
Land	Undeveloped	Forested	Upland		Conifer	C
Land	Undeveloped	Forested	Upland		Deciduous	D
Land	Undeveloped	Forested	Upland		Mixed	M
Land	Undeveloped	Forested	Upland		Mosaic	MO

SUB-APPENDIX B

Riverine habitat and LWD field data collection forms and criteria

IN-RIVER HABITAT UNIT SURVEY CODE SHEET AND CRITERIA

Habitat Unit Survey Datasheet Codes

Survey Reaches (OR Operational Reach)

- A (OR 1)** RM 0.0 - 2.7
Confluence with Skykomish River upstream to BPA transmission line crossing
- B (OR 1)** RM 2.7 - 4.3
BPA transmission line crossing upstream to Jackson Powerhouse
- C (OR 2)** RM 4.3 - 9.7
Jackson Powerhouse upstream to City of Everett Diversion Dam
- D (OR 3)** RM 9.7 - 16.5
City of Everett Diversion Dam upstream to Culmback Dam

Habitat Unit Codes

Core Unit Types

Riffle	R
Pool	P
Sub-surface flow	SSF
Wetland	W
Obscured	OB
Other	OT

Pool forming features (Pg 24 TFW Manual Pleus et al. 1999)

1	LWD log(s)
2	LWD rootwad(s)
3	LWD jam
4	Roots of standing trees or stump(s)
5	Boulder(s)
6	Bedrock
7	Channel bedform
8	Resistant bank
9	Artificial bank
10	Beaver dam
11	Other / unknown

Sub - unit types (see Flosi et al. 1998)

Pool	MCP	main channel pool	(e.g. trench pool, mid-channel pool, channel conf. pool, step pool)
	SCP	scour pool	(e.g. corner pool, scour enhanced by root wad - log - boulder)
	BKW	backwater pool	
Riffle	LGR	Low gradient riffle	(shallow swift turbulent water, exposed cobble dominated substrate, <4% gradient)
	HGR	High gradient riffle	(swift turbulent water, exposed boulder dominated substrate, >4% gradient)
	GLD	Glide	(wide uniform channel bottom, lacking pronounced surface turbulence)
	CAS	Cascade	(steepest riffle habitat consisting of alternating small waterfalls and shallow pools)

Unit Category

- primary units: dominant units in the mainchannel
- secondary units: sub-dominant units within the main channel that span less than 50% of the wetted channel width along less than half their channel length
- side channel units: units in smaller clearly defined channels that are separated from main low flow channel (say by an island for example)

LWD Survey Codes and Associated Criteria

- ZONE 1 defined as the portion of the bankfull channel that is wetted at the time of the survey, regardless of whether the water is flowing or stagnant
- ZONE 2 defined as the area between the bankfull channel edge on both banks, below an imaginary line that connects those points, above the wetted gravel bars channel surface, and includes areas such as dry gravel bars

LWD Log Criteria

- 1 dead
- 2 the root system (if present) no longer supports the weight of the stem / bole
- 3 minimum diameter of 0.1 meters along 2 meters of its length, AND
- 4 minimum 0.1 meter of length extending into the bankfull channel

LWD Rootwad Criteria

- 1 dead
- 2 root system detached from original position
- 3 minimum diameter of 0.2 meters with a total length <2 meters; AND,
- 4 minimum 0.1 meter of length extending into the bankfull channel

LWD Jam Identification / Criteria

- (a) minimum 10 qualifying pieces of LWD either physically touching at one or more points, or associated with jam structure
- (b) minimum 0.1 meter of one LWD piece's length extending into the bankfull channel

LWD KEY PIECE CRITERIA

See pg 17 and Appendix C of TFW Large Woody Debris Survey Manual (Schuett-Hames et al. 1999)

LWD Anchoring (see "Stability Factors" pg 20 Schuett-Hames et al. 1999)

- R Rootwad
P Pinned
B Boulder
U Unanchored

LWD Decay Class (see pg 22 TFW Manual Schuett-Hames et al. 1999)

	Bark	Twigs	Texture	Shape	Wood Color
1	Intact	Present	Intact-Firm	Round	Original
2	Intact	Absent	Intact-Firm	Round	Original
3	Trace	Absent	Smooth	Round	Original-Darkening
4	Absent	Absent	Abrasion - Holes	Round-Oval	Dark
5	Absent	Absent	Vesicular	Irregular	Dark

SUB-APPENDIX C:

RIPARIAN COVER TYPE DESCRIPTIONS AND DENSITY DESCRIPTIONS

Cover Type Descriptions

SERAL STAGE DEFINITIONS

SEEDLING / SAPLING – The seedling / sapling seral stage is characterized by small trees, shrubs, and herbaceous vegetation. The average diameter of trees is generally less than 1 inch, with heights generally less than 15 feet tall. The growth and development of the canopy of the stand is generally low, providing less than 30 percent canopy coverage. This stage may last for 10 to 15 years after a final even-aged stand regeneration harvest or forest fire.

POLE – The pole seral stage is dominated by conifer or deciduous trees. The average diameter of trees is generally between 1 and 9 inches in diameter, with heights ranging from 15 to 50 feet tall. The amount and type of understory vegetation present in this cover type would depend on the density of the stand and the length of time in this seral stage. Younger stands with less canopy coverage would have understory conditions similar to seedling/sapling stands. Older stands, or stands with greater canopy closure, may have very low density of understory vegetation.

MID-SUCCESSIONAL – The mid-successional seral stage is dominated by conifer or deciduous trees. The average diameter of trees is generally between 10 and 20 inches in diameter, with heights ranging from 50 to 100 feet tall. Canopy closure is generally uniform within the stand. Snags are generally suppression killed and of small diameter. Dead and down woody material is often small in diameter or in late stages of decay.

MATURE – The mature successional seral stage is dominated by conifer or deciduous trees. The average diameter of trees is generally greater than 20 inches in diameter, with heights greater than 100 feet tall. The canopy structure is usually less uniform than mid-successional stands allowing more light penetration to the forest floor for the development of understory vegetation.

OLD-GROWTH – The old-growth seral stage is generally dominated by conifer species, although there may be a deciduous component present also. The average diameter of tree is generally greater than 24 inches, with heights greater than 100 feet. A multi-layered canopy and highly variable canopy closure is generally present. Shade tolerant shrub species and conifers are generally present in the middle or understory canopy position.

DENSITY DEFINITIONS

Stand density for cover type mapping is best identified using standard vertical stereo pair aerial photos. The density attribute represents the percent occupancy of the site by the overstory forest canopy.

LOW – The low density represents a canopy closure level less than 30 percent.

MEDIUM – The medium density represents a canopy closure level between 30 and 60 percent.

HIGH – The high density represents a canopy closure level greater than 60 percent.

Appendix 5

Rotary Screw Trap Protocols Used to Capture Smolts During Outmigration

Field Manual – Rotary Screw Trap Protocols

Protocol adapted from Seiler and Volkhardt, 2005 and Murdock et al. 2001

SUMMARY

In accordance with local, state, federal and tribal agency regulations, investigators will use floating, rotary screw traps to collect downstream-migrating smolts for estimating the total number (abundance) of smolts produced within the watershed or basin. Traps will operate at minimum the entire period of the smolt emigration. Trapping efficiency will be estimated throughout the trapping period by using a mark-recapture methodology. Methods for operating the trap, estimating trap efficiency, and determining the frequency at which efficiency tests will be conducted are described in Murdoch et al. (2000). Numbers of smolts will be reported for populations or subpopulations. The Fulton-type condition factor, a measure used to describe the well-being of smolts within a population or sub-population, will be estimated from length and weight measurements taken from captured fish. Genetic samples may be collected to characterize (via DNA microsatellites) the within- and between-population genetic variability of smolts.

PURPOSE

Operating a downstream migrant trap allows investigators to sample salmonids produced in a watershed or tributary over time. The sample in itself is valuable as it documents the presence or absence of migrating juveniles. The sample can also determine the age, the condition, timing, species, rearing history and genetic characteristics at migration. Furthermore, if the location of the trap and hours of operation are held reasonably constant from year to year, catch of a given species or catch per unit effort can be used as an index of downstream migrant production (Seiler and Volkhardt, 2005).

Trapping information can be used to create estimates of the total freshwater production by using a simple mark-recapture population estimation methodology. The proportion of marked fish appearing in a random sample estimates the proportion of marked fish in the total population. The proportion captured, or trap efficiency, is estimated by conducting a series of trap efficiency experiments over the trapping season (Seiler and Volkhardt, 2005). Trap efficiencies can vary from day to day as discharge fluctuates, thus requiring frequent calibration.

This protocol describes methods used to achieve estimates of wild, downstream-migrant salmonid production using a rotary screw trap. Since a rotary trap samples only the upper portion of the water column, they are generally not very useful for capturing species that migrate along the bottom of the river (e.g., lamprey). Traps can be scaled to operate in various sized streams,

but are most commonly used in streams that are too large or powerful to employ a fence weir (e.g., ~10 to 15-m or larger channels) (Seiler and Volkhardt, 2005).

The rotary screw trap is used in medium to large rivers. The screw trap consists of a cone covered in perforated plate that is mounted on a pontoon barge (Figure 1). Within the cone are two tapered flights that are wrapped 360-degrees around a center shaft. The trap cone is oriented with the wide end facing upstream and uses the force of the river acting on the tapered flights to rotate the cone about its axis. Downstream migrating fish are swept into the wide end of the cone (typically either 5 ft or 8 ft in diameter) and are gently augured into a live box at the rear of the trap. A winch is used to adjust the fore elevation of the cone (Seiler and Volkhardt, 2005).

BACKGROUND

Traditionally, fishery managers have relied on escapement estimates to monitor anadromous salmonid population status and management effectiveness (Ames and Phinney 1977; Beidler and Nickelson 1980; Hilborn et al. 1999). In many salmon-bearing systems, population abundance is only monitored during the spawning stage. By estimating population abundances at earlier life stages researchers are able to partition survival among life-stages and develop hypotheses for restoration actions (Moussalli and Hilborn 1986, Mobrand et al. 1997).

Monitoring smolt abundance is particularly powerful since it enables the partitioning of mortality between the freshwater, egg-to-smolt life stages, and the marine life stages of smolt-to-adult (Seiler and Volkhardt, 2005). Juvenile fish traps have also been used to estimate the abundance, timing, size, survival, and behavior of downstream-migrant anadromous salmonids (Tsumura and Hume 1986; Baranski 1989; Orciari et al. 1994; Thedinga et al. 1994; Letcher et al. 2002; Wagner et al. 1963; Hartman et al. 1982; Orciari et al. 1994; Olson et al. 2001; Schoeneman et al. 1961; Wagner et al. 1963; Tsumura and Hume 1986; Olsson et al. 2001; Letcher et al. 2002; Brown and Hartman 1988; Roper and Scarnecchia 1996).

While estimating smolt abundance is the most common reason for operating a screw trap, the collection of downstream migrants also has wide utility. Traps can be used to monitor the effects of river management on wild stocks, such as the effectiveness of diversion, lock, and dam management. Traps can also be used to validate assumptions regarding the effect of watershed restoration programs and land-use policies on fish populations and to assess survival between life stages, such as egg-to-smolt survival or parr-to-smolt over-winter survival (Seiler and Volkhardt, 2005).

In addition to monitoring wild populations, traps are useful for evaluating hatchery programs and hatchery/wild fish interactions. These studies may include evaluating the instream survival of hatchery fish following release and evaluating treatments such as rearing strategy, release timing, release location, and flow manipulation on groups of hatchery fish. These later uses can evaluate hatchery supplementation strategies and avoidance of hatchery and wild fish interactions. In addition to abundance estimates, investigators use scoop and screw traps to collect samples of downstream migrants for such purposes as genetics sampling, fish disease research, predation

(gut content) evaluations, and wild stock marking and tagging projects (Seiler and Volkhardt, 2005).

On the west coast of the United States and Canada, juvenile fish traps have primarily been used to estimate the natural production of juvenile coho (*Oncorhynchus kisutch*), sockeye (*O. nerka*), and steelhead (*O. mykiss*) from 5th order and smaller basins (Nickelson 1998). Nevertheless, with careful planning reasonably accurate production estimates have been obtained when 6th order and larger systems have been trapped (Schoeneman et al. 1961, Thedinga et al. 1994). For example, side-by-side scoop and screw traps have been used to successfully yield estimates of yearling coho and sub-yearling chinook migrants since 1990 in the Skagit River, a 7th order basin (Seiler et al. 2003).

SAFETY

When positioned in the river, screw traps (and the associated rigging) represent a hazard to boaters, float tubers, and swimmers. Wires and cables should be marked with bright colored flagging so as to be easily viewed by river users. Wires and cables should be high enough above the river to allow safe passage of boats. Precautions should be taken to make sure that all lines are secure and that bolts and shackles on the trap are tightened. Signs should be positioned both upstream and downstream of the trap to instruct boaters how to safely avoid the trap. Other protective measures may include flashing lights to improve the visibility of the trap and deflectors to help prevent water users and large woody debris from entering the trap (Seiler and Volkhardt, 2005). A minimum of two persons shall operate the trap at any given time. Life jackets shall be worn at all times by personnel while traveling to and from or while operating the trap. Do not take the boat in front of the trap while it is fishing. Standard precautions should be taken by personnel to keep hands and loose clothing away from the cone and axle and other moving trap parts during trap operation. Efforts shall be made to minimize the amount of time spent in front of the rotating cone.

EQUIPMENT

Trap/pontoon structure, anchor cables, boat (if necessary to reach trap), dip nets, fish anesthetic (MS 222), marking devices (scissors, dye, etc.), buckets (for collecting and working fish), brush/water pump for cleaning trap, flood lights (for night work), aeration equipment.

SITE SELECTION

If the natural production of salmon is to be monitored, selection of trapping sites should be viewed from a variety of scales. At the watershed scale the river or stream should either be devoid of hatchery fish or all hatchery fish should be identifiable so that wild fish can be enumerated. Precision of the estimates increases with higher trap efficiency (i.e. proportion of migrants captured); therefore it is generally better to select sites where a higher proportion of the total flow can be screened through the trap. This becomes a trade-off, however, if the trap is

placed below a hatchery release site since higher trap efficiencies can result in very large numbers of hatchery fish entering the trap following a fish release. Where this occurs, good communication between the trap operators and hatchery staff must be maintained to avoid a fish kill. In general, it is best to avoid these situations when choosing a trap site.

Another consideration when selecting watersheds is the hydrologic pattern of the basin. Flow is dependent on variables such as landform, geology, land cover, climate, and precipitation patterns, which of course, cannot be controlled. Since trap efficiency and migration rates often change dramatically with flow, rivers exhibiting a flashy hydrograph are very difficult to trap due to large fluctuations in flow conditions and debris loads. The effect of these variables on stream discharge needs to be considered when estimating total freshwater production (Seiler and Volkhardt, 2005).

Within a watershed, the trap should be placed as low in the watershed as practicable. Species exhibiting a stream-type life history pattern, such as coho salmon and steelhead often migrate within basin and rear away from their natal streams. Therefore, the smolt production measured from part of the basin may represent a variable proportion of the progeny from the adults that spawned upstream of the trap. Furthermore, species with an ocean-type life history pattern, such as pink salmon (*O. gorbuscha*), often spawn lower in the watershed. Estimating production for these species requires trap placement as low in the system as possible (Seiler and Volkhardt, 2005).

At the site scale, water velocity, depth, and proportion of the flow screened are also important considerations for trap placement. Velocity is an especially important consideration if trapping strong swimming species such as steelhead trout, and becomes less important when trapping newly emerged fry. For most species, water velocities of at least 1-mps (3-cfs) are desirable for scoop trap operation and over 2-mps (6-cfs) may be required to capture and retain most steelhead smolts. Similar velocities are recommended for screw trap operation. Screw traps should rotate at least 5-6 rotations per minute for retention of larger smolts. Care must be taken that the water depth under the trap and live well will be sufficient over all flow conditions expected during the outmigration period or damage to the equipment may result during low flow conditions. It is usually best to select a site where a relatively high proportion of the total flow can be screened through the trap in order to achieve the highest trap efficiency. The requirement for adequate velocity, depth, and trap efficiency usually argues for placing the trap in the thalweg of the channel. Consideration must be given, however, to the number of migrants captured. The investigator may opt to operate the trap in a slightly less advantageous position to avoid causing stress or predation in the live well by capturing and holding too many migrants (Seiler and Volkhardt, 2005).

Screw traps are inherently noisy due to the rotation of the trap cone about its central axis. Migrants will avoid the trap if they are aware of its presence; therefore, it is best to select a site where the trap noise can be masked in order to maintain higher trap efficiency. Fortunately, higher velocity reaches are also noisy reaches. In smaller rivers, these conditions are encountered at the head-end of a pool or chute where water velocities over an elevation drop (e.g., riffles, cascades, or falls) can be directed into the trap. In larger rivers, channel constrictions may afford the best sites (Seiler and Volkhardt, 2005).

In addition to the above-mentioned criteria, consideration must be given to anchoring the trap in the stream. Scoop and screw traps can be anchored by cables to the base of stout trees on each bank, to anchors affixed to bridge abutments, retaining walls, or bedrock, or to a high lead suspended across the river. In the early 1960's, the mainstem Columbia River was trapped using a series of scoop traps cabled to large concrete blocks submerged in the river (Schoeneman et al. 1961 as cited in Seiler and Volkhardt, 2005).

Finally, investigators need to consider access and security when selecting trapping locations. Traps anchored in the river are a public curiosity and can undergo theft or vandalism when not attended. Ideally, the trap site would be located near a launch/recovery site to ease trap installation and removal (Seiler and Volkhardt, 2005).

PERMITTING

Before any thought to installation and active trapping can begin, all necessary permits must be obtained from appropriate local, state, federal and tribal agencies. Sufficient time must be allotted during the planning period to secure permits. The completion of the JARPA, or the Joint Aquatic Resources Permit Application, can be filled out once and used as the standard application for most permits. A list of the necessary permits required for installation of the rotary trap on the Okanogan River, and their issuing agencies, is listed below:

- Section 10 Incidental Take Permit NOAA Fisheries
- Hydraulic Project Approval Washington Department of Fish & Wildlife
- Scientific Collection Permit Washington Department of Fish & Wildlife

Each permit carries with it various stipulations for trap deployment that must be rigidly adhered to. Several contain language requiring periodic reporting of operations and data while others need only be kept apprised of the continuation of trapping efforts from year to year.

PREPARATION AND INSTALLATION

Before trapping can begin, all equipment and supplies must be assembled to accomplish project objectives. At a minimum, this includes the trap/pontoon structure and appropriate anchoring cables, a means to get to the trap (e.g., boat or gangplank), dip nets for removing and handling fish, data forms, fish anesthetic, a marking device (e.g. scissors, dye, etc.), tanks or buckets for working up captured fish, a trap cleaning device (e.g. brooms, water pump and nozzle), and lights for night work (Seiler and Volkhardt, 2005).

The approach for trap installation depends on the size and weight of the trap used. Small traps that use lightweight aluminum pontoons can be transported disassembled in pickup beds and assembled on-site. Components of larger, heavier traps can be trucked to the site using a low-boy

trailer. In this case, on-site assembly requires the use of a loader or other heavy equipment to move the components into place. A third option is to truck an assembled trap to the site and position it at the water's edge using a boom truck or crane (Seiler and Volkhardt, 2005).

Once assembled at the water's edge, the trap is ready to be positioned in its fishing location. The approach used to accomplish this will depend on the size of the trap and stream, and the distance from the launch site to the fishing site. Small traps operating on small streams can be pushed and pulled into position by hand. Bow-mounted cables or ropes can be attached to trees or other anchoring structures on the banks. Movement of the trap into its final position can be accomplished by using hand winches or chainfalls. If the trap is anchored to trees, some method should be used to spread the load over the trunk and prevent girdling. Fabric straps make useful attachments (Seiler and Volkhardt, 2005).

Larger traps may use bow winches, mounted port and starboard, to store the attachment cable or rope. The most direct approach is to run the cabling out to the attachment points and pull the trap into position using the winches. Another approach is to attach the cabling directly from the trap to a highline that has been strung over the river. For larger traps (e.g., 8-foot diameter cone rotary screw trap), the trap should be secured in the river with 10 mm ($\frac{3}{8}$ in.) aircraft cable attached to a 13 mm ($\frac{1}{2}$ in.) aircraft cable and pulley system strung above the river between two large trees or bridge pilings on either bank (Murdoch et al. 2001). The position of the trap can be adjusted by the tension of the highline and length of the bow cables that are attached to it using a chainfall or similar device. The use of bow-mounted winches is the preferred approach since it makes repositioning the trap much easier (Seiler and Volkhardt, 2005).

In some cases, the launch point may be some distance from the fishing site. In this situation, the trap can be "walked" into position by alternating port and starboard attachment points either upstream or downstream and tightening or loosening the bow cables as necessary using winches. In navigable waters, a boat can be used to push the trap to a point near the trap site where one of the above methods can be used to secure the trap to its fishing position (Seiler and Volkhardt, 2005).

SAMPLING DURATION

The time frame for operation of the trap varies with the target species and trapping location. Table 1 provides general migration timing for Washington rivers. Downstream migration timing in specific watersheds can vary from these general guidelines. Timing may need to be investigated during the first year of monitoring where it is not well known (Seiler and Volkhardt, 2005).

Table 1. Generalized migration timing for anadromous salmonids in Washington State.

Species	Age	Migration Period
Chinook	0, 1	January – July/August
Coho	1	April – June
Sockeye	0	January – May
Chum	0	February – April
Pink	0	January - May
Steelhead	2	March – May
Cutthroat	0, 1, 2	January – December*
* Migration timing for cutthroat vary widely.		

In order to estimate production, traps should be operated throughout the migration period for the target species. Migration rates for most species are often highest at night; however, daytime migration rates can also be high on some streams, particularly where turbidity levels are high. At a minimum, the investigator should stratify trapping periods to reflect different migration/capture rates. This often means checking the trap and processing the catch at dawn and at dusk to measure day and night catch rates. This doesn't infer that these are the only times to check the trap. Catch rates and debris loads determine the frequency of trap maintenance. Stratification facilitates sub-sampling and estimating catches during periods when trapping is suspended (Seiler and Volkhardt, 2005).

PROCEDURE

Trap Operation

The screw trap is lowered into its fishing position by cables attached to the forward and/or aft ends of the trap structure. Typically, a single hand-winch or chainfall is used to raise and lower each end. The forward end of the cone should be lowered until the axle is at the water's surface. The aft end is lowered so that fish can swim from the aft screw chamber into the live well, but not so low that they can ride the debris drum over the back of the trap (Seiler and Volkhardt, 2005).

Since the screw is constantly rotating, relatively little debris builds up on the screw's outer screen. As the debris drum removes much of the debris entering the trap, this gear requires less cleaning than a scoop trap. During each trap check, organic debris remaining in the live well is removed and returned to the river; man-made trash is collected and properly disposed of. The trap can usually remain in operation during this procedure. The date and time of the trap check is recorded. If the trap is outfitted with a counter to record rotations, the count is recorded. Rotations per minute are also recorded during the trap check. These later data are used to estimate the time fished if debris stops the screw between trap checks. Catch is enumerated by species and other data/samples are taken as required by the study (Seiler and Volkhardt, 2005).

Traps are checked as often as necessary to provide for the safe holding and handling of captured fish, and maintain the efficient operation of the gear. At a minimum, the trap should be checked at dawn and at dusk in order to evaluate day vs. night capture rates. When operated during period of high discharge, the trap will be checked and cleaned more frequently. Where sub-yearlings are captured, holding these in close proximity to larger piscivorous fish such as Northern Pikeminnow and sculpins increases the likelihood that catch counts on the sub-yearlings will be biased low due to live-box predation (Seiler and Volkhardt, 2005).

Some investigators have placed tree branches or other debris in the live well to provide refuge for small fish. Care must be taken when using this approach since the debris may cause de-scaling as turbulence in the live well increases. The safest approach for maintaining fish health and minimizing predation is to frequently check and remove fish from the trap (Seiler and Volkhardt, 2005).

Daily Capturing Procedure

Fish will be removed from the livebox with dipnets every morning and placed in an appropriate holding container. Fish will be identified to species, counted, scanned for a PIT tag and released off the back of the trap. Fish that are to be measured and weighed will be placed into a bath containing an anesthetic solution of MS-222 at a concentration of 50-60 mg/L (Please refer to Appendix 2 for more detailed information on MS-222). All fish placed into an anesthetic bath will be allowed to become mildly sedated before being measured and weighed, and completely recover before being transported in 5 gallon buckets to a release site. Fish should be fully recovered from the anesthetic prior to release (Seiler and Volkhardt, 2005). Note that all fish species react differently in their exposure to MS-222. Regardless, steelhead will be worked up first and released first to reduce the amount of time they spend out of the river (NOAA Section 10 permit). All anesthetized fish will be allowed to fully recover in fresh water prior to being released in an area of calm water downstream from the smolt trap. Juvenile target salmonid species will be held in separate live boxes attached to the end of the main pontoons for use during mark/recapture efficiency trials conducted in the evening.

Length and Weight

Fish that are to be used in the trap efficiency trial will not be anesthetized and thus will not be measured or weighed.

A random sub-sample of 10 fish per species per day will be weighed, measured and recorded if time permits; anesthetize these fish before working them up. Make sure to allow anesthetized

fish adequate time to fully recovery before returning them to the river downstream of the trap. Enter data onto the data sheet and then to the spreadsheet.

Every steelhead handled out-of-water for the purpose of recording biological information must be anesthetized. Anesthetized fish must be allowed to fully recover in a recovery tank before being released. Steelhead that are simply counted must remain in water but do not need to be anesthetized.

Biometric measurements will be taken from fish that will not be marked so as to not expose marked fish to excessive handling. Fork length and weight to 0.1g will be recorded for the first 10 randomly selected fish of each species on each trapping day. Fish that are notably larger or notably smaller should also be measured and weighed with a notation of not being a random sample.

Length and weight measurements will be recorded for all target species, except on days when high numbers are captured, and then only target species used in mark/recapture efficiency trials are measured and weighed. Fork length to the nearest millimeter and weight to the nearest 0.1 g will be measured. A Fulton type condition factor ($W \times 105 / FL^3$) will be calculated for all target species sampled. The degree of smoltification (parr, transitional, or smolt) will be determined by visual examination. Juvenile Chinook, sockeye, and steelhead *O. mykiss* will be classified as parr if parr marks are distinct, transitional if parr marks are not distinct, and smolts if parr marks are not visible and the fish exhibited a silvery appearance.

Condition

The Fulton-type condition factor describes the well-being of smolts within a population or subpopulation. Smolts collected with traps will be measured (fork length; mm) and weighed (to 0.1 g). Fulton-type condition will be estimated with methods described in Anderson and Neumann (1996).

Genetics

Genetic characterization (via DNA microsatellites) describes within- and between-population genetic variability of smolts. DNA samples from a systematic sample of smolts¹ will be collected and analyzed according to the WDFW protocols contained in Appendix 1.

Trap Efficiency Tests

Trap efficiency is measured by the rate that marked fish released above the trap are recaptured. Mark/recapture efficiency trials will be conducted throughout the trapping season when a minimum of 30 individual fish of a given target species are captured within a three day period. If less than 30 fish are captured within a three day period, all fish will be released unmarked. Bismark Brown 'Y' dye will be used at a concentration of 0.25 to 0.4 g of the powdered dye will be added to 5-gallons of water for marking the mucous layer of fish used in trap efficiency trials. Other marking methods, including applications of a fin clip, caudal punch, freeze brand or PIT tag, require handling and the application of MS-222 and will thus not be used.

¹ The total number of smolts needed to characterize within and between-population genetic variability is presently unknown. Therefore, "k" (i.e., the kth smolt sampled) remains undefined.

The release point selected should be far enough upstream as to provide for a similar distribution across the channel compared to unmarked fish (at least 2 pool/riffles sequences), but not so far upstream that predation on marked fish is substantial. Murdoch et al. recommends that the release point be located at least 1 km upstream of the trap. Try to release each group of marked fish evenly across the river to avoid biasing their lateral distribution and along approximately 100 m of the bank in pools or in calm pockets of water where possible. To reduce predation subsequent to recapture, marked fish should be released during the time strata that they migrate (Seiler and Volkhardt, 2005).

Mark groups can be comprised of hatchery fish or fish that have been previously captured in the trap. However, using hatchery fish complicates the study since one must assume their probability of capture is the same as for naturally reared fish. Groups of marked fish representing each targeted species are released upstream of the trap over the period of their migration.

While hatchery fish used for calibration may be of the same species and age as their wild counterparts, they may be larger, behave differently, and consequently, may be captured at higher or lower rates than wild fish. Rates of instream predation and residualism are likely higher for hatchery fish. For these reasons, trap efficiency estimates resulting from release groups using hatchery fish may be biased low (Seiler and Volkhardt, 2005).

Flow is the dominant factor affecting downstream migrant trapping operations in any system. It affects trapping efficiency and migration rates since high flows often stimulate fish to migrate. Therefore, minimal trap efficiencies may occur at the same time that peak flow events are causing migration rates to increase (Seiler and Volkhardt, 2005).

Visibility, fish size, and noise are other factors that affect trap efficiency. Larger downstream migrants, especially steelhead and coho, may be able to avoid capture when the trap is visible by swimming around the trap or back out of the mouth of the trap, especially where velocities are low. Some portion of ocean-type Chinook salmon may rear upstream for a short period of time and grow prior to migration; therefore, efficiency for a species may change over time. Fish behavior may also be important. Some species may primarily migrate down the thalweg of the channel whereas a higher proportion of others may use the channel margins. Noise created by the trap causes an avoidance response. This is mitigated through proper site selection as discussed above (Seiler and Volkhardt, 2005).

These factors indicate that efficiency tests should, if possible, be conducted over the entire migration period, over a range of flows and turbidity levels, and for each species whose production is to be estimated (Seiler and Volkhardt, 2005).

Emigration estimates can be calculated using estimated daily trap efficiency derived from the regression formula using trap efficiency (dependent variable) and discharge (independent variable) as described in Murdock et al. 2001.

A valid estimate requires the following assumptions to be true concerning the trap efficiency trials:

- 1) All marked fish passed the trap or were recaptured during time period *i*.

- 2) The probability of capturing a marked or unmarked fish is equal.
- 3) All marked fish recaptured were identified.
- 4) Marks were not lost between the time of release and recapture.

Incidental Species

When time permits, incidental species should be measured and weighed as described for target species. All incidental species will be released downstream of the trap.

DATA ANALYSIS

ESTIMATING TOTAL MIGRATION

Estimating migration for any period, whether a short time interval or an entire season, requires catching fish and estimating trap efficiency. Estimating abundance from a set of trapping data is not always straightforward. A variety of approaches have been used. In many cases the most appropriate approach will not become apparent until after all of the field work is completed and the data is analyzed. The biologist needs to always temper his/her decision on the approach with knowledge of the behavior of the targeted species. A plausible rationale should be developed to explain and support these decisions. Four general approaches are outlined in this section (Seiler and Volkhardt, 2005).

Estimating discreet outmigration periods using individual trap efficiency estimates

This approach estimates migration for discreet time periods, typically a day or a week, using a single test to estimate trap efficiency or by pooling several efficiency trials to develop a mark-recapture based estimate of the migration for the time period.

Migration over the discreet period, N_i , is found using the simple equation;

$$N_i = \frac{M_i C_i}{R_i} \quad (1)$$

Bias in this estimate can be reduced using the Peterson mark-recapture equation;

$$N_i = \left[\frac{(M_i + 1)(C_i + 1)}{(R_i + 1)} \right] - 1 \quad (2)$$

Where

M_i = Number of fish marked and released during discreet period i ,

C_i = Number of unmarked fish captured during discreet period i , and

R_i = Number of marked fish recaptured during discreet period i .

The variance, $V(N_i)$, of the Peterson estimate can be calculated using;

$$V(N_i) = N_i^2 \frac{(C_i - R_i)}{[(C_i + 1)(R_i + 2)]} \quad (3)$$

Total juvenile production is estimated by the sum of the estimated migrations over discrete periods and the variance of the total production is the sum of the variances. The 95% confidence interval (CI) is $\pm 1.96(\text{sd})$.

This approach assumes each estimate of trap efficiency is an accurate measure of the proportion of downstream migrants caught in the trap. Since each test actually represents a single measure, it would be expected to include error. Assuming error is normally distributed, this approach argues for estimating discrete periods of short duration (e.g., 1 day) since cumulative error from many samples should approach zero. We cannot assume error is normally distributed where trap efficiencies are low, however. Estimates of efficiency that are lower than the true efficiency cannot offset those that are higher as the true value approaches zero (Seiler and Volkhardt, 2005).

A variation of this approach is to use another trap upstream to capture and mark migrants over the trapping season. The recapture of these migrants in the downstream trap over the season represents a single mark-recapture experiment. Since both marked and unmarked fish should have an equal chance of being captured over time, the timing distribution of marked releases should reflect the migration timing for the species. Therefore, a weir trap located in a tributary is the best choice for this second trap since it is designed to catch 100% of the passing migrants over the entire season. Total production is estimated using Equation 1, substituting the total migration (N), total catch of marked and unmarked fish (C), total marked releases (M), and total recaptures (R), for N_i , C_i , M_i , and R_i in the equations. Variance, $V(N)$, is estimated by the variance of the trap efficiency estimate, R/M , which is a binomial multiplied by the C^2 over $(R/M)^4$. This reduces to:

$$V(N) = \frac{\frac{R}{M} (1 - \frac{R}{M})}{M} * \frac{C^2}{(\frac{R}{M})^4} = \frac{C^2 M (M - R)}{R^3} \quad (4)$$

Modeling Trap Efficiency

This approach estimates trap efficiency from an independent variable, typically stream flow. A series of trap efficiency tests are conducted over a range of flows and analyzed to determine if a significant relationship can be established. When using regression analysis, it has been suggested that the observed F should exceed the chosen test percentage point by a factor of four or more for the relationship to be considered of value for predictive purposes (Draper and Smith 1998).

Using this approach, migration on day i , N_i , and its variance, $V(N_i)$, are estimated by;

$$N_i = \frac{C_i}{\hat{\theta}_i} \quad (5)$$

$$V(N_i) = V(\hat{\theta}_i) \frac{C_i^2}{\hat{\theta}_i^4} \quad (6)$$

If linear regression is used to estimate trap efficiency, its variance is estimated by;

$$V(\hat{\theta}_i) = MSE \left[1 + \frac{1}{n} + \frac{(X_i - \bar{X})^2}{\sum_{i=1}^n (X_i - \bar{X})^2} \right] \quad (7)$$

where:

$\hat{\theta}_i$ = The trap efficiency predicted on the day i by the regression equation, $f(X_i)$,

MSE = The mean square error of the regression,

n = The number of trap efficiency tests used in the regression, and

X_i = The independent variable on day i .

Stratifying Trap Efficiency

Like #2, this approach also predicts trap efficiency using an independent variable. In this case, efficiencies are fairly constant over some range of the independent variable or a condition class. Then as the independent variable passes some threshold or another condition class occurs, efficiencies change or “step” to a new level. For example, if the trap is placed in a “U”-shaped channel adjacent to a wide gravel bar, trap efficiencies may be at one level when flows are contained in the channel and another when higher discharge causes a substantial portion of the flow to spread out across the gravel bar. Fish size may change over the trapping season causing changes in trap efficiency by time strata. Turbidity levels may cause changes in efficiencies as well. In some locations, fish are better able to avoid traps during day fishing periods. In this case, efficiency data would be stratified by condition class (i.e., day and night periods). Mean trap efficiency is calculated for each strata (Seiler and Volkhardt, 2005).

Migration is estimated for discreet periods when the independent variable is within a defined stratum by dividing the sum of the catch by the mean trap efficiency for the stratum. The

variance of the estimate is calculated using Equation 6, substituting the mean trap efficiency for the stratum, \bar{e}_j , for the predicted trap efficiency on day i . (Seiler and Volkhardt, 2005).

Back-Calculating Production

Using this approach, fish captured in the screw trap are marked or tagged and released downstream. Recapture occurs at another location and/or life stage and a Peterson estimate of production is made. Typically, recaptures occur when the returning adults are sampled in a fishery, upon the spawning grounds, or at another sampling location such as a trap. The term “back-calculating production” generally refers to calculating downstream migrant production from the recapture of adults marked as downstream migrants captured in the trap. However, production estimates could also be achieved using this method by sampling marked juveniles from the lower river or estuary (Seiler and Volkhardt, 2005).

Production is estimated using the same equation described for the variation of approach #1 above. The variance is estimated by Equation #4. This approach is most useful where trap efficiency estimates are difficult to make. If mark or tag sampling occurs while the juvenile fish are still on their seaward migration, then this approach could be used for all species. If sampling will not occur until the adults return, then this method is more easily applied where nearly the entire cohort returns in a single year (e.g. coho). Age sampling would be required for this approach to work for species that return to spawn in multiple year classes (Seiler and Volkhardt, 2005).

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