4 FISH AND AQUATIC RESOURCES

Through evaluation of existing information and consultation with agencies, tribes and other stakeholders (relicensing participants), SCL has identified the need for the fish and aquatic related resource studies listed below. The plans for these proposed study components are described in this PSP.

Proposed studies related to fish and aquatic resources

- Mainstem Aquatic Habitat Modeling Study:
  - Habitat Mapping
  - Hydraulic Routing
  - Physical Habitat Model Development
  - Habitat Suitability Indices Development:
    - Fish HSI
    - Macrophyte HSI
    - Periphyton and Benthic Macroinvertebrate HSI
- Sediment Transport and Boundary Reservoir Tributary Delta Habitats:
  - Tributary Delta Habitat Modeling
  - Tributary Delta Sediment Processes
  - Mainstem Sediment Transport
- Fish Distribution, Timing, and Abundance Study:
  - Passive and Active Sampling
  - Biotelemetry
- Large Woody Debris Management Study
- Productivity Assessment
- Fish Entrainment and Habitat Connectivity Study:
  - Turbine Entrainment
  - Spillway Entrainment
- Recreational Fishery Study:
  - Recreational Creel and Angler Surveys
  - Triploid Trout Biotelemetry
  - Triploid Trout Management
- Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats

The list of studies proposed by SCL incorporates all fish and aquatic studies identified and requested by relicensing participants. In some cases there are minor differences in the number of sample sites or the geographic range of specific study components, and these differences are identified in the consultation section of each study plan. Additional implementation details of the study efforts will be developed by SCL and the Technical Consultant in coordination with SCL and relicensing participants during the first quarter of 2007.

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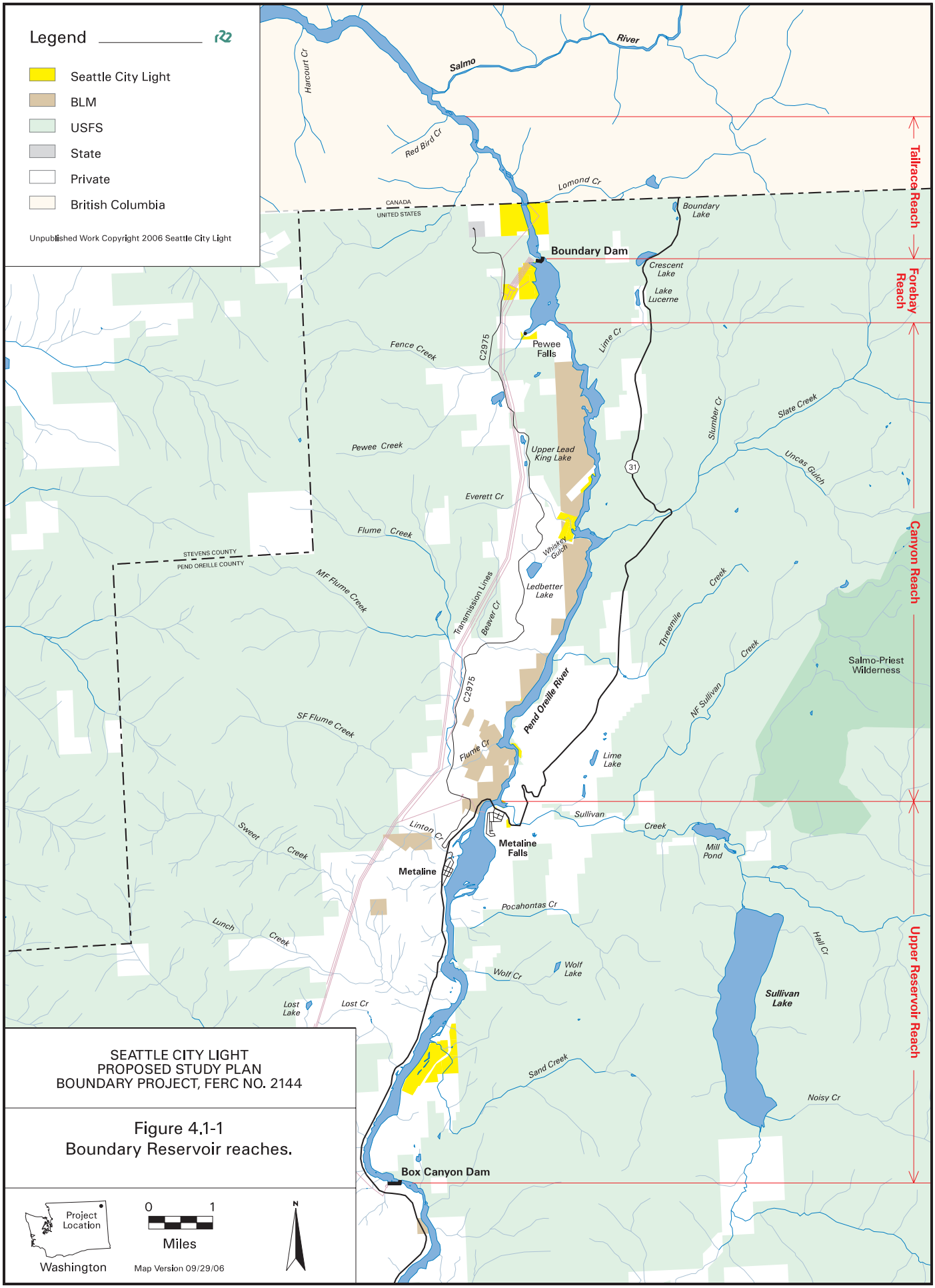
4.1. Mainstem Aquatic Habitat Modeling Study

The Boundary Project is operated in a load-following mode, generating power during peak-load hours and curtailing generation during off-peak hours. This operating regime allows SCL to meet continued service area load growth and provide regional system reliability. The capacity of the six turbines is about 55,000 cfs, which is more than double the average annual flow of the Pend Oreille River (SCL 2006). The combination of little reservoir storage capacity in relation to inflow and the large turbine capacity means that load-following operations can cause the water surface elevations in the Forebay and Tailrace reaches to fluctuate more than 10 feet per day. (See section 1.3.5 for a description of Project operations.) These flow and associated pool level fluctuations alternately inundate and dewater shallow water areas of the Pend Oreille River, affecting aquatic habitats and biota. This section describes modeling of mainstem aquatic habitats to support an evaluation of the effects of Project operations.

Fluctuations in the elevation of the Boundary Reservoir pool occur in response to natural flow fluctuations and the load-following operational strategy used at the Project. Flow fluctuations in the Boundary Project forebay extend upstream but attenuate, or dampen, as they travel the 17.5 mile reach upstream to Box Canyon Dam. Variations in channel morphology of the Pend Oreille River upstream of Boundary Dam affect the rate of travel time and attenuation of reservoir pool level fluctuations. For instance, the constriction and change in bed profile at the site of Metaline Falls slows the passage of water which delays the response time of the Upper Reservoir Reach to rapid changes in downstream pool level fluctuations. When the Project is operating at reservoir water surface elevations lower than the hydraulic control at Metaline Falls, fluctuations in water levels observed at the Boundary forebay may not extend upstream of Metaline Falls.

BC Hydro's Seven Mile Dam is located 11 miles downstream of Boundary Dam, and at full pool the Seven Mile Dam backs water up to the tailwater of Boundary Dam. Similar to the Boundary Project, the Seven Mile Project is operated as a load-following hydropower facility, and pool level fluctuations at the Seven Mile forebay can travel upstream to the Boundary Dam tailrace. Consequently, the effects of Boundary Project operations on aquatic habitats below Boundary Dam are influenced by Seven Mile Project operations. At low Seven Mile pool levels, riverine habitat is present in the Boundary Dam tailwater, but at high Seven Mile pool levels the riverine habitat becomes reservoir habitat.

The Seven Mile Project completed upgrades in April 2003 to provide increased generation capacity (Calder et al. 2004). There are also plans by the Columbia Power Corporation to add capacity at the downstream Waneta Project. As of October 2006, the Waneta capacity upgrade was under environmental review in British Columbia. If implemented, the Waneta upgrade could affect the power generation strategy at both the Waneta Project and the Seven Mile Project. If the Waneta capacity upgrade is implemented, it is likely that changes to Seven Mile operations will increase the frequency and duration of inundation of the Boundary Dam tailrace.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Lake Lucerne
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Forebay Reach
Canyon Reach
Upper Reservoir Reach
Fence Creek
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Pewee Falls
Lime Cr
Slumber Cr
Slate Creek
Pewee Creek
Upper Lead King Lake
Uncas Gulch
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Everett Cr
Flume Creek
Whiskey Gulch
STEVENS COUNTY
PEND OREILLE COUNTY
Mf Flume Creek
Ledbetter Lake
Transmission Lines
Beaver Cr
Threemile Creek
Salmo-Priest Wilderness
NF Sullivan Creek
Pend Oreille River
SF Flume Creek
Flume Cr
Lime Lake
Sullivan Creek
Linton Cr
Metaline Falls
Metaline
Sweet Creek
Mill Pond
Pocahontas Cr
Lunch Creek
Hall Cr
Wolf Cr
Wolf Lake
Sullivan Lake
Lost Lake
Lost Cr
Sand Creek
Noisy Cr
Box Canyon Dam
SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144
Figure 4.1-1
Boundary Reservoir reaches.
Project Location
Washington
0
1
Miles
Map Version 09/29/06
N

In general, aquatic habitat in Boundary Reservoir can be divided into shallow and deep water habitats. The littoral zone, or shallow water habitat, is the bottom area along the shoreline where the level of light penetration is sufficient for photosynthesis. This area usually supports larger and more diverse populations of plants and animals than deep water habitats. Depending upon the substrate type, water velocity, and other characteristics, portions of the littoral zone may have aquatic macrophytes that contribute to primary production and provide unique habitat for some aquatic species or lifestages. The deep water zone consists of the open water parts of the reservoir. In general, the deep water zone is less productive than the littoral zone and has a different community of aquatic fauna, although some species (perhaps at different lifestages) may be found in both zones.

Areas of the river channel that are alternately wetted and dewatered by water level fluctuations are termed the varial zone (Figure 4.1-2). The varial zone typically encompasses some or all of the littoral zone. If the magnitude and frequency of water level fluctuations is low, the varial zone can be highly productive. However, as the magnitude and frequency of water level fluctuations increase, the abundance and diversity of periphyton and benthic macroinvertebrates (BMI) are reduced (Fisher and LaVoy 1972; Ward 1992).

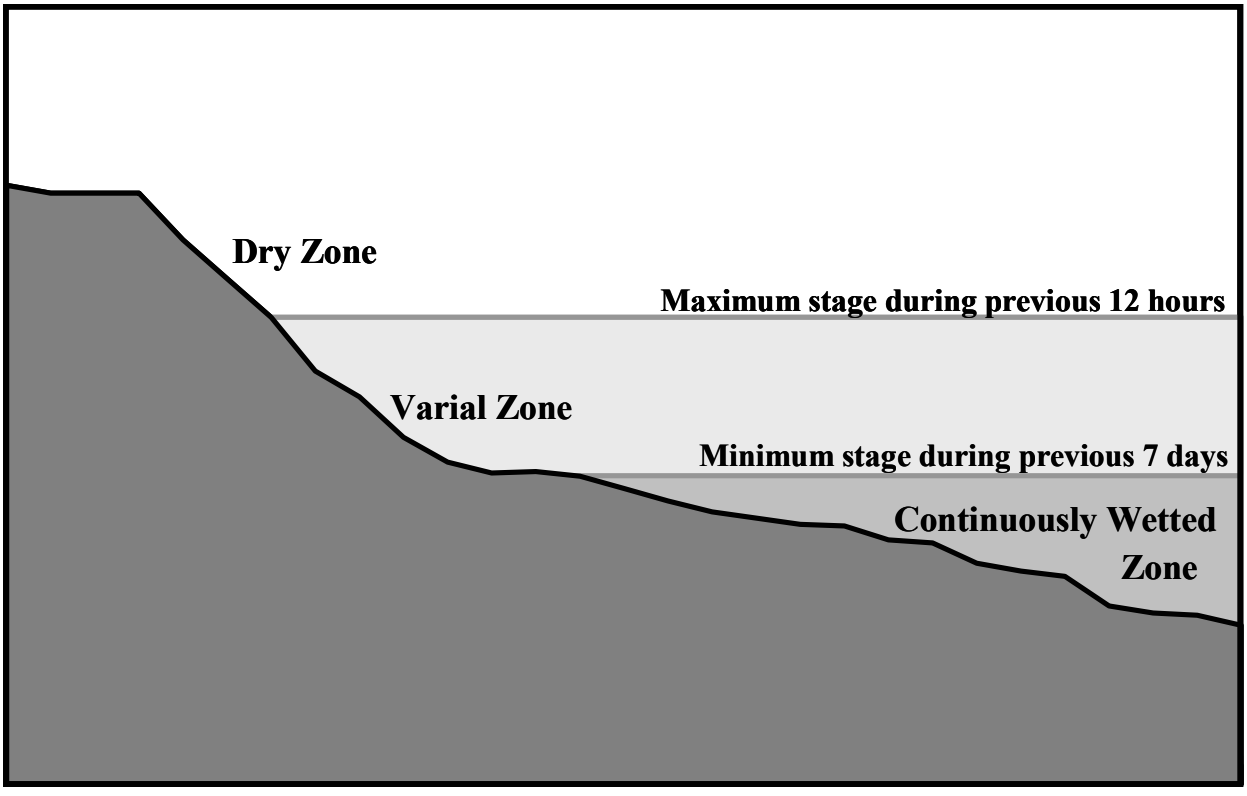

Figure 4.1-2. Example cross-section of a hypothetical channel margin that depicts extent of varial zone as defined by maximum stage during previous 12 hours.

The mainstem aquatic habitat model is the core tool that will be used for assessing changes in aquatic habitat under alternative operational scenarios at the Boundary Project. A conceptual framework for the mainstem aquatic habitat model is depicted in Figure 4.1-3. Several of the Boundary Project relicensing fish and aquatic resource studies are designed as components to the aquatic habitat model or provide, verify, or improve upon biological information critical to running the model. Fundamentally, the mainstem aquatic habitat model is a spatial and temporal representation of physical characteristics considered biologically important as aquatic habitat in Boundary Reservoir and the tailrace. The physical characteristics considered in the model include the following:

- Water depth
- Water level fluctuations (including magnitude, frequency and rate of change)
- Water velocity
- Substrate type (e.g., boulder, cobble, gravel, sand, fines, etc.)
- Cover for fish (including macrophytes)

The mainstem aquatic habitat model integrates hydraulic modeling, reservoir bathymetry, and biological information on the distribution, timing, abundance, and suitability of habitat to estimate metrics (such as varial zone area and frequency of inundation and dewatering) that will be used to compare the effects of alternative operational scenarios.

The mainstem aquatic habitat model will estimate metrics along transects selected to describe representative and distinct habitats. Distinct habitats may include low-gradient bars, depressions, backwater sloughs, fish spawning locations, macrophyte beds or other habitats. These habitat features may support high-value aquatic resources, but because they are found in only a small proportion of the reach, they may not be adequately described by transects selected to describe major morphological channel types. The number, location, and placement of transects will be selected in coordination with relicensing participants.

The following study efforts provide information for, or are components to, the mainstem aquatic habitat model. These studies may also have objectives beyond support of the mainstem aquatic habitat model:

- *Scenario Tool* (see section 1.4.3). This tool will be used to model Boundary Project power generation under alternative operational scenarios. Hourly data on Boundary Project forebay and tailrace water surface elevations, flow, and power generation metrics will be developed for each alternative operational scenario to be considered during the relicensing process. Output from the Scenario Tool is used as input to the hydraulic routing model.
- *Habitat Mapping* (this study plan). This study component inventories and maps current aquatic habitat types in Boundary Reservoir. The results will be used for selecting the location of and weighting transects to be used in the mainstem aquatic habitat model.

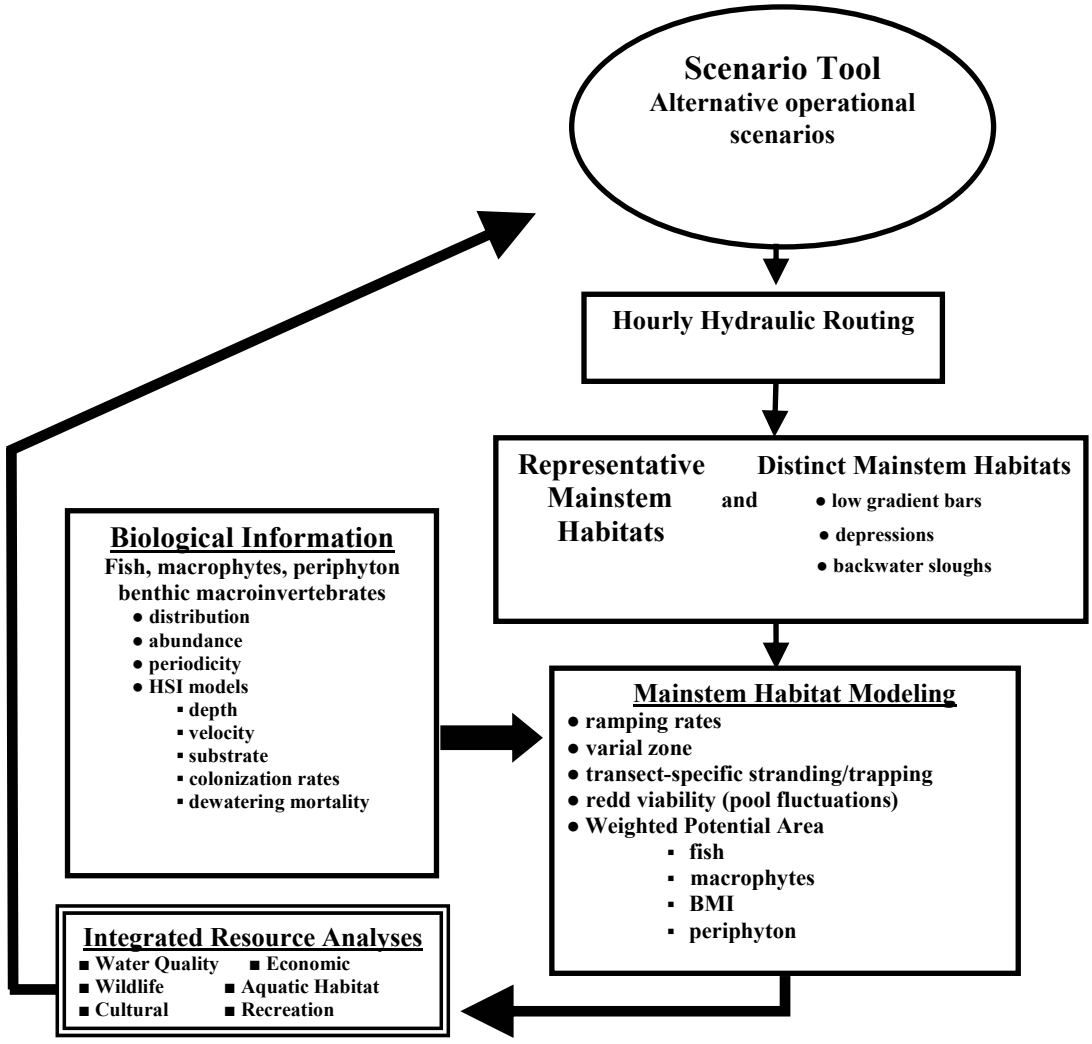

Figure 4.1-3. Conceptual workflow for Mainstem Aquatic Habitat Modeling.

- *Hydraulic Routing Model* (this study plan). This model will be developed from bathymetry data collected in 2006 and used to translate output from the Scenario Tool to water surface elevations and mean column velocity at each of the transects in the mainstem aquatic habitat model on an hourly basis.
- *Habitat Suitability Index (HSI) Studies* (this study plan). The results of these study efforts will be depth, velocity, substrate, cover, colonization and dewatering habitat suitability indices (HSI) for selected fish species and life stages, macrophytes, and macroinvertebrates. Suitability is an index value from 0.0 to 1.0, where 1.0 is optimal. HSI curves are used to translate physical characteristics under the different operational scenarios to an index of the amount of potential habitat that is suitable for the selected species.

- *Tributary Delta Habitats in Boundary Reservoir* (section 4.2). This study will develop models to describe the effects of Project operation on habitats within tributary deltas. Because tributaries contain a source of water separate from the mainstem river, habitat models will be developed that are similar to, but separate from, mainstem river transects. The study will also consider potential changes in delta channel morphology under different operational scenarios over a 50-year period (potential length of the new FERC license for the Project).
- *Mainstem Sediment Transport* (section 4.2). The study will be used to estimate the net change in the volume of sediment deposited in Boundary Reservoir over the potential 50-year term of a new license. The study results will also delineate zones of sediment erosion and accumulation in the Boundary Reservoir portion of the Pend Oreille River.
- *Fish Distribution, Timing, and Abundance Studies* (section 4.3). These studies provide biological information on fish distribution, abundance and periodicity in Boundary Reservoir using passive and active sampling methods and biotelemetry.

4.1.1. Nexus Between Project Operations and Effects on Resources

As described above, the current load-following operational strategy at the Boundary Project results in daily pool level fluctuations in the reservoir and tailrace. The shoreline area affected by cyclical inundation and dewatering is known as the varial zone. The varial zone potentially contributes to primary and secondary productivity and supports rearing and adult lifestages of target fish species. Alternative operational scenarios could result in changes in the frequency, magnitude and duration of varial zone inundation and dewatering, affecting the abundance and type of aquatic biota present in the varial zone.

4.1.2. Agency Resource Management Goals

Several natural resources agencies have jurisdiction over aquatic species and their habitats in the Project area. These agencies will be using the results of the Mainstem Aquatic Habitat Modeling and other fish and aquatic studies to satisfy their respective mandates. The following agencies are those with management responsibility in the context of FERC relicensing of the Boundary Project and management goals related to habitat for aquatic species.

Colville National Forest

The USDA Forest Service (USFS) in general and the Colville National Forest specifically have several guidance documents related to managing aquatic habitat. These include:

- The Colville National Forest Land and Resource Management Plan (a.k.a., the Colville National Forest Plan)
- The Inland Native Fish Strategy (INFISH)

Goals pertinent to these two documents are provided in more detail below.

Colville National Forest Plan (USFS 1988)

The Colville National Forest Plan (CNFP) guides natural and cultural resource management activities on USFS-managed lands and waters and establishes management standards and guidelines. It describes resource management policies and prescriptions, levels of resource production and management, and the availability and suitability of lands for resource management. The CNFP is currently being updated by the USFS and is scheduled to be completed in the fall of 2006. Changes to the CNFP, as amended, may affect aquatic-related management within the Project vicinity.

The CNFP includes a number of broad forest management goals:

- *Fisheries* — Provide a diversity of high quality aquatic habitats which insures viable populations of fish in sufficient numbers to meet angler demands.
- *Water* — Provide for the continued supply of high quality water which meets established standards.
- *Riparian* — Provide and manage for riparian plant communities which maintain a high level of riparian dependent resources.
- *The Forest in Ten Years* — Native fish species will be encouraged with the objective of restoring populations of native trout to selected forest streams and lakes. Introduced species will continue to enhance angling in locations where they provide a superior fishery. Stream crossings of Class I and II streams will be minimized. Stream crossing structures will be designed to provide the least resistance to upstream fish passage. Bridges or bottomless arches will be used instead of culverts that cannot be installed to allow passage of native trout. Drainage from roads and ditches will be successfully dispersed prior to entering streams.
- *The Forest in Fifty Years*:
    - Values of fisheries will continue to grow both on and off the Forest. Riparian values will be well recognized.
    - Riparian areas will be occupied by diverse, healthy plant communities and water quality will consistently exceed state standards. Water quantity may increase slightly.

The USFS has identified beaver (aquatic and riparian, aspen or willow) and trout (lacustrine, riverine & riparian) as management indicator species for aquatic or riparian habitat within the Colville National Forest because they are species with special habitat needs that may be influenced significantly by planned management programs and that are commonly hunted, fished, or trapped. For trout, the habitat capability objectives are to maintain or improve habitat with an emphasis on native species.

The CNFP includes the following standards and guidelines for fisheries, to be followed when evaluating or implementing management activities:

1. Fish habitat enhancement will be carried out as indicated in the discussion of the "Wildlife Program." Statewide Comprehensive Fish and Wildlife Plans, coordinated

with the Washington Department of Wildlife, will be updated annually as a source document to prioritize fisheries projects. The Forest's fisheries program will be responsive to the projects of the Northwest Power Planning Council, the Upper Columbia United Tribes, and the Colville Confederated Tribes.

2. Protect existing fish habitat from degradation where feasible. Rehabilitate habitats which have been degraded as a result of management activities where degradation is unavoidable. Mitigation will be at the affected site, when possible, but may be through off-site habitat enhancement when on-site mitigation is not possible.
3. Emphasize management of native fish species habitat. Non-native species may be managed for in waters where they can be expected to provide at least 15 percent more biomass production or 15 percent more angler days recreation than native species. Non-native species may be used to provide diversity only where they will not adversely affect native fish or other native organisms in the affected or adjacent waters.
4. Road crossings of Class I and II streams and fish-bearing Class III streams will be the minimum necessary. Existing crossings will be used whenever possible. New crossings will be located at areas of the least possible stream gradient. Stream crossing structures will provide the least resistance to upstream fish passage. Bridges or bottomless arches will be used instead of culverts unless the culvert can be installed in a manner that will allow passage of native trout during their spawning period. Drainage from roads will be dispersed prior to entering streams.
5. Maintain the general character of aquatic and riparian habitat features. Maintain a natural source of large woody debris to provide structural fish habitat.
6. In-stream migration barriers will normally be removed unless desired to prevent immigration by non-native, invasive fish or other aquatic organisms or when their removal would cause degradation to the stream and/or aquatic habitat.
7. Maintain water quality parameters within the range of good fish habitat conditions, and within State water quality standards, as follows:
    - Streams:
        - *Temperature* — Less than 16 degrees Celsius, provided that temperature increases resulting from a non-point source will not exceed 2.8 degrees Celsius above the natural base-line of the stream.
        - *pH* — Natural levels are normally between 6.5 and 9.0 on the Colville N.F. Man-caused variation will not exceed 0.2 units.
        - *Dissolved oxygen* — More than 9.5 mg/L.
        - *Total dissolved gas* — Not to exceed 110 percent of saturation.
        - *Turbidity* — Changes not to exceed 5 NTU where base-line turbidity is less than 50 NTU; changes not to exceed a 10 percent increase where base-line is more than 50 NTU.
        - *Sedimentation* — Management activity caused suspended and bedload sediments that accelerate channel changes and/or reduce bank stability

will be considered excessive, and mitigation will be implemented. Signs of unacceptable sedimentation are new bank cutting, bar building, filling of pools, covering of spawning gravels and riffles, bright colored bottom materials, and lack of or significant changes in population composition of aquatic invertebrates. In the event of such occurring, an assessment of the drainage will be done to determine probable cause and need for action to correct or mitigate for habitat degradation.

- Lakes:
  - Natural water quality parameters will vary in lakes depending on the depth, volume, bottom materials, water sources, soils, vegetation, etc. Meeting standards for the source streams will normally protect lakes adequately. Unacceptable changes will be assessed to determine the causes, and appropriate protective or corrective actions will be taken.

Inland Native Fish Strategy (INFISH)(USFS 1995)

INFISH was originally developed as an interim strategy for National Forest lands and BLM lands while a long-term strategy to protect native fish was under development. The long-term strategy, called the Interior Columbia Basin Ecosystem Management Project, which included a much broader scope than native fish, was completed in 2003 (See Internet URL: www.icbemp.gov). However, as part of the Memorandum of Understanding that completed the project, it was agreed that the INFISH strategy for native fish would continue until local administrative unit land use plans were amended or revised (e.g., the CNFP). The following is an excerpt from INFISH describing its goals:

- *Riparian Goals* — The goals establish an expectation of the characteristics of healthy, functioning watersheds, riparian areas, and associated fish habitats. Since the quality of water and fish habitat in aquatic systems is inseparably related to the integrity of upland and riparian areas within the watersheds, the strategy identifies several goals for watershed, riparian, and stream channel conditions. The goals are to maintain or restore:

  (1) water quality, to a degree that provides for stable and productive riparian and aquatic ecosystems;

  (2) stream channel integrity, channel processes, and the sediment regime (including the elements of timing, volume, and character of sediment input and transport) under which the riparian and aquatic ecosystems developed;

  (3) instream flows to support healthy riparian and aquatic habitats, the stability and effective function of stream channels, and the ability to route flood discharges;

  (4) natural timing and variability of the water table elevation in meadows and wetlands;

  (5) diversity and productivity of native and desired non-native plant communities in riparian zones;

  (6) riparian vegetation, to:

(a) provide an amount and distribution of large woody debris characteristic of natural aquatic and riparian ecosystems;

(b) provide adequate summer and winter thermal regulation within the riparian and aquatic zones; and

(c) help achieve rates of surface erosion, bank erosion, and channel migration characteristic of those under which the communities developed.

(7) riparian and aquatic habitats necessary to foster the unique genetic fish stocks that evolved within the specific geo-climatic region; and

(8) habitat to support populations of well-distributed native and desired non-native plant, vertebrate, and invertebrate populations that contribute to the viability of riparian-dependent communities.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is the principal federal agency responsible for conserving, protecting and enhancing non-commercial fish, wildlife and plants and their habitats. The agency enforces federal wildlife laws, administers the Endangered Species Act (ESA), manages migratory bird populations, restores nationally significant fisheries, and conserves and restores wildlife habitat such as wetlands. For the Boundary Project, USFWS efforts include overseeing the recovery of bull trout, which are listed as threatened under the ESA. The USFWS has a number of goals and objectives during the FERC relicensing process for the Boundary Project, as follows:

- General Goals:
  1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
  2. Recover federally proposed and listed species.
  3. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.
  4. Once the licensing process is complete, consider implementation of an adaptive management plan to incorporate new information or new management strategies over the term of the license. The adaptive approach is particularly appropriate where there are insufficient data and/or biological uncertainties about those measures that will be most effective for meeting ecosystem goals and objectives.
- Goals for Aquatic Ecosystems:
  1. Protect, enhance, or restore diverse high-quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed, and mitigate for loss or degradation of these habitats.
  2. Maintain and/or restore aquatic habitat connectivity in the watershed to provide movement, migration, and dispersal corridors for salmonids and other aquatic organisms and provide longitudinal connectivity for nutrient cycling processes.

3. Restore naturally reproducing stocks of resident fish to historically accessible riverine habitat, using native stocks where feasible, with priority given to the restoration of listed native stocks.
4. Provide an instream flow regime that meets the spawning, incubation, rearing, and migration requirements of wild salmonids and other resident fish and amphibian species, throughout the Project area.
5. Meet or exceed federal and state regulatory standards and objectives for water quality in the basin.
6. Minimize current and potential negative Project operation effects on water quality and downstream fishery resources.

- Goals for Endangered, Threatened and Proposed Species:
  1. Reduce Project effects on bald eagles, spotted owls, and other threatened, endangered, and proposed species.
  2. Explore opportunities for potential protection, mitigation and enhancement measures for threatened, endangered, and proposed species.
  3. Gain a better understanding of bull trout population trends, migration, habitat loss, present usage and continuing impacts as related to the Project.

In addition, an overarching USFWS goal for the new licensing of the Project is to have FERC include protection, mitigation and enhancement measures that sustain normal ecosystem functional processes, including geomorphic, hydrologic and hydraulic patterns, and water chemical and physical parameters, as license conditions. Maintaining and improving these functional processes throughout the term of the new license will, in turn, provide the habitat to support healthy fish and wildlife populations.

Environmental Protection Agency (EPA)

The Clark Fork – Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan was prepared in 1993 as a cooperative effort among the states of Montana, Idaho, and Washington with assistance from the EPA (EPA 1993). This report summarizes three years of water quality research in the Clark Fork-Pend Oreille basin and provides a management plan for protection of the basin's water quality. This report identifies management objectives for the Clark Fork basin, Lake Pend Oreille, and the Pend Oreille basin including an objective to improve Pend Oreille River water quality through macrophyte management and tributary nonpoint source controls. Several actions as related to this objective include:

1. Develop and maintain programs to educate the public on their role in protecting and maintaining water quality.
2. Control Eurasian watermilfoil by education, rotovation, and research into alternative methods.
3. Establish and maintain a water quality monitoring network to monitor effectiveness and trends and to better identify sources of pollutants.

Washington Department of Fish and Wildlife

WDFW has a responsibility to protect, preserve, perpetuate, and manage fish and wildlife resources in Washington State. WDFW has produced two guidance documents regarding the management of native salmonids:

- The Joint WDFW/Tribal Wild Salmonid Policy (WDFW 1997) ; and
- The Bull Trout and Dolly Varden Management Plan (WDFW 2000)

The goals described in these documents are summarized in the following excerpts.

Wild Salmonid Policy

- *Overarching Goal*. The goal of this Wild Salmonid Policy is to protect, restore, and enhance the productivity, production, and diversity of wild salmonids and their ecosystems to sustain ceremonial, subsistence, commercial, and recreational fisheries, non-consumptive fish benefits, and other related cultural and ecological values.
- *Conserving Genetic Diversity*. Genetic diversity within and among stocks will be maintained or increased to encourage local adaptation and sustain and maximize long-term productivity. Conditions will be created that allow natural patterns of genetic diversity and local adaptation to occur and evolve.
- *Ecological Interactions*. 1) Wild salmonid stocks will be maintained at levels that naturally sustain ecosystem processes and diverse indigenous species and their habitats. 2) Healthy populations of other indigenous species will be maintained within levels that sustain or promote abundant wild salmonid populations and their habitats.
- *Fish Access and Passage*. 1) Provide, restore, and maintain safe and timely pathways to all useable wild salmonid habitat in fresh and marine waters, for salmonids at all life stages. 2) Ensure salmonids are protected from injury or mortality from diversion into artificial channels or conduits (irrigation ditches, turbines, etc.). 3) Ensure natural fish passage barriers are maintained where necessary, to maintain biodiversity among and within salmonid populations and other fish and wildlife.
- *Basin Hydrology and Streamflow*. Maintain or restore the physical processes affecting natural basin hydrology. In addition, manage water use in a manner that would optimize stream flows for salmonid spawning, incubation, rearing, adult residency, and migration, that would address the need for channel-forming and maintenance flows, and that would address the impacts of water withdrawals on estuarine and marine habitats.
- *Water Quality and Sediment Quality, Delivery and Transport*. 1) Provide for water and sediments of a quality that will support productive, harvestable, wild salmonid populations, unimpaired by toxic or deleterious effects of environmental pollutants. 2) Manage watersheds, stream channels, wetlands, and marine areas for natural rates of sediment erosion, deposition, and routing that will support salmonids at all life stages. There should be no net loss of wetlands that are utilized by salmonids or that

support salmonid habitat through water quality and stormwater retention. When possible, wetlands supporting salmonids and their habitat should be increased.

- *Riparian Areas and Wetlands*. Functional riparian habitat and associated wetlands are protected and restored on all water bodies that support, or directly or indirectly impact, salmonids and their habitat. There should be no net loss of wetlands that are utilized by salmonids or that support salmonid habitat through water quality and stormwater retention. When possible, wetlands supporting salmonids and their habitat should be increased.
- *Lakes and Reservoirs*. Maintain and restore lake and reservoir habitats that are conducive to wild salmonid passage, rearing, adult residency and spawning. Maintain or restore adequate flows through reservoirs to ensure optimal and timely passage of outmigrant smolts.

Bull Trout and Dolly Varden Management Plan

- *Management Plan Goal*: To restore/maintain the health and diversity of bull trout and Dolly Varden stocks and their habitats to/at self-sustaining levels that would allow recreational utilization within resource protection guidelines.
- *Maintain and Restore Stock Distribution*. The Department will manage native char stocks and their habitat to promote distribution throughout their historic range. Restoration efforts will be accomplished through the development of recovery plans that will address reasons for decline, historic distribution and solutions to restore depressed stocks to healthy levels. The implementation strategy: 1) Habitat necessary for sustaining critical life history stages of native char including spawning and rearing will be protected or restored through efforts described in the habitat maintenance objectives. 2) The Department will work through processes identified in the habitat maintenance objectives to protect current migratory corridors connecting remote headwater areas and restore historical migration corridors.
- *Reestablish Stocks in Historically Inhabited Areas*. Stocks will be provided mechanisms (e.g., re-establishing migration corridors) that will promote natural recruitment of native char to formerly inhabited areas. In areas where the success of natural recruitment is improbable, supplementation may be employed to seed these areas. Supplementation will be limited to situations where: a) a stock is well below desired levels and it cannot rebuild itself due to some cause other than overfishing; b) a stock is being reintroduced to an area it formerly occupied; and c) the risks of potential stock loss through extinction are greater than the genetic risks due to gene flow or extinction risks due to the supplementation process itself.
- *Conserve Genetic Diversity of Stocks*. Genetic diversity will be maintained within and among stocks to allow local adaptation to occur with changing environmental conditions over the long term.

Washington Department of Ecology (Ecology)

Ecology created the Aquatic Plant Technical Assistance Program in 1994 to provide technical expertise within Ecology and other agencies and the general public regarding aquatic plant ecology, taxonomy, and management. This program has three main goals related to aquatic plants, which are identified below (Parsons 2001).

1. Provide technical assistance and education on aquatic plant identification and management.
2. Evaluate plant community structures and the existence or potential for aquatic plant related problems in selected water bodies.
3. Assist with evaluating Freshwater Aquatic Weed Program grant applications.

Water Resource Inventory Area (WRIA) 62

Numerous agencies and stakeholders formed the Water Resource Inventory Area (WRIA) 62 planning unit in 1998 whose goal is to "develop strategies that will balance competing demands for water, while at the same time addressing local concerns, preserving and enhancing the health of the watershed and considering the economic stability of the watershed." In January of 2005, a Watershed Management Plan for WRIA 62 was completed (Golder Associates 2005). This plan identified the following goal and objective that are related to the management of aquatic plants:

- WQUAL-2: Watershed Planning Implementing Body support of actions that aim to reduce Eurasian watermilfoil and other aquatic nuisance weeds in WRIA 62.

  Objective: Reduce Eurasian watermilfoil and other aquatic nuisance weeds in WRIA 62

Columbia River Subbasin Plans

In 2004, the Northwest Power Planning Council completed the Intermountain Province Subbasin Plan. This plan identifies recommended management actions that will be used to guide the review, selection, and funding of projects in the subbasin (GEI 2004). The management plan objective and strategies developed to achieve this objective as related to aquatic macrophytes in the Pend Oreille River are outlined below.

- Subbasin Objective 1B9: Control the spread (allow 0 acres) of Eurasian Watermilfoil in the subbasin.

  Strategy a: Inventory and map locations of milfoil occurrence.

  Strategy b: Evaluate the impact of extended dewatering and exposure to freezing temperatures on milfoil shoots.

4.1.3. Study Goals and Objectives

The goal of the Mainstem Aquatic Habitat Modeling Study and its component study efforts is to provide quantitative indices of the effects of existing and alternative Project operational scenarios on aquatic habitats. The objectives of the study are as follows:

1. Map the current aquatic habitat in Boundary Reservoir and tailrace.
2. Select transects to measure and model mainstem Pend Oreille River habitat types.
3. Develop a hydraulic routing model that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios.
4. Develop new, or modify existing, Habitat Suitability Indices for selected target species and lifestages.
5. Develop an integrated mainstem aquatic habitat model that produces a time series of data for a variety of biological metrics under alternative operational scenarios. These metrics include (but are not necessarily limited to):
   - water surface elevation at selected reservoir locations;
   - water velocity within transect subdivisions (cells) over a range of flow and reservoir pool levels;
   - varial zone area (Figures 4.1-4 and 4.1-5);
   - frequency and duration of exposure/inundation of the varial zone at selected reservoir locations (Figures 4.1-4 and 4.1-5); and
   - habitat weighted usable area.
6. Conduct a variety of post-processing comparative analyses derived from the output metrics estimated under the mainstem aquatic habitat model. These include (but are not necessarily limited to):
   - ramping rates;
   - juvenile fish stranding/trapping;
   - fish nest viability;
   - macrophyte distribution and abundance; and
   - distribution and abundance of periphyton and benthic macroinvertebrates under alternative operational scenarios.

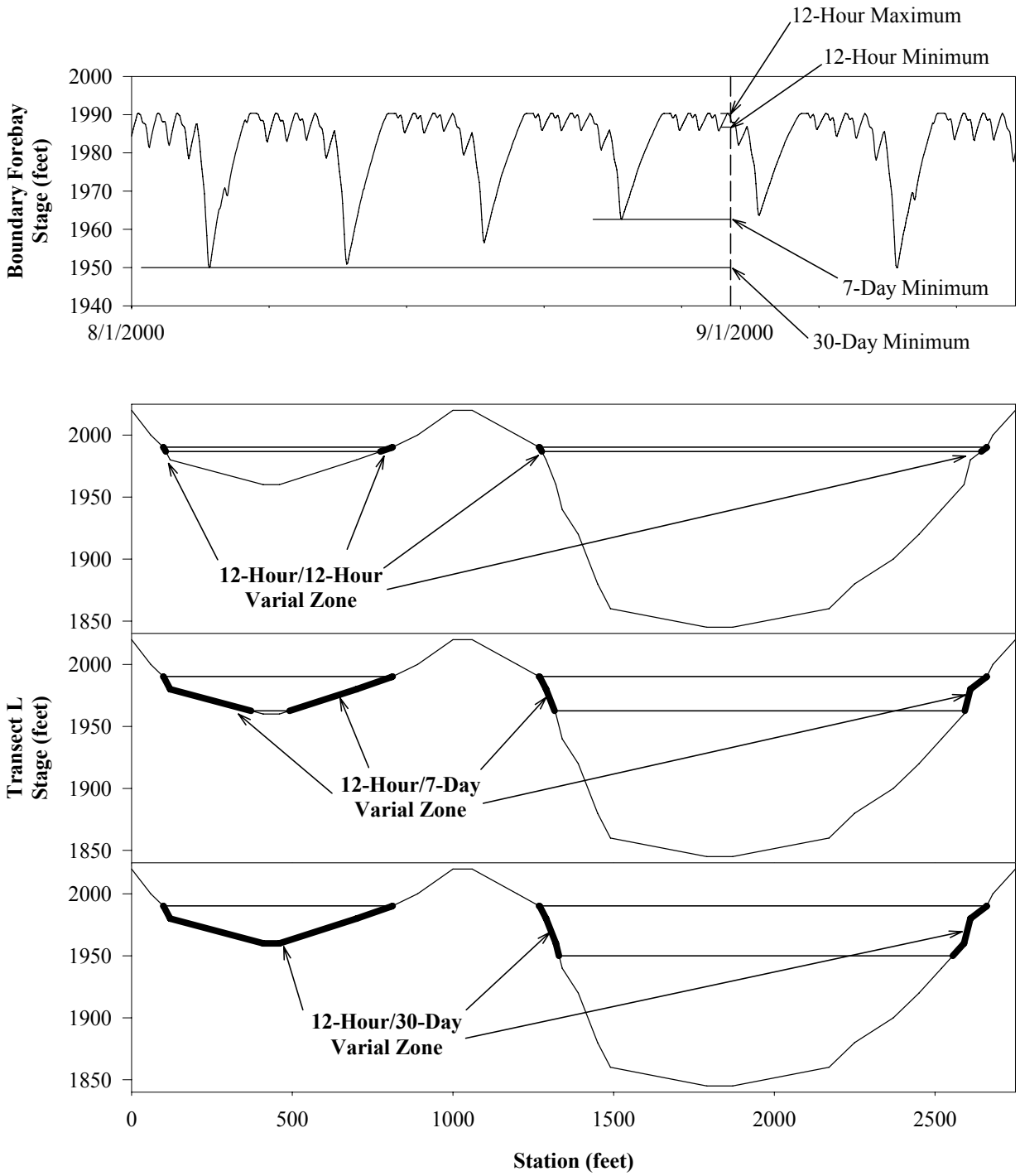

Figure 4.1-4. Illustrative snapshot of mainstem aquatic habitat model output at hypothetical Transect L, downstream of Metaline Falls, for hourly water surface elevation and varial zone area under a hypothetical scenario with maximum pool level fluctuations of up to 40 feet during August 2000. Varial zone stability calculated using 12-hour, 7-day, and 30-day indices.

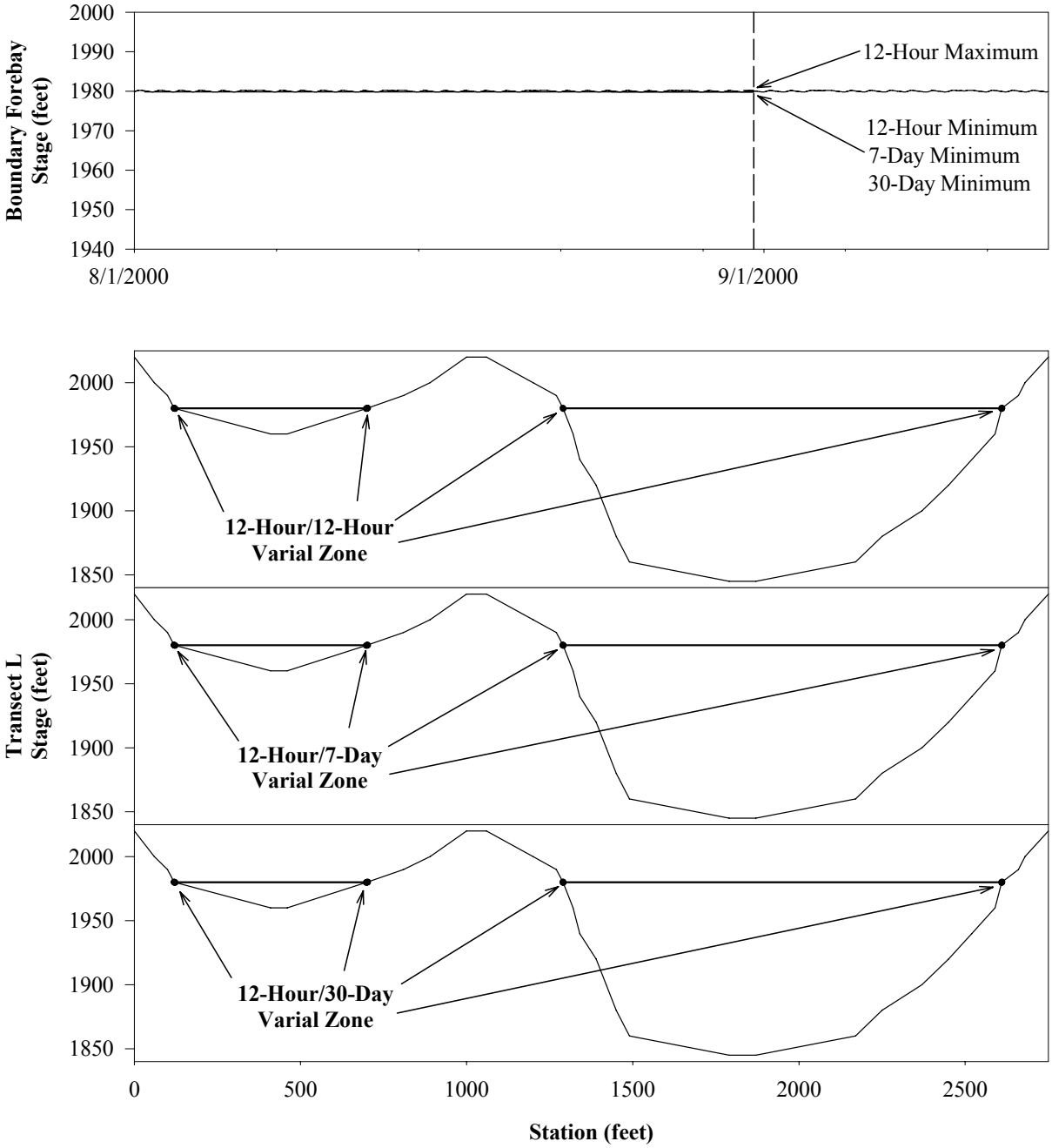

Figure 4.1-5. Illustrative snapshot of mainstem aquatic habitat model output at hypothetical Transect L, downstream of Metaline Falls, for hourly water surface elevation and varial zone area during August 2000 with a relatively stable reservoir pool level during August 2000. Varial zone stability calculated using 12-hour, 7-day, and 30-day indices.

4.1.4. Need for Study

Summary of Existing Information

There is little quantitative information regarding the current distribution and type of aquatic habitats in Boundary Reservoir and the tailrace. Studies by McLellan (2001) and R2 Resource Consultants, Inc. (1998) focused on the collection of fish and zooplankton abundance, distribution, and periodicity information. Information regarding aquatic habitat availability and quality was collected incidentally and was mostly inferred rather than measured. Native salmonid use of aquatic habitats in Boundary Reservoir and its tailrace appears to be limited on a seasonal basis due to high summer water temperatures. Thermal refugia may be present at the mouths of some tributaries (e.g., Slate Creek) during these periods.

Information on channel morphology in the Project area is available from bathymetry data and aerial photographs collected in 2005 and 2006. Bathymetry data collected in 2006 will provide bathymetry information between Box Canyon Dam RM 34.5 and the international border at RM16. Two-foot contours will be generated to an elevation of approximately 1,950 feet NGVD29 (1,954 feet NAVD 88), and 5-foot contours will be generated for depths below this elevation. Bathymetry of Seven Mile Reservoir from Seven Mile Dam to the confluence with the Salmo River has been reported by Klohn Crippen Consultants and ASL Environmental Services (2005). The bathymetry was reportedly derived from 1:50,000 scale Natural Resources Canada NTS maps. SCL is in the process of obtaining these data; if the data are not available or not sufficiently robust, SCL will contact BC Hydro to determine an appropriate course of action (see Hydraulic Routing study component).

Some information on the distribution of macrophytes is reported in section 4.6, Botanical Resources, of the PAD (SCL 2006). Macrophyte beds in Boundary Reservoir are a habitat feature that provides cover, vertical structure, and substrate for macroinvertebrates and spawning by some fish species. Cover types in the Boundary Project vicinity were delineated on true-color aerial photographs (scales of 1 inch = 1,000 feet and 1 inch = 600 feet) taken in August 2005. Mapping and verification methods are described in the Early Information Development Plan for Cover Type Mapping (Dwerlkotte and McShane 2005). Cover types were field verified in September 2005. A vegetation cover type map (Figure 4.6-1 in the PAD) shows the distribution of macrophytes, which corresponds to the area mapped as Lacustrine Aquatic Bed. This cover type includes shallow water areas that are characterized by the presence of aquatic vegetation, primarily milfoil, coonwort (*Ceratophyllum demersum*), and elodea (*Elodea canadensis*) (SCL 2006). Eurasian watermilfoil and curly pondweed are found in shallow coves and bays of Boundary Reservoir, and dense mats of macrophytes have been found in side channels near RM 19.5, upstream of Metaline Falls between RM 27 and RM 29, and between the gaging station and Metaline Falls at RM 31–33. A total of 13 aquatic bed species were identified (Table 4.1-1).

Table 4.1-1. Aquatic macrophytes found in the aquatic bed cover type (SCL 2006).

Common Name	Latin Name	Number of Sites Observed
Coon's tail	*Ceratophyllum demersum*	1
Oxeye daisy	*Chrysanthemum leucanthemum*	1
Canadian waterweed	*Elodea Canadensis*	2
Common St Johnsworth	*Hypericum perforatum*	1
Owyhee mudwort	*Limosella acaulis*	1
Water mudwort	*Limosella cf. aquatica*	1
Spike watermilfoil	*Myriophyllum spicatum*	2
Common plantain	*Plantago major*	1
Variable leaf pondweed	*Potamogeton cf. gramineus*	1
Whitewater crowfoot	*Ranunculus aquatilis*	1
Persistent sepal	*Rorippa calycina*	1
American speedwell	*Veronica Americana*	1
Horned pondweed	*Zannichellia sp.*	1

Need for Additional Information

The Boundary Project is currently operated as a load-following facility with generation shaped to deliver power during peak-load hours. Reservoir forebay pool levels typically fluctuate within a 10-foot range during the summer recreation season and may fluctuate within a 20-foot range during the fall, winter and spring. Daily reservoir level fluctuations may exceed these ranges in response to load demand. Fluctuations in reservoir water surface elevations will cause shallower portions of the Pend Oreille River to alternate between wet and dry conditions on an hourly or daily basis. This cycle of inundation and dewatering may affect the survival and growth of fish, macrophytes, periphyton and benthic macroinvertebrates in channel margin habitats.

As previously indicated, little quantitative information is available regarding the physical habitat characteristics of Boundary Reservoir and its tailrace. Potential effects of existing Project operations on aquatic habitats and biota and potential benefits and impacts of alternative operational scenarios have not been quantitatively analyzed. The mainstem aquatic habitat model will integrate Project operations, physical and hydraulic data, and biological information to quantify potential Project effects. The model will provide an analytical framework for assessing alternative operational scenarios and quantitative metrics that will aid in comparing the alternatives. Project effects will be quantified using indices of potential habitat rather than estimates of the number of fish produced or lost under alternative operational scenarios.

4.1.5. Detailed Description of Study

Study Area

The study area includes all of Boundary Reservoir and portions of the Pend Oreille River mainstem downstream of Boundary Dam that could potentially be affected by Boundary Project operations. The study area is divided into the following four reaches:

- Upper Reservoir Reach — Box Canyon Dam to Metaline Falls to (RM 34.5 – 27.8)
- Canyon Reach — Metaline Falls to downstream end of Z-Canyon (RM 27.8 – 19.4)
- Forebay Reach — Downstream end of Z-Canyon to Boundary Dam (RM 19.4 – 17.0)
- Tailrace Reach — Boundary Dam downstream to Red Bird Creek confluence with the Pend Oreille River, British Columbia (RM 17.0 – 13.1)

The effects of Boundary Project operations on aquatic habitats below Boundary Dam are influenced by Seven Mile Project operations. At low Seven Mile Reservoir pool levels, riverine habitat is present in the Pend Oreille River downstream to the confluence with Red Bird Creek. At high Seven Mile Reservoir pool levels the riverine habitat above the Red Bird creek confluence becomes reservoir habitat. SCL is proposing to collect data on up to 3.9 miles of the Pend Oreille River channel exposed under low Seven Mile Reservoir pool levels. There are plans by the Columbia Power Corporation to add capacity at the downstream Waneta Project. If the Waneta Project upgrade is approved and the effects on Seven Mile Project operations identified, the downstream extent of the Tailrace Reach may be reduced to reflect the effects of changes in Seven Mile Project operations.[1] SCL will continue discussions regarding the downstream extent of studies with relicensing participants during the fall of 2006, and if deemed appropriate, SCL may limit downstream investigations to the U.S./Canada border.

Description of Study Components

The Mainstem Aquatic Habitat Modeling Study consists of the following components:

- Habitat Mapping
- Hydraulic Routing
- Physical Habitat Model Development
- HSI development, for:
  - fish;
  - macrophytes; and
  - periphyton and benthic macroinvertebrates.

[1] As of October 2006, the Waneta Project turbine capacity upgrade was under environmental review in British Columbia. If implemented, the Waneta Project upgrade could affect the power generation strategy at both the Waneta Project and the Seven Mile Project. If the Waneta Project upgrade is implemented, it is likely that changes to Seven Mile Project operations will increase the frequency and duration of inundation of the Boundary Project tailrace. Since the Waneta Project upgrade is still in development, there is some uncertainty regarding the downstream spatial extent of the effects of Boundary Project operations.

Habitat Mapping

The mainstem aquatic habitat model will be used to evaluate the effects of alternative Boundary Project operational scenarios on aquatic habitats and biota in the Pend Oreille River. One of the initial model development tasks will be the selection of transects. These transects will be representative of habitat conditions based on channel morphology and major habitat features. Transects may also be selected to describe distinct habitat features that are important to aquatic biota, but may not be adequately described by representative transects. In order to select transects, specific information on both channel morphology and other important habitat features within Boundary Reservoir will be needed. This information will allow SCL and relicensing participants to decide on the number and placement of transects to best represent the system within the modeling platform.

The Habitat Mapping study component provides the critical information needed about the distribution of major and distinct habitat features in the study area to select representative transects for the Aquatic Habitat Model and assign appropriate weighting to each selected transect.

Proposed Methodology

The distribution and proportion of major habitat types in the Pend Oreille River from Box Canyon Dam to just above the Salmo River confluence will be identified using analyses of bathymetric data, aerial photography, site-specific biological surveys, and relicensing participants' knowledge of the Project area. The location and distribution of distinct habitat types, including low gradient bars, backwater sloughs, depressions, areas of intense fish spawning activity and macrophyte beds, will also be identified using available information and the results of site-specific surveys. The specific tasks involved in this study component are described below.

Task 1) Channel Typing

Use bathymetric data and aerial mapping techniques to determine the proportion of major channel types by reach and for the total analysis area: the Upper Reservoir Reach, extending from Box Canyon Dam downstream to the Metaline Falls hydraulic feature (6.7 river miles); the Canyon Reach, extending from, and including, Metaline Falls downstream to the mouth of the canyon (8.4 river miles); the Forebay Reach, defined as the Pend Oreille River extending from the mouth of the canyon downstream to Boundary Dam (2.4 river miles); and the Tailrace Reach, extending from Boundary Dam downstream to the confluence of Red Bird Creek (3.9 river miles).

Task 2) Wetted Width Calculations

Using a Geographical Information System (GIS) database to process available bathymetry, calculate the average full pool wetted channel width of the Pend Oreille River from Box Canyon Dam downstream to the confluence of Red Bird Creek. Calculate the percentage of channel length by reach having a width greater than 1.5 times the average channel width of the total analysis area, the length of channel having a width less than 0.5 times the total average, and the

length of channel having a width 0.5 to 1.5 time the average channel width or other indices of channel morphology .

Task 3) Wetted Surface Area Calculations

Use the results of the bathymetric survey and the GIS to calculate by reach the total wetted surface area of the Pend Oreille River channel under full pool conditions. Calculate by reach the total wetted surface area having a depth greater than 10 feet, 20 feet, 30 feet, 40 feet, 50 feet, and 100 feet. Develop maps of the Pend Oreille River channel displaying the depth profiles obtained using the bathymetric data.

Task 4) LWD Mapping

Using existing aerial photography, map existing locations of large wood pieces within the full pool surface area of the Pend Oreille River channel. Conduct a field survey of the shorelines of the Pend Oreille River within the analysis area and record the number, volume and type of large woody pieces by reach on an aerial map of the Pend Oreille River (see Large Wood Management Study Plan, section 4.4, for the definition of large wood categories).

Task 5) Aquatic Vegetation Mapping

Using existing aerial photography, map existing beds of aquatic vegetation within the full pool surface area of the Pend Oreille River channel. Conduct field surveys to verify and confirm and, where appropriate, adjust the vegetation maps. Using a stratified sampling scheme, estimate vegetation density, species, and percent of native versus non-native aquatic vegetation. Field surveys will be conducted during a period of peak macrophyte growth.

Task 6) Interviews

Interview relicensing participants, local biologists, anglers, and other personnel familiar with the Project area and identify areas supporting fish spawning and other areas of concentrated biological activity. Record spawning areas by species on aerial maps of the Project area. Field observations of fish spawning sites collected as part of the 2007 Habitat Suitability Information field validation effort will be used to confirm or adjust the location of potential spawning areas.

Task 6) Data Compilation

Compile information on channel width, depth, LWD, macrophytes, concentrated biological activity and channel types to determine the location and distribution of representative and distinct habitat types.

Work Products

The Habitat Mapping study component will include the following work products:

- Map and tabular summary of channel types
- Map and tabular summary of LWD
- Map and tabular summary of aquatic vegetation types

- Tabular summary of wetted width and wetted surface area calculations
- Documentation of interviews

These work products and other results of the aquatic habitat mapping study will be compiled and presented in a draft and final study report. The report will include the methodology used to distinguish habitat types, a description of the data collection methods and information collected, and tables summarizing the channel morphology and channel habitat types by river mile. A draft report will be produced by December 31, 2007, and a final report will be produced by February 15, 2008.

Schedule

The schedule for completing the Habitat Mapping component of this study is provided in Table 4.1-2.

Table 4.1-2. Schedule for the Habitat Mapping study component.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Study startup	------							
Channel Typing		--						
Channel length & surface area calculations			--					
Large woody debris mapping		---------	▲					
Aquatic vegetation mapping			▲					
Fish spawning area mapping		---------						
Information compilation				●	■			

Hydraulic Routing

Load-following operations at Boundary Project, designed to deliver power during peak-load hours, cause fluctuations of water surface elevations in the forebay of Boundary Reservoir and fluctuations in flow releases to the Boundary Tailrace. Slow moving waves (water surface fluctuations) originating in the forebay of Boundary Reservoir travel upstream through the Pend Oreille River to as far as Box Canyon Dam, and flow fluctuations originating in the tailrace of Boundary Project travel downstream to as far as just above the confluence with the Salmo River. A one-dimensional, unsteady-flow, hydraulic model will be used to analyze the translation and attenuation of water surface elevation and flow fluctuations upstream and downstream from Boundary Dam. The results of the hydraulic model will be used to support the analysis of impacts of Project operations on aquatic habitats in the Pend Oreille River between Box Canyon Dam and the confluence of Red Bird Creek (just upstream of the confluence of the Salmo River with the mainstem Pend Oreille River).

During peak load hours, additional flow is released through Boundary Powerhouse to meet power demands. The forebay water surface elevation in Boundary Reservoir is drawn down to provide the additional flow for peak power generation. During off-peak load hours, flows through the powerhouse are reduced, and Boundary Reservoir is refilled to create available usable storage for the next peak load period. The fluctuations in water surface elevations in the forebay of Boundary Reservoir create waves that travel the 17.5-mile-long distance from the source at Boundary Dam upstream to Box Canyon Dam. These waves attenuate, or dampen, as they travel upstream, and the range of fluctuation of water surface elevation is reduced when they reach Box Canyon Dam. Under certain conditions when the Boundary Reservoir forebay water surface elevations fluctuate below some threshold elevation, the waves do not travel past Metaline Falls, and the reach of the Pend Oreille River between Metaline Falls and Box Canyon Dam is not impacted by downstream fluctuations of water surface elevation at Boundary Dam.

Similarly, fluctuations in flow releases from Boundary Dam create waves that travel downstream through the Pend Oreille River. The distance that these waves travel depends on the water surface elevation maintained in the forebay of Seven Mile Reservoir. When the forebay water surface elevation of Seven Mile Reservoir is at normal maximum, the reservoir extends upstream and inundates the Boundary Dam tailrace. When the forebay water surface elevation of Seven Mile Reservoir is at maximum drawdown, the reservoir is assumed to extend upstream of the confluence of the Salmo River near Red Bird Creek, and the waves created by fluctuating flow releases from Boundary Powerhouse would travel downstream from the Boundary Project tailrace to the confluence with Red Bird Creek.

The waves created by load-following operations at the Boundary Project impact the aquatic habitat of the Pend Oreille River both upstream and downstream from Boundary Dam, especially along the margins of the river that are alternately wetted and dewatered (the varial zone). To analyze the impacts of alternative Project operational scenarios on aquatic habitat, a hydraulic routing model will be used to translate the effects of changes in Boundary Project forebay water surface elevations and tailrace flows associated with Project operations to Pend Oreille River locations extending from Box Canyon Dam downstream to near the confluence with Red Bird Creek.

Proposed Methodology

The U.S. Geological Survey (USGS), SCL, and BC Hydro currently collect hourly hydrologic data in the Pend Oreille River. It is assumed that these data will continue to be collected in 2007 and 2008, and will be available for use in the hydraulic routing model. These data, needed for the hydraulic routing model, consist of the following:

- Hourly flow data from the US Geological Survey for the Pend Oreille River below Box Canyon Dam (Gage No. 12396500).
- Hourly flow data from Seattle City Light for total flow release from Boundary Reservoir (power generation plus spill).
- Hourly water surface elevation data from BC Hydro for the Seven Mile reservoir forebay.

Additional information is needed to develop and calibrate the hydraulic routing model, and to provide a consistent input database to allow for comparison of alternative Project operational scenarios. The additional data required consist of the following:

- Surveys of Boundary Reservoir and the immediate tailrace conducted in 2006 will provide vertical resolution of 2-foot contours for wetted areas down to a depth of approximately 40 feet from the full pool water surface and 5-foot contours below a depth of 40 feet from the full pool water surface for the reach of the Pend Oreille River between Box Canyon Dam and the U.S.-Canada border. SCL is currently assessing the suitability of existing bathymetric data from the U.S.-Canada border to the confluence with Red Bird Creek. The costs required to acquire these bathymetric data (from hydrographic and LIDAR [Light Detection And Ranging] surveys) are not included in this study plan.
- Water surface elevation data (15-minute readings) covering a continuous period encompassing at least one spring and summer will be needed from stage recorders deployed in the Pend Oreille River at the following locations:
  - Just downstream of Box Canyon Dam
  - Just upstream from Metaline Falls
  - Just downstream from Metaline Falls
  - At the downstream end of the Canyon Reach
  - In the Boundary Project forebay
  - In Boundary Project tailrace
  - At the old bridge site upstream from the confluence with the Salmo River
- Water surface elevation data will be needed from the stage recorders deployed at these seven selected sites during 2007 to develop and calibrate the hydraulic routing model. Additional water surface elevation data from the stage recorders will be needed in 2008 to help establish a link between the hydraulic routing model and the mainstem aquatic habitat modeling transects.
- The conversion between vertical elevation references (CGVD28, NGVD29 and NAVD88) will be needed to convert all elevation data to a common datum.
- A time series of hourly flow releases from Box Canyon Dam to the Pend Oreille River will be needed for use as input to the hydraulic routing model. These flow hydrographs will be assumed to be the same for all alternative Boundary Project operational scenarios.
- The effects of alternative operational scenarios on hourly water surface elevations in the Boundary Reservoir forebay and hourly flow releases (power generation plus spill) from Boundary Dam to the Pend Oreille River will be needed from the Boundary Project operations Scenario Tool to be used as input to the hydraulic routing model.
- The potential response of Seven Mile Project operations to changing Boundary Project operations will be needed (either from BC Hydro, or from SCL in

coordination from BC Hydro). The specific information needed consists of hourly Seven Mile forebay water surface elevations for each Boundary operational scenario and each hydrologic period of interest.

The specific tasks involved in this study component are described below.

Task 1) Routing Model Construction

A one-dimensional, unsteady-flow, hydraulic routing model will be constructed to allow for the routing of flow and stage fluctuations in the Pend Oreille River from Boundary Dam to Box Canyon Dam and from Boundary Dam to Seven Mile Dam. The routing model will be developed using cross-sectional profile data derived from bathymetric and LIDAR surveys.

Task 2) Model Calibration

The hydraulic routing model will be calibrated to match observed hourly stages obtained from stage recorders by adjusting equivalent channel roughness. The resulting model will reflect indices of wave speed, attenuation, and accretion to translate Boundary Reservoir forebay water surface elevations and tailrace flows to upstream and downstream locations.

Task 3) Evaluate Need for Separate Seasonal Models

The need for separate hydraulic routing models for summer and winter periods will be evaluated. If deemed necessary, separate seasonal-specific hydraulic routing models will be developed to account for the additional hydraulic roughness associated with seasonal growth and die-back of aquatic vegetation.

Task 4) Model Documentation and Executable Model

An executable model and supporting documentation will be prepared that can be used in the development of the mainstem aquatic habitat model and post-processing of operational scenarios developed using the Boundary Project Scenario Tool.

Work Products

Work products will consist of a calibrated executable model and a draft report by December 31, 2007, describing the methods used to develop the routing model, channel cross-section profiles, and details of model calibration. The December 31, 2008, report of the Mainstem Aquatic Habitat Modeling Study will include the final summary of the Hydraulic Routing study component.

Schedule

The schedule for completing the Hydraulic Routing component of this study is provided in Table 4.1-3.

Table 4.1-3. Schedule for the Hydraulic Routing study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	--------										
Confirm availability and adequacy of bathymetric data (Box Canyon to Seven Mile Dam)	--------										
If needed, collect bathymetric data for Seven Mile Dam to Boundary Dam *		-----									
Construct cross-sections for hydraulic routing model		--------	-------								
Obtain and analyze hourly stage and flow data	---------	---------									
Develop and calibrate flow routing model		------	------	------							
Draft Report				●							
Continue to collect water surface elevation data at selected sites to help calibrate the Mainstem Aquatic Habitat Modeling transects					--------	-------	-------				
Final Report							■				

* task not included in budget estimate

Physical Habitat Model Development

This study component develops the core structure of the mainstem aquatic habitat model. It uses the information or technical analyses performed in other study components as a basis for developing the model structure (e.g., Habitat Mapping) or as part of internal model processes (e.g., Hydraulic Routing and HSI curves).

Proposed Methodology

There are 11 tasks specific to the mainstem aquatic habitat model development and analyses. These tasks are described below.

Task 1) Transect Selection

In coordination with relicensing participants, use the results of the Habitat Mapping study component to select transects within the mainstem Pend Oreille River to describe representative habitat conditions based on channel morphology and major habitat features. As needed, additional habitat transects will be selected to describe distinct habitat features such as localized areas of fish trapping, stranding, and localized spawning that may not be adequately described by transects used to describe representative habitat features. Transects will also be located at some of the water surface elevation recorders (see Hydraulic Routing Model study component above)

to assist in calibrating the flow routing model to mainstem habitat transects. For planning purposes, it is assumed 50 transects, distributed as follows, will be required to describe aquatic habitat conditions within the Pend Oreille River:

- Upper Reservoir Reach (Box Canyon Dam downstream to Metaline Falls, 6.7 river miles) — 20 transects.
- Canyon Reach (Metaline Falls downstream to mouth of canyon, 8.4 river miles) — 14 transects.
- Forebay Reach (Mouth of canyon downstream to Boundary Dam, 2.4 river miles) — 4 transects.
- Tailrace Reach (Boundary Dam downstream to Red Bird Creek [just above confluence with the Salmo River], 3.9 river miles) — 12 transects.

Task 2) Stakeholder Site Visit

Conduct a site visit with personnel from agencies, tribes and other stakeholders to confirm/modify habitat transect selection.

Task 3) Substrate and Aquatic Vegetation Characterization

Characterize and map substrate and vegetation along habitat transects to a depth of 40 feet below the full pool water surface during two periods of macrophyte growth. The first should occur during a period of abundant macrophyte growth (e.g., late August low-flow conditions). The second should occur during a period of sparse macrophyte growth (e.g., early April). An underwater video camera may be used to characterize and map substrate and macrophytes in water too deep to observe from the surface. Substrate characterization of the channel bed at depths greater than 40 feet will rely on acoustic backscatter collected during the 2006 bathymetric surveys.

Task 4) Velocity and Depth Measurements

Measure velocities, water surface elevation and bottom profile habitat transect alignments under three stable flow conditions and full pool elevations:

- High flows (i.e., above 40,000 cfs). These typically occur in late May or early June.
- Mid-range flows (i.e., about 20,000 cfs). These typically occur in July.
- Low flows (i.e., below about 12,000 cfs). These typically occur in August.

Task 5) Develop Cross-sectional Profiles

Develop cross-sectional profiles for each of the mainstem habitat transects and subdivide transects into cells (n= 20 to 100 cells).

Task 6) Hydraulic Model Integration

Integrate each of the measured mainstem habitat transects into the hydraulic routing model described above to translate changes in Boundary Project forebay water surface elevations and tailrace flows to each of the measured mainstem habitat transects.

Task 7) Calibrate Hydraulic Model

Calibrate the hydraulic routing model to match observed velocities within cells along the habitat transects by adjusting equivalent channel roughness.

Task 8) Downramping Analysis

Calculate the number of hours with downramping rates exceeding 1, 2, 4, 6 and 12 inches per hour associated with each alternative operational scenario and selected hydrologic period. The number of hours of downramping exceeding each criterion will be calculated by month and by annual total for each of the measured mainstem habitat transects. The number of hours of downramping exceeding each criterion will be calculated as a reach-averaged, transect-weighted total for the entire study area Box Canyon Dam downstream to Red Bird Creek and for the four mainstem Pend Oreille reaches (Upper Reservoir Reach, Canyon Reach, Forebay Reach, and Tailrace Reach).

Task 9) Varial Zone Model

Develop a varial zone habitat model to quantify the magnitude, frequency and duration of the channel area that is exposed to inundation and dewatering. The varial zone analysis is conducted by discrete portions of mainstem transects (i.e., cells) using an hourly time step that considers fluctuations in water surface elevations that occurred before and after the hour of interest. The analysis is conducted by cell and by hour for mainstem transects of interest. The varial zone is defined as the area between the high water surface elevation and the low water surface elevation using a range of time periods to reflect the aquatic species and lifestage of interest. A range of time periods are presented for planning purposes; the selection of time periods to define the upper and lower extent of the varial zone for the Boundary Project will be coordinated with relicensing participants. Information on the rate of colonization, dewatering mortalities and conditions supporting suitable habitats for organisms of interest will be developed as part of the HSI study component.

For planning purposes, the upper end of the varial zone is assumed to be the highest water surface elevation within the previous 12-hour period. In other words, the upper edge of the varial zone extended to the upper wetted channel margin. Three different time scales are used to determine the lower extent of the varial zone. The bottom of the varial zone is based on the minimum reservoir water surface elevation during the previous 12 hours, 7 days, or 30 days. An example of the results of the varial zone analysis for a hypothetical transect under two alternative operational scenarios is presented in Figures 4.1-4 and 4.1-5. The three different varial zone analyses provide the following information on a range of environmental resources and Project effects:

- 12-hr/12-hr time series:[2]
  - Indicator of risk of immediate dewatering mortality due to hourly load-following operations.
  - Indicator of effects of water level changes on aquatic biota such as fry or benthic macroinvertebrate drift that colonize shallow mainstem areas within hours of rewetting of habitats.
  - Results can be used to indicate potential interference of smallmouth bass spawning activity associated with reservoir pool level fluctuations.
- 12-hr/7-day time series:
  - Indicator of risk of dewatering due to daily changes in load-following (weekday versus weekend operations).
  - Indicator of effects of water level changes on periphyton and benthic macroinvertebrate species that have recolonized shallow mainstem areas within days of rewetting of habitats.
- 12-hr/30-day time series:
  - Indicator of risk of dewatering due to seasonal changes in Project inflow associated with storage in upstream reservoirs.
  - Indicator of effects of water level changes on aquatic biota that require weeks to months to establish an assemblage of species.

The portion of the channel margin below the minimum varial zone will not receive further consideration during the varial zone analysis.

The varial zone will be calculated as the channel area (channel width times assumed channel length) for each habitat transect by month and annual total for each alternative operational scenario and selected hydrologic period. The varial zone area will also be calculated as a reach-averaged, transect-weighted total for each of the four mainstem reaches and as a reach-averaged, transect-weighted total for the entire study area between Box Canyon Dam downstream to the confluence of Red Bird Creek (just above confluence with the Salmo River). The time periods used to define the varial zone will be developed in coordination with relicensing participants as part of the Habitat Suitability Indices Development study component and will be developed to reflect rates of habitat colonization and dewatering-related mortality for the aquatic species and lifestages of interest.

Task 10) Habitat Weighted Usable Area

Translate changes in water surface elevation at each of the measured mainstem habitat transects into changes in depth, velocity, substrate, and cover. Use habitat suitability index (HSI) curves developed for species and lifestages of interest to translate changes in hydraulic conditions to indices of habitat suitability (see the Habitat Suitability Indices Development study component

[2] The varial zone area between the highest water surface elevation in the previous 12 hours and the lowest water surface elevation in the following 12 hours.

described below). Quantify the area of Pend Oreille River channel containing suitable habitat indices for target species and lifestages of interest for each alternative operational scenario under Boundary Reservoir forebay pool levels at elevations 1,990, 1,980 and 1,970 feet NGVD 29 (1,994, 1,984, and 1,974 feet NAVD 88, respectively).

Task 11) Post-Processing

Use the hydraulic-routing and habitat models to process output from the Boundary Project operations Scenario Tool (see section 1.4.3) for each operational scenario and hydrologic period to quantify effects of Boundary Project operations on:

- downramping rates;
- varial zone area;
- effective spawning areas for fish species of interest (i.e., spawning sites remain wetted through egg hatching);
- weighted usable area for fish species and lifestages of interest;
- macrophyte distribution and growth and potential benefits or impacts of changes in abundance; and
- periphyton and benthic macroinvertebrates abundance.

The various indices of Project effects on mainstem aquatic habitats will be summarized and tabulated to allow ready comparison of the effects of an existing operations scenario to alternative operational scenarios. It is anticipated that the varial zone analysis will be used as a primary indicator of the effects of operational scenarios on aquatic habitats in the mainstem Pend Oreille River. Analyses of weighted usable area will be developed for species and lifestages of interest, but the results may be of primary interest in identifying the spatial distribution of potential habitats. Each indicator of environmental effect will be tallied separately, and the relative importance of the effects of Project operations on various aquatic resources may be determined independently by interested parties.

Work Products

A draft report will be produced by December 31, 2007, describing the first year's progress in developing the mainstem aquatic habitat model. The draft report will include a summary of the transect selection process and describe their location. The draft report will also present the results of substrate and aquatic vegetation characterization along the selected transects. It is anticipated that final development of the aquatic habitat model will occur after completion of the subcomponent models and studies at the end of 2008 and that details of the subcomponent model studies will be documented in stand-alone reports or as appendices to the Mainstem Aquatic Habitat Modeling report. A second draft report describing any field data collected during 2008, the final aquatic habitat model structure, and the initial results of model testing will be produced by December 31, 2008. Final model runs and post-processing of the output will be documented in a final report to be produced by June 30, 2009.

Schedule

The schedule for completing development of the Mainstem Aquatic Habitat Model is provided in Table 4.1-4.

Table 4.1-4. Schedule for development of the Mainstem Aquatic Habitat Model.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	----------										
Habitat Mapping/Transect Selection		-▲▲									
Stakeholder Site Visit			▲▲▲								
Hydraulic Routing		-------	----------	----------							
HSI Development	---------	▲▲	▲▲	▲▲	▲▲	▲▲	----------				
Substrate and Vegetation Characterization			▲▲			▲▲▲					
Collect Velocities and depths			▲▲▲	▲▲▲		▲▲▲	▲▲▲				
Develop Varial Zone Model				------	------	------	------	-------			
Hydraulic Model Integration and Calibration							------	------			
Downramping Analysis								-------	-------	-------	
Habitat WUA								-------	-------	-------	
Post-Processing								-------	-------	-------	
Reporting				●				●(		■	

Habitat Suitability Indices Development

HSI curves represent an assumed functional relationship between an independent variable, such as depth, velocity, and substrate, and the response of a species life stage to a gradient of the independent variable (suitability), which is expressed over a scale of 0.0 (poor habitat) to 1.0 (best habitat) (Bovee 1982) (Figure 4.1-6). In traditional instream flow studies, HSI curves for depth, velocity, substrate and/or cover are combined in a multiplicative fashion to rate the suitability of discrete areas of a stream for use by a species and lifestage of interest. HSI curves translate hydraulic and channel characteristics into measures of overall habitat suitability in the form of weighted usable area (WUA). Depending on the extent of data available, HSI curves can be developed from the literature, or from physical and hydraulic measurements made in the field in areas used by the species and life stages of interest (Bovee 1986). HSI curves for the Boundary Project will be based on information contained in available literature and validated with site-specific data where it can be obtained.

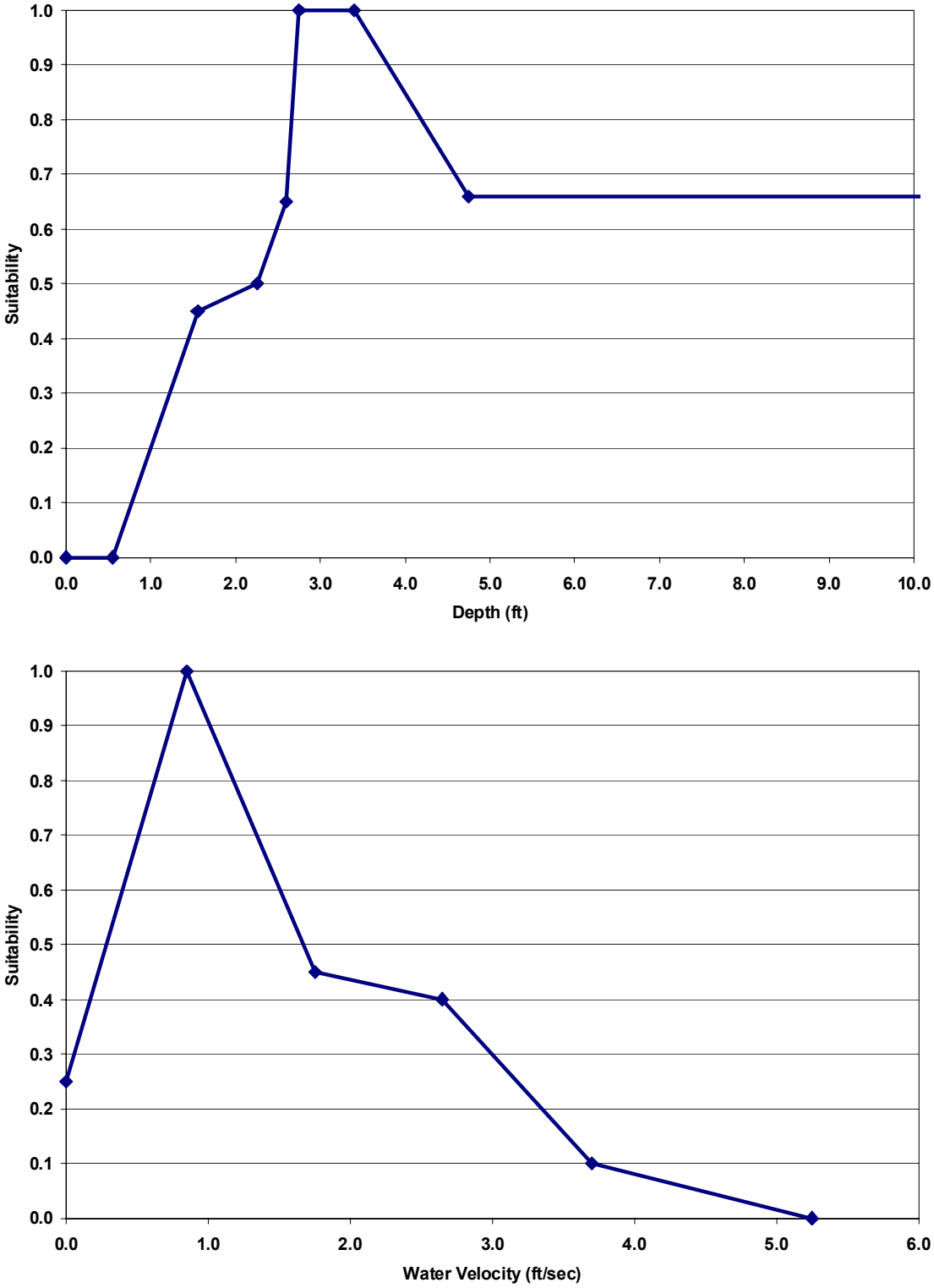

Figure 4.1-6. Example depth (top) and water velocity (bottom) HSI curves for juvenile rainbow trout. Source: WDFW and Ecology (2003).

For use in the mainstem aquatic habitat model, HSI curves will also need to be developed to describe the response of aquatic organisms to cyclic inundation and dewatering. For instance, periphyton (algae growing on substrates) will colonize a site if it contains suitable depth, velocity and substrate, but colonization may not occur until the area has been inundated for a period of time. Conversely, the effects of dewatering of the site on periphyton production will depend on the duration of dewatering and conditions at the time of the dewatering (e.g., hot summer day compared to winter). The following sections describe development of HSI curves for fish, macrophytes, and periphyton and benthic macroinvertebrates.

Fish HSI

The fish community in Boundary Reservoir is dominated by non-salmonids with northern pikeminnow and largescale sucker representing the highest relative abundance based on surveys by McLellan (2001). Salmonids represented about 3.4 percent of the catch, of which about two-thirds of the salmonids were mountain whitefish. From a fisheries management perspective, the important fish species in Boundary Reservoir and the tailrace are the native salmonids (bull trout, westslope cutthroat trout, and mountain whitefish) and a non-native sport fish (smallmouth bass). For the purposes of this study, relicensing participants also tentatively agreed to include a native minnow (peamouth) as an indicator for prey species. Infrequent observations of reservoir and tributary delta habitat use by native salmonids may increase the reliance on literature-based HSI curves. HSI curves developed for fish species and lifestages of interest will be used in the Tributary Delta Modeling Study (see section 4.2) as well as this Mainstem Aquatic Habitat Modeling Study.

Proposed Methodology

In developing the proposed methodology for this study component, the following assumptions were made:

- Habitat conditions available within the Boundary Project area during the 2007 and 2008 study period may not represent the full range of conditions potentially available under alternative Boundary Project operational scenarios. For some organisms, such as macrophytes or benthic macroinvertebrates, habitat suitability information may not be available, or may require biological surveys to be conducted outside of the Project area.
- A level of effort is described for planning purposes, but details of the sampling program, including selection of sample location, timing, and intensity and data analysis procedures, will be developed in coordination with relicensing participants.

Development of the fish HSI for this study component includes the following six tasks:

Task 1) Develop Draft HSI Curves. Develop draft HSI curves for target species and lifestages using available scientific literature. For planning purposes, the species consist of native salmonids, select sport fish species and a native minnow species (Table 4.1-5). Potential sources of information include the Internet, university libraries, peer-reviewed periodicals, and government and industry technical reports. Special emphasis will be given to information obtained from similar biological and hydrological systems (fish species

composition, stream/reservoir size, geographic location, and project configuration and operation). Habitat suitability information will address fish responses to changes in depth, velocity, substrate, cover, macrophyte beds, indices of stranding and trapping (depressions and isolated pools), rates of colonization and stranding and trapping mortality.

Task 2) *Develop a Periodicity Table*. Develop a species and lifestage periodicity table applicable to the Pend Oreille River from Box Canyon Dam downstream to just above the Salmo River confluence using available scientific literature. The periodicity information will be used to define temporal and spatial changes in fish distribution and abundance, identify time periods when young fish are the most susceptible to stranding, and assist in analyses of the results of the aquatic habitat modeling efforts.

Task 3) *Collect Site-Specific Habitat Suitability Information*. Collect site-specific habitat suitability information using HSI-focused biotelemetry and spawning survey field efforts supplemented by information collected while conducting other studies involving fish sampling surveys (Table 4.1-5). Habitat use information (i.e., water depth, velocity, substrate type, and macrophyte density) will be collected at the location of each identified target fish and lifestage. If available, a minimum of 50 habitat use observations will be collected for each target species life stage.

Task 4) *Stranding and Trapping Field Surveys*. Conduct field surveys of potential stranding and trapping areas prior to and immediately following flow fluctuation events. Surveys will be conducted during times of the year when fish are most likely to be susceptible to stranding and trapping (e.g., July–September). For planning purposes, it is assumed that five areas with conditions presenting a high stranding and trapping risk will be surveyed once per month from July through September during 2007 and 2008. Prior to scheduled reductions in reservoir pool levels, electrofishing surveys will be conducted to determine the number, size and species of fish in the targeted areas. During and immediately following a scheduled drop in reservoir pool level, identified stranding and trapping areas will be surveyed to quantify the number, size and species of fish stranded or trapped by the reduction in pool level. When feasible, surveys will be scheduled when pool levels have been relatively constant during the antecedent period.

Task 5) *Habitat Utilization Frequency Histograms*. Develop a histogram (i.e., bar chart) for each of the habitat parameters (e.g., depth, velocity, substrate, cover/ macrophyte use, rate of colonization) using the site-specific field observations. The histogram developed using field observations will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling.

Table 4.1-5. Potential data sources for habitat suitability information.

Species and Lifestages of Interest	Literature	Site-Specific Validation Data				
		Biotelemetry	Distribution and Abundance Surveys	Habitat Transect Surveys	Trapping and Stranding Surveys	HSI Spawning Surveys
Bull Trout *(Salvelinus confluentus)*						
▪ adult	P	P	S			
▪ spawning	P	P				
▪ incubation	P					
▪ fry	P					
▪ juvenile	P					
Westslope Cutthroat Trout *(Oncorhynchus clarki lewisi)*						
▪ adult	P	P	S			
▪ spawning	P	P				
▪ incubation	P					
▪ fry	P					
▪ juvenile	P					
Mountain Whitefish (*Prosopium williamsoni*)						
▪ adult	P	P	S			
▪ spawning	P	P	S			
▪ fry	P		S		S	
▪ juvenile	P		S		S	
Columbia Redband Trout (*Oncorhynchus mykiss gairdneri*) (below Boundary Dam)						
▪ adult	P	P	S			
▪ spawning	P	P				
▪ fry	P					
▪ juvenile	P					
Smallmouth Bass (*Micropterus dolomieu*)						
▪ adult	P	P	S			P
▪ spawning	P	P				P
▪ incubation	P					P
▪ fry	P		S		S	
▪ juvenile	P		S		S	
Peamouth (*Mylocheilus caurinus*)						
▪ adult	P		S		S	
▪ spawning	P		S		S	
▪ fry	P		S		S	
▪ juvenile	P		S		S	
Size / species susceptibility to stranding and trapping						
	P		S		P	

Notes:

P=Primary data sources, S= Secondary data sources

Blank cells indicate few site-specific data points are expected from this source

Task 6) Stakeholder and Expert Panel. Convene a panel of relicensing participants and, if desired, regional experts (agency, tribal, industry and university researchers) to confirm HSI curves for each target species and lifestage. Using a roundtable discussion format, the panel members will review literature-based life history information and site-specific data to develop a final set of HSI curves. These curves will be used in the mainstem and tributary delta aquatic habitat modeling efforts to define the relationship between habitat quantity and quality for each of the target species under alternative operational scenarios.

Work Products

The final work product of this study effort will consist of HSI curves for the target fish species and lifestages. A draft report describing survey methods, results of 2007 monitoring, and discussion of recommendations for 2008 HSI sampling efforts will be produced by December 31, 2007. A final report describing survey methods and results of 2007 and 2008 monitoring will be produced by November 15, 2008.

Schedule

The development of fish HSI for this study component is scheduled to begin in early 2007 and end in 2008 (Table 4.1-6). The majority of data collection will occur in the summer of 2007 with the 2008 field season available if additional data collection is required.

Table 4.1-6. Schedule for fish HSI development.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
Develop literature-based HSI curves and periodicity		---						
Field data collection		▲▲	▲▲	▲▲	▲▲	▲▲		
Develop final HSI curves and periodicity							---	---
Reporting				--●				--■

Macrophyte HSI

Macrophytes are emergent, submergent, or floating aquatic plants growing in or near the water. Macrophytes can be beneficial to lakes and reservoir systems because they provide cover for fish and substrate for aquatic invertebrates, but the overabundance of macrophytes can become problematic by interfering with recreational activities, affecting the water quality and enhancing internal nutrient loading from the sediments. Macrophyte growth has become an increasing problem in Boundary Reservoir because the shallow water areas of the reservoir system are conducive to the growth of macrophytes. Non-native invasive species, such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curly pondweed (*Potamogeton crispus*), have spread in the shallow, low-velocity areas throughout the Pend Oreille River system (EPA 1993, Pelletier

and Coots 1990). Eurasian watermilfoil and curly pondweed are found in shallow coves and bays of Boundary Reservoir, and dense mats of macrophytes have been found in side channels upstream of Peewee Creek near RM 19.5, upstream of Metaline Falls between RM 27 and RM 29, and between the gaging station and Metaline Falls at RM 31–33. The distribution of macrophytes in Boundary Reservoir corresponds to the area mapped as Lacustrine Aquatic Bed in the vegetation cover type map presented in the Boundary Project Pre-Application Document (SCL 2006, Figure 4.6-1). This cover type includes shallow water areas, that are characterized by the presence of aquatic vegetation, primarily milfoil, coonwort, and elodea.

Eurasian watermilfoil grows in still to flowing waters, can tolerate salinities of up to 15 parts per thousand (ppt) and pH values from 5.4 to 11, and has been found abundant across a broad range of alkalinity (WSNWCB [undated]; Madsen 1998). Milfoil forms dense mats of vegetation on the water surface, which reduces light penetration and can displace native species of aquatic vegetation (CWS 2003). Its growth begins in early spring, often earlier than other aquatic plants, as temperatures reach 15˚C, and it blooms from June through August (WSNWCB [undated]). A light compensation point of only 1–2 percent enables watermilfoil to photosynthesize in deeper water than other rooted plants (Engel 1995). Milfoil can disperse by fragmentation of plant parts (Hamel 1990). Each fragment can grow roots and develop into a new plant, allowing it to disperse quickly and aggressively. In the late summer and fall the plants become brittle and naturally break apart, promoting colonization of other areas.

In addition to Eurasian watermilfoil, a reconnaissance level survey of Boundary Reservoir in 2005 indicated the presence of another non-native invasive species of macrophyte, curly pondweed, in the Project vicinity (Colleen McShane, EDAW, personal communication, 2005). Curly pondweed also begins growth in early spring and spreads by vegetative turions or seeds (WSNWCB 2004). Typically, peak biomass is reached in late spring or early summer and decline begins in summer in response to increasing water temperatures. Before decline, the plants grow turions or buds that survive in a dormant state until winter or early spring. Little information is available regarding the distribution of curly pondweed in the Pend Oreille River.

Aquatic macrophyte biomass has been found to be greatest in the littoral regions of the Pend Oreille River at depths of less than 10 feet (Falter et al. 1991). Little to no growth has been found at depths greater than 18 feet. Maximum macrophyte biomass in the mainstem occurs in the latter part of July and in August (Pelletier and Coots 1990). The dense growth of milfoil slows water velocities and allows nutrients and sediments to precipitate out of the water column (EPA 1993).

Many factors influence the growth of aquatic macrophytes such as shading, toxicity, turbidity, water temperature, and gradient, but the main factors are depth, water column velocity, nutrients, and substrate. In general, submerged macrophytes have been found to grow to a depth of two to three times the Secchi depth (Nichols 2001). However, a study by Canfield et al. in 1985 found the depth of colonization by macrophytes to be slightly more than the Secchi depth. This study developed the following regression model between the maximum depth of plant colonization (MDC, meters) and Secchi depth (meters): Log MDC = 0.62logSD +0.26 (Welch 1992) (Figure 4.1-7). The depth of colonization will vary depending on the species present. Growth of milfoil has been found to be poor in shallow water of less than 3.28 feet (1 meter) (Smith and Barko

1990). Abundant milfoil growth appears between depths of 1.6 to 11.5 feet (CWS 2003), but some growth has been found at depths as high as 16.4 feet (Pend Oreille County 2003).

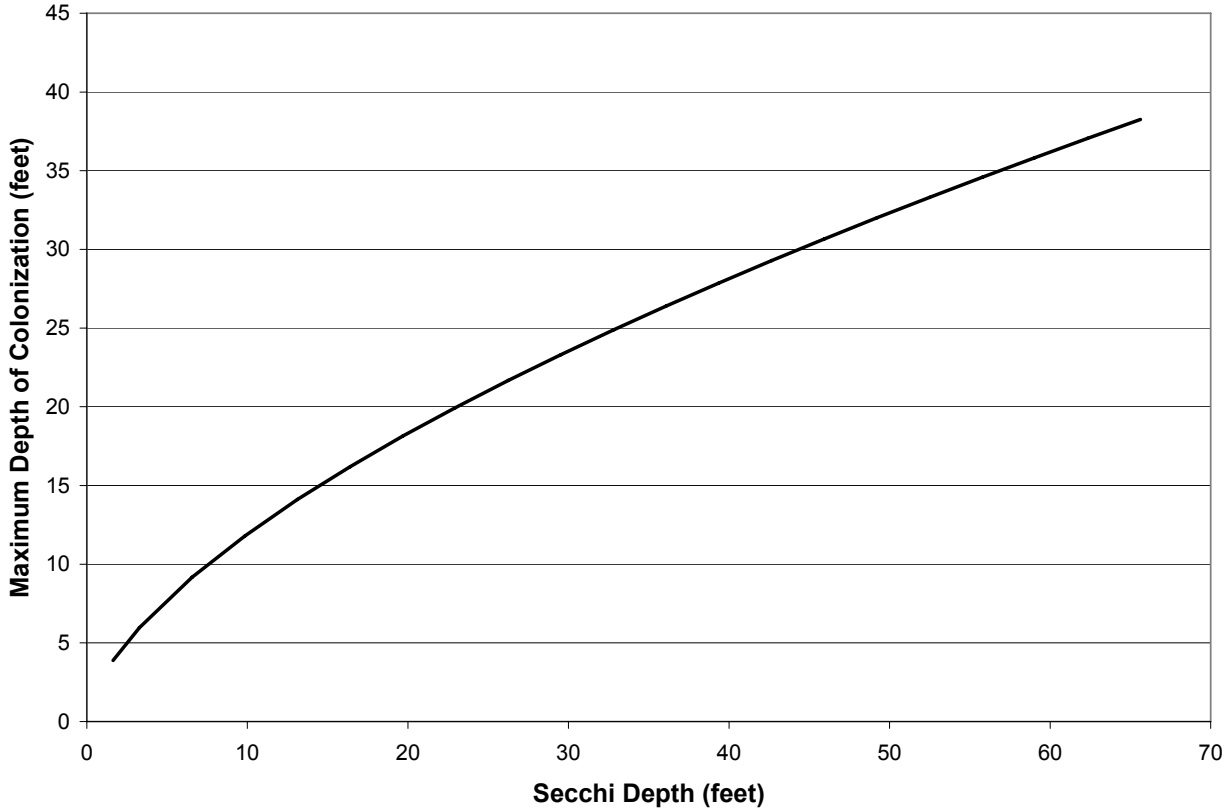

Figure 4.1-7. Regression model relationship developed by Canfield et al. in 1985 between Secchi depth and the maximum depth of colonization.

Water column velocity also influences the growth and abundance of aquatic macrophytes. In general, abundant macrophyte growth occurs in areas exposed to slow velocities with growth declining when velocities increase. One study found that at velocities less than 0.2 m/s (0.66 ft/s) 75 percent of the reach was occupied by aquatic vegetation, but that percentage decreased to only 10 percent in areas with velocities greater than 0.9 m/s (2.95 ft/s) (Henriques 1987). In a different study, data from 29 transects for five hydrologically stable streams were compiled and a curve developed for habitat preference as a function of mean water velocity. Habitat preference was analyzed for *Elodea Canadensis*, *Myriophyllum triphyllum*, *Potamogeton cheesemanii*, and *Ranunculus trichophyllus*. This study found habitat preference to be lowest in velocities less than 0.05 m/s (0.16 ft/s), to increase steadily until approximately 0.4 m/s (1.3 ft/s), and to decrease slightly until 0.6 m/s (1.97 ft/s) (Riis and Biggs 2003). In addition, this study found a threshold velocity of 0.8 m/s (2.6 ft/s) above which no macrophyte growth occurred. The above studies represent the type of information available in the literature, but additional understanding is necessary in order to evaluate the applicability to species within Boundary Reservoir.

Another factor influencing the growth of macrophytes is the availability of nutrients. Aquatic macrophytes can either utilize water column nutrients or absorb nutrients from the sediments (Davis and Brinson 1980). A study by Bole and Allan (1978) found that milfoil first utilizes phosphorus from the sediment until the water column concentration reaches a threshold value above which the uptake from the water column increases. Studies like these suggest that sediment nutrition dominates over water column concentrations in influencing macrophyte growth (Welch 1992). As such, substrate is also an important factor influencing the growth and abundance of macrophytes. Studies have found milfoil to grow best on fine-textured inorganic sediments (WSNWCB [undated]; Smith and Barko 1990) and relatively poorly on highly organic sediments (>20 percent organic content) or coarse substrates (WSNWCB [undated]; Smith and Barko 1990; Pend Oreille County 2003). In addition, growth of milfoil in full sediment (undiluted with sand) has been found to be nearly 5 times greater than growth in full sand and high water concentrations of nutrients (Welch 1992).

Another factor present within Boundary Reservoir that may also inhibit macrophyte growth is the frequency of dewatering or inundation. On other lakes and reservoirs, water level manipulation has been used effectively to manage macrophyte growth. However, the effectiveness of drawdown is dependent on several factors such as the degree of desiccation, the composition of the substrate, the species present, and the air temperature (WSNWCB [undated]). Lowering the water level in winter exposes sediments to freezing and loss of water, while dewatering during the summer causes desiccation and exposure to high temperatures; both conditions can kill plants (WSNWCB [undated]). The length of exposure required to cause death varies within the literature and little information is available regarding the impacts of short-term dewatering. Several studies found that exposure duration of as little as 3–4 days is sufficient to kill plants (CWS 2003; WSNWCB [undated]), whereas others suggest that only prolonged (one month or more) exposure is sufficient to achieve macrophyte control (Cooke 1980). Milfoil is particularly resistant to exposure and may require three or more weeks of exposure to achieve control (Cooke 1980). In addition, some studies suggest that some species, such as milfoil, may be enhanced by water level drawdown by creating favorable habitat conditions where they can out-compete other macrophytes (Smith and Barko 1990; WSNWCB [undated]).

Proposed Methodology

The proposed method to assess the impact of alternative Project operational scenarios on the growth and distribution of macrophytes within Boundary Reservoir is to develop and field validate HSI curves. These curves will then be used in the Mainstem Aquatic Habitat and Tributary Delta Aquatic Habitat modeling to evaluate the potential distribution of macrophytes under alternative operational scenarios. The work effort for this study has been divided into the following seven tasks:

Task 1) Literature Review. Conduct a literature review to develop seasonal periodicity and HSI curves for macrophyte growth within the Pend Oreille River. HSI curves will be developed for macrophyte growth as a function of depth, velocity, substrate, and frequency of inundation and dewatering (rates of macrophyte colonization and dewatering mortality). Available information on the duration and severity of freezing and desiccation necessary to retard growth

will be compiled to assist in the evaluation of reservoir drawdown as a potential opportunity for control of invasive macrophytes.

Task 2) *Aquatic Plant Field Surveys*. Conduct field surveys of aquatic plant distribution and abundance data along depth, velocity, and substrate gradients in established macrophyte beds exposed to a range of inundation and dewatering conditions. Field data collection efforts may be extended to the Box Canyon Reservoir to represent habitat suitability under the range of reservoir pool level fluctuations associated with run-of-river conditions. Field surveys will consist of measurements of macrophyte abundance, depth, velocity, substrate, and frequency of inundation and dewatering. Field surveys will be conducted during peak macrophyte growth periods (i.e., August or September). Where possible, HSI field surveys will be integrated into ongoing mainstem habitat transect measurement efforts (see Physical Aquatic Habitat Model Development described above) or other macrophyte study efforts. For planning purposes, macrophyte bed measurement sites may be immediately above or below Box Canyon Dam, across from the town of Metaline, and in the divided channel across from the Lime Creek confluence.

Task 3) *Validate HSI curves for depth, velocity, substrate, and frequency of inundation*. Use literature-based information from Task 1 and field data from Task 2 to validate HSI curves for depth, velocity, substrate, and frequency of inundation as a function of macrophyte abundance. To do this, a histogram (i.e., bar chart) will be developed for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of inundation and dewatering) using the site-specific field observations. The histogram developed using field observations will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling. In order to validate literature-based habitat suitability information with site-specific observations, it will be assumed that all suitable habitats within the Pend Oreille River have been colonized by aquatic macrophytes. Areas above or below Box Canyon, across from the town of Metaline, and in the divided channel across from the Lime Creek confluence are exposed to a range of pool level fluctuations. Measurements of macrophyte density in these areas will be correlated to the frequency of inundation and dewatering associated with antecedent Boundary Project operations or Box Canyon Project operations (for data collected in Box Canyon Reservoir). Data collection in Box Canyon Reservoir is proposed to validate portions of the draft HSI curves with a low amount of pool level fluctuation that are not observable under current operations in Boundary Reservoir.

Task 4) *Develop HSI curves for pH and DO*. Use water quality and abundance data available from the Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir (3.4) to develop an HSI curve for pH and dissolved oxygen as a function of macrophyte abundance. Macrophyte abundance and water quality data will be provided by the Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir. This information will be used

to help interpret the effects of aquatic macrophyte density and distribution on aquatic biota.

Task 5) *Confirm macrophyte HSI curves*. Convene a panel of relicensing participants and, if desired, regional experts (agency, tribal, industry and university researchers) to confirm macrophyte HSI curves. Using a roundtable discussion format, the panel members will review literature-based life history information and site-specific data to develop a final set of HSI curves.

Task 6) *Provide finalized information to Aquatic Habitat Models*. Provide finalized HSI curves, periodicity, and colonization information for use in conjunction with the mainstem physical habitat model described above and for use in the Tributary Delta Habitat Modeling Study (4.2). Estimates of macrophyte distribution and abundance under alternative Boundary Project operational scenarios will be used to evaluate the effects of operations on changes in aquatic habitats, and will also be used to evaluate the efficacy of operational measures to control invasive macrophytes.

Lowering water levels in the winter can cause Eurasian watermilfoil plant buds to freeze, which reduces growth the following summer. Lowering water levels in summer can expose sediments to desiccation, which can also kill some aquatic plants. Because of the limited ability of the Project to affect reservoir drawdown upstream of Metaline Falls (see the Hydraulic Routing component of this study plan), drawdown periods sufficient to fully desiccate or freeze nonnative macrophytes may not be achievable in the areas of greatest watermilfoil infestation. The results of the mainstem and tributary delta habitat modeling studies can be used to identify the magnitude and duration of potential reservoir drawdown and the areas of macrophyte infestation that can be affected by Project operations. The results of these analyses will be used to develop an Aquatic Macrophyte Management Plan, which SCL will submit as part of its Application for 401 Water Quality Certification (see section 3.4).

Task 7) *Provide necessary information to the Productivity Assessment Study*. Provide macrophyte abundance, distribution and productivity data developed in this study component for use in the Aquatic Productivity Study (section 4.5), where the information can be used to evaluate the potential need and opportunities for macrophyte management.

Work Products

A draft report describing survey methods, results of 2007 monitoring, and discussion of recommendations for 2008 HSI sampling efforts will be produced by December 31, 2007. A final report describing survey methods and results of 2007 and 2008 monitoring will be produced by November 15, 2008. The final work product of this study effort will consist of HSI curves for macrophytes as a function of depth, velocity, substrate, and frequency of inundation.

Schedule

The development of macrophyte HSI for this study component is scheduled to begin in early 2007 and end in 2008 (Table 4.1-7). The majority of data collection will occur in the summer of 2007, with the 2008 field season available if additional data collection is required.

Table 4.1-7. Schedule for macrophyte HSI development.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
Develop literature-based HSI curves and periodicity		---	---					
Field Data Collection			▲▲				▲▲	
Develop Final HSI Curves and periodicity							---	---
Reporting				●				■

Periphyton and Benthic Macroinvertebrate HSI

Periphyton and benthic macroinvertebrates (BMI) are organisms that live on the bottom of a river or lake, or on substrates attached to the bottom such as logs or plants. Periphyton are a complex matrix of algae and bacteria that are primary producers (see Aquatic Productivity, 4.5). Primary production forms the basis of the food chain and refers to the rate of biomass formation of organisms that photosynthesize. Periphyton use energy from the sun and nutrients for growth, and in turn, are fed upon by BMI and some fish. The BMI community is an assemblage of organisms, large enough to be seen by the unaided eye, that are involved in the recycling of nutrients and the decomposition of organic materials such as leaves, and thus facilitate the transfer of energy from organic matter resources to fish and other larger organisms (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990).

The littoral habitat of lakes, reservoirs, and large rivers is the bottom area along the shoreline where the level of light penetration is sufficient for photosynthesis (Wright and Szluha 1980; Wetzel 2001). This area usually supports larger and more diverse populations of periphyton and BMI than deeper water habitats (Wright and Szluha 1980; Ward 1992; Thorp and Covich 2001; Wetzel 2001). The vegetation and substrate heterogeneity of the littoral habitat provide an abundance of microhabitats supplying food and shelter, which in turn enhances invertebrate production (Wright and Szluha 1980; Gerritsen et al. 1998).

As described above, the varial zone typically encompasses some or all of the littoral zone. If the magnitude and frequency of water level fluctuations is low, the varial zone can be highly productive. However, as the magnitude and frequency of water level fluctuations increase, the abundance and diversity of periphyton and BMI is reduced in the varial zone (Fisher and LaVoy 1972; Ward 1992). Several studies have reported that load-following flow releases associated with hydropower production can substantially reduce the species diversity and abundance of periphyton and BMI both above and below hydropower projects (Brusven et al. 1974; Gislason

1985; Perry and Perry 1986; Troelstrup and Hergenrader 1990; Blinn et al. 1995; DeVries et al. 2001; Grzybkowska and Dukowska 2002) and within reservoirs subject to drawdown (Fillion 1967; Paterson and Fernando 1969; Kaster and Jacobi 1978; May et al. 1988; Chisholm et al. 1989; Furey et al. 2006).

Fisher and LaVoy (1972) examined BMI communities along a sand/gravel bar below a hydroelectric dam on the Connecticut River in Massachusetts. Fluctuations of approximately 3.3 feet at the bar completely submerged it during high flows, and exposed much of it during low flows. Four zones were established along a transect running from high (Zone 1, exposed 70 percent of the summer) to low (Zone 4, constantly submerged) water marks. Results indicated reduced diversity, biomass, densities, and taxa richness in Zones 1 and 2. Metric values and community compositions of Zone 4 did not differ significantly from Zone 3, which was exposed for 13 percent of the summer, suggesting that the benthic community established at those levels was adapted to brief exposure periods.

Blinn et al. (1995) determined that discharge fluctuations during the summer and winter influenced the benthic community in the Colorado River downstream of Glen Canyon Dam, Arizona. The annual mean biomass of macroinvertebrates in a continuously inundated section of the channel was more than four times the biomass of macroinvertebrates in the proximal varial zone. Algal communities showed a 50 percent reduction in biomass after two days of repeated 12-hour exposures, and more than 70 percent reductions in biomass after five days (Blinn et al. 1995). Gislason (1985) concluded that the effects of power peaking adversely influenced insect density along the margins of the Skagit River, Washington. Under fluctuating flows, insect density increased in the direction from shallow to deep water, and density decreased with increasing number of hours of dewatering prior to sampling. Diversity appeared to increase with water depth, and decrease with increased duration of dewatering.

Studies on the lower Flathead River have demonstrated that BMI production in the varial zone is severely limited due to daily dewatering (Perry and Perry 1986; Hauer and Stanford 1991; DeVries et al. 2001). DeVries et al. (2001) also found that benthic macroinvertebrate density and taxa richness in margin areas of the lower Flathead River was significantly lower relative to the community in mid-channel areas. The benthic fauna in margin areas contained a much higher percentage of snails, aquatic earthworms, and chironomids than mid-channel habitats. Chironomids and oligochaetes are often the taxa collected in significant numbers in these frequently exposed zones (Fisher and LaVoy 1972; Brusven et al. 1974; Gislason 1985; Perry and Perry 1986; Troelstrup and Hergenrader 1990; Blinn et al. 1995; DeVries et al. 2001; Grzybkowska and Dukowska 2002; Furey et al. 2006). These organisms are often able to survive or take advantage of water-level fluctuations by burrowing deep into the substrates (Fillion 1967; Paterson and Fernando 1969; Kaster and Jacobi 1978), or by possessing life history strategies that facilitate colonization of and survival in disturbed habitats such as varial zones (Furey et al. 2006).

Little fishery or limnological research had been conducted on Boundary Reservoir. Basic water quality and periphyton data were collected at the Metaline Falls Bridge and at the mouth of the Z Canyon in October 1962 by the Washington State Pollution Control Commission (Pine and Clemetson 1962 as cited in McLellan 2001). In 2000, the Washington Department of Fish and

Game (WDFG) conducted a baseline fisheries assessment of the reservoir and its tributaries that included, among other studies, periphyton and benthic macroinvertebrates sampling of the reservoir during a period from August through October (McLellan 2001). Periphyton was sampled during the late summer at two stations: in the forebay of Boundary Dam and at the Metaline Falls Bridge. Periphyton was sampled with two DuraSampler periphyton samplers floated at the reservoir surface at each station. Estimates of chlorophyll *a*, density, and bio-volume were made for each sample. Sixteen species of periphyton were identified from samples collected from Boundary Reservoir. Mean density of periphyton in Boundary Reservoir was estimated at 258/cm^2 (± 325), with higher densities at the Boundary Dam forebay. Mean biovolume of periphyton was 130 mm^3/cm^2 (± 143). McLellan (2001) found that periphyton production, according to periphyton chlorophyll *a* values, was greater than phytoplankton production.

Benthic macroinvertebrates were collected with Hester-Dendy round plate samplers (0.13m^2). A set of three samplers was placed in both the forebay of Boundary Dam and at the Metaline Falls Bridge. The samplers were deployed during two separate periods, designated as "summer" and "fall" samples, for 4–5 weeks per period. Samplers were dominated by cladoceran zooplankton, snails, and chironomid larvae during the two periods. McLellan (2001) concluded that secondary aquatic productivity of macroinvertebrates was relatively low in Boundary Reservoir compared to other northwest reservoirs and lakes. However, the study also cautioned that its conclusions were based on a limited number of macroinvertebrate samples from Boundary Reservoir.

Additional information on benthic macroinvertebrates has been collected upstream in the Pend Oreille River in Box Canyon Reservoir. During 1988, 1989, and 1990, quantitative BMI sampling was conducted in Box Canyon Reservoir using a Ponar dredge to collect three grabs in soft substrates at each of 11 study sites (Ashe and Scholz 1992). Samples were collected in March, April, June, July, September, and October during 1988 and 1989. In 1990, samples were only collected in April, July, and September. Chironomids were the most abundant organisms collected in benthic samples during all three years of the study (Ashe and Scholz 1992). Oligochaeta, Talitridae, and Sphaeriidae were also prominent organisms in the benthos during the study. Additional BMI sampling was conducted in the tributaries and sloughs of the Pend Oreille River within the Box Canyon Reservoir, as well as a feeding habits study for target fish species.

Proposed Methodology

In developing the proposed methodology for this study component, the following assumptions were made:

- Habitat conditions available within the Boundary Project area during the 2007 and 2008 study period may not represent the full range of conditions potentially available under alternative Boundary Project operational scenarios. In order to describe the response of periphyton and benthic macroinvertebrates to specific environmental conditions associated with the range of pool level fluctuations, biological surveys may need to be conducted upstream or downstream of Boundary Reservoir.

- A level of effort is described for planning purposes but details of the sampling program, including selection of specific sampling transects, timing, methodology, and data analysis procedures will be developed by the Technical Consultant in coordination with SCL and relicensing participants.

Development of the periphyton and benthic macroinvertebrate HSI for this study component encompasses the following six tasks:

Task 1) *Literature-based Benthic HSI Curves*. Develop literature-based draft HSI curves for BMI and periphyton communities. Because BMI and periphyton communities are comprised of numerous taxa, the HSI curves will be developed for commonly used benthic metrics (density, taxa richness-based measures, diversity, or dominant taxa) selected to summarize and describe the communities. Habitat suitability information will address BMI and periphyton responses to changes in depth, velocity, substrate, rates of colonization and frequency of inundation and dewatering. Potential sources of information include the Internet, university libraries, peer-reviewed periodicals, and government and industry technical reports. Special emphasis will be given to information obtained from similar hydrological systems (stream/reservoir size, geographic location, and project configuration and operation).

Task 2) *Benthic Communities on Hard Substrates*. Collect site-specific habitat suitability information for BMI and periphyton communities using artificial substrate sampling to approximate hard substrate surfaces for the colonization of BMI and periphyton. For planning purposes, artificial substrates for BMI sampling are assumed to consist of small rock baskets (e.g., Whitlock-Vibert boxes), and artificial substrates for periphyton sampling are assumed to consist of unglazed tiles. Artificial substrates will be preconditioned prior to deployment by being placed for 4 weeks in Boundary Reservoir and then air-dried. Where possible, sampling sites will be located along mainstem habitat transects measured for the Physical Aquatic Habitat Model Development study component described above. Each site will be sampled using paired "fixed" and "floating" sampling units. The floating sampling unit will consist of sets of three to five artificial substrate samplers suspended from a buoy at the water surface, with each sampling set deployed at incremental depths (e.g., every 5 feet) from just below the water surface to the euphotic depth (i.e., 3 times the Secchi depth). Artificial substrates for the "floating" units will maintain their respective depth positions regardless of Project operations, thereby describing the response of organisms in the absence of pool level fluctuations.

A second series of "fixed" sampling units will be installed either along the nearby shoreline or off a nearby vertical face, with each unit deployed at 5-foot depth increments ranging from full pool to the euphotic depth (Table 4.1-8) under maximum expected reservoir drawdown for the sample period. The sampling units will be in fixed positions, so some units will be dewatered and inundated repeatedly, thereby describing the response of organisms to fluctuating reservoir water surface elevations at that site. Sampling will be conducted at a site below Metaline Falls in either the Canyon Reach or Forebay

Reach to describe the response of BMI and periphyton to the effects of pool level fluctuations in that reach. Artificial substrate sampling will also be conducted at a site in the Upper Reservoir Reach to describe the response to a smaller range of pool level fluctuation. Artificial substrate sampling will take place during spring, summer, autumn, and winter for 8-week periods. For planning purposes, artificial substrates are assumed to be deployed on April 5, July 7, September 12 and December 8 and retrieved 8 weeks later on May 31, September 1, November 7 and February 2, respectively.

Refinements of the sampling strategy may be developed by the Technical Consultant in the first quarter of 2007 in coordination with SCL and relicensing participants, provided the refinements satisfy the primary sampling objectives. For instance, it may be more effective to add a "fixed" sample set to a site within the lower Box Canyon Reservoir to describe an environment associated with few pool level fluctuations instead of using "floating" sample sets.

Table 4.1-8. Estimated monthly euphotic depth of Boundary Reservoir based on Secchi disk readings and extrapolations of turbidity readings.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estimated Euphotic Depth (feet)	34.5	34.5	27.1	19.7	15.7*	16.7*	28.5*	44.3*	39.4*	34.5*	34.5	34.5

* Estimated euphotic depth based on three times the Secchi disk readings reported by McLellan (2001).

Task 3) *Benthic Communities on Soft Substrates*. Collect site-specific habitat suitability information for BMI and periphyton communities on soft substrates (i.e., fine sediments) using substrate-appropriate sampling methodologies to collect BMIs and periphyton. Sampling will be conducted at one site in either the Canyon Reach or Forebay Reach to describe the effects of pool level fluctuations in that reach, one site in the Upper Reservoir Reach to describe a smaller range of pool level fluctuation, and at one site within the lower Box Canyon Reservoir to describe the effects of a minimum pool level fluctuation scenario. Where possible, sampling sites in Boundary Reservoir will be located along mainstem habitat transects measured for the Physical Aquatic Habitat Model Development study component described above. Samples will be collected at incremental depths ranging from full pool to the euphotic depth under maximum expected reservoir drawdown for the sample period. Three to five soft substrate samples will be collected per depth strata on each shoreline.

Task 4) *Benthic Colonization Rates*. Conduct a field study to estimate potential BMI and periphyton colonization rates for different seasons within Boundary Reservoir. For summer and winter periods, sets of three to five preconditioned artificial substrates will be deployed incrementally for set periods of colonization time (e.g., 8, 6, 4, 2, and 1 weeks) and then pulled simultaneously

at the conclusion of the colonization period (see Table 4.1-9). Artificial substrates will be deployed at a set depth below a buoy, or at an elevation within the euphotic zone where they will remain wetted through the incubation period. Besides their use for HSI curve development, results of the colonization studies will also be used to adjust, if necessary, deployment times for artificial substrates in Task 3.

Table 4.1-9. Potential deployment and retrieval schedule for artificial substrates from selected sites during two seasonal periods of colonization.

Season	Colonization Period	Deployment Date	Retrieval Date
Summer	8 weeks	July 7	September 1
	6 weeks	July 21	September 1
	4 weeks	August 4	September 1
	2 weeks	August 18	September 1
	1 week	August 25	September 1
Winter	8 weeks	December 8	February 2
	6 weeks	December 22	February 2
	4 weeks	January 5	February 2
	2 weeks	January 19	February 2
	1 week	January 26	February 2

Task 5) *Validation of Benthic HSI Curves*. Develop a histogram (i.e., bar chart) for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of dewatering) using the site-specific field observations. The histogram developed using field observations will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling.

Task 6) *Finalize Benthic HSI Curves*. Convene a panel of relicensing participants and, if desired, regional experts (agency, tribal, industry and university researchers) to confirm HSI curves for each benthic metric. Using a roundtable discussion format, the panel members will review literature-based benthic community information and site-specific data to develop a final set of HSI curves. These curves will be used in the aquatic habitat modeling study to define the relationship between habitat quantity and quality for each of the selected benthic metrics under various operational scenarios.

Work Products

The final work product of this study effort will consist of HSI curves for target metrics for use in this Mainstem Aquatic Habitat Modeling Study and in the Tributary Delta Habitat Modeling Study (section 4.2). Information developed during this study effort will also be used to support the Aquatic Productivity Study (section 4.5). This study effort will produce two year-end draft reports. The first-year draft report will describe survey methods, results of 2007 efforts, and a discussion of recommendations for 2008 HSI sampling efforts. The second-year draft will describe survey methods and the results of 2007 and 2008 efforts. A final report will also be produced at the conclusion of the study.

Schedule

The schedule for development of periphyton and benthic macroinvertebrate HSI as part of this study component is shown in Table 4.1-10. During the first quarter of 2007, the Technical Consultant will make refinements to the study as needed, in coordination with SCL and relicensing participants. Research, sampling, and sample analysis will take place throughout the remainder of 2007, with a first draft report due by December 31, 2007. Sampling efforts will be completed by the first quarter of 2008, with continued analysis and research continuing through the third quarter. A second draft report will be produced by November 1, 2008 and a final report by December 15, 2008.

Table 4.1-10. Schedule for periphyton and benthic macroinvertebrate HSI development.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	------							
Develop literature-based HSI curves and periodicity		------	------					
Hard Substrate Sampling		▲▲	▲ ▲	▲▲	▲			
Soft Substrate Sampling		▲	▲	▲	▲			
Colonization Rate Study			▲▲▲	▲	▲▲			
Develop final HSI curves and periodicity							------	---
Data analysis and reporting		---	------	---●	-----	-----	-----	●--■

4.1.6. Composite Schedule

The schedule for completing all components of the Mainstem Aquatic Habitat Model is provided in Table 4.1-11.

Table 4.1-11. Schedule for development of all components of the Mainstem Aquatic Habitat Model.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	▬										
Habitat Mapping: LWD / macrophyte		▲▲	▲								
Mainstem Transect Selection		▬	▬▲								
Stakeholder Site Visit			▲▲▲								
Hydraulic Routing: data collection and reporting		▬	▬	▬●	▬	▬	▬■				
Hydraulic Routing: develop executable model			▬	▬							
HSI Fish, Macrophyte, Periphyton and BMI: Develop literature -based curves		▬	▬								
HSI Fish, Macrophyte, Periphyton and BMI: Field data collection	▬	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲				
HSI Fish, Macrophyte, Periphyton and BMI: Develop final curves/periodicity							▬	▬■			
Substrate and Vegetation Characterization			▲▲			▲▲▲					
Collect Velocities and depths			▲▲▲	▲▲▲		▲▲▲	▲▲▲				
Develop Varial Zone Model				▬	▬	▬	▬	▬			
Hydraulic Model Integration and Calibration							▬	▬			
Downramping Analysis								▬	▬	▬	
Habitat WUA								▬	▬	▬	
Alternate Scenario Post-Processing								▬	▬	▬	
Reporting				●				●		■	

4.1.7. Consistency with Generally Accepted Scientific Practice

Habitat Mapping. Studies regarding habitat mapping and the distribution and abundance of aquatic macrophytes and large woody debris are commonly conducted at many hydroelectric projects as part of FERC licensing (e.g., Watershed GeoDynamics 2005, R2 Resource Consultants 2003, R2 Resource Consultants 2004). Mapping surveys will utilize protocols similar to those performed at other hydroelectric projects. Aquatic mapping data collection efforts will follow Ecology identification manuals (Ecology 2001).

Hydraulic Routing. One-dimensional unsteady flow hydraulic models are commonly used to route flow and stage fluctuations through rivers and reservoirs. Examples of public-domain computer models used to perform these types of processes include FEQ (USGS 1997), FLDWAV (U.S. National Weather Service 1998), UNET (U.S. Army Corps of Engineers 2001), and HEC-RAS (U.S. Army Corps of Engineers 2002a, 2002b, and 2002c). The HEC-RAS model has proven to be very robust under mixed flow conditions (subcritical and supercritical), as will be expected in the vicinity of Metaline Falls of the Pend Oreille River. The HEC-RAS model also has the capability of automatically varying Manning's "n" with stage through the use of the equivalent roughness option. Another feature of HEC-RAS is the capability of varying Manning's "n" on a seasonal basis. The need for this capability may arise in reaches of the Pend Oreille River where macrophytes grow during the summer and then die off during the rest of the year. The robust performance and flexibility of HEC-RAS make this model the appropriate choice for routing stage fluctuations through Boundary Reservoir from the forebay of Boundary Dam to Box Canyon Dam.

Mainstem Aquatic Habitat Model Development. Physical habitat models are often used to evaluate alternative instream flow regimes in rivers (e.g., the Physical Habitat Simulation [PHABSIM] modeling approach developed by the U.S. Geological Survey; Waddle 2001). The proposed approach for assessing the effects of different operational scenarios on habitat in the mainstem is analogous to the PHABSIM approach in that hydraulic modeling is translated to indices of habitat availability using HSI curves. Indeed, many of the HSI curves to be used in the proposed study will be drawn directly from, or modified from, HSI curves used in the PHABSIM approach. One of the major differences between PHABSIM and the proposed approach is the implementation of hydraulic models to quantify the magnitude, frequency and duration of reservoir water surface elevation fluctuations. The proposed study uses HEC-RAS and tributary flow modeling to obtain water depths and velocities, which is more appropriate for the hydraulic conditions in the study area, while PHABSIM uses a variety of water surface elevation and hydraulic simulation programs more appropriate for modeling riverine flow conditions. The proposed modeling approach is consistent with the use of physical habitat models used at other hydroelectric projects to assess the effects of alternative operational scenarios on aquatic habitat.

HSI Development. HSI curves have been utilized by natural resources scientists for over two decades to assess the effects of habitat changes on biota. HSI curves were developed by the USFWS for use with fish and wildlife (see http://www.nwrc.usgs.gov/wdb/pub/hsi), but their usage has also included periphyton and wetland tree habitats (e.g., Tarboton et al. 2004). The proposed method for the development and verification of HSI curves is analogous to the methods described for fish in Bovee (1986) and USFWS (1981). Aquatic plant data collection efforts will follow Washington State sampling protocols and identification manuals (Parsons 2001; Ecology 2001). The sampling devices proposed for collecting BMI are consistent with the devices described in Rabeni (1996). Artificial substrates (Hester-Dendy multi-plate samplers) were used previously in Boundary Reservoir by McLellan (2001). The proposed fish sampling and observation methods are consistent with those described in Murphy and Willis (1996). The proposed use of and expert panel to develop and verify fish, macrophyte, periphyton and benthic macroinvertebrate HSI curves is modified from that described by Crance (1987).

4.1.8. Consultation with Agencies, Tribes, and Other Stakeholders

Input regarding the Mainstem Aquatic Habitat Modeling Study was provided by relicensing participants during workgroup meetings. Workgroup meetings were held in Spokane, Washington, on May 23, 2006, and August 14, 2006, and in Metaline Falls, Washington, on June 27, 2006. During the May workgroup meeting, outlines for the development of Aquatic Habitat Modeling, the Fish HSI, and Macrophyte HSI components of the study plan were presented and discussed with relicensing participants. At the June workgroup meeting, the Habitat Mapping and Periphyton and Benthic Macroinvertebrate study components were presented and discussed with relicensing participants. At the August workgroup meeting, an overview of the aquatic habitat modeling study was presented and discussed with relicensing participants. The proposed Aquatic Habitat Modeling study plan was developed from the outline and relicensing participant comments. Comments provided by relicensing participants on the review outlines for this study plan are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Mainstem Aquatic Habitat Modeling outline and the various HSI study components presented at the workgroup meetings. WDFW provided additional comments on the periphyton and benthic macroinvertebrate aspect of habitat suitability information in a letter to SCL dated August 28, 2006 (included in Attachment 4-1). In this letter, WDFW requested that the number of sample sites be increased to adequately characterize and account for the variability in substrate types and water velocities found in the range of habitats available in Boundary Reservoir. As described in the study plan, paired samples of fixed and float-suspended artificial substrates are proposed to isolate and identify the effects of pool level fluctuations on periphyton and benthic macroinvertebrates. SCL understands that there may be differences in the response of organisms depending on the substrate type and water velocity, but believes that the proposed sampling program is sufficient to support development of HSI curves. The HSI curves will be used as part of the mainstem habitat modeling effort to calculate an index of the effects of Project operations on periphyton and benthic macroinvertebrates. The HSI information will not be used to calculate productivity, which will be addressed in the Aquatic Productivity Study (see section 4.5).

In its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), the USFS submitted a request for a study titled Effects of Current Operations (Ramping) and Alternative Operations on Aquatic Habitat and Biota. In this letter, the USFS requested that a model utilizing habitat suitability curves be developed to quantify the amount of habitat available to salmonids at full pool versus various stages of reservoir drawdown. They also requested that areas presenting a risk of stranding and trapping be surveyed following downramp events, and substrate sampling occur at 1-hour, 2-hour, 4-hour and 8-hour intervals from the start of a downramp event. SCL's proposed mainstem aquatic habitat model, as described in this study plan, was designed to provide the information requested by the USFS. Surveys of areas presenting a risk of stranding/trapping are proposed prior to and following a downramp event in Task 4 of the HSI:Fish study component, and analyses of substrates are designed for hourly intervals. In a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the proposed aquatic habitat modeling and ramping rate study outlines presented at the workgroup meetings and that the hourly intervals were provided as an example

rather than an explicit study request. As noted in the proposed study plan, additional implementation details of the study components will be developed in early 2007 when the Technical Consultant finalizes the study design, in coordination with SCL and relicensing participants.

In its August 31, 2006, PAD/Scoping comments, the USFS also submitted a request for an Aquatic Plant Management Control Study. SCL is not proposing to conduct this requested study, as explained in section 3.6. However, the Mainstem Aquatic Habitat Modeling Study will provide information on the expected distribution and abundance of aquatic macrophytes under alternative Project operational scenarios. Alternative Project operations to be evaluated may include scenarios designed to control the growth of aquatic macrophytes through reservoir drawdown. The results of these analyses will be used in development of an Aquatic Macrophyte Management Plan that SCL will submit as part of its Application for 401 Water Quality Certification with the Washington Department of Ecology.

4.1.9. Progress Reports, Information Sharing, and Technical Review

Relicensing participants will have opportunities for study coordination through regularly scheduled meetings, reports and, as needed, technical subcommittee meetings. Reports are planned for preparation at the end of 2007 and 2008 for each of the Mainstem Aquatic Habitat Model study components. Relicensing participants will have the opportunity to review and comment on these reports. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with agencies, tribes, and other stakeholders to discuss the study results, as described in section 1.2.4 of this document. Relicensing participants will also have the option to participate in site visits during transect selection and participate on panels as part of the HSI curve development process. Workgroup meetings are planned to occur on a quarterly basis, and workgroup subcommittees will meet or have teleconferences as needed.

4.1.10. Anticipated Level of Effort and Cost

Habitat Mapping. Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $100,000 to $140,000; estimated study costs are subject to review and revision as additional details are developed. To obtain efficiencies in the overall relicensing work effort, portions of this study will be conducted in conjunction with the Large Wood Management Study (section 4.4).

Hydraulic Routing. The estimated cost to implement this effort and develop a routing model of the Pend Oreille River from Seven Mile Dam to Box Canyon Dam ranges from $160,000 to $200,000; estimated study costs are subject to review and revision as additional details are developed. This level of effort assumes that adequate bathymetric and LIDAR data are available.

Physical Habitat Model Development. Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $500,000 to $575,000. Estimated study costs do not include habitat mapping, development of the hydraulic routing model, HSI information, or development

and processing of Scenario Tool output. Estimated study costs are subject to review and revision as additional details are developed.

Fish HSI Development. Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $80,000 to $120,000. The majority of the field survey efforts will be conducted under the Fish Distribution, Timing and Abundance Study (section 4.3).

Macrophyte HSI Development. Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $72,000 to $108,000.

Periphyton and Benthic Macroinvertebrates HSI Development. Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $160,000 to $240,000. Estimated study costs are subject to review and revision as additional details are developed.

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4.2. Sediment Transport and Boundary Reservoir Tributary Delta Habitats

Deltas are depositional features that form where flowing water, such as tributary streams, enter a static water body such as a lake or reservoir. Where tributary streams enter a flowing body of water, such as a larger river, sediments may be deposited at the confluence, forming a delta, or the tributary sediments may be transported downstream by mainstem river currents. The proportion of tributary sediments that is deposited as a delta or transported downstream is influenced by the volume and particle size distribution of the sediments, tributary and mainstem river flows and, in the case of the Boundary Project, the water surface elevation of the reservoir.

Tributary deltas are transition areas between the tributaries and reservoir that, depending upon their physical characteristics, provide a variety of ecological functions. Fish may congregate at the tributary confluence to feed on aquatic organisms transported downstream in the tributary flow, may use the deltas as temperature refugia, or may stage in delta habitats prior to spawning runs; fry and juvenile fish may rear in complex habitats associated with the deltas; and the influx of tributary water may provide protection from dewatering associated with reservoir pool level fluctuations. Physical characteristics that influence these functions include water depth, velocity and temperature; substrate size; cover (large woody debris and other structures); nutrients in the form of leaf and needle litter; and the frequency and magnitude of disturbance.

There are 28 tributaries that drain to Boundary Reservoir (Table 4.2-1); including 13 unnamed drainages. Most of the tributaries are very small, and may not contain measurable surface flow during late summer months. However, some tributaries to the Boundary Reservoir represent potential year-round habitat for native salmonids. Portions of tributary deltas may also be present in the varial zone, and therefore are potentially affected by fluctuations in pool levels. This study examines the potential effects of Project operations on the quantity and quality of tributary delta habitat and potential changes in tributary delta morphology under future Project operations. Because they represent potential high aquatic resource value areas and have a source of inflow separate from the mainstem Pend Oreille River, the delta areas of major tributaries will require a modeling approach specific to their physical characteristics.

This study complements, but is separate from, the Mainstem Aquatic Habitat Modeling Study described in section 4.1. Three interrelated modeling components are needed to evaluate the effects of Boundary Project operations on delta habitats. Physical habitat modeling of major tributary deltas, analogous to the mainstem aquatic habitat model described in section 4.1, will translate depth, velocity, substrate, and cover suitability indices to estimates of weighted usable area (WUA). The latter two sediment modeling exercises are needed to determine if, and how, tributary delta morphology might change over the potential 50-year term of a new FERC license for the Project.

Table 4.2-1. Adfluvial habitat and known sport fish present in tributaries that drain into Boundary Reservoir.

Stream Name	Pend Oreille River Mile	Length of Adfluvial Habitat (Feet)	Known Sport Fish Present[1]
Unnamed No. 1	18.1	82[2]	
Pewee Creek	19.0	0[3]	CTT, EBT
Unnamed No. 2	19.1	129[2]	
Lime Creek	20.5	6,746[3]	EBT
Everett Creek	22.8	60[2]	
Whiskey Gulch	22.9	547[2]	
Slate Creek	23.1	3,474[3]	EBT, CTT, RBT
Beaver Creek	25.2	0[3]	
Threemile Creek	25.2	0[3]	EBT, RBT
Unnamed No. 3	26.4	58[2]	
Flume Creek	26.8	1,626[3]	EBT
Sullivan Creek	27.9	21,729[3]	EBT, CTT, RBT, MWF, BNT, BLT, KOK, BBT
Unnamed No. 4	28.1	77[2]	
Linton Creek	28.5	19,159[2]	
Unnamed No. 5	28.9	130[2]	
Unnamed No. 6	29.1	955[2]	
Pocahontas Creek	29.5	16,480[2]	
Unnamed No. 7	29.7	53[2]	
Unnamed No. 8	31.3	66[2]	
Wolf Creek	31.4	236[2]	
Sweet Creek\Lunch Creek	32.0	3,202[3]	EBT, CTT, RBT, MWF, BNT, BLT
Unnamed No. 9	32.3	67[2]	
Sand Creek	32.6	1,498[3]	EBT, CTT, RBT
Lost Creek	33.1	165[2]	CTT
Unnamed No. 10	33.6	99[2]	
Unnamed No. 11	33.8	78[2]	
Unnamed No. 12	34.1	102[2]	
Unnamed No. 13	34.5	4,184[2]	

Notes:

1 Blanks indicate nonfish-bearing stream or not surveyed. EBT=eastern brook trout; CTT= cutthroat trout; RBT= rainbow trout; MWF= mountain whitefish; BNT= brown trout; BLT= bull trout; KOK= kokanee; BBT= burbot. Sources: USFS (2005d); McLellan (2001); FERC (1998).

2 The length of adfluvial habitat is the distance from the mouth of the stream to the lowermost stream segment in the Salmonscape Geographic Information System (WDFW 2002) with a gradient greater than 20% and does not consider the quality of the adfluvial habitat for sustaining fish.

3 The length of adfluvial habitat is the distance from the mouth of the stream to the lowermost migration barrier identified by McLellan (2001) and does not consider the quality of the adfluvial habitat for sustaining fish.

4.2.1. Nexus Between Project Operations and Effects on Resources

The Boundary Project is operated with a load-following strategy that results in daily fluctuations in pool level, as described in section 1.3.5 of this PSP. As noted in section 1.3.5, the change in bathymetry and narrowing of the Pend Oreille River at the Metaline Fall hydraulic feature may result in significant differences in both the range of daily water surface fluctuations and the rate of change above and below Metaline Falls (i.e., range and rate both appear to be reduced above as compared to below Metaline Falls).

Tributary deltas generally form in shallow shoreline areas if the local reservoir sediment transport capacity is insufficient to mobilize sediment delivered from the tributary. Portions of tributary deltas could occur within the varial zone, which ranges between the minimum and maximum pool level. Project operations have the potential to affect the morphology of tributary deltas primarily within the Boundary Reservoir drawdown zone. These potential effects may have related effects on the quality and quantity of tributary delta habitats.

4.2.2. Agency Resource Management Goals

A description of relevant agency management goals is provided in the Mainstem Aquatic Habitat Modeling Study (see section 4.1.2).

4.2.3. Study Goals and Objectives

The goal of this study is to evaluate the effects of Project operations on aquatic habitats in the deltas of major tributary streams within the Boundary Reservoir drawdown zone. The objectives of the study are to: 1) collect physical and hydraulic site information; 2) evaluate changes in delta morphology and characteristics over the potential term of the new FERC license; 3) develop models of delta habitats at the mouths of major tributaries that reflect potential changes in delta morphology; and 4) prepare quantitative comparisons of delta fish habitats under alternative operational scenarios.

4.2.4. Need for Study

Summary of Existing Information

Very little information is available regarding the physical characteristics of tributary deltas in Boundary Reservoir. Fish surveys have suggested that some tributary deltas (e.g., Slate Creek) may provide thermal refugia for native salmonids when mainstem river temperatures become too warm. Aerial photography suggests that some of the tributaries have readily identifiable deltas (e.g., Sullivan Creek and Sweet Creek) while others deposit tributary sediments into deep portions of the reservoir or do not transport sufficient sediment to the mouth of the tributary to develop a delta. Scour and deposition in the mainstem may also affect the development of deltas at the mouth of tributaries.

In preparation for relicensing studies, SCL has obtained high-resolution topographic and bathymetric data for Boundary Reservoir and its vicinity. This information will be critical for identifying and selecting potential transects to describe delta habitats in the proposed study.

Need for Additional Information

Information on the type of aquatic habitats available within deltas located at tributary mouths is needed to evaluate the effects of Boundary Project operations on these potential high resource value habitats. As noted, this study is separate from, but complementary to, the Mainstem Aquatic Habitat Model Study (4.1).

4.2.5. Detailed Description of Study

Study Area

The study area encompasses delta areas and the lower reaches of major tributaries draining to Boundary Reservoir. For planning purposes, it is assumed that six to eight tributaries will be studied in detail; these include Sand Creek, Sweet Creek, Sullivan Creek, Slate Creek (Washington), Flume Creek, and Pewee Creek. Final selection of tributary deltas to be studied will occur in coordination with relicensing participants.

Description of Study Components

This study includes three interrelated components: Tributary Delta Habitat Modeling, Tributary Delta Sediment Processes, and Mainstem Sediment Transport.

Tributary Delta Habitat Modeling

The size and morphology of a tributary delta and its importance as aquatic habitat over the duration of the new FERC license depends upon a number of factors. Among these, some of the more important include:

- the volume and size distribution of sediment transported by the tributary to its mouth;
- the capacity of the tributary to transport sediment to its mouth;
- the reservoir bathymetry at the tributary mouth;
- the capacity of the mainstem Pend Oreille River to transport sediment delivered by the tributary;
- Boundary Project Operations that affect mainstem sediment transport capacity; and
- fish species and life stage habitat response to water depth, velocity, and substrate.

This study component proposes a physical habitat modeling approach supported by field measurements of physical characteristics at selected tributary mouths and deltas. A conceptual work plan for the study is provided in Figure 4.2-1. Three important parameters in the habitat models will be water depth, water velocity, and substrate composition. Consequently, potential changes in delta morphology need to be addressed during model development. As described below in more detail, the study efforts will characterize tributaries based on the size of the delta and potential effects of Project operations on changes in delta morphology over the potential 50-year license term. Tributaries will be categorized by type based on the following characteristics:

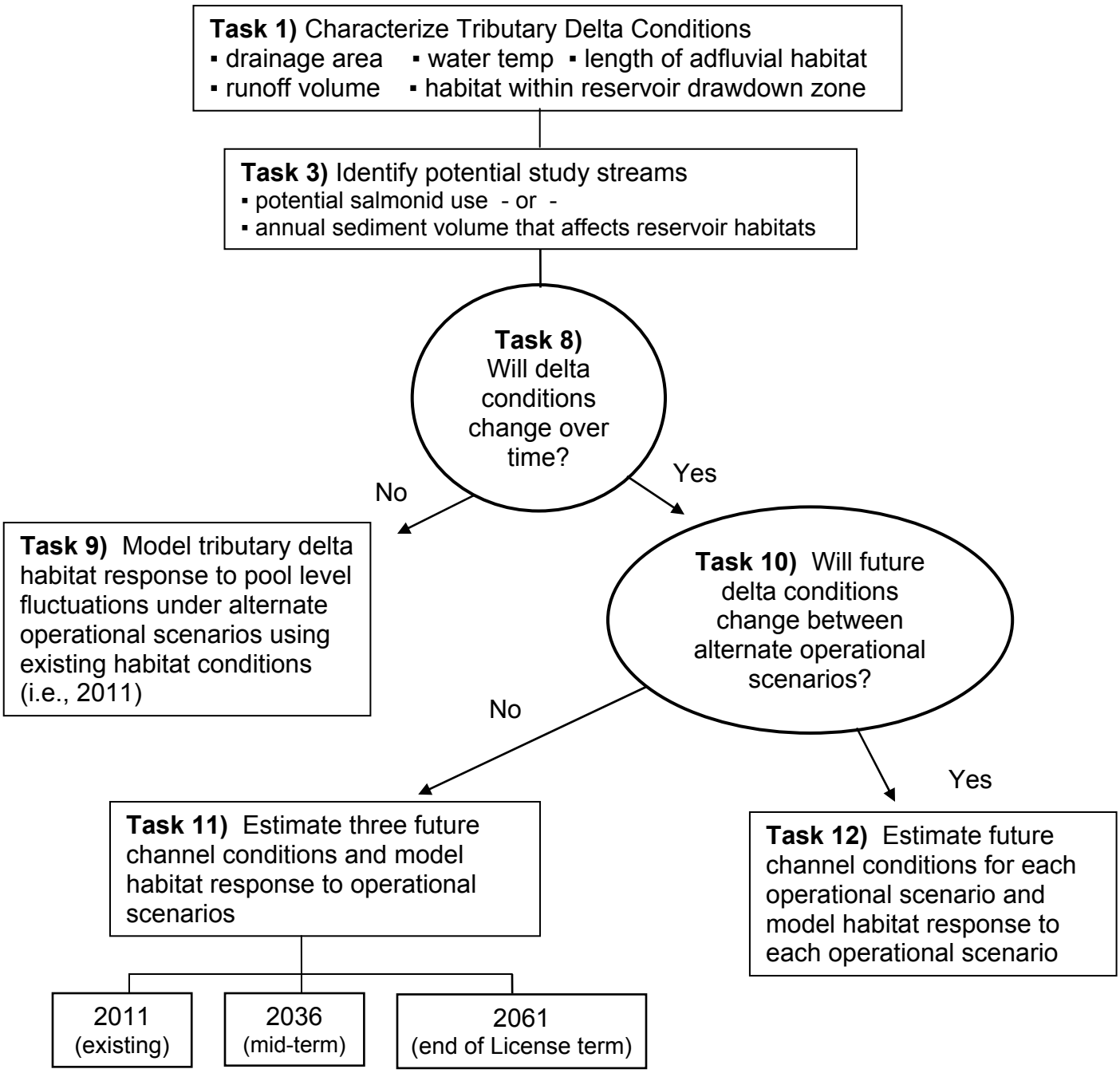

Figure 4.2-1. Conceptual work plan for tributary delta habitats in the Boundary Reservoir drawdown zone. Numeral designations refer to tasks described in the study methodology.

Type 1) Tributaries that do not have significant deltas, or where tributary sediments are deposited well below the reservoir water level fluctuation zone (these will be dropped from further study because there is no effect by Project operations);

Type 2) Tributaries that have significant deltas, but the existing size and morphology is not expected to change substantially over the term of a new FERC license;

Type 3) Tributaries that have significant deltas that are expected to change substantially over the course a new FERC license, but these changes are independent of operational scenario; and

Type 4) Tributaries that have significant deltas that are expected to change substantially over the course of a new FERC license, and these changes are influenced by alternative operational scenarios.

The work effort for this study component has been divided into 13 tasks. Tasks 4, 9, and 11 are decision points for categorizing tributaries into one of the four types based upon the results of preceding tasks. The physical habitat model development tasks (Tasks 10, 12, and 13) will vary depending on the tributary type. Tasks 1 includes the analysis of effects of alternative operational scenarios on tributary habitats, which will be conducted in 2009 as part of an overall Mainstem Habitat Modeling and Scenarios Analysis.

Several assumptions were identified during development of the proposed methodology. If the assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- Bathymetry will be available for Boundary Reservoir.
- Topographic maps and/or GIS coverage will be available for all tributary watersheds.
- Tributary flow records will be available from the U.S. Geological Survey, or will be synthesized as part of the Mainstem Sediment Transport study component.
- The Scenario Tool will be used to determine effects of various operating scenarios on hourly water surface elevations in the Boundary Reservoir forebay.
- A hydraulic unsteady flow model will be developed to translate hourly reservoir water surface elevations to the tributary mouths (see Hydraulic Routing Model study component of the Mainstem Aquatic Habitat Modeling Study, 4.1)
- Information on fish use of habitats at tributary mouths will be developed as part of the Fish Distribution, Timing and Abundance Study (4.3).

Proposed Methodology

The 13 tasks for the Tributary Delta Habitat Modeling study component are described in more detail below.

Task 1) Characterize Tributary Delta Conditions

Characterize the following hydrologic and physical conditions of tributaries draining to Boundary Reservoir:

- Drainage Area — Based upon available watershed topography (GIS or maps).
- Runoff volume — see Mainstem Sediment Transport study component.
- Water temperature — Based upon existing available data and supplemented by ongoing monitoring efforts.
- Drawdown zone habitat length — Based upon bathymetric maps and aerial photos, estimate the drawdown zone habitat length at each confluence with Boundary Reservoir.
- Length of adfluvial fish habitat — Based upon available existing information.

Task 2) Tributary Delta Reconnaissance

General. Conduct a reconnaissance-level site visit to each tributary delta. Visually assess the morphological conditions at each tributary confluence with Boundary Reservoir including any observations of fish use, macrophyte growth, substrate types, large woody debris and other structures associated with potential fish use of the area. Photograph each tributary mouth and delta from at least three common viewpoints.

Cultural Resource Features. The Cultural Resources Workgroup noted that a correlation has been observed between certain topographic features and the potential for prehistoric archaeological deposits (e.g., prehistoric weirs and Native American fishing features). During the reconnaissance of the tributary deltas, researchers will observe and record the presence of any of the following features:

- *Fire-cracked rock (FCR)* — Should researchers, in the examination of parallel sloughs, identify an interior perpendicular "barb" that cannot be accounted for by natural landform development processes, the survey team shall examine the inundated margins of the barb for any indication of cultural deposits (e.g., fire-cracked rock [FCR]). Fire-cracked rock can be readily identified and differentiated from naturally occurring gravel substrates in the Pend Oreille valley in that it typically has at least one, more typically three, angular and crenulated facet(s) in an environment where naturally deposited gravels should have a water smooth and rounded cross sectional profile. The site of these observations and collections shall be marked on aerial photographs and the GPS coordinates will be recorded and provided to the Cultural Resources Workgroup. A simple description of the observations will also be recorded at the time of such discoveries; each description will include the relative density of FCR (estimate number of rocks per square meter) and best estimate of the FCR scatter's size in both length and width.
- *FCR clusters* — Should clusters of FCR, on either the out-board or in-board meander scars in inundated tributary alluvial fans, be observed within the margins of the tributary's main channel, the survey team is to make notation of their presence, estimate their relative density, and provide an estimate of their dimensions. These

observations are to be marked on aerial photographs and the GPS coordinates recorded and the data provided to the Cultural Resources Workgroup.

Task 3) Identify Potential Study Streams

Use the results from Tasks 1, 2, and tributary sediment yield and flow estimates from the Mainstem Sediment Transport study component to identify study streams that provide potential high value aquatic resource values, or that potentially contribute sufficient sediment volume to affect reservoir habitats. Tributaries that enter the reservoir where the shoreline water depth is deep enough to fully submerge the delta sediment deposits under all Project operations may be eliminated from further analyses. Final selection of tributaries to be modeled using site-specific data will be coordinated with relicensing participants.

Task 4) Delta Water Temperature Monitoring

During the summer and early fall of 2007 and 2008, deploy anchored thermographs along the bed of the thalweg of selected tributaries to assess the effects of fluctuating reservoir pool levels on tributary water temperatures. Locations should include one in the tributary upstream of the reservoir fluctuation zone, one in the mainstem Pend Oreille River, and one to three locations in the varial zone. Use a constant reading temperature and depth probe during deployment of temperature recorders to identify suitable locations. Record these locations relative to the longitudinal profile of the tributary delta. Prior to deployment, the temperature recorders will be calibrated according to the manufacturer's specifications, and for verification, calibration curves will be developed using a certified thermometer over the range of water temperature expected in the field (about 10–25°C). Recording intervals should be set to every 30 minutes or less. Water temperatures will be recorded during July through October 2007; the thermographs will be inspected and the data will be downloaded each month.

Task 5) Physical Habitat Data Collection

Collect physical habitat data along longitudinal and cross-sectional transects, to be located in the lower reaches and deltas of the selected representative tributaries, as follows:

- Identify the sediment deposition zone from the tributary and collect a longitudinal bottom profile along the thalweg from the lowest pool elevation to at least two times the stream bankfull width above the deposition zone (except Pewee Creek, where if included in the study, data will only be collected in the deposition zone).
- Collect cross-sectional information perpendicular to the tributary and delta stream course to describe physical and hydraulic conditions upstream, within, and if applicable, downstream of the sediment deposition zone extending to the low reservoir pool water surface elevation. Tributary deposition zones are expected to begin upstream of the full pool water surface elevation but may not extend down to the water surface elevation at the low reservoir drawdown levels. Transect selection will be coordinated with the relicensing participants; however, for planning purposes, it is assumed that 8 to 14 transects will be established, including the following locations:

  - tributary channel between the lowermost end of the deposition zone and the low reservoir pool water surface elevation (2–3 transects depending on length and complexity of the channel);
  - lowermost end of the deposition zone (1 transect);
  - within the deposition zone (2–5 transects);
  - uppermost end of the deposition zone (1 transect); and
  - upstream of the deposition zone extending into the tributary channel (2–4 transects).
- Each cross-sectional transect in the depositional zone should be a minimum of two bankfull widths in length or the width of the depositional zone, whichever is longer, while those upstream of the depositional zone should be a minimum of one bankfull width. Information to be collected at the highest available tributary flow under low reservoir pool level conditions includes:
  - bed profile (all elevations to be tied into a common benchmark with a known elevation);
  - crossing location from the longitudinal transect;
  - Wolman pebble count (minimum of 100 particles);
  - mean column water velocity, water surface elevation, and flow direction relative to the transect alignment at each vertical (minimum of 20 verticals per transect);
  - embeddedness at three locations along each transect (25 percent, 50 percent, and 75 percent of transect);
  - macrophyte density;
  - substrate; and
  - cover (for fish).
- The flow at each tributary will be measured at one transect and water surface elevations measured at all transects under medium and low tributary flow conditions when the reservoir pool level is low.
- Identify, measure (including base elevation), and describe any large woody debris or other structures that could affect localized scour during periods when the Boundary Reservoir pool level is at a lower elevation.
- Photo-document measured transects and structures observed.

Task 6) Future Tributary Sediment Supply

The sediment supplied by each tributary to the delta will be determined as part of Task 2 of the Mainstem Sediment Transport component of this study. A time series of daily sediment supply will be determined on a grain-size specific basis for each tributary for the time period from 1987 to 2004 (considered representative of long-term future hydrologic conditions).

Task 7) Mainstem Sediment Transport Capacity

Use the HEC-RAS model developed for the Pend Oreille River (as part of the Hydraulic Routing Model component of the Mainstem Aquatic Habitat Modeling Study, described in section 4.1) to determine the hydraulic transport capacity of the mainstem to transport sediment from the toe of the tributary delta. Each tributary delta will grow until some balance is reached between the sediment delivered by the tributary and the capacity of the mainstem to transport sediment from the toe of the tributary delta. The timeline for this balance to be reached will be estimated for each tributary.

Task 8) Identify Type 2 Tributaries

Identify whether the size and morphology of each tributary delta within the reservoir drawdown zone are expected to change over the next 50 years (potential term of a new license) (see Figure 4.2-1). Tributaries that are not expected to change are Type 2 Tributaries (see the Tributary Delta Sediment Processes component of this study).

Task 9) Develop Type 2 Physical Habitat Models

If tributary delta conditions within the reservoir drawdown zone are not expected to change over the next 50 years, construct a transect-based habitat model to evaluate effects of alternative Project operational scenarios (e.g., Scenario 1, Scenario 2, etc.) on tributary habitats within the reservoir drawdown zone (Figure 4.2-1) (one multi-transect-based model per tributary to characterize effects of alternative operational scenarios on aquatic habitats). For each model, the following steps will be taken:

- Translate changes in water surface elevation at each of the measured delta habitat transects into changes in depth, velocity, substrate, and cover.
- Use Habitat Suitability Index (HSI) curves developed for species and lifestages of interest to translate changes in hydraulic conditions to indices of habitat suitability (see Mainstem Aquatic Habitat Modeling Study, 4.1).
- Using the longitudinal profile of the tributary delta, identify any potential barriers to fish migration.
- As the reservoir pool level rises, tributary delta habitats will be inundated, transforming stream habitat into reservoir habitat. The analysis of hourly reservoir water surface elevations produced by the Hydraulic Routing Model component (4.1) will allow the change in habitats to be quantified and the results used to evaluate fluctuations in reservoir pool levels.

Task 10) Identify Type 3 and 4 Tributaries

If the size and morphology of the tributary delta are expected to significantly change over the potential 50-year term of a new license (i.e., net aggradation or degradation), identify whether the size and morphology is expected to change in response to alternative operational scenarios. Seasonal flow records from the Salmo River indicate that high flows (and tributary sediment transport) typically occur during the snowmelt season (May and June). The forebay in Boundary Reservoir is typically maintained at or near full pool level when there are high flows during May

and June; thus, changes in tributary delta morphology may occur over time but may not be influenced by alternative operational scenarios (see Figure 4.2-1). If morphological changes in a tributary delta are expected to be the same under each alternative operational scenario, it is considered to be a Type 3 delta with model development occurring under Task 12. Type 3 deltas will be identified as part of Task 2 of the Delta Sediment Processes component of this study. Alternatively, if changes in tributary delta morphology are scenario-specific, the tributary delta is considered a Type 4 delta and model development will occur under Task 13.

Task 11) Develop Type 3 Physical Habitat Models

If changes in tributary delta morphology are not operation scenario-specific, construct a transect-based habitat model for each target tributary for three time periods: existing, mid-license term (i.e., 2036) and end of the potential new license period (i.e., 2061). One transect-based model per tributary per time period (each with a different delta morphology) will be developed to characterize effects of each alternative operational scenario for a total of three transect-based models per tributary (Table 4.2-2). Similar to the Type 2 tributaries, each of the three models per tributary will translate changes in water surface elevation at each of the measured delta habitat transects into changes in depth, velocity, substrate, and cover, and use HSI curves to translate changes in hydraulic conditions to indices of habitat suitability.

Table 4.2-2. Number of habitat models needed per tributary delta for each of the four types.

Tributary Type	Description	Number of Models per Tributary
Type 1	No significant delta present, or delta is below minimum reservoir pool water surface elevation	Not modeled[1]
Type 2	Delta morphology not expected to significantly change over next 50 years	1
Type 3	Delta morphology expected to change, but delta morphology is not significantly influenced by alternative operational scenarios	3 Models[2]
Type 4	Delta morphology expected to change, and delta morphology will be significantly influenced by alternative operational scenarios	Up to 3 Models[2] per operational scenario

Notes:

1 Dropped from detailed study

2 Separate models developed to describe morphology anticipated in Year 2011, 2036, and 2061.

Task 12) Develop Type 4 Physical Habitat Models

If the size and morphology of the tributary delta (deposition zone) are expected to significantly change over the next 50 years and alternative operational scenarios are expected to affect the size and shape of tributary morphology, a transect-based habitat model will be constructed for each target tributary under existing, mid-license term (i.e., 2036) and end of the potential new license period (i.e., 2061) for each scenario, resulting in three transect-based models being constructed for each scenario and tributary (Table 4.2-2). Similar to the Type 2 tributaries, each of the three models per tributary per scenario will translate changes in water surface elevation at each of the

measured delta habitat transects into changes in depth, velocity, substrate, and cover, and use HSI curves to translate changes in hydraulic conditions to indices of habitat suitability.

Task 13) Run Physical Habitat Models

Evaluate the response of tributary habitat conditions to alternative operational scenarios. Use the Scenario Tool (see section 1.4.3) to predict Boundary forebay water surface elevations under alternative operational scenarios. The mainstem hydraulics routing model will then be used to translate those water surface elevations to water surface elevations at each tributary mouth. The tributary habitat models will then be used to evaluate changes in habitat conditions under each scenario (Figure 4.2-2).

Analysis of effects of alternative operational scenarios on tributary habitats will be conducted in 2009 as part of the Scenarios Analysis and in combination with analysis of the Mainstem Aquatic Habitat Modeling Study (section 4.1).

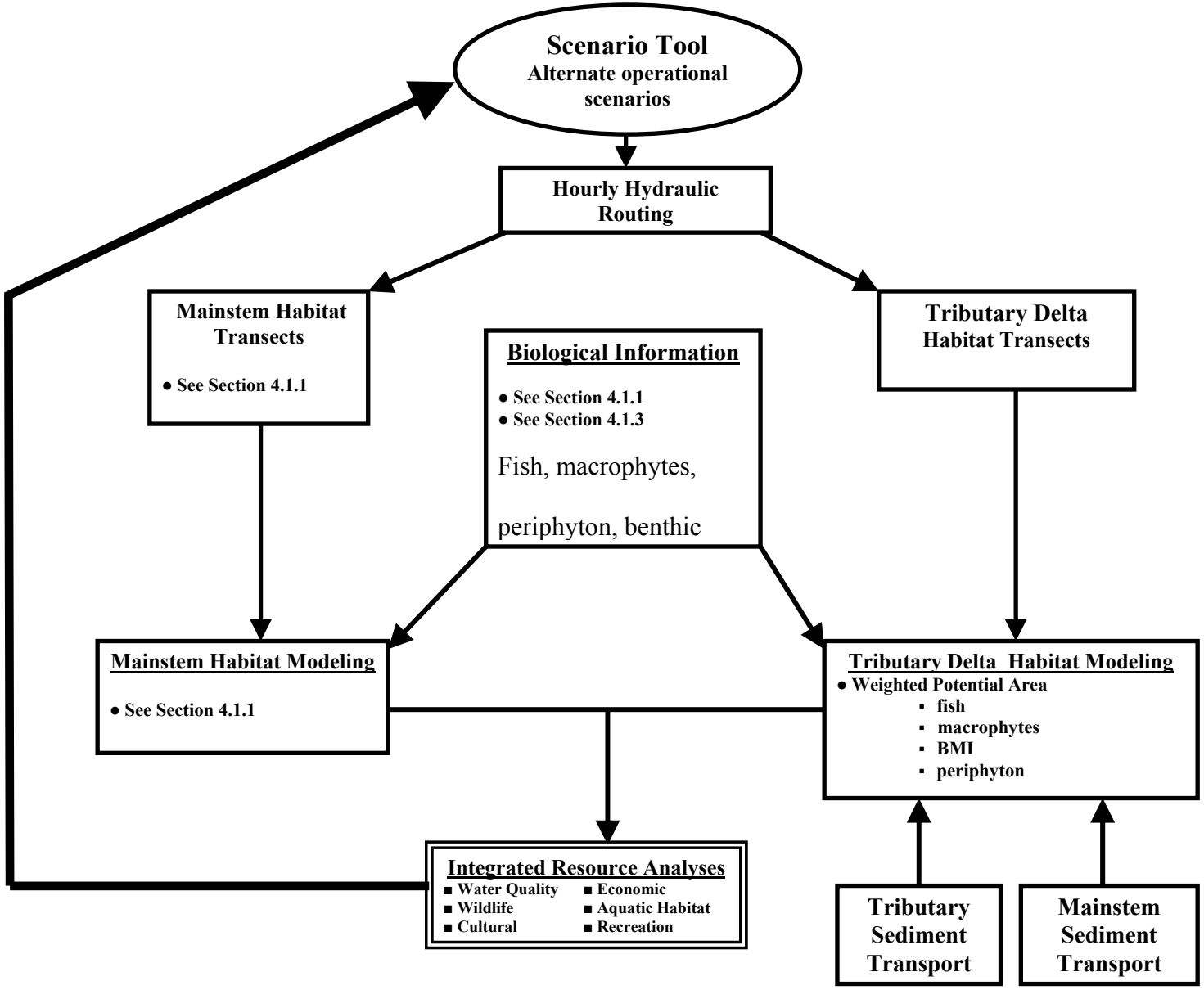

Figure 4.2-2. Conceptual workflow for integration of tributary modeling results into the Scenario Tool (see section 1.4.3).

Work Products

A draft report describing survey methods, results of 2007 data collection, and if needed, discussion of recommendations for supplemental 2008 delta surveys will be produced by December 31, 2007. An interim report describing survey methods and results of fieldwork and analysis will be produced by December 31, 2008.

Schedule

The schedule for completing the Tributary Delta Habitat Modeling component of this study is provided in Table 4.2-3.

Table 4.2-3. Schedule for the Tributary Delta Habitat Modeling study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	---										
Characterize tributary delta conditions		--									
Identify study streams			--								
Estimate total sediment supply from Mainstem and Delta Sediment Transport Studies		------	---------								
Temperature collection			▲▲▲								
Tributary delta surveys			▲▲▲	▲▲▲							
Quantify changes in tributary delta morphology under alternative operational scenarios using the mainstem HEC-RAS model					-----						
Determine if tributary morphology is expected to change over time					--------						
Construct habitat models for tributaries where scenarios do not affect morphology						------	---------				
Construct habitat models for tributaries where scenarios affect morphology								-----	--------	------	
Use hydraulic routing model and tributary habitat models to quantify effects of operational scenarios								-----	--------	------	
Reporting				●				●		■	

Tributary Delta Sediment Processes

The erosion, transport, and accumulation of sediment within select tributary deltas of the Pend Oreille River may affect aquatic habitats by altering channel morphology and the size and

distribution of channel substrates. This study effort will evaluate the effects of Project operations on the delta morphology of major tributaries within the Pend Oreille River from Box Canyon Dam downstream to Boundary Dam. The net change in the volume of sediment deposited on the tributary deltas will be estimated and potential zones of erosion and accumulation of sediment within the deltas will be delineated.

The construction of a dam and impoundment of water in a river can impact the morphology and sediment transport regime of tributaries to the reservoir. As the tributary enters the reservoir, the coarser portion of the total sediment load, referred to as bed-material load, settles out on the topset slope of the delta, as illustrated in Figure 4.2-3. Bed-material load generally consists of relatively coarse substrate (cobbles, gravel, and sand). The finer portion of the total sediment load, referred to as wash load (because it is generally "washed" through a river without depositing), is transported further into the reservoir, where some of it will accumulate on the reservoir bottom and the remainder will be passed through the reservoir. The wash load generally consists of relatively fine sediment (clay and silt).

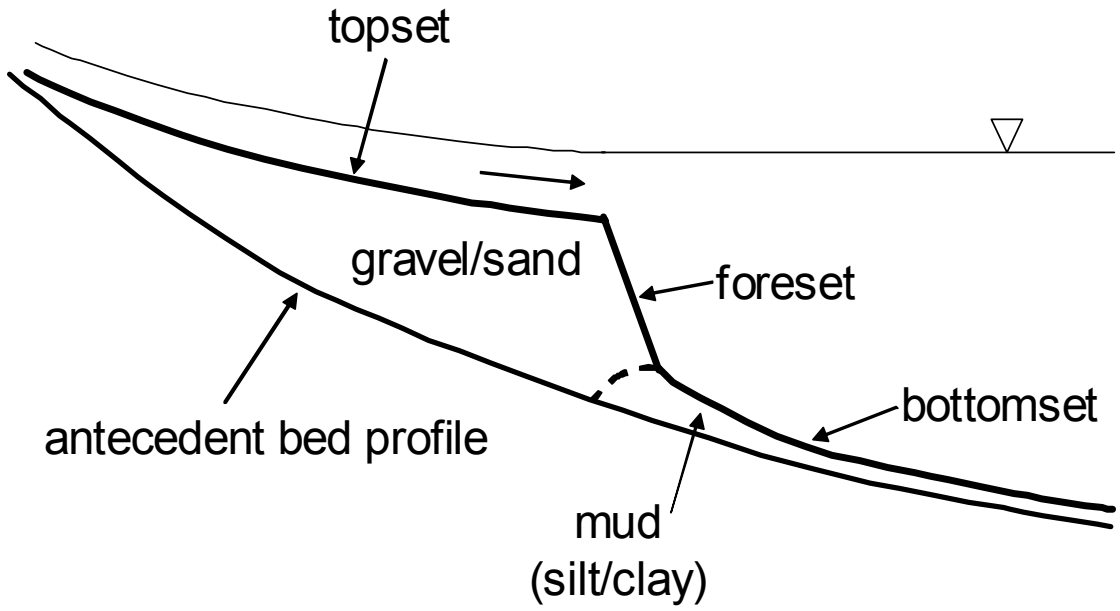

Figure 4.2-3. Conceptual longitudinal profile of tributary delta morphology (from Parker 2004).

The wash load will be suspended in the water column when it reaches the end of the topset slope. If this sediment-laden mixture is heavier than the water in the reservoir, then it will plunge downward and form a turbidity current that flows along the bottom of the reservoir (Fan and Morris 1992). Otherwise, it will generally disperse and mix with the water in the reservoir.

As the delta accumulates sediment, the leading edge of the delta (foreset slope shown in Figure 4.2-3), will advance further into the reservoir. If the delta is confined within a narrow canyon, then it will advance forward in one direction. Otherwise, the tributary will intermittently avulse, and the accumulated sediment will spread laterally and form a delta fan (Parker et al. 1998a and 1998b, Sun et al. 2002, and Kostic and Parker 2003a and 2003b).

The sediment accumulated within tributary deltas may also be eroded by several different potential mechanisms. These erosional processes include the following:

- Direct erosion from the main current of the Pend Oreille River. If the leading edge of the topset slope advances far enough into the reservoir to where it is exposed to the main current of the Pend Oreille River, then bed material transported by the tributary will become available for transport by the Pend Oreille River.
- Headcutting erosion in the tributary channel when the water surface elevation in the reservoir drops below the tributary delta channel (Morris and Fan 1997). This process will rework the sediment that had previously accumulated on the topset slope of the delta and transport it further into the reservoir.
- Shoreline erosion of the leading edge of the tributary delta associated with fluctuations of water surface elevation in the reservoir.

Thus, both accumulation and erosion of sediment may shape the morphology of the tributary delta. The sediment transport regime of the tributary deltas will also be linked with fluvial processes in the mainstem Pend Oreille River (see Mainstem Sediment Transport study component). The wash load in the tributaries (clay and silt) will be available for transport by the mainstem Pend Oreille River. Depending on how far the topset slope of the tributary delta has advanced into the reservoir, the bed-material load (sand, gravel, and cobbles) may also become available for transport by the Pend Oreille River.

The tributary delta sediment processes study will provide morphological information to be used in the Tributary Delta Habitat Modeling study component. The tributary delta sediment processes study will estimate whether the morphology of each delta is expected to change over the next 50 years (potential term of a new license) and whether any expected changes are expected to depend on various operational scenarios. If changes to tributary delta morphology are expected, then the predicted delta morphology will be estimated for use in the tributary delta habitat study for mid-license term (i.e., 2036) and end of the potential new license period (i.e., 2061) for each alternative operational scenario.

Proposed Methodology

In developing the proposed methodology for the Tributary Sediment Processes component of this study, a summary of existing information needed to conduct the study was compiled, a list of additional information needed to conduct the study was prepared, and underlying assumptions of the study were defined. The following available existing information will be needed to conduct this study:

- Bathymetry of the Pend Oreille River from Box Canyon Dam to Boundary Dam (USGS 1938), based on surveys conducted in 1934 by the U.S. Geological Survey (USGS) in cooperation with the Washington Department of Conservation and Development. The contour interval of the land surface adjacent to the river was 20 feet. Thalweg profile elevations were determined at intervals ranging from 1 to 20 feet.

- Bathymetry of the Pend Oreille River from Metaline Falls to the proposed Boundary Dam transect site (SCL 1957) based on surveys conducted in 1956 by Northern Pacific Mapping Services, Inc. Contour intervals on these maps were 20 feet.
- Topographic maps and GIS coverage of the entire drainage basin of the Pend Oreille River upstream from Boundary Dam, including portions that extend into Canada.
- At least a 30-year period of daily flow records (1967 through 2006) will be needed from the following gage sites: the USGS gage for the Priest River near the confluence with the Pend Oreille River (USGS Gage 12395000); and from the Water Survey of Canada gage for the Salmo River near Salmo (Gage No. 08NE074).
- Daily flow records covering a shorter period of time (1994 through 2005) will be needed from the USGS for Sullivan Creek at Metaline Falls (Gage No. 12398000).

The additional data required to conduct the tributary delta sediment study consist of the following:

- Study stream selection will be coordinated with relicensing participants as part of the Tributary Delta Habitat Modeling study component.
- The results from a cumulative total of 48 to 132 Wolman pebble count surveys Wolman (1954) of surface layer delta sediment deposits from 6 to 8 tributaries of the Pend Oreille River between Box Canyon Dam and Boundary Dam will be needed (see Tributary Delta Habitat Modeling study component).
- Current bathymetry of the Pend Oreille River (including tributary delta zones) from Box Canyon Dam downstream to Boundary Dam will be needed with 2-foot contours in areas less than 40 feet deep below normal full pool level and 5-foot contours in areas greater than 40 feet deep.
- Bathymetric changes of the tributary delta morphology from 1967 to 2006 will be determined as part the Mainstem Sediment Transport study component.
- Tributary delta cross-section profiles will be surveyed and a HEC-RAS (U.S. Army Corps of Engineers 2002a, 2002b, and 2002c) hydraulic model will be developed for each tributary delta as part of the Tributary Delta Habitat Modeling study component.
- A time series of daily flows and daily sediment loads will be developed for each tributary from 1987 to 2004 as part of the Mainstem Sediment Transport study component.
- The effects of alternative operational scenarios on hourly water surface elevations in the Boundary Reservoir forebay and hourly flow releases (power generation plus spill) from Boundary Dam will be available as output from the Scenario Tool (section 1.4.3).
- The effects of hourly Project operations on hourly hydraulic conditions (depth, velocity, and shear stress) in the Pend Oreille River extending from Box Canyon Dam to just above the Salmo River confluence will be available from the hydraulic unsteady flow routing model (Mainstem Aquatic Habitat Modeling Study, 4.1).

In developing the proposed methodology for this study component, the following assumptions were made:

- Seasonal and daily runoff patterns from ungaged tributaries to the Pend Oreille River between Box Canyon Dam and Boundary Dam will be assumed to be similar to seasonal and daily runoff from the Priest River and the Salmo River.
- The magnitude of seasonal and daily runoff patterns from ungaged tributaries to the Pend Oreille River between Box Canyon Dam and Boundary Dam will be assumed to be proportional to tributary drainage area.
- Average annual sediment input to the Pend Oreille River between Box Canyon Dam and Boundary Dam from tributary streams is assumed to be proportional to tributary drainage area (downstream from any major lakes or reservoirs within each tributary).
- Daily sediment input to the Pend Oreille River between Box Canyon Dam and Boundary Dam from tributary streams is assumed to depend on the magnitude of the daily flow in the tributary streams.

The sediment processes associated with tributary deltas can be complex, especially if the delta spreads laterally as it forms when it enters a reservoir. Tributary delta sediment processes have attracted the recent attention of various researchers (Parker et al. 1998a and 1998b, Sun et al. 2002, and Kostic and Parker 2003a and 2003b). Current knowledge of the physical processes associated with tributary delta morphology is sufficient to develop a simplified model to analyze the effects of Project operations on the sediment processes of the Pend Oreille River tributary deltas. A model will be developed to estimate potential changes to tributary delta morphology based on estimates of daily flow and sediment supply to each tributary mouth, and hourly water surface elevations in the mainstem Pend Oreille River from the Hydraulic Routing Model. In developing this model, the following assumptions, will be made to estimate the effects of Project operations on tributary delta habitats.

- The morphology of the delta will be assumed to change by accumulating sediment along both the topset slope and the foreset slope of the delta surface as a result of bed material accumulation.
- Accumulation of bed-material load within the tributary channel of the delta will be assumed to match the accumulation of bed material load on the delta floodplain surface, so that the current shape and alignment of the tributary channel across the topset slope of the delta remains constant. In other words, the effects of channel avulsion on the alignment of the tributary channel will be ignored, but the effects of channel avulsion on long-term accumulation of sediment on the delta surface will be accounted for.
- Bed-material load will be assumed to accumulate uniformly across the entire surface of the foreset slope, so that the front edge of the delta maintains a similar shape as it advances towards the mainstem Pend Oreille River channel. When the front edge of the delta reaches the mainstem, the bed-material load delivered by the tributary will become a source of sediment to the mainstem, and no more sediment will accumulate on the front edge of the delta.

- The density of sediment deposits will be assumed to be constant as sediment accumulates on the delta. In other words, the effects of consolidation of sediment deposits associated with the increasing weight of overburden sediment deposits will be ignored.

A phased approach will be used in the tributary delta sediment processes study to provide morphological information to be used for each tributary selected in the tributary habitat study. The proposed phased approach is outlined in the three tasks described below.

Task 1) Phase 1, Evaluate Potential Delta Change

Determine if the tributary delta morphology is expected to change over the next 50 years (potential term of a new license). If no changes are expected, then the current morphology of the tributary may be used directly for habitat evaluations.

Task 2) Phase 2, Predict Delta Change Common to All Scenarios

If the tributary delta morphology is expected to change, then determine whether the change in morphology is expected to differ among alternative operational scenarios. If changes to tributary delta morphology are not expected to be scenario-specific, then the predicted delta morphology will be estimated for use in the tributary delta habitat study for mid-license term (i.e., 2036) and at the end of the potential new license period (i.e., 2061).

Task 3) Phase 3, Predict Delta Change Associated with Specific Scenarios

If changes to tributary delta morphology are expected to differ among operational scenarios, then the predicted delta morphology will be estimated for use in the tributary delta habitat study for mid-license term (i.e., 2036) and at the end of the potential new license period (i.e., 2061) for each alternative operational scenario.

If the topset slope of the tributary delta is predicted to advance into the reservoir, where it would become exposed the main current of the Pend Oreille River, then the quantity of bed material delivered by the tributary to the mainstem would be estimated for use in the Mainstem Sediment Transport study component.

Work Products

Work products will consist of a site-specific model for each selected tributary delta, and a draft report describing the methods and results of the determination of potential changes in tributary delta morphology at mid-license term (2036) and at the end of the potential new license term (2061).

Schedule

The schedule for completing the Tributary Delta Sediment Processes component of this study is provided in Table 4.2-4.

Table 4.2-4. Schedule for the Tributary Delta Sediment Processes study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	---										
Compile information		---	---	---							
Determine if tributary delta morphology is expected to change over time					---						
Predict estimated future tributary delta morphology for 2036 and 2061 for tributaries where morphology is not expected to depend on potential alternative operational scenarios.						---	---				
Predict estimated future tributary delta morphology for 2036 and 2061 for tributaries where morphology is expected to depend on various alternative operational scenarios.								---	---	---	
Reporting							●			■	

Mainstem Sediment Transport

The erosion, transport, and accumulation of sediment within the mainstem Pend Oreille River may affect aquatic habitats by altering channel morphology and the size and distribution of channel substrates. This study effort will evaluate the effects of Project operations on channel morphology within the Pend Oreille River from Box Canyon Dam downstream to just above the confluence of the Salmo River. The net change in the volume of sediment deposited in the study will be estimated, and zones of erosion and accumulation of sediment within the study reach will be delineated. Existing Conditions, as described by bathymetry data collected in 2006, will be compared to conditions over the potential term of a new license.

The construction of a dam and impoundment of water can impact the channel morphology and sediment transport regime in both the upstream and downstream directions. Upstream from the dam, some of the incoming sediment will be trapped as it enters the reservoir, and the remainder of the sediment will be passed downstream. The ratio of the weight of sediment trapped in the reservoir divided by the total weight of incoming sediment is referred to as the "trapping efficiency" of the reservoir. The sediment trapped in the reservoir will be coarser than the sediment passed downstream. The sediment deposited in the reservoir will generally be sorted longitudinally with the coarser sediments accumulating further upstream from the dam, and the finer sediments accumulating closer to the dam.

Downstream from the dam, the sediment transport regime will be impacted by two confounding processes: reduced supply of sediment to the river just downstream from the dam; and altered flow regime. Just below the dam, the substrate may become coarser and the channel may

become incised. Further downstream from the dam, these processes will diminish and possibly reverse, as the river receives additional sediment from downstream tributary sources.

In addition to potential impacts to the mainstem channel morphology and substrate texture, there may also be potential impacts to tributary channel morphology and substrate texture in the vicinity of the confluence of tributaries with the mainstem river channel. Upstream from the dam, delta formation and accumulation of fine sediments may be the result. Downstream from the dam, tributaries may become perched above the incised mainstem channel and the substrate of the tributary may coarsen. The response of the tributaries, which are linked to processes that occur in the mainstem, will be the focus of the Tributary Delta Sediment Processes study component.

Proposed Methodology

In developing the proposed methodology for the mainstem sediment transport study a summary of existing information needed to conduct the study was compiled, a list of additional information that may be needed to conduct the study was prepared, and underlying assumptions of the study were defined. The following available existing information will be needed to conduct this study:

- Bathymetry of the Pend Oreille River from Box Canyon Dam to the international border (USGS 1938), based on surveys conducted in 1934 by the USGS in cooperation with the Washington Department of Conservation and Development. The contour interval of the land surface adjacent to the river was 20 feet. Thalweg profile elevations were determined at intervals ranging from 1 to 20 feet.
- Bathymetry of the Pend Oreille River from Metaline Falls to the proposed Boundary Dam site (SCL 1957) based on surveys conducted in 1956 by Northern Pacific Mapping Services, Inc. Contour intervals on these maps were 20 feet.
- Topographic maps and GIS coverage of the entire drainage basin of the Pend Oreille River upstream from the confluence with the Salmo River, including portions that extend into Canada.
- At least a 30-year period of daily flow records (1967 through 2006) will be available from the USGS for the Priest River near the confluence with the Pend Oreille River (USGS Gage 12395000; and from the Water Survey of Canada for the Salmo River near Salmo (Gage No. 08NE074).
- Daily flow records covering a shorter period of time (1994 through 2005) are available from the USGS for Sullivan Creek at Metaline Falls (Gage No. 12398000).

In addition to the information listed above, additional information may be needed to develop and calibrate the mainstem sediment transport model. This information would be developed by other relicensing study efforts in 2007 and 2008 and includes the following:

- Bathymetry of the Pend Oreille River from the international border to the location of Seven Mile Dam. Bathymetry of Seven Mile Reservoir from Seven Mile Dam to the confluence with the Salmo River has been reported by Klohn Crippen Consultants and ASL Environmental Services (2005). The bathymetry was reportedly derived

from 1:50,000 scale Natural Resources Canada NTS maps. SCL is currently assessing the suitability of existing bathymetric data from the U.S.-Canada border to the confluence with Red Bird Creek. Costs for a bathymetric survey in 2007 are not included in the task effort.

- Bathymetry of the Pend Oreille River from Box Canyon Dam downstream to the International Border will be needed with 2-foot contours in areas less than 40 feet deep below normal full pool level and 5-foot contours in areas greater than 40 feet deep. Bathymetry of Boundary Reservoir is being surveyed during 2006, but the final processed datasets may not be available until late 2006.
- The effects of alternative operational scenarios on hourly water surface elevations in Boundary Reservoir forebay and hourly flow releases (power generation plus spill) from Boundary Dam will be obtained from the Scenario Tool (1.4.3).
- The effects of hourly Project operations on hourly hydraulic conditions (depth, velocity, and shear stress) in the Pend Oreille River extending from Box Canyon Dam to just above the Salmo River confluence will be needed from the hydraulic unsteady flow routing model (see Mainstem Aquatic Habitat Modeling Study , 4.1)
- The results from a cumulative total of 48 to 132 Wolman pebble count surveys Wolman (1954) of surface layer delta sediment deposits from six to eight tributaries of the Pend Oreille River between Box Canyon Dam and just upstream of the Salmo River confluence will be obtained from the Tributary Delta Habitats Modeling study component.
- Mainstem substrate grain size composition along transects of the Pend Oreille River between Box Canyon Dam and just upstream of the Salmo River confluence will be obtained from the Mainstem Aquatic Habitat Modeling Study.

The following assumptions were made when developing the list of tasks to be conducted as part of this study component:

- The effects of the Boundary Project extend downstream in the Pend Oreille River to the confluence of Red Bird Creek, which enters on the left bank just above the confluence of the Pend Oreille River and the Salmo River. Future changes in Seven Mile Project operations may alter the downstream influence of the Boundary Project (refer to section 4.5.5.1.2 in the PAD [SCL 2006] for additional detail).
- Lake Pend Oreille and Priest Lake (combined drainage area ~ 24,500 mi^2) are assumed to trap the entire incoming bed-material load (cobbles, gravel, and sand).
- Albeni Falls Dam is assumed to pass all of the incoming bed load and suspended load to the Pend Oreille River between Lake Pend Oreille and Albeni Falls Dam. Bed load is defined as the coarser portion of total sediment load that moves on or near the streambed by rolling, sliding, or saltating (i.e., bouncing). Suspended load is defined as the finer portion of total sediment load that is transported while suspended above the streambed. The primary source of bed load in the reach above Albeni Falls is assumed to be the Priest River (with effective drainage area limited to the portion downstream from Priest Lake).

- Box Canyon Dam is assumed to pass all of the incoming bed load and suspended load to the Pend Oreille River between Albeni Falls Dam and Box Canyon Dam.
- The grain size distributions of surface layer delta sediment deposits from sampled tributaries will be assumed to be representative of grain size distributions of the bed load from unsampled tributaries of the Pend Oreille River between Lake Pend Oreille and just upstream of the Salmo River confluence.
- Seasonal and daily runoff patterns from ungaged tributaries to the Pend Oreille River between Lake Pend Oreille and just upstream of the Salmo River confluence will be assumed to be similar to seasonal and daily runoff from the Priest River and the Salmo River.
- The magnitude of seasonal and daily runoff patterns from ungaged tributaries to the Pend Oreille River between Lake Pend Oreille and just upstream of the Salmo River confluence will be assumed to be proportional to tributary drainage area.
- Average annual sediment input to the Pend Oreille River between Lake Pend Oreille and just upstream of the Salmo River confluence from tributary streams is assumed to be proportional to tributary drainage area (downstream from any major lakes or reservoirs within each tributary).
- Daily sediment input to the Pend Oreille River between Lake Pend Oreille and just upstream of the Salmo River confluence from tributary streams is assumed to depend on the magnitude of the daily flow in the tributary streams.

The focus of this study will be on predicting erosion, transport, and accumulation of sediments in the mainstem Pend Oreille River over the potential 50-year term of a new license. The first major task will be to examine patterns of erosion and accumulation of sediment in the river from 1967 to 2006 to serve as a guide for predicting future process patterns.

The second major task will be to estimate future input of sediment to the Pend Oreille River. Sediment supply to the study reach can come from the following sources:

- Releases from Box Canyon Dam (to be estimated in this study);
- Tributary input (to be estimated in this study); and
- Shoreline erosion (to be estimated in Shoreline Erosion Study).

The third major task will be to develop a sediment routing model to route sediment input from the various sources through the study reach, and to track where sediment is eroded and accumulated. The model will be calibrated to reproduce the historical patterns of erosion and accumulation (from 1967 to 2006). Historical supply of sediment will be assumed to be similar to estimated future inputs. A one-dimensional hydraulic model (see Hydraulic Routing Model study component, 4.1) will be used to help determine sediment transport capacity, based on historical flow releases from Box Canyon Dam, historical reservoir levels in the forebay of Boundary Project, historical flow releases from Boundary Dam to the Pend Oreille River, and historical reservoir levels in the forebay of the Seven Mile Project.

The fourth major task will be to predict future patterns of erosion and accumulation of sediment in the Pend Oreille River over the potential duration of the new license. These four tasks are described in more detail below.

Task 1) Delineate Zones of Erosion and Accumulation of Sediment from 1967 to 2006

The results of bathymetry and/or topographic surveys conducted prior to Project construction will be compared to current (i.e., 2006) bathymetry to delineate zones of erosion and accumulation of sediment in the Pend Oreille River between Box Canyon Dam and just upstream of the confluence with the Salmo River between 1967 and 2006. The volumetric change in zones where erosion and accumulation of sediment has occurred will be estimated.

Task 2) Characterize Sediment Supply

The average annual sediment supply to the Pend Oreille River from Box Canyon Dam and from tributaries to the Pend Oreille River between Box Canyon Dam and just upstream of the Salmo River confluence will be estimated. The average annual total sediment supply will be subdivided into components based on grain size (clay, silt, sand, gravel, and cobble). Guidelines established by the U.S. Bureau of Reclamation (USBR 1987) will be used to estimate bed load (gravel and cobble) as a portion of suspended load (clay, silt, and sand). The silt, sand, and gravel components will be further subdivided into size classes based on the phi classification scale (Lane 1947). Techniques used to estimate average annual sediment supply will include at least one watershed-based method and one method based on evaluating changes in reservoir bathymetry.

The sediment supply to the study reach will be estimated using watershed-based methods such as USGS (1962), Dendy and Bolton (1976), or U.S. Bureau of Reclamation (1987). These methods are used to estimate sediment yield from a watershed on an average annual basis (tons per square mile per year). The results developed using the watershed-based methods will be compared with available literature and discussed with local land and water management agencies.

The reservoir trapping efficiency of Boundary Reservoir will be calculated using methods such as Churchill (1948), Brune (1953), Borland (1971), and the modified Brune curve method (Linsley et al. 1986). The volume of sediment accumulated in Boundary Reservoir from 1967 to 2006 will be estimated using the information determined in the first major task. The density of the accumulated reservoir deposits will be estimated using methods developed by the U.S. Bureau of Reclamation (1987). Densities estimated using these methods typically range from about 80 to 90 pounds per cubic foot. The reservoir sedimentation volume, reservoir sediment density, and the reservoir trapping efficiency will be used to estimate the average annual quantity (tons) of sediment supplied to the reservoir over the term of the existing FERC license.

The previously described sediment supply estimates will be reviewed, and an appropriate average annual sediment supply (tons per year) will be selected to be used for evaluating all future sediment processes. The total average annual sediment supply to the Pend Oreille River from releases from Box Canyon Dam and from tributary sources will be apportioned on the basis of drainage area.

A sediment supply versus flow rating curve will be developed for flow releases from Box Canyon Dam and from the tributary sources for each of the grain size fractions. The sediment supply-rating curve will be assumed to have the following form:

$$Q_s = a(Q - Q_c)^b$$

where Q_s is the sediment transport rate in acre-feet per year, Q is the flow discharge rate in cfs, and Q_c is a critical flow rate to mobilize sediment. A value of 2.0 will be used for the exponent b, as recommended by the U.S. Army Corps of Engineers (1995). The coefficient "a" will be determined by applying the rating curve to 1967 to 2006 daily flows to match the average annual sediment supply. The critical flow, Q_c, for silt and clay will be assumed to be zero. A critical flow will be estimated for sand, gravel, and cobbles by applying the HEC-RAS model developed for each tributary to determine how much flow it would take to mobilize the substrate in each of the tributaries. A critical flow for sand, gravel, and cobbles will be estimated for flow releases from Box Canyon Dam from discussions with operators of Box Canyon Dam.

A time series of daily flows from tributaries (from 1967 to 2006) to the Pend Oreille River between Box Canyon Dam and the confluence with the Salmo River will be developed using flow records from the Priest River and the Salmo River as a guide. A time series of daily sediment supply (from 1967 to 2006) to the Pend Oreille River from Box Canyon Dam and from tributaries to the Pend Oreille River between Box Canyon Dam to just above the Salmo River confluence will be developed for each of the grain size classifications previously discussed.

The estimated sediment supply to the Pend Oreille River from Box Canyon Dam and tributary sources will be combined with estimates of shoreline erosion (see Shoreline Erosion Study, section 2.1) to determine a time series (1987 to 2004) of total sediment input to Boundary Reservoir. The average annual volume of sediment input from Box Canyon Dam and tributary streams estimated for the period 1987 to 2004 will be assumed to represent average annual sediment input under future conditions.

Task 3) Develop and Calibrate Sediment Routing Model

One-dimensional sediment transport models are commonly used to analyze the erosion, transport, and accumulation of sediment in rivers and reservoirs. Examples of public-domain computer models used to analyze these types of processes include HEC-6 (U.S. Army Corps of Engineers 1993), EFDC1D (EPA 2001), and GSTAR-1D (USBR 2006). These models, as well as other available models will be reviewed for applicability to the study reach of the Pend Oreille River, where the stage and flow can vary on an hourly basis. If an appropriate model can be found from among those currently available, then that model will be utilized for this study. Otherwise a simplistic, site-specific, one-dimensional sediment transport model will be developed for this study.

The study reach will be subdivided into sediment routing cells to include and correspond with habitat transects (see Mainstem Aquatic Habitat Modeling Study, 4.1). The sediment routing model will be developed and calibrated to match historical sediment accumulation patterns within the reservoir. Flow and reservoir forebay pool level records from 1967 to 2006 will be

utilized to calculate hourly velocity, depth, and shear stress within each sediment routing cell using the hydraulic routing model (see Hydraulic Routing Model study component, section 4.1). Model calibration will consist of selecting appropriate methods for bed load (gravel and cobble) and bed-material load (sand, gravel, and cobble) to match historical accumulation patterns. The difference between the bed-material load and the bed load will consist of the sand portion of the bed-material load. Sediment transport methods to be considered for the sediment routing model will include but not be limited to the following:

- Bed load — Meyer-Peter and Muller (1948) and Parker (1990a and 1990b); and
- Bed-material load — Engelund and Hansen (1972), Ackers and White (1973), Yang (1973, 1979, and 1984), and Wilcock and Crow (2003).

Task 4) Predict Future Patterns of Erosion and Accumulation

The calibrated sediment routing model will be used to predict erosion and accumulation of sediment and effects on channel morphology under the existing operations scenario. Potential changes in channel morphology, areas of continued sediment erosion and deposition will be identified and used to interpret the results of other studies, such as the macrophyte study component of the Mainstem Aquatic Habitat Modeling Study (section 4.1).

Work Products

Work products will consist of a draft report describing the estimation of sediment supply to the Pend Oreille River between Box Canyon Dam and Boundary Dam and a draft report describing development and calibration of sediment routing model.

Schedule

The schedule for completing the Mainstem Sediment Transport component of this study is provided in Table 4.2-5.

Table 4.2-5. Schedule for the Mainstem Sediment Transport study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	---										
Determine historical patterns of mainstem sediment erosion and accumulation		---									
Estimate daily time series by size fraction of sediment supplied to the Pend Oreille River between Box Canyon Dam and Boundary Dam.		---	---								
Develop and calibrate the sediment routing model.				---	---						
Use sediment routing model to predict future patterns of mainstem sediment erosion and accumulation						---	---	---			
Reporting				●				■			

4.2.6. Consistency with Generally Accepted Scientific Practice

Tributary Delta Habitat Modeling: Physical habitat models are often used to evaluate alternative instream flow regimes in rivers (e.g., the Physical Habitat Simulation [PHABSIM] modeling approach developed by the USGS; Waddle 2001). The proposed approach for assessing the effects of alternative operational scenarios on habitat in the tributary deltas (and mainstem) are analogous to the PHABSIM approach in that hydraulic modeling is translated to indices of habitat availability using habitat suitability index (HSI) curves. Indeed, many of the HSI curves to be used in the proposed study will be drawn directly from, or modified from, HSI curves used in the PHABSIM approach. One of the major differences between PHABSIM and the proposed approach is the incorporation of hydraulic models. The proposed study uses HEC-RAS and tributary flow modeling to obtain water depths and velocities, which is more appropriate for the hydraulic conditions in the study area, while PHABSIM uses a variety of water surface elevation and hydraulic simulation programs more appropriate for modeling riverine flow conditions. The proposed custom modeling approach is consistent with the use of physical habitat models used at other hydroelectric projects to assess the effects of alternative operational scenarios on aquatic habitat.

Tributary Delta Sediment Processes: The sediment processes associated with tributary deltas can be very complex, especially if the delta spreads laterally as it forms when it enters a reservoir. Tributary delta sediment processes have attracted the recent attention of various researchers (Parker et al. 1998a and 1998b, Sun et al. 2002, and Kostic and Parker 2003a and 2003b). However, currently available "off-the-shelf" models may have to be adapted to analyze the sediment processes associated with the Pend Oreille River tributary deltas. Current knowledge of the physical processes associated with tributary delta morphology is sufficient to

develop simplistic site-specific models to analyze the effects of Project operations on the tributary deltas.

Mainstem Sediment Transport: One-dimensional sediment transport models are commonly used to analyze the erosion, transport, and accumulation of sediment in rivers and reservoirs. Examples of public-domain computer models used to analyze these types of processes include HEC-6 (U.S. Army Corps of Engineers 1993), EFDC1D (EPA 2001), and GSTAR-1D (USBR 2006). Each model has its own unique strengths and limitations. These models, as well as other available models, will be reviewed for applicability to the study reach of the Pend Oreille River, where the stage and flow can vary on an hourly basis. If an appropriate model can be found from among those currently available, then that model will be utilized for this study. Otherwise a simplistic, one-dimensional, site-specific sediment transport model will be developed for this study.

4.2.7. Consultation with Agencies, Tribes, and Other Stakeholders

Tributary Delta Habitat Modeling: Input regarding the Tributary Delta Habitat component of the Sediment Transport and Boundary Reservoir Tributary Delta Habitats study was provided by relicensing participants during a workgroup meeting held in Spokane, Washington, on May 23, 2006. During the workgroup meeting, an outline for the Tributary Delta Habitat Modeling Study was presented and discussed with relicensing participants. Comments provided by relicensing participants on this review outline are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

Tributary Delta Sediment Processes: Input regarding the Delta Sediment Processes component of the Sediment Transport and Boundary Reservoir Tributary Delta Habitats study was provided by relicensing participants during workgroup meetings held in Spokane on May 23, 2006, and on August 14, 2006. During the May workgroup meeting, an outline for the Tributary Delta Sediment Processes was presented and discussed with relicensing participants. During the August meeting, the linkage between the Tributary Delta Sediment Processes study and the Mainstem Sediment Transport study was presented and discussed. Comments provided by relicensing participants regarding this study component are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

Mainstem Sediment Transport: Input regarding the Mainstem Sediment Transport component of the Sediment Transport and Boundary Reservoir Tributary Delta Habitats study was provided by relicensing participants during workgroup meetings held in Metaline Falls, Washington, on June 27, 2006, and in Spokane on August 14, 2006. During the June workgroup meeting, background on the issues associated with mainstem sediment transport was presented and discussed with relicensing participants. During the August workgroup meeting, an outline for the Mainstem Sediment Processes was presented and discussed with relicensing participants. Comments provided by relicensing participants regarding this study component are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Tributary Delta Habitats and Mainstem Sediment Transport study outlines presented at the workgroup meetings. In a letter to SCL dated August 28, 2006 (included in Attachment 4-1), WDFW reiterated the importance of tributary delta habitats and indicated that they could not find an electronic version of the Tributary Delta study outline that had been presented at the May 23, 2006 workgroup meeting. An electronic version of the study outline was subsequently provided to WDFW.

The USFS did not specifically reference the tributary delta and sediment transport study outlines in its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006b). However, in a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the study outlines. As noted in the proposed study plan, additional implementation details of the study components will be developed in early 2007 when the Technical Consultant finalizes the study design in coordination with SCL and relicensing participants.

4.2.8. Progress Reports, Information Sharing, and Technical Review

Relicensing participants will have opportunities for study coordination through regularly scheduled meetings, reports and, as needed, technical subcommittee meetings. Reports are planned for preparation at the end of 2007 and 2008 for each of the three components of this study. Relicensing participants will have the opportunity to review and comment on these reports. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with agencies, tribes, and other stakeholders to discuss the study results, as described in section 1.2.4 of this document. Relicensing participants will have the option to participate in site visits during transect selection and participate on panels as part of the HSI curve development process. Workgroup meetings are planned to occur on a quarterly basis, and workgroup subcommittees will meet or have teleconferences as needed.

4.2.9. Anticipated Level of Effort and Cost

Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated total cost to implement the three components of this effort (Tributary Delta Habitat Modeling, Tributary Delta Sediment Processes, and Mainstem Sediment Transport) at the Boundary Project ranges from $300,000 to $425,000; estimated study costs are subject to review and revision as additional details are developed.

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4.3. Fish Distribution, Timing, and Abundance Study

Fishery resources in the Boundary Project area consist of native and introduced salmonids, native non-game species, and introduced warmwater sport fish. During summer months, the water temperature of the Pend Oreille River upstream of Boundary Dam (i.e., Boundary Reservoir) is at the upper limit for trout, which means that trout may congregate in coldwater refugia such as the mouth of tributary streams during warm summer months. When the weather turns cold, native salmonids may distribute throughout the reservoir, but little information is available on fish distribution in Boundary Reservoir during the late fall, winter and early spring. Boundary Reservoir supports bass and other warmwater sport fish, and it is unclear how those species interact with native salmonids. Bass typically spawn and rear in shallow littoral habitats, so understanding seasonal habitat use of the variety of fish and other aquatic biota inhabiting Boundary Reservoir will be important to evaluating the effects of Project operations.

Bull trout is a native salmonid that has rarely been observed in Boundary Reservoir or its tributaries; however, the species is listed as threatened under the Endangered Species Act (ESA), and the potential recovery of bull trout is a major concern of agencies, tribes, and other stakeholders (relicensing participants). Westslope cutthroat trout is another native salmonid that, although not currently listed under the ESA, is a concern of relicensing participants.

The physical habitat modeling efforts proposed in sections 4.1 and 4.2 require information on the distribution and periodicity of different life stages for the fish species of interest. Not all life stages of the target fish species may be present in Boundary Reservoir. For example, bull trout and cutthroat trout spawn in streams and rivers, but are not known to spawn in Boundary Reservoir. Mountain whitefish are known to spawn along shorelines and gravel bars in large river/reservoir systems, but whitefish spawning has not been documented for Boundary Reservoir.

This study is designed to provide baseline biological information and supporting information for the Mainstem Aquatic Habitat Modeling Study (see section 4.1). This study will obtain key life history information about the fish in Boundary Reservoir using two sampling approaches. The first sampling approach uses active and passive capture methods to identify the seasonal timing, distribution and abundance of fish at a variety of locations in Boundary Reservoir and downstream of Boundary Dam. The second sampling approach uses biotelemetry to monitor the movements and habitat utilization of tagged fish.

4.3.1. Nexus Between Project Operations and Effects on Resources

Boundary Project operations, such as the load-following strategy described in the Mainstem Aquatic Habitat Modeling study plan, affect water depths and velocities in Boundary Reservoir and the Project tailrace (Boundary Tailrace Reach), and affect the frequency of inundation and dewatering of the littoral zone. These changes to aquatic habitats can affect the growth and reproduction of fish and other aquatic organisms. An understanding of the timing, distribution and abundance of native and non-native fish species that inhabit Boundary Reservoir and the Boundary Tailrace Reach is needed to support an evaluation of the effects of existing operations and alternative operational scenarios. Biological information such as seasonal movements of

native salmonids and the magnitude and periodicity of adfluvial and riverine fish migrations can aid discussions regarding the feasibility and need for habitat connectivity for native salmonids at the Boundary Project.

4.3.2. Agency Resource Management Goals

A description of relevant agency management goals is provided in the Mainstem Aquatic Habitat Modeling Study (see section 4.1.2).

4.3.3. Study Goals and Objectives

The goal of this study is to fill data gaps in the existing information regarding the abundance, distribution, and periodicity of fish in Boundary Reservoir and to provide additional information to aid discussions regarding the feasibility and need for habitat connectivity for native salmonids at the Boundary Project. The objectives of this study are as follows:

1) Determine seasonal changes in the distribution and relative abundance of native salmonids, non-native salmonids and non-salmonids, particularly important sport fish species, in Boundary Reservoir.
2) Determine seasonal changes in the distribution and relative abundance of native salmonids and the magnitude and periodicity of upstream and downstream adfluvial fish migration behavior in selected tributaries to Boundary Reservoir;
3) Determine seasonal changes in the distribution and relative abundance of native salmonids in the Tailrace Reach.
4) Identify movements of target fish species (i.e., bull trout, westslope cutthroat trout, and mountain whitefish) in Boundary Reservoir and the Boundary Tailrace Reach.
5) Evaluate the effects of Boundary Project operations on hourly, daily and seasonal native salmonid movements in the Tailrace Reach.
6) Obtain information on habitat-use characteristics of target fish species to support validation of Habitat Suitability Indices using site-specific data (see HSI-fish component of the Mainstem Aquatic Habitat Modeling Study, section 4.1).
7) Collect tissue samples to identify the genetic signature of any bull trout or cutthroat trout captured in Boundary reservoir or tailrace.

4.3.4. Need for Study

Summary of Existing Information

A primary source of recent information on the general distribution and abundance of fish and other aquatic biota in Boundary Reservoir are surveys conducted by the Washington Department of Fish and Wildlife (WDFW) in 2000 (McLellan 2001). The electrofishing and gill net sampling surveys were conducted seasonally (spring, summer, and fall) throughout the reservoir. Based upon these sampling efforts, McLellan (2001) observed that Boundary Reservoir is dominated by non-salmonids. Northern pikeminnow and largescale sucker were the most abundant species, making up 33.4 percent and 26.8 percent of the total catch, respectively (Table

4.3-1). Salmonids represented 3.4 percent of the total catch, and the majority of salmonids in the catch were mountain whitefish (67 percent). No bull trout or white sturgeon were captured during the WDFW surveys. Supplemental sampling designed to evaluate whether white sturgeon inhabit Boundary Reservoir was conducted in 2005; Howell and McLellan (2006) conducted set line fishing but did not capture any sturgeon in Boundary Reservoir. McLellan (2001) concluded that most fish in Boundary Reservoir used the littoral zone, while few fish used the deep water zone.

Table 4.3-1. Species composition in Boundary Reservoir during 2000 from surveys conducted during spring, summer, and fall. Source: McLellan (2001).

Species	Species Composition				Size Range (TL)	
	by Number		by Weight			
	(n)	(%n)	(kg)	(%W)	Min	Max
Black crappie *(Pomoxis nigromaculatus)*	6	0.3	0.7	0.2	135	218
Brown bullhead *(Ictalurus melas)*	21	1.2	5.7	1.4	231	292
Brown trout *(Salmo trutta)*	6	0.3	3.0	0.7	271	452
Burbot *(Lota lota)*	4	0.2	0.7	0.2	241	431
Cutthroat trout *(Oncorhynchus clarki)*	2	0.1	0.5	0.1	312	375
Lake trout *(Salvelinus namaycush)*	2	0.1	1.0	0.2	318	474
Largemouth bass *(Micropterus dolomieui)*	8	0.4	3.4	0.8	81	432
Largescale sucker *(Catostomus macrocheilus)*	489	26.8	185.5	44.6	32	552
Longnose sucker *(Catostomus catostomus)*	31	1.7	12.8	3.1	68	434
Mountain whitefish *(Prosopium williamsoni)*	42	2.3	9.3	2.2	91	411
Northern pikeminnow *(Ptychocheilus oregonenesis)*	609	33.4	118.4	28.5	50	550
Peamouth *(Mylocheilus caurinus)*	126	6.9	20.5	4.9	70	357
Pumpkinseed *(Lepomis gibbossus)*	5	0.3	0.3	0.1	110	167
Rainbow trout *(Oncorhynchus mykiss)*	11	0.6	4.3	1.0	182	480
Redside shiner *(Richardsonius balteatus)*	197	10.8	3.6	0.9	43	180
Smallmouth bass *(Micropterus dolomieui)*	131	7.2	15.7	3.8	55	402
Tench *(Tinca tinca)*	29	1.6	22.3	5.4	145	460
Yellow perch *(Perca flavescens)*	103	5.7	8.1	1.9	52	252

McLellan (2001, Appendix E) reported the results of their surveys by species, season, and reservoir section, but no discussion of spatial (by section) or temporal distribution patterns was included in the body of the report. Analysis of the data tables in the appendices to the McLellan 2001 report suggest that catch rates were generally higher in the summer and fall relative to the spring surveys. Electrofishing surveys generally had higher capture rates in the Upper Reservoir compared to the Canyon and Forebay Reaches (Figure 4.1-1), while horizontal gill net catch rates were variable with no strong patterns discernable among the different sections. McLellan (2001) reported that high flows occurred during the spring surveys. Seasonal differences in

catch per unit effort may have been the result of spring high flows or fish activity levels, which may have affected capture efficiency rather than actual changes in fish abundance or distribution. Apparent spatial differences in capture rates for electrofishing surveys may have occurred because the Upper Reservoir Reach (upstream of Metaline Falls) is relatively shallow and is likely to result in higher electrofishing efficiency compared to the deeper Canyon Reach and Forebay Reach (Boundary Dam to the downstream end of the Canyon Reach). Overall, the available information from McLellan (2001) provides an indication of spatial and temporal patterns of reservoir use by the fish community, but represents only one year of sampling effort.

In recent years, declines in native resident salmonid populations, such as bull trout and westslope cutthroat trout have placed increased emphasis on these species. Available information specific to the distribution and abundance of native salmonids (Andonaegui 2003; USFS 2006a; R2 Resource Consultants, Inc. 1998; Terrapin Environmental 2000; Cascades Environmental Services 1996; McLellan 2001; TERA Corporation 1982) suggests that bull trout are rare in Boundary Reservoir and are rare or not present in accessible tributaries. Adfluvial fish habitat within tributaries to Boundary Reservoir is limited due to natural upstream migration barriers, small stream size, and poor habitat quality (SCL 2006). Since the early 1980s, documented observations of ten bull trout have occurred in Boundary Reservoir or its tributaries. One gutted bull trout carcass was observed in Sullivan Creek (McLellan 2001), indicating it had been captured by an angler, but it is unknown if the fish was captured in Sullivan Creek or discarded there by the angler. Three bull trout have been captured in Boundary Reservoir near the mouth of Slate Creek, but have not been observed within the creek (R2 Resource Consultants, Inc. 1998; Andonaegui 2003). Three individual bull trout have been captured within or near the mouth of Sweet Creek (Andonaegui 2003). Gill net and electrofishing sampling throughout Boundary Reservoir during the spring, summer, and fall 2000 failed to capture any bull trout (McLellan 2001).

Cutthroat trout and mountain whitefish have been more frequently observed in Boundary Reservoir and its tributaries compared to bull trout. During the WDFW nighttime surveys (McLellan 2001), mountain whitefish (42 fish) and cutthroat trout (2 fish) represented about 2.4 percent of the 1,822 fish captured in Boundary Reservoir during their gill net and electrofishing surveys. Recreational anglers surveyed by R2 Resource Consultants, Inc. (1998) captured 3 cutthroat trout and 3 mountain whitefish out of a total catch of 455 fish during 1997. Most of the mountain whitefish were captured in the Upper Reservoir Reach and a few were captured in the Canyon Reach. No mountain whitefish were captured in the Forebay Reach. Cutthroat trout are known to be present in Pewee Creek, Slate Creek, Threemile Creek, Sullivan Creek, Sweet Creek, Sand Creek, and Lost Creek. Mountain whitefish are known to be present in Sweet Creek and Sullivan Creek (McLellan 2001, USFS 2006a).

During 1994 and 1995 fisheries studies were conducted on behalf of British Columbia Hydro (BC Hydro) in anticipation of expanding the capacity of the Seven Mile Project. Between summer 1999 and spring 2000, additional fisheries studies were funded by Seattle City Light. The fisheries studies during 1999 and 2000 in Seven Mile Reservoir utilized a variety of capture methods including boat electrofishing (depths less than 13.1 feet), backpack electrofishing (depths less than 4.9 feet), setlines, beach seines, and Gee (minnow) traps. The boat electrofishing captured nearly 96 percent of all fish collected (17,809 fish). Investigators were

particularly interested in determining if white sturgeon and bull trout were present within Seven Mile Reservoir. Set lines targeting sturgeon were fished a total of 21,618 hook-hours (one hook fished for one hour is one hook-hour) during the 1994/1995 and 1999/2000 studies, but no sturgeon were captured. R.L. & L. and Taylor Associates (2001) concluded that currently no white sturgeon utilize Seven Mile Reservoir. Four bull trout were captured during the 1994 surveys and two bull trout were captured during the 1999/2000 surveys in lower Seven Mile Reservoir.

Snorkel surveys, spawning surveys, and radio telemetry studies in the Salmo River have confirmed five areas with bull trout spawning, and the Salmo River spawning population of bull trout has been estimated at approximately 200 individuals (Baxter 1999). Baxter (1999) concluded that the Salmo River bull trout population exhibits a fluvial life history pattern. That is, bull trout spawn in the Salmo River and its tributaries, remain in the river, and rarely migrate into Seven Mile Reservoir. Baxter (1999) based this conclusion primarily on the size of bull trout observed during snorkel and spawning surveys and the behavior of radio-tracked bull trout, none of which were observed to move into Seven Mile Reservoir. BC Hydro is planning to conduct a biotelemetry study to evaluate potential adfluvial bull trout movements in the Salmo River and Seven Mile Reservoir in 2007.

The upper section of Seven Mile Reservoir, between Boundary Dam and the Salmo River confluence, is shallower and narrower than the lower section of the reservoir (R.L. & L. and Taylor Associates 2001). The greatest depth measured at a water quality sampling site just north of the U.S.-Canada border was approximately 19.7 feet. Mean daily water temperatures measured at this site from August 19, 1999, to June 19, 2000, ranged from 33.8°F (1.0°C) to 75.0°F (23.9°C).

Redside shiners, largescale and longnose suckers, northern pikeminnow, and peamouth dominate the fish community in the upper Seven Mile Reservoir. Sport fish are a minor component to the fish community. The major difference between the lower Seven Mile Reservoir and the upper Seven Mile Reservoir was the relatively low abundance of smallmouth bass and the relatively high abundance of mountain whitefish in the upper section. During 1999/2000, R.L. & L. and Taylor Associates (2001), conducted beach seine and backpack electrofishing adjacent to the island located across and slightly downstream from the Boundary tailrace boat ramp. No fish were captured by beach seine (five hauls total during fall, winter, and spring) while 6 largescale suckers were captured by electrofishing (average area fished was 2,839 ft^2 during spring, summer, fall, winter). No bull trout were captured anywhere in the upper section during sampling conducted in 1999/2000 (R.L. & L. and Taylor Associates 2001).

In addition to bull trout observed in the Salmo River, bull trout have been observed in three of the smaller tributaries to Seven Mile Reservoir: Nine Mile Creek (5 fish), Harcourt Creek (1 fish), Lomond Creek (1 fish), and Tillicum Creek (R.L. &. L. and Taylor Associates 2001; R.L. & L. 1991; Andonaegui 2003). R.L. & L. and Taylor Associates (2001) assessed the habitat conditions in the lower 328 to 984 feet of eight tributaries draining to Seven Mile Reservoir. Five of these tributaries, including Harcourt Creek, had impassable barriers (4 with natural barriers, 1 with a culvert barrier) within 328 feet of their confluence with the reservoir. Tributaries without impassable barriers in their lower reaches included Nine Mile Creek (3.5

miles long), Russian Creek (1.0 mile long) and Lomond Creek (4.7 miles long). Although no bull trout were captured in Tillicum Creek during the surveys by R.L. & L. and Taylor Associates (2001) and R.L. & L. (1999), Andonaegui (2003) cited information indicating that bull trout had been observed in the creek during the early 1980s by the USFS. An impassable culvert barrier in lower Tillicum Creek was identified by R.L. & L. and Taylor Associates (2001).

Need for Additional Information

Site-specific knowledge of the distribution, timing and abundance of fish in Boundary Reservoir primarily depends on the results of surveys conducted by WDFW during the spring, summer and fall of 2000 using multiple sampling methods (McLellan 2001). Collection efforts specific to bull trout have observed few bull trout or other cutthroat trout (R2 Resource Consultants, Inc. 1998; Terrapin Environmental 2000), but some uncertainty exists regarding potential seasonal movements. Additional surveys will supplement and help to verify assumptions drawn from the previous surveys concerning the distribution and relative abundance of fish in Boundary Reservoir and the Tailrace Reach. Additional surveys are needed to verify assumptions regarding temporal and spatial patterns of fish use, particularly juvenile fish that could be vulnerable to stranding. This study is intended to fill gaps in information needed to support discussions regarding Boundary Project operations and issues of habitat connectivity (see section 4.6).

In addition to collecting baseline fish and aquatic information, aspects of this study are designed to complement and support other fish and aquatic studies as follows:

- Mainstem Aquatic Habitat Modeling Study (section 4.1) — Fish collected during electrofishing and biotelemetry will provide information to validate literature-based habitat suitability index (HSI) curves.
- Sediment Transport and Tributary Delta Habitats (section 4.2) — Gill net, angling, electrofishing and fyke nets will provide data on fish use of tributary delta habitats.
- Fish Entrainment and Connectivity (section 4.6) — Deployment of gill nets in the Forebay Reach, especially if gill nets are placed immediately in front of the spillway during springtime periods without active spilling, may provide information on the size and species of fish potentially entrained during spill conditions.

4.3.5. Detailed Description of Study

Study Area

The study area encompasses all of Boundary Reservoir from Box Canyon Dam downstream to the tailrace of Boundary Dam and a portion of upper Seven Mile Reservoir that could potentially be affected by Boundary Project operations. The study area is divided into four reaches (Figure 4.1-1):

- Upper Reservoir Reach — Box Canyon Dam downstream to Metaline Falls (RM 34.5 to RM 27.8)

- Canyon Reach — Metaline Falls to downstream end of Z-Canyon (RM 27.8 to RM 19.4)
- Forebay Reach — downstream end of Z-Canyon to Boundary Dam(RM 19.4 to RM 17.0)
- Tailrace Reach — Boundary Dam to Red Bird Creek, British Columbia (RM 17.0 to RM 13.1)

SCL will continue discussions regarding the downstream extent of studies with relicensing participants during the fall of 2006, and if deemed appropriate, SCL may limit downstream investigations to the U.S.-Canada border. The lower reaches of selected tributaries draining to Boundary Reservoir will also be monitored to determine the timing and magnitude of adfluvial movements. For planning purposes, tributary deltas of interest are Sullivan Creek, Slate Creek, Sweet Creek and Flume Creek, but surveys of other tributaries may be added or substituted in response to additional information.

Description of Study Components

The study utilizes two approaches for obtaining key life history information about the fish that inhabit Boundary Reservoir. The first approach uses passive and active methods to capture fish throughout the year at a variety of locations in Boundary Reservoir and downstream of Boundary Dam. The second method utilizes biotelemetry to monitor the movements and habitat utilization of individuals.

Passive and Active Sampling

A combination of gill net, electrofishing, angling, minnow trap, snorkeling, and fyke net trapping techniques will be used to sample fish in the Tailrace Reach, Boundary Reservoir, and moving in and out of selected tributaries draining to Boundary Reservoir. Several assumptions are associated with the use of the proposed methods:

- Boat-mounted electrofishing is the most effective means of capturing fish in littoral areas (<10 feet deep) of Boundary Reservoir. Gill net sampling is the most effective means of capturing fish in deep water areas (>10 feet deep) of Boundary Reservoir.
- Boat electrofishing and gill net sampling will require nighttime sampling to increase the efficiency of fish capture.
- All fish sampling and handling techniques described within this study will be conducted under state and federal biological collection permits, and state and federal regulatory agencies will grant permission to conduct the sampling efforts.
- Fish sampling techniques provide imperfect estimates of fish use and abundance. Comparison of multiple sampling methods provides the opportunity to identify potential biases, highlight strengths and weaknesses of each method and ultimately improve estimates of fish distribution and abundance.
- Native salmonids utilize thermal refugia near the mouths of, or within, tributaries during the summer when mainstem Pend Oreille River temperatures exceed thermal

tolerance thresholds (approximately 15°C), providing a high likelihood of capturing target species if they are present.

- Some details of the sampling scheme have been provided for planning purposes; however, modifications may be appropriate as the initial results of 2006 reconnaissance sampling become available. A final sampling scheme will be developed by the Technical Consultant in the first quarter of 2007 in coordination with SCL and relicensing participants and after the results of the 2006 reconnaissance efforts are available.

Proposed Methodology

The work effort for active and passive fish sampling is divided into 14 tasks, as described below.

Task 1) Reservoir Gill Net Sampling

Deploy variable mesh gill nets approximately once per month during 2007 and 2008 (see Table 4.3-2). Depending on weather conditions, gill nets may not be deployed during December through February if freezing weather conditions restrict the use of nets. Gill nets will be deployed in a stratified sampling scheme designed to cover a range of habitat types. Where possible, similar habitat types will be sampled in each of three reaches (i.e., Upper Reservoir, Canyon and Forebay). The location of each gill net set will be mapped using handheld Global Positioning System (GPS) units and marked on high resolution aerial photographs. If a single net provides sufficient depth coverage, shallow water habitats (less than 50-foot depth) can be sampled using single gill nets set horizontally. Where the reservoir is greater than 50 feet but less than 100 feet, habitats will be sampled using paired horizontal sets, with one net deployed at the surface and one net deployed near the bottom. Deep water habitats, where the reservoir is greater than 100 feet deep, will be sampled using single gill nets deployed vertically. The length, number of panels, and mesh of the gill nets will be consistent with nets used by WDFW to sample the reservoir in 2000 (McLellan 2001).

Table 4.3-2. Proposed sampling methods and intensity for determining distribution, timing, and abundance of fish in Boundary Reservoir.

Sample Method	Sample Period [1] (2007/2008)	Survey Frequency	Sample Time (day/night)
Gill net	Jan – Dec	monthly	night
Electrofishing	Jan – Dec	monthly	day and night
Angling	Mar – Nov	monthly	day and night
Mainstem fyke net	Mar – Nov	monthly	night
Tributary fyke net	Mar –- Nov	6 days/month	day and night
Tributary snorkeling	Mar – Nov	monthly	night

1 No boat work will occur in the reservoir Forebay Reach during periods of potential spillway use.

For planning purposes, it is assumed there will be five sample sites in each of the Upper Reservoir, Canyon, and Forebay reaches. The Upper Reservoir Reach is assumed to consist of three shallow-water sites and two moderate-depth sites. The Canyon and Forebay reaches are assumed to consist of three deep-water sites, one moderate depth site and one shallow-water site per reach. In addition to the 15 sample sites identified through a stratified sampling scheme, two additional sites will be selected if needed to increase the capture of native salmonids for the biotelemetry studies. Gill net soak times are assumed to consist of three 1-hour sets per site; however, the soak time may be adjusted based on mainstem water temperatures and potential mortality of native salmonids. If the mortality or injury rate of captured fish becomes unacceptable, sampling frequency for gill nets may be reduced to less than once per month. If fish mortalities associated with gill net sets are acceptable to the regulatory agencies, overnight gill net sets may be substituted for two 1-hour sets for some months of the year.

Task 2) Tailrace Gill Net Fishing

Deploy variable-mesh gill nets, horizontally in the pool at the base of the spillway, within the turbine outfall pool, and at one site near or below the hydraulic control below the tailrace, for at least three 1-hour sets during monthly sampling efforts (Table 4.3-3). Deep pools near the base of the dam may contain exposed rebar or jagged pieces of concrete and where the water depth exceeds 50 feet, gill nets will not be deployed within 20 feet of the channel bottom. Gill nets will also not be deployed within 20 feet of the dam structure to avoid potential entanglement with protruding rebar and construction debris. Sample sites located in water exceeding 50 feet will consist of paired net sets, with one net set towards the surface and one net set mid-water column. The location of each gill net set will be mapped using handheld GPS units and marked on high-resolution aerial photographs. The gill net soak time will be developed in coordination with the relicensing participants after the results of the 2006 gill net reconnaissance efforts are available. The length, number of panels and mesh of the gill nets will be consistent with nets used by WDFW to sample the reservoir in 2000 (McLellan 2001).

Table 4.3-3. Proposed sampling methods and intensity for determining timing, distribution and abundance of fish in the Tailrace Reach.

Sample Method	Sample Period (2007/2008)	Surveys Frequency	Sample Time (day/night)
Electrofishing	Jan – Dec	1	day and night
Snorkel	Jan – Dec	1	day and night
Gill Net	Apr – Nov	1	night
Fyke Net	Apr – Nov	1	night

Task 3) Reservoir Electrofishing Sampling

Conduct monthly, boat-mounted electrofishing surveys using standardized transects within the Upper Reservoir, Canyon, and Forebay reaches of Boundary Reservoir (see Table 4.3-2). The electrofisher will be operated and configured with settings consistent with guidelines established

by WDFW (WDFW 2005). For planning purposes, it is assumed there will be eight sample transects in the Upper Reservoir Reach, six sample transects in the Canyon Reach, and four sample transects in the Forebay Reach. The location of each electrofishing transect will be mapped using handheld GPS units and marked on high-resolution aerial photographs. Where significant portions of transects are too shallow to be sampled using a boat-mounted electrofisher, select portions of transects will be sampled using a backpack-mounted electrofisher.

To the extent possible, electrofishing transects will be standardized and repeated during each sampling period to evaluate temporal changes in fish distribution. Habitat measurements will be collected at each site and changes noted between sample periods. The length and width of each sample transect will be recorded, and a map of each transect developed showing the bottom profile, substrate, macrophytes and other cover types. The electrofishing start and stop times will be recorded and the reservoir water surface elevation relative to an arbitrary benchmark will be measured using a hand level. The site of fish captured during each electrofishing effort will be recorded on a map of the sample area. Where safety concerns can be adequately addressed, electrofishing will be conducted after sunset; otherwise electrofishing surveys will be conducted during daylight hours.

In order to develop HSI information, mean column velocity information will be collected when target lifestages and species are captured (see list of target species and lifestages in the HSI-Fish component of the Mainstem Aquatic Habitat Modeling Study, section 4.1). The velocity data associated with capture sites, and depth and substrate information from the transect maps will allow the development of HSI data for validation of literature-based HSI curves.

The electrofishing transects will be used in conjunction with stranding and trapping surveys described in the HSI-fish component of the Mainstem Aquatic Habitat Modeling Study (section 4.1).

Task 4) Tailrace Electrofishing

A boat-mounted electrofisher will be used to sample standardized transects within the tailrace area between Boundary Dam and the U.S.-Canada border (see Table 4.3-3). For planning purposes, it is assumed that four transects will be surveyed in the Tailrace Reach. The electrofisher will be operated and configured with settings consistent with guidelines established by WDFW (WDFW 2005). The location of each electrofishing transect will be mapped using handheld GPS units and marked on high-resolution aerial photographs. To the extent possible, electrofishing transects will be repeated during each sampling period to evaluate temporal changes in fish distributions. Where safety concerns can be adequately addressed, electrofishing will be conducted along two transects during daylight hours and conducted along all four transects during nighttime hours.

Task 5) Reservoir Fyke Net Sampling

Conduct fyke net sampling using fyke nets set overnight once per month in shallow (≤ 6 feet deep), slow-velocity (< 1 feet per second) areas of Boundary Reservoir (Table 4.3-2). For planning purposes, it is assumed that two fyke nets will be deployed in the Upper Reservoir

Reach, one net deployed in the Canyon Reach, and one net deployed in the Forebay Reach. Each fyke net will be configured with one or two wings to guide fish to the net mouth. A live car with a watertight reservoir will be located at the small end of the fyke net throat to hold captured fish until they can be processed. The live car will be checked regularly to ensure that captured fish do not become stranded during receding water levels. The location of the fyke net sets will be mapped using a handheld GPS unit and marked on high resolution aerial photographs.

Task 6) Tailrace Fyke Net Trapping

Conduct fyke net sampling using one fyke net set overnight once per month in a shallow (≤ 6 feet deep), moderate-velocity (< 3 feet per second) area of the Tailrace Reach (see Table 4.3-3). The fyke net will be configured with one or two wings to guide fish to the net mouth. A live car with a watertight reservoir will be located at the small end of the fyke net throat to hold captured fish until they can be processed. The live car will be checked regularly to ensure that captured fish do not become stranded by receding water levels. The location of the fyke net set will be mapped using a handheld GPS unit and marked on high-resolution aerial photographs. The location of the fyke net may vary between sampling periods to maximize the opportunity to identify a location where fish can be captured; however, due to the high velocities experienced in the tailrace during periods of power generation, there may be few potential sites to install a fyke net. Placement of super sacks, or other environmentally-friendly anchoring techniques, may be needed to deploy fyke nets in the tailrace.

Task 7) Tributary Fyke Net Sampling

Deploy fyke nets designed to collect downstream migrating fish near the mouth of Slate, Sullivan, Flume, Sand, and Sweet creeks. The nets will be installed in a run habitat section of the tributaries above the reservoir fluctuation zone. Once a satisfactory site has been identified, the same location will be used during each of the subsequent collection periods. The traps will be operated continuously for a three-day period every two weeks from March through November 2007 and 2008, weather and flow conditions permitting. Each fyke net will be configured with two wings to guide the majority of water and fish to the net mouth. Where possible, the guide nets will be configured to maintain a narrow open channel along one bank. Where the channel size or configuration does not allow an open channel to be maintained, the area below the fyke net will be checked regularly to asses whether fish are blocked and cannot pass upstream. A live car will be located at the downstream end of the fyke net throat to hold captured fish until they can be processed. The fyke net wings and live car will be checked regularly to clear debris and to ensure that captured fish do not become injured. The location of the fyke net sets will be mapped using a handheld GPS unit and marked on high-resolution aerial photographs.

Task 8) Tributary Snorkeling

Two experienced biologists will conduct monthly nighttime snorkel surveys within 1,000-foot reaches starting within or below the reservoir fluctuation zone and extending upstream into the tributary above the maximum reservoir water surface elevation in Slate, Sullivan, Flume, Sand, and Sweet creeks. Snorkelers will record water temperatures at the start and end of the survey and will visually identify and record the number of fish by size and species. The location of each snorkel survey transect will be mapped using handheld GPS units and marked on high-resolution aerial photographs.

Task 9) Tailrace Snorkeling

Two experienced biologists will conduct snorkel surveys along two standardized transects in littoral areas during both day and night during each field survey effort. Snorkelers will visually identify and record the number of observed fish by size and species. The location of each snorkel survey transect will be mapped using handheld GPS units and marked on high resolution aerial photographs.

Task 10) Angling

During field trips organized for gill net sampling, hook-and-line angling will be conducted on an opportunistic basis to sample near the mouths of Boundary Reservoir tributaries targeting the capture of native salmonids using artificial lures with single barbless hooks. The primary objective of hook and line sampling will be to capture native salmonids for use in biotelemetry studies; a secondary objective will be to evaluate seasonal fish distribution.

Task 11) Fish Handling

Record the date, start and stop times, and level of effort for all sampling efforts. Record water temperature and dissolved oxygen. Identify all captured fish to species, measure to the nearest millimeter (mm) total length, and weigh to the nearest gram (g). If present, observations of poor fish condition, lesions, external tumors or other abnormalities will be noted. When more than 30 fish of a similar size class and species of fish are collected at one time, the total number will be recorded and a subset of the sample measured and weighed to provide at least 30 measurements for each species and size class.

SCL will examine fish for external signs of gas bubble trauma when scheduled surveys below Boundary Dam are conducted within one week following a spill event. This evaluation will only occur if a scheduled fish sampling event occurs within one week following a spill event; no fish collection surveys will be scheduled specifically to evaluate evidence of gas bubble trauma on fish below Boundary Dam. Although a systematic appraisal of all fish captured will only be conducted during the one-week period following spill, records will be kept of any fish showing obvious signs of gas bubble trauma, regardless of when those fish are captured in relation to spill. The following information will be recorded for each fish showing signs of trauma: species, life-stage, and capture location, time, and date. All fish showing signs of trauma will be photographed.

Tissue samples will be collected from all captured bull trout and cutthroat trout using protocols prescribed by an accredited conservation genetics laboratory, such as the USFWS Region 1 Conservation Genetics Lab in Longview, Washington. All salmonids and smallmouth bass greater than 150 mm in length will be scanned for passive integrated transponder (PIT) tags using a portable tag reader. A PIT tag will be implanted into all native salmonids and smallmouth bass that do not have tags and are 150 mm and larger. If the fish are in good condition, numbered Floy, Petersen disc, or other external tags will be placed on all salmonids or bass greater than 150 mm in length. If appropriate, ice, aerators, and anti-stress (slime-coat) medications will be used to reduce stress and injury to captured salmonids. Sampling operations may be halted or modified at locations which have a high likelihood of capturing native

salmonids when water temperatures are high enough (greater than 20°C) to present a risk to captured native salmonids. This sampling effort will be coordinated with biotelemetry studies to maximize use of captured native salmonids.

If native salmonids are recaptured in the Box Canyon or Boundary Project tailrace that have exhibited continued efforts to move upstream, these fish will be considered for transport and release to upstream habitats. A decision to move a fish upstream will be developed in coordination with SCL, other relicensing participants, and Pend Oreille County PUD's upstream transport program. A decision to move a fish upstream will consider whether the natal stream can be identified through genetic testing and the value of gathering additional information on fish movement obtained by releasing the fish at its point of capture.

Task 12) Data Analysis

Evaluate spatial and temporal comparisons of catch per unit effort by species and sampling method and length/weight/condition factor. Identify sampling areas and reaches where there is spatial and temporal overlap by fish species utilizing Boundary Reservoir. Evaluate spatial and temporal overlap using the results of the gill net, electrofishing and angling efforts and the results of the biotelemetry tracking of native salmonids, smallmouth bass and triploid trout.

Native salmonid tissue samples will be provided to an accredited conservation genetics lab. SCL will fund the lab to conduct analyses to describe the genetic relationship of sampled fish with other samples taken in the general area. The contracted genetics laboratory must have access to the existing genetic signatures of bull trout from the Salmo River and the Lake Pend Oreille/Priest River populations and the existing genetic signatures of westslope cutthroat trout from Lake Pend Oreille and tributaries to Box and Boundary reservoirs. The statistical results should include the probabilities associated with correctly or incorrectly assigning the captured trout to nearby known populations (i.e., probabilities associated with Type I and Type II errors). The results of the genetics analyses will be provided to relicensing participants. Although the analyses will be done by the genetics lab, interpretation of the results will likely require consultation with SCL, other relicensing participants, and the Bull Trout Recovery Team.

Task 13) Alternative 2008 Reservoir Sampling Methods

Depending upon the results of the 2007 surveys, alternative sampling methods may be appropriate for the 2008 field season, including beach seines and other trap types. Beach seines can be a very effective capture method for some species and lifestages within some habitat types (e.g., gravel or sand substrates and a shallow, gradually sloping bathymetry). Because beach seine effectiveness is strongly influenced by site characteristics, comparisons between sites may be limited. If the currently proposed methods (gill net, electrofishing, fyke net, and angling) are ineffective during 2007, alternative sampling methods will be considered for 2008.

Work Products

A draft report describing survey methods, results of 2007 monitoring, and discussion of recommendations for 2008 fish sampling will be produced by December 31, 2007. A final report describing survey methods and results of 2007 and 2008 monitoring will be produced by

December 31, 2008. Electronic copies of processed data sheets will be made available upon request.

Schedule

The proposed schedule for completing the Passive and Active Sampling component of the Fish Distribution, Timing and Abundance Study is provided in Table 4.3-4.

Table 4.3-4. Proposed schedule for conducting Passive and Active Sampling study component.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	------							
Reservoir gill net sampling	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Monthly tailrace gill net sampling		▲▲▲	▲▲▲	▲▲▲		▲▲▲	▲▲▲	▲▲▲
Monthly reservoir electrofishing	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Monthly tailrace electrofishing	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Monthly reservoir fyke net	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Monthly tailrace fyke net sampling		▲▲▲	▲▲▲	▲▲▲		▲▲▲	▲▲▲	▲▲▲
Angling	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Tributary fyke net	▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Reservoir Beach seine*					▲▲▲	▲▲▲	▲▲▲	▲▲▲
Data analysis and reporting				---●				----■

* Alternative sampling methods to be considered for 2008 if other methods are ineffective.

Biotelemetry

Biotelemetry is the proposed method to collect behavioral, habitat utilization, and periodicity information for native salmonids in Boundary Reservoir and the Tailrace Reach. Due to the low density of native salmonids, particularly bull trout and westslope cutthroat trout in Boundary Reservoir, capture or observation methods such as electrofishing, gill netting, angling, traps, weirs, or snorkeling/scuba may not collect sufficient numbers of fish to draw conclusions concerning their use of reservoir habitats. In contrast to other methods, biotelemetry collects a relatively large amount of information on relatively few individuals.

Several assumptions, listed below, are associated with the use of the proposed biotelemetry survey techniques. If the following assumptions prove false, the study component may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- Adequate numbers of subject fish will be available for tagging. Native salmonids can be captured as part of the passive and active sampling described above and tagged without injury.
- Behavioral effects of fish capture and tagging can be identified and differentiated from behavioral responses to Project operations. If native salmonids are unavailable for tagging, brown trout and other non-native salmonids are not suitable surrogate species to evaluate behavior of native salmonids.
- Either radio or acoustic transmitters will be used in the Tailrace Reach. A decision on which technology to use will depend upon field testing conducted during 2006.
- Acoustic or Combined Acoustic and Radio Transmitter (CART) tags will be used in Boundary Reservoir because water depths in the Forebay and Canyon reaches are too deep to effectively use radio tags.
- A variety of transmitter sizes and longevities (5 to 10 sec pulse interval) will be used depending upon the size of fish available for tag implants:[3]
  - fish weighing 295 to 400 grams (approximately 325 to 360 mm in length)
    - position only – 180 to 320 day tag life
  - fish weighing 400 grams (approximately 360 mm in length) or larger
    - position only – 265 to 400 day tag life
    - depth/temp – 40 to 100 day tag life (2 to 5 sec pulse interval)
  - fish weighing 1,256 grams (approximately 535 mm in length) or larger (5 sec pulse interval)
    - CART – 661 days
- Priority for long-life/CART/depth/temperature transmitters, subject to fish size constraints, is as follows: 1) bull trout, 2) westslope cutthroat trout, 3) mountain whitefish. Long-life tags have a higher priority over depth/temperature tags.
- The risk of stress-related death or abnormal behavior from handling and the surgical procedure is too high when receiving waters are greater than 15°C.
- Nighttime mobile tracking can be conducted safely in Boundary Reservoir and tagged fish locations can be accurately determined.
- A level of effort is described for planning purposes, but the actual sampling program, including selection of equipment, pulse intervals, and battery size will be developed by the Technical Consultant[4] in coordination with SCL and relicensing participants.
- During mobile tracking, the location of the tracking boat, when maneuvered close to the apparent tagged fish position, is presumed to be the fish location.

[3] Fish sizes, pulse intervals, and tag longevity ranges are approximate and subject to change depending upon the choice of vendor for biotelemetry equipment and transmitters. Longer pulse intervals increase transmitter longevity, but increase the risk of non-detection of tagged fish. Larger batteries increase the longevity and size of transmitters, but also increases the minimum fish size required for tagging.

[4] The Technical Consultant that will conduct the studies is expected to be under contract by mid-January 2007 and will be responsible for obtaining biotelemetry equipment to be used in the study.

Proposed Methodology

The work effort for this study has been divided into five tasks, as described below.

Task 1) Deployment of Detection Equipment

Deploy an array of fixed directional and omnidirectional hydrophones/receivers and/or buoyed wireless hydrophones to detect tagged fish at strategic locations within the reservoir. The number, type and location of hydrophones/receivers and other aspects of study design will be developed by the Technical Consultant in coordination with SCL and relicensing participants. For planning purposes, receiver coverage should include the following locations:

- Sweet Creek above the confluence with the Pend Oreille River
- Pend Oreille River above Metaline Falls
- Sullivan Creek above the confluence with the Pend Oreille River
- Pend Oreille River below Metaline Falls
- Slate Creek above the confluence with the Pend Oreille River
- Pend Oreille River at the downstream opening of the Canyon Reach
- base of Pewee Falls
- the Boundary forebay area immediately downstream of the trash rack
- Boundary Dam left and right bank spillways
- Boundary spillway tailrace and turbine outfall pools
- Pend Oreille River at the U.S./Canadian border
- Lomond and Russian creeks above the confluence with the Pend Oreille River
- Pend Oreille River near the confluence of Red Bird Creek (near the upper end of Seven Mile Reservoir under minimum operating pool levels)

BC Hydro is planning to conduct biotelemetry studies of the Salmo River and lower Seven Mile Reservoir in 2007 and receivers installed as part of those efforts may be substituted for the Pend Oreille River near Red Bird Creek receiver (personal communication, James Baxter, biologist, BC Hydro, February 9, 2006). One or more receivers will also need to be installed immediately below Box Canyon Dam; however, these receivers may be provided by Pend Oreille County PUD. Biotelemetry studies are being conducted by the PUD in response to Box Canyon Project licensing requirements (Pend Oreille County PUD 2006) and it is assumed that receivers installed by the PUD will be complementary to Boundary Project biotelemetry efforts.

Task 2) Fish Collection and Tagging

Fish to be implanted with tags will be captured as part of the Passive and Active Sampling component of the Fish Distribution, Timing and Abundance Study. Up to 30 bull trout, 30 mountain whitefish, and 30 westslope cutthroat trout from Boundary Reservoir will be tagged

with an acoustic or CART transmitter attached intraperitoneally using surgical techniques similar to those described by McCleod and Clayton (1997) and Brown et al. (1999). Tagged fish will be released in the vicinity of their capture location. Similarly, up to 20 bull trout, 20 cutthroat trout, and 20 mountain whitefish will be tagged and released in the Tailrace Reach. Surgery on the salmonids will only occur if subject fish can be released into water temperatures less than 15°C, either in the form of ambient mainstem temperatures or thermal refugia near tributary mouths. Each fish will also be tagged with a numbered Floy, Petersen disc, or other external tag, and a Passive Integrated Transponder (PIT) tag. Up to 20 smallmouth bass, captured during the springtime recreational bass derby, will be tagged with a CART or other transmitter and released. Coordination will occur with the Recreational Fishery Study (see 4.7) to recover any transmitters implanted in Floy-tagged fish captured and retained by anglers as part of the recreational fishery.

Task 3) Fixed and Mobile Tracking

During 2007 mobile tracking by boat will occur approximately every other week, weather permitting, during April through October. During November to March mobile tracking will occur once per month, weather permitting. Downloading of stored data and any required maintenance of fixed receivers will occur as part of tracking field trips. If the fixed receivers located at tributary mouths indicate that CART-tagged fish have entered a tributary, then the upper extent of tributary habitat use by these fish will be documented via mobile tracking. If mobile tracking in tributaries on the ground (on foot or by vehicle) cannot locate CART-tagged fish, at least two attempts at aerial tracking of tagged fish in tributaries using helicopter-mounted or airplane-mounted receivers will be conducted. Monitoring of tagged fish will continue for a second year (2008), but the frequency may be scaled back if the results of this and other ongoing studies indicate little movement occurs during some months. Any change to sampling frequency will be developed in coordination with relicensing participants. During mobile tracking, GPS units will be utilized to the extent adequate signals are available. Alternatively, tagged fish locations will be pinpointed on aerial photographs. Habitat information, utilizing underwater video, if necessary, will be collected at the location of tagged fish including water depth, velocity, temperature, substrate type, macrophyte density, and cover. Coordination will occur with the Recreational Fishery Study (section 4.7) to collect location information on transmitters implanted into triploid rainbow trout.

Task 4) Intensive Mobile Tracking

Intensive surveys will be conducted on a select number of tagged bull trout or cutthroat trout utilizing coldwater tributary delta habitats when mainstem water temperatures exceed 18°C. The intent of this task is to evaluate potential use of coldwater refugia by bull trout and cutthroat trout and the potential movement of bull trout and cutthroat trout in response to hourly water level fluctuations. If possible, locate and track fish tagged with transmitters outfitted with temperature/depth sensors. If not already present as part of Task 1, deploy one or more anchored hydrophones to monitor movements in and out of the coldwater refugia in the delta area. Utilize mobile tracking techniques on a 24-hour basis to obtain frequent (every 2 hours or less) positions to discern movements. Collect vertical temperature profiles at each tagged fish location. Ideally, the tracking team will obtain information over an entire 24-hour period on all of the tagged fish in a single tributary delta area, such as Slate Creek (or two adjacent coldwater tributary deltas).

Intensive mobile tracking will occur during at least three 24-hour periods during each study year, provided bull trout or cutthroat trout with active tags are available.

Task 5) Data Analysis and Report Preparation

Hourly operational information on Box Canyon Dam (flow) and Boundary Dam (flow and pool elevation) will be obtained. Conduct analyses to determine if spatial or temporal movement patterns of tagged fish are correlated with Box Canyon and/or Boundary Project operations. Analyze patterns of habitat utilization from data collected at tagged fish locations. Coordinate analysis of the data with the HSI-Fish component of the Mainstem Aquatic Habitat Modeling Study (section 4.1).

Work Products

Work products for the Biotelemetry study component include the following:

- Tabular summary of tagged fish length, weight, tag size and model, tagging date, release time, and release site.
- Tabular summary and GIS maps of tagged fish locations.
- Tabular and/or graphic summary of tagged fish habitat utilization.
- Draft and final reports describing the methods and results of the study component.

Electronic copies of process data sheets will be made available upon request.

Schedule

The schedule for completing the biotelemetry component of the Fish Distribution, Timing and Abundance Study is provided in Table 4.3-5.

Table 4.3-5. Schedule for completing the Biotelemetry study component.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
Install fixed receivers	▲							
Monitor fish movements using fixed receivers [1]		---	---	---	---	---	---	---
Monthly mobile tracking [1]		▲ ▲ ▲	▲ ▲ ▲	▲ ▲	▲ ▲	▲ ▲ ▲	▲ ▲ ▲	▲ ▲
Data analysis and reporting				---●				---■

1 Timing and duration of fish tracking assumes that target species implanted with radio/acoustic tags are available for tracking.

4.3.6. Consistency with Generally Accepted Scientific Practice

Passive and Active Sampling — Electrofishing, gill nets, minnow traps, and fyke nets are commonly used methods for sampling fish populations (Murphy and Willis 1996; Backiel and Welcomme 1980). Angling is primarily proposed as a collection method to obtain fish for biotelemetry studies rather than a tool for sampling the population, but some biological information (e.g., length and weight) of captured fish will also be collected. Angling using single barbless lures or flies has become a common method for capturing subject fish (especially bull trout) for biotelemetry studies (e.g., Chamberlain 2002; Pillipow and Williamson 2004).

Biotelemetry — Biotelemetry studies on native salmonids and other fish species has occurred as part of licensing studies for the Box Canyon Project (Pend Oreille County PUD 2000) and the Lower Clark Fork Projects (Noxon Rapids and Cabinet Gorge) (Avista Corporation 2005, Weitkamp et al. 2003). Biotelemetry studies have also been recently completed at the Albeni Falls Project to evaluate the need and feasibility of providing passage at that project (Geist et al. 2004, Scholz et al. 2005). This study proposal utilizes methods similar to those used at these nearby hydroelectric projects.

4.3.7. Consultation with Agencies, Tribes, and Other Stakeholders

2006 Early Information Studies — During a November 30, 2005, relicensing workshop, SCL was asked to consider initiating biological studies of fish distribution and movement during 2006 prior to submittal of the PSP. SCL had not planned to initiate field studies in 2006 in advance of the formal PSP process. However, in response to input from relicensing participants, SCL reallocated funds allowing for limited investigations to support study planning and design. The scope of these 2006 efforts was discussed at Fish and Aquatics meetings held on February 1 and February 16, 2006, and a conference call held on March 8, 2006. During these meetings and the conference call, relicensing participants requested that biotelemetry studies of native salmonids be initiated in 2006. In response, SCL developed a list of potential study efforts related to biotelemetry study design. During the summer and fall of 2006, SCL implemented the following studies, which were ranked highest in addressing biotelemetry study design uncertainties:

- *Conduct Gill Net Sampling to Evaluate Presence of Native Salmonids within Boundary Tailrace Area* — Determine whether target species (bull trout, rainbow and westslope cutthroat trout, and whitefish) can be captured in the Boundary tailrace area using gill nets and angling.
- *Conduct Gill Net Sampling to Evaluate Presence of Native Salmonids at Mouth of Select Boundary Reservoir Tributaries* — Determine whether target species (bull trout, rainbow and westslope cutthroat trout, and whitefish) can be captured at the mouth of selected tributaries to the Boundary Reservoir using gill nets and angling.
- *Test Use of Biotelemetry Systems* — Identify the effective range of acoustic and radio biotelemetry systems to support the design of biotelemetry studies to be conducted in 2007 and 2008.
- *Evaluation of Boundary Tailrace Access* — Identify conditions affecting boat launch and retrieval at Boundary tailrace boat ramp and hydraulic conditions affecting use of boats in Boundary tailrace area.

Terrapin Environmental of Twisp, Washington, was hired by SCL to conduct monthly gill net and angling surveys in the Boundary tailrace and at the mouth of four Boundary Reservoir tributaries during July through November 2006. LGL Limited of Ellensburg, Washington, was selected by SCL to conduct the evaluation of acoustic and radio biotelemetry in the Boundary tailrace and forebay areas. Final reports of these 2006 study efforts will be available to relicensing participants by early 2007.

Passive and Active Sampling — Input regarding the Passive and Active Sampling component to the Fish Distribution, Timing, and Abundance study was provided by relicensing participants during workgroup meetings. Workgroup meetings were held in Spokane, Washington, on May 23, 2006, and in Metaline Falls, Washington, on June 27, 2006. During the May workgroup meeting, an outline for sampling the Tailrace Reach was presented and discussed with relicensing participants. During the June meeting, an outline for sampling Boundary Reservoir was presented and discussed. The proposed Passive and Active Sampling component to the study plan was developed from these outlines and relicensing participant comments. Comments provided by relicensing participants on the review outlines for this study component are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Fish Distribution, Timing and Abundance study outlines presented at the workgroup meetings. However, the USFWS noted a concern about the use of Floy tags as external markers for native salmonids. Because Floy tags will also be used for triploid trout, the USFWS noted that anglers may misidentify native salmonids, which could lead to inadvertent take of protected species. SCL acknowledges the potential problem and has modified the study plans to consider the use of alternative external tags. As noted in the proposed study plan, final implementation details for the study components will be developed in early 2007 when the Technical Consultant finalizes the study implementation details in coordination with SCL and relicensing participants. The color, size, and marking of external tags, if used, will be developed by species and coordinated with relicensing participants.

In a letter to SCL dated August 28, 2006, WDFW submitted questions regarding the number of sample sites and sampling locations (see letter from WDFW included in Attachment 4-1). SCL provided additional detail in the study plans and intends to finalize the study implementation details when the Technical Consultant is retained in early 2007. Any remaining questions regarding the sampling strategy will be addressed in coordination with relicensing participants at that time. WDFW commented that collecting samples of stomach contents from smallmouth bass during the annual bass fishing derby was inadequate to draw conclusions regarding predation. In addition, WDFW noted that an extensive stomach content sampling program involving both native and non-native salmonids would be necessary if the objective is to evaluate potential competition for forage resources. In response, SCL dropped the smallmouth bass stomach content sampling effort and dropped reference to evaluating potential salmonid competition from the study proposal.

In its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006b), the USFS recommended that a "Bull and Westslope Cutthroat Trout Genetic Study" be conducted, and if tagged fish are found to have originated from upstream areas, those fish be transported and released to their homewaters. In a follow-up conference call on September 8, 2006, USFS and SCL agreed that if tagged native salmonids were recaptured after exhibiting continued efforts to move upstream, those fish would be considered for upstream transport in coordination with relicensing participants. The USFS also recommended that Sand Creek be included for fyke net sampling, requested more extensive tributary snorkeling and electrofishing surveys, and requested that fish be examined for gas bubble trauma. In response, SCL modified the study plan to include Sand Creek for fyke net sampling, included examining fish in the Boundary tailrace for evidence of gas bubble trauma, but did not modify the study plan to include additional tributary snorkeling and electrofishing surveys.

General information on species and habitats in tributaries are available through habitat and/or fish surveys conducted during 1997, 1999, and 2000 (R2 Resource Consultants, Inc. 1998, Terrapin Environmental 2000, McLellan 2001). Snorkeling is proposed within 1,000 foot reaches starting within or below the reservoir fluctuation zone and extending upstream into the tributaries, but SCL is not proposing to conducted snorkeling and electrofishing of all representative tributary habitats to develop population estimates. As part of the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats study (see section 4.8), critical data gaps in high priority streams will be identified, and where appropriate, surveys will be conducted to fill those gaps. In the follow-up conference call on September 8, 2006, USFS staff indicated that they were in general agreement with the study outlines presented at the workgroup meetings. When compiled, the existing information, information developed in the lower tributary reaches, and through the Tributary Habitats study (see section 4.8) would be expected to meet the USFS's need for information on tributary habitats and biota.

Biotelemetry — Input regarding the Biotelemetry component to the Fish Distribution, Timing, and Abundance study was provided by relicensing participants during workgroup meetings. A workgroup meeting was held in Spokane on May 23, 2006. During this workgroup meeting, separate outlines for conducting biotelemetry in the Tailrace Reach and Boundary Reservoir were presented and discussed with relicensing participants. The proposed Biotelemetry component to the study plan was developed from these outlines and relicensing participant comments and recommendations. Comments provided by relicensing participants on the review outlines for this study component are summarized in Attachment 4-1 and can be found in meeting summaries available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

In its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006b), the USFS requested that a "Native Salmonid Presence and Migration Study" be conducted. The USFS requested that SCL conduct biological surveys and biotelemetry studies targeting salmonids. The requested study would involve both fixed receiver and mobile tracking, and tracking of radio-tagged fish that enter tributaries to the furthest upstream distance. SCL's proposed Fish Distribution, Timing and Abundance study, specifically the Biotelemetry component, was designed to provide the information requested by the USFS. As described in Task 3 of the Biotelemetry study component, if the fixed receivers located at tributary mouths

indicate that CART-tagged fish have entered a tributary, then the upper extent of tributary habitat use by these fish will be documented via mobile tracking. If mobile tracking in tributaries on the ground (on foot or by vehicle) cannot locate CART-tagged fish, at least two attempts at aerial tracking of tagged fish in tributaries using helicopter-mounted or airplane-mounted receivers will be conducted. In a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the study outlines presented at the workgroup meetings and that additional details of the study components can be developed in early 2007 when the Technical Consultant finalizes the study implementation details in coordination with SCL and relicensing participants.

4.3.8. Progress Reports, Information Sharing, and Technical Reviews

A draft report will be produced by December 31, 2007, describing the first year's tracking results, analyses, and recommendations, if any, for modifying 2008 tracking procedures. A final report describing the biotelemetry methods and results of 2007 and 2008 efforts will be produced by December 31, 2008. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with agencies, tribes, and other stakeholders to discuss the study results, as described in section 1.2.4 of this document. In addition, relicensing participants will have opportunities to discuss and comment on study progress during quarterly workgroup meetings and ad hoc subcommittee meetings, as needed.

4.3.9. Anticipated Level of Effort and Cost

Passive and Active Sampling — Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this study component at the Boundary Project range from $690,000 to $980,000, of which approximately 70 percent is anticipated for reservoir and tributary sampling and approximately 30 percent towards tailrace sampling; estimated study costs are subject to review and revision as additional details are developed.

Biotelemetry — The total estimated cost of implementing the Biotelemetry study component is expected to range from $600,000 to $750,000; estimated study costs are subject to review and revision as additional details are developed.

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4.4. Large Woody Debris Management Study

Woody debris can be an important component of aquatic habitat in both riverine and reservoir habitats (Bjornn and Reiser 1991, Northcote and Atagi 1997). Woody debris provides habitat complexity and cover for fish, provides substrates for periphyton and macroinvertebrates, and can contribute to the localized storage of sediments. As woody debris decomposes, it may also provide nutrients to the water column and sediments (Harmon et al. 1986). Large wood entering Boundary Reservoir may lodge along the reservoir margins or may float downstream. Wood entering the Project forebay area may collect along a log boom structure or may catch and be removed at trashracks. The Boundary Project does not have a formal large woody debris management plan, but wood periodically gathered from the log boom and trash rack is cut into pieces and made available at no charge to the recreational public for their use (e.g., firewood).

Large woody debris (LWD) in reservoirs can be divided into three categories, each with distinct biological functions, based upon wood location: 1) submerged LWD, 2) floating LWD, and 3) shoreline LWD; each of these three categories of LWD is described in more detail below.

Submerged LWD. The biological effects associated with submerged wood in reservoirs have been studied more thoroughly in systems containing warmwater fisheries than coldwater fisheries. Two reviews prepared by Ploskey (1985) and Laufle and Cassidy (1988) almost exclusively involve studies of warmwater lacustrine systems. During the late 1980s, several papers were published from field studies conducted in Wyman Lake, Maine, to determine the ecological importance of submerged pulpwood logs on fish (Moring et al. 1986; Negus 1987; Moring et al. 1989). All three of these papers showed that suckers and shiners were attracted to areas containing large concentrations of submerged logs, while yellow perch were more abundant in non-log areas.

A common practice observed throughout central and southeastern United States is the retention of standing timber during the filling of a new reservoir to provide fish and wildlife habitat (Laufle and Cassidy 1988). Studies have shown that such reservoir structures function well as fish attractants and produce higher standing crops of warmwater sport fish such as largemouth bass and crappie (Layher 1984; Willis and Jones 1984, as cited in Ploskey 1985).

In coldwater systems, selective clearing in the littoral zone and at the mouth of tributaries may reduce the accumulation of woody debris that could otherwise impede the movement, spawning, or feeding of salmonids (Faubert 1982, as cited in Ploskey 1985). Research on a small, uncleared reservoir located on the Falls River, British Columbia, determined the surfaces of standing flooded timber contained diverse and abundant periphyton and invertebrate communities (Anonymous 1983). Stomach analysis of cutthroat trout and Dolly Varden collected from the reservoir showed that more than half of the prey taken by these two species were found on the submerged tree surfaces, suggesting the standing submerged timber was highly important to the production of these two salmonid species. Northcote and Atagi (1997) reviewed proposed plans to harvest submerged timber in Nechako Reservoir, British Columbia, and concluded that the removal of standing, floating, and submerged trees in the littoral zone would negatively impact those species of periphyton and invertebrates that colonize the surface of submerged timber. The authors suggested that a reduction in these taxa could impair the

existing fish community's (including kokanee and rainbow trout) feeding, growth, and production potential.

Floating LWD. Information on the function of floating LWD in coldwater lakes and reservoirs is scarce. In warmwater lakes, floating rafts of wood provide rearing habitat and escape cover for juvenile fish, increase habitat complexity, and provide additional surface area for invertebrate production. On Cazenovia Lake, New York, Helfman (1979) observed that substantially greater numbers of juvenile warmwater species utilized the area directly beneath artificial floats compared to an adjacent empty frame control float. Predator species were also observed near the floats, but there was no evidence that the floating cover, rather than the presence of prey species, attracted the predators. Helfman (1979) suggested that the area of floats used in his experiments might have been too small to attract substantial numbers of predator fish species. Floating debris rafts likely provide larger juvenile and subadult salmonids cover from terrestrial predators. However, floating debris rafts may also provide nesting platforms and potential resting areas for avian piscivorous predators.

Shoreline LWD. If woody debris is delivered to Boundary Reservoir from tributaries or Box Canyon Reservoir, a portion could eventually become stranded on the floodplain or gravel bars and, when inundated during high pool conditions, increase the complexity of littoral habitats for aquatic invertebrates and fish. Wood remaining on the floodplain reduces water velocity, allowing suspended sediments to be deposited adjacent to the anchored wood. These sediments provide ideal conditions for the establishment of new riparian vegetation (Maser and Sedell 1994). Wood lodging along the tributary deltas may provide cover during upstream and downstream fish movements between tributaries and the reservoir environment.

4.4.1. Nexus Between Project Operations and Effects on Resources

Boundary Project operations may affect the volume and type of large wood within the Pend Oreille River through active removal of wood at trash racks and other Boundary Project facilities.

4.4.2. Agency Resource Management Goals

A broad set of agency management goals are provided in section 4.1.2. In regards to fisheries for the Colville National Forest, one of the Standards and Guidelines is "Maintain the general character of aquatic and riparian habitat features. Maintain a natural source of large woody debris to provide structural fish habitat" (USFS 1988). Similarly, in the USFS's Inland Fish Strategy (USFS 1995), one of the riparian goals is to "provide an amount and distribution of large woody debris characteristic of natural aquatic and riparian ecosystems."

4.4.3. Study Goals and Objectives

The goal of this study is to gather information pertinent to developing a large woody debris management plan under the new Project license. The objective of this study is to quantify the volume, type and location of large wood within Boundary Reservoir and evaluate management alternatives to increase the availability of large wood in the reservoir.

4.4.4. Need for Study

Summary of Existing Information

A log boom structure is employed in the Project forebay to intercept and contain large debris floating downstream and prevent floating debris from potentially interfering with Project operations. A trash rack measuring 290 feet long and 100 feet deep with a clear opening between bars of 5-1/2 inches is located at the entrance to the forebay and is designed to prevent woody debris and other objects from entering the intake tubes and potentially damaging turbines and other structural components to the facility. The Boundary Project does not have a formal large woody debris management plan, but wood periodically gathered from the trash rack and log boom is cut into pieces and made available at no charge to the recreational public for their use (e.g., firewood). The current distribution, size, and abundance of submerged, floating or shoreline wood within Boundary Reservoir has not been quantified.

Need for Additional Information

This study is needed to fill information gaps regarding current LWD management practices at Boundary Reservoir and to quantify existing LWD abundance and distribution. The size and volume of LWD annually removed at Boundary Dam should be quantified to identify the scope of existing wood removal operations and to identify alternative wood management opportunities.

4.4.5. Detailed Description of Study

Study Area

The study area includes all of Boundary Reservoir from Box Canyon Dam to Boundary Dam.

Proposed Methodology

A number of assumptions, listed below, are associated with the use of the proposed methodology. If the following assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- The volume and type of LWD within Boundary Reservoir may affect multiple resource values such as the productivity of aquatic habitats, recreational boating, Project operations and maintenance, bird nesting, availability of recreational firewood, cultural resources, and fishing access.
- Land-use management within the tributary drainage basins pertaining to the growth and potential recruitment of LWD is not affected by Boundary Project operations.
- The minimum size of wood to be classified as LWD will be determined by the Technical Consultant in coordination with SCL and relicensing participants; however, for planning purposes, the minimum size of wood to be classified as LWD is 30 cm in diameter and 3 m long (1.0 foot by 9.8 feet) (AREMP and PIBO 2004; USFS 2001; R2 Resource Consultants 2003).

The work effort for this study has been divided into five tasks, as described below.

Task 1) Existing LWD Management Activities at Boundary Project

Describe existing Boundary Project LWD management activities, including the timing, volume, and type of debris removed from trash racks and other Boundary Project facilities.

Task 2) Existing LWD Management Activities at Box Canyon Project

Contact and interview Pend Oreille County PUD representatives to identify LWD management activities associated with operation of Box Canyon Dam.

Task 3) LWD Mapping

In coordination with the Habitat Mapping effort in the Aquatic Habitat Modeling study (section 4.1), use aerial photos to map the existing distribution of LWD in Boundary Reservoir. Conduct a survey of reservoir shorelines by boat to verify the aerial photo mapping results. During the boat survey, determine the functional quality (e.g., size distribution and decay class) and volume of LWD sampled. Estimate the total LWD volume and size distribution along Boundary Reservoir shorelines.

Task 4) Quantify LWD Removal

Quantify the volume, size and type of wood removed from trash racks and other Boundary Project facilities.

Task 5) LWD Management Alternatives

Evaluate LWD management alternatives and potential effects on multiple resources in Boundary Reservoir. Potential management alternatives may include, but not be limited to, the following:

- Collect LWD at the Boundary Dam trash rack and log boom and release it into the Boundary Dam tailrace.
- Dispose of LWD collected at the Boundary Dam trash rack and log boom by cutting it up into recreational firewood, or other beneficial uses.
- Dispose of LWD collected at the Boundary Dam trash rack and log boom, and place and anchor the collected wood, or an equivalent volume of LWD obtained elsewhere, at suitable locations in Boundary Reservoir for enhancement of native salmonid aquatic habitat while avoiding the potential for fish entrapment.

4.4.6. Work Products

Work products for the Large Woody Debris Management Study include a tabular summary of LWD survey results. A draft report describing Boundary Reservoir LWD survey methods and results of 2007 monitoring, and an evaluation of the LWD management alternatives will be produced by December 31, 2007. A final report describing study methods and results will be produced by March 31, 2008.

4.4.7. Consistency with Generally Accepted Scientific Practice

Studies regarding the distribution and abundance of large woody debris are commonly conducted at many hydroelectric projects as part of FERC licensing (e.g., Watershed GeoDynamics 2005 and R2 Resource Consultants, Inc. 2003). The LWD survey proposed in the current study plan utilizes protocols similar to those performed at other hydroelectric projects.

4.4.8. Consultation with Agencies, Tribes, and Other Stakeholders

Input regarding the Large Woody Debris Management Study was provided by relicensing participants during Fish and Aquatic Workgroup meetings. An outline for the Large Woody Debris study plan was presented and discussed with relicensing participants during a workgroup meeting held in Metaline Falls, Washington, on June 27, 2006. The proposed Large Woody Debris Management Study plan was developed from the outline and relicensing participant comments. Comments provided by relicensing participants on the review outline for this study are summarized in Attachment 4-1 and can also be found in meeting summaries (available on SCL's relicensing website, http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the large Woody Debris Management study outline presented at the workgroup meeting. The USFS did not specifically reference the large woody debris study outline in its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), but in a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the outlines. As noted in the proposed study plan, additional details will be developed in early 2007 when the Technical Consultant finalizes the study implementation details in coordination with SCL and relicensing participants.

4.4.9. Schedule

The schedule for completing the Large Woody Debris Management Study is provided in Table 4.4-1.

Table 4.4-1. Schedule for completing the Large Woody Debris Management Study.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
LWD Mapping		---	▲ ▲ ▲					
Evaluate LWD Management Alternatives			---	---				
Reporting				●	---■			

4.4.10. Progress Reports, Information Sharing, and Technical Review

Draft and final study reports for this study will be available to relicensing participants. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with relicensing participants to discuss the study results, as described in section 1.2.4 of this document. In addition, relicensing participants will have opportunities to discuss and comment on the study's progress at quarterly workgroup meetings and ad hoc subcommittee meetings, as necessary.

4.4.11. Anticipated Level of Effort and Cost

Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $25,000 to $40,000; estimated study costs are subject to review and revision as additional details are developed. To obtain efficiencies in the overall relicensing work effort, portions of this study will be conducted in conjunction with the Habitat Mapping component of the Aquatic Habitat Model study.

4.4.12. Literature Cited

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4.5. Productivity Assessment

The productivity of aquatic systems is characterized by primary and secondary productivity. Primary production forms the basis of the food chain and refers to the rate of biomass formation of organisms that photosynthesize. Primary producers in aquatic systems include phytoplankton (free-floating algae), periphyton (algae attached to substrata), and macrophytes (plants large enough to be visible to the naked eye). The littoral habitat of the reservoir refers to the channel area where the level of light penetration reaching the bottom is sufficient for photosynthesis. This area usually supports larger and more diverse populations of periphyton and macrophytes than deeper water habitats. In addition to using energy from the sun, primary producers also need organic nutrients, such as carbon, nitrogen and phosphorus, for growth.

Secondary productivity forms the second level of the food chain and refers to the rate primary producers are synthesized into animal tissue. Examples of secondary producers in aquatic systems include zooplankton and benthic macroinvertebrates (BMI), which in turn are eaten by organisms higher in the food chain such as fish. Both primary and secondary productivity are important in riverine systems because it partially controls the magnitude of fisheries that can be sustained. Therefore, it is important to understand the productivity of the Boundary Reservoir reach of the Pend Oreille River and how the productivity may or may not be affected by alternative operational scenarios.

4.5.1. Nexus Between Project Operations and Effects on Resources

Operations of the Boundary Project affect the water depth and velocity of the Pend Oreille River and the frequency of inundating and dewatering portions of the littoral zone of Boundary Reservoir. These factors can directly influence the growth of periphyton, macrophytes, zooplankton and BMI, all which are indices of aquatic productivity.

4.5.2. Agency Resource Management Goals

Agency Resource Management Goals are described under the Mainstem Aquatic Habitat Modeling study plan (see section 4.1.2).

4.5.3. Study Goals and Objectives

The goal of the Productivity Assessment study is to determine the effects of current Project operations and alternative operational scenarios on primary and secondary productivity in Boundary Reservoir. The objective of this study is to quantify indices of primary and secondary productivity in reaches of the Pend Oreille River within the Boundary Project area under hydraulic conditions expected from alternative operational scenarios. The Productivity Assessment will consist of evaluating nutrients, phytoplankton, periphyton, and macrophytes as indices of primary productivity, and zooplankton and BMI as indices of secondary productivity.

4.5.4. Need for Study

Summary of Existing Information

Available information for Boundary Reservoir and other areas of the Pend Oreille River suggest the productivity is low. A study of water quality in the Pend Oreille River by the U.S. Environmental Protection Agency (EPA) in 1993 classified the system as oligo-mesotrophic based on nutrient concentrations, algal growth, and water clarity (EPA 1993). Oligotrophic systems are nutrient poor and contain little aquatic plant or animal life. Typically, oligotrophic systems have chlorophyll *a* concentrations less than 3 mg/m^3, total phosphorus concentrations between 5-10 µg/L, total nitrogen concentrations less than 250 µg/L, and Secchi depths greater than 16.5 feet. Boundary Reservoir has nutrient and phytoplankton values within these ranges (Table 4.5-1). Analysis of data collected in Boundary Reservoir between 1984 and 2002 shows a mean total phosphorus concentration of 11.3 µg/L and a mean total Kjeldahl nitrogen concentration of 93.8 µg/L (Land and Water Consulting 2004). Chlorophyll *a* has been reported at concentrations of 1–3 mg/m^3 and Secchi depths in the range of 9.8–19.5 feet. Although Boundary Reservoir is in the oligotrophic range based on nutrients and phytoplankton, it is classified as oligo-mesotrophic based on the presence of aquatic macrophytes.

Table 4.5-1. Comparisons of lake trophic standards to measurements of Boundary Reservoir.

	Trophic Type [1]	Chlorophyll *a* (mg/m^3)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Secchi Depth (ft)
Trophic Standards	Ultraoligotrophic	0.01–0.5	<1–5	<1–250	
	Oligotrophic	0.3–3			17.7–92.8
	Oligomesotropic		5–10	250–600	
	Mesotrophic	2–15			4.9–26.5
	Mesoeutrophic		10–30	500–1,100	
	Eutrophic	10-500	30-100		2.6-23
	Hypereutrophic		100->500	500–>15,000	1.3–1.6
Boundary Reservoir	Pend Oreille River at Metaline[2]		11.3	93.8	4.6–14.7
	Boundary Reservoir 1996[3]	1.4–2.9	4–17	<100–138	13.5–21
	Boundary Reservoir 2000[4]	1.05	11		10.5–-12.8

Source

1 Adapted from Wetzel (1983)
2 Ecology (2005)
3 Herrera (1998)
4 McLellan (2001)

Aquatic macrophytes refer to aquatic plants such as milfoil that use energy from the sun (i.e., autotrophs) to grow. Aquatic macrophyte biomass has been found to be greatest in the littoral regions of the Pend Oreille River at depths of less than 10 feet (Falter et al. 1991). Little to no growth has been found at depths greater than 18 feet. Maximum macrophyte biomass in the mainstem occurs in the latter part of July and in August (Pelletier and Coots 1990).

A baseline fisheries assessment in Boundary Reservoir conducted in 2000 also found productivity to be low. Mean chlorophyll *a* concentrations were 1.05 mg/M^3, periphyton chlorophyll *a* concentrations were 5.7 mg/m^3 and zooplankton abundance was an average of 5 organisms/L (McLellan 2001). These values are low when compared to other lakes and reservoirs (Table 4.5-2). This study found 18 species of phytoplankton with a mean density of 1,140 org/ml. All species were from four classes of phytoplankton: Clorophyta, Chrysophyta, Cryptophyta, and Eubacteria. The phytoplankton species found in Boundary Reservoir are dominated by cryptophytes, greens, and diatoms. This selection of species is indicative of populations early in succession prior to high grazing pressure, suggesting that grazing by zooplankton in Boundary Reservoir is low (McLellan 2001). Sixteen species of periphyton were also identified with a mean density of 2.59×10^6 organisms/m^2. This study also found 20 species of zooplankton with a mean density of 5 organisms/L. Densities of copepods were the highest during the summer, whereas rotifers were more abundant in the fall. The low density of cladocerans may have indicated heavy predation pressure, but McLellan (2001) also noted a general low abundance of fish in open-water habitats.

McLellan (2001) suggested that the short retention time of the Boundary Reservoir system may cause low densities of zooplankton because cladoceran generation times (>7.5 days) are longer than the retention time of Boundary Reservoir. The time required for water to pass through a reservoir is termed the hydraulic retention or residence time. Reservoir retention times are a function of inflow and reservoir capacity. The volume of Boundary Reservoir is relatively small, with 95,000 acre-feet of storage at the full-pool forebay elevation of 1,990 feet NGVD 29 (1,994 feet NAVD 88) and 43,000 acre-feet of storage available within the 40-foot maximum drawdown allowed under the current license. At full pool, the residence time of Boundary Reservoir is approximately 43.4 hours under the average annual inflow of 26,480 cfs (SCL 2006). At the 40-foot maximum allowable drawdown, the residence time of Boundary Reservoir is approximately 24.2 hours under the average annual inflow. The hydraulic retention time increases as inflow decreases, and during August low flow conditions, hydraulic residence times may exceed two weeks. In addition, there may be embayments with lower velocity water where hydraulic residence time increases. However, hydraulic retention times are influenced by reservoir capacity and inflow and during the majority of the year hydraulic residence time is measured in hours or days rather than weeks.

The total volume of water stored within Boundary Reservoir fluctuates on a 24-hour cycle due to the load-following operational strategy, as described in section 1.3.5. Under current operations, the reservoir pool level is usually maintained within a 10-foot daily drawdown cycle during the summer (forebay elevation 1,980–1,990 feet NGVD 29 [1,984–1,994 feet NAVD 88]). During the fall, winter and spring, the water surface elevation within the reservoir forebay is typically maintained between elevations 1,990 feet and 1,970 feet NGVD 29 (1,994–1,974 feet NAVD 88). Under the current load-following operational strategy, there is little net daily change in reservoir storage; in other words, on a daily basis, outflow equals inflow.

Productivity information is also available for Box Canyon Reservoir located immediately upstream of Boundary Reservoir. Data for Box Canyon Reservoir suggests productivity is slightly higher than in Boundary Reservoir, but still relatively low. Phosphorus concentrations

have been reported in the range of 10–40 µg/L (Skillingstad and Scholz 1993) and nitrogen concentrations in the range of 5–157 µg/L (Land and Water Consulting 2004). Falter et al (1991) reported peak chlorophyll *a* levels at 3.5 and 4.1 mg/m^3. One study found phytoplankton densities to be positively correlated to macrophyte biomass (Falter and Riggers 1993), suggesting that aquatic plants may be acting as a nutrient pump from the sediment to the water column through their growth and senescence (FERC 2000). Zooplankton data were collected at 11 sites in Box Canyon Reservoir in both the littoral and deep water areas in 1989 and 1990 (Ashe et al. 1991). Zooplankton abundance was higher in the littoral areas (mean of 34.5 organisms/L) than in the mid-channel areas (mean of 12.3 organisms/L). A different study on the effects of the Ponderay pulp and paper mill built on the Pend Oreille River in Box Canyon Reservoir also studied zooplankton communities (Skillingstad et al. 1993). This study found 22 species of zooplankton from 15 genera. Mean densities ranged from 8.5 to 22 org./L with monthly mean concentrations highest in June and August and lowest in October and April. These values are medium to low when compared to densities from other lakes (Table 4.5-2).

Table 4.5-2. Comparison of primary and secondary productivity in Boundary Reservoir and other lakes and reservoirs.

Location	Chlorophyll a Concentration (µg/L)	Zooplankton Abundance (organisms/L)
Boundary Reservoir	1.05 (1)	5 (1)
Box Canyon Reservoir	1.02 (2)	Main channel – mean 12; range 3-40 Littoral – mean 34; range 3-149 (3)
Sprague Lake	36.3 (1)	40 (1)
Rock Lake	19.6 (1)	2 (1)
Deer Lake	2.0 (1)	109 (1)
West Medical Lake		204 (1)
Lake Michigan	1-3 (4)	91 (4)
Lake Erie	1-7 (5)	322 (4)

Source

1 McLellan (2001)
2 Falter et al. (1991)
3 Ashe et al. (1991)
4 Makarewicz et al. (1994)
5 World Lakes Database (2006)

Need for Additional Information

Available information indicates that under existing conditions primary and secondary productivity in Boundary Reservoir is low. The operation of Boundary Reservoir has the potential to affect aquatic productivity by changing the frequency of inundation and dewatering of littoral habitats, which potentially support higher densities of periphyton and macrophytes than deeper water habitats. Water depth and velocity in both littoral and deep water habitats may change under potential alternative operational scenarios, thereby affecting primary and secondary productivity. Primary and secondary productivity form the basis of the food chain and

affect the abundance, growth, and distribution of fish within Boundary Reservoir. As such, it is important to understand both aquatic productivity under existing conditions and how aquatic productivity may or may not be affected under alternative operational conditions.

4.5.5. Detailed Description of Study

Study Area

The study area for this study includes Boundary Reservoir and an approximately 4-mile reach of the Pend Oreille River downstream of Boundary Dam. (Refer to section 1.3 of this PSP for a description of the Boundary Project location, facilities, and reservoir.) The Aquatic Habitat Model, which will be used to evaluate the effects of alternative operational scenarios on aquatic habitats and biota in the Pend Oreille River, will be developed for the Pend Oreille River between the confluence with Red Bird Creek (RM 13.1) upstream to Box Canyon Dam (RM 34.5). For purposes of the Aquatic Habitat Model development and Productivity Assessment, four reaches have been identified to describe this area. The first reach (Upper Reservoir Reach) is from Box Canyon Dam downstream to Metaline Falls. This reach is wide and shallow with a gentle slope. The second reach (Canyon Reach) is from Metaline Falls downstream to the mouth of the canyon. This reach is characterized by a deep, narrow gorge with steep walls. The third reach (Forebay Reach) is from the mouth of the canyon downstream to Boundary Dam. This reach is relatively wide and deep. The last reach (Tailrace Reach) is from Boundary Dam downstream to the confluence with Red Bird Creek. This reach is regulated both by flow releases from Boundary Dam and the operations at Seven Mile Reservoir. SCL will continue discussions regarding the downstream extent of studies with relicensing participants during the fall of 2006, and if deemed appropriate, SCL may limit downstream investigations to the U.S.-Canada border.

Proposed Methodology

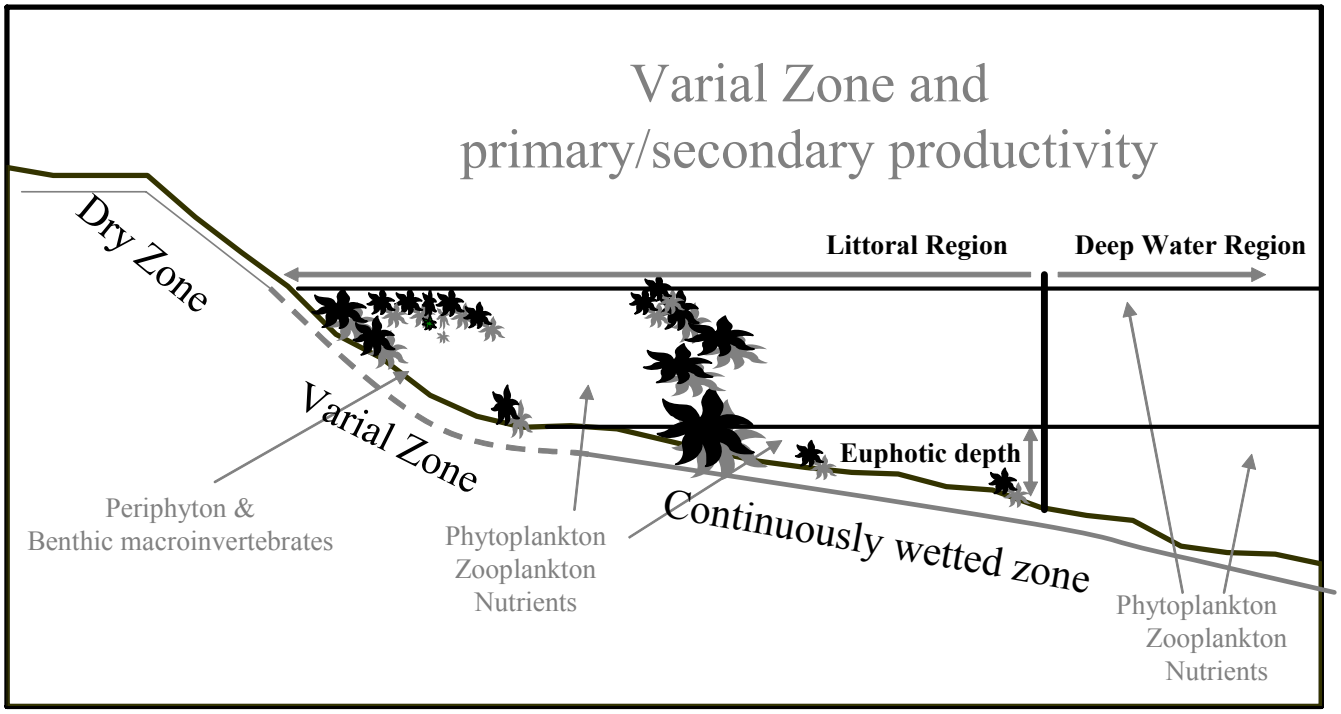
The effects of Project operations on aquatic productivity will be described using six indices of productivity (nutrients, phytoplankton, periphyton, macrophytes, zooplankton, and BMI) (Figure 4.5-1). No attempt will be made to integrate the six indices into a measurement of total reservoir productivity, and the number of organisms potentially produced under each operational scenario will not be quantified. Instead, each of the indices will be assessed as a potential percent change from existing operations, and each constituent will be evaluated and reported as a separate index of productivity. Two separate approaches are proposed for the assessment. The first approach will be used for the attached fauna (macrophytes, BMI, and periphyton). The second approach will be used for nutrients and planktonic fauna.

The methodology for macrophytes, BMI, and periphyton will be to calculate potential habitat indices for existing operations and alternative operational scenarios using the Aquatic Habitat Model (described in section 4.1) and the Scenario Tool (described in section 1.4.3) (Figure 4.5-2). Data describing the physical and hydraulic characteristics of the Pend Oreille River will be collected along transects and potential habitat conditions modeled under the Aquatic Habitat Modeling study. Information on the response of macrophytes, BMI, and periphyton to changes in hydraulic conditions will be developed as part of the Habitat Suitability Index (HSI) study (see section 4.1). Habitat suitability information (i.e., HSI curves) represent a functional relationship

between the independent variables depth, velocity, substrate, and frequency of inundation/dewatering and the response of organisms to a gradient of the independent variable (suitability), which is expressed over a scale of 0.0 (poor) to 1.0 (best). Output from the Scenario Tool and the Hydraulic Routing Model (see section 4.1) will predict hourly flow and water surface elevations at transects within the Project area. The Aquatic Habitat Model will be used to predict depth and velocities within cells, or transect subdivisions. The HSI curves will be used in the aquatic habitat model to quantify the area of Pend Oreille River channel containing potentially suitable habitat. This process will be repeated to determine an index of potential productivity for each of the macrophyte, BMI, and periphyton indices under existing operations and for alternative operational scenarios to be evaluated by the Technical Scenarios Team.

Productivity for nutrients, phytoplankton, and zooplankton will be estimated using measurements of upper and lower bounding conditions, and interpolation between those bounds to estimate productivity under alternative operational scenarios (Figure 4.5-2). Measurements of nutrients, phytoplankton, and zooplankton will be collected in Boundary Reservoir under operational and environmental conditions experienced in 2007 and 2008. The measurements of Boundary Project conditions will represent one bounding condition and will be compared to measurements of conditions in the Box Canyon tailrace or the Box Canyon Reservoir as the other bounding condition. Box Canyon Reservoir is located immediately upstream of the Boundary Project and is exposed to a smaller range of pool level fluctuation. Measurement of productivity indices in areas exposed to either Boundary or Box Canyon operations will represent a contrast in operational conditions, and the effects of alternative Boundary Project operational scenarios will be interpolated between the two bounding scenarios.

The effects of Boundary Project operations on nutrients, phytoplankton, and zooplankton may vary between littoral habitats and deep water habitats. The littoral area is assumed to extend to the euphotic depth below the maximum reservoir drawdown for the time period under consideration. The euphotic depth represents the depth where light intensity falls to 1 percent of the surface light. The euphotic depth will be estimated as three times the depth of Secchi disk readings (McLellan 2001). In order to evaluate both littoral and deep water habitats, Boundary Reservoir will be subdivided into deep water and littoral habitats based on the seasonal Secchi disk readings and channel cross-section data available from the Mainstem Aquatic Habitat Model (section 4.1). One result from the Mainstem Aquatic Habitat Model will be estimates of the amount of deep water and littoral habitat area under alternative operational scenarios. Measurements of nutrients, phytoplankton and zooplankton data will be collected in both littoral and deep water areas in Boundary Reservoir to represent one bounding condition. Measurements of nutrients, phytoplankton and zooplankton will also be collected in littoral and deep water habitats in the Box Canyon tailrace or reservoir. Interpolation between the bounding conditions (Boundary 2007/2008 operations compared to Box Canyon operations) may identify differences in the effects of Project operations between littoral and deep water habitats.



Deep and Littoral Regions

Nutrients: elements required for plant growth, generally nitrogen, and phosphorus

Phytoplankton: algae that grow in the open waters

Zooplankton : grow in the open water and feed on phytoplankton

Littoral Region

Macrophytes: aquatic plants that are either emergent, submergent, or floating

Periphyton: algae that grow on substrates, primarily in water penetrated by light

Benthic macroinvertebrates: grow on substrates, highest density of most species in water penetrated by light

Figure 4.5-1. Indices of primary and secondary productivity.

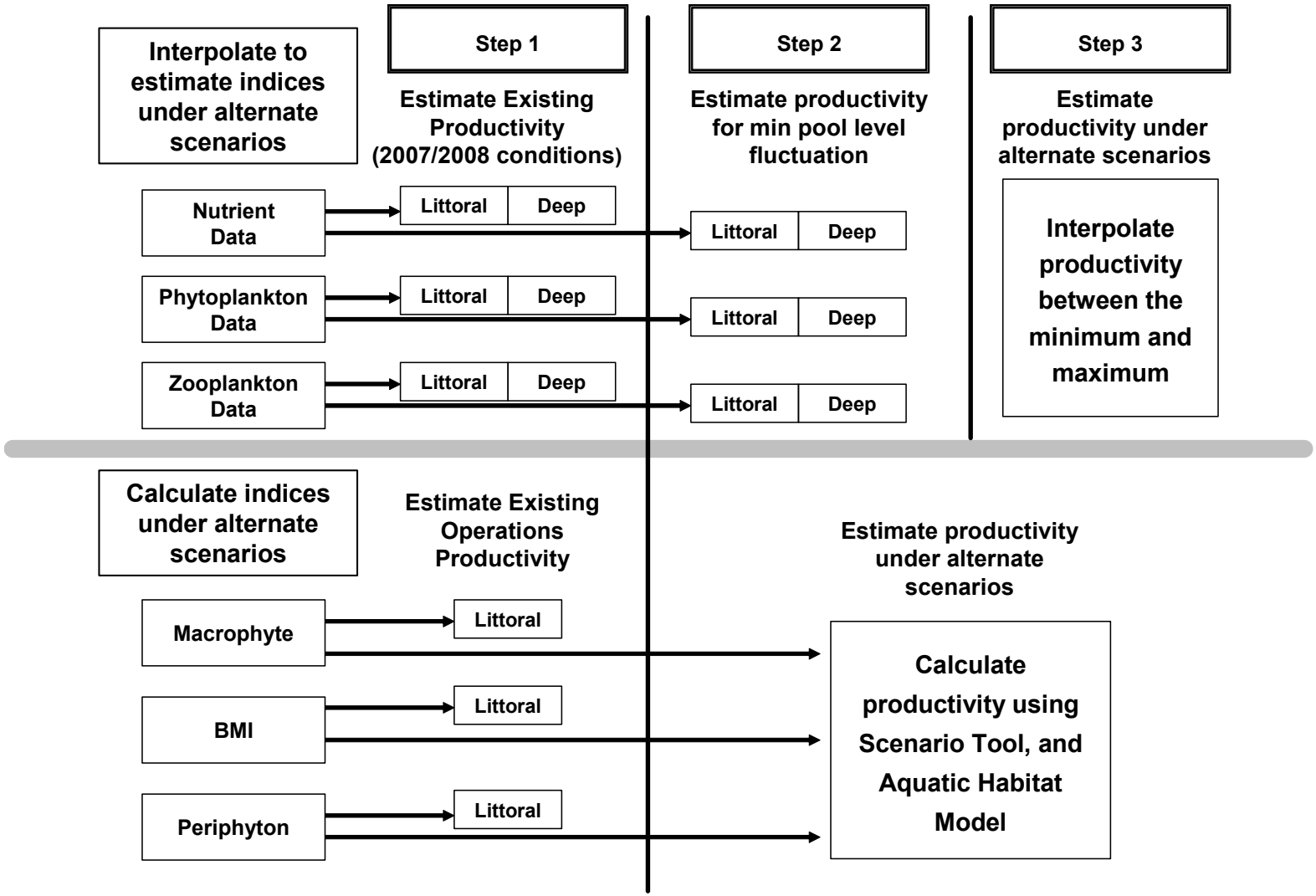


Figure 4.5-2. Productivity Assessment flowchart.

Macrophytes colonize littoral areas and supply food and shelter, which enhances invertebrate production. The effects of Project operations on littoral habitat productivity may also be affected by the presence or absence of submerged or emergent aquatic macrophytes. Measurements of nutrients, phytoplankton and zooplankton will be collected in littoral areas both within and outside of macrophyte beds as part of the Water Quality Constituent and Productivity Monitoring study (see section 3.3). If the presence of macrophytes is found to have a significant effect on nutrient, phytoplankton and zooplankton productivity, the assessment of the effects of Project operations on littoral habitats may be conducted separately for areas with and without macrophyte beds.

Specific steps for calculating macrophyte, benthic macroinvertebrate and periphyton indices, and interpolating productivity indices for nutrients, phytoplankton and zooplankton are outlined below.

Task 1) Data Collection and Compilation

Collect and compile data from other Boundary Project relicensing studies to be used in the productivity analyses. Indices of productivity to be analyzed are nutrients, phytoplankton, zooplankton, macrophytes, periphyton, and BMI for both the deep water and littoral habitats, if applicable (Table 4.5-3). Data will be compiled from the following studies: Water Quality Constituent and Productivity Monitoring, Relationship of pH and DO to Macrophytes, and Aquatic Habitat Model (Periphyton and Macroinvertebrates subsection).

a) Nutrient, Secchi depth, phytoplankton, and zooplankton data will be provided by the Water Quality Constituent and Productivity Monitoring study (methods are described in section 3.3). These data will be available at eight stations (Table 4.5-4) by season in deep water and littoral habitats (Table 4.5-5). Nutrient data will be in concentration form, Secchi depth data will be in feet, phytoplankton abundance will be in chlorophyll *a* concentration, and zooplankton data will be in organisms per unit volume. Additional indices of zooplankton abundance, such as species composition and size, will be developed as described in the Water Quality Constituent and Productivity Monitoring Study (see section 3.3). These indices are available to supplement and interpret changes in zooplankton abundance measured as organisms per unit volume. Nutrient data will only be available in the deep water habitats, while phytoplankton and zooplankton data will be available in the deep water habitat and littoral habitats without macrophytes. As described in the Water Quality Constituent and Productivity Monitoring Study (described in section 3.3), zooplankton will be collected every 2 hours over a 24-hour cycle to provide an indication of diurnal changes in the zooplankton community. Total phosphorus and total Kjeldahl nitrogen will be representative of nutrient requirements for productivity.

b) An assessment of macrophytes will be conducted under the Aquatic Habitat Modeling study, macrophyte HSI development subsection. This information will be used in the aquatic habitat model to estimate the potential colonization area for macrophytes under alternative operational scenarios. This information will then be combined with the information under the present study to estimate aquatic productivity for littoral habitats by reach.

c) Periphyton and BMI data will be provided by the Aquatic Habitat Model (Periphyton and Macroinvertebrate subsection). This study will provide HSI information, which will be used in the Aquatic Habitat Model to quantify the effects of Boundary Project operations on BMI and periphyton. This information will then be combined with the information under the present study to estimate aquatic productivity for littoral habitats by reach. It is assumed the BMI data will be summarized in number per unit area and periphyton data will be summarized in biomass or chlorophyll *a* per unit area.

d) Information on the morphology of the Pend Oreille River within the Boundary Reservoir will be available from the hydraulic routing component of the Mainstem Aquatic Habitat Modeling Study (see section 4.1). This information will be used to assess whether the primary study reaches (i.e., Upper Reservoir, Canyon, Forebay and Tailrace) should be sub-divided into separate zones for productivity field sampling. While Boundary Reservoir appears to be well-mixed, some reservoirs have embayments or arms that are hydraulically isolated from the main channel. For instance, the base of Pewee Falls is in a large embayment where the localized morphology may affect the hydraulic retention time, and thus, zooplankton productivity. If the Pewee Falls embayment is hydraulically isolated, separate zooplankton measurements may be appropriate for the main Forebay Reach and the Pewee Falls arm of the Forebay Reach.

Table 4.5-3. Summary of productivity data, study collecting the data, and study conducting the analysis.

Constituent	Primary/Secondary Productivity	Habitat (Deep Water or Littoral)	Constituent Description	Data Source	Analyses
Nutrients	Primary	Both	Concentration of phosphorus and nitrogen	WQ: C*onstituent and Productivity Monitoring*	F&A: *Productivity Analyses*
Phytoplankton	Primary	Both	Concentration of chlorophyll *a*	WQ: C*onstituent and Productivity Monitoring*	F&A: *Productivity Analyses*
Zooplankton	Secondary	Both	Number per liter, species present	WQ: C*onstituent and Productivity Monitoring* F&A: P*roductivity Analyses*	F&A: *Productivity Analyses*
Macrophytes	Primary (with Secondary influences secondary)	Littoral	Mapping, abundance, % native/non-native species	WQ: R*elationship of pH and DO to Macrophytes* F&A: *HSI-Macrophyte Assessment*	F&A: *Aquatic Habitat Model*
Periphyton	Primary	Littoral	Number per square meter, biomass	F&A: *Aquatic Habitat Model (Benthos subsection)*	F&A: *Aquatic Habitat Model*
BMI	Secondary	Littoral	Biomass, number per square meter, species present	F&A: *Aquatic Habitat Model (Benthos subsection)* F&A: *Productivity Analyses*	F&A: *Aquatic Habitat Model*

Notes:
F&A – Fish and Aquatics Study
WQ – Water Quality Study

Table 4.5-4. Summary of productivity data available from the Water Quality Constituent and Productivity Monitoring study.

Sample station	Location description	Productivity Data Collected
Box Canyon Tailrace	In Boundary Reservoir just downstream of Box Canyon Dam	Chlorophyll *a*, nutrients, zooplankton, Secchi depth
Wolf Creek	Pend Oreille River adjacent to Wolf Creek inlet (upstream of Metaline Falls)	Chlorophyll *a*, nutrients, zooplankton, Secchi depth
Metaline Old	Old channel of the Pend Oreille River across from the city of Metaline (upstream of Metaline Falls)	Chlorophyll *a*, nutrients, Secchi depth
Pend Oreille Mine	Downstream of mine tailings (downstream of Metaline Falls)	Chlorophyll *a*, nutrients, Secchi depth
Slate Creek	Downstream of Slate Creek across from campsite on left bank (downstream of Metaline Falls)	Chlorophyll *a*, nutrients, Secchi depth, zooplankton,
Everett Creek Island	Upstream of Everett Creek Island (downstream of Metaline Falls)	Chlorophyll *a*, nutrients, Secchi depth
Boundary Reservoir Forebay	Boundary Forebay	Chlorophyll *a*, nutrients, zooplankton, Secchi depth
Boundary Tailrace	Downstream of Boundary Dam	Chlorophyll *a*, nutrients, zooplankton, Secchi depth

Table 4.5-5. Summary of productivity methods used in the Water Quality Constituent and Productivity Monitoring study.

Parameter	Number of Analyses	Method
Secchi Depth	1 per station	Average of two readings in deep water habitats
Chlorophyll *a*	2 per station 3 per zooplankton station	One at surface and one at approximately 15 feet in the deep water habitat One in the littoral habitat without macrophytes
Nutrients (Kjeldahl nitrogen, total phosphorus, orthophosphorus)	1 per station	Surface sample in the deep water habitat
Zooplankton	4 tows per station	2 tows in the littoral habitat (without macrophytes) and 2 tows in the deep habitat

Task 2) Field Sampling

Conduct field sampling to collect additional remaining productivity data to be used in the productivity analyses. Collect field samples of nutrients, phytoplankton, and zooplankton in the Box Canyon Forebay in both the littoral and deep water regions for all seasons. Data will be collected in the deep water region and in both the macrophyte and non-macrophyte areas of the littoral region (see section 3.3).

Task 3) Estimate Productivity for Macrophytes, BMI, and Periphyton: Calculation Methodology

Calculate indices of aquatic productivity (weighted usable area) for macrophytes, BMI, and periphyton under existing operations and each alternative operational scenario using HSI curves and the aquatic habitat model. Each productivity constituent will be calculated and reported separately by reach. Using the HSI curves and information on the depth and velocity, the aquatic habitat model will identify a habitat preference for each cell of the model. Each of these cells will be combined to estimate a potential weighted useable area for macrophytes, BMI, and periphyton.

Task 4) Estimate Productivity for Nutrients, Phytoplankton, and Zooplankton: Interpolation Methodology

a) Calculate indices of aquatic productivity for the 2007/2008 operations. Use data collected in Boundary Reservoir in Tasks 1 and 2 along with estimates of the littoral and deep water areas from the aquatic habitat model and areas with and without macrophyte growth from the habitat mapping task to estimate indices of 2007/2008 productivity for nutrients, phytoplankton, and zooplankton.

b) Calculate aquatic productivity in Boundary Reservoir under the minimum expected range of pool level fluctuations. Nutrients, phytoplankton, and zooplankton will be calculated and reported on separately by littoral and deep water areas within each reach.

   Estimate productivity in the deep water regions of Boundary Reservoir. Use the deep water region productivity data collected for the Box Canyon Tailrace and Forebay sites in Tasks 1 and 2 to determine an appropriate productivity index value. This value is representative of productivity in the remainder of the reservoir under the scenario describing the minimum expected range of pool level fluctuations. Scale the minimum fluctuation scenario estimate by the total amount of deep region area (available from the Aquatic Habitat Model study) within each reach.

   Estimate productivity in the littoral regions of Boundary Reservoir by reach. Use the productivity data collected for the Box Canyon Tailrace and Forebay sites in Tasks 1 and 2 to determine an appropriate productivity index value. This value is representative of productivity in the remainder of the reservoir under the minimum fluctuation scenario. Scale the minimum fluctuation scenario estimate by the littoral region area (available from the Aquatic Habitat Model study) to estimate productivity for each reach. Data will be collected in Task 2 in both the macrophyte and non-

macrophyte regions of the reservoir and if significant differences are observed, productivity will be estimated in each of these areas separately.

c) Using the productivity bounds for the 2007/2008 operation and minimum pool level fluctuation scenarios calculated in Tasks 5 and 6 to estimate the relative amount of productivity under other operational scenarios. Relative productivity for other scenarios can be estimated by scaling the productivity information by the area of deep and littoral regions calculated for alternative operational scenarios in the Aquatic Habitat Model study.

The above interpolation methodology for nutrients, phytoplankton, and zooplankton relies on productivity information that may vary either longitudinally in the reservoir, in the deep water versus littoral regions of the reservoir, or in areas with and without macrophytes. For the interpolation methodology to be effective, it is assumed that the longitudinal variation in productivity is significantly less than the variation in productivity between the deep water and littoral regions. Box Canyon forebay and/or tailrace data will be used to estimate productivity at different locations in the reservoir under the minimum reservoir fluctuation scenario. However, it may not be appropriate to use the Box Canyon forebay or tailrace data if the longitudinal variation is substantial because it may not be representative of different locations in Boundary Reservoir. As a result, if data collection efforts find the longitudinal variation in productivity is significant, the outlined methodology will be inconclusive. Under these circumstances, the productivity analysis will instead have to rely on the measured data and general productivity characterizations to assess productivity under alternative operational scenarios.

Task 5) Compilation of Results

Compile a table using the calculations completed in Tasks 1 through 4 of the percent change in productivity comparing alternative operational scenarios to 2007/2008 conditions (nutrients, phytoplankton and zooplankton), or an existing operations scenario (macrophytes, BMI and periphyton). Each of the indices will be assessed as a potential percent change and each constituent will be evaluated and reported as a separate index of productivity. No attempt will be made to integrate the six indices into a single measurement of reservoir productivity, and the number of organisms potentially produced under each operational scenario will not be quantified. Summary data will also be provided by reach and by littoral or deep water habitat in supporting documentation.

4.5.6. Work Products

The results of the productivity study will be compiled and presented in a draft and final study report. The report will include the following information:

- A description of data collection methods
- A summary of field data compiled from other relicensing studies used in the analysis
- A summary of field data collected under the present study for the analysis
- A description of productivity calculations
- A discussion of 2007/2008 productivity conditions within Boundary Reservoir

- A comparison of productivity under alternative operational scenarios

A draft report will be produced by June 30, 2008, and a final report will be produced by August 31, 2008.

4.5.7. Consistency with Generally Accepted Scientific Practice

The methods described herein have been developed in consultation with the agencies, tribes, and other stakeholders. All data collection efforts will follow state or federal guidelines. In addition, any laboratory analysis will be conducted by an Ecology- or EPA-certified facility.

4.5.8. Consultation with Agencies, Tribes, and Other Stakeholders

Input regarding the Productivity Assessment study was provided by relicensing participants during Workgroup meetings. Workgroup meetings were held in Spokane, Washington, on June 27, 2006, and on August 14, 2006. During the June workgroup meeting, an outline for the Productivity Assessment study plan was presented and comments were provided by relicensing participants. The proposed Productivity Assessment study plan was developed from the outline based on agency and relicensing participant comments. Relicensing participants attending the June 27 workgroup meeting included Pend Oreille County PUD, WDFW, USFS, and CCRIFC. Comments provided by relicensing participants on the review outline for this study plan are summarized in Attachment 4-1 and can also be found in the workgroup meeting summaries (available on SCL's relicensing website, http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Productivity outline presented at the workgroup meetings. The USFS did not specifically reference the Productivity Assessment study outline in its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), but in a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the outlines. In a letter to SCL dated August 28, 2006, WDFW requested additional detail on several of the study tasks, and requested additional zooplankton sample sites, sample frequency, and sample analysis (see WDFW's letter, included in Attachment 4-1). In response, SCL revised the text of the study plan and included reference to the Water Quality Constituent and Productivity Monitoring Study Plan (see section 3.3), which includes additional descriptions of sample sites, frequency and sample analysis. Many of the requested modifications are described in section 3.3, and SCL intends to finalize the study implementation details when the Technical Consultant is retained in early 2007. Any remaining questions regarding the sampling strategy will be addressed in coordination with relicensing participants at that time.

4.5.9. Schedule

The Productivity Assessment is scheduled to begin in early 2007 and extend through mid-2008 (Table 4.5-6). Any necessary field data collection will be conducted during the summer of 2007.

Table 4.5-6. Study schedule, Productivity Assessment.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Study mobilization/startup	------							
Data Collection		------	------	------				
Field Sampling			▲▲					
Data Compilation					------			
Productivity Calculations						------		
Reporting						●	■	

4.5.10. Progress Reports, Information Sharing, and Technical Review

Draft and final study reports for this study will be available to relicensing participants. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with relicensing participants to discuss the study results, as described in section 1.2.4 of this document. In addition, relicensing participants will have opportunities to discuss and comment on study progress at quarterly workgroup meetings and ad hoc subcommittee meetings, as needed.

4.5.11. Anticipated Level of Effort and Cost

Based on a review of field effort, analysis, documentation, and report writing, the estimated cost to complete this study for the Boundary Project ranges from $140,000 to $180,000.

4.5.12. Literature Cited

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4.6. Fish Entrainment and Habitat Connectivity Study

The Boundary Project is designed to store Pend Oreille River water behind the 340-foot-high Boundary Dam and release it through six large turbines. When flow in the Pend Oreille River exceeds the capacity of the turbines, water is released through spillway or sluiceway structures built into the dam. Fish moving downstream through the Pend Oreille River may pass through the dam along with the flow (hence the term entrainment), and be exposed to potential injury or mortality during downstream passage. Fish attempting to move upstream through the Pend Oreille River are blocked by Boundary Dam, essentially preventing the connection between fish and aquatic habitats downstream and upstream of the dam.

Boundary Dam was built without facilities designed to pass fish or provide connectivity between upstream and downstream habitats. Grand Coulee and Chief Joseph dams, both federal power facilities, block anadromous fish migration more than 200 miles downstream of Boundary Dam, and the height (340 feet) and large flow volume (average annual flow of 26,480 cfs [SCL 2006]) at Boundary Dam presents significant challenges to structural options to protect fish passing the dam. In recent years, declines in native resident fish populations, such as bull trout, have placed increased focus on resident fish migration. Primary concerns at the Boundary Project center on three native fish species found at the Project: bull trout, westslope cutthroat trout and mountain whitefish.

Similar to most other salmonids, bull trout and westslope cutthroat trout are known for their ability to return to natal streams for spawning, an aspect of their life history that contributes to genetic isolation and adaptation to local environmental conditions. Migration barriers are clearly an isolating mechanism for local populations. Types of barriers are waterfalls, landslides, water withdrawals, road crossings, and dams. A local population that lives above a barrier can only contribute individuals (and their genes) in a downstream direction. If that local population is extirpated then there is virtually no opportunity for the local population to become re-established unless other local populations are present farther upstream or there is human intervention.

Although there are no anadromous fish at the Boundary Project, resident fish moving downstream may pass through or over Project facilities at Boundary Dam. There are four potential pathways through which fish can pass downstream through Boundary Dam water intakes. These are the turbines, spillways, sluiceways, and the skimmer gate. Entrainment can potentially cause direct injury or mortality of fish through strike, shear, grinding, turbulence, cavitation, pressure changes, or gas bubble disease from supersaturated total dissolved gas (TDG) levels. In addition, injured fish could incur delayed mortality through predation.

The number of fish susceptible to entrainment into Project facilities depends on many inter-related physical and biological factors including entrainment route, flow and spill levels, reservoir pool level, hydroelectric production levels, time of year, and the abundance, distribution, behavior, and life history of the species of interest. The likelihood that fish would pass through a particular pathway is a function of which pathways are open and passing flow, what percentage of the overall river flow each pathway is passing at the time, the relative depth of the pathway entrance in the water column, and the time of year relative to the fish species and its movement patterns both laterally in the river and vertically in the water column. In

conjunction with physical factors, biotic factors also influence fish species susceptibility to entrainment. These include diurnal and/or seasonal movement patterns, fish size, swimming speed, life history requirements, relative size of the population, and density-dependent influences.

Boundary Dam is configured with six deep water turbine intakes 30 feet wide by 34 feet high (horseshoe-shaped in cross section) located at an invert elevation of 1,903 feet NGVD 29 (1,907 feet NAVD 88) in the Boundary Project forebay (Figure 4.6-1). The forebay channel (190 feet wide at the trash rack and 500 feet long) is located along the left abutment of the dam. A trash rack structure spans the channel approximately 200 feet from the nearest turbine intake. The forebay channel was excavated during Project construction and resembles a large, short canal. Fish may enter the Boundary Project forebay channel due to migratory behavior, density dependent movements, or drift in the river currents.

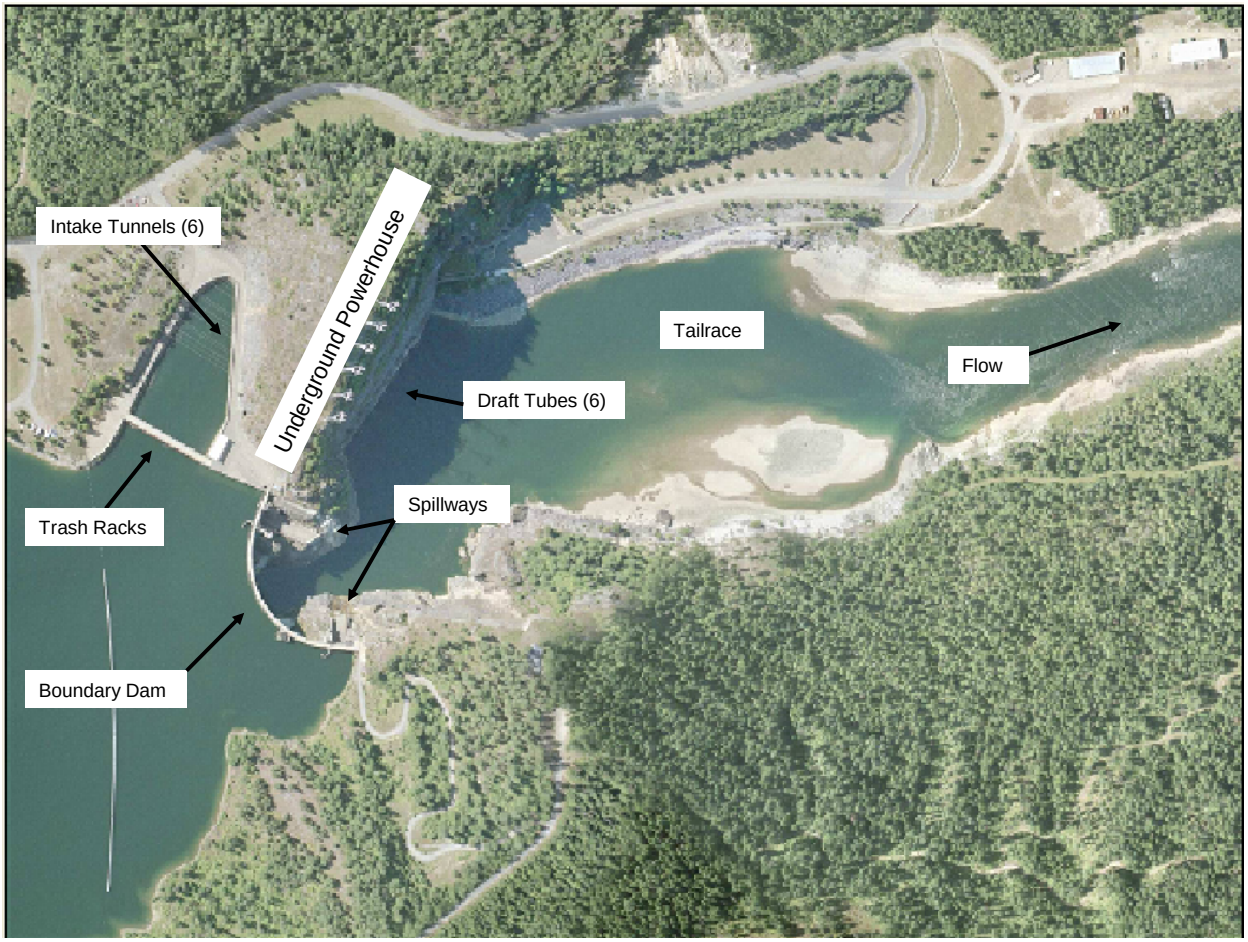

Figure 4.6-1. Aerial overview of Boundary Dam and associated facilities.

Boundary Dam has two spillways, one on either side of the main arch dam section (Figure 4.6-2). Both spill gates are bottom-opening Tainter gates 50 feet high by 45-feet wide. When fully closed, the top of the gates are at an elevation of 1,990 feet NGVD 29 (1,994 feet NAVD 88), which corresponds to the normal maximum pool elevation of Boundary Reservoir in the forebay.

The spillway chutes do not extend all the way to the tailwater. Spillway 1, on the left bank looking downstream, extends 197 feet horizontally downstream from the crest. The end of the spillway chute has a flip bucket with a radius of 35 feet that causes the discharge to be released at an upward angle of about 21 degrees at an elevation of 1,904.6 feet. Spillway 2, on the right bank, is a shorter chute, extending 93.9 feet horizontally downstream of the crest, and does not include a flip bucket. Flow is discharged from this spillway at a downward angle of about 5.7 degrees. The flow then plunges into a pool in the tailrace.

Figure 4.6-2. Potential entrainment paths through the Project include the intakes to the six penstocks, Spillways 1 and 2 and the skimmer gate. The seven sluiceways are not shown in this figure.

Boundary Dam includes seven sluiceways located at about mid-height of the dam that discharge into the plunge pool below the dam. The sluiceways are generally used to supplement the spill flow during extreme high-flow events. The sluiceways are submerged on the upstream side of the dam and are rectangular in shape, with a reducing area in the downstream direction through the dam. At the discharge end, on the downstream face of the dam, the sluiceways are 21 feet high by 17 feet wide. The flow capacity of each of the seven sluiceways is approximately 35,000 cfs with the forebay at normal full pool. The invert of the sluiceway outlet is at elevation

1,791.5 feet NGVD 29 (1,795.5 feet NAVD 88). The sluice gates are either fully open or fully closed, and cannot be throttled.

A surface-oriented gate is located adjacent to Spillway 1 on the left bank looking downstream (see Figure 4.6-2). The gate is 26 feet wide by 8 feet tall with an invert at elevation 1,982.0 feet NGVD 29 (1,986 feet NAVD 88). The flow capacity of the skimmer gate fully lowered is estimated to be approximately 1,800 cfs with the forebay at elevation 1,990.0 NGVD 29 (1,994.0 feet NAVD 88). Use of the skimmer gate was discontinued in the 1980s.

The Boundary Project is operated using a load-following strategy (see section 3.4 in the Boundary Project Pre-Application Document, SCL 2006). The Project has a maximum turbine flow capacity of 55,000 cfs, which is more than twice the average annual flow of the Pend Oreille River near Boundary Dam (SCL 2006). Flow releases through the Boundary Project spillways are typically much less frequent than at non-peaking hydroelectric projects. Based on an analysis of hourly flow records, spill events are most likely to occur during the April through July period (Table 4.6-1). During power production, fish passing downstream in the Pend Oreille River may encounter water velocities in the turbine intakes that are greater than their ability to avoid. Water velocities in the turbine intake tunnels exceed 10 feet per second at maximum turbine flow capacity.

When powerhouse flows reach capacity (i.e., 55,000 cfs) during higher flow or flood conditions, the spillway gates are opened to pass flows downstream. The spillways are used until half their discharge capacity (total of approximately 54,000 cfs) is reached, then the sluiceway gates are opened to accommodate additional flow, with the sluice gates closest to the center of the dam opened first to reduce the possibility of eroding the abutments on the downstream side of the dam. Consequently, the sluiceways are usually not utilized until river flows exceed 109,000 cfs.

Table 4.6-1. Monthly 10 and 50 percent exceedance flows in the Pend Oreille River below the Boundary Project, hourly flow record 1987 to 2004 (R2 Resource Consultants 2006a).

Month	10% Exceedance (cfs)	50% Exceedance
January	32,725	16,100
February	33,488	15,400
March	37,792	18,700
April	51,403	26,050
May	72,069	36,700
June	88,668	41,250
July	47,521	22,200
August	26,906	12,300
September	21,310	14,650
October	26,330	21,500
November	27,200	20,250
December	25,490	17,100

The proposed Fish Entrainment and Habitat Connectivity Study will address both turbine and spillway entrainment. Beyond the study phase, development of a Connectivity Management Plan component is proposed to evaluate the results of this study in the overall context of relicensing study results and to identify an appropriate response to the information. Relicensing studies addressing fish movement, tributary access, aquatic habitats, aquatic productivity, entrainment, and total dissolved gas will be used to ascertain those effects that have a nexus to current and future Project facilities and operations, and identify Project-induced impacts to fish and aquatic resources. SCL anticipates that the Connectivity Management Plan will be developed in 2009, using the results of these relicensing studies. The Plan will be developed in coordination with relicensing participants and will identify a comprehensive set of protection, mitigation, and enhancement (PME) measures for consideration in the FERC and related regulatory processes, as deemed appropriate. Potential connectivity measures may take the form of structural, operation, habitat, production, or other methods. These PME measures will be evaluated with the agencies, tribes and other stakeholders, and will help in the development of Section 18 and Section 4(e) terms and conditions, including implementation schedules.

The overall process for addressing entrainment and habitat connectivity issues, as well as defining potential management responses during the relicensing process, is presented in Table 4.6-2. This table illustrates how fish and aquatic resources will be evaluated during the period extending from the development of this PSP through preparation of the Preliminary License Proposal and Final License Application.

4.6.1. Nexus Between Project Operations and Effects on Resources

If fish pass downstream through Boundary Dam facilities, they are exposed to potential injury and mortality. Depending upon the route, the risk of entrainment and the magnitude of injury and mortality can vary considerably. Operating conditions such as river flow, generating level, and pool level can affect what routes are available and the susceptibility of fish to entrainment.

4.6.2. Agency Resource Management Goals

General agency management goals are described in section 4.1.2. In addition, regulatory agencies have also developed the following goals, objectives, or action items related specifically to fish protection at water control facilities:

- USFWS — Identify barriers or sites of entrainment for bull trout and implement tasks to provide passage and eliminate entrainment (USFWS 2002).
- USFWS — Maintain and/or restore aquatic habitat connectivity in the watershed to provide movement, migration, and dispersal corridors for salmonids and other aquatic organisms and provide longitudinal connectivity for nutrient cycling processes.
- WDFW — Fish Access and Passage. 1) Provide, restore, and maintain safe and timely pathways to all useable wild salmonid habitat in fresh and marine waters, for salmonids at all life stages. 2) Ensure salmonids are protected from injury or mortality from diversion into artificial channels or conduits (irrigation ditches, turbines, etc.). 3) Ensure natural fish passage barriers are maintained where necessary, to maintain biodiversity among and within salmonid populations and other fish and wildlife (WDFW 1997).

Table 4.6-2. Proposed timeline for the Boundary Project fish entrainment and connectivity program.

	2006	2007	2008	2009	2010	2011	2012…
Integrated Licensing Process	Preliminary Study Plan	Conduct Studies	Conduct Studies	License Application	EIS Review	License Issued	
Fish and Aquatic Studies	▫ Study plan development ▫ Early information development efforts	Proposed Studies / Study Elements: ▫ Turbine entrainment ▫ Spillway entrainment ▫ Forebay fish timing, abundance and movements ▫ Genetics ▫ Tailrace fish timing, abundance and movements ▫ Habitat distribution ▫ Water quality	Continue Studies	Continue Selected Studies Connectivity Management Plan ▫ Structural options ▫ Habitat options ▫ Production options ▫ Other options	Continue Selected Studies	Continue Selected Studies	
Post-Licensing Process						Develop Implementation Plans	Begin Plan Implementation

4.6.3. Study Goals and Objectives

The goal of the Fish Entrainment and Habitat Connectivity Study is to estimate the number, size, species, and timing of fish that may be entrained within the Boundary Project turbine intakes and spillways. The limited frequency, duration of use, and flow conditions associated with the use of the sluiceways, and the discontinued use of the skimmer gate, reduces the need to quantify the number of fish potentially entrained though these pathways (R2 Resource Consultants 2006b). For this reason, the assessment of the potential impact of fish entrainment at the Boundary Project will focus on entrainment through the turbine and spillway pathways. Study results will be used to quantify the effects of Boundary Project operations on hourly, daily, diel, and seasonal entrainment of fish within Boundary Reservoir. Study results will be used to evaluate the potential benefit and efficacy of fish protection measures and opportunities to establish connectivity between habitat and populations upstream and downstream of Boundary Dam.

4.6.4. Need for Study

Summary of Existing Information

An understanding of the abundance, distribution, and periodicity of fish in Boundary Reservoir is important for determining what species may be vulnerable to entrainment. However, few studies have been conducted in Boundary Reservoir. The most comprehensive surveys, conducted by McLellan (2001), occurred seasonally (spring, summer, and fall) during 2000 and consisted of electrofishing and gillnet sampling throughout the reservoir. Based upon these collections, Boundary Reservoir appears to be dominated by non-salmonids such as northern pikeminnow and largescale sucker (see Table 4.3-1, in the Fish Distribution, Timing and Abundance Study). McLellan (2001) concluded that most fish in Boundary Reservoir used the littoral (shallow) zone, while few fish used the pelagic zone (deep water).

Appendix E in McLellan (2001) reported the results of their surveys by species, season, and reservoir section, but no discussion of spatial (by section) or temporal distribution patterns was included in the body of the report. The data tables suggest that catch rates were generally higher in the summer and fall relative to the spring surveys. Electrofishing surveys generally had higher capture rates in the Upper Reservoir (Sections 3 and 4) compared to the Canyon and Forebay Reaches (Sections 1 and 2), while horizontal gillnet catch rates were variable with no strong patterns discernable among the different sections. McLellan (2001) reported that high flows occurred during the spring surveys. Seasonal differences in catch per unit effort may have been the result of spring high flows or fish activity levels, which may have affected capture efficiency rather than actual changes in fish abundance or distribution. Apparent spatial differences in capture rates for electrofishing surveys may have occurred because the Upper Reservoir Reach is relatively shallow, which is likely to result in higher electrofishing efficiency compared to the deeper Canyon and Forebay Reaches. Overall, the available information from McLellan (2001) is inadequate to draw strong conclusions concerning spatial and temporal patterns of reservoir use by the fish community, but is useful in describing relative abundance of the different fish species residing in the reservoir. A study is proposed to supplement the available information on fish distribution, abundance, and periodicity (see section 4.3).

Nearby hydroelectric projects include the Waneta Project at RM 0.5, the Seven Mile Project at RM 6.0, and the Box Canyon Project at RM 34.5. Site-specific entrainment studies have not

been conducted at any of these projects; however, fish distribution surveys have been conducted in all three reservoirs and concluded that native salmonids are rare (R.L. & L. 1999; R.L. & L. and Taylor Associates 2001, Ashe and Scholz 1992). Neither the Waneta nor Seven Mile projects have facilities to connect fish populations or habitats around the dams. BC Hydro, which runs the Seven Mile Project, is planning to implement a biotelemetry study of bull trout from the Salmo River to evaluate whether bull trout are being entrained at Seven Mile Dam (BC Hydro Project Team 2003). The Pend Oreille County Public Utility District, which operates the Box Canyon Project, is planning to conduct entrainment studies at Box Canyon Dam beginning in 2007 (EES Consulting 2006).

As described above, if fish pass downstream through Boundary Dam facilities, they are exposed to potential injury and mortality. However, entrainment does not necessarily lead to mortality of all fish. R.L.&L. and Taylor Associates (2001) suggested that the presence of exotic fish in Seven Mile Reservoir was due to entrainment from upstream projects, but no empirical evidence was provided to indicate the potential magnitude of entrainment. Although no site-specific field study of injury or mortality has been conducted at the Boundary Project, the mortality for different size classes of fish was estimated for each potential passage route. R2 Resource Consultants (2006b) used an equation developed by the U.S. Department of Energy's Advanced Hydro Turbine System to estimate fish passage mortality. The procedures used to estimate entrainment mortality and the results of the analysis were reviewed by relicensing participants, and agreement was reached in 2006 that the mortality estimates could be used in place of site-specific mortality studies (R2 Resource Consultants 2006b). If fish pass through the spillway, the majority will be killed, while a large percentage of fish are expected to survive passage through the turbines (Table 4.6-3). A detailed discussion of factors related to injury and mortality of fish during entrainment at the Boundary Project is presented in the summary report (R2 Resource Consultants 2006b).

Table 4.6-3. Estimated ranges of fish mortality for existing downstream passage routes (R2 Resource Consultants 2006b)

Passage Route	Range of Estimated Mortality by Fish Length			Comments
	100 mm	250 mm	600 mm	
Turbines 51–54	6% – 15%	13% – 33%	26% – 65%	Original Units
Turbines 55–56	5% – 12%	11% – 28%	23% – 59%	New Units (larger turbines with fewer buckets & higher flow)
Spillways	50% – 80%	35% – 65%	20% – 50%	Depends on spill flow rate Spillway 1 better for smaller fish Spillway 2 better for larger fish
Sluiceways	40% – 70%	25% – 55%	10% – 40%	Speculative based on assumed reduction from spill estimates Assumes adjacent sluiceways are not operated simultaneously Does not consider influence of TDG impacts
Skimmer Gate	0% – 20%	10% – 30%	50% – 80%	Assumes fully aerated spray with freefalling fish upon tailrace entry

Need for Additional Information

The proposed entrainment study is designed to estimate the number and species of fish that could potentially be entrained through the Project turbines and spillways. The results of the study will be combined with the estimates of fish entrainment mortality to evaluate the potential risk of Project operation on the fish populations in the Pend Oreille River.

4.6.5. Detailed Description of Study

Study Area

The study area encompasses the Forebay Reach, Boundary Dam and associated structures, and the Pend Oreille River in the immediate vicinity of the Boundary Dam tailrace (Figure 4.6-1).

Description of Study Components

The proposed effort consists of Turbine Entrainment and Spillway Entrainment study components. Sluiceway and skimmer gate entrainment components are not proposed for this study because the skimmer gates have not been used since 1986 and the sluiceways are only used infrequently during major spill events.

Turbine Entrainment

Hydroacoustic monitoring is the proposed method to estimate the number, size, and timing of fish entrained within the Boundary Project turbine intakes. Fyke net sampling within intake tunnel gate wells will be used to verify hydroacoustic targets and identify the species composition of entrained fish. Other methods of estimating entrainment were considered, but the proposed methods were considered preferable given the site characteristics and desire for robust study results. Gill nets will be deployed in the Forebay Reach as part of the Fish Distribution, Timing and Abundance Study (section 4.3), and while the results will indicate the number, size and species of fish in the general vicinity of the spillway and trashrack structures, they will not identify whether those fish passed downstream through the dam. Scoop or screw-traps could be placed downstream of the turbine outfalls, but fish that were injured or killed during turbine passage might pass under these surface-oriented traps and avoid detection. A fyke net array could be placed at the turbine outfall and designed to subsample all portions of the water column, but procedures for anchoring the net leads to the outfall structure may prove more difficult than attaching nets to a frame lowered into the gatewell slot.

A number of assumptions, listed below, are associated with the use of the proposed methods. If the following assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- Fixed-location hydroacoustic transducers can be installed at the entrance to the Boundary Project intake tunnels and used to quantify the timing, number and size of hydroacoustic targets passing into the intakes.
- Fyke net sampling within the Boundary intake tunnels or draft tubes can be used to validate and translate hydroacoustic targets into the number, size, and species of fish.

- Trapping efficiency of entrained fish does not differ among species, and is not affected by whether a fish is dead or alive.
- Both hydroacoustic and fyke net sampling provide imperfect estimates of fish entrainment. Comparison of sampling methods provides the opportunity to identify potential biases and highlight strengths and weaknesses, and the use of two methods will improve overall sampling effectiveness.
- If discrepancies are identified between hydroacoustic and fyke net sampling, fyke net sampling is expected to provide a better estimate of fish entrainment (species, size, and number) than hydroacoustic sampling.
- All fish captured within the fyke nets will suffer injury or mortality. Federal and state collecting permits will be obtained that allow sampling to continue up to a defined level of take.

Proposed Methodology

The work effort for this study has been divided into six tasks, as described below.

Task 1) Deploy Intake Hydroacoustic System

Design, install, and test a hydroacoustic system to enumerate targets within or passing into Boundary Project intake tunnels. A stratified sampling program will be developed to extrapolate the results obtained for the hydroacoustic measurement fields to the total intake area for all six intakes and correlated to the duration, timing and magnitude of generation. Testing will be conducted to identify effective transducer aiming angle, ping rate, and mounting depth. The hydroacoustic sampling approach, including number and type of transducers, transducer locations, and data analysis procedures will be identified by the Technical Consultant in coordination with SCL and relicensing participants.

Task 2) Intake Hydroacoustic Monitoring

Continuously monitor a hydroacoustic array 24 hours per day and 7 days per week throughout the year, with weekly data downloads. Sampling will continue for two-years; however, when 12 months of sampling have been completed and analyzed, sampling during some periods may be curtailed based on site conditions (for example, during December and January if ice conditions interfere with readings). Any change in sampling procedures will be coordinated with relicensing participants.

Task 3) Fyke Net Array Installation

Use a stacked fyke net assembly, consisting of an array of multiple fyke nets, to sample two turbine intakes that are being monitored using hydroacoustics. Access to the Boundary Project intakes will be gained through the intake tunnel gate slot; however, if site constraints prevent use of the intake gate slot, the fyke net assemblies will be installed in the draft tube gate slots, or draft tube exits. The selection of intake tunnels to sample using fyke nets will reflect physical site constraints, turbine frequency of use, and distribution of fish between turbine intakes based on early hydroacoustic sampling results. Turbines that are in frequent use, provide physical access for net deployment, and appear to pass a greater proportion of fish relative to the other intakes will be given highest consideration for sampling. The selection of intakes to sample will

be identified by the Technical Consultant in coordination with SCL and relicensing participants. Note that if a fyke net array can be attached at the turbine outfall and designed to effectively sample all portions of the water column, this attachment location may be substituted for the turbine intake gatewell slot. Accuracy of entrainment estimates will depend on robust estimates of trapping efficiency. Methods will be developed by the Technical Consultant in coordination with SCL and relicensing participants.

Task 4) Fyke Net Sampling

Develop a stratified, subsampling approach to guide fyke net sampling. For planning purposes, sampling is expected to occur for at least four 24-hour periods per month. Depending on the rate of fish and debris build-up in the cod end of the fyke nets, nets may be fished continuously for 24-hour periods, or split into shorter time intervals. Install fyke net assemblies prior to project start-up during each sampling period. If high flows result in extended periods of continuous operation, short-term shut-down of sampled intakes may be needed to install and retrieve fyke nets. Planned nighttime generation and planned spill events may be required during some months to provide adequate day versus night comparisons and evaluation of spillway hydroacoustic signatures.

Task 5) Fish Handling

Identify and quantify all fish collected during fyke net sampling; fish will be identified to species and measured to the nearest millimeter (mm) total length. All captured salmonids will be scanned for tags, including scanning for passive integrated transponder (PIT) tags using a portable tag reader.

Task 6) Data Analysis

Quantify the size, number and species of fish entrained within the Project intakes correlated to the duration, timing and magnitude of generation. Hydroacoustic target counts and signal strengths will be translated into the number and size of entrained fish using the results of the fyke net sampling. The results of fyke net sampling will also be used to identify the relative proportion of species entrained into the intakes. Data analysis procedures will be developed by the Technical Consultant in coordination with SCL and relicensing participants.

Work Products

The work products for the turbine entrainment study component will include tabular summaries of the relative proportion, size, number, and species of fish entrained within the Project intakes. Statistical analyses that correlate the magnitude of entrainment to the duration, timing and magnitude of generation will also be summarized and described in text. Electronic copies of datasheets, including at a minimum species, size, timing, total dissolved gas level, and flow, will be available on request.

Schedule

The schedule for completing the Turbine Entrainment component of this study is provided in Table 4.6-4.

Table 4.6-4. Proposed schedule for conducting the Turbine Entrainment study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	---										
Hydroacoustic sampling		---	---	---	---	---	---	---	---		
Fyke net fabrication		---	---								
Fyke net sampling				---	---	---	---	---	---		
Data analysis				---				---	---		
Reporting				•				■		■	

Spillway Entrainment

Hydroacoustic monitoring is the proposed method to estimate the number, size, species and timing of fish entrained within Boundary Dam Spillways 1 and 2. Fyke net sampling within the Boundary Project intake tunnel gate wells will be used to verify hydroacoustic targets and identify species composition of entrained fish.

A number of assumptions, listed below, are associated with the use of the proposed methodology. If the following assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- The species composition of fish captured in the turbine fyke nets is similar to the composition of fish entrained in the spillways.
- Fixed-location hydroacoustic transducers can be installed at the entrance to the Boundary Project spillway gates and used to quantify hydroacoustic targets passing through a defined field of view when spill gates are in use.
- Hydroacoustic target signatures can be adequately translated to size and numbers of fish.
- Hydroacoustic sampling provides an imperfect estimate of fish entrainment. If needed, other potential sampling methods will be considered to identify potential bias, highlight strength and weaknesses and used to improve overall sampling effectiveness.
- Spillway discharge, and associated potential spillway fish entrainment, primarily occurs from early April through mid-July. If no spill events occur during the initial period of hydroacoustic monitoring, planned spill events will be scheduled to evaluate potential spillway entrainment.

Proposed Methodology

The work effort for this study has been divided into five tasks, as described below.

Task 1) Deploy Spillway Hydroacoustic System

Design, install, and test hydroacoustic systems within Spillways 1 and 2. A level of effort is described for planning purposes, but the selection of hydroacoustic equipment, number and type of transducer, transducer location, aiming angle, depth of attachment and transducer ping rate will be identified by the Technical Consultant in coordination with SCL and relicensing participants.

Task 2) Spillway Hydroacoustic Monitoring

Continuously monitor Spillway gates 1 and 2 using hydroacoustics for the period April through July during 2007 and 2008. Monitoring will occur 24 hours per day and 7 days per week throughout the sampling season with weekly data downloads. Hydroacoustic sampling will be extended if a high likelihood of spill events can be forecast outside of the April through July period.

Task 3) Hydroacoustic Data Analysis

Quantify the number and signal strength of hydroacoustic targets entrained within the Project spillways. The hydroacoustic array will provide estimates of the number and strength of targets passing through a defined field of view which will be extrapolated to the entire spillways and correlated to spill timing, duration and magnitude. A stratified sampling approach and data analysis procedure will be developed by the Technical Consultant in coordination with SCL and relicensing participants.

Task 4) Translate Hydroacoustic Data to Fish Data

Translate spillway hydroacoustic target signatures to numbers, size and species of fish using:

- the relationship between spillway hydroacoustic target signatures and the results of simultaneous fyke net sampling of the turbine intakes;
- the results of biological sampling in the forebay and immediately in front of the spillway gates during days/nights when spillways are not in use (see 4.3, Fish Distribution, Timing and Abundance Study);
- the relationship between turbine intake hydroacoustic target signatures and fish size and species; or
- if spillway hydroacoustic target signatures cannot be translated to fish size and numbers using these available data, other opportunities to translate hydroacoustic targets to numbers and size of fish will be considered including, but not limited to, an underwater video system installed to record the passage of fish during periods of spillway use, or a screw trap or scoop trap installed in the tailrace during spill conditions.

Task 5) Fish Data Analysis

Estimate the number, size and species of fish passing through the spillways for a range of spill conditions. Data analysis procedures will be developed by the Technical Consultant in coordination with SCL and relicensing participants.

Work Products

The work products for the spillway entrainment study component will include tabular summaries of the relative proportion, size, number and species of fish entrained within the Project intakes. Statistical analyses that correlate the magnitude of entrainment to the duration, timing and magnitude of generation will also be summarized and described in text. Electronic copies of datasheets, including at a minimum species, size, timing, total dissolved gas level, and flow, will be available on request.

Schedule

The proposed schedule for completing the Spillway Entrainment component of this study is provided in Table 4.6-5.

Table 4.6-5. Proposed schedule for conducting the Spillway Entrainment study component.

Activity	2007				2008				2009		
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q
Technical Consultant study refinement	--------										
Hydroacoustic sampling		----------	----------	----------	----------	----------	----------	----------	----------		
Data analysis				------				----------	----------		
Reporting				●				■		■	

4.6.6. Consistency with Generally Accepted Scientific Practice

The proposed study methods have been developed in consultation with the agencies, tribes, and other stakeholders. The study approach and methods are consistent with those used as part of licensing studies on large rivers throughout the northwestern United States (e.g., Columbia River, Snake River, Lewis River, and Cowlitz River) to evaluate the impact of turbine entrainment on fish species.

4.6.7. Consultation with Agencies, Tribes, and Other Stakeholders

Input regarding the Fish Entrainment and Habitat Connectivity Study was provided by relicensing participants during workgroup meetings. Workgroup meetings were held in Spokane, Washington, on April 20, 2006, and May 23, 2006. During the April workgroup meeting, outlines for turbine and spillway entrainment sampling at the Boundary Dam were presented and discussed with relicensing participants. Following the April workgroup meeting, the USFWS provided written comments on the study outlines (see Attachment 4-1). During the May workgroup meeting, SCL responses to the USFWS comment letter were discussed and relicensing participants provided additional feedback and continued discussions of entrainment sampling at the Boundary turbine intake tubes. The proposed study plan for the Fish Entrainment and Habitat Connectivity study was developed from these outlines and relicensing participant comments. Stakeholder Comments provided by relicensing participants on the review outlines are summarized in Attachment 4-1 and can be found in meeting summaries available on SCL's relicensing website (www.seattle.gov/light/news/issues/bndryRelic/).

As part of an early information development effort, SCL contracted with R2 Resource Consultants to compile existing information regarding Project facilities and evaluate the risk of injury and mortality if native salmonids passed downstream through various routes. The objective of this effort was to support future stakeholder discussions of potential fish connectivity and entrainment protection measures. No site-specific field studies of entrainment or upstream and downstream fish connectivity were conducted in 2006. As part of the early information development effort, descriptions of existing Boundary Project facilities and operations and background information relevant to upstream and downstream fish connectivity and entrainment were compiled for the Boundary Project. Because the movement and potential connectivity of fish throughout the Pend Oreille River system is pertinent to the issue of fish passage at the Boundary Project, a summary of existing and planned fish connectivity programs was also compiled for other hydropower projects on the Pend Oreille River.

Fish that might be migrating downstream and pass through Project facilities may be directly injured or killed or indirectly impacted if they are made temporarily more vulnerable to predation due to disorientation and stress. The summary report of the early information development effort presented estimated ranges of fish mortality for existing downstream passage routes based on a review of available information in the literature (see Table 4.6-3). SCL proposed to adopt these mortality estimates in lieu of conducting site-specific studies of entrainment mortality. The USFS, in an e-mail dated May 8, 2006, and the USFWS in an e-mail dated July 21, 2006 (see Attachment 4-1), agreed to the use of the mortality estimates in lieu of site-specific studies for purposes of Boundary Project relicensing. During the August 14, 2006, workgroup meeting, relicensing participants confirmed that the estimated turbine and spillway mortality rates described in Table 4.6-3 could be used during relicensing in place of empirically derived results.

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the turbine and spillway study outlines presented at the workgroup meetings, noting that written comments had previously been provided and discussed (see May 23, 2006, meeting record). WDFW (in a letter to SCL dated August 28, 2006) and the USFS (in its PAD/Scoping comment letter, filed with FERC on August 31, 2006 [USFS 2006]) did not specifically reference the entrainment study outlines in their letters, but in a follow-up conference call with USFS staff on September 8, 2006, USFS staff indicated that there was general agreement on the outlines. SCL intends to finalize the study implementation details when the Technical Consultant is retained in early 2007. Any remaining questions regarding the sampling strategy will be addressed in coordination with relicensing participants at that time.

4.6.8. Progress Reports, Information Sharing, and Technical Review

A draft report for this study will be produced by December 31, 2007, describing the first year's monitoring results and analyses and recommendations, if any, for modifying 2008 survey procedures. Relicensing participants will be provided an opportunity to discuss the draft report and results at one (or more, if necessary) stakeholder meetings and make written comments. A final report describing survey methods and results of 2007 and 2008 monitoring will be produced by December 31, 2008. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with agencies, tribes, and other stakeholders to discuss the study results, as described in section 1.2.4 of this document.

4.6.9. Anticipated Level of Effort and Cost

Seattle City Light envisions that turbine and spillway entrainment study components will be implemented as a combined effort to increase study efficiencies and ensure the use of complementary equipment where feasible. The total estimated cost of implementing both study components is expected to range from $1,800,000 to $2,500,000; estimated study costs are subject to review and revision as additional details are developed.

4.6.10. Literature Cited

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4.7. Recreational Fishery Study

Recreational fishing (boat and bank) is one of the activities enjoyed at the Project. Information on the current level of recreational fishing activity in the Project reservoir is sparse, and additional information is needed to characterize recreational fishing resources and demand for recreational fishing opportunities at the Project. During electrofishing and gillnetting surveys of fish populations in Boundary Reservoir in 2000, over 60 percent of the fish captured were either northern pikeminnow or largescale suckers (McLellan 2001), both species of which are typically not considered to be popular sport fish. Sterile triploid trout have been planted at the Project to increase sport fishing harvest while minimizing the risk of hybridization with native species. Planting triploid trout as part of a recreational fish planting program can help balance the demands for both consumptive fishing opportunities and conservation of native stocks. Information on the distribution and abundance of sport fish species will be developed through the Fish Distribution, Timing and Abundance Study (described in section 4.3 of this PSP). The Recreational Fishery Study is designed to obtain information about the level of effort and harvest in the recreational fishery and the level of angler satisfaction.

4.7.1. Nexus Between Project Operations and Effects on Resources

Boundary Project operations may affect recreational fishing opportunities by altering aquatic habitats that support the distribution and diversity of fish species. Pool level fluctuations as part of Project operations may also affect recreational user access to the reservoir by changing conditions at boat ramps available to the public. Currently, SCL voluntarily contributes to the recreational sport fishery through the purchase and release of triploid rainbow trout in Boundary Reservoir. In addition, SCL voluntarily holds the reservoir pool level within the top 10 feet during the summer recreation season so that boat ramps are accessible during much of the day. This study examines the post-stocking distribution of triploid trout, harvest level, and potential interactions of triploid rainbow trout and native salmonids.

4.7.2. Agency Resource Management Goals

A broad set of agency management goals are provided in section 4.1.2. In regards to fisheries for the Colville National Forest, one of the Forest Management goals is to "Provide a diversity of high quality aquatic habitats which insures viable populations of fish in sufficient numbers to meet angler demands" (USFS 1988). The Colville National Forest Land and Resource Management Plan (USFS 1988) states that trout are to be used as the management indicator species for aquatic habitat, in part because they are a species commonly fished. Colville National Forest standards and guidelines (USFS 1988) include: "Emphasize management of native fish species habitat. Non-native species may be managed for in waters where they can be expected to provide at least 15 percent more biomass production or 15 percent more angler days recreation than native species. Non-native species may be used to provide diversity only where they will not adversely affect native fish or other native organisms in the affected or adjacent waters."

The overarching goal of bull trout and Dolly Varden management plan by the Washington Department of Fish and Wildlife (WDFW 2000) is "To restore/maintain the health and diversity of bull trout and Dolly Varden stocks and their habitats to/at self-sustaining levels that would

allow recreational utilization within resource protection guidelines." As part of the joint Washington Department of Fish and Wildlife (WDFW)/Tribal Wild Salmonid Policy (WDFW and WWTT 1992), the overarching goal is "to protect, restore, and enhance the productivity, production, and diversity of wild salmonids and their ecosystems to sustain ceremonial, subsistence, commercial, and recreational fisheries, non-consumptive fish benefits, and other related cultural and ecological values."

4.7.3. Study Goals and Objectives

The goal of this study is to obtain information regarding the recreational fishery that can aid SCL and relicensing participants in understanding the effects of the Boundary Project on recreational fisheries, potential interactions between planted fish and native salmonids, and determine if opportunities to enhance the triploid trout program are considered desirable and appropriate. The study objectives are to: 1) conduct recreational creel surveys (creel survey and angler survey components) that identify current recreational fishing activity and success rates (boat and bank) on the reservoir; 2) determine angler opinions and values regarding maintaining or improving recreational fishing opportunities in the future at Boundary Reservoir, addressing both native salmonids and non-salmonids; 3) use biotelemetry to identify movements of newly released and carry-over triploid rainbow trout in Boundary Reservoir; 4) evaluate habitat-use characteristics of triploid rainbow trout; 5) identify potential positive and negative effects of the triploid trout stocking program; and 6) evaluate stocked triploid trout patterns of dispersal, growth, survival, and susceptibility to angling.

4.7.4. Need for Study

Summary of Existing Information

Boundary Reservoir currently supports a recreational fishery that targets planted triploid rainbow trout and naturally reproducing populations of non-native warm and cool water species such as smallmouth bass and yellow perch. However, most of the fish in Boundary Reservoir are non-sport species and, during a baseline fisheries assessment in 2000, less than 9 percent were found to be trout or bass (McLellan 2001).

Access to Boundary Reservoir for recreational fishing occurs primarily from three boat ramps. SCL operates one boat ramp located at the Forebay Recreation Area in the Forebay Reach (the reach from Boundary Dam to Z Canyon). Other boat ramps are located at Metaline Waterfront Park (operated by the Town of Metaline) and near Box Canyon Dam at Campbell Park (operated by the Pend Oreille County Public Utility District [PUD]). Creel surveys are a useful method for understanding what species and how many fish are being captured in the sport fishery and where sport fishing effort is expended. During the summer of 1997, creel surveys indicated the Upper Reservoir Reach (the reach from Metaline Falls to Box Canyon Dam) was the most heavily fished area of the reservoir (R2 Resource Consultants 1998). Over 92 percent of the fishing effort in Boundary Reservoir was expended in the Upper Reservoir Reach on the 17 days surveyed over a 6-week period. Northern pikeminnow were the most commonly caught sport fish (1.4 fish per hour fished) in the 1997 summer recreational fishery, although northern pikeminnow are not considered a popular catch. Rainbow trout were the second most commonly captured fish in the recreational fishery (less than 0.1 fish per hour), but at a much lower

frequency than northern pikeminnow. Excluding northern pikeminnow, combined sport fish catch rates in the Upper Reservoir Reach during the summer of 1997 were less than 0.2 sport fish per hour (1.2 sport fish per angler) (R2 Resource Consultants 1998). In contrast, creel surveys at Box Canyon Reservoir between 1948 and 1969 yielded an average of approximately 3.5 sport fish per angler hour (FERC 2004). No information is available on whether northern pikeminnow were killed and discarded, kept, or released unharmed after capture. Presumably, most legal-sized trout were retained by anglers, but records for triploid trout suggest that some anglers release a substantial number of captured triploid trout (Solonsky 2005).

Trout have been stocked into the Pend Oreille River by the WDFW on a periodic basis since 1946, but the available stocking records do not always specify whether releases occurred in Box Canyon Reservoir or Boundary Reservoir or where in the reservoirs the stocking occurred (McLellan 2001). Extensive stocking of rainbow trout occurred in 1946, 1947, and 1951 (77,000 to 1.9 million per year), but then ceased until 1989. Smaller releases occurred in 1989 and 1991–1993. Beginning in 1995, fingerlings were reared in net pens to a catchable size before release. Most of these releases occurred in Box Canyon Reservoir, but 15,000 fish were planted in Boundary Reservoir near Boundary Dam in 1998 (McLellan 2001). With the exception of 600 eastern brook trout released into the Pend Oreille River in 1999, all fish plants have been rainbow trout.

In addition to plantings by WDFW, since 2001 SCL has sponsored the stocking of triploid rainbow trout into Boundary Reservoir (Solonsky 2005). Triploid rainbow trout are sterile but have higher growth rates than diploid trout because little to no energy is utilized for reproductive processes. Triploid trout provide a benefit to the recreational fishery, but do not pose a threat to the genetic integrity of naturally spawning trout populations. Stocking of triploid trout into Boundary Reservoir has generally occurred during the spring (March) or fall (October or November) and has ranged from 450 to 6,300 triploid rainbow trout per year (Solonsky 2005).

Since 2002, the annual springtime Bassin' Assassin Derby, hosted by the Western Star Bar and Grill (in Metaline), has been held in Boundary Reservoir. Only smallmouth bass are counted in the derby. Participants may each weigh-in as many smallmouth bass as they want on both Saturday and Sunday, but only their largest fish for the day counts. Cash prize winners are the top three anglers with the largest combined weight of their largest fish on Saturday and Sunday.

During 2006, SCL took advantage of the event to collect information on recreational fishing. A questionnaire was developed for the derby, and SCL staff interviewed 59 anglers from 24 boats. A total of 135 anglers entered the derby, and 55 fish were weighed-in over the two-day event. The size of smallmouth bass ranged from less than 1 pound to 4.1 pounds. Based on reported size at age (Wydoski and Whitney 2003), 23 of the fish were at least six years old. Anglers reported catching 93 smallmouth bass during the derby. Fish lengths were available for 54 of the smallmouth bass submitted for the derby. Based upon length categories in Anderson and Neuman (1996), 1 fish (2 percent of measured submitted fish) would have been considered trophy-sized, 19 memorable (35 percent), 17 preferred (32 percent), and 14 (26 percent) quality-sized fish. Anglers reported catching several other species, including largemouth bass, walleye, triploid rainbow trout, whitefish, northern pikeminnow, peamouth, and sucker. River flows through the reservoir were relatively high during the derby (in the range of 50,000 cfs), so

reservoir velocities were relatively high and, according to anglers, fishing was difficult. Mean catch rate was about 0.2 smallmouth bass per angler per hour based on interviews. A common comment by anglers was that high currents and the lack of a dock at the Metaline Waterfront Park boat ramp made access challenging for the derby.

Need for Additional Information

Little existing information is available to discern the level of satisfaction by anglers for fishing in Boundary Reservoir or the desirability for expanded fishing opportunities (i.e., increased abundance of specific sport fish species). In some cases, the desire of the recreational angling community for harvestable fish stocks may be in conflict with some state and federal fish management objectives which, in part, may be in response to recovery efforts for ESA-listed species.

4.7.5. Detailed Description of Study

This study includes three components: Recreational Creel and Angler Surveys, Triploid Trout Biotelemetry, and Triploid Trout Management. Each of these components is described in more detail below, under Description of Study Components.

Study Area

The study area for all three study components is Boundary Reservoir from Boundary Dam to Box Canyon Dam. (Refer to section 1.3 of this PSP for a description of the Boundary Project location, facilities, and reservoir.) Sampling will occur along selected sections of the shoreline (to be coordinated with relicensing participants) and at the three boat launch areas. Information on recreational fishing in Boundary Reservoir tributary streams will be collected as part of the fishing surveys, but the primary focus of this study will be Boundary Reservoir. Roving boat surveys are not anticipated in this study.

Description of Study Components

Recreational Creel and Angler Surveys

Proposed Methodology

The proposed study component includes both creel and angler surveys. The methodology assumes that responses from anglers surveyed are representative of all boat and bank anglers that fish Boundary Reservoir during the survey period.

This study component includes four tasks, as described below.

Task 1) Creel Survey

Coordinate with the Boundary Project relicensing Recreation, Land Use, Aesthetics and Socioeconomics (RLAS) Workgroup in the design of creel survey questions and appropriate methodology to estimate the spatial and temporal level of effort, catch rate (i.e., kept or released), and harvest rate (i.e., fish kept) during the 2007 and 2008 recreational fishery seasons

at Boundary Reservoir and its tributaries. Identify target species sought by anglers. Fishing effort and catch rates will be estimated for the Upper Reservoir, Canyon, and Forebay reaches plus reservoir tributaries. Surveys will primarily involve angler interviews at boat ramp access points, but will also include interviews with bank anglers.

Task 2) Tagged Fish Reward Program

In coordination with the Reservoir Fish Distribution and Abundance, Triploid Rainbow Trout Management, and Biotelemetry studies, implement a reward program for the reporting of tagged fish by recreational anglers. Brochures and signs detailing the information desired and preferred release of tagged fish will be developed and distributed in areas frequented by recreational anglers potentially fishing Boundary Reservoir.

Task 3) Angler Survey

Coordinate with the Boundary Project relicensing RLAS Workgroup in the design of angler survey questions and appropriate methodology to collect information on the human dimension of recreational fishing at Boundary Reservoir. This survey component will be designed to estimate angler values and opinions regarding:

- potential reduction, maintenance, or enhancement of the triploid rainbow trout stocking in Boundary Reservoir;
- potential reduction, maintenance, or enhancement of non-native sport fish (especially smallmouth bass, largemouth bass, and yellow perch) in Boundary Reservoir sport fishery;
- potential opportunities to catch native trout and less popular native fish, such as northern pikeminnow and mountain whitefish in the sport fishery;
- potential reservoir pool level fluctuations and boat ramp access under alternative Project operational scenarios;
- potential future fishery management goals at Boundary Reservoir; and
- concerns about exotic macrophyte distribution and density.

Additional information will also be collected from angler survey participants including their origin, party size, watercraft type, where they launched their boat, do they go bank fishing, other activities enjoyed while in the Project area, where they are staying the night, other alternative fishing locations compared to the Project, and perceptions of crowding or conflicts encountered.

Depending upon the complexity or length of angler survey questions and its methodology, this component of the overall Recreational Creel and Angler Surveys may be conducted separately or in combination with the creel survey component. If conducted separately, the angler survey component may be distributed as a follow-on, mail-in questionnaire to creel survey respondents, or questionnaires may be provided at kiosks located at the three public boat ramps on the reservoir. This angler survey component will be conducted during the 2007 recreational fishing season at Boundary Reservoir. Based on the results of the 2007 survey effort, this survey

component may be continued during the 2008 recreational fishing season to increase the number of completed questionnaires.

Task 4) Smallmouth Bass Derby Monitoring

In coordination with the existing organized fishing derby at Boundary Reservoir, SCL will request that derby participants record their catch, effort, and approximate fishing location while at the reservoir. SCL will use this derby as an opportunity for public outreach to inform anglers about tagging and other fishery-related studies being conducted as part of relicensing and the need to recover tags from harvested fish or tag information from fish captured and released. SCL will distribute Task 3 survey questions during the derby and/or interview anglers.

Work Products

The work products for the Recreational Creel Surveys include the following:

- Tabular summaries and analysis of creel survey responses.
- Tabular summaries and analysis of angler survey responses.
- Tabular summaries and descriptions of the smallmouth bass derby monitoring.
- Draft and final reports describing the methods and results of the study component.

Schedule

The schedule for completing the Recreational Creel and Angler Survey is provided in Table 4.7-1.

Table 4.7-1. Schedule for completing the Recreational Creel and Angler Surveys.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
Design of recreational creel survey components, questionnaires, and other public information material	---							
Conduct creel survey component		▲▲	▲▲	▲▲		▲▲	▲▲	▲▲
Conduct angler survey component		▲▲	▲▲	▲▲		▲*▲	▲*▲	▲*
Fishing derby activities		▲▲				▲▲		
Reporting				---●				---■

* Additional field sampling, if needed.

Triploid Trout Biotelemetry

Proposed Methodology

Biotelemetry is the proposed method to collect behavioral, habitat utilization, and periodicity information for triploid trout.

A number of assumptions, listed below, are associated with the use of the proposed methodology. If the following assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- Behavioral effects of fish tagging can be differentiated from behavioral effects of stocking stress and response to habitat fluctuations associated with Project operations. The behavior of newly-released triploid trout may be different from the behavior of carry-over triploid trout that have overwintered a year or more in the Boundary Reservoir area.
- Acoustic transmitters will be used to track triploid trout because water depths in the Forebay and Canyon Reaches are too deep to effectively use radio tags.
- A range of transmitter sizes and longevities (5 to 10 sec pulse interval) will be used depending upon fish size:[5]
  - 295 to 400 grams (approximately 325 to 360 mm in length)
    - Position only – 180 to 320 day tag life
  - 400 grams (approximately 360 mm in length) or larger
    - Position only – 265 to 400 day tag life
- Triploid trout will be available in the spring and fall as part of typical triploid trout stocking procedures. Carry-over triploid trout that have overwintered at least one year in the Boundary Reservoir area can be captured by fishing or as part of the Passive and Active Sampling component of the proposed Fish Distribution, Timing, and Abundance Study (section 4.3).
- An array of fixed directional and omnidirectional hydrophones/receivers and/or buoyed wireless hydrophones will be available as part of the Biotelemetry component to the Fish Distribution, Timing, and Abundance Study to detect tagged fish at strategic locations within Boundary Reservoir. The number, type and location of hydrophones/receivers and other aspects of study design will be developed by the Technical Consultant in coordination with SCL and relicensing participants. For planning purposes, receiver coverage is expected to include the following locations:
  - Forebay area immediately downstream of the trashrack
  - Left and right bank spillways
  - Base of Peewee Falls
  - Pend Oreille River at the lower opening of the Canyon Reach
  - Pend Oreille River below Metaline Falls

[5] Fish sizes, pulse intervals, and tag longevity ranges are approximate and subject to change depending upon the choice of vendor for biotelemetry equipment and transmitters.

  - Pend Oreille River above Metaline Falls
  - Pend Oreille River near the Box Canyon tailrace
- During mobile tracking, the location of the tracking boats, when maneuvered close to the apparent tagged fish position, is presumed to be the tagged fish location.

The work effort for this study component has been divided into five tasks, as described below.

Task 1) Pre-stock Tagging

During each spring and fall of 2007 and 2008 implant acoustic tags into 10 triploid trout prior to release in the lower and upper reservoir areas (total 40 fish per year). Acoustic transmitters will be attached intraperitoneally using surgical techniques similar to those described by McCleod and Clayton (1997) and Brown et al. (1999). Each fish implanted with an acoustic tag will be identified with a numbered Floy, Petersen disc, or other external tag and a Passive Integrated Transponder (PIT) tag.

Task 2) Carry-over Tagging

In conjunction with the Fish Distribution, Timing, and Abundance Study, capture 10 carry-over triploid trout that have overwintered in Boundary Reservoir in the upper and lower reservoir areas (total 20 fish per year) and implant acoustic/temp/depth tags into the trout prior to release. Acoustic transmitters will be attached intraperitoneally using surgical techniques and each fish implanted with an acoustic tag will be identified with a numbered Floy, Petersen disc, or other external tag and PIT tag, if not already present.

Task 3) Fixed and Mobile Tracking

As part of the biotelemetry component of the Fish Distribution, Timing, and Abundance Study, mobile tracking by boat during 2007 will occur approximately every other week, weather permitting, during April through October. During November to March mobile tracking will occur once per month, weather permitting. Downloading and any required maintenance of fixed receivers will occur as part of tracking field trips. Monitoring will continue for a second year (2008), but the frequency may be scaled back if the results of this and other ongoing studies indicate little movement occurs during some months. Any change to sampling frequency will be developed in coordination with relicensing participants. During mobile tracking, GPS will be utilized to the extent adequate signals are available. Alternatively, tagged fish locations will be pinpointed on aerial photographs. Habitat information, utilizing underwater video, if necessary, will be collected at the location of tagged fish including water depth, velocity, temperature, substrate type, macrophyte density, and cover.

Task 4) Angler Outreach Program

Develop and implement an outreach program with local sport fishermen to recover transmitters and external tags attached to fish captured in the sport fishery.

Task 5) Data Analysis and Report Preparation

Evaluate the movement of newly released and carry-over triploid trout. Hourly operational information on Box Canyon Dam (flow) and Boundary Dam (flow and pool elevation) will be obtained. Conduct analyses to determine if spatial or temporal movement patterns of tagged triploid trout are correlated with Box Canyon and/or Boundary operations. Analyze and discuss overlaps in habitat utilization between triploid trout and native salmonids (bull trout, westslope cutthroat throat, and mountain whitefish). Use the information to evaluate triploid trout stocking strategies, including the number and size of planted fish.

Work Products

The work products for the Triploid Trout Biotelemetry Study component include the following:

- Tabular summary of tagged fish species, length, weight, tag size and number, tagging date, and release site.
- Tabular summary and GIS maps of tagged fish movements.
- Tabular and/or graphic summary of tagged fish habitat utilization.
- Draft and final reports describing the methods and results of the study component.

Schedule

The schedule for completing the Triploid Trout Biotelemetry investigation is provided in Table 4.7-2.

Table 4.7-2. Schedule for completing the Triploid Trout Biotelemetry investigation.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	----							
Install fixed receivers [1]	▲							
Monitor fish movements using fixed receivers [2]		----	----	----	----	----	----	----
Monthly mobile tracking [2]		▲ ▲ ▲	▲ ▲ ▲	▲ ▲	▲ ▲	▲ ▲ ▲	▲ ▲ ▲	▲ ▲
Data analysis and reporting				---●				---●

1 Fixed receivers installed as part of biotelemetry component of the Fish Distribution, Timing, and Abundance Study.

2 Timing and duration of fish tracking assumes that target species implanted with radio/acoustic tags are available for tracking.

Triploid Trout Management

Proposed Methodology

A number of assumptions, listed below, are associated with the use of the proposed methodology. If the following assumptions are false, the study may fail to meet one or more of its objectives or may require substantial changes to the methodology:

- In addition to the data collection efforts described below, this study will draw upon the results of the Triploid Trout Biotelemetry, the Recreational Creel Survey, and the Fish Distribution, Timing, and Abundance studies.
- The number and size of triploid trout to be stocked into Boundary Reservoir during 2007 and 2008 will be similar those stocked in 2006. During 2006, approximately 4,500 fish were stocked in March and a similar number is expected to be stocked in October. During 2007 and 2008, the stocked fish will be split between two locations: near the Forebay Recreation Area boat ramp and near the Metaline Waterfront Park boat ramp.

This study component includes four tasks, as described below.

Task 1) External tagging

Prior to being stocked in Boundary Reservoir, a subsample of the fish to be released will be tagged using colored, numbered Floy, Petersen disc, or other external tags. For planning purposes, it is assumed that 10 percent of the fish will be tagged, but the number of tagged fish may be adjusted based on early tag returns. For planning purposes it is assumed that triploid trout will be released from two locations (Upper Reservoir reach and Forebay reach) during three time-periods (Spring 2007, Fall 2007 and Spring 2008). Each tagged fish will be weighed and measured (total length) before release.

Task 2) Angler Outreach Program

In coordination with the Recreational Creel and Angler Surveys study, sports anglers will be encouraged to report the time, location and length of recaptured tagged fish through implementation of a reward program for the reporting of tagged fish. Brochures and signs detailing the information desired and preferred release of tagged fish will be developed and distributed in areas frequented by recreational anglers potentially fishing in Boundary Reservoir.

Task 3) Habitat Use

Analyze the spatial distribution patterns of triploid trout captures and compare habitat use information developed from the triploid trout and Fish Distribution, Timing, and Abundance biotelemetry studies. Describe potential spatial and temporal habitat overlaps between triploid trout and bull trout, cutthroat trout, and smallmouth bass.

Task 4) Demographics

Based upon tag returns, biotelemetry and other information, describe post-stocking movements of triploid trout and the growth, catch, and harvest of stocked triploid trout.

Task 5) Management Options

In combination with the available scientific literature, use the results of the external tagging, recreation creel survey, biotelemetry, and the reservoir fish distribution and abundance studies to develop a range of alternative triploid trout management options for Boundary Reservoir. Discussion will include the potential benefits and drawbacks of alternative strategies.

Work Products

The work products for the Triploid Trout Management Study components include the following:

- Tabular summary of externally-tagged triploid trout release and recovery locations and time between release and recapture.
- Text description comparing triploid trout habitat use to bull trout and cutthroat habitat use.
- Tabular summary and discussion of externally-tagged triploid trout growth, catch and harvest.
- Text description of triploid trout management options in the Boundary Reservoir.
- Draft and final reports describing the study methods and results.

Schedule

The schedule for completing the Triploid Trout Management study component is provided in Table 4.7-3.

Table 4.7-3. Schedule for completing the Triploid Trout Management study component.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---							
External Tag Triploid Trout	▲▲	▲▲▲		▲▲▲		▲▲▲		
External Tag Recovery		---	---	---	---	---	---	
Reporting				---●				---■

4.7.6. Consistency with Generally Accepted Scientific Practice

Recreational Creel and Angler Surveys. Creel and angler surveys such as proposed in this study plan are a common sampling method used to understand the effects of sport fishing on fish populations and to understand the perspectives and desires of anglers (Malvestuto 1996; Knuth and McMullin 1996).

Triploid Trout Biotelemetry. Biotelemetry studies of native salmonids and other fish species have occurred as part of licensing studies for the Box Canyon Project (FERC No. 2042) (Pend Oreille County PUD 2000) and the Lower Clark Fork Projects (Noxon Rapids and Cabinet Gorge, FERC No. 2058) (Avista Corporation 2005, Weitkamp et al. 2003). Biotelemetry studies have also been recently completed at the federal Albeni Falls Project to evaluate the need and feasibility of providing passage at that project (Geist et al. 2004, Scholz et al. 2005). The Triploid Trout Biotelemetry component of this study proposal utilizes methods similar to those used at these nearby hydroelectric projects.

Triploid Trout Management. Externally tagging sport fish to monitor post-release movement and catch returns is a traditional method in fisheries science (Murphy and Willis 1996).

4.7.7. Consultation with Agencies, Tribes, and Other Stakeholders

Input regarding the Recreational Creel and Angler Survey and the Triploid Trout Management components to the Recreational Fishery study was provided by relicensing participants during a June 27, 2006, Fish and Aquatic Resources Workgroup meeting held in Metaline Falls, Washington. During this meeting, an outline for each of these study components was presented and discussed. Input from relicensing participants regarding the Triploid Trout Biotelemetry component was provided during an April 20, 2006, workgroup meeting held in Spokane, at which the outline for this study component was presented and discussed. The proposed study plan was developed from the outlines and relicensing participant comments. Comments provided by relicensing participants on the review outlines for this study plan are summarized in Attachment 4-1 and can also be found in the workgroup meeting summaries (available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Triploid Trout Biotelemetry and Recreational Creel Survey study outlines presented at the workgroup meetings. The USFWS noted that the results of the triploid trout study should describe both positive and negative aspects related to potential interactions with native species. The USFWS also noted a concern about the use of Floy tags as external markers for native salmonids. Because Floy tags will also be used for triploid trout, the USFWS noted that anglers may misidentify native salmonids which could lead to inadvertent take of protected species. SCL acknowledges the problem and has modified the study plans to consider the use of alternative types of external tags. As noted in the proposed study plan, details such as the color, size, and marking of external tags, if used, will be developed by species and coordinated with relicensing participants.

In its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), the USFS did not specifically reference the Triploid Trout Biotelemetry or Recreational Creel Survey study outlines, but did request a Recreation Resource study. SCL's proposed Recreation Resource study plan is provided in section 6.1. In a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the study plan outlines.

In a letter to SCL dated August 28, 2006 (see Attachment 4-1), WDFW provided suggestions to improve the study, and cautioned about the expectations and applicability of the results to defining species interactions. In response, SCL incorporated WDFW's suggestions in the study

plan and scaled back the stated study objectives. The study implementation details will be finalized when the Technical Consultant is retained in early 2007, and any remaining questions regarding the sampling strategy will be addressed in coordination with relicensing participants at that time.

4.7.8. Progress Reports, Information Sharing, and Technical Review

An interim report describing survey methods and results of 2007 monitoring will be produced by December 31, 2007. A draft report describing the methods and results of 2007 and 2008 survey efforts will be produced by November 15, 2008, and a final report of the Triploid Trout Management study will be produced by December 31, 2008. The interim, draft, and final study reports will be available to relicensing participants. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with agencies, tribes, and other stakeholders to discuss the study results, as described in section 1.2.4 of this document. Relicensing participants will also have opportunities to discuss and comment on the progress of the study during quarterly workgroup meetings and ad hoc subcommittee meetings, as needed.

4.7.9. Anticipated Level of Effort and Cost

Recreational Creel and Angler Surveys — Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement the Recreational Creel and Angler Surveys at the Boundary Project ranges from $100,000 to $150,000; estimated study costs are subject to review and revision as additional implementation details are developed.

Triploid Trout Biotelemetry — Significant cost efficiencies for this study component are available since fixed and mobile tracking will be conducted as part of the Boundary Reservoir Biotelemetry component of the Fish Distribution, Timing and Abundance Study (described in section 4.3 of this PSP). The total estimated cost of implementing the triploid trout biotelemetry study is expected to range from $60,000 to $80,000; estimated study costs are subject to review and revision as additional implementation details are developed.

Triploid Trout Management — Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement at the Triploid Trout Management study component for the Boundary Project ranges from $55,000 to $85,000; estimated study costs are subject to review and revision as additional implementation details are developed.

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4.8. Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats

Tributary streams contribute water, nutrients, sediment, and woody debris to habitats within Boundary Reservoir portion of the mainstem Pend Oreille River. In addition to the role of tributaries in physical stream processes, tributary streams can provide a source of refuge, recruitment, and foraging to fish that inhabit Boundary Reservoir. Conversely, fish that exhibit a primarily riverine life history may use Boundary Reservoir for refuge, recruitment and foraging on a short-term basis. Fish that migrate between lakes or rivers and streams are considered to exhibit an adfluvial life history trait. Project operations can cause fluctuations in Boundary Reservoir water surface elevations, but evaluating the effects of Project operations will depend, in part, on understanding factors affecting adfluvial fish populations. For instance, the Pend Oreille River supports a mix of coldwater and warmwater, native and non-native fish species. During summer months, Pend Oreille River water temperatures up to 24ºC have been measured within the Boundary Project area (SCL 2006). High water temperatures may cause native salmonids, such as bull trout and westslope cutthroat trout to seek cold water refugia, such as tributary streams with water temperatures less than those found in mainstem habitats.

4.8.1. Nexus Between Project Operations and Effects on Resources

Information on factors affecting aquatic productivity in tributary reaches is needed to evaluate the role of tributary streams in the seasonal distribution and abundance of fish, particularly native salmonids, in Boundary Reservoir. Information on the potential movement of fish between mainstem and tributary habitats will be developed as part of the Fish Distribution, Timing and Abundance Study (section 4.3). However, information on factors affecting aquatic productivity in tributary habitats is needed to evaluate the influence of Project operations on fish that may exhibit an adfluvial life history. In addition, information on factors affecting aquatic productivity in Boundary Reservoir tributary streams may be helpful in identifying potential measures designed to offset impacts to aquatic resources associated with Project operations.

4.8.2. Agency Resource Management Goals

A broad description of agency management goals is provided in the Aquatic Habitat Modeling Study (see section 4.1.2).

4.8.3. Study Goals and Objectives

The goal of this study is to compile and evaluate information on Boundary Reservoir tributaries that will provide context for studies of the effects of Boundary Project operations on aquatic resources. The objective of this study is to inventory information on physical habitats and fish in Boundary Reservoir tributaries and to evaluate factors affecting tributary productivity.

4.8.4. Need for Study

Summary of Existing Information

An initial review of the available information suggests that compared to the upstream Box Canyon reservoir system and the downstream Waneta and Seven Mile reservoir systems, there is relatively little adfluvial habitat available in Boundary Reservoir tributaries (Figure 4.8-1). Even in the absence of upstream migration barriers, the total drainage area of Boundary Reservoir tributaries is much less than upstream and downstream reservoir systems (Figure 4.8-2). However, fish in tributary streams may use Boundary Reservoir at some portion of their life cycle (as discussed in section 4.3). Understanding factors affecting tributary populations may provide additional insight into understanding the relative abundance and distribution of these species within Boundary Reservoir and effects of Boundary Project operations. For instance, brook trout are non-native salmonids known to occupy many of the tributaries that drain to Boundary Reservoir (Figure 4.8-3). Brook trout have been cited as a threat to native salmonids as a result of interbreeding and competitive interactions (Andonaegui 2003). Brook trout may be suppressing native trout populations in some tributary reaches and affecting the potential distribution of native salmonids to other Boundary Project area habitats.

Need for Additional Information

Biological and physical habitat surveys of tributaries to Boundary Reservoir have been conducted by tribal, federal and state resource agencies, and data from these surveys are available as Geographic Information System (GIS) databases and as published and unpublished (gray) literature. After compiling the available information and developing an initial list of factors affecting productivity, additional site-specific field information may be needed to refine a list of factors affecting aquatic productivity and evaluate whether any of those factors can be modified through human intervention.

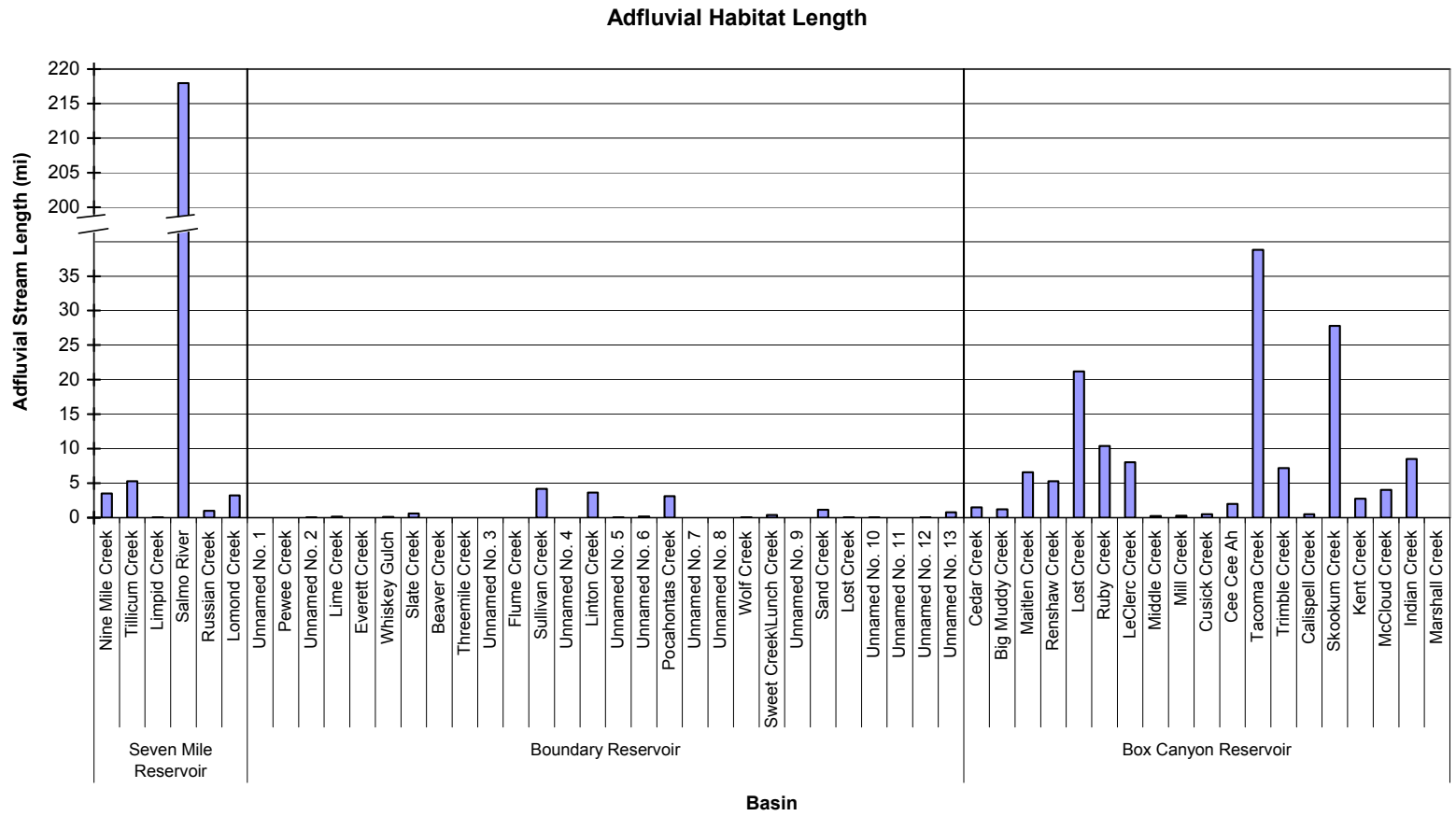


Figure 4.8-1. Length of adfluvial habitat in tributary basins draining to Seven Mile, Boundary, and Box Canyon Reservoirs based upon the location of the lowermost tributary fish passage barrier. Source of barrier information: Seven Mile Reservoir - R.L. &L and Taylor and Associates (2001), Sigma Engineering LTD (1996); Boundary Reservoir – McLellan (2001); Box Canyon Reservoir – Andomaegui (2003). For basins without specific barrier information, adfluvial habitat was assumed to be limited to average reach gradients of less than 16% based upon GIS data from BCMSRM (2001) and NWIFC and WDFW (2002).

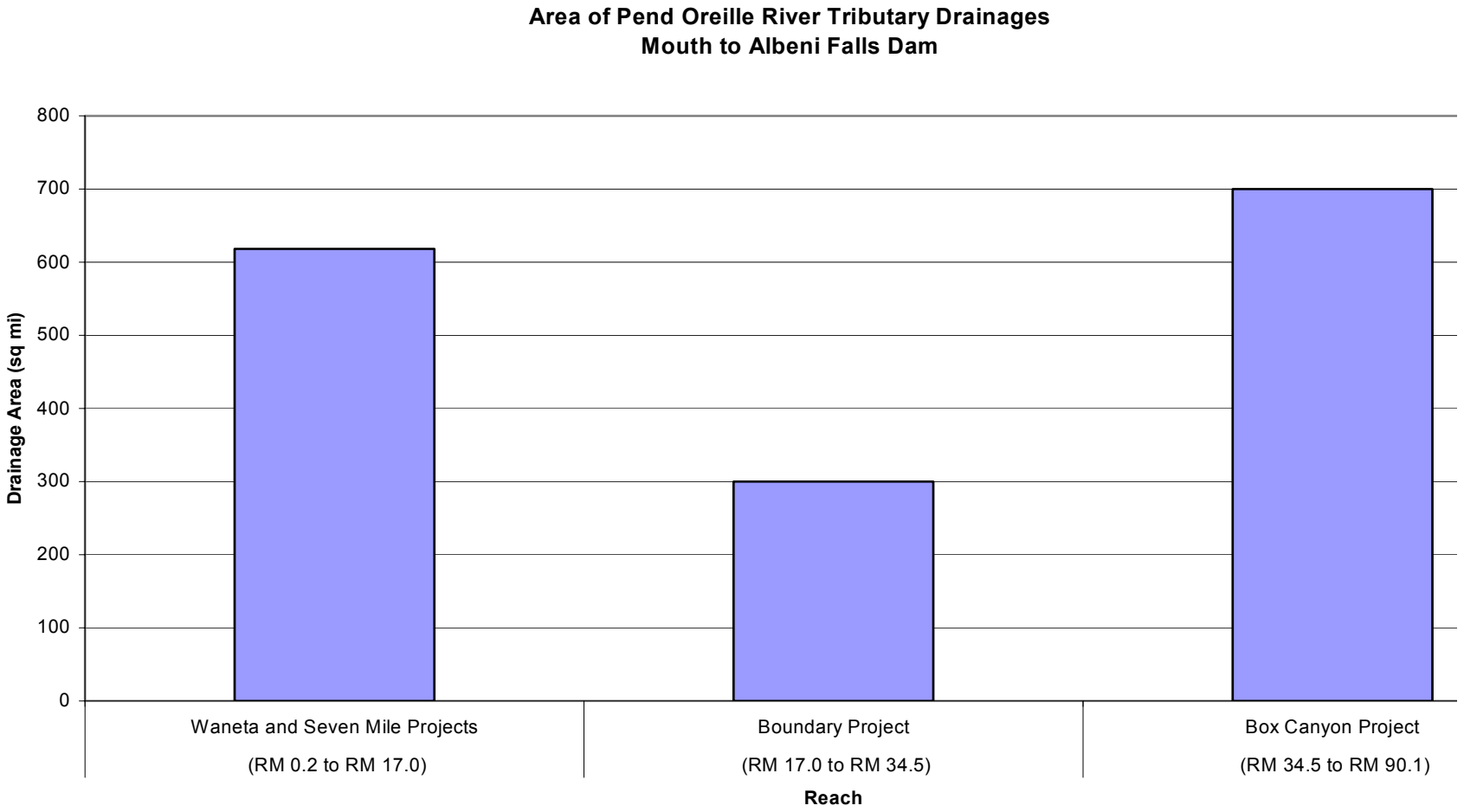
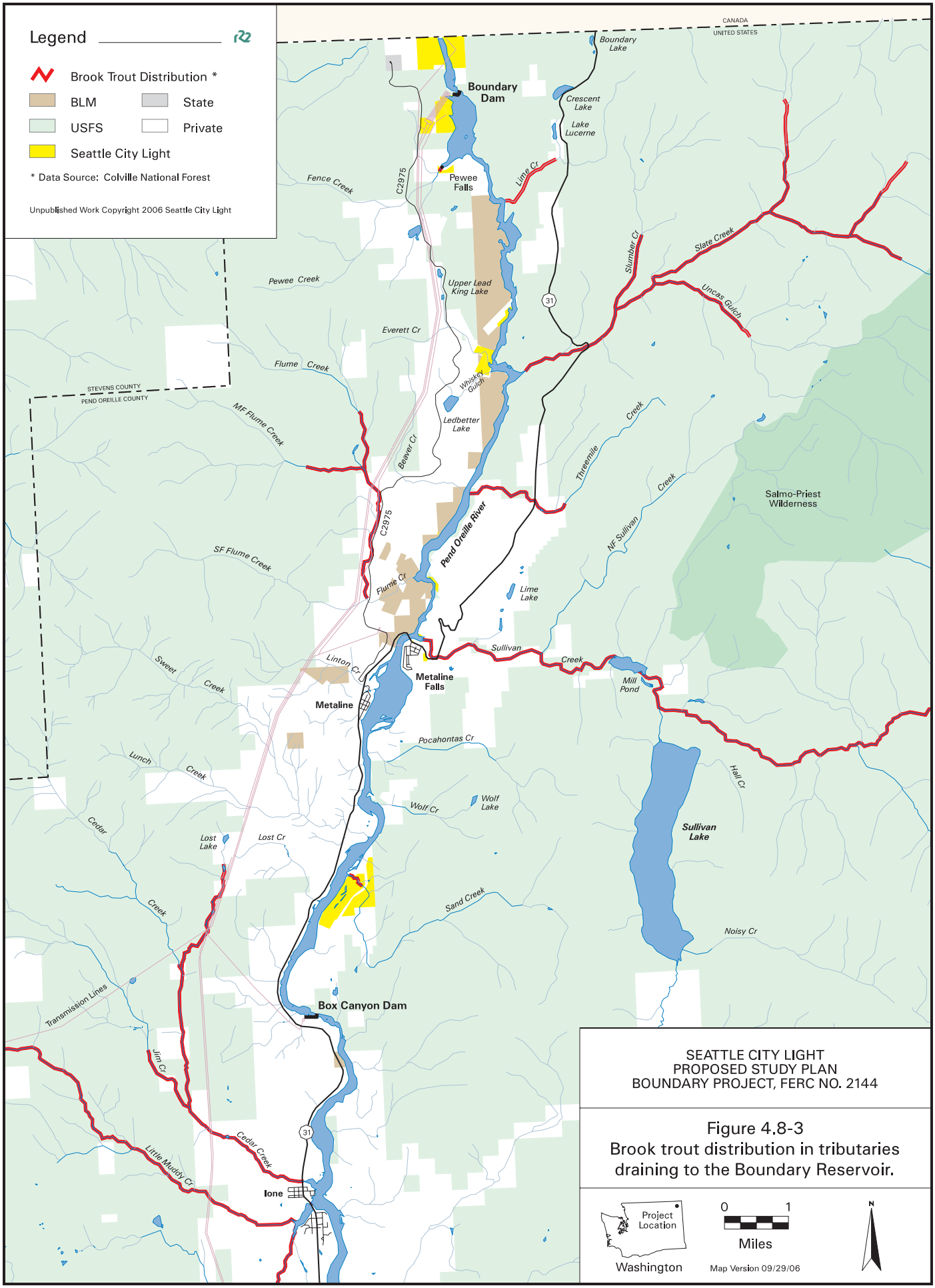


Figure 4.8-2. Drainage area of tributary basins contributing to the Pend Oreille River from the mouth to Albeni Falls Dam. Sources: USGS stream gage site information at Newport, below Box Canyon Dam, and at the International Border; (Pommen Water Quality Consulting 2003).


Legend
Brook Trout Distribution *
BLM
State
USFS
Private
Seattle City Light
* Data Source: Colville National Forest
Unpublished Work Copyright 2006 Seattle City Light
CANADA
UNITED STATES
Boundary Lake
Boundary Dam
Crescent Lake
Lake Lucerne
Fence Creek
C2975
Pewee Falls
Lime Cr
Slumber Cr
Slate Creek
Uncas Gulch
Pewee Creek
Upper Lead King Lake
Everett Cr
Flume Creek
Whiskey Gulch
STEVENS COUNTY
PEND OREILLE COUNTY
MF Flume Creek
Ledbetter Lake
Beaver Cr
Threemile Creek
Salmo-Priest Wilderness
NF Sullivan Creek
Pend Oreille River
SF Flume Creek
Flume Cr
Lime Lake
Sullivan Creek
Limton Cr
Metaline Falls
Metaline
Sweet Creek
Mill Pond
Pocahontas Cr
Lunch Creek
Hall Cr
Wolf Cr
Wolf Lake
Cedar Creek
Lost Lake
Lost Cr
Sullivan Lake
Sand Creek
Noisy Cr
Transmission Lines
Box Canyon Dam
Jinn Cr
Little Muddy Cr
Cedar Creek
Ione
SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144
Figure 4.8-3
Brook trout distribution in tributaries draining to the Boundary Reservoir.
Project Location
Washington
0
1
Miles
Map Version 09/29/06
N

4.8.5. Detailed Description of Study

Study Area

The study area for this effort will consist of tributary stream streams draining to the Pend Oreille River from Box Canyon Dam downstream to Boundary Dam.

Proposed Methodology

The proposed study effort for the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats consists of five tasks, as described below.

Task 1) Review and Compile Available Information

Available hydrology, water quality, fish habitat, fish presence and abundance, and migration barrier information for tributaries draining to Boundary Reservoir will be reviewed and compiled. The existing GIS database (USFS 2005) contains information on stream length, width, gradient, flow, water quality, riparian conditions, fine and coarse sediment sources, and road, railroad, or utility crossings. The database will be reviewed to identify data gaps or inconsistencies between data from alternate sources. Available aquatic habitat and fish distribution information for tributaries draining to Boundary Reservoir will be obtained from the following sources:

- Andonaegui (2003)
- Cascade Environmental Services (1996)
- Connor et al. (2005)
- Entrix (2001, 2002)
- McLellan (2001)
- R2 Resource Consultants (1998)
- Terrapin Environmental (2000)
- USFS (1998)
- USFS (1996)
- USFS (2005)
- WDFW (2003)

During 2007, and 2008, additional information gathered through the field efforts associated with the Fish Distribution, Timing and Abundance Study (section 4.3) will be added to the database.

Task 2) List of Productivity Factors

Based upon a review of materials in Task 1, develop a list of factors affecting the productivity of native biota and their habitats specific to each Boundary Reservoir tributary. Types of factors to be considered might include, but not be limited to:

- instream habitat quality, such as the distribution of large woody debris, stream bank erosion;
- riparian land-use practices;
- fish migration barriers, man-made or natural;
- presence of non-native species; and/or
- native species recruitment.

Task 3) Draft Limiting Factors Matrix

Prepare a matrix of factors limiting the productivity of native species for each tributary. Criteria to be considered when developing a matrix of factors limiting productivity will be identified with relicensing participants and may include length of stream affected, existing species, water temperature, existing land-use, riparian habitats and access. This matrix will be used to assess the likelihood that factors limiting productivity in each stream can be altered.

Task 4) Identify Data Gaps

Review available information supporting the matrix developed in Task 3 and identify potential data gaps and the need for supplemental information. Determine, in consultation with relicensing participants, the need to conduct additional field surveys in select tributary reaches to fill critical data gaps. For planning purposes, we assumed additional field surveys would require two weeks of field effort for three people.

Task 5) Finalize Limiting Factors Matrix

Review the matrix of factors limiting production developed in Task 3, and in view of additional information acquired as part of this and other relicensing study efforts during 2008, develop a final matrix of factors limiting productivity in each stream. Prepare a report that describes the factors limiting productivity of native species in each tributary and an evaluation of general feasibility regarding whether those factors can be changed through human intervention.

4.8.6. Work Products

The work products for this study include the following:

- An electronic database containing the available information from Boundary Reservoir tributaries on hydrology, water quality, fish habitat, fish presence and abundance, channel morphology, riparian conditions, and migration barriers.
- A final matrix of factors limiting the productivity of native species in Boundary Reservoir tributaries.
- A final report including the final matrix of limiting factors and a description of the methods and results of any field surveys conducted to fill data gaps.

4.8.7. Consistency with Generally Accepted Scientific Practice

Biological and physical habitat surveys of tributaries to Boundary Reservoir have been conducted by Tribal, federal and state resource agencies, and data from these surveys are available as GIS databases and as published and unpublished (gray) literature. If additional field survey information is needed to provide additional detail on a tributary reach of particular interest, field surveys will be conducted consistent with accepted techniques as described in Bain and Stevenson (1999). However, if additional information is needed to verify existing data, or to respond to gaps in data coverage, the field methods and procedures used in the original survey may be adopted to ensure data consistency.

4.8.8. Consultation with Agencies, Tribes, and Other Stakeholders

A draft outline of the study plan for the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats was distributed to relicensing participants prior to a Fish and Aquatic Workgroup meeting held in Spokane, Washington, on August 14, 2006. During this workgroup meeting, the outline was presented and relicensing participants provided comments. The draft study plan was developed from the outline and in response to relicensing participant comments. Comments provided by relicensing participants on the review outline for this study plan are summarized in Attachment 4-1 and can also be found in meeting summaries available on SCL's relicensing website (www.seattle.gov/light/news/issues/bndryRelic).

In the PAD/Scoping comment letter filed by the USFWS with FERC on September 1, 2006 (USFWS 2006), the USFWS endorsed the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats study outline that was presented at the workgroup meetings. In the USFS's PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), and WDFW's August 28, 2006 comment letter to SCL, the Factors Affecting Tributary Habitats outline was not specifically referenced, but the USFS indicated its interest in tributary habitats and biota in its comments on Native Salmonid Presence and Migration Study request. During a follow-up conference call on September 8, 2006, USFS staff indicated that there was general agreement on the outlines presented at the workgroup meetings. They agreed that their need for information on tributary habitats and biota would probably be met by a combination of existing information on tributary habitats and biota, the results of snorkel surveys in the lower tributary reaches, and information developed as part of this tributary habitats study.

4.8.9. Schedule

The schedule for completing the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats is provided in Table 4.8-1.

Table 4.8-1. Schedule for completing the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	---------							
Compile and review tributary, habitat, barrier, and distribution information		---------	-----	-				
Develop an initial list of potential factors affecting the productivity of native species in tributaries				---	------		---------	
Determine the need for additional information					------			
Conduct field surveys, if needed						▲▲▲	▲	
Review and revise the list factors affecting productivity of native species in Boundary tributaries.							----------	---
Reporting					•			■

4.8.10. Progress Reports, Information Sharing, and Technical Review

An interim report summarizing tributary habitat conditions will be prepared by November 15, 2007. A draft report describing the methods and results of 2007 efforts, an initial ranked list of factors affecting productivity specific to each Boundary tributary stream, and if necessary, a proposed list of additional information needs will be developed by March 2008. A final report of the Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats will be produced by December 31, 2008. The interim, draft, and final study reports will be available to relicensing participants. Prior to release of the Initial and Updated study reports (which will include the results of this study), SCL will meet with relicensing participants to discuss the study results, as described in section 1.2.4 of this document.

4.8.11. Anticipated Level of Effort and Cost

Based on a review of study costs associated with similar efforts conducted at other hydropower projects, the estimated cost to implement this effort at the Boundary Project ranges from $60,000 to $80,000; estimated study costs are subject to review and revision as additional details are developed.

4.8.12. Literature Cited

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Attachment 4-1: Summary of Stakeholder Comments on Draft Fish and Aquatic Resources Study Plans

Summary of comments on draft Fish and Aquatic Resources study plans made at the Fish and Aquatic Workgroup meetings (2006).

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Draft Fish and Aquatic Study Outlines; Turbine Entrainment					
Verbal	4-20-06	D. Robison	WDFW	Robison asked if a threshold velocity was needed for the fyke nets (method proposed by SCL for turbine entrainment study) to function properly.	The nets take shape as the result of velocity and these velocities would be present under the sampling conditions, when the units are operating. SCL and the technical consultants eventually selected to conduct the studies will ensure that all sampling equipment works properly.
Verbal	4-20-06	D. Robison	WDFW	Robison asked whether the fyke nets would be damaged by debris carried with the flow into the intakes.	The trash racks at the upstream end of the forebay would, as they currently do, catch large debris but smaller debris would enter the nets. The nets would be constructed to withstand some debris entrainment. Fyke netting in the proposed fashion has been conducted at other sites and shown to be effective.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda (USFS) stated that the study approach called for placing fyke nets in one or two intakes based on which intakes were shown via hydroacoustics to have the greatest number of detections in front of them. Shuhda asked what would be done if hydroacoustics indicates that fish distribution is uniform across the face of the intakes.	The purpose of the hydroacoustics is to translate the fyke net results to the other intakes. Three factors would be considered when deciding in which units to place the fyke nets: 1) which intakes have the greatest number of hydroacoustic detections, 2) which units are used preferentially for generation, and 3) which intakes will best accommodate placement of the nets.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked what would be done with the fish captured in the fyke nets.	All fish captured in the nets would likely be dead and SCL would document the species and size of each fish and whether it has a tag. Genetics samples would be collected from bull trout and cutthroat trout captured in the nets
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked if SCL would shut down its units if a radio-tagged bull trout is	SCL is not proposing to shut the units down. Under the USFWS permit

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				detected in the forebay while the fyke nets are in place, to avoid potential mortality of the bull trout.	#TE005885-0, SCL is allowed to take two bull trout per calendar year.
Verbal	4-20-06	D. Robison	WDFW	Robison asked whether SCL would be willing to shutdown units during high flows to place fyke nets.	Units would be shut down as needed if a fyke net sampling event is scheduled during a period of high flows.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked how hydroacoustics sampling would be set up so that results would best indicate the number of fish that are being entrained, as opposed to those simply in the vicinity of the intakes.	Specifics related to the configuration of the hydroacoustics detection array would be worked out with the technical consultant selected to conduct the study. However, the goal will be to get the best estimate of the number of detections at risk of turbine entrainment.
Verbal	4-20-06	D. Robison	WDFW	Shuhda asked why SCL had abandoned DIDSON (Dual Frequency Identification Sonar) as a potential method for assessing turbine entrainment	Given the limitations of DIDSON, it would be less effective than the combined use of hydroacoustics and intake fyke netting for assessing the extent of turbine entrainment.
Verbal	4-20-06	S. Jungblom	Pend Oreille PUD	Scott Jungblom asked if it would be advantageous to place the transducers on the fyke net frames.	The confined environment of the intakes would likely interfere with the ability to perceive signals around the periphery of the detection beam.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney stated that it would be useful to conduct sampling under operating conditions similar to those expected under the new FERC license, for example operations designed for TDG abatement.	Such sampling could occur if there is some certainty regarding the nature of future operations at the time the turbine entrainment study is conducted. However, operational changes undertaken to reduce TDG concentrations would be designed to not exacerbate adverse impacts on fish.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying turbine entrainment at Boundary Dam appeared to be appropriate.	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Draft Fish and Aquatic Study Outlines; Spillway Entrainment					
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked if DIDSON was still being considered as a tool for assessing spillway entrainment.	DIDSON appears to have limited utility for attempting to quantify spillway entrainment and the proposed approach would be more effective.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked if tailrace sampling might be used to assess species composition of fish entrained in spill.	Tailrace netting is not ruled out as a possible sampling approach for assessing spillway entrainment. However, fish that die during spillway passage might become lodged in the tailrace substrate, which would limit the value of trying to capture fish in the tailrace using a surface-oriented screw or scoop trap to assess spillway entrainment.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying spillway entrainment at Boundary Dam appeared to be appropriate.	Comment acknowledged.
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson referred to Task 2 of the spillway entrainment study outline and stated that limiting studies to the period of April through July could result in a lack of data for other periods of the year when spill could occur. Donaldson noted, for example, that spill could occur in winter as the result of rain-on-snow events.	Significant spill would likely occur during the April through July period, as evidenced by 10-percent flow exceedance data. However, the spillway entrainment monitoring period would be adjusted if significant spill occurs outside the April through July period.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Draft Fish Connectivity Early Information Development (EID) Report; information for evaluating the need for fish passage					
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked whether Canada's position regarding downstream fish passage at Boundary Dam—i.e., concern about downstream passage of nonnative fish species—was being considered. Llewellyn added that the interest in upstream passage appears to be driven by U.S. agencies and tribes and asked whether SCL had contacted Canadian agencies regarding their interest in upstream passage.	The determination to pass fish was a regulatory issue to be decided by the stakeholders, including USFWS and the USFS, which have conditioning authority. SCL's objective was not to make a determination on the desirability of passage but to ensure that appropriate information was available to allow regulators to make informed decisions.
Verbal	4-20-06	S. Deeds	USFWS	Deeds stated that the management goals of the USFWS would not be based on habitat availability or productivity estimates derived from tributaries downstream of Boundary Dam. Rather, said Deeds, the objective is to allow fish passed downstream at Boundary Dam—currently those surviving entrainment—an opportunity to migrate back upstream to their natal waters.	SCL had thought the return of fish previously passed downstream at the Project was only part of the issue and that the management agencies would be concerned about connectivity at a larger scale, which was the basis for seeking direction from the agencies on how to assess habitat availability downstream of Boundary Dam.
Verbal	4-20-06	D. Robison	WDFW	Robison stated that WDFW was primarily concerned with upstream fish passage to allow for the return of fish that originate in Washington waters.	Same response as in preceding row.
Verbal	4-20-06	S. Jungblom	Pend Oreille PUD	Jungblom stated that if the decision to implement fish passage was to be based on entrained fish, then the estimates of entrainment appeared to be the information needed by the agencies.	Entrainment studies were planned for both the turbines and spillway.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney stated that what is most important to the Kalispel Tribe is the establishment of upstream passage at Boundary Dam.	Comment acknowledged.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda stated that the USFS is	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				concerned with all native fish attempting to pass Boundary Dam, regardless of their origin. Shuhda stated that the goal of the USFS is to ensure that ongoing adverse effects on aquatic connectivity associated with the Boundary Project are mitigated under the new FERC license, adding that the studies outlined by SCL would be necessary to ascertain what mitigation is needed.	
Verbal	4-20-06	D. Robison	WDFW	Robison stated that the EID did not really address connectivity but fish passage at Boundary Dam. Doug stated that connectivity is a more comprehensive issue, related to the ability of fish and other aquatic organisms to access the full range of their natural habitat. For example, said Doug, connectivity in the Project area includes access to the reservoir's tributaries.	Connectivity in the larger sense does involve, among other things, tributary access. However, from a practical standpoint it is essential to deal with issues in manageable pieces and that to do this SCL had decided to address connectivity, i.e., fish passage, at the dam first. Tributary access would be addressed at a subsequent meeting aimed at identifying studies needed to assess conditions in tributary deltas, particularly in response to variability in reservoir surface elevation.
Verbal	4-20-06	D. Robison	WDFW	Robison asked for more detail regarding the process to be used to arrive at decisions about fish passage at the dam.	The purpose of the PSP is to identify studies that would be the basis of decisions made about fish passage and indicated that Table 5-1 in the EID provides an overview of the proposed Boundary Project Fish Connectivity Program.
Estimates of turbine and spillway mortality (a component of the draft Fish Connectivity EID)					
Verbal	4-20-06	D. Robison	WDFW	Robison asked whether the seven conditions potentially damaging to fish (identified in the EID) were directly proportional to head.	Some of the conditions are more detrimental to fish as head increases, for example shear and pressure changes.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Verbal	4-20-06	D. Robison	WDFW	Referring to Table 4-1 in the EID (i.e., Turbine Characteristics), Robison asked for an explanation of the significance of the "number of buckets" associated with turbine units 51 through 56.	The number of buckets is equivalent to the number of blades, the turbine feature that results in fish strike. The greater the number of blades for a turbine of a given size, the higher the probability of strike.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked whether entrainment mortality estimates calculated by Peter Christensen (R2) accounted for direct mortality only or if they included delayed mortality as well.	Estimates were based on direct mortality.
Verbal	4-20-06	D. Robison	WDFW	Robison asked if the flip bucket at the downstream end of Spillway #1 has adverse effects on fish as they pass over it.	The flip bucket has a 35-ft radius, so that fish should suffer no impacts resulting from contacting it. However, flow passing over the flip bucket is released at an upward angle, which is relevant in terms of effects on fish. Fish leaving Spillway #1 are launched upward with the water and then fall to the tailrace. This situation likely results in minimal impacts to small fish, unless they strike rocks in the tailrace, but likely results in higher mortality of large fish. In contrast, Spillway #2 has no flip bucket, so water passing over the spillway flows downward. In this case, shear is the primary cause of adverse effects on fish. Fish moving in the center of the spill jet from Spillway #2 should enter the tailrace safely, whereas those at the periphery of the jet will experience strong shear forces. Large fish are more resistant to shear than are small fish so that small fish entrained in Spillway #2 likely suffer higher mortality than large fish.
Verbal	4-20-06	D. Robison	WDFW	Referring to Table 4-2 in the EID (Estimated Mortality for Existing Downstream Passage Routes), Robison	SCL did not consider any specific opening except that it would be high enough to ensure that at least about a foot

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				asked how far open the spillway gates were considered to be when deriving the spillway mortality estimates.	of depth is maintained across the concrete chute spillway. This would represent a flow of at least about 3,000 cfs, or a gate opening of greater than 2 feet. The wider the spill gate opening, the lower the likelihood of fish mortality.
Verbal	4-20-06	C. Vail	WDFW	Vail asked how SCL operates the spillway gates.	When powerhouse flows reach capacity (i.e., 55,000 cfs) during higher flow or flood conditions, the spillway gates are opened first until half their discharge capacity (total of approximately 54,000 cfs) is reached, then the sluiceway is opened, with the sluice gates closest to the center of the dam opened first to reduce the possibility of eroding the abutments on the downstream side of the dam. Half the spillway gate capacity is reserved to maintain a steady forebay elevation while sluice gates are being opened. The sluice gates are either fully open or fully closed, and cannot be throttled.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked for clarification as to when the sluiceways at Boundary Dam are operated.	The sluiceways are only operated when flow through the powerhouse and over the spillways is maximized. SCL avoids using the sluiceways because the sluice gates cannot be throttled, so that there is no ability to regulate the volume of flow passing through them.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney said that based on the information in Table 4-2 of the EID, entrainment mortality for all sizes of salmonids through all avenues of passage appeared to average about 35 to 40 percent.	Comment acknowledged.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	In response to SCL's request that stakeholders approve the use of entrainment mortality estimates	Stakeholders were asked to provide SCL with comments on the Fish Connectivity EID and a decision as to whether the

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				provided in Table 4-2 of the EID, thereby eliminating the need to conduct entrainment mortality studies, Maroney stated that he needed to think about it before agreeing to use the mortality estimates.	entrainment mortality estimates developed by Peter Christensen (R2) would be acceptable for use in the relicensing by May 16, 2006.
Verbal	4-20-06	T. Shuhda	USFS	In response to SCL's question identified in the preceding row, Shuhda stated that he would need to review the relevant section of the Franke et al. (1997) report to ensure that the predictive equations—and the studies whose results correlate with the equations' output—are relevant to the Boundary Project. Shuhda stated that if stakeholders are unconvinced of the applicability of the equations, it would be necessary to conduct turbine mortality studies with proxy salmonids. Shuhda added that in addition to turbine mortality it would also be necessary to address injury and that the same was true for fish entrained in the spillway or sluiceways.	Same response as in preceding row.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed to provide SCL with comments on the Fish Connectivity EID and a decision as to whether the entrainment mortality estimates developed by Peter Christensen (R2) would be acceptable for use in the relicensing by May 16, 2006.	SCL agreed to the proposed deadline for submittal of feedback.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda stated that the USFS was willing to accept the use of the spillway mortality estimates.	Comment acknowledged.
Verbal	8-14-06	Stakeholders	Multiple	Stakeholders agreed that SCL's estimates of turbine and spillway fish mortality rates could be used during the	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				relicensing in place of empirically derived results.	
Draft Fish and Aquatic Study Outlines; Tailrace Fish Distribution					
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked whether SCUBA diving, in addition to snorkeling, had been considered as a sampling method.	SCUBA had been evaluated but was considered to have low data return for the cost in the tailrace, especially because using SCUBA among Project structures would require support barges and additional surface personnel.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked if the study would shed light on whether bull trout in the tailrace were attempting to move upstream.	The tailrace fish distribution study would address bull trout presence, but the sampling gear would not differentiate upstream migration from other behaviors.
Verbal	4-20-06	S. Deeds	USFWS	Deeds stated that genetics samples could shed light on the origin of fish captured in the tailrace.	Genetics data would be analyzed as part of fish distribution studies to help identify fish origins.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney provided an overview of bull trout and cutthroat trout genetics studies being conducted in the lower Pend Oreille basin, including work done by the Kalispel Tribe, USFWS, and WDFW	None.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked how genetics information would be used in the relicensing.	Genetics data would be analyzed as part of fish distribution studies to help identify fish origins.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying tailrace fish distribution at Boundary Dam appeared to be appropriate.	Comment acknowledged.
Draft Fish and Aquatic Study Outlines; Tailrace Biotelemetry					
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked if fish in the tailrace would be tracked during high flows.	Fixed receivers would be in place in the tailrace at all times and are expected to detect fish under the range of flows. Mobile tracking will also be conducted in the tailrace and Seven Mile Reservoir, although it is yet to be determined at what

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
					flow mobile tracking would no longer be feasible or safe. Work conducted by SCL in 2006 will be used to help make determinations about when and how biotelemetry will be conducted.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked where fish for the tailrace biotelemetry study would be captured.	All fish to be tagged as part of the tailrace biotelemetry study would be captured between Boundary Dam and the US-Canada border.
Verbal	4-20-06	L. Matthews	Columbia Power	Matthews asked what would be done if insufficient numbers of native salmonids were captured in this area.	Efforts applied to capture fish would be substantial but if target sample sizes are unattainable, SCL will conduct studies with as many fish as possible.
Verbal	4-20-06	S. Deeds/ J. Maroney	USFWS/ Kalispel Tribe	Deeds and Maroney stated that native redband (rainbow) trout should be included in the tailrace biotelemetry study.	SCL agreed include native redband (rainbow) trout in the tailrace biotelemetry study.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked whether additional salmonids would be tagged in 2008 if the target number of 20 individuals of each species was not attained in 2007. Shuhda also asked if additional fish would be tagged to replace any whose tag dies during the study.	Tagging will continue in 2008, if necessary, and fish with dead tags will be replaced, if additional fish can be captured.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying tailrace biotelemetry at Boundary Dam appeared to be appropriate.	Comment acknowledged.
Draft Fish and Aquatic Study Outlines; Fish distribution, timing, abundance and species interactions in the Boundary Reservoir					
Verbal	5-23-06	Scott Deeds	USFWS	Deeds stated that CART tags, unlike acoustic tags, would allow for fish movements in the lower portions of reservoir tributaries to be monitored with the fixed receivers at the tributary mouths, i.e., even without the use of mobile tracking in the tributaries.	Decisions about the selection of tags will be made when the results of the 2006 field studies are available and a contractor for the 2007-2008 field seasons has been selected.

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Verbal	5-23-06	Scott Deeds	USFWS	Deeds stated that Floy tags could be lost and that PIT-tags would likely generate more useful information because of their higher retention rate.	Unlike PIT-tags, which require a detector, Floy tags can be detected and read by anyone, including anglers. In other research situations, return rates on Floy tags by anglers have averaged about 12 percent. Floy tags will alert anglers that a particular fish is part of a study, which may promote rapid release of that fish.
Verbal	5-23-06	Curt Vail	WDFW	Vail stated that he was aware of Floy-tag return rates as high as 40 percent when a reward was provided for returns.	SCL agreed to consider a reward program to increase Floy tag return rates.
Verbal	5-23-06	Scott Jungblom	Pend Oreille PUD	Jungblom stated that an advantage of PIT tags is that they could be detected by the PIT-tag detector that will be in place at the base of Box Canyon Dam.	SCL agreed that fish in good condition, i.e., showing low signs of stress, captured when water temperatures are low, would receive PIT-tags, in addition to radio tags (or acoustic/CART) and Floy tags.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that setting gill nets monthly would likely provide better data than setting them every six weeks and requested that SCL change the study plan so that gill nets are set once per month. Robison added that if mortality or injury rates of priority species are unacceptable, the frequency of net sets can be reduced.	SCL agreed to revise the SCL agreed to revise the *Fish Distribution, Timing, and Abundance* study plan so that gill nets will be set monthly instead of at six-week intervals, with the caveat that sampling frequency will be reduced if mortality or injury rates of native salmonids are unacceptable.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda noted that the study plan called for determining gill net soak time after the results of 2006 sampling are available. Tom asked for a brief characterization of the scope of the 2006 gill net sampling.	Variable-mesh gill net sampling would take place in the Boundary Dam tailrace and at the mouths of Flume, Slate, Sullivan, and Sweet creeks. At least initially, gill nets will be set for 1-hr periods.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked whether electrofishing transects would be laterally or longitudinally oriented.	Electrofishing transects would be oriented parallel to the shoreline.
Verbal	6-27-06	Mark Tiley	CCRIFC	Tiley asked whether gill nets are expected to become entangled on	Sharp rocks rather than submerged wood are expected to interfere with gill net

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				submerged large wood in the reservoir, noting that if they do, it could result in fish mortality.	sampling. Nets will be set using strong lines to ensure retrieval of nets, even if mesh is torn, to reduce the risk of losing nets and creating a 'ghost-fishing' situation.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked how tributary fyke netting would be conducted so that downstream migrants can be distinguished from upstream migrants.	Leads to the fyke nets would extend in a open 'V' across the width of the channel with the open portion facing upstream into the current, thereby reducing the risk of upstream migrating fish entering the nets. Upstream migration of fish would be assessed with biotelemetry.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda questioned whether deploying fyke nets with leads extending across the channel would significantly disrupt upstream migration of native salmonids during some sampling periods.	Nets would be deployed for short enough periods that they would not disrupt upstream migration of salmonids. If fish are observed holding downstream of the nets, the leads can be modified to provide an upstream passage corridor.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked if a fish weir and trap would be implemented to assess upstream tributary migration if an insufficient number of fish are captured for biotelemetry studies or if for some other reason the results of biotelemetry studies are not conclusive.	Evaluation of study results would occur in fall 2006, after which sampling protocol could be modified if needed. If insufficient numbers of bull trout or other target species are captured in 2006, it will be necessary to re-assess the design of this and several other Fish and Aquatics studies.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda stated that the reservoir fish distribution and abundance study plan should be modified so that it states explicitly that alternative sampling methods will be developed if those initially employed are unsatisfactory. Also, the study plan should include a statement that water temperature and dissolved oxygen will be measured at all fish sampling sites.	SCL agreed to modify the study plan according to Tom Shuhda's recommendations.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked if tagged fish attempting	SCL and stakeholders agreed that all

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				to pass upstream at Box Canyon Dam would be moved upstream and released into Box Canyon Reservoir as part of Pend Oreille PUD's interim fish passage program.	tagged salmonids in the Box Canyon tailrace, bull trout in particular, that appear to be actively attempting to migrate upstream should be transferred to Box Canyon Reservoir as part of Pend Oreille PUD's interim fish passage program.
Draft Fish and Aquatic Study Outlines; Reservoir Biotelemetry					
Verbal	4-20-06	D. Robison	WDFW	Robison asked whether mobile tracking would be undertaken to determine whether native salmonids are searching for and occupying cold-water refugia, such as tributary deltas and areas of groundwater inflow.	Mobile tracking will shed light on which habitats are used by native salmonids. However, habitat modeling would be the primary method used to assess habitat suitability in tributary deltas and that the proposed approach to modeling would be the focus of the May 2006 Fish & Aquatics Workgroup meeting. If captured fish are large enough, some fish could be fitted with depth and temperature tags to evaluate whether they are using areas of groundwater inflow.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney stated that smallmouth bass, which are a valuable sport fish in Boundary Reservoir, should be included in the reservoir biotelemetry study. Joe added that because smallmouth spawn in shallow, near-shore areas, their habitat is likely to be affected by fluctuating reservoir surface elevation.	SCL planned to address smallmouth with habitat modeling as part of the varial zone study. Biotelemetry is typically applied when the objective is to gain much information regarding a small population of organisms, such as bull trout in Boundary Reservoir. In the case of an abundant organism, such as smallmouth bass, other techniques, in this case sampling with electrofishing, gill nets, and fyke nets may provide sufficient data to validate habitat suitability curves. Nevertheless, SCL agreed to consider whether to include smallmouth bass in the reservoir telemetry study and report back to stakeholders. Follow-up: At the May 23, 2006 Fish &

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					Aquatics Workgroup meeting, SCL stated that it would tag smallmouth bass, some of which could be tagged when they are caught by anglers during the annual Boundary Reservoir bass tournament.
Verbal	4-20-06	J. Maroney	Kalispel Tribe	Maroney asked if reservoir-specific habitat suitability indices would be developed for smallmouth bass for use in the modeling study	The proposed approach is to validate habitat suitability indices with observations made in Boundary Reservoir.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda asked if a reservoir fish distribution study, like that proposed for the tailrace, was planned.	A reservoir fish distribution study plan is in preparation and will be discussed at the June 2006 workgroup meeting.
Verbal	4-20-06	T. Shuhda	USFS	Shuhda (USFS) stated that if radio-tagged fish pass stationary receivers at tributary mouths, it would be useful to employ mobile tracking to evaluate their habitat use in the tributaries upstream of the fixed receiver. Shuhda stated that such an effort would not be undertaken to assess direct impacts of Project operations on tributary habitat, because the habitat in question is outside the Project's influence. However, said Shuhda, the data provided by mobile tracking in tributaries would be useful in identifying potential sites that could be enhanced as mitigation for the ongoing impact of inundation of 17 miles of river resulting from the existence of Boundary Reservoir. Tom stated that the USFS is particularly interested in fish habitat use in Sullivan, Slate, Sweet, and Flume creeks.	SCL agreed to consider the USFS request and report back to stakeholders regarding its decision. Follow-up: SCL agreed to conduct mobile tracking within tributaries if a radio-tagged fish was recorded passing a stationary receiver into the tributary.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying reservoir biotelemetry at Boundary	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				Dam appeared to be appropriate.	
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda stated that biotelemetry data could be used to assess whether particular cascading falls on some tributaries are indeed barriers to fish passage, acknowledging that a lack of data showing fish passage would not necessarily mean that a waterfall represents a barrier.	It would be difficult to conduct mobile tracking on foot of fish movements in tributaries. However, it might be possible to conduct flights over tributaries in an attempt to detect radio tags.
Draft Fish and Aquatic Study Outlines; Triploid Trout Biotelemetry					
Verbal	4-20-06	D. Robison	WDFW	Robison asked if SCL intended to post signs to alert anglers that they should return tagged fish to the reservoir.	Posters will be displayed at boat launches to alert anglers about tagged fish.
Verbal	4-20-06	D. Robison	WDFW	Robison asked if anglers could be queried as to where and when radio-tagged fish are captured, information that could be useful is assessing angler effort and harvest.	SCL proposes to conduct a creel survey to address the issues raised by WDFW and that the study plan for this survey would be reviewed at the June 2006 Fish & Aquatics Workgroup meeting.
Verbal	4-20-06	All stakeholders	All stakeholders	Stakeholders agreed that the overall proposed approach to studying triploid trout biotelemetry at Boundary Dam appeared to be appropriate.	Comment acknowledged.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that spatial overlap between native and stocked trout would not be sufficient to conclude that competition is occurring between them. Robison stated that if the system is below carrying capacity, triploid trout and native salmonids could occupy the same areas without affecting each other's abundance or condition.	Given the low productivity of the reservoir, it seems that spatial overlap could signify potential competition. Spatial overlap could also indicate a risk of inadvertent capture of protected species by recreational anglers targeting triploid trout.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that similarity in diet based on stomach content analysis alone would not be sufficient to conclude that triploid rainbow trout are competing with native salmonids. Robison said it would be necessary to	If growth rates are high for both native and triploid trout, then excessive competition is unlikely to be occurring. The current number of triploid trout stocked annually—about 4,500—is small relative to the size of the reservoir.

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				have estimates of prey availability, trout abundance, and predation rates to assess whether competitive interaction is occurring.	Planting catchable-sized, rather than fingerling, triploid trout could reduce potential concerns regarding competition for food resources.
Verbal	6-27-06	Curt Vail	WDFW	Vail stated that potential competition between native and stocked trout is more likely when stocked fish are released at a small size and remain in the reservoir for a longer period before being harvested. Vail stated that stocking catchable-sized triploid trout in Boundary Reservoir would be unlikely to result in much competition.	Comment acknowledged.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that WDFW would be concerned about any recommendation to discontinue the triploid trout stocking program, because native salmonids would likely be insufficient for providing a fishery in Boundary Reservoir.	Comment acknowledged.
Verbal	6-27-06	Curt Vail	WDFW	Vail stated that cutthroat trout abundance in Boundary Reservoir is not limited by the presence of triploid rainbow trout and that any attempt to increase the number of cutthroat in the reservoir would need to involve management activities in tributaries, such as a reduction in the number of eastern brook trout.	Comment acknowledged.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda stated that a primary concern of the USFS is whether or not stocked triploid rainbow trout have the potential to prey on juvenile bull trout at the mouths of tributaries or in the tributaries themselves.	Comment acknowledged.

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Draft Fish and Aquatic Study Outlines; Hydraulic Routing Model					
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson asked why modeling would only extend downstream to Redbird Creek.	Redbird Creek is located at the approximate location of Seven Mile Reservoir's minimum surface elevation, i.e., the location of the minimum backwater effect of Seven Mile Dam, below which operations of the Boundary Project would have little effect.
Draft Fish and Aquatic Study Outlines; Aquatic Habitat Modeling					
Verbal	5-23-06	Doug Robison	WDFW	Robison questioned whether collecting data during a single spring and summer would be sufficient, stating that winter is, and is likely to be, the period when daily drawdown of the reservoir would be greatest.	Spring and summer will suffice for developing the habitat model, because the full range of surface elevations is experienced during this period. Low reservoir levels often occur in spring during the pre-runoff period. The early spring/late summer period will also provide a range of macrophyte densities, which influence channel roughness and, therefore, velocities.
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson asked if habitat maps would be produced based on the bathymetry data currently being collected.	After data are checked and final maps are produced, SCL will make them available to stakeholders by posting them on the SCL website.
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson asked if maps would be produced depicting velocity vectors in the reservoir under various flows.	A map of the velocity distribution across transects could be produced from information used to develop the aquatic habitat model.
Verbal	5-23-06	Tom Shuhda	USFS	Shuhda asked how far up the bank modeling transects would extend.	All transects would extend above the high-water mark on both sides of the reservoir.
Verbal	5-23-06	Doug Robison	WDFW	Robison asked how flow variability would affect velocity and depth data collection at transects, stating that it would not be possible to collect data at all transects during a single flow.	Transect data would be collected independently at each transect and then be linked during model development.
Verbal	5-23-06	Doug Robison	WDFW	Robison asked why varial zone	The time periods used to assess impacts

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				modeling would be conducted at different time scales.	in the varial zone, which will be developed in collaboration with stakeholders, would vary to reflect colonization rates and dewatering-related mortality for a variety of aquatic species.
Verbal	5-23-06	Tom Shuhda	USFS	Referring to the cross-section schematics, Shuhda asked whether there would be much difference in varial zone impacts over time, given the relatively consistent mode of operation at the Boundary Project.	During certain times of year—for example during the shift from fall to winter operations—there would be differences in short- and longer-term effects on the varial zone. The ability to analyze the varial zone over different timeframes might also be more important for potential future operating scenarios than for existing operations.
Verbal	5-23-06	Bill Duncan	Teck Cominco	Duncan stated that there would not only be spatial variation in varial zone impacts resulting from differences in reservoir geometry (i.e., above and below Metaline Falls) but also in response to differences in substrate—e.g., benthic macroinvertebrates associated with fine substrates would likely tolerate dewatering longer than those associated with coarse substrates.	Comment acknowledged.
Verbal	5-23-06	Tom Shuhda	USFS	Tom Shuhda (USFS) asked how tributary deltas would be addressed in the context of the varial zone analysis.	Evaluation of tributary deltas would be conducted as a separate study, which would be reviewed later in the meeting.
Verbal	5-23-06	Doug Robison	WDFW	Robison expressed concern that transects would not capture the full range of topographical variability present in the reservoir.	Representative transects would be selected to ensure that habitat modeling adequately characterized reservoir conditions. Transects would be carefully selected in collaboration with stakeholders. IFIM studies are routinely carried out in this way, i.e., transects are selected to represent conditions by habitat type and by reach.
Verbal	5-23-06	Doug Robison	WDFW	Robison asked if the weighting of	Weighting could, but would not

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				transects would vary for different analyses.	necessarily, vary between specific analyses; for example, an assessment of Project impacts on smallmouth bass spawning habitat would only consider transects where spawning had been observed.
Verbal	5-23-06	Tom Shuhda	USFS	Shuhda asked if a modeling evaluation similar to that being proposed for Boundary Reservoir had been conducted in other locations.	Comparable modeling results for the mainstem Skagit River, developed as part of the relicensing of the Baker River Project (FERC No. 2150), were presented by SCL.
Verbal	5-23-06	Mark Tiley	CCRIFC	Tiley asked whether modeling macroinvertebrate habitat would involve assessment of the minimum period that substrate must be wetted before it is usable by macroinvertebrates.	Macroinvertebrate recolonization rates would be integrated into the modeling.
Verbal	5-23-06	Mark Tiley	CCRIFC	Tiley asked whether macroinvertebrate recolonization rates would be determined empirically in Boundary Reservoir.	Recolonization rates will be based on available scientific literature and rates derived from site-specific measurements.
Verbal	5-23-06	Tom Shuhda	USFS	Shuhda asked whether the modeling would be able to account for increased predation rates on juvenile native fish species resulting from concentration of juvenile fish during decreases in reservoir surface elevation.	At this time the modeling is not designed to address changes in predation. Biotelemetry would be the tool used to assess fish movements in response to reservoir surface elevation changes, but fish evaluated with biotelemetry would have to be of a minimum size before they could be tagged.
Verbal	5-23-06	Doug Robison	WDFW	Robison stated that it was unclear as to how the issue of fish stranding would be addressed.	Stranding would be addressed through modeling of the varial zone and through ramp rates (i.e., the rate of change in reservoir surface elevation) in various habitat types and at different locations within the study area.
Verbal	5-23-06	Doug Robison	WDFW	Robison asked what fieldwork would be conducted to validate modeling to	Electrofishing would be conducted at some areas/transects prior to a reduction

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				assess stranding.	in pool level to identify the resource at risk. Following the reduction in pool level, surveys would be conducted in those areas to locate and count any stranded fish. Fish periodicity would be taken into account when determining when such fieldwork should be conducted.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that habitat will vary along a laterally oriented transect and asked how this variability would be addressed as part of habitat modeling.	The habitat is expected to vary laterally along transects and the use of multiple transects across major habitat features will provide a sufficient sample size to account for habitat variability.
Draft Fish and Aquatic Study Outlines; Habitat Suitability Information					
Verbal	5-23-06	Curt Vail, Tom Shuhda	WDFW, USFS	Vail and Shuhda stated that understanding the effects of potential future operating scenarios on macroinvertebrates, particularly from the standpoint of food availability for fish, would be important.	Modeling the effects of alternative operating scenarios on macroinvertebrates is described in the Productivity Assessment Study.
Verbal	5-23-06	Mark Tiley	CCRIFC	Tiley noted that a species of the genus *Hydra* appeared to be displacing native macroinvertebrates in some regulated rivers in the region. Tiley stated that environments characterized by substantial short-term flow fluctuation appeared to favor this organism. Tiley stated that it would be beneficial if studies could evaluate whether proposed Project operations will influence the proliferation of the *Hydra* species, and as a result assess the influence of this organism on native macroinvertebrates.	SCL presented a brief overview of Hydra colonization at the June 27, 2006 workshop and noted that a 2001 study conducted by WDFW indicated that Hydra comprised 1 to 16.6 percent of the macroinvertebrate community in Boundary Reservoir. SCL noted that the macrobenthic invertebrate components of the habitat modeling and productivity studies will provide additional information on potential Hydra colonization in Boundary Reservoir.
Verbal	5-23-06	Scott Jungblom	Pend Oreille PUD	Jungblom stated that it should not be too difficult to model the effects of proposed alternatives on	Comment acknowledged and incorporated into the Aquatic Productivity Assessment Study plan (4.5).

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				macroinvertebrates at the family level. Jungblom said that samples collected at a few sites, over the range of available substrate sizes, should suffice for validation. Jungblom added that it would be important to develop estimates of recolonization and survival rates on dewatered substrates.	
Verbal	5-23-06	Tom Shuhda	USFS	Shuhda asked how the proposed modeling approach would address the issue of Project effects on phytoplankton and zooplankton communities, including assessment of impacts on overall reservoir productivity.	Reservoir productivity will be addressed as part of a separate Fish and Aquatics study (see 4.5).
Verbal	5-23-06	Curt Vail	WDFW	Vail stated that yellow perch could be removed from the list of species for which HSI curves are developed, stating that yellow perch are adaptable and prolific and not a species of concern to WDFW in Boundary Reservoir.	SCL agreed to remove yellow perch from the HSI table and from subsequent model-based analysis.
Verbal	5-23-06	Tom Shuhda	USFS	Shuhda stated for the record that the USFS is concerned with native fish species, native sport fish in particular, and their forage species.	Comment acknowledged.
Draft Fish and Aquatic Study Outlines; Benthos (benthic macroinvertebrates and periphyton) a subset of the aquatic habitat modeling HSI					
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that in addition to model results, stakeholders would need to see reports documenting sampling and summarizing the results of data collection for all model components, for example the data related to colonization rates of benthos. Without these summary reports, it would be impossible for stakeholders to understand and be able to judge the	Summary reports would be provided for studies completed during the relicensing process, including those used to develop the aquatic habitat model. Such reports would not only be important to stakeholders during relicensing but also to subsequent researchers and resource managers in the Project area in the years after relicensing.

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				reliability of model results.	
Verbal	6-27-06	Doug Robison	WDFW	Robison asked how the littoral zone would be defined, given the range in Boundary Reservoir pool elevation.	The littoral zone would be defined as the area ranging from full pool to the euphotic depth under maximum expected reservoir drawdown for the sample period.
Verbal	6-27-06	Scott Jungblom	Pend Oreille PUD	Jungblom stated that the proposed design of floating sampling units would preclude access by benthic organisms moving along the substrate, which would provide low estimates of colonization rates.	This approach also requires that fixed sampling units only be subject to colonization by drifting organisms, to make results from the fixed stations comparable to those from the floating units.
Verbal	8-14-06	Doug Robison	WDFW	Robison asked how temporal variability in periphyton habitat suitability within a given cell would be addressed.	Weighted Potential Area would be calculated hourly and then summed to represent the value for the one-year modeling period.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda asked if periphyton and BMI sampling would occur monthly during the collection period.	Artificial substrate sampling would take place during eight-week periods in spring, summer, autumn, and winter.
Verbal	8-14-06	Doug Robison	WDFW	Robison noted that in addition to model results, stakeholders would need to see reports documenting sampling and summarizing the results of data collection for all model components.	Reports documenting sampling and summarizing results of the 2007 through 2008 field studies would be provided to stakeholders.
Draft Fish and Aquatic Study Outlines; Tributary Delta Sediment Transport and Habitat Modeling					
Verbal	5-23-06	Curt Vail	WDFW	Vail asked how delta modeling would account for changes in land use and the concomitant potential for increases or decreases in sediment loading.	Assumptions would be made regarding sediment yield under current land uses.
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson asked whether the tributary delta study would address the potential for sediment accumulation at tributary mouths to block fish passage into the tributaries.	Assessing potential changes in tributary access would be a component of the analysis.
Verbal	5-23-06	Rick Donaldson	USFWS	Donaldson asked whether mainstem	Mainstem sediment transport would be

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				sediment transport would be addressed as part of the Fish and Aquatics study program.	covered at the August 14 Workgroup meeting.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda asked if the analysis would account for the effect of reservoir fluctuations on tributary deltas.	Evaluating the effects of reservoir fluctuations on tributary delta habitats is a major objective of the tributary delta modeling study.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda noted that changes in tributary deltas over time could affect fish access to those tributaries and asked how such changes would be addressed.	Tributary delta configuration would be predicted for two future dates, 25 and 50 years following issuance of the new Project license.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda asked if predictions of tributary delta configurations for Sullivan Creek would include removal of Mill Pond.	Predictions about the Sullivan Creek delta would be based on current watershed and land use conditions.
Draft Fish and Aquatic Study Outlines; Effects of Sediment Transport on Mainstem Channel Morphology					
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked what portion of the Project area was represented by pre-Project bathymetry.	Pre-Project bathymetry had only been measured for the river downstream of Metaline Falls. Pre-Project topographic maps exist for the river upstream of Metaline Falls but their resolution (i.e., 20-ft contours) would likely only identify major changes in bed profiles. The scale of the pre-Project maps may preclude their use for assessing minor changes in the volume of sediment deposition (such as 1 to 2 ft of deposition).
Verbal	6-27-06	Curt Vail	WDFW	Vail asked if it would be possible to estimate the size fraction of sediment captured by the reservoir since construction of the dam.	Rough estimates of sediment size fractions captured by the reservoir will be developed using estimates of reservoir velocities along mainstem transects.
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that recent increases in the abundance of Eurasian watermilfoil have increased channel roughness and thereby the reservoir's ability to trap fine sediment.	Effects on sediment deposition patterns related to increases in channel roughness resulting from the proliferation of milfoil can be addressed with the HEC-RAS model.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda noted that Slide 5 of Al SCL's presentation identified releases of sediment from Box Canyon Dam as the largest volume of sediment supply to the Project area, followed by tributary input and shoreline erosion, respectively. Shuhda asked how this ranking was determined and questioned whether shoreline erosion should be third given the large surface elevation changes that take place on a daily basis in Boundary Reservoir.	Preliminary calculations based on watershed area and other factors support the ranking of the three sources. However, the results of the mainstem sediment transport study, as well as the shoreline erosion study being conducted by the Terrestrial Resources Workgroup, would be used to either confirm or refute these rankings.
Verbal	8-14-06	Doug Robison	WDFW	Robison agreed that Lake Pend Oreille captures most of the sediment that originates upstream of the lake. However, Robison said that if this is the case, then the sediment transport capacity of the lower Pend Oreille is very high.	The sediment transport capacity of the lower Pend Oreille River is high. However, in this type of situation, where sediment transport capacity has been high for an extended period, significant channel armoring takes place, so that the effect of the heightened transport capacity is minimal.
Verbal	8-14-06	Gary Birch/ Doug Robison	BC Hydro/WDFW	Birch referred to a plot of annual suspended sediment load (tons) for the period from 1968 through 2003. Birch noted that during this period there had been three natural production signals for white sturgeon that spawn at the confluence of the Pend Oreille and Columbia rivers. Birch stated that results of fish sampling reveal that these signals occurred in 1974, 1982, and 1997, three years during which suspended sediment load in the Pend Oreille was at or near its highest levels. Birch stated that sturgeon biologists believe that recruitment is most successful during periods of high turbidity caused by suspended sediment. Robison added that the	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				sturgeon also respond to high flows, which would accompany periods of high sediment load.	
Verbal	8-14-06	Doug Robison	WDFW	Robison asked why the relationship between suspended sediment load and flow below Boundary Dam was linear.	This pattern was the result of low seasonal variability in the relationship between the two variables. Unlike many situations, there appeared to be no significant shifts in sediment load associated with the rising and falling limbs of the hydrograph.
Verbal	8-14-06	Doug Robison	WDFW	Robison noted that the study area was divided into sediment routing cells. Robison asked why the depiction of gradient was so high downstream of Boundary Dam, given that Seven Mile Reservoir backs up to Boundary Dam much of the time.	The plot showed channel bed gradient, not the gradient of the water surface. Future operations of Seven Mile Reservoir are likely to be affected by the Waneta Dam Expansion Project. Until it is clear what those effects are, channel conditions between Boundary Dam and Redbird Creek will be modeled as part of the Boundary Relicensing aquatic habitat studies. The important thing is that the model will be available to assess habitat conditions in this reach regardless of how it is affected by the Waneta Expansion.
Verbal	8-14-06	Doug Robison	WDFW	Robison asked if sediment deposition estimates for a given sediment routing cell would reflect cumulative deposition or only deposition resulting from sediment supplied by the cell immediately upstream.	The accumulation in a cell would be cumulative.
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda stated that macrophyte beds are likely to intercept sediment and asked whether this effect of macrophytes would be accounted for in the sediment transport analysis.	Macrophytes reduce water velocities, which in turn results in greater sediment deposition in and around the beds. Water velocity will be accounted for in the evaluation of sediment deposition.
Verbal	8-14-06	Gary Birch	BC Hydro	Birch asked if the study would predict increases or decreases in sediment	The study would predict increases or decreases in sediment accumulation as the

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				accumulation as the result of future changes in Project operations.	result of future changes in Project operations.
				Doug Robison (WDFW) asked if the study would provide predictions of changes in reservoir cross section profiles over the new license term.	The study would not predict changes in reservoir cross section profiles.
Draft Fish and Aquatic Study Outlines; Productivity Analysis					
Verbal	6-27-06	Doug Robison	WDFW	Robison asked if the effect of both magnitude and rate of reservoir drawdown would be evaluated as part of the productivity analysis.	The magnitude, but not the rate, of drawdown would be evaluated with regard to nutrients and the productivity of phytoplankton and zooplankton. However, both magnitude of drawdown and velocities associated with various pool levels would be assessed as part of the aquatic habitat modeling for macrophytes, periphyton, and BMIs.
Verbal	6-27-06	Doug Robison	WDFW	Robison asked if productivity data would be collected during more than one season.	Benthos data would be collected in summer and winter, and nutrient, phytoplankton, and zooplankton data would be collected during spring, summer, and winter. The field schedule is described in the *Water Quality Constituent and Productivity Monitoring* study plan.
Verbal	6-27-06	Doug Robison	WDFW	Robison asked if productivity constituents would be evaluated cumulatively or individually.	Each productivity constituent would be evaluated individually and there would be no attempt to integrate them or to predict differences in actual numbers of fish among alternatives based on primary or secondary productivity.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked how the effect of Project operations on macrophytes, along with the resulting indirect effect on phytoplankton and zooplankton productivity, would be addressed.	The aquatic habitat model would be used to link Project operations to macrophyte abundance and these results could be analyzed in conjunction with phytoplankton and zooplankton data collected from macrophyte beds.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda asked what alternative	Bioenergetics modeling has been applied

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				approaches there were to the proposed productivity analysis.	to assess lake and reservoir productivity, but such an approach involves many assumptions and provides solutions with wide error bands. Bioenergetics modeling would be unlikely to produce results that would be useful for decision-making regarding potential operating alternatives.
Verbal	6-27-06	Mark Tiley	CCRIFC	Tiley asked what analysis there would be to assess the effects on introduced fish species resulting from changes in reservoir productivity related to potential modification of Project operations under a new FERC license.	Potential changes in habitat for introduced species would be evaluated quantitatively using the aquatic habitat model, but the effects of productivity on introduced species would only be evaluated qualitatively.
Verbal	8-14-06	Bill Duncan	Teck Cominco	Duncan stated that differences among scenarios in the degree of zooplankton entrainment could influence productivity and asked if entrainment was being addressed.	Zooplankton drift samples will be collected in the Box Canyon Dam and Boundary Dam tailraces to assess the extent of entrainment under existing conditions, which can be used to evaluate changes associated with alternative operations.
Verbal	8-14-06	Doug Robison	WDFW	Robison stated that an understanding of productivity alone would not necessarily allow for an assessment of impacts associated with a given scenario. For example, a particular operating scenario could result in a situation where fish are precluded from gaining access to zooplankton prey. Robison stated that in this case, levels of productivity could be acceptable, but impacts to fish could be significant.	To some degree data collected during the field study will shed light on zooplankton size-distributions in various parts of the reservoir, which in turn will provide insight into whether or not the effects of fish predation vary throughout the reservoir. With the information that is being gathered, SCL hopes to be able to assess the relative merits of a set of potential future operating scenarios, but it will be impossible to account for everything, particularly given the rigorous timeframe established by the ILP.
Verbal	8-14-06	Doug Robison	WDFW	Robison stated that artificial substrates suspended in the water column would preclude access to crawling BMIs and asked if this would result in non-	The proposed approach requires that fixed sampling units only be subject to colonization by drifting organisms, so that results from the fixed stations are

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				representative results.	comparable to those from the floating units in all ways except for their exposure to different reservoir surface elevation regimes.
Verbal	8-14-06	Doug Robison	WDFW	Robison asked if the baskets deployed for BMI sampling would contain native substrate.	The rocks used in the baskets will be taken from the reservoir, cleaned, dried, and then placed in the baskets prior to their installation. This approach will provide a rate of colonization that is closer to natural conditions than if freshly quarried rocks were used.
Draft Fish and Aquatic Study Outlines; Recreational Creel Surveys					
Verbal	6-27-06	Curt Vail	WDFW	Vail stated that the organizers of the smallmouth bass derby are required by WDFW to file a report with the state of Washington each year and that these reports would provide some information on angler use, catch, and harvest.	Comment acknowledged.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda stated that the survey forms should not only address fishing pressure in the reservoir but also in the tributaries.	SCL agreed that survey forms associated with recreational creel surveys would include a section to address angler use, catch, and harvest in tributaries to Boundary Reservoir.
Draft Fish and Aquatic Study Outlines; Large woody debris recruitment and management					
Verbal	6-27-06	Doug Robison	WDFW	Robison stated that of the options identified as large wood management strategies, placing wood in the reservoir or at tributary mouths to provide fish habitat would be best.	Comment acknowledged.
Verbal	6-27-06	Tom Shuhda	USFS	Shuhda stated that good locations for placement of large wood would be the Box Canyon tailrace and in tributaries, to benefit native salmonids. Shuhda stated that it would be important not to locate wood so that it improves habitat	SCL agreed to revise the *Large Woody Debris Management Study* (4.4) to state that wood would be placed to benefit native rather than nonnative fish species and to avoid increasing the potential for fish entrapment.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				for nonnative species, smallmouth bass in particular. Shuhda added that placement of wood would need to be based on hydraulic analyses so that it did not result in trapping of fish during reductions in flow/pool elevation.	
Draft Fish and Aquatic Study Outlines; Assessment of Factors Limiting Aquatic Productivity in Tributary Habitats					
Verbal	8-14-06	Tom Shuhda	USFS	Shuhda noted that SCL had mentioned removal of barriers on Sullivan Creek as a potential enhancement opportunity. However, said Shuhda, the Sullivan Creek Project not only interrupts fish passage but affects fish by interrupting downstream movement of bedload and influencing stream temperatures. Shuhda added that given these complexities, it would be critical to have enough information to be able to make decisions regarding effective mitigation opportunities in Sullivan Creek.	Comment acknowledged.
Verbal	8-14-06	Joe Maroney/ Tom Shuhda	Kalispel Tribes/ USFS	Maroney stated that the Kalispel Tribe could provide fish habitat information for tributaries to Sullivan Lake, and Shuhda replied that the USFS could as well.	Comment acknowledged.
Verbal	8-14-06	Doug Robison	WDFW	Robison asked how far upstream the tributary analysis would extend.	Existing information will be used to characterize tributaries as far upstream as there are available data; the work would be primarily a GIS exercise.
Verbal	8-14-06	Doug Robison	WDFW	Robison stated that the Project nexus statement in the tributary assessment study plan needed strengthening, as it was less clearly stated than in other study plans.	SCL would attempt to revise the statement of Project nexus, to the extent possible, given the nature of the study.
Verbal	8-14-06	Joe Maroney	Kalispel Tribes	Maroney asked to what extent stakeholders would be involved in	SCL will coordinate with stakeholders on what information should be included and

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				developing the list of factors affecting the productivity of native biota and habitat in the tributaries.	how to go about gathering it.

From: "Al Solonsky" <Al.Solonsky@Seattle.Gov>
To: <tshuhda@fs.fed.us>
Cc: <kdemsey@easystreet.com>
Sent: Tuesday, May 09, 2006 6:41 AM
Subject: Re: Turbine Mortality Report

Thanks Tom. We're hoping others will be on the same page at our meeting on the 23rd. We'll bring it up and ask. With regard to data used for spillway estimates, I expect citations are referenced in the bibliography section, but I don't have it in front of me. I don't think they have a annotated bibliography, but let me ask what they've got and I'll get back to you.

>>> Thomas H Shuhda <tshuhda@fs.fed.us> 05/08/06 10:40 AM >>>
Thanks, Al. Nice to review the document. I am satisfied with the recognition by SCL of the range of mortality of fish associated with the operation of their turbines in the EID for Fish Connectivity. I am also
satisfied with the document, after review, used as a reference. I agree
that SCL does not need to conduct a study to determine if there is mortality occurring due to turbine operations at Boundary Dam. If you wish a more formal response than this, please let me know.

Can you let me know where I can review R2's Annotated bibliography of literature regarding mechanical injury with emphasis on effects from spillways and stilling basins? I would like to review this refernce. Thanks!!

Tom Shuhda
Forest Fish Biologist
Colville National Forest
509 684-7211

"Any society that would give up a little liberty to gain a little security
will deserve neither and lose both." - Benjamin Franklin

From: <Scott_Deeds@fws.gov>
To: "Al Solonsky" <Al.Solonsky@Seattle.Gov>
Cc: "Barbara Greene" <barbara.greene@Seattle.Gov>; <kdemsey@easystreet.com>; <philgert@r2usa.com>; <randallfilbert@msn.com>; <sdpadula@aol.com>
Sent: Thursday, May 18, 2006 12:16 PM
Attach: fercSCL-fishspillstudy509.doc
Subject: Re: comments on EID and studies

Hi Al,

Sorry that we are a late. Please find attached our comments for the spillway and turbine entrainment studies (from Rick Donaldson) and the Boundary fish distribution study and EID (from myself). We reviewed the three other studies and have no substantive comments at this time. I wish I could have come up with more time to review the EID - hopefully we will be given another opportunity as edits are incorporated.

Thanks, have a great day, and see you next week,
Scott

(See attached file: fercSCL-fishspillstudy509.doc)

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"Al Solonsky" <Al.Solonsky@Seattle.Gov> 05/16/2006 01:25 PM

To: <Scott_Deeds@fws.gov>
cc: <sdpadula@aol.com>, <kdemsey@easystreet.com>, <randallfilbert@msn.com>, <philgert@r2usa.com>, "Barbara Greene" <barbara.greene@Seattle.Gov>
Subject: Re: comments on EID and studies

Thanks Scott. We would like to get feedback and comments, so we'll look

forward to your stuff tomorrow.

>>> <Scott_Deeds@fws.gov> 05/16 10:53 AM >>>
Hi Al,

Just wanted to let you know that I have been able to spend a little time reviewing and am hoping to get you some comments soon. However, I need to discuss some things with Rick D. but he has pretty much been gone for the last 4 weeks on family leave. He is in today - but in meetings, so hopefully at some point we can meet up. I know you would like and it was agreed upon to have comments back today, but it may be tomorrow before I can get them out.

Thanks and hope all is well,
Scott

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USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT SPILLWAY ENTRAINMENT STUDY (undated, 041406.doc)

Assumptions; A2: *"Hydroacoustic target signatures can be adequately translated to size and numbers of fish"* Should add the following: ***"however, determination of fish by species, cannot accurately be determined using this methodology."***

Task Activities, T2: *"Continuously monitor Boundary spillway gates #1 and #2 using hydroacoustics for the period April through July during 2007 and 2008."* The duration of monitoring will need to be adjusted depending on when spill occurs. Thus monitoring may occur earlier or later than April or July each year.

Task Activities, T3: *"The hydroacoutics array will provide estimates of the number and strength of targets passing through a defined field of view which will be extrapolated to the entire spillways and correlated to spill timing, duration, and magnitude."* The methods used to conduct the study, whether using hydroacoustic devices alone, or in conjunction with fyke netting, or some additional method (such as an underwater video system), will need to be adequate to collect sufficient empirical data to ensure an accurate accounting of the target fish species in the spillway. ***OR SOME WORDING SIMILAR TO THIS!!

Task Activities, T4, fourth bullet: *"if spillway target signatures cannot be translated to fish size and numbers using these available data. . ."* Need to modify this phrase as shown as follows in bold font: *"if spillway target signatures cannot be translated to fish size, **~~and~~** numbers, **and species**, using these available data. . . ."*

Task Activities, T4, fourth bullet: *"other opportunities to translate hydroacoustic targets to numbers and size of fish will be considered including, but not limited to and underwater video system installed to record the passage of fish during periods of spillway use, or a screw trap or scoop trap. . . ."* We agree that some other devices may be required to provide a more accurate portrayal of fish numbers, size, and species in the spillway.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT TURBINE ENTRAINMENT STUDY (dated April 20, 2006)

General Comment: Does SCL intend to conduct any studies that would pass fish (surrogate or target fish species) through the turbines to determine the extent of mechanical injury and mortality in the existing turbines under existing operational scenarios? SCL may need to compare the results of injury and/or mortality conducted under existing operations with alternative operational scenarios to determine possible means to reduce mechanical injury or mortality to target fish species passing through the generating turbines. At some point this could include modification of the existing turbines or their operation to reduce mechanical injury or mortality to target fish species.

Assumptions, A2: *"Fyke net sampling with the Boundary intake tunnels or draft tubes can be used to validate and translate hydroacoustic targets into the number and size of fish."* Suggest modifying this sentence to read as follows: *"Fyke net sampling with the Boundary intake tunnels or draft tubes can be used to validate and translate hydroacoustic targets into the number,* ***~~and~~*** *size,* ***and species*** *of fish."*

Assumptions, A5: *"All fish captured within the fyke nets will suffer injury or mortality; however, federal and state collecting permits can be obtained to allow sampling."* Need to modify this sentence as shown as follows in bold font: *"All fish captured within the fyke nets will suffer injury or mortality;* ***therefore, ~~however~~*** *federal and state collecting permits* ***will need to ~~can~~*** *be obtained to allow sampling."*

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT BOUNDARY RESERVOIR FISH DISTRIBUTION STUDY
(undated, 041406.doc)

Assumptions; A2: "*Acoustic transmitters will be used because forebay water depths are too deep to effectively use radio tags*." The use of Lotek CART tags should be further considered for at least some of the large adult bull trout (maybe 5 fish). This would also provide a real test to see which tag type may be most effective in the Boundary reach.

Assumptions; A5: "*A range of transmitter sizes and longevities (5 to 10 sec pulse interval) will be used depending upon fish size*:" Because bull trout and westslope cutthroat trout are limited here and may be difficult to capture, we feel at least initially, that longer lasting tags (ie. up to 400 days) should be used over the depth/temperature tags (up to 100 days). We understand that depth/temperature data can be valuable, but we believe that location data that may give insight into cold water refugia locations, tributary use, possible spawning streams, migration timing etc. is most valuable and longer lasting tags are necessary.

Task Activities, T3: "*Tag up to 30 bull trout, 30 mountain whitefish, and 30 westslope cutthroat trout with acoustic transmitters attached intraperitoneally using surgical techniques. A numbered Floy tag will also be implanted into each fish*." These fish should also be PIT tagged as Floy tags can be more easily lost.

Task Activities, T5: "*Use mobile tracking to locate the positions of tagged fish once per month (as weather conditions allow during winter months) between Boundary Dam and Box Canyon Dam. Utilize GPS to the extent adequate signals are available or pinpoint locations on aerial photographs. Collect habitat information at the location of tagged fish including water depth, velocity, temperature, substrate type, macrophyte density and cover*." We believe that at least seasonally (maybe April-June and August-

October) when bull trout are known to make migration movements, tracking should be done more frequently (every 10 days at a minimum). This may better help identify cold water refugia, potential spawning tributaries, foraging areas etc.

Task Activities, T9: "*Utilize manual tracking techniques throughout a tracking day (sunrise to sunset) to obtain frequent (every 2 hours or less) positions to discern daily movements. Ideally, the tracking team would obtain information over an entire day on all of the tagged fish in a single tributary delta area, such as Slate Creek (or two adjacent coldwater tributary deltas). Target the level of effort to 3 days for 3 fish (or more) of each species during each study year*." Because bull trout are known to be sedentary during day light hours, with foraging, migration etc. primarily occurring during the night, tracking from sunrise to sunset (a tracking day) may limit and bias your data. Also, during summer months when water temperatures rise to levels that force bull trout into cold water sites - water temperatures cool somewhat at night and bull trout are best able to make movements at this time. Geist et al. 2004 tracked numerous bull trout below Albeni Falls Dam in 2003 with this type of behavior, moving from coldwater refugia up to the dam.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S EARLY INFORMATION DEVELOPMENT: FISH CONNECTIVITY AT THE BOUNDARY HYDROELECTRIC PROJECT (dated April 2006)

General Comment: Based on FWS guidance, peer review, and our draft recovery plans, we no longer use the original subpopulation terminology that was used at the time of listing for bull trout, but use the core area, core population, and local population structure for describing a bull trout unit. You identify this on page 2-3, however use the subpopulation language prior to this in the document. We recommend using the core area and local population structure versus the subpopulation.

General Comment: There are numerous documents (DuPont and Horner 2002, 2003; and Geist et al 2004) that report on bull trout telemetry studies conducted in the Pend Oreille River (both above and below Albeni Falls Dam) and in the lower Priest/East River systems. Information from these documents would greatly enhance this document when describing life history, migration timing, recent observations etc. for bull trout. This information may be more applicable than using information from other systems (Salmo) that likely have a different life history strategy.

Page 2-10, 1st paragraph: "*There have been seven documented observations of bull trout within Box Canyon Reservoir since 1988*." This is incorrect! Geist et al 2004 and Scholz et al 2005 identify at least nine bull trout captured and implanted with transmitters in 2003 and 2004 below Albeni Falls Dam, Geist et al 2004, also capture numerous other bull trout but did not implant with transmitters. So there was at least 12-13 alone captured in 2003/2004.

Page 2-11, 4th paragraph: "*Since that time bull trout harvest has declined to a low of 621 fish in 1985, and capture of bull trout became illegal in 1996 (Scholz et al. 2005).*" I believe this statement to be inaccurate – it became illegal to "harvest" bull trout in 1996 as they can still be captured legally if it is incidental to fishing for other species.

Page 2-11, 4th paragraph: "*Lake Pend Oreille and the Pend Oreille River were the historical foraging grounds for juvenile and adult bull trout, but currently utilization is restricted primarily to Lake Pend Oreille (Scholz et al. 2005).*" Again I don't think this statement is accurate. These areas were also utilized as migratory corridors and for overwintering. Furthermore, utilization is not restricted to Lake Pend Oreille. Last year alone, 52 bull trout redds were documented in the East River watershed, this would equate to roughly 150 adult bull trout migrating through the Pend Oreille River in the spring and a smaller number (post spawning mortality) in the fall. This does not take into account the unknown hundreds or more juveniles that outmigrate during the year to Lake Pend Oreille, and subadults that may use seasonally for forage etc. Geist et al 2004 also document that two of the six bull trout that they tracked, spent the entire winter in the Pend Oreille River.

Page 2-13, last paragraph: "*Individual bull trout have been periodically observed within the Pend Oreille River or tributaries downstream of Albeni Falls, but the source of these individuals is unknown. Historically, the Priest River and perhaps other tributaries to Lake Pend Oreille were considered the most likely source of bull trout in the mainstem Pend Oreille River downstream of Albeni Falls because bull trout numbers declined rapidly after construction of Albeni Falls Dam in 1952 (Scholz et al. 2005).*" Again, more than just "individual bull trout" were observed by Geist et al 2004 (in 2003) and based on genetic samples taken (as discussed with Joe Maroney), some of these fish closely align with East River fish while the rest are awaiting assignment based on further analyses. Furthermore, while the Priest River and Lake Pend Oreille may have been sources of some bull trout in the Pend Oreille River below Albeni Falls Dam, we feel that the most likely source of bull trout were the tributaries (below Albeni Falls Dam) of the Pend Oreille River themselves and that these fish had the same life history strategy as those in the East River and the construction of Albeni Falls Dam and Box Canyon Dam eliminated this migratory form.

Page 3-1, 2nd paragraph: "*The USFWS have listed bull trout as threatened under Endangered Species Act. Five Distinct Population Segments (DPS) of bull trout (Klamath River, Columbia River, Jarbidge River, Coastal-Puget Sound, and St. Mary-Belly River) were listed as threatened under the ESA by the USFWS on October 28, 1999.*" While kind of accurate, here is what we use:

"On June 10, 1998, the Service published a final rule listing the Columbia River and Klamath River Distinct Population Segments (DPSs) of bull trout as threatened (63 FR 31647) under authority of the Endangered Species Act (Act) of 1973, as amended. With the listing of the Jarbidge River population (64 FR 17110) and the Coastal-Puget Sound

and St. Mary-Belly River populations (64 FR 58910) on November 1, 1999, all bull trout in the coterminous United States received protection under the Act."

Therefore, the final listing rule for the bull trout population in the coterminous United States consolidates the five DPSs into one listed taxon (64 FR 58930). However, although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed.

Page 3-1, 3rd paragraph: "*Within the Columbia River distinct population segment bull trout exhibit resident*, fluvial, *and adfluvial life history strategies*". Fluvial bull trout are known to occur throughout the Columbia basin as well and should be added to this sentence.

Page 3-2, 3rd paragraph: *"As described previously, bull trout have been rarely observed in Boundary Reservoir or its tributaries and the few fish observed have been adult-sized fish."* In 2000, WDFW (McLellan) observed a 12" bull trout in Sweet Creek and in 1997 SCL (R2) caught an 8" fish in the reservoir. In general, these fish are not of adult size and we would consider them juvenile or subadult fish.

Page 3-9, 1st paragraph: "*Scholz et al. (2005) suggested that bull trout spawning migrations could begin as early as May or June to take advantage of higher flows when entering small spawning tributaries that may have intermittent flow at their mouths later in the year.*" This migration timing is well documented within Pend Oreille Lake, the Priest/East River, and throughout the bull trout range, so it is more than just "suggest and could".

Page 3-9, 1st paragraph: "*Garrett and Bennet (1995) observed that half the fish they tracked returned to Box Canyon Reservoir to overwinter following spawning in October, while the other half overwintered in their spawning tributary.*" I believe that these were brown trout in the Garrett and Bennett study – the way the paragraph reads would lead the reader to thin these were bull trout – please verify.

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To: <maryv@aimcomm.com>; <arnw@amrivers.org>; <bswift@amrivers.org>; <okeefe@amwhitewater.org>; <sdpadula@aol.com>; <Km.Meidal@bchydro.bc.ca>; <maureen.dehaan@bchydro.bc.ca>; <power.records@bchydro.bc.ca>; <Vladimir.Plesa@bchydro.bc.ca>; <eric.weiss@bchydro.com>; <gary.birch@bchydro.com>; <harry.brownlow@bchydro.com>; <paul.vassilev@bchydro.com>; <diane_stutzman@blm.gov>; <richard_bailey@blm.gov>; <blaula@bowater.com>; <machtolfpa@bowater.com>; <skeelssl@bowater.com>; <vaughngm@bowater.com>; <ssorby@cahnrs.wsu.edu>; <dermot.randles@cascade.sierraclub.org>; <bill@ccrifc.org>; <amnomee@cdatribe-nsn.gov>; <qmatheson@cdatribe-nsn.gov>; <judy.mcquary@columbiapower.org>; <lea.dreher@columbiapower.org>; <llewellyn.matthews@columbiapower.org>; <victor.jmaeff@columbiapower.org>; <bill.towey@colvilletribes.com>; <don.hurst@colvilletribes.com>; <joe.peone@colvilletribes.com>; <patti.bailey@colvilletribes.com>; <sheri.sears@colvilletribes.com>; <tnturner@comcast.net>; <Allyson.Brooks@dahp.wa.gov>; <rob.whitlam@dahp.wa.gov>; <Ed.Tulloch@deq.idaho.gov>; <mcleljgm@dfw.wa.gov>; <robisdlr@dfw.wa.gov>; <vailcav@dfw.wa.gov>; <thepoint@direcway.com>; <4paul2hohlt@earthlink.net>; <acquarterhorses@earthnet.ws>; <daniel.millar@ec.gc.ca>; <dkni461@ecy.wa.gov>; <jbel461@ecy.wa.gov>; <jojo461@ecy.wa.gov>; <jpar461@ecy.wa.gov>; <EverettCA@edaw.com>; <McShaneC@edaw.com>; <psyk.christine@epa.gov>; <rueda.helen@epa.gov>; <martin.don@epamail.epa.gov>; <richard.raymond@esenvironmental.com>; <david.turner@ferc.gov>; <Frank.Winchell@ferc.gov>; <bmhiggins@fs.fed.us>; <dhsieh@fs.fed.us>; <dwilkins@fs.fed.us>; <gkoehn@fs.fed.us>; <jridlington@fs.fed.us>; <kahlenslager@fs.fed.us>; <lwilson@fs.fed.us>; <mbodie@fs.fed.us>; <mgerdes@fs.fed.us>; <rbonacker@fs.fed.us>; <skramer@fs.fed.us>; <tshuhda@fs.fed.us>; <dan_trochta@fws.gov>; <rich_torquemada@fws.gov>; <rick_donaldson@fws.gov>; <colin.spence@gov.bc.ca>; <kathy.eichenberger@gov.bc.ca>; <northwest@hydroreform.org>; <jime@iac.wa.gov>; <dosterman@knrd.org>; <ffinley@knrd.org>; <jgross@knrd.org>; <jmaroney@knrd.org>; <kjlyons@knrd.org>; <mwingert@knrd.org>; <rentz@knrd.org>; <greenleaf@kootenai.org>; <jennifer@kootenai.org>; <kdemsey@longviewassociates.com>; <rfilbert@longviewassociates.com>; <shurley@longviewassociates.com>; <keith.kirkendall@noaa.gov>; <mark.schneider@noaa.gov>; <stephanie_toothman@nps.gov>; <susan_rosebrough@nps.gov>; <jking@nwcouncil.org>; <shorton@nwcouncil.org>; <tgrover@nwcouncil.org>; <lawr.v.salo@nws02.usace.army.mil>; <kevin_devitt@or.blm.gov>; <macdonaldbru@pac.dfo-mpo.gc.ca>; <portol@pac.dfo-mpo.gc.ca>; <jim.harris@parks.wa.gov>; <commissioners@pendoreille.org>; <Dcummings@pendoreille.org>; <jmarthaller@pendoreille.org>; <mbrown@pendoreille.org>; <rcurren@pendoreille.org>; <jforman@plix.com>; <andre.coleman@pnl.gov>; <bob.johnson@pnl.gov>; <don@pocd.org>; <office@pocmuseum.org>; <jonley@popud.com>; <mcauchy@popud.com>; <pbuckley@popud.com>; <sjungblom@popud.com>; <cutter@potc.net>; <lonnie@potc.net>; <faith@povn.com>; <jhall_tedd@povn.com>; <sparky@povn.com>; <dianetristatecouncil@sandpoint.net>; <ruthtristatecouncil@sandpoint.net>; "Barbara Greene" <barbara.greene@Seattle.Gov>; "Doug Rough" <doug.rough@Seattle.Gov>; "John Halliday" <HallidJ@Seattle.Gov>; "Lisa Rennie" <Lisa.Rennie@Seattle.Gov>; "Mary Pat DiLeva" <marypat.dileva@Seattle.Gov>; "Michele Lynn" <michele.lynn@Seattle.Gov>; <randya@spokanetribe.com>; <gerry@streamkeepers.bc.ca>; <bill.duncan@teckcominco.com>; <dave.godlewski@teckcominco.com>; <kevin.kinsella@teckcominco.com>; <mark.tiley@telus.net>; <fkrause@tnc.org>; <klovell@tu.org>; <jeffrey.c.laufle@usace.army.mil>; <marian.l.valentine@usace.army.mil>; <michael.j.egge@usace.army.mil>; <selkirkloop@verizon.net>; <cindy.preston@wadnr.gov>; <kurt@washingtontrout.org>; <martink@wsdot.wa.gov>; <glenn@wshsinc.com>
Cc: <kdemsey@easystreet.com>; <randallfilbert@msn.com>; <mkeefe@r2usa.com>; <philgert@r2usa.com>; "Christine Pratt" <Christine.Pratt@Seattle.Gov>; "Kim Pate" <Kim.Pate@Seattle.Gov>
Sent: Thursday, June 22, 2006 12:54 PM
Subject: Re: Water Quality and Fish & Aquatics Workgroup Materials

Thanks Mark. We appreciate your comments on the meeting summary and

have done some research of our own. We were planning to discuss this at our Fish & Aquatics work group meeting next Tuesday.

>>> "Mark Tiley" <mark.tiley@telus.net> 06/22 11:21 AM >>>
Hi all. In review of the meeting minutes for both the Water Quality and the
Fish and Aquatics working Group meetings I noted a couple of errors in regards to my documented comments on Hydra. I do not know for certain whether the Hydra observed downstream of Keenleyside or Revelstoke Dams are
native or introduced. I did not state that they are an introduced species.

I posed the question "can Hydra establish on soft bottom substrate or will
Hydra be less dominant on soft bottom substrate" to Limnologist Chris Perrin
who conducted recent invertebrate assessments downstream of Revelstoke and
Keenleyside Dams and observed the dominance in the invertebrate community by
Hydra. I believe his response was that he did not feel that Hydra would be
not be able to establish and dominate the invertebrate community on soft
bottom substrates. I suggest contacting BC Hydro who hired Chris Perrin to
obtain the above mentioned studies.

Cheers,
Mark.
----- Original Message -----
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Sent: Wednesday, June 21, 2006 3:33 PM
Subject: Water Quality and Fish & Aquatics Workgroup Materials

> The Water Quality and Fish & Aquatics Workgroup materials are posted
on
> BRIMS. The link is below.
>
> https://www.seattle.gov/light/news/issues/bndryRelic/br_schedule.asp

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> No virus found in this incoming message.

Boundary Project tailrace area

BOUNDARY PROJECT RELICENSING

FISH AND AQUATICS

Meeting Summary

Meeting Date: June 23, 2006
Meeting Location: USFWS Office, Spokane, WA

In attendance:

Rick Donaldson	USFWS (United States Fish and Wildlife Service)
Rich Torquemada	USFWS
Al Solonsky	Seattle City Light
Phil Hilgert	R2 Resource Consultants

Introduction

The objective of the meeting was to review information regarding mortality estimates developed for fish passing through turbines, spillways, and sluiceways at the Boundary Hydroelectric Project (FERC No. 2144). Fish mortality estimates had been developed using an office-based analysis and had been described in a draft Early Information Development (EID) report titled "Fish Connectivity at the Boundary Hydroelectric Project" dated April 2006. The results of the analyses had been discussed at the April 20, 2006 stakeholder workshop, but Rick Donaldson (USFWS) and Rich Torquemada (USFWS) had not attended the April 20th meeting.

Al Solonsky (SCL) noted that at the April 20, 2006 meeting, SCL had asked stakeholders if turbine and spillway entrainment mortality estimates (Table 4-2 of the EID) developed by SCL could be used in the relicensing process in lieu of conducting studies to estimate entrainment mortality. Al noted that Tom Shuhda (USFS) had replied to this request, indicating that the USFS was prepared to allow SCL to use the turbine mortality estimates. Al noted that SCL would prefer to know as soon as possible whether use of the entrainment mortality estimates would be acceptable so there would be adequate time to reflect the decision in the Proposed Study Plan document.

Al Solonsky and Phil Hilgert (R2) then described development of the fish mortality estimates associated with entrainment. Al and Phil described the four potential avenues of downstream passage at the Boundary Project: turbines, spillways, sluiceways, and the skimmer gate and the mortality estimates developed for each route. They also explained the background of the predictive equations of turbine mortality developed using the US Department of Energy's (DOE) Advanced Hydro Turbine System Program (AHTSP) (Franke et al. 1997) (for detail regarding these analyses see the *Fish Connectivity at the Boundary Hydroelectric Project EID, Entrainment: Physical Risk*

Factors). Peter Christensen (R2) had conducted the analysis of potential entrainment mortality at Boundary Dam reported in the April EID report and was available if technical questions arose that Al and Phil were unable to address. Al and Phil proceeded to give a shortened version of the April 20th presentation and also briefly described the proposed site-specific field studies designed to estimate the number, timing and species of fish entrained in the turbines and spillways.

Meeting Results

Rick Donaldson (USFWS) stated they appreciated the presentation and discussion and they would consider the proposal to utilize the mortality estimates in lieu of the results of Project-specific mortality studies. However, the USFWS needed more time to review the EID and its supporting documents before making a decision; Rick added that the USFWS would send a letter stating its decision by July 21, 2006.

From: "Barbara Greene" <barbara.greene@Seattle.Gov>
To: <Rick_Donaldson@fws.gov>; "Phil Hilgert" <philgert@r2usa.com>; "Al Solonsky" <Al.Solonsky@Seattle.Gov>
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Sent: Friday, July 21, 2006 3:10 PM
Attach: Barbara Greene.vcf
Subject: Re: FWS response on possible Turbine Mortality Study

Rick,

Since Al is out until Monday, I wanted to thank you for your consideration of our proposed approach on turbine entrainment. We appreciate your time in reviewing the report and studies, and look forward to proceeding with the plans we've outlined. If there is more information we can provide on any of the studies, please don't hesitate to give me or Al a cal.

Thanks Rick, it was great to see you this week.

Barbara

Barbara Greene
Boundary Relicensing Program Lead
Seattle City Light
206.615.1091
barbara.greene@seattle.gov

>>> <Rick_Donaldson@fws.gov> 7/21/2006 3:00 PM >>>

Hi Al - -

Based on our review of the April 2006 version of Seattle City Light's draft
EID document, and the outlines of the following proposed studies discussed
in the fish work group meetings, including: Turbine Entrainment (4-20-06);
Spillway Entrainment (undated); Fish Distribution, Timing, Abundance and
Species Interactions in the Boundary Reservoir (6-27-06); and Fish Distribution in the Boundary Tailrace (undated) - - - and consideration of
information that you and Phil Hilgert presented to both Rich Torquemada
and I on June 23, 2006, we agree with your position that there is no

need
to proceed with a turbine injury/mortality study at this time. We
are
optimistic that the data obtained from the proposed studies, if
successful,
should provide us with information we are all seeking regarding
potential
(or need for) mitigation measures for aquatic species associated with
Boundary Dam. We look forward to working with you designing and/or
finalizing the proposed aquatic studies during the coming weeks.

Thanks for the special briefing last month!

Rick

ps- for some reason I can't find Phil Hilgert's email address. Could
you
send that my way when you get a chance.

Thanks

rd

_____

Rick Donaldson
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DEPARTMENT OF FISH AND WILDLIFE
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HABITAT PROGRAM
Major Projects Division

August 28, 2006

Allan Solonsky
Seattle City Light
P.O. Box 34023
Seattle, WA 98124-4023

SUBJECT: **WDFW Comments on Study Proposals, Boundary Hydroelectric Project, FERC No. 2144.**

Dear Allan,

The Washington Department of Fish and Wildlife (WDFW) has completed review of the various study proposals developed to date and offers the following comments. While many of our comments and concerns have already been expressed in workgroup meetings and may be repeated here, we have a few additional comments. Comments are listed by study proposal.

Fish and Aquatic Resources

Productivity Assessment

Comments on the Productivity Assessment are focused on the June 27th study proposal (proposal) and on the presentation given at the August 14th workgroup meeting.

This study should include a goal along with the objective. The goal should be to determine Project effects on productivity. Also, a description of methods is necessary to help understand how these tasks will be performed.

It is unclear in the proposal if and how reservoir residence time will be considered in the analysis. This should be made clear in the various tasks.

On page 3, of the proposal, (b) mentions that productivity data from Box Canyon tailrace side will be used. Please include a description of methods used to collect the data at Box

Canyon. For example, how was zooplankton data collected and how do the methods compare to those that will be used in the forebay and other places in Boundary reservoir.

In the presentation handout, slide 8, concentrations of zooplankton are implying productivity in the reservoir. Actual productivity in the reservoir should not be measured by concentration alone. It is likely that the majority of zooplankton is being entrained from production in impoundments upstream with longer residence time, i.e. Lake Pend Oreille. The concentration measurements more appropriately characterize forage availability. Furthermore, zooplankton concentrations should include species richness, abundance and size, i.e. for daphnia, cladocera and copepods. This will be important for adequately characterizing the forage base for salmonids and other fish. As indicated on slide 7, a measurement of organisms per liter or species present provides little information on forage quality/quantity for salmonids and other fish. Please modify the proposed data collection to improve the forage base and productivity assessment.

Slide 9 indicates that measurements will be collected spring, summer, fall, and winter. Project operations often vary the pool on an hourly and daily basis. Operations and zooplankton concentrations/specie/size vary by season; however, diurnal characteristics of zooplankton and daily operations need to be examined as well. Project effects are likely to be evident on an hourly or daily basis than on a seasonal basis. Please modify the proposed data collection to include more detailed time series measurements.

Slide 10, Step 2, please clearly define minimum pool level fluctuation scenario. The *Productivity Study* refers to calculating aquatic productivity under the maximum expected range of pool level fluctuations (T3) and estimating aquatic productivity under the minimum expected range of pool level fluctuations (T4). Hypothetically, if minimum pool fluctuations are defined as 10 feet and maximum is defined as 12.5 feet, then the percent change (T5) will not fairly illustrate project effects. It will merely show the difference in productivity at those levels of operation. With just two points (levels of operation for a given season), it would seem that modeling and estimating relative productivity for other scenarios (e.g full pool) could lead to a highly inaccurate estimate. It should not be assumed that productivity is linear with various reservoir levels. We believe the full range of operations should be considered in determining project related effects. Productivity at various levels of operation should be quantified to adequately determine the effects of project operations.

Slide 12, Periphyton HSI Curve: Dewatering mortality and colonization need to be quantified. Quantification of these variables for BMIs will also be very important in characterizing potential project effects.

Slide 13, Productivity Calculations: Please clearly define how production will be calculated (also refer to comments on slide 8).

Slide 14: What is the integrated habitat suitability factor? Please provide a detailed explanation.

We recognize that the study proposal on productivity is in development; however, these comments should apply to the individual parameters where appropriate. We look forward to providing additional review as the proposal becomes more refined.

Benthos: *a subset of the Aquatic Habitat Modeling Study, Habitat Suitability Information (6-19-06 Draft)*

Page 1: This study should include a goal along with the objective. The goal should be to determine Project effects on benthic macroinvertebrate production.

For BT2, BT3 and BT4: It is stated that one sampling site will be below Metaline Falls and one will be above Metaline Falls. Two sampling sites are inadequate to adequately characterize and account for the variability in substrate and habitat. Various substrate types will influence species diversity and colonization, especially for the fixed sampling units. More than two floating sampling units need to be deployed to account for various habitat types influenced by varying velocity environments: forebay, eddies, inlets, canyons etc. We request that the number of sampling sites be increased. For fish management purposes, our agency typically applies a standard error of at least 50% of the mean.

Fish Distribution, Timing, Abundance and Species Interactions in the Boundary Reservoir

Many of our comments and questions on this study focus on the task activities, i.e. sampling strategies and techniques.

T1: Will the stratified sampling be randomized? The number of sample sites in each of the reaches may be inadequate: strata based means and errors of catch may occur if there are not at least two sets of each type (bottom, mid, and surface).

T2: How were sample sizes determined? How will sample locations be selected?

T5: We are concerned about blockage of the entire stream for sampling. Provisions need to be included for fish to move upstream. Fyke nets may be problematic during periods of high flow. Flows in Sullivan Creek increase drastically after October 1, when the lake is drawn down. A screw trap or incline plane trap may be more appropriate for sampling in Sullivan Creek.

T6: What are the size classes for fish that will be applied?

T8: One time collection of diets is not adequate for determining substantial predation and/or diet overlap. Please consider expanding the data collection.

T9: If data collected on stomach content samples from triploid trout is for the purpose of assessing potential competition for forage resources with native salmonids, then the same

data needs to be collected from native salmonids, otherwise conclusions may not be valid.

T10: Second bullet: …information on the distribution and abundance of fish in the reservoir and tributary mouths will be useful in interpreting potential species interactions. What species interactions are being inferred here? Fourth bullet: it is unclear exactly what the Tributary Delta Habitat Modeling will address, and how. Please provide additional information.

Triploid Rainbow Trout Management

A2: Change the first sentence to include, "The number *and size* to be stocked into Boundary…"

T2: Consider putting phone number or address on tags to increase the reporting rate. Another option is to only put "reward" on the tags for triploid rainbow trout. The brochures and signs should also provide general information on the tagging program.

T3: Data on spatial distribution patterns of triploid trout captures will be extremely limited from angler tag returns. Little emphasis should be placed on this data. Spatial and temporal habitat overlaps do not indicate a positive or negative impact. Forage availability and species preference are important in determining influences of competition.

T4: Data from tag returns will likely be very limited; therefore, it may have little applicability for determining survival, catch, and harvest. For this, there must be a creel survey that assumes a 100% tag return rate or have tag retention or reporting study conducted.

T5: A discussion on the potential benefits and drawbacks of each strategy relative to the potential recovery of native salmonids and recreational angling opportunities is ambitions considering the limited data collection. This study basically assesses the success of triploid trout releases that provide a recreational fishery, and not much else. Please consider scaling back the expectations and applicability of the data.

Recreational Creel Surveys

Additional information is needed on methodology to provide useful comments. In the objective, fishing activity should refer to angler hours or days and success rates should be defined (are catch and harvest rates being referred to here?).

T3: The third bullet refers to "traditionally less desirable native fish." We suggest changing the wording to "*less popular native fish*." The last three bullets are not creel questions.

The “additional information” that will also be gathered contains part of the creel data that needs to be collected. Creel is to assess fishing activity. A recreational use survey would be for everything else: i.e. other activities, where they are staying, alternative fishing locations and perceptions.

Effects of Sediment Transport on Mainstem Channel Morphology

At the bottom of page one, it is stated that tributary channel morphology as affected by the Project will be looked at in a separate study of Tributary Delta Habitats. A Fish and Aquatic Study titled Tributary Delta Habitats could not be found for comment. Tributary deltas are important habitats for fish and need to be considered in an evaluation of sediment transport and channel morphology.

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We appreciate the opportunity to review these proposals and provide comment. If you have any questions, you may contact me by email (robisdlr@dfw.wa.gov) or by phone at 509-892-1001 ext. 322.

Best regards,

Doug Robison
Mitigation Coordinator

Seattle City Light ***FINAL***
Boundary Project Relicensing
September 8, 2006 USFS Conference Call
9:00 AM – 10:45 AM

Participants
Glen Koehn (U.S. Forest Service) only first 15 minutes of conference call
Tom Shuhda (U.S. Forest Service)
Barbara Greene (Seattle City Light)
Al Solonsky (Seattle City Light)
Steve Padula (Long View Associates)
Phil Hilgert (R2 Resource Consultants)

Introduction
The purpose of the conference call was to discuss five of the U.S. Forest Service (USFS) Study Requests recently filed with FERC that pertain to fisheries topics. Al Solonsky (SCL) had arranged the conference call with Tom Shuhda (USFS) earlier in the week to discuss the five fisheries related USFS Study Requests and identify if there were any substantive differences with the study outlines that SCL developed in collaboration with stakeholders at Fisheries and Aquatics (F&A) workgroup meetings in April, May, June and August of 2006.

The Conference Call was initiated by SCL at 9:00 AM
Al Solonsky (SCL) began the conference call by asking Tom Shuhda (USFS) and Glenn Koehn (USFS) if they agreed with SCL writing up a summary of the conference call and sending it to the USFS for review. Al Solonsky (SCL) said that after there was agreement on the wording of the conference call summary, SCL would file the summary with FERC as part of the consultation record that will be incorporated into the PSP. Al Solonsky (SCL) said that the summary would help FERC compare SCL's PSP to be filed in October with the recently filed USFS Study Requests. Al Solonsky (SCL) mentioned that SCL also planned to include a description of what occurred in the conference call in the consultation section of each relevant study in the PSP. Barbara Greene (SCL) reinforced the objective of helping FERC understand where differences and similarities were between USFS study requests and SCL study proposals. Glenn Koehn (USFS) and Tom Shuhda (USFS) both agreed to review a draft summary of the conference call.

Al Solonsky (SCL) said that he thought there were few substantive differences between the USFS Study Requests that were filed with FERC and the study outlines that SCL had developed with stakeholders at F&A workgroup meetings. Tom Shuhda (USFS) agreed. Al Solonsky (SCL) further explained that in reviewing the USFS Study Requests, it was difficult to verify where the studies were actually identical and areas where the USFS was recommending a different approach or methodology. Al Solonsky (SCL) said that he wanted to step through each USFS Study Request where SCL had a question and see if there were truly differences and if so, see if agreement could be reached.

Glenn Koehn (USFS) said that the USFS felt the need to file study requests to ensure their perspectives on the studies were a part of the FERC record, and because the study outlines that SCL developed with stakeholders at workgroup meetings were not yet in the official FERC

record. Glenn Koehn (USFS) further stated that the USFS would provide its formal comments on the studies included in the PSP once it was filed with FERC. Barbara Greene (SCL) said that it had been difficult to identify which SCL study outlines, or parts of SCL study outlines the USFS agreed with because the USFS did not reference any SCL workgroup efforts. Barbara Greene (SCL) added that the USFWS recently filed study requests with FERC and simply listed the SCL study outlines that had been developed in workgroups and identified that the USFWS agreed with them. Steve Padula (LVA) added that the USFS did not reference in their cover letter to FERC any consultation with SCL that had occurred over the past six months, so it was difficult to know how the USFS officially viewed F&A workgroup products.

Glenn Koehn (USFS) and Tom Shuhda (USFS) both stated that the USFS was in general agreement with all of the proposed SCL studies. USFS agreed that once the PSP is on the record, they would meet to discuss any remaining differences. Tom Shuhda (USFS) said that there were very few places where the USFS wanted any changes to study designs or study components.

Al Solonsky (SCL) proposed to begin the discussion with the genetics/fish transportation question, since that was one item that was briefly discussed when the conference call was arranged.

1. Genetics (USFS Study Title: Bull and Westslope Cutthroat Trout Genetic Study Requests)

Al Solonsky (SCL) said that most likely all bull trout that might be caught in the reservoir during the study phase would be from areas upstream of the project and transporting bull trout that were captured back upstream would most likely eliminate all research components developed to identify their behavior in the project area. Tom Shuhda (USFS) agreed that maybe not all westslope and bull trout that originated from upstream areas should be transferred back upstream, since it would not allow SCL to study these fish to obtain migratory behavior and habitat use information. Tom Shuhda (USFS) mentioned his desire to balance the need to protect sensitive species, like bull trout, and the need to obtain behavioral information from these fish in the project area. Phil Hilgert (R2) said he would add language into the PSP that would address transporting native fish in consultation with resource agencies and coordination with Pend Oreille PUD's trap and transport program at the Box Canyon Dam if specific native fish that were tagged in Boundary reservoir continued to attempt to move upstream to natal habitat and were recaptured. Phil Hilgert (R2) stated that the PSP would identify a fish transportation alternative if specific knowledge existed that the fish originated from upstream, it was clear that no additional migratory information could be obtained from the fish and the fish was not able to provide any additional habitat preference information.

Al Solonsky (SCL) asked Tom Shuhda (USFS) if the genetic signatures were identified throughout the watershed well enough to identify where any fish that might be captured originated. Tom Shuhda (USFS) said that he was not sure of the exact status of basin-wide genetic mapping, but mentioned that he thought genetic signatures were available for bull trout in the Salmo Basin, Pend Oreille Lake and Priest River area. Phil Hilgert (R2) added that a rapid genetic identification process was developed and currently underway at Avista's Cabinet Gorge Project. Al Solonsky (SCL) mentioned that the Kalispel Tribe had funding to pull together a

basin-wide genetic analysis of westslope and bull trout. Tom Shuhda (USFS) and Al Solonsky (SCL) agreed that they did not know the current status of this effort, but it should be explored and unknowns should be identified.

Al Solonsky (SCL) mentioned that USFWS genetic kits were in use by contractors currently sampling at the Project and genetic samples would be taken on salmonids in agreement with the study design that was developed with stakeholders for this year's efforts. Tom Shuhda (USFS) mentioned that he knew USFS and SCL were in agreement with taking genetic samples.

Phil Hilgert (R2) said that it was SCL's intention to have the USFWS analyze the samples. Steve Padula (LVA) asked who would be most appropriate for interpreting genetic information to characterize the bull trout population in the basin. Tom Shuhda (USFS) said geneticists would do the actual analysis, but it would probably leave room for interpretation and he hoped this would be done by the bull trout recovery team. Tom Shuhda (USFS) said that he hoped this would help in understanding historical genetic connectivity.

2. Entrainment (USFS Study Title: Fish Entrainment Study Request)

Al Solonsky (SCL) asked Tom if the USFS was in agreement with SCL's entrainment study outline presented earlier this summer and posted on the SCL relicensing website. Tom Shuhda (USFS) said that the USFS was in agreement with the study outline and discussions that had occurred during SCL's summer F&A workgroup meetings. Al Solonsky (SCL) asked if Tom Shuhda (USFS) concurred that SCL did not need to perform a spillway or turbine mortality or injury study. Tom Shuhda (USFS) said that the USFS is willing to accept SCL's mortality and injury estimates and that nothing in the USFS fish entrainment study request was in conflict with the agreement that had been reached in workgroup meetings.

3. Ramping Rate Studies (USFS Study Title: Effects of Current Project Operations (Ramping) and alternative Operations on Aquatic Habitat and Biota Study Request

Al Solonsky (SCL) asked Tom if the USFS was in general agreement with the ramping studies as proposed by SCL during summer 2006 F&A workgroup meetings. Tom Shuhda (USFS) said they were. Al Solonsky (SCL) mentioned that there were a few places where SCL would like to see if there were any differences in study approach and asked to go through several items in the Methods section of the USFS's study request.

- Al Solonsky (SCL) started with the USFS's request to characterize water surface elevations and stage fluctuations over the past ten years. Al Solonsky (SCL) said that this information was being compiled, along with other hydrological information into a database. Al Solonsky (SCL) said that it was SCL's intention to make this database available to all stakeholders. Al Solonsky (SCL) said that the bathymetric survey that was currently underway would need to be finished before the hydrology could be completed and it was SCL's plan to complete this task and make the information available to stakeholders for agreement before the information would be used in modeling efforts. Tom Shuhda (USFS) agreed with this approach.
- Al Solonsky (SCL) asked if the model identified in the same paragraph as the request for historical stage fluctuations was the same model that had been proposed by SCL to

address information needs to evaluate ramping events. Tom Shuhda (USFS) said it was and there was agreement on this modeling effort.

- Al Solonsky (SCL) asked if the 1, 2, 4 and 8 hour intervals identified in the USFS methodology were firm numbers of interest to the USFS, rather than the hourly analysis proposed by SCL. Tom Shuhda (USFS) said that USFS intervals were provided as an example, but SCL's study outline and modeling proposal utilizing hourly intervals was fine.
- Al Solonsky (SCL) asked if the same intervals identified by the USFS in the next sentence that described site specific validation were specific study recommendations. Tom Shuhda (USFS) said that they were also examples and that hourly intervals or intervals to be determined by further stakeholder collaboration as described in SCL's study outline would be fine.
- Al Solonsky (SCL) asked if the time intervals for substrate sampling were firm USFS recommendations and if the locations and time periods for analysis were specific requests. Tom Shuhda (USFS) said that if SCL followed the design of the substrate study outline developed in the F&A workgroup that this study design would meet the needs of the USFS.

4. Tributary Studies (USFS Study Title: Native Salmonid Presence and Migration Study)

Al Solonsky (SCL) explained that he thought SCL had incorporated adfluvial life history information into their study outlines. Al Solonsky (SCL) explained that SCL has proposed to monitor movement of fish from the reservoir into tributaries with radio tags and monitor movement of fish from tributaries into the reservoir with fyke netting. Al Solonsky (SCL) also mentioned the work that would be done to assess habitat conditions at the tributary deltas. Al Solonsky (SCL) didn't see the specific link to the project in conducting snorkeling or electrofishing in tributaries above the influence of project operations that was requested by the USFS.

Tom Shuhda (USFS) said that it would be good to track the status of tributary fish populations and that this effort would provide information for potential off-site mitigation in the form of potential stream habitat restoration. Phil Hilgert (R2) discussed the tributary studies that had been outlined in F&A workgroup meetings. Phil Hilgert (R2) said that a fair amount of information had already been collected in tributaries and it would be reviewed to see if there were data gaps. Phil Hilgert (R2) said that other efforts in the tributary study outline would identify off-site mitigation opportunities. Tom Shuhda (USFS) thought that this would probably meet the needs of the USFS.

5. Aquatic Plant Management (USFS Study Title: Aquatic Plant Management Control Study)

Al Solonsky (SCL) mentioned that it appeared there was one difference between the USFS's Aquatic Plant Management Control Study Request and SCL's proposed Aquatic Habitat Modeling and Habitat Suitability Information for Macrophytes Study. Tom Shuhda (USFS) agreed that the difference was the USFS's addition of a study of drawdown as a treatment. Tom Shuhda (USFS) added that other control treatments could be studied as well. Tom Shuhda (USFS) said that it would be best to see what methods are most successful to help identify long-term control methods. Phil Hilgert (R2) said that SCL's modeling studies get at the same

question. Phil Hilgert (R2) described SCL's proposed methodology, whereby various areas in the drawdown zone of the reservoir would be studied in comparison to the occurrence and density of macrophyte beds. Phil Hilgert (R2) described how operations of the project would be compared with the occurrence and density of macrophyte beds. Phil Hilgert (R2) said that the modeling efforts proposed by SCL could also be used to identify conditions for macrophytes under various operating scenarios, including running a scenario that looked at various winter drawdowns. Phil mentioned that modeling would also be backed up with field data Phil Hilgert (R2) said that he could add some additional language into SCL's study plan in the PSP to describe how information from the macrophyte study could address questions about long-term control. Tom Shuhda (USFS) said that he thought this would meet what the USFS is looking for.

The Conference Call ended at 10:45 AM

Seattle City Light

Memorandum

DATE: September 11, 2006

TO: Consultation file

FROM: Al Solonsky

SUBJECT: Phone call with Joe Maroney (Kalispel Tribe, Department of Natural Resources)

I called Joe Maroney on Monday, September 11th to see how he was doing and ask why we didn't get any PAD comments from the Tribe. Joe said that they were busy on stuff for Box Canyon and had several deadlines they had to meet on that project. Joe said to assume that if we don't hear from the Tribe, things are fine. Joe said that of the workgroup meetings he was able to participate in, our approach to doing studies was in line with what approach the Tribe would take. Joe did say that the modeling work is complicated and he would appreciate a sit-down with Phil and me sometime in late October or November to go through this work. I told him that sounded fine and I would get back to him when I knew Phil's schedule and set something up.