Proposed Study Plan
Boundary Hydroelectric Project (FERC No. 2144)

Seattle City Light

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Proposed Study Plan for the Boundary Hydroelectric Project (FERC No. 2144)

1 INTRODUCTION

1.1. General

This document presents Seattle City Light's (SCL's) Proposed Study Plan (PSP) for the Boundary Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 2144. The PSP details the plans for those studies identified by SCL as necessary to develop sufficient information for FERC's analysis of the Project relicensing. This determination of study need is based on a review and evaluation of existing information, as summarized in SCL's Pre-Application Document (PAD) for the Boundary Project relicensing (SCL 2006), as well as consultation with agencies, tribes, and other stakeholders (relicensing participants).

Recognizing the significant benefit of avoiding the need for dispute resolution regarding the proposed study program, which could jeopardize the timing of any disputed studies, SCL has aimed for achieving a high level of concurrence with relicensing participants on the PSP. Toward this end, SCL has endeavored to engage relicensing participants in meaningful discussions in the form of an intensive series of workgroup meetings over five months to develop proposed language regarding the suite of studies to be conducted as well as the design of individual studies.

This PSP encompasses a total of 24 individual study plans, which have been prepared in consultation with relicensing participants.[1] These study plans are listed in Attachment 1-1, along with the corresponding resource issue(s) that each plan is designed to address. The study plan components are organized by resource area. For each proposed study within a resource area, the PSP provides all information specified under FERC's Integrated Licensing Process (ILP) requirements (CFR 18 Part 5, § 5.11), along with additional information on the proposed study, such as consultation related to study plan development. Presentation of the information for each proposed study is organized as follows:

- Summary description of proposed study
- Explanation of Project nexus to proposed study
- Discussion of any known resource management goals of the agencies or Indian tribes with jurisdiction over the particular resource
- Description of study goals and objectives
- Description of relevant existing information and the need for the information to be provided by the proposed study

[1] A summary of relevant consultation is attached to each study plan.

- Detailed description of the study and methodology to be used[2]
- Consistency of the proposed study method with generally accepted scientific practice
- Consultation with agencies, tribes, and other stakeholders
- Schedule for conducting the study
- Provisions for periodic progress reports
- Anticipated level of effort and cost

Following the description of the proposed studies within a resource area, the PSP addresses any studies that were requested by agencies, tribes, or other stakeholders (in conjunction with comments on the PAD and FERC's Scoping Document 1) for that resource area that were not adopted in the PSP. For each of these study requests, SCL's rationale for not including the study plan within the PSP is provided, with reference to the criteria set forth in CFR 18 Part 5, § 5.9(b).

The process and schedule for finalization of the study plan, including development of detailed implementation plans, and opportunities for relicensing participants to be updated on the results of the studies are described in section 1.2.

Ultimately, the results of the relicensing studies program will be synthesized into comprehensive analyses to characterize Project-related resource impacts and evaluate potential protection, mitigation, and enhancement (PME) measures. These supporting impacts/PME analyses will be presented in the Preliminary Licensing Proposal (PLP), which will be filed with FERC in April 2009, and ultimately in the License Application, which must be filed no later than September 30, 2009. Because these analyses do not themselves involve field work or other data collection (rather, they will be syntheses of results from various studies), they are not included as proposed studies in this PSP. However, SCL does intend to engage relicensing participants in discussions regarding these impacts/PME analyses through the course of consultation leading up to filing of the PLP and License Application. SCL's proposed plan for involving relicensing participants in the development of the PLP is described in section 1.2.5.

1.2. Process and Schedule Overview

1.2.1. PSP Comment Period

Consistent with requirements under CFR 18 Part 5, § 5.11(e), SCL will conduct a formal study plan meeting with relicensing participants within 30 days of the deadline date for filing the PSP. This initial meeting is scheduled for November 15, 2006, in Spokane, Washington. Subsequent study plan meetings will be scheduled as needed in an effort to resolve any outstanding issues following the initial meeting and prior to the due date for comments on the PSP.

Comments on the PSP must be filed with FERC within 90 days after the PSP is filed (CFR 18 Part 5, §5.12), or no later than January 15, 2007. Any revised information or study requests must

[2] The study area varies among the various different studies; the study area for each particular study is described in each individual study plan.

also be filed in conjunction with the PSP comments. Comments on the PSP should clearly explain any study plan concerns, and any proposed modifications to the PSP must address the criteria in CFR 18 Part 5, § 5.9(b).

1.2.2. Revised Study Plan and Final Study Plan Determination

Upon receiving the comments on the PSP, SCL will begin to make the requested study plan changes it feels are warranted and will also prepare and distribute to relicensing participants a summary of SCL's proposed responses to all of the PSP comments. In January, SCL will meet with relicensing participants regarding its proposed responses to PSP comments and attempt to resolve any remaining study disputes, to the extent that time allows.

By February 14, 2007, within 30 days of the due date for comments on the PSP, SCL will file a Revised Study Plan (RSP) with FERC that will specifically address all comments received on the PSP. In accordance with CFR 18 Part 5, § 5.13(a), the RSP will also include a description of the efforts made to resolve differences over study requests. For any requested study that SCL does not adopt in the RSP, SCL will explain the rationale for its decision with reference to the criteria set forth in CFR 18 Part 5, § 5.9(b).

FERC will issue its final study plan determination by March 16, 2007, within 30 days from filing of the RSP (CFR 18 Part § 5.13(c)). If any portions of the final study plan determination are disputed by federal agencies with Section 4(e) and Section 18 authority or an agency or Tribe with authority to issue Section 401 water quality certification for the Project, a formal dispute resolution process will be initiated, as provided for under CFR 18 Part § 5.14, and a final study dispute determination (constituting amendment of the approved study plan) for the disputed study components will be issued in June 2007. (Refer to Table 2.2-2 in section 2.2.1 of the PAD for additional detail regarding specific study dispute resolution steps and milestones.)

1.2.3. Refinement of Study Implementation Details

The PSP study plan elements describe the planned study approach in sufficient detail for the parties to understand and agree on the proposed study program. Greater specificity regarding the details of study implementation (e.g., specific sampling sites and transect selection, if not identified in the PSP) may be needed for some of the studies before field work begins. SCL proposes to include interested relicensing participants, as well as the researchers who will be conducting the studies, in this study implementation planning.

By the end of 2006, SCL plans to have selected and retained the Technical Consultant that will implement the relicensing study program. Following the filing of the RSP and prior to actual initiation of the studies, the Technical Consultant will participate, with SCL and relicensing participants, in developing and refining any remaining details related to implementation of the studies. The major steps SCL proposes for study implementation planning (for non-disputed studies) are as follows:

- Shortly following issuance of the RSP, the Technical Consultant will assist SCL in drafting study implementation plans describing the proposed study implementation details. These drafts will be targeted for completion no later than the end of March.

- Starting in early April, SCL will meet with relicensing participants to review and discuss the proposed study implementation plans. Subsequently, agreed-upon implementation details would be incorporated into the study implementation plans. The implementation plans will be targeted for completion by end of April. (Dates for completion of the implementation plans will likely be staggered, starting with those for studies with the earliest scheduled field work.)
- Following the April workgroup meetings, the Technical Consultant will begin conducting the studies.

The recommended steps and schedule outlined above are shown in Table 1.2-1. For any disputed studies, adjustments will be made to this approach, if feasible, to accomplish the same implementation planning for those studies.

Table 1.2-1. Proposed steps and schedule for study plan finalization.

Timeframe (2007)	Task
February 14	RSP filing due date
Mid- to late February	Technical Consultant provides general recommendations to SCL on developing field-related implementation details to be presented in study implementation plans
Late Feb. / Early March	RSP comments due
March	Technical Consultant assists SCL with drafting of study implementation plans
Mid-March	FERC Study Plan Determination issued
Early April	Begin series of stakeholder workgroup meetings to review and discuss the proposed study implementation details
Mid- to late April	Study implementation plans completed
Mid- to late April	Studies commence, as implementation plans are completed, and according to study schedules

1.2.4. Study Reporting and Study Plan Modification

Formal reporting requirements related to the progress of the relicensing study program include the Initial Study Report (March 2008), the Updated Study Report (March 2009), and the corresponding meetings to discuss these reports (CFR 18 Part 5, § 5.13(a)). In addition, SCL plans to provide informal updates on a quarterly basis to keep relicensing participants abreast of study progress and communicate significant developments. The proposed timeline for study progress reporting is presented in Table 1.2-2.

Table 1.2-2. Proposed study progress reporting and stakeholder review opportunities, including the FERC-required Initial Study Report and Updated Study Report.

Progress Report / Information Sharing	Proposed Timeframe	Review Comments Due
Updates on study implementation	August/September 2007	NA
Review of preliminary Year 1 study results	January 2008	NA
Initial Study Report [1]	February 2008 [3]	Approximately 60 days [4]
Initial Study Report meeting (meeting on study results and any proposals to modify study plan) [1]	Within 15 days from initial study report	Disputes/requests to amend study plan due within 30 days from study report meeting summary
Updates on study implementation	June/July and September/Oct	NA
Review of preliminary Year 2 study results	December 2008	NA
Review "cross-over" study results	January 2009	NA
SCL files Updated Study Report [2]	February 2009 [3]	Approximately 60 days [4]
Updated Study Report meeting (meeting on updated study results and any proposals to modify study plan) [2]	Within 15 days from updated study report	Disputes/requests to amend study plan due within 30 days from study report meeting summary

1 Required under 18 CFR Part 5, section 5.15(c).

2 Required under 18 CFR Part 5, section 5.15(f).

3 The Initial Study Report must be filed no later than 1 year after FERC approval of the study plan (18 CFR, Part 5, section 5.15(c)(1)).

4 Applicant (SCL) must hold a meeting within 15 days of issuance of the study report (18 CFR Part 5, section 5.15(c)(2)) and issue a meeting summary within 15 days of the meeting (18 CFR Part 5, section 5.15(c)(3)). Stakeholders then have 30 days to file any disputes or requests to amend the study plan (18 CFR Part 5, section 5.15(c)(4)).

One of the main purposes of the quarterly updates will be to inform and obtain input from relicensing participants as studies progress regarding potential resource conflicts and potential mitigation opportunities. Further, as described throughout this PSP, SCL plans to provide a number of study-specific opportunities for continuing stakeholder involvement regarding study progress. These study-specific opportunities, which may or may not occur in conjunction with the quarterly updates, include, among others: reviewing proposed activities for Phase 2 of the Evaluation of Total Dissolved Gas (TDG) and Potential Abatement Measures, which will include identifying structural and/or operational TDG abatement alternatives resulting from Phase 1 of the TDG study (see section 3.1); and planning for Phase 2 of the Toxics Assessment, as well as development of a Phase 2 study plan (see section 3.2).

Following each official Study Report meeting (see Table 1.2-2), the FERC ILP regulations provide the opportunity for SCL and/or relicensing participants to request modifications to the study plan in light of the progress of the study program and results to date (CFR 18 Part § 5.15(c)(2)). For example, SCL may desire to modify portions of certain study plans if it appears that such modifications are warranted based on new information that clarifies future operations

of Seven Mile Reservoir (immediately downstream from Boundary Dam) as a result of the proposed expansion of the Waneta Project. SCL will continue to closely monitor the Waneta Project expansion proceedings and will consult with Boundary Project relicensing participants regarding any new information on Seven Mile Project operations that may have implications on potential effects of Boundary Project operations.

1.2.5. Development of Preliminary Licensing Proposal

The relicensing studies will provide much of the information necessary for determining and characterizing Project impacts and identifying appropriate PME measures in light of those impacts. As noted above, SCL's comprehensive impacts analysis and proposed PME measures will be presented in the PLP, to be filed in April 2009. Although not required to do so under FERC's ILP rules, SCL intends to involve relicensing participants in substantive discussions related to development of the PLP. SCL recognizes that it will be a challenge to accomplish this enhanced level of consultation on the PLP while still meeting the stringent process timelines of the ILP. SCL's proposed PLP stakeholder involvement plan and schedule, which attempts to make the most effective use of the limited time available to interact with relicensing participants prior to issuance of the PLP, is summarized in Attachment 1-2.

A major limitation on the time available for developing the PLP is that full results from several of the more significant planned studies will not be available until late 2008, or in some cases, early 2009. Furthermore, for some of the more complex issues (e.g., TDG abatement), sufficient data to yield conclusive results may not be available until after the License Application has been filed. To help alleviate the time limitations inherent in the ILP, SCL plans to provide relicensing participants with its preliminary conclusions regarding Project impacts and potential PME measures, to the extent possible and appropriate, in conjunction with the reporting of results from the first study season (late 2007 / early 2008). The impacts analysis and PME proposals will be refined based on the second year of study results and input from relicensing participants.

Figure 1.2-1 shows the general timeframes and relationships among the sequence of steps toward developing the PLP. As shown conceptually in Figure 1.2-1, relicensing participants will have the opportunity to provide input in the areas of study interpretation and Project impacts analysis as well as the development of PME proposals to be presented in the PLP. Further detail on the study timeframes, interrelationships among study elements, and opportunities for relicensing participants to provide input is provided in each specific resource area section in this PSP.

It should be noted that for studies extending well into 2009, final conclusions regarding Project impacts and appropriate mitigation may not be timely for presenting in the PLP, or even in the License Application; rather, the final proposals related to these topics in the License Application may take the form of proposed processes for continued study and consultation toward ultimate development of appropriate PME measures. SCL also intends to engage relicensing participants in discussion regarding these continuing processes during the development of the PLP and License Application.

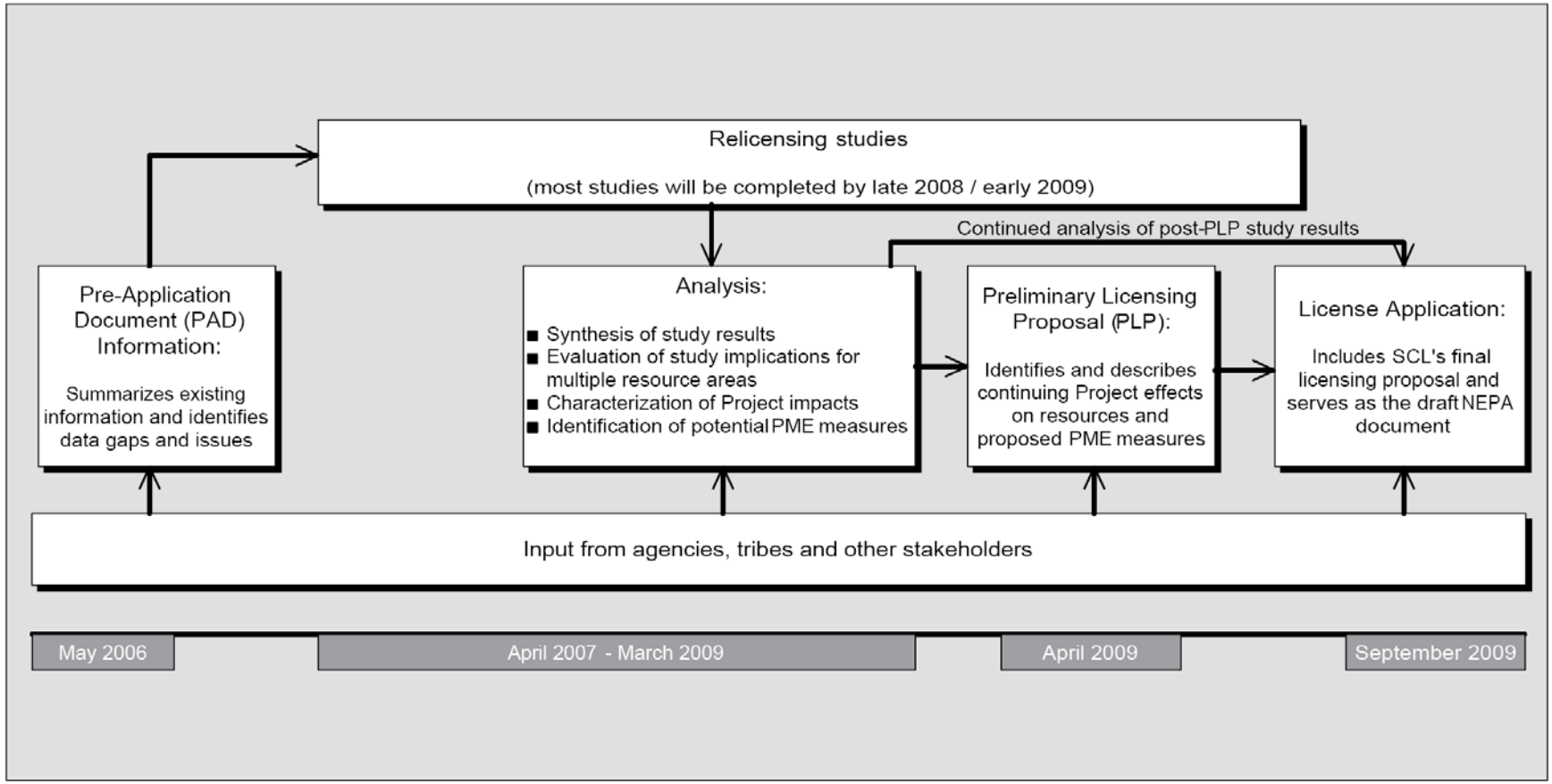


Figure 1.2-1. General sequence of steps, timeframes, and junctures for stakeholder input related to development of the Preliminary Licensing Proposal.

While not requested as a stand-alone study, an integrated resource analysis (i.e., analysis of results from multiple studies and different resource areas) is alluded to in some aspects of formal study requests and accompanying comments filed by relicensing participants. Specifically, in the PAD/Scoping comment letter filed by the USDA Forest Service (USFS) with FERC on August 31, 2006 (USFS 2006), the USFS requested that the proposed Big Game Study include identification and discussion of impacts on big game from Project-related recreational activities; by contrast, in the PSP, the effects of Project-related recreation are proposed to be assessed in a separate study (Recreation Resource Study). Similarly, the USFS, in its comments on FERC's Scoping Document 1 (USFS 2006), suggested that the environmental analysis for the relicensing include evaluation of the effects of macroinvertebrates on primary and secondary productivity in Project-related waters, and should also evaluate the effects of noxious weeds on wildlife and sensitive plant species habitat. To clarify, SCL does propose to develop the information that will be needed to conduct the requested integrated resource analysis, including the specific aspects identified by the USFS; the integrated resource analysis itself will not be conducted as part of the relicensing studies program, but instead will be a subsequent step, as described above and illustrated in Figure 1.2-1.

In a related comment on the PAD (USFS 2006), the USFS requests that SCL explain what method it will use to consider potential effects of proposed PME measures on the local economy, also suggesting that a regional economic analysis is not the appropriate tool in this licensing process and that the analysis should consider market and non-market benefits of proposed PME measures. SCL agrees that an appropriate methodology to describe potential socioeconomic effects, both costs and benefits, associated with potential PME measures on the local economy will be needed for the License Application. However, it would be premature to begin the analysis without the benefit of information from the study program because so little is known about what actions and PMEs will be proposed. SCL will seek input from the USFS and other interested parties on selection of an appropriate methodology to describe non-monetary benefits of proposed PME measures.

For the reasons described above, and in light of the numerous and closely spaced steps outlined in Attachment 1-2, SCL believes it would not be feasible to conduct a synthesis of study results / integrated resource analysis and development of PME measures as part of the relicensing study program described in this PSP. SCL's rationale for this conclusion is briefly summarized as follows:

- Synthesis/analysis of results from multiple studies (a fundamental component of impacts analysis and, hence, identification of appropriate PME measures) cannot be conducted until the results from all the studies described in this PSP are available.
- Synthesis of results and development of PME measures do not comprise a scientific study. In particular, the evaluation of potential PME measures involves a cost/benefits analysis that must weigh environmental and developmental factors; such an analysis is based on consideration of sometimes competing values, in addition to objective information gathering and analysis.
- SCL has proposed provisions for involving relicensing participants in the synthesis of study results and development of PME measures, as outlined in Attachment 1-2, separate from the relicensing studies program *per se*. These provisions go well

beyond the requirements of the ILP and represent SCL's good-faith effort to offer relicensing participants an effective opportunity for substantive input within the ILP framework.

As in the approach it has taken with regard to development of this PSP, SCL hopes to achieve as much consensus as possible among relicensing participants on the licensing proposal prior to filing the PLP, to improve chances for a positive relicensing outcome and to foster effective working relationships with relicensing participants in the next license term. SCL believes its proposed approach is well-suited to accomplishing these objectives, and is feasible within the constraints of the ILP.

1.3. Boundary Project Overview

This section provides a brief overview of the Project location, facilities, and operations, including lands and facilities that SCL has identified for possible addition to the Project under the new license. The studies described in this PSP have been designed to develop the necessary information to evaluate the Project as described in this section. For more detail regarding the Project's facilities and operations, please refer to the PAD (SCL 2006; available on the Boundary Project relicensing website, www.seattle.gov/light/news/issues/bndryRelic/).

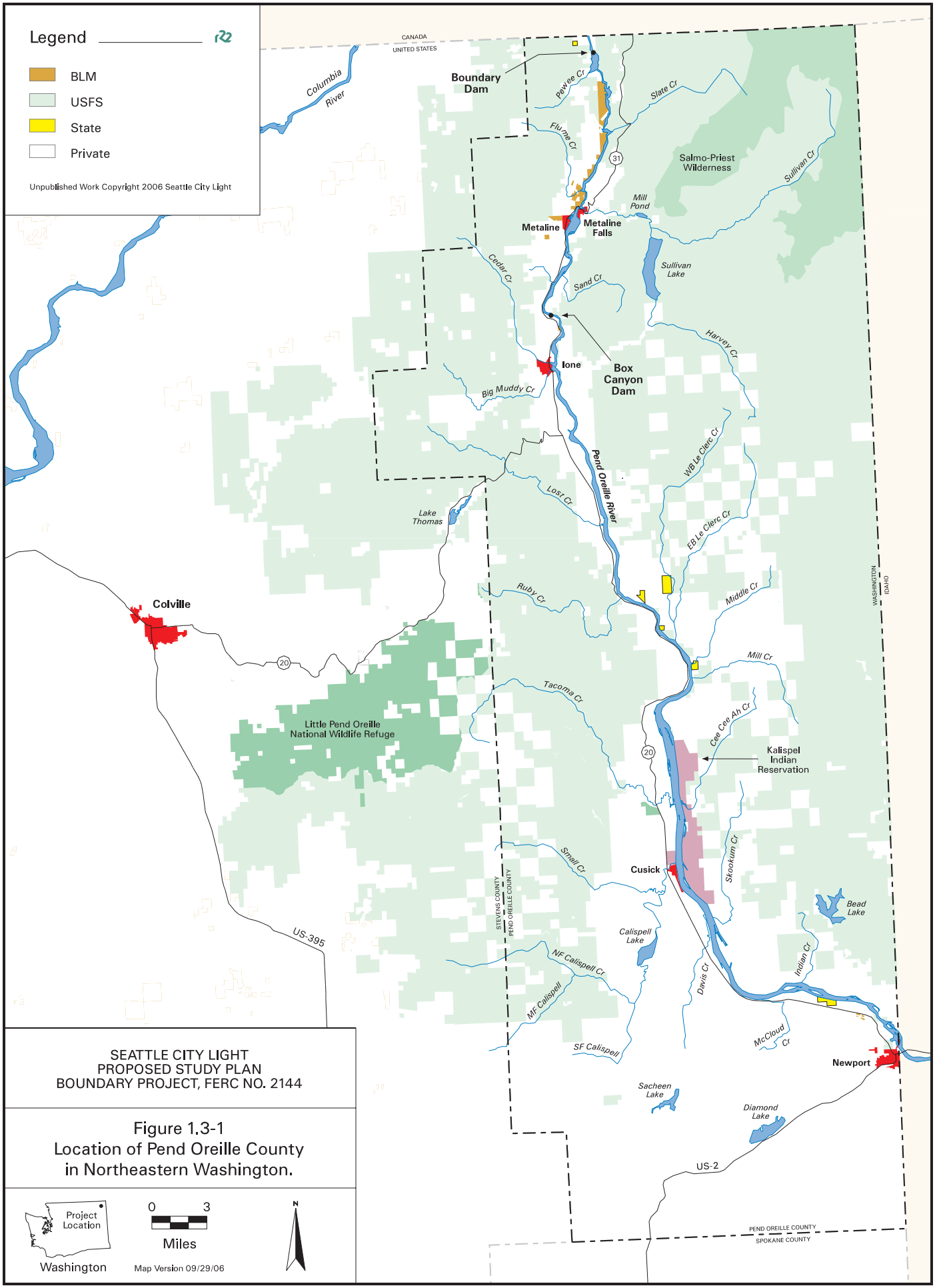
[Note: Because SCL is in the process of converting all Project information from an older elevation datum to a more recent elevation datum, key elevations are provided relative to both the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88) throughout this PSP. A conversion table for key Project elevations is provided as Attachment 1-3. Future licensing documents will primarily cite elevations relative to NAVD 88.]

1.3.1. Project Location

The Boundary Project is located on the Pend Oreille River in northeastern Washington, one of a total of eleven hydroelectric and storage projects within the Clark Fork - Pend Oreille River basin. The dam is located 1 mile south of the Canadian border, 16 miles west of the Idaho border, 107 miles north of Spokane, and 10 miles north of Metaline Falls, in Pend Oreille County (Figure 1.3-1). The dam is at river mile (RM) 17.0 on the Pend Oreille River, in the NW 1/4 of Section 10, Township 40N, Range 43E, Willamette Meridian. The upstream end of the Project reservoir (Boundary Reservoir) is located immediately downstream of the Box Canyon Dam, at RM 34.5, in the NE ¼ of Section 19 of Township 38N, Range 43E. The Project facilities, surrounding geographic features, and land ownership are shown on the general location map in Figure 1.3-2.

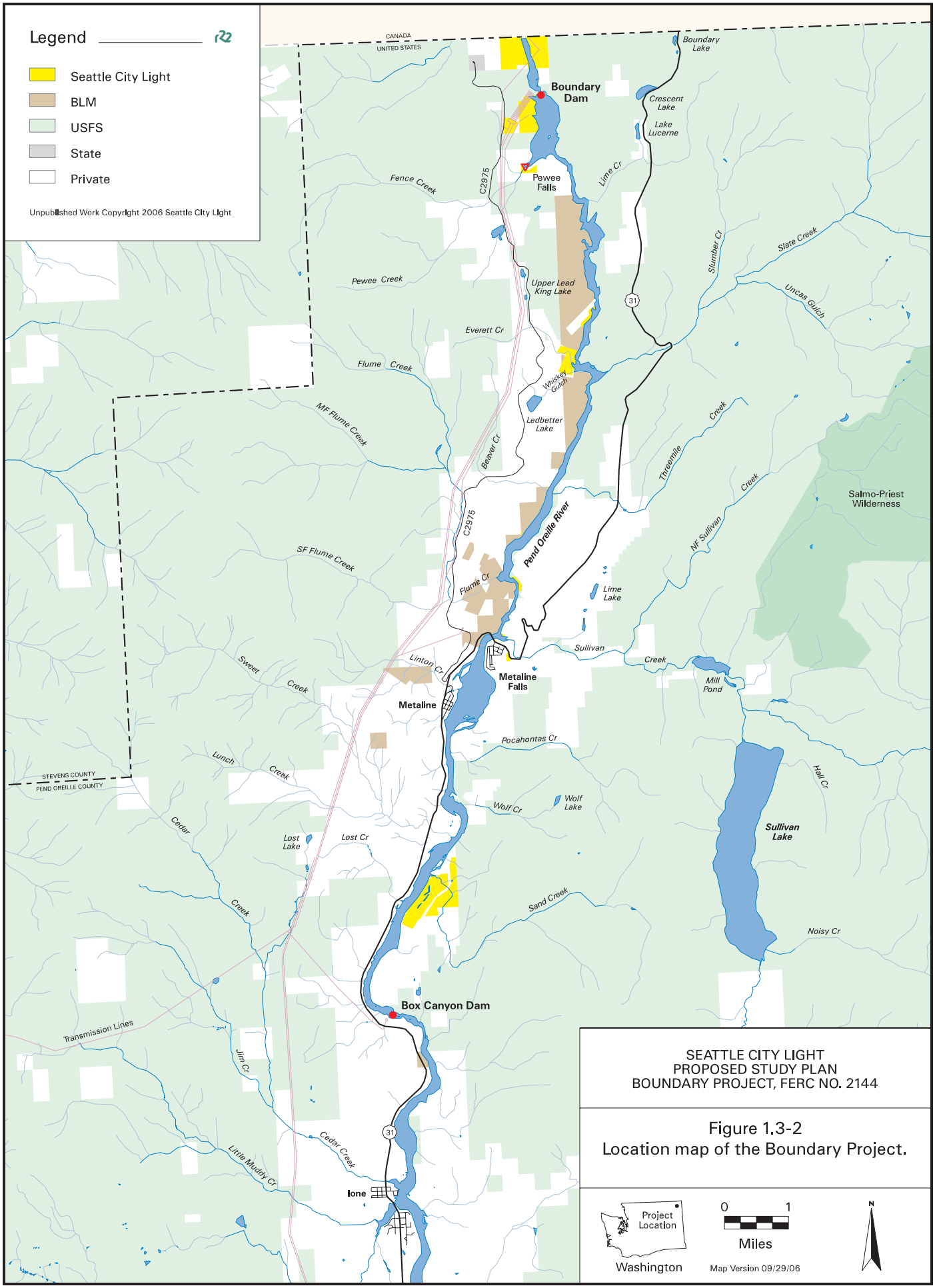
1.3.2. Project-Related Facilities, Lands, and Roads

Licensed in 1961, the Project principally consists of an arch dam, reservoir, and underground power plant. The Project began commercial operation in 1967, with turbine-generator Units 51 through 54. In accordance with a 1982 license amendment approving expansion of the Project, Units 55 and 56 were constructed in two previously excavated bays in the machine hall and came on line in 1986.



SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144

Figure 1.3-1
Location of Pend Oreille County in Northeastern Washington.



SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144

Figure 1.3-2
Location map of the Boundary Project.

The forebay for the power plant was excavated from the left abutment upstream of the dam. A trashrack structure prevents floating debris from entering the forebay. Six gate-controlled power tunnels and six penstocks connect the forebay with the machine hall, which is located underground in a pyramidal rockmass adjacent to the left abutment of Boundary Dam. Six turbine-generator units, installed in the machine hall, discharge into the Pend Oreille River below the dam through six draft tubes. Six transformers, which step up the generator output, are connected via the approximately 0.5-mile-long Project transmission lines to a non-Project switchyard, which is integrated into the transmission line system of the Bonneville Power Administration (BPA). The total generation capacity of the Project is approximately 1,070 MW.

The Project also includes two recreation facilities — the Tailrace Recreation Area below the dam and the Forebay Recreation Area above the dam. A third SCL-owned recreation facility near the Project — the Vista House (which affords the public views of the dam), located on the east side of the river — is not included in the current Project license. Also not included within the Project boundary, but purchased by SCL as mitigation to fulfill the requirements of Article 51 of the license, is approximately 155 acres of land that SCL has set aside as a wildlife preserve; this land, referred to as the Boundary Wildlife Preserve (BWP), is located between RM 31.6 and RM 32.5 adjacent to the Upper Reservoir Reach (see section 1.3.3, below). SCL anticipates that the 155-acre BWP will be formally included in the new Project license.

There are three Project-related roads (i.e., roads that have been identified as receiving Project-related use). These include (1) the West Side Access Road, which provides access to the entrances of the machine hall and dam access tunnels; (2) the access road from the Vista House to the crest of the dam; and (3) the access road to the Vista House, off State Route (SR) 31 near the U.S.-Canada border. The first road is contained within the FERC Project boundary as currently licensed; neither of the other two roads is within the Project boundary.

Project-related lands and existing facilities that are not in the current Project license but that SCL proposes to add into the Project under the new license are as follows:

- Project maintenance buildings and yard located just north of the current Project boundary
- Vista House and access road to the crest of the dam
- Boundary Wildlife Preserve (BWP)

1.3.3. Boundary Reservoir

Boundary Reservoir extends 17.5 miles upstream from the dam (RM 17.0). The reservoir occupies three main reaches; from downstream to upstream these are:

- *Forebay Reach* — this reach is relatively wide and extends upstream from Boundary Dam (RM 17) to approximately RM 19.4.
- *Canyon Reach* — this reach occupies a narrow gorge extending from the downstream end of Z Canyon (RM 19.4) upstream to Metaline Falls (RM 27.8).
- *Upper Reservoir Reach* — this reach is wider and shallower than the downstream two reaches, and extends from Metaline Falls up to Box Canyon Dam (RM 34.5).

Total storage in the reservoir (between elevations 1,740 and 1,990 feet NGVD 29 [1,744–1,994 feet NAVD 88]) is approximately 95,000 acre-feet, and total useable storage (between elevations 1,950 and 1,990 feet NGVD 29 [1,954–1,994 feet NAVD 88]) is approximately 43,000 acre-feet at the normal full-pool elevation of 1,990 feet NGVD 29 (1,994 feet NAVD 88).

1.3.4. Project Coordination with Upstream and Downstream Projects

The Pend Oreille River is a highly regulated river with several hydroelectric projects located upstream and downstream of the Boundary Project. The Box Canyon Project and Seven Mile Project are immediately upstream and downstream of the Boundary Project, respectively. Albeni Falls Dam regulates nearly all the flow in the river upstream of Box Canyon Dam. The Boundary Project operation creates a backwater effect on the tailwater of Box Canyon Dam. As a result, a tailwater encroachment agreement is in place between the Public Utility District No. 1 of Pend Oreille County (PUD) and the City of Seattle to compensate for lost generation due to backwater effects in compliance with Article 48 of the current FERC operating license for the Boundary Project. In addition, the City of Seattle and British Columbia Hydro and Power Authority (BC Hydro) have an agreement in place for tailwater encroachment losses caused by the Seven Mile Project generating station, located downstream of the Boundary Project in Canada.

1.3.5. Project Operations

The Boundary Project is operated in a load-following mode that shapes available water to deliver power during peak-load hours with a total plant capability of 1,070 MW from its six turbines. This operating regime allows SCL to meet continued service area load growth and provide regional system reliability. The normal maximum reservoir water surface is at elevation 1,990 feet NGVD 29 (1,994 feet NAVD 88). The reservoir has relatively little useable storage (about 43,000 acre-feet) within the maximum drawdown of 40 feet (elevation 1,990 to elevation 1,950 feet NGVD 29 [1,994–1,954 feet NAVD 88]) authorized under the current license. During the summer recreation season (approximately Memorial Day weekend through Labor Day weekend), SCL voluntarily restricts the water surface fluctuations to a 10-foot range (between elevations 1,980 and 1,990 feet NGVD 29 [1,984–1,994 feet NAVD 88]) to facilitate reservoir access and related recreational activities during daytime hours. For the remainder of the year, the water surface may fluctuate between elevations 1,990 feet and 1,970 feet NGVD 29 (1,994–1,974 feet NAVD 88). Storage between elevation 1,970 feet and elevation 1,950 feet NGVD 29 (1,974–1,954 feet NAVD 88) is reserved for extreme system load requirements. Flood storage is not provided, and other than the operating goals noted above, there are no seasonal or minimum flow requirements.

For the purposes of planning and conducting relicensing analyses, SCL believes that the hydrologic record from 1987–2004, the period of record since the major expansion of the Project to add the last two generating units, is representative of the existing and expected range of water surface elevations due to Project operations and inflows to Boundary Reservoir. Annual ranges of water surface elevations in the Boundary Reservoir forebay and the Pend Oreille River below Box Canyon Dam (Primary Gage 12396500) for the years 1987–2004 (based on USGS gage data) are summarized in Table 1.3-1. The effect of Metaline Falls is most apparent when the

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Table 1.3-1. Annual number of hours that water surface elevations in the forebay of Boundary Reservoir and in the Pend Oreille River at the Primary USGS Gage below Box Canyon Dam (Gage No. 12396500) are within specified elevation range (NGVD 29, based on Calendar Years 1987 through 2004). (See Attachment 1-3 for conversion of NGVD 29 elevations to NAVD 88 elevations.)

	Number of hours that water surface elevation is within specified elevation range															
	Greater than or equal to 1950 and less than 1960		Greater than or equal to 1960 and less than 1970		Greater than or equal to 1970 and less than 1980		Greater than or equal to 1980 and less than 1990		Greater than or equal to 1990 and less than 2000		Greater than or equal to 2000 and less than 2010		Greater than or equal to 2010 and less than 2020		Total	
Year	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)	Boundary Reservoir Forebay	Pend Oreille River Below Box Canyon Dam (USGS Primary Gage 12396500)
1987	0	0	0	0	391	0	8,197	1,230	172	978	0	0	0	0	8,760	2,208
1988	0	0	43	0	629	0	7,918	5,956	194	2,828	0	0	0	0	8,784	8,784
1989	18	0	140	0	1,021	0	7,359	4,488	223	4,113	0	159	0	0	8,760	8,760
1990	0	0	41	0	1,342	0	7,202	3,239	176	4,440	0	695	0	0	8,760	8,374
1991	0	0	15	0	1,142	0	7,454	3,309	149	4,520	0	932	0	0	8,760	8,760
1992	0	0	1	0	409	0	8,141	5,382	233	3,258	0	0	0	0	8,784	8,639
1993	0	0	5	0	726	0	7,759	4,758	270	4,002	0	0	0	0	8,760	8,760
1994	0	0	7	0	549	0	7,965	5,786	240	2,974	0	0	0	0	8,760	8,760
1995	14	0	37	0	869	0	7,687	3,326	154	5,320	0	115	0	0	8,760	8,760
1996	0	0	2	0	333	0	8,349	2,276	100	4,571	0	1,422	0	0	8,784	8,269
1997	0	0	0	0	284	0	8,364	1,937	112	4,283	0	698	0	920	8,760	7,838
1998	0	0	0	0	84	0	8,474	2,856	202	4,455	0	251	0	0	8,760	7,562
1999	0	0	5	0	554	0	8,048	3,481	153	4,469	0	810	0	0	8,760	8,760
2000	0	0	2	0	862	0	7,878	5,420	42	3,364	0	0	0	0	8,784	8,784
2001	2	0	61	0	742	0	7,915	6,880	40	1,880	0	0	0	0	8,760	8,760
2002	0	0	0	0	587	0	8,151	4,979	22	2,777	0	1,004	0	0	8,760	8,760
2003	0	0	11	0	1,102	0	7,634	5,501	13	3,113	0	146	0	0	8,760	8,760
2004	0	0	11	0	1,855	0	6,906	6,268	13	2,516	0	0	0	0	8,784	8,784
Raw Average	2	0	21	0	749	0	7,855	4,282	139	3,548	0	346	0	51	8,767	8,227
Adjusted Average	*2*	*0*	*21*	*0*	*749*	*0*	*7,855*	*4,563*	*139*	*3,781*	*0*	*369*	*0*	*54*	*8,767*	*8,767*
Frequency based on Adjusted Average	***0.02%***	***0***	***0.2%***	***0***	***9%***	***0***	***90%***	***52%***	***2%***	***43%***	***0***	***4%***	***0***	***0.6%***	***8,767***	***8,767***

Note:

The available record of water surface elevations for the Primary USGS Gage on the Pend Oreille River below Box Canyon Dam (Gage No. 12396500) for the period from 1987 to 2004 is incomplete.

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frequency of water surface elevations between 1,970 feet and 1,980 feet (1,974–1,984 feet NAVD 88) is compared to elevations between 1,980 feet and 1,990 feet (NGVD 29) for the Boundary Reservoir forebay and USGS gage below Box Canyon (above Metaline Falls), as shown in Table 1.3-1. As indicated in Table 1.3-1, the water surface at the Boundary Reservoir forebay only dropped below elevation 1,970 feet (NGVD 29) an average of 23 hours a year for a frequency of less than 0.3 percent of the time. The information in Table 1.3-1 indicates that the water surface at the USGS gage below Box Canyon never dropped below elevation 1,980 feet (NGVD 29).

Water surface elevations less than 1,970 feet (NGVD 29) in the Boundary Reservoir forebay for the period 1987–2004 (Table 1.3-1) most likely occurred as a response to different system load conditions including, but not limited to: (1) balancing the SCL system load to comply with the Skagit River fishery agreement (no daytime ramping is allowed at the Skagit Project in February, March, April, and May), and (2) maximum generating capacity was reached at other projects under increased demand conditions.

These statistical summaries of water surface elevations for the Boundary Reservoir forebay and Pend Oreille River below Box Canyon Dam are preliminary and based on incomplete gage data. This information will be refined and analyzed through incorporation of the final Project hydrologic record (see section 1.4.2, below), comparison with Project operations data, and use of the operations and hydraulic models described in section 1.4.3 of this PSP.

When the Project is operating at forebay water surface elevations lower than the top of Metaline Falls (approximate water surface range of elevation 1,980 feet to elevation 1,975 feet NGVD 29 [1,984 – 1,979 feet NAVD 88]), there are almost no daily water surface elevation fluctuations in the upper reservoir reach at the two USGS gages (primary and auxiliary) below Box Canyon Dam. (Refer to Figure 3.4-6 in the PAD for illustration of this effect.) The change in bathymetric characteristics of Boundary Reservoir at Metaline Falls may result in significant attenuation in the upstream reach of the reservoir (above Metaline Falls) of the relatively large water surface elevation fluctuations that occur in the portion of the reservoir downstream of Metaline Falls. (Refer to the Figures 3.4-3 through 3.4-5 in the PAD for illustration of this phenomenon.) In addition to the apparent dampening of the magnitude of water surface elevation fluctuations, the constriction at the site of Metaline Falls, which slows the passage of water, may also slow the response time of the Upper Reservoir Reach to elevation changes in the Canyon Reach and Forebay Reach of the reservoir.

Recent installation of stage recorders (in September 2006; discussed in Attachment 1-4, under Water Resources — Hydrology) in conjunction with ongoing hydrologic analysis and use of the Scenario Tool (discussed below in sections 1.4.2 and 1.4.3, respectively) will provide the basis for SCL in the near term to achieve a more precise understanding of elevation stage changes in the Upper Reservoir Reach compared to concurrent changes in the downstream Canyon and Forebay reaches. This understanding will be critical to several study implementation planning efforts, including analysis of peak flood flow conditions above Metaline Falls (see section 3.1), development of the hydraulic routing model (part of the Mainstem Aquatic Habitat Modeling Study, described in section 4.1), and several terrestrial resource studies (described in section 5).

1.4. Ongoing Relevant Studies and Analyses

SCL is currently undertaking a number of studies and analyses that are relevant to, but not incorporated in, the study program outlined in this PSP. These efforts, which are described in this section, include water temperature modeling, hydrology analyses, and use of an operational Scenario Tool application. SCL initiated these efforts prior to the formal relicensing study program because they are prerequisite to other studies and needed to be started in advance to be available to inform the study program. A TDG abatement alternatives assessment process is also currently underway; SCL's efforts to date related to the ongoing TDG abatement process are described in the Existing Information section of the TDG study plan (section 3.1 of this PSP).

SCL also previously completed (in 2005 and 2006) selected field and research efforts to provide additional basic resource information on the Project vicinity (such as vegetation cover and existing recreation facilities). Development of this basic background information was undertaken in advance of the formal study program to help focus study planning and thereby make the maximum use of the limited field seasons available under the ILP. The results of these early information development (EID) efforts were described in the PAD (to the extent they were completed at that time) and are also summarized as applicable in the relevant portions of this PSP. The completed and upcoming EID efforts are not discussed below but are listed and described briefly in Attachment 1-4.

Although the ongoing studies and analyses described below are not presented as study plans, SCL did carefully consider them in light of the FERC PSP requirements to ensure these efforts reflect consistency with the FERC study criteria (CFR 18 Part 5, § 5.9(b)), such as addressing a nexus between Project operations and resource effects and using methods that comport with standard industry practice. SCL has also presented information regarding these early efforts to relicensing participants during development of this PSP.

1.4.1. Temperature Modeling

Temperature modeling of the Boundary Project area is needed to satisfy regulatory requirements associated with certification of the Project under Section 401 of the federal Clean Water Act (401 certification) and for the Washington-Idaho Interstate Temperature TMDL processes. Although this modeling is being conducted prior to initiating the formal relicensing studies program, it addresses a nexus between Project operations and resource effects, and has implications for evaluation of potential alternative operational scenarios. Temperature modeling is being conducted for SCL by Battelle, Pacific Northwest National Laboratory.

The primary objective is to develop a predictive temperature model of the Pend Oreille River from the tailrace of Box Canyon Dam to the International Border downstream of Boundary Dam. The model, which is based on a state-of-the-art, industry-standard program (CE-QUAL-W2; Cole and Wells 2002), will be used to understand the physical processes controlling water temperature in the system, including the effects of Boundary Reservoir on existing conditions and potential future operating scenarios. The model will be used to demonstrate the Project's compliance with the Washington Department of Ecology's water temperature standards for the lower Pend Oreille River as part of the 401 certification process and will be linked to other CE-

QUAL-W2 models developed for the remainder of the Pend Oreille River in Washington and Idaho to establish waste load allocations (WLAs) as part of the Interstate Temperature TMDL process.

Specific objectives being addressed as part of temperature modeling are as follows:

- Review and processing of available bathymetric, hydrologic, meteorological, and water quality data needed for setup and calibration of the model
- Setup and calibration of the model for simulation of hydrodynamics and temperature
- Conducting model application and analyses for the following scenarios:
  - Existing condition — Linkage of individual reaches of the model for the calibration condition to simulate the entire system using inflow data
  - Natural Thermal Potential (NTP) — Simulation of temperature in the Project portion of the Pend Oreille River system in the absence of the Project, but with all other hydrologic and land-use conditions remaining the same
  - Alternatives — Simulation of the temperature response in the Project area for alternative operational scenarios that may be identified during the FERC relicensing process

Following completion of the tasks identified above (other than the modeling of alternative operational scenarios), anticipated to be finished in late 2006 or early 2007, a draft report will be prepared to summarize the results of the modeling effort. The report will include background, objectives, results, and a summary of the temperature modeling results. The report will also include a detailed account of model setup, calibration, and application and provide conclusions and recommendations based on model results. Data products provided in the report will include:

- Graphical presentation of model inputs
- Temperature prediction time-series and vertical profiles compared to the observed data
- Model calibration results and a list of model parameters
- Model application results for existing conditions and NTP

1.4.2. Hydrology Dataset and Statistics

Hydrologic conditions influence the way the Project operates. Daily reservoir surface elevation is influenced by changes in releases from upstream projects and inflow to Boundary Reservoir, in addition to operation of the Boundary Project. Analyses of existing hydrology data have been initiated by SCL to produce the reliable hydrologic dataset and statistics (hydrologic record) that are needed to conduct environmental and energy production analyses (as described in section 1.4.3) for FERC relicensing of the Project. These hydrology analyses therefore indirectly address a nexus between Project operations, resource effects, and potential alternative operational scenarios.

The primary sources of hydrologic data for the Project are USGS gages 12396500 (Pend Oreille River below Box Canyon) and 12398600 (Pend Oreille River below Boundary Dam), as well as SCL Boundary Project forebay water surface elevation records. The hydrologic analyses are being completed by R2 Resource Consultants on behalf of SCL based on the data from these gages, hydrographic and topographic surveys, and stage recorder data. The analyses involve a rigorous quality assurance procedure to identify and correct errors before data are used in finalizing study implementation plans and subsequent modeling. The end product will be a high-quality hourly hydrologic record that will be used to assess potential Project effects.

The quality assurance process will include a water balance comparison of inflow to Boundary Reservoir with outflow from Boundary Reservoir plus the change in reservoir storage. Missing data will be estimated using streamflow records from nearby watersheds with similar characteristics or from synthesized data. Accurate reservoir bathymetry data are currently being collected to help quantify the available reservoir storage. Following completion of the bathymetry survey, the reservoir elevation/storage capacity curve will be updated, and the quality assurance process will be completed. A technical summary report including a database with hourly records of hydrologic data and statistics will be available in January 2007. Results from this technical summary report will be used as input for study implementation planning and related modeling efforts.

1.4.3. Technical Scenario Team and Modeling Efforts

Proposed Study Plan Modeling Efforts

Computational analysis and modeling of Project operations, hydrology, habitat analyses, and biologic time series are proposed for use in the Boundary Project relicensing effort to evaluate a range of potential environmental impacts associated with alternative operational scenarios. The models will be used to compare the environmental and economic effects of alternative Project configurations (scenarios) developed and evaluated by the Boundary Project resource workgroups during the course of the relicensing process. Relicensing participants and SCL staff are currently represented in the resource workgroups.

Scenario Tool

SCL began developing a Scenario Tool in 2005 to optimize and simulate hydrologic regimes and operating and physical constraints related to existing operations and assess potential future operation of the Project. The Scenario Tool, which is based on an optimization engine that operates as an add-in to Microsoft Excel® software, will be used to help assess potential future Project energy production associated with alternative operational scenarios. The Scenario Tool calculates Project generation, upstream and downstream hydrologic conditions given reservoir inflows, generating targets and reserves, upstream and downstream water level ramping, and upstream and downstream channel routing. The Scenario Tool will produce hourly discharge output (in cfs) for use as input to the models that will be used in the relicensing studies described in this PSP.

SCL presented information on the Scenario Tool to relicensing participants at workshops and workgroup meetings in November 2005, February, May and August 2006, during development

of study plans presented in subsequent sections of this PSP. During these engagements, SCL provided and discussed a description of input data (hydrologic, operational and physical constraints, future constraints, etc.), information about how the Scenario Tool will generate output data, and example graphical and tabular output from runs of the Scenario Tool.

Development of the Scenario Tool is continuing in 2006, using the hydrologic record described in section 1.4.2 as part of the input data.

Habitat Analysis and Other Resource Models

Potential environmental impacts associated with existing and various alternative Project operation scenarios will be evaluated using models described in the Fish and Aquatic Resources section of this PSP (section 4). These models include the mainstem aquatic habitat model, which is the core tool that will be used for assessing changes in aquatic habitat in the mainstem Pend Oreille River (including Boundary Reservoir) under different operational scenarios at the Boundary Project, and various tributary habitat models, which will be used to evaluate changes in habitat conditions in tributaries to Boundary Reservoir under each alternative operating scenario. These fish and aquatic resource models will route output from the Scenario Tool and associate the hydrologic signal with downstream aquatic habitat features. For example, using these models, alternative ramping rate strategies can be evaluated in terms of instream habitat indicators. The models have been designed for use by fish resource experts familiar with hydraulic modeling and data processing. (Conceptual workflow diagrams for integration of the mainstem aquatic habitat modeling results and the tributary modeling results into the Scenario Tool application are presented in section 4, Figures 4.1-3 and 4.2-2, respectively.)

Currently, the Scenario Tool and resource models are separate and unique pieces of software. During 2007–2008, when studies are being initiated and conducted, SCL will integrate the modeling systems. To facilitate and coordinate the integrated modeling effort, SCL proposes the formation of the Technical Scenario Team (TST), as described below.

Technical Scenario Team

SCL proposes a Technical Scenario Team (TST), envisioned as a working group consisting of representatives from agencies, tribes and other stakeholders, SCL, and consultants with expertise in modeling analyses to coordinate the modeling efforts for the Boundary Project relicensing. The intent is for the TST to be a multiple-resource group to ensure that modeling requests contain well-formed input sets and that model results are produced with a high level of confidence and understanding among relicensing participants. The main reason for forming the TST is to make the most efficient use of the time and resources of all interested relicensing participants. A proposed flow diagram showing the general function of TST and envisioned integration of the Scenario Tool, habitat analysis, and other resource modeling proposed in the PSP is shown in Figure 1.4-1.

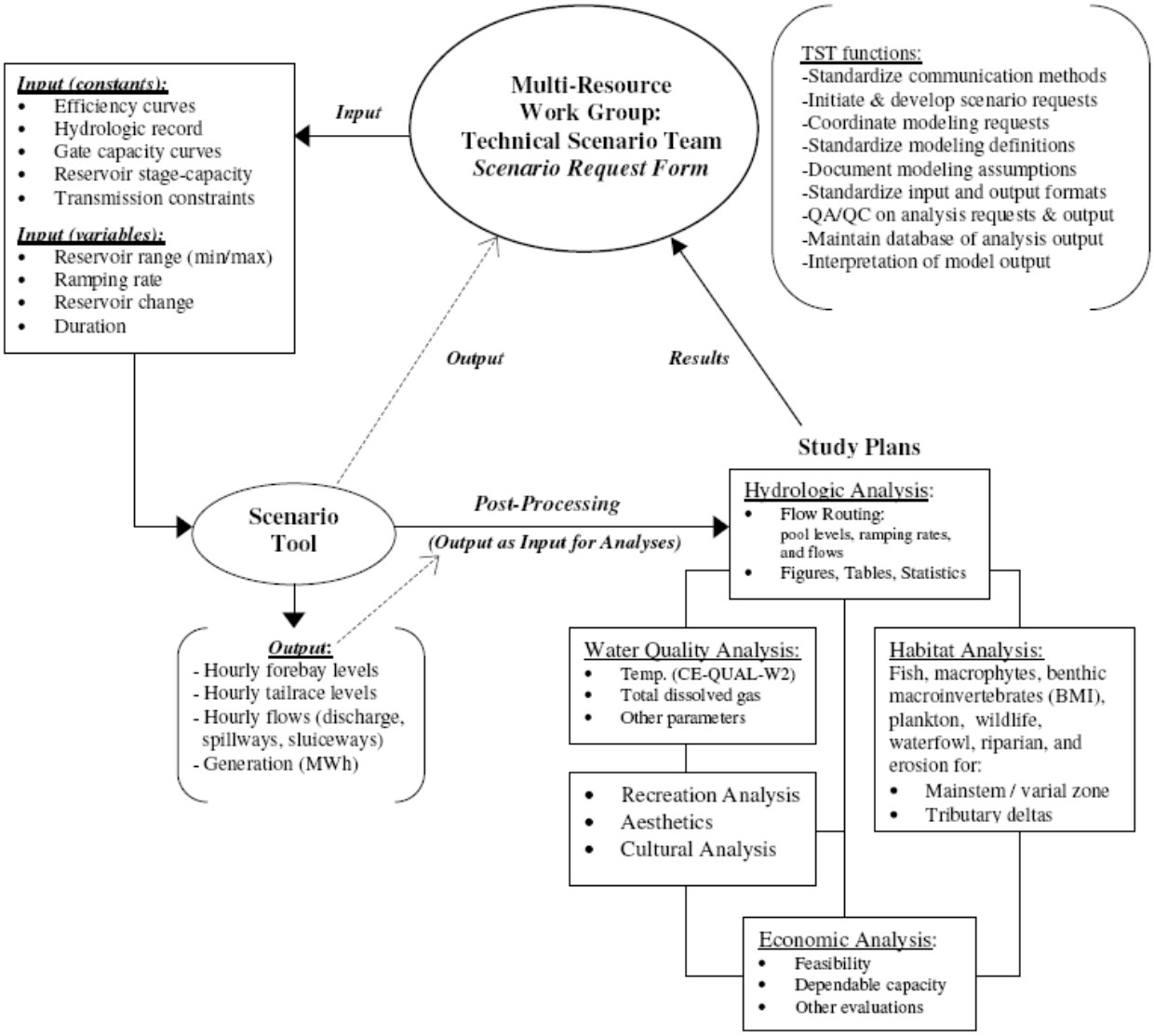

Figure 1.4-1. Conceptual workflow for integrated resource analyses.

The following functions would be performed by the TST:

1. Standardize methods of communication with resource groups
2. Initiate and develop scenario requests
3. Coordinate modeling requests to avoid redundant analyses
4. Standardize and document modeling definitions and assumptions
5. Define and standardize model input and output formats
6. Provide quality assurance and quality control (QA/QC) on analysis requests and modeling output
7. Maintain a database of analysis results
8. Provide interpretation of model output to resource groups

The TST would help develop and receive input in the form of modeling requests from the resource workgroups. Using standardized definitions for input parameters and alternative operational scenarios, the TST would ensure that the modeling request contains a well-formed input set for analysis. As proposed, the TST would provide QA/QC for the Scenario Tool output, habitat analysis modeling output, and other resource analyses. The intent of the QA/QC effort would be to ensure that analysis results are consistent with the input assumptions prior to the transmittal of the results to the resource workgroups.

Modeling Limitations

Mathematical modeling as part of the Boundary Project relicensing analysis will permit an evaluation of the economic and physical consequences of potential alternative operational scenarios. Models are inherently limited as representation of any real problem, and model input data, including objectives and assumptions, can be controversial or uncertain; therefore, field data collection is required and proposed to proof or calibrate the models that will be used in the relicensing analysis. SCL recognizes that results of any quantitative analysis of alternatives are usually only a small part of the input to the overall planning and decision-making process.

Evaluation of Alternative Scenarios to Inform Development of PME Measures

The Scenario Tool and other models to be used in the Boundary Project relicensing analysis, as described above, are intended to provide SCL and relicensing participants with comparative information needed to evaluate the effects of the existing and alternative operational scenarios for use in the evaluation of potential PME measures as part of development of the PLP and Final License Application.

1.5. Literature Cited

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Attachment 1-1: Summary List of Proposed Studies

Attachment 1-1. Summary of studies proposed in this PSP to address identified resource issues. [3]

Identified Resource Issue	Proposed Study Plan [a]	PSP Section
Geology and Soils		
Contribution of the Project to shoreline and hillslope erosion	▪ Erosion Study	2.1
Water Resources		
Potential Project-related flooding of private property adjacent to upper portion of Boundary Reservoir	▪ Analysis of Peak Flood Flow Conditions Above Metaline Falls	3.1
	Other relevant study: ▪ Mainstem Aquatic Habitat Modeling Study (hydraulic routing model component) (*Described under Fish and Aquatic Resources*)	4.1
Contribution of the Project to total dissolved gas (TDG) in the Pend Oreille River below the Project	▪ Evaluation of TDG and Potential Abatement Measures	3.2
	Other relevant studies: ▪ Fish Distribution, Timing, and Abundance Study (*Described under Fish and Aquatic Resources*)	4.3
	▪ Fish Entrainment and Habitat Connectivity Study (*Described under Fish and Aquatic Resources*)	4.6
Effect of the Project on toxic compounds in Boundary Reservoir	▪ Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus	3.3
General water quality in Boundary Reservoir and relation to fish and habitat	▪ Water Quality Constituent and Productivity Monitoring	3.4
	Other relevant study: ▪ Mainstem Aquatic Habitat Modeling Study (aquatic plant habitat suitability component) (*Described under Fish and Aquatic Resources*)	4.1

[3] No study plans are proposed specific to socioeconomic or tribal resources; identified issues in these resource areas are being addressed through studies proposed for other resource areas and will be further addressed in the development of the Preliminary Licensing Proposal, as discussed in section 1.2.5 of this PSP (see PAD [section 5] for additional detail on identified issues relevant to socioeconomic and tribal resources).

Identified Resource Issue	**Proposed Study Plan** [a]	**PSP Section**
pH and dissolved oxygen (DO) in Boundary Reservoir	▪ Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir	3.5
Fish and Aquatic Resources		
Effect of load-following operations and pool-level fluctuations on fish and aquatic species and habitats	▪ Mainstem Aquatic Habitat Modeling Study; study includes the following components: ▪ Habitat mapping ▪ Hydraulic routing model ▪ Physical habitat model development ▪ Habitat suitability index (HIS) development, for: - Fish - Macrophytes - Periphyton and benthic macroinvertebrates	4.1
Sediment transport and effect of reservoir fluctuations on tributary delta habitat	▪ Sediment Transport and Boundary Reservoir Tributary Delta Habitats Study; study includes the following components: ▪ Tributary delta habitat modeling ▪ Evaluation of tributary delta sediment processes ▪ Evaluation of mainstem sediment transport	4.2
Abundance, distribution, and periodicity of fish in Boundary Reservoir	▪ Fish Distribution, Timing, and Abundance Study; study includes the following components: ▪ Passive and active sampling ▪ Biotelemetry	4.3
Effect of Project operations on wood recruitment and transport	▪ Large Woody Debris Management Study	4.4
Aquatic productivity in Boundary Reservoir	▪ Productivity Assessment	4.5

Identified Resource Issue	Proposed Study Plan [a]	PSP Section
Fish entrainment and connectivity	▪ Fish Entrainment and Habitat Connectivity Study; study includes the following components: ▪ Evaluation of potential turbine entrainment ▪ Evaluation of potential spillway entrainment	4.6
Recreational fishery at the Project	▪ Recreational Fishery Study; study includes the following components: ▪ Recreational creel and angler surveys ▪ Triploid trout biotelemetry ▪ Triploid trout management	4.7
Effect of Project operations on habitat in Boundary Reservoir tributaries	▪ Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats	4.8

Identified Resource Issue	Proposed Study Plan [a]	PSP Section
Botanical and Wildlife Resources		
Waterfowl nesting habitat and productivity at Boundary Reservoir	▪ Waterfowl/Waterbird Study	5.1
	Other relevant studies: ▪ Mainstem Aquatic Habitat Modeling Study (hydraulic routing and aquatic plant habitat suitability components) (*Described under Fish and Aquatic Resources*)	4.1
Status of cottonwood and other riparian-dependent plant species adjacent to Boundary Reservoir	▪ Inventory of Riparian Trees and Shrubs	5.2
	Other relevant studies: ▪ Erosion Study (*Described under Geology and Soils*)	2.1
	▪ Mainstem Aquatic Habitat Modeling Study (hydraulic routing model component) (*Described under Fish and Aquatic Resources*)	4.1
	▪ Sediment Transport and Boundary Reservoir Tributary Delta Habitats (*Described under Fish and Aquatic Resources*)	4.2
Effect of the Project on rare, threatened, and endangered (RTE) plant species	▪ Rare, Threatened, and Endangered (RTE) Plant Species Inventory	5.3
Effect of the Project on RTE wildlife species	▪ RTE Wildlife Species Study	5.4
Effect of the Project on deer, elk, and other big game species	▪ Big Game Study	5.5
Effect of the Project on bats	▪ Bat Surveys and Habitat Inventory	5.6

Identified Resource Issue	Proposed Study Plan [a]	PSP Section
Recreation and Land Use		
Recreational use, opportunities and demand in the Project area	▪ Recreation Resource Study; study includes the following components: ▪ Recreation surveys ▪ Regional recreation analysis ▪ Dispersed recreation use, access, and condition analysis ▪ Future recreation use analysis ▪ Recreation carrying capacity analysis	6.1
	Other relevant studies: ▪ Recreational Fishery Study (*Described under Fish and Aquatic Resources*) ▪ Erosion Study (*Described under Geology and Soils*)	 4.7 2.1
Project-related roads system (condition and needs) and public access	▪ Land and Access Study	6.2
	Other relevant studies: ▪ Erosion Study (*Described under Geology and Soils*) ▪ Big Game Study (*Described under Botanical and Wildlife Resources*) ▪ Recreation Resource Study	 2.1 5.5 6.1

Identified Resource Issue	Proposed Study Plan [a]	PSP Section
Aesthetic/Visual Resources		
Effect of the Project on visual character and visual quality	▪ Aesthetic/Visual Resource Study	7.1
	Other relevant studies:	
	▪ Erosion Study (*Described under Geology and Soils*)	2.1
	▪ Recreation Resource Study (recreation surveys component) (*Described under Recreation and Land Use*)	6.1
Cultural Resources		
Effect of the Project on cultural resources	▪ Cultural Resource Study	8.1
	Other relevant studies:	
	• Erosion Study (*Described under Geology and Soils*)	2.1
	• Dispersed Recreation Use, Access, and Condition Analysis (a component of the Recreation Resources Study) (*Described under Recreation and Land Use*)	6.1
	• Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats (*Described under Fish and Aquatic Resources*)	4.8
	• Bat Surveys and Habitat Inventory (*Described under Botanical and Wildlife Resources*)	5.6

Note:

a Shaded studies are being conducted under another resource area. The study plans for these studies are designed to address all identified issues within all of the relevant resource areas.

Attachment 1-2: Steps and Schedule for Stakeholder Involvement in PLP Development

Attachment 1-2. Steps and schedule for stakeholder involvement in PLP development.

Timeframe	SCL Tasks	Interactions with Stakeholders
Late 2007 – early 2008	First-year studies completed	
Early December 2007 – late January 2008	SCL reviews draft study reports and develops preliminary conclusions (if possible/appropriate) regarding Project impacts and potential PME measures	
January 2008		Hold workgroup meetings to review results of studies and discuss preliminary conclusions regarding Project impacts and potential PME measures
Mid-February 2008	SCL compiles all study reports into a comprehensive Initial Study Report	
Late February 2008	SCL files Initial Study Report with FERC	
Mid-March 2008		Official study report meeting and follow-up (meeting summary, etc.)
2008	Study program continues	
September – October 2008		SCL initiates discussions with stakeholders re: beginning to develop PLP: Hold workgroup meetings to discuss second-year study results available to date, and any implications for preliminary conclusions regarding Project impacts and potential PME measures Firm up plans/schedule with stakeholders for interactions in early 2009
October 2008	Begin drafting the PLP	
Late 2008 – early 2009	Remainder of studies completed	
November – early December 2008		Hold additional workgroup meetings to discuss second-year results, etc., for studies not discussed at Sept/Oct. workgroup meetings
Early December 2008 – mid-	Updated Study Report process:	

Timeframe	SCL Tasks	Interactions with Stakeholders
March 2009:		
Mid-February 2009	After review by SCL, study reports are all compiled into a comprehensive Updated Study Report	
Late February 2009	SCL files Updated Study Report with FERC	
Mid-March 2009		Official study report meeting and follow-up (meeting summary, etc.)
December 2008 – April 2009	PLP development:	
December 2008– mid-February 2009	SCL begins framing the PLP: Identify implications of study results for all cross-over issues Identify all Project impacts (based on information to date) and appropriate PMEs	
Late January 2009		Hold workshop with stakeholders to discuss cross-over issues (plus any remaining study results not covered previously)
Late February 2009		Hold workshop with stakeholders to discuss Project impacts and SCL's proposed PME measures
March – April 2009	Final drafting, reviewing, and revisions of PLP	
Late April 2009	File PLP (plus draft BA and draft HPMP) with FERC	
April–September		Continue discussions as needed with stakeholders regarding PMEs (to be reflected in License Application)
May – August 2009	Complete all studies and address PLP comments	
Early September 2009	Finish all drafting and review of License Application	
Mid-September 2009	File License Application with FERC	

Attachment 1-3: Conversion Table for Key Project Elevations

SCL Boundary Project
Datum Conversion of Key Features
10/02/06

Feature	Elevation (NGVD 1929, Feet)	Elevation (NAVD 1988, Feet)
Crest of Dam	2000	2004.03
Maximum Operating Pool	1990	1994.03
Minimum Operating Pool	1950	1954.03
Spillway Crest	1946	1950.03
Minimum Intake Pool	1903	1907.03
Normal Tailwater	1729	1733.03

Attachment 1-4: List of Early Information Development Efforts

List of Early Information Development Efforts

Seattle City Light's (SCL's) additional early information development (EID) activities completed in 2005–2006 are listed below by resource area. As described in the PAD, these EID efforts were undertaken prior to the development of this PSP to provide additional background information that has been essential to focusing study efforts and otherwise informing development of the PSP. The EID efforts are listed below, with a brief description of each effort. Relicensing participants were consulted and provided input on the EID plans, and have been periodically updated on the progress of these efforts. Many of the EID results are presented in the PAD, and other results (e.g., the Review of EPA Data for the Lower Pend Oreille Mines and Mills [see Attachment 3-1]) are included in this PSP. The remainder (e.g., ongoing water temperature data collection and development of reservoir bathymetry mapping) will be incorporated into the results of the studies described in this PSP.

Project-Wide Efforts

- *Aerial imagery* – SCL contracted for aerial mapping and LIDAR (Light Detection And Ranging) imagery services to obtain up-to-date images of the Boundary Project facilities and associated area. Color aerial flights were conducted to produce orthophotographs and LIDAR imagery was obtained to produce contour maps. These resources have been used for field mapping (e.g., for the cover type mapping presented in the PAD) and will continue to be an important tool for field mapping of various resources in the Project area.

Water Resources — Water Quality

- *Ongoing water temperature data collection* — SCL continued its temperature monitoring program, initiated in 2004, in 2006 at the established monitoring sites throughout Boundary Reservoir and in the tailrace of Boundary Dam. Results to date were presented in the PAD.
- *Water quality data collection* —SCL collected background data for a range of water quality parameters that will be used in the assessment of overall water quality conditions and to support fisheries studies. Results to date were presented in the PAD.
- *Evaluation of toxics* — During preliminary planning for the relicensing effort in spring 2005, SCL identified toxic substances (toxics) as an issue that needed to be addressed as part of the FERC relicensing and Washington State 401 certification processes. A Toxics Inventory and Screening was conducted by SCL in 2005 to identify toxics of potential concern in the Project area, and the results of this inventory and screening were presented in the PAD. The Toxics Inventory and Screening primarily focused on water quality data, but also reviewed sediment and fish tissue data and potential sources of contamination. An additional evaluation of toxics was conducted in 2006 by reviewing information contained in the Environmental Protection Agency's (EPA) Preliminary Assessments and Site Investigations Report for the Lower Pend Oreille River Mines and Mills (Ecology and Environment 2002). The review of the EPA data is summarized in Attachment 3-1 to the Water Resources section of this PSP (section 3).

Water Resources — Hydrology

- *Development of basemap including reservoir bathymetry* — Existing land-based orthophoto mapping was combined with reservoir bathymetric data (developed in 2006) to produce basemaps that will be used in various resource studies proposed in this PSP.
- *Reservoir physical characterization* — This effort involved GIS-based computation, graphing, and mapping of reservoir parameters, including elevation/surface-area and elevation/capacity relationships. The results provide basic Project information that will be used in studies proposed in this PSP and in development of the License Application.
- *Installation/operation of stage recorders in tailrace and reservoir* — Stage recorders were installed and operated starting in early September 2006 in the Boundary Dam tailrace and at locations throughout the reservoir. The water-level information obtained through this network of stage recorders will be used as needed to help inform study implementation and will be used in the development of the reservoir hydraulic routing model (part of the proposed fish and aquatic studies program; see section 4.1 of this PSP).
- *Literature/data review on interactions between Project flow releases and downstream reservoir operations and on relative contributions of Boundary, Waneta, Seven-Mile and tributaries to flow effects downstream from Project* — SCL reviewed available literature and data regarding the interplay between current operations at the Boundary Project and downstream projects, and how those operations together with contributions from tributaries may affect flows. This is an important first step in understanding the extent to which the Boundary Project may affect downstream fish and aquatic resources. The information obtained through this review has informed (and may continue to inform) decisions regarding the appropriate extent of studies of downstream flow effects.
- *Identification of potential future changes in operation of the Waneta, Seven Mile, and Box Canyon projects and the upper Pend Oreille River system* — In 2006, SCL continued to monitor developments in the Pend Oreille River basin and worked to identify potential changes in operations at other projects and the nature of any attendant implications for Boundary Project operations or effects under the new license. This information has been taken into consideration in the development of this PSP, will be used to helping determine whether any future modifications to the Boundary Project relicensing study program may be appropriate, and will be critical in the evaluation of study results.

Fish and Aquatic Resources

- *Monitoring of fishing derby* — SCL collected observations and data in 2006 at a fishing derby (the "Bassin Assassin" derby) that takes place annually in Boundary Reservoir. This background information facilitated development of the study design for the proposed Recreational Fishery Study (described in section 4.8).
- *Installation of receiver in tailrace* — SCL is cooperating in the biotelemetry study planned by BC Hydro to evaluate bull trout movement patterns in Seven Mile Reservoir. As part of this study, in 2007 SCL will fund the installation and operation of a receiver at

Boundary Dam. The study will be ongoing during the 2007–2008 relicensing studies program.

- *Testing of fish capture methods in tailrace and reservoir tributary mouths* — To inform study design for the proposed investigation of the presence of native salmonids in the tailrace area (described in section 4.6) and the study design for the Fish Distribution, Timing, and Abundance Study (described in section 4.3), SCL in 2006 tested the efficacy of potential methods for this study. This effort included the following investigations:
    - Gill net sampling to evaluate presence of native salmonids within the Project tailrace area and at the mouth of selected Boundary Reservoir tributaries. The objective of this investigation was to determine whether target species (bull trout, rainbow and westslope cutthroat trout, and whitefish) can be captured in the Boundary tailrace area and/or at the mouth of selected tributaries to the Boundary Reservoir using gill nets.
    - Evaluation of Boundary Dam tailrace access. The objective of this evaluation was to identify conditions affecting boat launch and retrieval at the Boundary Dam tailrace boat ramp and hydraulic conditions affecting use of boats in the tailrace area.
    - Test use of biotelemetry systems. The objective of the test was to identify the effective range of acoustic and radio biotelemetry systems to support the design of biotelemetry studies to be conducted in 2007 and 2008, as described in this PSP.

Botanical and Wildlife Resources

- *Invasive plant species inventory* — A preliminary inventory of invasive plant species was conducted in the Project vicinity during September 2005, in conjunction with other EID efforts. The results of this preliminary inventory were presented in the PAD. An additional survey was conducted in 2006 to complete the invasive plant species inventory. Revisions were made to the original plan based on agency comments, most notably, the expansion of the study area to include land bounded by the major north/south highways in the Project vicinity.
- *Cover type mapping* — SCL produced detailed cover type maps to provide baseline information on upland, wetland, riparian, and littoral cover types for the Project area. These maps were field verified in 2005 and presented in the PAD. The cover type maps will serve as the basis for many of the terrestrial resource studies planned for 2007/2008. Revisions were made to the original plan based on agency comments, most notably, the expansion of the study area to include land bounded by the major north/south highways in the Project vicinity.
- *RTE plant survey* — SCL conducted a reconnaissance survey in 2005 to verify previously mapped rare, threatened, and endangered (RTE) plant occurrences in the Project area. In the course of this inventory, several new occurrences of RTE plants were also documented. The results of this survey were published in the PAD and used as the basis for development of the proposed RTE Plant Species Inventory study plan presented in section 5.3 of this PSP.

Recreation and Land Use

- *Abandoned Peewee Falls trails* — Two former trails, both with views of Peewee Falls, are known to have existed in the Project area in the past but have been abandoned for various reasons. In 2006, SCL researched the history of these trails to assess the current condition of the trails and understand why they had been abandoned. This information will be incorporated into the Recreation Resources Study to evaluate the potential for the abandoned trails to serve as recreational opportunities in the future
- *Potential Project boundary encroachments* — SCL conducted research and reconnaissance in 2006 to determine whether existing development along the reservoir shoreline may be encroaching upon the FERC Project boundary. To investigate potential encroachments, SCL assessed existing conditions using GIS-based maps, on-site investigations, and recent orthographic photos. All observed access points and shoreline-related development was documented. The results of this effort will factor into the evaluation of study results.
- *Shoreline development trends* — Assessing future trends in shoreline development on adjoining private lands along the reservoir is important to define appropriate future shoreline management measures that may be needed within the FERC Project boundary. Such measures could include implementing a shoreline permitting system or shoreline management plan. SCL in 2006 conducted a shoreline development trends analysis to identify the amount and type of shoreline development that may be expected at Boundary Reservoir over the term of the new license. This analysis investigated potential future land sales/transfers and identified historic use trends to develop an understanding of the type and scale of future development pressure along the Project reservoir. This analysis involved interviews with local land management agencies, business owners, real estate professionals, and others to develop a deeper understanding of land ownership and use trends in the Project vicinity. Additionally, statewide, county-wide and localized economic, real estate, and demographic data were used to characterize recent trends. Along with the boundary encroachment information described above, the results of this effort will factor into the evaluation of study results.
- *Boat ramp usability at varying reservoir levels* — Anecdotal reports reveal that the boat launch at the Forebay Recreation Area is unusable when the reservoir is below elevation 1,980 feet NGVD 29 (1,984 feet NAVD 88). Using the recently developed reservoir bathymetric mapping, SCL will conduct a systematic investigation to confirm the usability of this ramp or other ramps located along the reservoir, at various reservoir operating levels within this 10-foot range or other range (in general, a minimum of 3 feet of water depth at the toe of the ramp lane is needed for proper boat ramp access). This investigation will be completed prior to implementation of the proposed Recreation Resource Study and the results incorporated into the background information and analysis for that study.
- *Project-related roads* — Project-related roads, such as those accessing the Project machine hall and maintenance yard are needed to support Project operations. These roads require some level of maintenance to ensure continued safe and efficient access and to protect resources. These roads may also be used by the public to access Project features such as the Forebay Recreation Area. SCL conducted research in 2006 to clarify

ownership of and maintenance responsibilities for Project-related roads. A map of roads within the Project boundary has been produced. This information will be integrated with information on roads and road use within the study area that will be collected for three proposed studies — the Big Game Study (section 5.5), the Lands and Access Study (section 6.2), and the Recreation Resource Study (section 6.1, under Dispersed Recreation Use, Access, and Condition Analysis).

Cultural Resources

- *Field reconnaissance* — SCL conducted a reconnaissance-level investigation of the presence of cultural resources in the Project vicinity in 2006 as a preliminary evaluation of the predictive model and to inform study design for the Historic Properties Inventory (described in section 8.1).

2 GEOLOGY AND SOILS

Based on review of existing information, reconnaissance-level surveys conducted by SCL, and input from agencies, tribes and other stakeholders (relicensing participants), shoreline stability along Boundary Reservoir and erosion associated with Project-related roads have been identified as potential issues associated with continued operation of the Project under a new license. Erosion (which may be controlled at least in part by Project-related factors and cumulative impacts) has potential implications for geology and soils, as well as several other resources, including riparian habitat, cultural resources, and land use. No other issues related to geology and soils have been identified as concerns related to relicensing of the Project. Based on the identified issues, SCL is proposing to conduct an Erosion Study, as described in this section of the PSP. No other studies related to geology and soils have been requested.

2.1. Erosion Study

The Boundary Project is located within the Okanogan Highlands physiographic province, which has a unique geology attributable to volcanism, intrusion of granitic rock, deformation and metamorphism of marine sediment accretionary terrains (Williams et al. 1995, Alt and Hyndman 1984). Continental glaciation approximately 20,000 to 10,000 years ago (Stoffel and others 1991) deeply eroded the bedrock and left areas of thick glacial and post-glacial related sediments. The Project is located in an area where the Pend Oreille River bisects the Selkirk Mountains and cuts through Metaline Limestone and Ledbetter Slate. These two formations are the predominant geologic features along Boundary Reservoir downstream of Metaline Falls. In addition, pockets of glacial related sediments are present between bedrock outcrops along the shoreline of the reservoir. The upstream portion of the reservoir, above Metaline Falls, is characterized by predominantly unconsolidated glacial sediments and side stream and mainstem river alluvial deposits with a few areas of bedrock consisting of Ledbetter Slate.

A reconnaissance-level survey conducted by SCL in 2005 identified erosion at numerous sites along the Boundary Reservoir shoreline and at a few locations along Project-related roads (SCL 2006). However, this survey did not assess erosion processes and causes, and there is insufficient information to determine the relative contribution to shoreline erosion from the presence of the reservoir, wave action, and/or water level fluctuations, or the impacts of these factors on resources. The Erosion Study described in this study plan is intended to address information needs related to Boundary Reservoir shoreline erosion and slope stability, as well as erosion and slope stability associated with Project-related roads. Specifically, the purpose of this study is to gather further information to determine the causes and potential impacts of erosion. The potential causes of shoreline erosion and erosion along Project-related roads include both Project-related factors and non-Project-related factors, and the study will provide information on the relative contribution of these factors. Results of this study will also be used to identify potential impacts of Project-induced erosion to other resources, including aquatic and riparian habitats, water quality, botanical, wildlife, cultural, and visual resources, land uses, and recreation uses. At sites where identified resource sites may be impacted by Project-related erosion, a general feasibility assessment of potential erosion control measures will also be conducted.

2.1.1. Nexus between Project Operations and Effects on Resources

Reconnaissance-level information collected by SCL for preparation of the Boundary Project Pre-Application Document (PAD) indicates that erosion is occurring at a number of locations around the shoreline of Boundary Reservoir (see PAD section 4.3; SCL 2006). In addition, erosion processes from Project operations specific to the SCL-owned Boundary Wildlife Preserve (BWP) were identified by Enserch Environmental (1994). The Enserch report also provided a general evaluation of Project-related erosion processes at other sites along the reservoir. Erosion and slope stability associated with Project-related roads were described in 1984 (Hart Crowser 1984). Except for the BWP, processes controlling erosion at specific sites along the reservoir shoreline and rates of erosion at these locations are not known. Factors potentially contributing to shoreline slope instability include erosion from Project operations and activities, as well as non-Project sources, including natural processes. Manifestations of shoreline erosion from reservoir operations and roads may include rills and gullies, seepage and frost wedging, frost heave, soil creep, ravelling, undercut slopes, topples, landslides, and sheet erosion. Many of these same manifestations can also result from non-Project-related activities, such as timber management, mining, road construction and maintenance, and natural slope processes. The proposed Erosion Study will provide information needed to understand the relative contributions of several potential factors that may be affecting shoreline and road erosion and associated slope stability. It will also provide information to assess the impacts of erosion on other resources.

2.1.2. Agency Resource Management Goals

In addition to providing information needed to characterize Project effects, the Erosion Study will provide information to help agencies with jurisdiction over geology and soil resources in the Project area to identify appropriate conditions for the new Project license pursuant to their respective mandates. The study should also help agencies with jurisdictional oversight by providing information to assess the relationship between erosion and land use, recreation, fish and wildlife habitat, botanical resources, and cultural resources. Agency management goals and policies associated with soils and erosion are summarized below.

U.S. Forest Service (USFS)

The National Forest Management Act of 1974 (16 U.S.C. §§ 1600-1614, as amended), Executive Orders, and USFS regulations direct the agency to “manage forest and rangelands in a manner that will improve soil productivity” (Forest Service Manual [FSM] 2550.3). Further, FSM 2554.04 states the USFS is to “monitor the soil resource to detect significant changes in soil properties resulting from the implementation of management plans” and to “use the results of monitoring to evaluate resource management actions and recommend adjustments to practices or mitigation to prevent significant impairment of long-term soil productivity” (FSH 2509.18, 2.03). The overall program focuses on soil productivity, sustainability, and inventories.

The Land and Resource Management Plan for the Colville National Forest (CNF) also includes a number of forest-wide standards and guidelines related to soils and erosion (USFS 1988). Those applicable to the Project include the following:

- National Forest system lands will be managed under the principle of multiple use and sustained yield without permanent impairment of land productivity.
- Identify areas of high soil erosion or mass failure potential and evaluate probable impacts of resource development.
- Comply with State requirements in accordance with the Clean Water Act through the selection and implementation of Best Management Practices. These Best Management Practices include practices to prevent or minimize erosion and runoff from roads, protection of riparian areas, and prompt revegetation of disturbed areas (USDA Forest Service, 1988).
- Revegetate cut and fill slopes and other large areas of disturbed soil, as quickly as possible with vegetation suitable for the management goals of the area.
- Management activity caused suspended and bedload sediment and/or changes in bank stability will be considered 'excessive' and mitigation will be implemented.
- Emphasize the protection and improvement of soil, water, vegetation, fish and wildlife resources while managing riparian areas.
- Emphasis will be given to control and reduction of noxious weed infestations.
- Protect eligible cultural resources from human depredation and natural destruction.

U.S. Bureau of Land Management (BLM)

The National Forest Management Act also applies to the BLM. The BLM is required to address the health and productivity of soils and evaluate the potential impacts of projects to soils when preparing resource management plans and subsequent environmental impact statements and environmental assessments.

Washington Department of Ecology (Ecology)

Ecology is responsible for administering the Shoreline Management Act (SMA) and for protecting and restoring waters of the state. The SMA is intended to protect shoreline natural resources, including "...the land and its vegetation and wildlife, and the waters of the state and their aquatic life..." against adverse effects. All allowed uses are required to mitigate adverse environmental impacts to the maximum extent feasible and to preserve the natural character and aesthetics of the shoreline. One of the purposes of Ecology's Water Quality Program is to prevent point-source pollution or reduce nonpoint-source pollution, or a combination of both. Sediment recruitment can be a point source of pollution but is commonly considered a type of nonpoint-source pollution.

Pend Oreille County

Pend Oreille County has a Shoreline Master Program with the overall goal of developing county shorelines in a way that protects against adverse effects to public health, land, vegetation, wildlife, waters, and aquatic life, and recognizes and protects private property and navigational

rights (Pend Oreille County 1974). The plan includes policies to reduce erosion from agricultural and forest practices, mining, and utilities.

2.1.3. Study Goals and Objectives

The primary goal of the Erosion Study is to provide the information needed to understand the relationship among several factors that may be contributing to erosion in the Project area and to identify effects of erosion on water quality, aquatic habitat, cultural resources, recreation, wildlife habitat, sensitive plants, noxious weed establishment and spread and scenic resources. Another goal is to provide information on sediment-related processes needed for fish and aquatic studies. The Erosion Study will address the following objectives:

- Identify erosion and slope failure locations along the reservoir shoreline, along Project-related roads or near Project facilities and determine the primary processes causing erosion and slope failures at these locations, including the potential contributions of Project operations (e.g., water levels and water level fluctuations), Project-related recreation (e.g., wave action from boating), non-Project sources (e.g., mining, timber management and harvest, and non-Project roads and railroads), and natural processes.
- Provide an estimate of erosion rates, area and volume of land that could be lost to erosion and slope failures at each of the identified sites over the term of the new Project license, and the sediment size fractions contributed at each identified erosion and slope failure site.
- Identify land ownership of areas affected by Project-related erosion and slope failures.
- Identify resource sites that may be impacted by Project-related erosion and slope failures and determine the feasibility of reducing erosion and slope failures at those sites.

2.1.4. Need for Study

Summary of Existing Information

A number of documents, as well as field observations, have identified shoreline erosion at numerous sites along Boundary Reservoir. The PAD provides a review of existing information and presents the findings of reconnaissance-level surveys and mapping conducted by SCL in 2005 (SCL 2006). These surveys mapped the entire shoreline, identified stable and unstable sections, and collected data on the slope, height, vegetative cover, and erosion processes for each shoreline section with evidence of erosion (see PAD section 4.3). Results of these surveys indicate that approximately 11.3 percent of the reservoir shoreline has intermediate stability and approximately 15.7 percent is unstable (Figure 2.1-1; Table 2.1-1). Enserch Environmental (1994) estimated that approximately 6 percent of the shoreline is experiencing significant erosion. Slope stability and erosion associated with roads and two landslides within the Project area were evaluated by Hart Crowser in 1984. Hart Crowser (1984) also provided a number of recommendations to reduce erosion and increase stability along portions of Project-related roads.

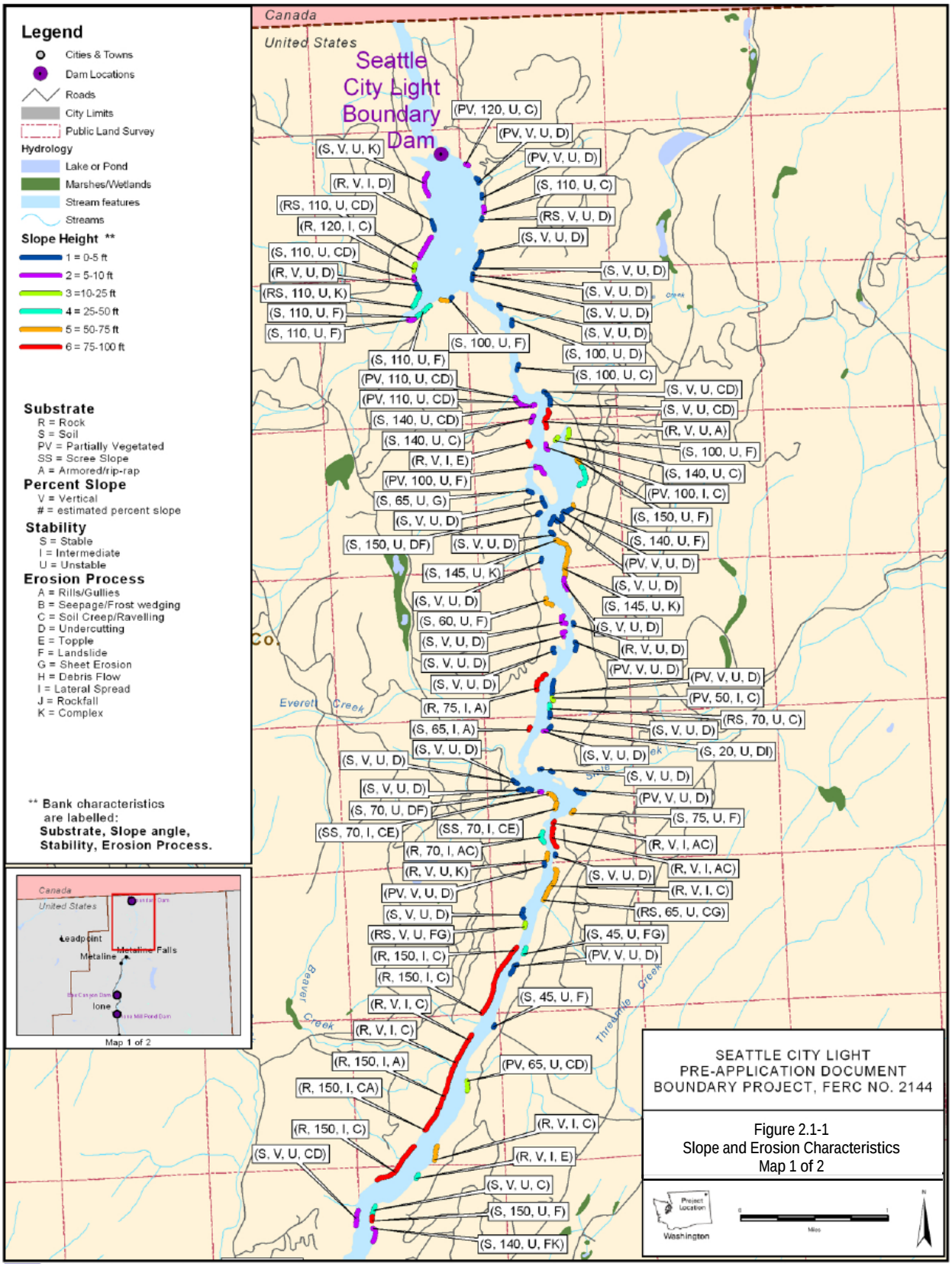

Figure 2.1-1. Slope and erosion characteristics, Boundary Reservoir (Map 1 of 2).

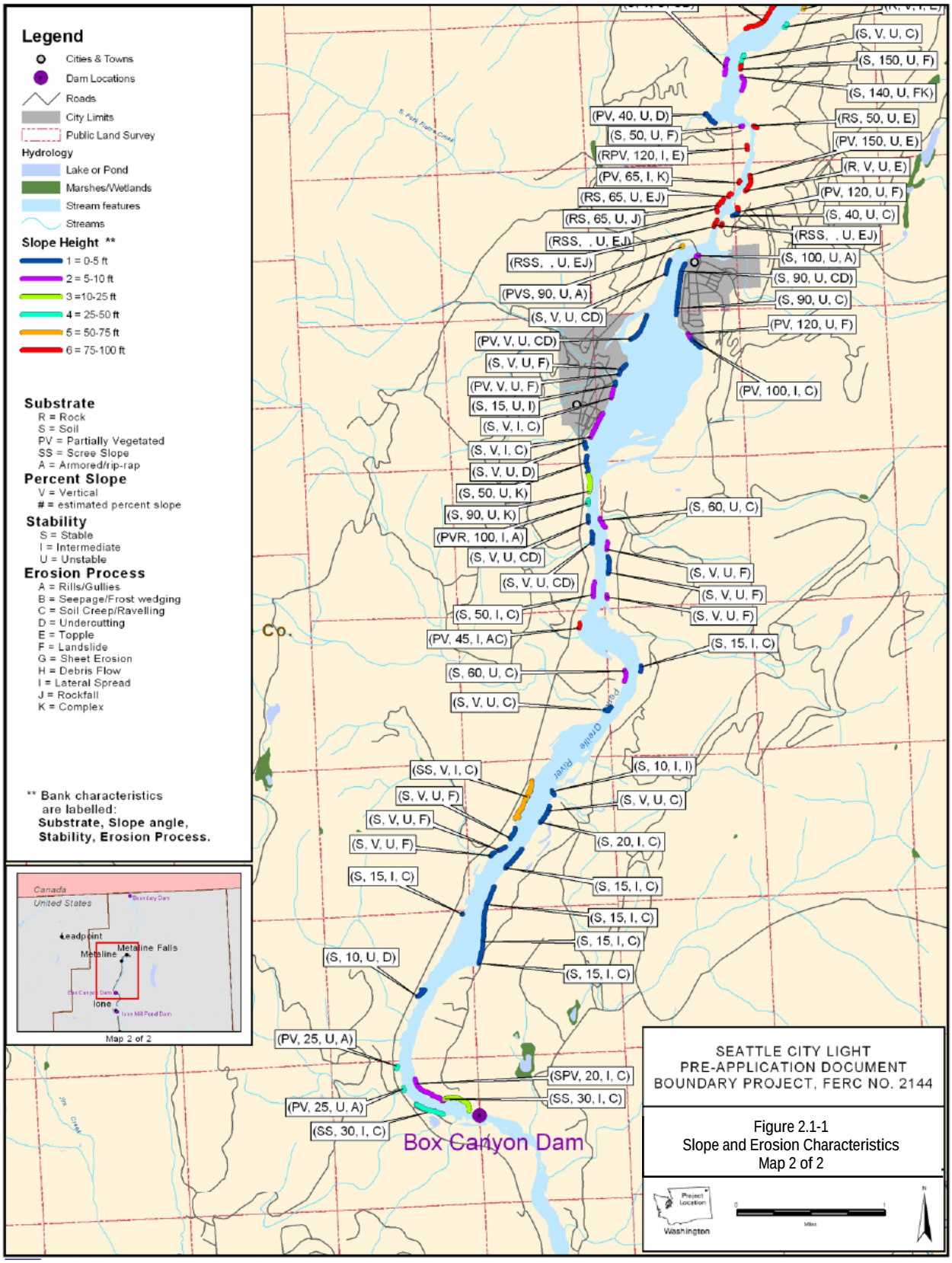

Figure 2.1-1. Slope and erosion characteristics, Boundary Reservoir (Map 2 of 2).

Table 2.1-1. Summary of Slope Stability along the Boundary Reservoir. (Source: SCL 2006)

Slope Height (ft)	Intermediate Stable Slopes Length (ft)	Percent of Total Shoreline	Unstable Slopes Length (ft)	Percent of Total Shoreline
0–5	5,435.20	2.2	17,688.55	7.3
5–10	3,638.39	1.5	8,366.80	3.5
10–25	1,539.32	0.6	1,697.24	0.7
25–50	1,938.31	0.8	3,116.88	1.3
50–75	3,714.40	1.5	3,936.74	1.6
75–100	11,097.59	4.6	3,284.49	1.4
TOTAL	27,363.22	11.3	38,090.70	15.7

Although erosion is evident along a number of reservoir shoreline sections, many of these sites are armored with coarse-grained lag deposits that limit further erosion. In general, areas with silt and fine sands are more susceptible to erosion from water level changes in the reservoir. Some steep slopes with thin soils over bedrock or compact soils may no longer be actively eroding; however, because the steep slope has been undercut, shallow slope failures may occur in the future. Slope failures that have impacted the reservoir from non-Project related processes are also present within the Project area. Two of these slope failures were identified by Hart Crowser (1984). Reconnaissance investigations of the Project vicinity in 2005 and 2006 indicate erosion associated with drainage along the railroad tracks south of Metaline Falls and two large slides related to non-Project road-cut failures.

Need for Additional Information

The existing information identifies the number and location of erosion sites along the Boundary Reservoir shoreline and provides some information characterizing each site. However, information is lacking on the contribution of Project operations to shoreline erosion and slope failures, the processes involved, and the associated effects on water quality, aquatic habitat, cultural resources, land use, recreation, and terrestrial habitats. In addition, the location, extent, causes, and impacts of erosion and slope failures associated with Project-related roads and facilities have not been thoroughly documented. The status of the implementation and the effectiveness of the recommendations made by Hart Crowser (1984) have not been evaluated.

2.1.5. Detailed Description of Study

Study Area

The study area for the Erosion Study will extend approximately 18 miles along the Pend Oreille River from the Box Canyon Dam tailrace downstream to the U.S.-Canada border and will encompass the following:

- Downstream of Metaline Falls — The reservoir, fluctuation zone (elevation 1,970–1,990 feet NGVD 29 [1,994 feet NAVD 88]), and the land within the FERC Project boundary (Project area), which includes most Project facilities, the area 200 horizontal feet (i.e., along the ground surface, perpendicular to the shoreline) beyond the high water level along both shorelines, and the transmission line right-of-way (ROW) from the powerhouse to the Bonneville Power Administration (BPA) interconnection.
- Upstream of Metaline Falls — The reservoir, fluctuation zone (elevation ≈1,985–2,015 feet NGVD 29 [2,019–1,989 feet NAVD 88], as measured at the USGS gage below Box Canyon Dam), and the land within 200 horizontal feet beyond the high water level (approximately 2,015 feet NGVD 29 [2,019 feet NAVD 88]) along both shorelines, extending south to the FERC project boundary for the Box Canyon Project. [1] [2]
- The BWP (155 acres) and adjoining SCL-owned property (85 acres).
- 100 feet around any Project works areas that extend outside the Project boundary.
- 100 horizontal feet along both sides of the river from Boundary Dam to the U.S.-Canada border (approximately 0.9 mile).
- All slopes potentially impacted by Project-related roads, which include the road between the Boundary Dam and the Vista House, the road to the dam off County Road 2975, and the County road from SR 31 to the Vista House.
- At locations where slopes potentially impacted by erosion and slope failures associated with the shoreline extend beyond the above described boundaries, the slope will be evaluated to the extent necessary to understand the relationship to the Project.

The ability to conduct surveys on private lands within the study area outside the FERC Project boundary (mainly upstream of Metaline Falls) may be limited due to access constraints in these areas.

Proposed Methodology

The Erosion Study will consist of seven tasks, each of which is described below. Implementation of this Erosion Study will be coordinated with fish and aquatic habitat and water quality studies, in particular the Sediment Transport and Boundary Reservoir Tributary Delta Habitats Study (described in section 4.2 of this PSP) and the Phase 1 Toxics Assessment:

[1] The estimated fluctuation range of approximately 1,985–2,015 feet upstream of Metaline Falls is based on the review of existing hydrology, as described in section 1.3.4 of this PSP (see Table 1.3-1). Following completion of the Hydrology Dataset and Statistics in January 2007 (see section 1.4.2), SCL will review and refine, as necessary, this elevation range.

[2] As indicated in this and other study plans in the PSP, SCL agrees it is appropriate to study the existing fluctuation range of the reservoir; however, for development of the Preliminary Licensing Proposal (PLP) and License Application, SCL will base its assessment of potential protection, mitigation, and enhancement measures on that portion of the fluctuation zone that is determined to be under the influence of Boundary Project operations, versus the effects of inflows and Metaline Falls that are beyond the control of the Project.

Evaluation of Contaminant Pathways and Potential Project Nexus (described in section 3.3). Modifications to proposed Erosion Study methods at some locations may be necessary depending on the needs of these other studies.

Task 1 – Information Review

The existing and available information will be reviewed to gain a better understanding and to describe current and historical conditions related to erosion in the study area. The following information should be included in the review:

- The PAD, especially section 4.3 (SCL 2006).
- Tabular and mapped data from the 2005 reconnaissance erosion study conducted for the PAD (includes length, height, slope, and vegetative cover for each mapped shoreline section with evidence of erosion).
- Boundary Reservoir, Hydrologic and Erosion Processes Affecting Boundary Wildlife Preserve (Enserch Environmental 1994), which is focused on the BWP.
- Slope Stability/Erosion Assessment, Boundary Project (Hart Crowser 1984), which is focused on six slides along access roads.
- Photographs and maps of the reservoir area downstream of Metaline Falls from 1965 (SCL 1966).
- Any available historic aerial photographs and site photos (potential sources include SCL, USFS 1944 aerial photographs, Washington Department of Natural Resources, Washington State Department of Transportation, Pend Oreille County and local historic societies).
- Current (2005) maps, aerial photographs at a scale of 1 inch = 100 feet, and LIDAR (Light Detection And Ranging) imagery of the Project area.
- Reconnaissance notes and photos used in preparation of the study plan.

Information will also be solicited from agency personnel, other stakeholders, and SCL staff familiar with the Boundary Reservoir shoreline and Project-related roads. This information will be incorporated into the Study Report and will also be used as guidance prior to the field investigation tasks.

Task 2 – Determine Shoreline Erosion and Slope Failure Processes At Identified Sites

The focus of this task will be to determine the erosion and slope failure processes for each shoreline section showing evidence of erosion. Most shoreline erosion and slope failure areas were identified and mapped during a reconnaissance survey in 2005. This map (see Figure 2.1-1) will be verified and refined as necessary. Each site in the 2005 reconnaissance survey database and any identified new sites will be assigned a unique number and will be field checked to determine the following:

1. The process, or processes, causing the erosion and/or slope failure.

2. The relationship of the erosion and/or slope failure process to Project operations, including the indirect effects of lack of vegetation in the fluctuation zone.
3. An estimate of the erosion rate over the life of the current license, 1967 to 2006 (past erosion rate), and the erosion rate over the next license period (future erosion rate) at the site.
4. Estimates of the area and volume of sediment that entered the reservoir from past erosion and/or slope failures and that are likely to enter the reservoir due to future erosion and/or slope failures.
5. An estimate of the sediment size fractions potentially entering the reservoir currently and in the future from erosion and/or slope failures.

Erosion processes will be determined by field observations and applying site-appropriate geology, geomorphology, and hydrology principles. For each shoreline erosion site, erosion process elements to identify and record will include but not be limited to: topography, soil type and subsoil characteristics (depth to bedrock, texture, rock content, signs of piping, gleyed colors, densic or other restrictive horizons), reservoir water level(s), ground water seepage, and evidence or observations of wind-driven waves, boat waves, roads, and/or recreational uses. Additional site characteristic elements to identify and record will include but not be limited to: dominant vegetation cover type(s) present, an ocular estimate of total plant cover, and estimate of total cover by life-form (tree, shrub, herbaceous) on adjacent undisturbed shoreline segments. Data from each shoreline erosion site will be recorded on a field form and entered into a database. In addition, a photograph or photographs will be taken of each site. Completion of this evaluation will allow for a determination as to whether the erosion is Project-related, and if so, how Project operations may be impacting the site.

The methods used to estimate past and future erosion rates and slope failures will vary from site to site depending on the type and extent of erosion, slope conditions, and vegetation. Techniques will include, but need not be limited to, the following:

- Projecting the slope aspect of the original topography.
- Estimating age of vegetation on past failed slopes.
- Measuring the root exposure of tree stumps in eroded areas.
- Reviewing available historic aerial or site-specific photographs and comparing them to present conditions. The Enserch Environmental Report (1994), for example, contains a large number of site-specific photographs that can be compared to determine changes at those locations since 1994. Photographs and maps of the reservoir downstream of Metaline Falls from 1965 (SCL 1966) can be used to identify areas of preexisting erosion and new erosion sites since 1965.

Estimated erosion rates over the current license period and the next license period may be different at a given site. Consequently, past and future estimates for each site will be developed and categorized within a range of erosion rates based on volume of sediment removed, shoreline regression, length of shoreline, and area impacted. A relative scale — ranging from no erosion to low to moderate and to severe, with example illustrations and definitions for each scale — will

be provided. For example, a low erosion rate for the period of the current FERC license might be less than 3 feet in depth and/or height from the high water mark, a moderate rate might be between 3 and 10 feet, and a high rate might be greater than 10 feet. The scale will be developed in coordination with the other resource workgroups and interested agency representatives.

Another important aspect of this task will involve identifying slopes with a high potential to fail as large slabs or slumps over the next license period as these areas may pose a significant risk to important resources. A relatively small area of toe slope erosion can create a fairly large potential failure on a steep slope.

Task 3 – Assess Erosion and Slope Stability Near Project Facilities

Project-related roads and transmission line routes cross steep slopes at a few locations. Erosion and slope stability will be assessed on steep portions of the transmission corridor within the Project area and on all Project-related roads. This assessment will involve field surveys of the slopes adjacent to Project-related roads and the transmission line. Existing erosion sites and unstable or potentially unstable slopes will be mapped on topographic maps or the current aerial photographs and entered into a Geographic Information System (GIS) database. The causes of erosion associated with roads and Project facilities will also be identified. If sites are identified where Project-related erosion is contributing sediment to wetlands or streams, these sites will be mapped.

Task 4 – Determine Land Ownership of Eroded Sites

Land ownership will be determined at all areas where Project-induced erosion or slope failures are identified. This process will involve using GIS to overlay the erosion maps with the land ownership map developed by SCL. GIS will then be used to calculate the linear feet and percent of erosion occurring in the study area by land ownership category.

Task 5 – Identify Resource Values Impacted by Erosion or Slope Failures

Identifying resource values potentially affected by Project-related erosion or slope failures will involve coordination with other resource workgroups. Resources potentially affected by shoreline or road erosion and slope failures include historic properties, recreational developments, dispersed recreation sites, structures and roads (both Project and non-Project), riparian areas and shoreline wetlands, rare plant populations, water quality, aquatic and terrestrial wildlife habitat, and key observation points. Specific locations of some sites with high resource values are currently known; others may not be identified until 2008–2009. Sites identified by resource workgroups as having important resource values will be assessed to determine if they are being impacted by Project-induced erosion and/or slope failures or may be impacted in the future.

An additional aspect of this task will be to assess whether eroded sites in the study area are providing conditions that favor the establishment and spread of noxious weeds. This assessment will involve combining information from the noxious weed inventory conducted by SCL in 2005 and 2006 with the map of identified erosion sites to determine if these sites are being colonized by invasive non-native plant species.

Task 6 – Feasibility Assessment for Stabilization of Identified Resource Sites

If important resource values are identified as at risk from Project-related erosion and/or slope failures, the sites will be further evaluated to determine if there are feasible means for reducing or treating the erosion or slope failure. This feasibility analysis will be based on field observations and knowledge of current erosion control and slope failure stabilization methods that may be suitable for the site. The analysis will provide a preliminary list of potential control measures necessary to reduce erosion at these sites. Detailed analyses for final design and construction of erosion control and slope stabilization measures will not be part of the study.

Task 7 – Documentation of Fieldwork and Effects Assessment

All identified erosion sites will be assigned a number and clearly identified on aerial photographs and on appropriate base maps. Data collected in Tasks 2 and 3 will be entered into a database and combined with data from previous surveys, if appropriate. The GIS-generated map of erosion and slope failure site locations from 2005 will be refined, with sites along Project-related roads and transmission lines added. A short narrative of field observations and conclusions about erosion processes, erosion rates, potential direct and indirect impacts from erosion to identified resources, and whether or not each erosion and/or slope failure site appears to be Project related will be provided for each site along with photos of each site.

2.1.6. Work Products

The results of the Erosion Study will be compiled and presented in a written study report completed in standard scientific format. The report will include the following information:

- A narrative describing the geologic setting relevant to the Project, an overview of Project operations and their relationship to the erosion analysis, a discussion of the methodologies used, and a description of erosion processes observed with selected examples.
- An updated and refined map showing each identified erosion and slope failure site. Aerial photographs may also be used to illustrate erosion processes and slope failures at some sites.
- A summary data table linked to the updated map of the erosion/slope failure sites that lists slope height, length, substrate, percent slope, vegetation cover, and erosion/slope failure process for each mapped and numbered site.
- Conclusions about erosion processes and rates, slope failures, and potential impacts to resources for each erosion and slope failure site.
- Information on any high-value resource sites that may be expected to be impacted by Project-related erosion or slope failures now or in the future and the feasibility of potential erosion control slope stabilization at these sites.
- A discussion of direct and/or indirect Project-related erosion processes in the study area, as determined from the results of this study. The full assessment of potential Project-related impacts, including the effects of the type and timing of Project operations and maintenance and Project-related recreation, will be part of the

integrated resource analysis conducted for development of the Preliminary Licensing Proposal (see section 1.2.5).

- An appendix with a narrative of field observations along with photos of each erosion site. Where possible, earlier photographs of these sites will be included.

GIS layers and metadata of shoreline erosion and slope failures, and the measurements associated with the study will be made available to the agencies upon request.

2.1.7. Consistency with Generally Accepted Scientific Practice

The methods described above were prepared by a Washington State Licensed Engineering Geologist. Methods for determining erosion processes and rates in lake settings were derived, in part, by approaches described by Vallejo and Degroot (1988), Reid et al. (1988), Enserch Environmental (1994), and Associated Earth Sciences (2003).

2.1.8. Consultation with Agencies, Tribes, and Other Stakeholders

This study plan was prepared with input from the USFS, WDFW, and Pend Oreille County Noxious Weed Control Board, which was provided at a meeting of the Terrestrial Resources Workgroup on July 26, 2006. Additional comments were provided by the USFS and WDFW at a Terrestrial Resources Workgroup meeting on August 15, 2006. Comments provided by relicensing participants on the draft study plan are summarized in Attachment 2-1 to this study plan and can also be found in the workgroup meeting summaries, available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

2.1.9. Schedule

The Erosion Study will be conducted in 2007. However, as other studies are completed, additional assessment may need to take place to incorporate identified resource values that might be impacted by Project-related erosion. The expected schedule summarized in Table 2.1-2.

Table 2.1-2. Schedule for the Erosion Study.

Activity	Timeframe
Review existing information and develop preliminary list of known and potential habitat sites, aquatic resource sites, cottonwood and cottonwood recruitment sites, cultural sites, and recreational sites to be included in the Erosion Study	February–March 2007
Complete study implementation planning details (for field components)	April 2007
Review existing data, reports and photographs	April–May 2007
Conduct erosion field assessments	May–August 2007
Prepare draft year-1 study report (first-year results)	September–October 2007
Submit draft year-1 study report for stakeholder review	December 2007
Revise and finalize year-1 study report	January 2008
Conduct 2008 follow-up assessments on any newly identified high-value resource sites (if required)	May–November 2008
Prepare draft Final study report	November 2008
Submit draft Final study report for stakeholder review	December 2008
Revise and finalize Final study report	January 2009

2.1.10. Progress Reports, Information Sharing, and Technical Review

In addition to preparing the study report (as described above), there will be several opportunities for information sharing and technical review with relicensing participants. Other workgroups and the USFS will be contacted to discuss potential resource values and local knowledge of erosion and slope processes and will be asked for input on the scale used to categorize erosion rates (see Task 2). In addition, agencies will be invited to participate in field assessments. Preliminary Erosion Study results will be communicated to other workgroups and relicensing participants in early 2008, as described in section 1.2.4 of this document.

2.1.11. Anticipated Level of Effort and Cost

The Erosion Study is expected to involve about 100 hours of field time, coordination with other studies, field documentation, data summary, analysis, and GIS mapping, report writing and preparation. The estimated cost for this study is $40,000–60,000.

2.1.12. Literature Cited

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Attachment 2-1: Summary of Stakeholder Comments on Erosion Study Plan

Summary of comments on Erosion Study Plan made at the Terrestrial Workgroup meetings (2006).

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Draft Terrestrial Study Plans: Erosion					
Verbal	7-26-06	M. Gerdes	USFS	M. Gerdes said that he had Nancy Glines (USFS geologist) and Kathy Ahslenger (USFS botanist) review the study plan. He said he would discuss the high points of their comments at this meeting, but he gave SCL a CD with a redlined copy of the Erosion Study.	Comment acknowledged.
Verbal	7-26-06	M. Gerdes	USFS	M. Gerdes said that one of the USFS's concerns is landslides and if they are related to Project operations.	SCL would specify erosion-induced landslides in the 2nd bullet in the goals and objectives section.
Verbal	7-26-06	M. Gerdes	USFS	M. Gerdes said that Nancy Glines (USFS) had additional comments, including: 1) potential monitoring as PME, 2) some surveys need to be done at low water levels, and 3) survey needs to consider backwater curves.	SCL thought these concerns would be addressed, but that he tried to avoid locking in to one method to maintain flexibility for different shoreline/access types.
Verbal	7-26-06	D. Robison	WDFW	D. Robison said that he did not think wording of Project impacts was consistent throughout the study plan. He said that impacts that are due to Project operations or Project-related are different things and they define scope and pertain to responsibility.	SCL would try to make language more consistent. When SCL uses the term 'Project operations,' they refer to reservoir operations, and 'Project-related' generally indicates something like recreation impacts.
Verbal	7-26-06	M. Gerdes	USFS	M. Gerdes said he would like to see a list of potential factors affecting erosion processes.	Those factors will be included.
Verbal	7-26-06	D. Robison	WDFW	D. Robison said he would like to clarify the purpose of information being collected to feed into Fish and Aquatic studies. He said he wanted to clarify what is being examined and to make sure that it matches up with what Fish and Aquatic studies	The Erosion Study could clarify that these data are being collected for use by the Fish and Aquatics group, and that Doug could further address this at the August Fish and Aquatic workgroup meeting. SCL will discuss the issue

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				need.	with Al Solonsky (SCL) and Phil Hilgert (R2 Resources)
Verbal	7-26-06	D. Robison	WDFW	D. Robison said that he had various concerns about erosion, including loss of land, infrastructure and habitat, and asked to what level SCL would be looking at affected resources.	Once all the erosion data are collected, these data would then be combined with information on resource sites to identify impacts to resources.
Verbal	7-26-06	D. Robison	WDFW	D. Robison asked if this study is specific to erosion or if it will include deposition as well. He said that sedimentation issues need to be looked at from both erosion and transport deposition (within and outside of Project) perspectives.	The scope of this study only examines erosion.
Verbal	7-26-06	J. Bodie	USFS	J. Bodie said that erosion coming from something deemed Project related could for example, cause deposition on a gravel bar allowing noxious weeds to colonize which would have an impact on Visual Resources.	SCL will further consider these issues and discuss them with stakeholders in August.
Verbal	7-26-06	D. Trochta	USFWS	D. Trochta asked if the recommendations contained in the 1984 Hart Crowser report were implemented by SCL.	SCL wasn't sure but the issue would probably be addressed in the report produced for the Erosion Study.
Verbal	8-15-06	M. Gerdes	USFS	M. Gerdes said that he wanted to make sure information from assessments by Hart Crowser and Associates (1984) and Enserch Environmental (1994) would be incorporated with SCL's 2005 assessment to elucidate how erosion sites have changed over time.	The photographs in the Enserch Environmental Report (1994) and 1965 photographs from SCL will be used to estimate rates of past erosion, as described in task 2 of the study plan. The Hart Crowser document (1984) is basically a letter report and does not include any photographs. A good deal of information was collected by SCL in 2005, including length and average height of erosion sites along the reservoir.
Verbal	8-15-06	M. Gerdes	USFS	M. Gerdes suggested that a GPS point be taken at erosion sites to provide a center point of erosion sites when placed within	SCL was concerned with that method due to safety and GPS coverage and accuracy. SCL has very detailed aerial

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				GIS maps.	maps that he thought might provide greater accuracy than GPS points.
Verbal	8-15-06	M. Gerdes	USFS	M. Gerdes suggested that geologists in the field make note of any noxious weeds sighted.	The reservoir has been surveyed for noxious weeds and that information would be noted in the Erosion Study. Also, it might not be advisable to rely on geologists to positively identify noxious weeds since that is not likely their area of expertise. Upon completion of the Erosion Study, results will be examined with information from other resource areas to identify how erosion is impacting other resources.
Verbal	8-15-06	M. Gerdes	USFS	M. Gerdes asked if 100 horizontal feet below Boundary Dam to the Canadian Border would be included in the study area. He said he thought it would be valuable information to have, although he realized it may be difficult to tease apart potential impacts from the Boundary Project from those caused by the operation of the downstream Seven Mile Project.	SCL had not yet made that determination and would need to give this issue more consideration.
Verbal	8-15-06	M. Gerdes	USFS	M. Gerdes suggested that SCL add two Work Products: 1) a description of conclusions of erosion site mitigation feasibility and potential control measures, and 2) an appendix with a data table that presents all parameters for each erosion site.	Comment acknowledged.
Verbal	8-15-06	D. Robison	WDFW	D. Robison said he continues to have questions about how SCL is defining the term "Project-related" (in this case it refers to erosion, but it is an issue that spans all resource disciplines). He said a major factor leading to erosion is inundation in the fluctuation zone preventing vegetative growth that would serve to stabilize slopes.	Colleen said that she thought this would be addressed in the examination of processes causing erosion. She said that SCL would add language to the study plan addressing this concern and Doug can let SCL know if it satisfies his concerns

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				He said that he thought this was a direct effect from Project operations and needs to be addressed. He wants to make sure that the right kinds of data are collected during the studies that will get at the effects the project is having that will require mitigation.	

3 WATER RESOURCES

Based on review of existing information, recommendations from independent experts, and input from agencies, tribes and other stakeholders (relicensing participants), Seattle City Light (SCL) has identified a number of relicensing issues related to water resources, as summarized in Attachment 1-1. Based on the identified water resource issues, SCL is proposing to conduct the following studies:

- Analysis of Peak Flood Flow Conditions Above Metaline Falls
- Evaluation of Total Dissolved Gas and Potential Abatement Measures
- Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus
- Water Quality Constituent and Productivity Monitoring
- Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir

The plans for these proposed studies are described in this section of the Proposed Study Plan (PSP). The Mainstem Aquatic Habitat Modeling Study is also relevant to water resources, as indicated in the summary table presented in Attachment 1-1; this study is described under the Fish and Aquatic resource section (section 4.1) of this PSP.

Also addressed in this section of the PSP are water resource related studies that were requested by agencies, tribes, or other stakeholders but that SCL has not adopted in the PSP. Only one water resources study that was requested by relicensing participants has not been adopted in this PSP; this study, an Aquatic Plant Management Control Study, which was requested by the USDA Forest Service (USFS), is briefly described in section 3.6, along with SCL's rationale for not including it in the PSP. The USFS-proposed Aquatic Plant Management Control Study would involve two components: 1) an assessment of the effect of existing Project operations on the distribution of nonnative aquatic macrophytes, and 2) an evaluation of macrophyte control techniques. (Follow-up consultation between SCL and the USFS regarding this issue took place during a conference call on September 8, 2006. A summary of the outcome of the conference call is included in Attachment 3-5.) SCL will address current and potential future distributions of aquatic macrophytes in Boundary Reservoir as part of aquatic habitat modeling studies. SCL anticipates that control strategies for aquatic macrophytes will be tested and implemented following issuance of the new FERC license (to be developed as part of the Aquatic Macrophyte Management Plan submitted as part of the application for 401 water quality certification). For greater detail regarding this issue see section 3.6.

The water quality studies proposed in this PSP are intended to provide information regarding specific resource aspects or components, including the potential for the Project to directly affect these components during the new license term. As explained in section 1.2.5, the results of the water quality and related studies described in this PSP will ultimately be synthesized for the purposes of the Preliminary Licensing Proposal (PLP) in an integrated resource analysis, which will yield more comprehensive conclusions regarding Project effects and appropriate protection, mitigation, and enhancement (PME) measures. As described in section 1.2.5, SCL will coordinate with relicensing participants during the development of the PLP.

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3.1. Analysis of Peak Flood Flow Conditions Above Metaline Falls

During the July 19, 2006, FERC scoping meeting, Mr. Karl McKenzie, owner of Riverview Trailer Court & RV Park in Metaline (Washington), suggested that Project operations may exacerbate flood conditions in the Upper Reservoir Reach of the Boundary Reservoir, resulting in the flooding of his and other homes in the town of Metaline. After reviewing the information presented in the Boundary Project Pre-Application Document (PAD; SCL 2006) and the comments provided during the scoping meeting, FERC identified a gap between existing information and the information needed to evaluate whether Project operations are influencing the duration and level of floods in the area (FERC 2006).

The purpose of this proposed study is to evaluate how Project operations may influence the duration and level of flood conditions in the town of Metaline. If Project operations are influencing the duration and level of flood conditions in the town of Metaline, this study will identify any opportunities and cost of implementing procedures that may attenuate the potential conditions.

The study will use recent topography and bathymetry to perform hydraulic modeling that characterizes the effects of reservoir conditions above Metaline Falls relative to Project operations during periods of high flows in 1972, 1974, and 1997 — the years Mr. Karl McKenzie indicated in the FERC scoping meeting that flooding had occurred.

3.1.1. Nexus Between Project Operations and Effects on Resources

Project operations affect reservoir levels on a weekly, daily or hourly level. There is some evidence to suggest that Metaline Falls acts as a hydraulic control point, resulting in significant attenuation of water surface elevations in the Upper Reservoir Reach. 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. The purpose of this study will be to more fully understand the relationship between operational influences of the Project on Boundary Reservoir reaches upstream and downstream of Metaline Falls.

3.1.2. Agency Resource Management Goals

Sections 4(e) and 10(a) of the Federal Power Act require the FERC to give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, FERC must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power and developmental values (including flood control).

Comments provided by Mr. Karl McKenzie during the FERC scoping meeting indicated that there might be some potential for the Project to influence flood levels. However, FERC notes in its study request (FERC 2006) that there is also information in the PAD that suggests that the natural constriction formed by the Canyon Reach and Metaline Falls prevents the Project from significantly affecting flood levels in the Upper Reservoir Reach. Therefore, to fully evaluate the Project's effect on flood conditions and to balance potential enhancement opportunities with

their costs, an analysis of flood flows and operations is needed and relevant to FERC's public interest determination.

3.1.3. Study Goals and Objectives

The goals of the Analysis of Peak Flood Flow Conditions above Metaline Falls Study are to evaluate how Project operations may influence the duration and level of flood conditions in the town of Metaline and to identify any opportunities and cost of implementing procedures that may attenuate those conditions. The objectives of the study are as follows:

1. Select transects (number and location) to measure and model the Upper Reservoir Reach adjacent to and in the vicinity of the town of Metaline.
2. Develop an unsteady-flow, hydraulic model that estimates water surface elevations and storage along modeled transects on an hourly basis under historic 1972, 1974, and 1997 high flow and operational conditions.
3. Document the flow conditions during which flooding of the Metaline area has occurred in 1972, 1974, and 1997; and, the reservoir and surrounding land elevations in the Metaline area during these flood events, if applicable.
4. Determine the operational feasibility, effects on generation, and cost of implementing any procedures that might attenuate flooding conditions attributable to Project operations.

3.1.4. Need for Study

Summary of Existing Information

The Pend Oreille River system is highly regulated, with flows into Boundary Reservoir controlled by several upstream projects including Box Canyon (Pend Oreille County PUD), Albeni Falls (U.S. Army Corps of Engineers), and Hungry Horse (U.S. Army Corps of Engineers). The Boundary Project is operated in a load-following mode to shape available water to deliver power during peak-load hours. The normal maximum reservoir water surface elevation is at 1,990 feet NGVD 29 (1,994 feet NAVD 88). Relative to the average daily river flow, the reservoir has relatively little storage capacity (about 43,000 acre-feet) within the authorized maximum drawdown of 40 feet (from elevation 1,990 to elevation 1,950 feet NGVD 29 (1,994–1,954 feet NAVD 88). From about Memorial Day weekend through Labor Day weekend, SCL voluntarily limits water surface fluctuations to a 10-foot range for reservoir access and recreation (between 1,980 and 1,990 feet NGVD 29 [1,984–1,994 feet NAVD 88]); during the remainder of the year, the water surface may fluctuate between 1,990 and 1,970 feet NGVD 29 (1,994–1,974 feet NAVD 88) in the Forebay and Canyon reaches of the reservoir. Storage between elevation 1,970 and 1,950 feet (1,974–1,954 feet NAVD 88) is reserved for extreme system load requirements. The Project license has no flood control requirements.

As described in section 1.4.2 of this PSP, analyses of existing hydrology data have been undertaken by SCL to produce the reliable hydrologic dataset and statistics (hydrologic record) that is needed to conduct environmental and energy production analyses (as described in section 1.4.3) for FERC relicensing of the Boundary Project. This hydrologic record for the Project will

be consistently used for evaluations of Project operations, resource effects, and potential alternative operational scenarios. The hydrologic record for the Pend Oreille River system and the Boundary Project will be completed by January 2007 and will be made available in the Information Library on the Boundary Project relicensing website (www.seattle.gov/light/news/issues/bndryRelic/).

Need for Additional Information

No formal studies have been done to evaluate the potential relationship of Project operations to flood flows on the McKenzie property in the town of Metaline and any other improved properties within the reservoir floodplain.

3.1.5. Detailed Description of Study

Study Area

The study area for this study includes Boundary Reservoir, from Box Canyon Dam, at river mile (RM) 34.5, to Boundary Dam, at RM 17.0. The study area also encompasses land adjacent to the reservoir sufficient to address the issue of the relation of Project operations to potential flood conditions on the McKenzie property in the town of Metaline and on any other improved properties within the reservoir floodplain. The portion of the study area that includes the town of Metaline is the Upper Reservoir Reach, from Box Canyon Dam to Metaline Falls to (RM 34.5 to RM 27.8). The two remaining reservoir reaches are downstream of Metaline Falls and include the Canyon Reach (RM 27.8 to RM 19.4) and the Forebay Reach (RM 19.4 to RM 17.0).

Proposed Methodology

A one-dimensional, unsteady-flow, hydraulic model will be constructed and used to analyze the Project operations relationships to the Upper Reservoir Reach relative to the Metaline area for 1972, 1974, and 1997 flows. The hydraulic model will be developed using hydrologic and hydraulic models by U.S. Army Corps of Engineers (USACE) including HEC-RAS and HEC-FDA (USACE 1998, 2000, 2002a, 2002b, 2002c, 2005). The results of the hydraulic model will be used to understand the relationship between operational influences above and below Metaline Falls relative to flood conditions to determine the Project's ability to attenuate flooding on the McKenzie property in the town of Metaline and any other improved properties within the reservoir floodplain.

The U.S. Geological Survey (USGS 2006) and SCL 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 model. These data consist of the following:

- Hourly flow data from the U.S. Geological Survey (USGS) for the Pend Oreille River below Box Canyon Dam (Gage No. 12396500; located upstream of Metaline, Washington). The maximum recorded daily mean flow of 136,000 cfs occurred June 13–14, 1972, which corresponded to a maximum tailwater elevation of 2,014.5 feet (NGVD 29) on June 14, 1972 (Pend Oreille County PUD 2000). This flow and

elevation is based on annual flow rate data recorded at this gage from January 1, 1953 to September 30, 1993, by the USGS (Pend Oreille County PUD 2000).

- Hourly flow data from Seattle City Light for total flow release from Boundary Reservoir (power generation plus spill). Four turbines were operating in 1972 and 1974, and all six turbines were operating in 1997.[1]
- Hourly flow data from the USGS for the Pend Oreille River below Boundary Dam (Gage No. 12398600) near the U.S.-Canada border.

Additional information is needed to develop and calibrate the hydraulic model, and to provide a consistent input database to allow for comparison of Project operations for 1972, 1974, and 1997. The additional data required consist of the following:

- Bathymetry surveys of Boundary Reservoir will be completed in 2006 and 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. The bathymetry survey will be merged with the LIDAR (Light Detection And Ranging) survey to produce a current 3-D basemap.
- 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, in the Upper Reservoir Reach.
    - Just upstream from Metaline Falls, in the Upper Reservoir Reach.
    - Just downstream from Metaline Falls, in the Canyon Reach.
    - At the downstream end of the Canyon Reach.
    - In the Boundary Project forebay, in the Forebay Reach.
- Water surface elevation data will be needed from the stage recorders deployed at these five selected sites during 2007 to develop and calibrate the hydraulic model. Additional water surface elevation data from the stage recorders may be needed in 2008 depending on the flow conditions in 2007.
- The conversion between vertical elevation references (NGVD29 and NAVD88) will be needed to convert all elevation data to a common datum.
- A time series of hourly flow releases for 1972, 1974, and 1997 from Box Canyon Dam to the Pend Oreille River will be needed for use as input to the hydraulic model.
- The potential effects of 1972, 1974, and 1997 historic operations on the hourly water surface elevations in the Upper Reservoir Reach of Boundary Reservoir will be assessed relative to the town of Metaline elevations based on the selected transects.

[1] The Project began commercial operation in 1967, with turbine-generator units Unit 51 through 54. In accordance with a 1982 license amendment approving expansion of the Project, Units 55 and 56 were constructed in two previously excavated bays in the machine hall and came on line in 1986.

The specific tasks involved in this study are described below.

Task 1) Hydraulic Model Construction

A one-dimensional, unsteady-flow, hydraulic model will be constructed to estimate flow and water surface elevations in the Upper Reservoir Reach of Boundary Reservoir using additional transects and consistent boundary conditions from the Mainstem Aquatic Habitat Modeling Study (section 4.1). The hydraulic model will be developed using cross-sectional profile data derived from bathymetric and LIDAR surveys.

Task 2) Model Calibration

The hydraulic model will be calibrated to match observed hourly stages obtained from stage recorders. The resulting model will translate Boundary forebay water surface elevations, as a result of 1972, 1974, and 1997 historic operations, to upstream locations on the McKenzie property in the town of Metaline and any other improved properties within the reservoir floodplain.

Task 3) Model Documentation and Executable Model

An executable model and supporting documentation will be prepared that can be used in the development of GIS maps that illustrate the 1972, 1974, and 1997 land and reservoir elevations on the McKenzie property in the town of Metaline and any other improved properties within the reservoir floodplain.

Task 4) Flood Analysis Documentation

If flooding conditions occurred due to Project operations in 1972, 1974, and 1997, determine the operational feasibility, effects on generation, and cost of implementing procedures that may attenuate any future Project-related flooding conditions on the McKenzie property in the town of Metaline and any other improved properties within the reservoir floodplain.

As described in section 1.2.3 of this PSP, by the end of 2006, SCL plans to have selected and retained the Technical Consultant that will implement the relicensing study program. Following the filing of the Revised Study Plan (RSP) and prior to actual initiation of the studies, the Technical Consultant will participate, with SCL and relicensing participants, in developing and refining any remaining details related to implementation of the studies.

3.1.6. 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 hydraulic model, channel cross-section profiles (transects), and details of model calibration. The December 31, 2008, report of the Analysis of Peak Flood Flow Conditions Above Metaline Falls will include the final summary of the Hydraulic Routing study component from the Mainstem Aquatic Habitat Modeling Study.

3.1.7. Schedule

The schedule for completing this study is provided in Table 3.1-1.

Table 3.1-1. Schedule for the Analysis of Peak Flood Flow Conditions Above Metaline Falls.

Activity	2007				2008			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Technical Consultant study refinement	--------							
Construct cross-sections for hydraulic model		--------	--------					
Obtain and analyze hourly stage and flow data	--------	--------						
Develop and calibrate hydraulic model		------	------	------				
Draft Report				●				
Continue to collect water surface elevation data at selected sites to help calibrate the model transects					--------	--------	--------	
Final Report							■	

3.1.8. Consistency with Generally Accepted Scientific Practice

One-dimensional unsteady flow hydraulic models are commonly used to evaluate flow and stage fluctuations through rivers and reservoirs. 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. The robust performance and flexibility of HEC-RAS make this model the appropriate choice for determining the relationship between Project operations, flood flows, and corresponding changes in reservoir water surface elevations from the forebay of Boundary Dam to Box Canyon Dam.

3.1.9. Consultation with Agencies, Tribes, and Other Stakeholders

This study plan was developed in response to FERC's official request (dated August 31, 2006) that SCL conduct a study to assess peak flood flow conditions above Metaline Falls (FERC 2006).

3.1.10. 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. 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. Relicensing participant workgroup meetings are planned to occur on a quarterly basis, and workgroup subcommittees will meet or have teleconferences as needed.

3.1.11. Anticipated Level of Effort and Cost

The estimated effort and cost for preparing the study plan, conducting the study, and preparing the report for the Boundary Project ranges from $30,000 to $60,000, subject to review and revision as additional details are developed.

3.1.12. Literature Cited

FERC (Federal Energy Regulatory Commission). 2006. Analysis of Peak Flood Flow Conditions above Metaline Falls. Study request dated August 31, 2006 for Project No. 2144-035-Washington, Boundary Hydroelectric Project, City of Seattle.

Pend Oreille County PUD (Pend Oreille County Public Utility District No. 1). 2000. Application for New License, Box Canyon Hydroelectric Project, FERC No. 2042. January 2000. Volume III of XIII, Appendix B-1, River Hydraulic Report, dated July 1996.

SCL (Seattle City Light). 2006. Pre-Application Document for the Boundary Hydroelectric Project (FERC No. 2144). Seattle, Washington. May 2006. Available online at http://www.seattle.gov/light/news/issues/bndryRelic/br_document.asp

USACE (U.S. Army Corps of Engineers). 1998. HEC-FDA Flood Damage Reduction Analysis User's Manual, Version 1.0, CPD-72, January 1998.

USACE. 2000. HEC-FDA Flood Damage Reduction Analysis software program, Version 1.2, March 2000. (HEC-FDA 2.0 under development).

USACE. 2002a. HEC-RAS River Analysis System User's Manual, Version 3.1, CPD-68, November 2002.

USACE. 2002b. HEC-RAS River Analysis System Hydraulic Reference Manual, Version 3.1, CPD-69, November 2002.

USACE. 2002c. HEC-RAS River Analysis System Applications Guide, Version 3.1, CPD-70, November 2002.

USACE. 2005. HEC-RAS River Analysis System software program, Version 3.1.3, released April 2004 with security patch update in January 2005.

USGS (U.S. Geological Survey). 2006. Online NWIS web data for the nation. http://waterdata.usgs.gov/nwis/qw.

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3.2. Evaluation of Total Dissolved Gas and Potential Abatement Measures

The FERC relicensing process and the related application for certification under Section 401 of the federal Clean Water Act (401 certification) requires characterization of existing water quality conditions in the Boundary Project area and a determination of whether water quality meets the Washington Department of Ecology (Ecology) regulatory standard of 110 percent total dissolved gas (TDG) saturation for aquatic biota. Based on existing information, the Project at times does not meet this standard and increases levels of TDG in the Pend Oreille River downstream of Boundary Dam. The purpose of this study is to better define the relationship between TDG levels and Boundary Project operations and to identify and evaluate potential operational and/or structural measures that could reduce elevated TDG levels that can impair beneficial uses for fish and other aquatic species downstream of the dam. The study will involve monitoring of TDG and detailed assessment of potential abatement measures. This study plan was developed in consultation with USDA Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), Washington State Department of Ecology (Ecology), Washington Department of Fish and Wildlife (WDFW), Confederated Tribes of the Colville Reservation, Kalispel Tribe of Indians, BC Hydro, and Teck Cominco, Ltd., as described in section 3.2.8, below.

The Pend Oreille River system (which includes the Clark Fork River basin upstream of Lake Pend Oreille) is highly regulated, with operations controlled at dams associated with several power production and/or storage projects. Flows into Boundary Reservoir are controlled by flows from upstream projects, including the Box Canyon Project (Pend Oreille County PUD), Albeni Falls Project (U.S. Army Corps of Engineers [USACE]), and other upstream projects such as Hungry Horse (U.S. Bureau of Reclamation).

Boundary Reservoir has a small useable storage capacity relative to the average daily river flow, as illustrated in Figure 3.2-1. As a result, instream flow releases to the Pend Oreille River from Boundary Dam on annual, seasonal, or monthly time intervals are largely controlled by the amount of water delivered from upstream projects such as Albeni Falls and Hungry Horse. Load-following operations at Boundary Dam primarily affect instream flow releases on a daily or hourly interval.

3.2.1. Nexus between Project Operations and Effects on Resources

TDG is a water quality constituent of concern in relation to the Boundary Project because past monitoring has shown that TDG measurements upstream and downstream of Boundary Dam exceeded the Ecology standard (110 percent saturation). Based on this monitoring, it has been determined that during times of spill, the Boundary Project increases TDG concentrations above this standard or increases TDG concentrations above upstream levels when upstream levels already exceed the standard.

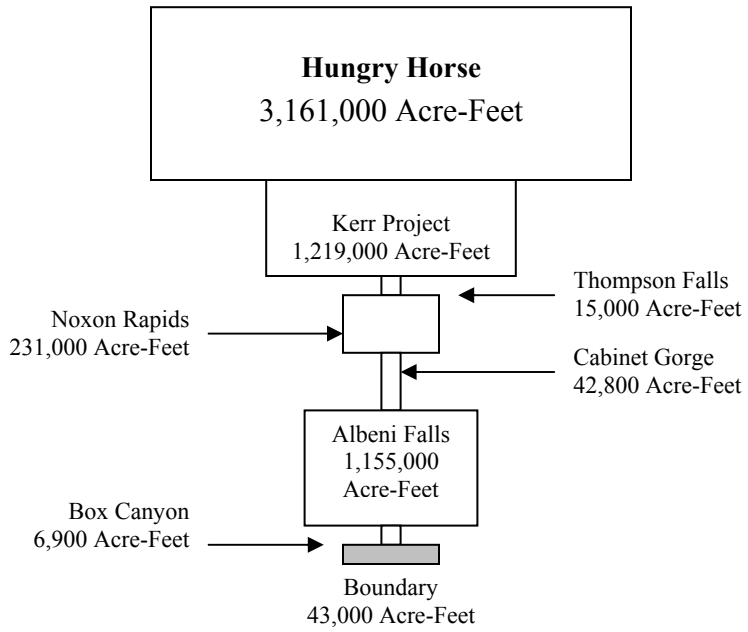

Figure 3.2-1. Hungry Horse to Boundary useable storage (acre-feet).

3.2.2. Agency Resource Management Goals

In addition to providing information needed to characterize Project effects, this proposed study will provide information to help agencies with jurisdiction primarily over water quality and aquatic resources in the Project area identify appropriate conditions for the new Project license pursuant to their respective mandates. The Evaluation of TDG and Potential Abatement Measures is specifically designed to meet 401 certification and relicensing requirements, but may also be relevant to recent or ongoing management activities by other agencies. A brief description of relevant resource management goals follows.

Washington Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA)

Washington State water quality standards related to TDG are summarized in Table 3.2-1. This table presents two sets of standards: the 1997 federally approved standards and revised standards adopted by Ecology in July of 2003. The 2003 revised standards cannot be used for regulating federal Clean Water Act actions until approved by the U.S. Environmental Protection Agency (EPA). EPA is in the process of reviewing these standards and in February 2005 provided a partial approval. Ecology is currently using the 2003 rule for the parts that EPA has approved (including TDG), but employs the 1997 rule for the parts that EPA has not yet approved (i.e., temperature). The last column of Table 3.2-1 identifies the TDG standard that is currently applicable. Both standards specify that all reservoirs with a mean detention time of 15 days or less are classified the same as the river section in which they are located. Boundary Reservoir

has a residence time of less than 4 days, and is therefore categorized under the Pend Oreille River water quality standards.

Table 3.2-1. Applicable Washington State surface water total dissolved gas (TDG) standards for the Pend Oreille River between the Idaho border and the Canadian border (WAC 1997; WAC 2003).

1997 Standard (Class A) [1]	2003 Standard (salmon and trout spawning, non-core rearing, and migration) [2]	Applicable Standard
Not to exceed 110 percent of saturation at any point of sample collection	Not to exceed 110 percent of saturation at any point of sample collection	2003 Standards

1 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. November 1997.

2 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. July 2003.

From 2001 through 2004, the U.S. Army Corps of Engineers (USACE) and Pend Oreille County Public Utility District (PUD) monitored TDG at the Idaho state line near Newport. The U.S. Geological Survey (USGS) has been monitoring in the forebay and tailrace of Boundary Dam, with supplemental monitoring performed by Ecology. Data from this monitoring show that total TDG frequently exceeds the State of Washington water quality standards. As a result, Ecology listed the Pend Oreille River on its 2002/2004 303(d) list of impaired waters and is in the process of developing the total maximum daily load (TMDL) for TDG in the Pend Oreille River jointly with the EPA and the Kalispel Tribe. The EPA is issuing this TMDL for all waters of the Kalispel Tribe of Indians, and Ecology is issuing this TMDL for all waters in the state. (A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water and establishes acceptable loads to achieve this end.)

Water quality standards established by both the State of Washington and the Kalispel Tribe set a criterion of 110 percent of saturation designed for the protection of fish and other aquatic organisms. Washington provides an exemption from the standards when flows exceed the seven-day, ten-year frequency (7Q10) flood flow, while Tribal standards apply at all flows.

Ecology's Water Quality Improvement Report documenting the Pend Oreille River TMDL for TDG, currently scheduled to be filed by December 15, 2006, will consist of two parts: Volume I, Study Findings, and Volume II, Implementation Strategy. TMDL allocations will be met primarily through TDG abatement plans developed under 401 certifications for FERC relicensing. Existing monitoring will continue to assess compliance with standards and effectiveness of the TMDL.

The 401 certification process for the Boundary Project will consider the Project's compliance with the Clean Water Act, water quality standards, and other appropriate requirements of state law, including what measures can be employed to protect the beneficial use of the waters associated with the Project (Ecology 2005). These beneficial uses include water supply, fish and wildlife habitat, generation of electricity, and recreation. Ecology, through the 401 certification

process, may require that specific actions or measures be included in the Project's license to support beneficial uses.

Water Resource Inventory Area (WRIA) 62

Numerous agencies and stakeholders in 1998 formed the Water Resource Inventory Area (WRIA) 62 planning unit, the goal of which 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 2005, a Watershed Management Plan for WRIA 62 was completed (Golder and Associates 2005). This plan identified the following five goals and related objectives for water quality:

- WQUAL-1: WRIA-wide coordination of water quality monitoring.
- 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.
- WQUAL-3a: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for tributary streams that originate within WRIA 62.

  Objective: Remove tributary streams in WRIA 62 from the 3030(d) list of impaired waters by meeting State and tribal (where appropriate) water quality standards in impaired tributary streams.
- WQUAL-3b: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for the mainstem of the Pend Oreille River.

  Objective: Meet State and tribal (where appropriate) water quality standards in the mainstem Pend Oreille River.
- WQUAL-5: Protect water bodies of high water quality and improve water quality of impaired water bodies.

  Objective: Maintain compliance with state water quality standards and prevent degradation of waters that meet or exceed state water quality standards 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 Columbia River subbasins (GEI 2004). The relevant management plan objectives identified in the subbasin plan as related to the Pend Oreille River are outlined below:

- Subbasin Objective 1B2: Improve water quality to meet or exceed applicable water quality standards in the Subbasin.

Strategy c: Identify pollution sources, causes, and constituents on tributaries and mainstem Pend Oreille River; determine and implement actions necessary to eliminate or mitigate effects.

Proposed Strategy e: Continue monitoring the water quality of Lake Pend Oreille, Clark Fork River and Pend Oreille River to insure it meets State and Federal standards.

The Evaluation of TDG and Potential Abatement Measures will provide information relevant to the objectives and strategies described above.

USDA Forest Service (USFS)

The Colville National Forest is located within the Pend Oreille River basin and as such, the USFS is a participating stakeholder in the relicensing of the Boundary Project. The USFS developed and completed the Land and Resource Management Plan for the Colville National Forest in 1988 (USFS 1988). Specific standards and guidelines in this plan related to TDG include:

1. Maintain water quality parameters within the range of good fish habitat conditions, and within State water quality standards, including the following:
   - *Total dissolved gas* – not to exceed 110 percent of saturation
2. Complying with State of Washington requirements in accordance with the Clean Water Act for protection of waters of the state through planning, application, and monitoring of Best Management Practices in conformance with the Clean Water Act, regulations, and federal guidance issued thereto.
3. In watersheds where project scoping identifies an issue or concern regarding the cumulative effects of activities on water quality or stream channels, a cumulative effects assessment will be made. This will include land in all ownerships in the watershed. Activities on National Forest System lands in these watersheds should be dispersed in time and space to the extent practicable, and at least to the extent necessary to meet management requirements. On intermingled ownerships, coordinate scheduling efforts to the extent practicable.

3.2.3. Study Goals and Objectives

The goal of the proposed Evaluation of TDG and Potential Abatement Measures is to identify all "reasonable and feasible" (Ecology 2005) improvements that could be used to meet the 110 percent standard by evaluating operational and/or structural modification alternatives to reduce TDG impairment at the Boundary Project in support of the Pend Oreille River TMDL for TDG and application for 401 certification. This goal will be accomplished by the following eight primary objectives for this study, which will be accomplished in two phases (with Phase 1 initiated in 2007 and Phase 2 following, as early as 2008):

1. Analyze hourly and 15-minute interval TDG data reported by the USGS from 1999 to 2005 for the forebay and tailrace fixed monitoring stations (FMS) relative to Pend Oreille River flow data, Project discharge and spill volumes to assess gas saturation.

2. Continue to monitor and collect Project forebay and tailrace FMS TDG data and assess the dissipation of TDG downstream of Boundary Dam.
3. Identify and provide brief summaries of the scope and results of the various TDG-related studies (Near-Field Effects Studies) and evaluations that have been conducted since 1998 concerning gas supersaturation at the Boundary Project.
4. Evaluate methods and controls to reduce air admission requirements for generating units #55 and #56 to reduce total dissolved gas.
5. Describe and evaluate a shortlist of six options and potential combinations of alternatives consisting of operational and structural control measures for reducing TDG production relative to the established criteria, especially TDG reduction performance.
6. Conduct a comparative analysis of the shortlist of operational and/or structural modification alternatives based on TDG reduction performance, hydraulic engineering methods, field testing, and modeling.
7. Identify the "preferred alternative modification strategy" (preferred alternative) for controlling and mitigating for TDG impairment based on the results of this study.
8. Identify the TDG and other monitoring and reporting activities that will be undertaken during the new license term, including those needed to evaluate the effectiveness of TDG control measures or other mitigation.

The following sections of this document provide a more detailed description of the proposed study for addressing these objectives in association with the Pend Oreille River TMDL for TDG, application for 401 certification, and economic feasibility analysis (Ecology 2006b) processes.

3.2.4. Need for Study

Many hydroelectric projects in the state of Washington — including the Grand Coulee Dam (USBR 1998), Cabinet Gorge Dam (Avista 2000), Chief Joseph Dam (USACE 2000), Priest Rapids Dam (Grant County PUD 2002), and Rocky Reach Project (Chelan County PUD 2003) — have conducted various TDG-related studies to assess operational and structural alternative measures. The need for this study and development of this study plan is informed by and benefits from these previous evaluations to ascertain a reasonable and feasible approach for assessing TDG impairment and potential abatement measures at the Boundary Project.

Summary of Existing Project Information

TDG has been documented in exceedance of Ecology standards throughout the Pend Oreille River. TDG levels in the river often exceed these standards during spill events at the hydropower facilities. TDG exceedances have been documented at the Albeni Falls, Box Canyon, and Boundary projects on the Pend Oreille River system.

SCL has carried out numerous investigations and peer reviews from 1998 through 2006 to initially assess and characterize the effect of existing operations at the Project on TDG levels in the Pend Oreille River downstream of Boundary Dam. These investigations consisted of

collection and analysis of dissolved gas data, and preliminary assessment of potential alternatives to reduce TDG supersaturation in the river below Boundary Dam. In addition, several steps were performed to determine the objectives of this proposed Evaluation of TDG and Potential Abatement Measures. SCL collected relevant data, information on the TDG measurements, drawings of Boundary Dam, and regional reports. SCL then retained several consultants experienced with regional gas abatement techniques to participate in brainstorming sessions to identify potential operational and structural alternatives for reducing TDG. The list of potential alternatives was reviewed by SCL to assess the applicability of solutions previously studied at other projects to Boundary Dam. Finally, SCL has consulted with Ecology and other relicensing participants regarding the objectives for this study.

TDG data collected by the USGS since 1999 in the Boundary Dam forebay and tailrace are available on the USGS online NWIS website at http://waterdata.usgs.gov/nwis/qw. SCL's Near-Field testing reports from 1998 through 2003, which comprise the historic TDG assessment activities collected prior to initiating assessment of potential operational and structural alternatives in 2004, also are available in the online Information Library on the Boundary Project relicensing website (www.seattle.gov/light/news/issues/bndryRelic/), as is the subsequent peer review of Columbia Basin Environmental's (CBE) 2002 spill testing (CBE 2003), conducted by Michael Schneider (USACE 2006). For a more detailed discussion regarding existing TDG data, please refer to section 4.4.5.3.7 of the Boundary Project relicensing Pre-Application Document (PAD), filed by SCL with FERC on May 5, 2006, and available on the Documents page of the relicensing website.

As described in section 1.4.2 of this PSP, analyses of existing hydrology data have been undertaken by SCL to produce the reliable hydrologic dataset that is needed to conduct environmental and energy production analyses (as described in section 1.4.3) for FERC relicensing of the Boundary Project. This hydraulic dataset will serve as the Project hydrologic record to be used consistently for evaluations of Project operations, resource effects, and potential alternative operational scenarios, and is therefore integral to the evaluation of TDG conditions and potential abatement measures as described in this study plan. The hydrologic record for the Pend Oreille River system and the Boundary Project will be completed by January 2007 and will also be available in the Information Library on the Boundary Project relicensing website.

USGS Data for the Boundary Project

Since 1999, a continuous data logger has been recording TDG at a USGS gage (#12398600) located approximately 0.75 miles downstream of Boundary Dam. SCL has an ongoing contract with the USGS for station maintenance and daily TDG data management for this TDG station. From 1999 to 2005, exceedances of the 110 percent standard occurred in five of the six years during 5.3 percent of the total number of days monitored (primarily from April through the beginning of July). Daily TDG values for this period, estimated assuming a barometric pressure of 760 mmHG, are presented in Figure 3.2-2.

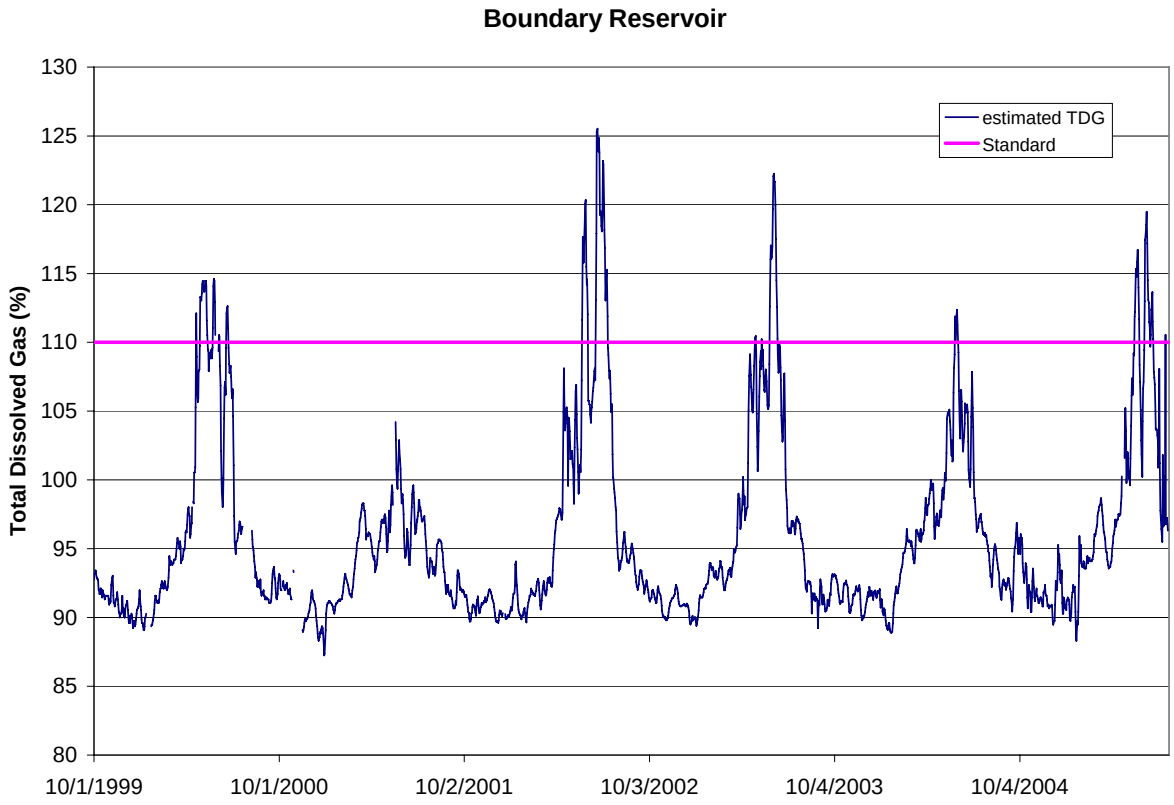

Figure 3.2-2. Measured TDG just downstream of Boundary Dam from 1999–2005 (Gage # 12398550). Note: Assumes an atmospheric pressure of 760 mmHg for the percent calculation (USGS 2005).

The elevated TDG above the 110 percent standard occurring between the months of April through early July in Figure 3.2-2 correlate to approximately 4 days of spill in 2000, 1 hour of spill in 2001 (drought year), 43 days of spill in 2002 due to high flows and spillway testing (CBE 2003), 11 days of spill in 2003, and 1 hour of spill in 2004 based on SCL System Control Center dispatch data.

Pend Oreille River TMDL for TDG

The Pend Oreille River was listed on the Ecology 2002/2004 303(d) list, based on TDG in exceedance of the 110 percent saturation criterion at multiple locations. This standard is to be met for all river flows downstream of the Kalispel Reservation up to the seven-day average, ten-year high flow (7Q10 flow), which is about 108,300 cfs for the Pend Oreille River in Washington state below Boundary Dam. As a result of this listing, Ecology will take action in accordance with its memorandum of understanding with EPA, and will develop a water cleanup plan for TDG based on establishment of TMDLs. A project schedule for the TDG TMDL was reported in the Quality Assurance Project Plan (Pickett 2004) and updated (Ecology 2006a) as listed in Table 3.2-2.

Table 3.2-2. Pend Oreille River Total Maximum Daily Load for Total Dissolved Gas Schedule (Subject to change by Ecology) (Ecology 2006a).

Report	Schedule
TMDL Report Submittal:	
Draft Technical Report (Vol. I, Study Findings)	May 16, 2006 (completed)
Draft TMDL (Vol. I and Vol. II, Implementation Strategy)	October 15, 2006
Final TMDL (Volumes I and II)	December 15, 2006

In completing the TDG TMDL, Ecology expects to rely heavily on historical and current data collected by the Pend Oreille County PUD, USGS, and USACE. Data from these sources and additional data collected by the USGS in 2004 will be used by Ecology to perform a simple spreadsheet-based analysis and, if necessary, a more complex modeling analysis of TDG in the Pend Oreille River system. Ecology's analysis will help determine loading capacity, pollutant allocations, and TMDL implementation to address the effects of TDG from hydroelectric projects and natural phenomena on the Pend Oreille River.

TDG Objective for the Boundary Project

State of Washington regulations require that the Project pass the 7Q10 flow while preventing the TDG concentration from exceeding 110 percent saturation. SCL is assuming that the Project will only be responsible for the TDG added relative to the difference between forebay and tailrace FMS TDG levels for flows less than the 7Q10. Depending on review of Project outage records, the 401 certificate may require SCL to accommodate the 7Q10 during a single unit outage; therefore, for a conservative design, SCL will assume that one generating unit (8,000 to 10,000 cfs) has an outage decreasing the total capacity of the plant from approximately 55,000 cfs to 45,000 cfs during high flows. This assumption creates a *design flow rate* of approximately 63,300 cfs, or the difference between the 7Q10 (108,300 cfs) and the assumed plant capacity of 45,000 cfs, for assessing an alternative or combination of alternatives without adding TDG when the level exceeds the 110 percent standard.

Need for Additional Information

Additional testing and ongoing TDG data collection is needed to further characterize Project effects on TDG in the Pend Oreille River downstream of the dam. Information is also needed to further evaluate potential measures that could be undertaken to help the Project achieve compliance with the Ecology standard for TDG. The potential gas abatement alternatives will require further analysis or evaluation to predict TDG reduction benefits associated with specific flow(s) relative to the percent of the 7Q10 flow. Further investigation will also include assessment of and need for the following:

1. Potential combination of alternatives.
2. Additional field testing and monitoring.
3. Identify TDG predictive tools (numerical analysis, etc.).
4. Physical and computational modeling methods.

The study may identify significant structural modifications that will require further evaluation and refinement prior to construction. Such additional work may include on-site geotechnical investigations, physical and computer hydraulic modeling, and final design work. The major uncertainties, anticipated future evaluations, and potential actions may include:

- Sources of incoming TDG and the ability, likelihood, and implications/results of any upstream TDG reduction efforts (e.g., at upstream hydroelectric developments).
- Estimated TDG exceedance levels for potential alternatives.
- Numerous engineering design and construction issues and associated requirements (e.g., bedrock integrity and other characteristics, tunnel lining and/or strengthening needs, and flow regulation capabilities [e.g., specific gate structure requirements, optimal inlet, outlet, and other optimal shaping and design considerations]).
- Potential impacts to other resources due to construction and operation.
- Benefits to the target resources as a result of the TDG Monitoring and Abatement Plan (401 certification).
- Actual TDG abatement performance of the implemented alternative by monitoring and other methods.

Assessment of Fish for Gas Bubble Trauma

TDG concentrations in excess of 110 percent saturation have been shown to cause gas bubble trauma in fish. Symptoms of gas bubble trauma vary from blistering beneath the skin when fish are exposed to low exceedances of the TDG standard to mortality when fish are exposed to extreme exceedances. Bubbles on external surfaces of juvenile salmonids have been shown to persist for up to 4 days (Hans et al. 1999).

SCL will examine fish for external signs of gas bubble trauma during surveys conducted below Boundary Dam, scheduled as part of its proposed Fish Distribution, Timing, and Abundance Study (section 4.3). This evaluation would only occur if a scheduled fish sampling event occurs within one week of spill; no sampling events will be scheduled specifically to address the effects of TDG on fish in the tailrace. 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.

3.2.5. Detailed Description of Study

Study Area

The reach of the Pend Oreille River from Boundary Dam (river mile [RM] 17.0) upstream (southerly direction) to Box Canyon Dam (RM 34.5) is the Boundary Reservoir. There are no major tributaries to the Pend Oreille River between Boundary Dam and Box Canyon Dam, but

minor flows are contributed to the reservoir from creeks such as Sullivan and Slate. For the purposes of this study, the reach of the Pend Oreille River from Boundary Dam downstream (northerly direction) to the U.S.-Canada border is considered the Boundary Project tailrace.

The study area for the Evaluation of TDG and Potential Abatement Measures extends from the Box Canyon tailrace FMS (#12396500) downstream through Boundary Reservoir and Dam to the U.S.-Canada border along the Pend Oreille River mainstem. TDG monitoring will be conducted at the existing USGS FMSs in the Boundary Reservoir in the forebay (#12398550) and tailrace (#12398600) locations as shown in Figure 3.2-3.

SCL Efforts to Date to Assess Potential TDG Abatement Measures

Historic and current efforts to identify, describe, preliminarily assess and rank operational and structural alternatives for gas abatement controls are presented in Attachment 3-1. Building on the results of the assessment presented in Attachment 3-1, the following sections discuss the possible TDG abatement measures that have been identified and describe the Phase 1 and Phase 2 study efforts.

Identification and Preliminary Assessment

Approximately 30 alternatives to reduce TDG were identified by SCL in 2003 and 2004. Twenty-four of the original 30 alternatives were preliminarily assessed by SCL as documented in the July 2005 options matrix (see Attachment 3-3). The 24 alternatives are categorized in the options matrix as follows:

- Operational Alternatives
- Structural Alternatives:
  - Spillway Structural Modification Alternatives
  - Sluice Gate Structural Alternatives
  - New Structure Alternatives
- Lower River Modification Alternatives

Many of the alternatives were further assessed by SCL in late 2005 and early 2006 as further described in this study plan. Initial findings from this exercise included the following:

- No ‘Operational Alternatives’ were considered to have the potential to significantly reduce TDG levels.

  (*Note*: This initial finding was stated prior to conducting sluice gate testing in April 2006. Also, a combination of operational and structural alternatives will be considered in this study.)

- No ‘Spillway Structural Modification Alternatives’ were selected for further consideration.

  (*Note*: These alternatives are currently not very promising due to the inability to predict the effect on TDG levels before the alternative is constructed. Previous spill test reports and subsequent peer review in 2006 support this general conclusion.)

Figure 3.2-3. Forebay and Tailrace Total Dissolved Gas Monitoring Locations.

- Most of the 'Sluice Gate Structural Alternatives' were discarded, except for one option.

  (*Note*: These alternatives were rejected over concerns about reducing the sluice gate capacity to pass the required Probable Maximum Flood (PMF), inability to predict the effect on TDG levels, and constructability issues.)

- Changes to the river channel downstream of the Boundary Project were initially considered, but were eliminated in early 2006 because they would be largely ineffective in reducing downstream TDG levels as measured at the tailrace FMS. The addition of new powerhouse capacity as a significant means of reducing downstream TDG was also dismissed due to the limited amount of new capacity that could be reasonably achieved and economically justified due to the relatively short period of high flows.

Only the operational and structural alternatives proposed for further evaluation are described in this study plan.

Ranking of Alternatives

SCL further assessed the 2006 list of operational and structural alternatives based on nine specific criteria prior to the June 2006 Water Quality work group meeting. These criteria, described in Table 3.2-3, are as follows:

- Hydraulic Capacity: Percent of 7Q10 (108,300 cfs)
- Effect on Ability of Project to Pass the PMF
- Potential TDG Benefit
- Constructability
- Operation and Maintenance (O&M) Challenge
- Cost
- Dam Safety
- Effects on Other Resources
- Effects on Fish (exclusion/passage)

A matrix was developed using these nine criteria to compare TDG options to each other as shown in Attachment 3-1, Alternatives Matrix and Ranking Criteria. These criteria are the basis for filtering and identifying the most promising alternatives for further evaluation as described in this study plan.

Table 3.2-3. Criteria used for filtering TDG abatement alternatives for the Boundary Project.

Criterion	Description and Matrix Scoring
Hydraulic capacity (percent of 7Q10 flow)	How much flow can the alternative pass? A score of 10 implies the option can pass the remainder of the 7Q10 after powerhouse flows (about 64,000 cfs). A 9 implies it can pass 90%, etc.
Effect on Ability to of Project to Pass PMF	The current FERC license requires that the Project be capable of passing the probable maximum flood (PMF) of 316,000 cfs through a combination of generation discharge, spillway and sluiceway discharges. The Project is currently capable of passing a total flow of approximately 360,000 cfs. Theoretically, the difference of approximately 44,000-cfs is the maximum impairment due to a modification. A score of 10 means the option will have no affect on the Project's ability to pass the PMF. A score of 1 means the option will certainly prevent the Project from passing the PMF. A score between 1 and 10 would be assessed if there is some uncertainty as to the effect of the option. An option should also be given a score between 1 and 10 if it will reduce the Project's capacity to pass water but it is yet unknown how much flow it will impair.
Potential TDG Benefit	One of the most challenging criteria to determine and the primary objective of the study. Would the option add gas to the river? No impairment (a score of 10) means that the water passed through this option would maintain at the same TDG level as the forebay level or if the structure will strip gas (tailrace TDG levels are lower than incoming).
Constructability	How has this type of alternative been constructed before? Is construction fairly standard or is this alternative difficult to construct due to other factors? A score of 1 would be assigned if the option required new, innovative, uncertain or risky construction methods that have not been industry tested. An option would be assigned a 10 if it required little or no construction such as an operational alternative.
Operation and Maintenance (O&M) Challenge	If the alternative consists of components not typically encountered at dams and powerplants, does it require other training by City crew to maintain? Is access to the alternative or specific areas of the alternative problematic? This score reflects if the option requires typical O&M or requires new skills not currently available at the Project. A score of 10 would indicate a very small or non-existent O&M challenge, and a 1 would indicate a large O&M challenge.
Cost	What is a reasonable cost relative to the benefits? How does initial Capital Improvement Project (CIP) cost compare to on-going O&M cost? Total costs (minus fish exclusion/passage cost) of designing, building, operating and maintaining the option (above existing plant O&M costs). An option would be assigned a 10 if there were little or no costs involved, and a 1 if costs were very high.
Dam Safety	Does the alternative modify the structure of the dam and/or powerhouse? Would the alternative affect current dam safety monitoring equipment? If so, how? What is the potential of the option to impact the structural integrity of the dam? An option that has no potential impact to the dam structure is given a score of 10.
Effect on Other Resources	Will this alternative adversely affect or conflict with other environmental and operational resources? Is so, how? This criterion is a measure of how the option affects other Project or utility resources such as the recreation areas, habitat, access roads, head on Project, aesthetics, etc. An alternative would be assigned a 10 if it had little or no effect on other resources, and a 1 for highly significant adverse effects.
Effects on Fish (exclusion/passage)	Will be informed by the findings of the Fish and Aquatic Resources studies. A score of 10 implies that no additional cost is required for fish exclusion or passage, nor will the option impair fish.

The criteria were given relative importance factors. For example, the ability to reduce TDG and effects on fish were given full weight or 100 percent, while constructability factors were weighted at 70 percent. Following the July 2006 Water Quality Workgroup meeting, the operational and structural alternatives were ranked by muting the "Cost" criteria to assess the sensitivity of the options to specific non-cost criteria and eventually, with other criteria filtering methods, provide a technical basis for further assessing alternatives as listed in Attachment 3-1, Matrix #1.

Sensitivity Analysis

Method

A sensitivity analysis was performed with Matrix #1 (see Attachment 3-1) to assess if one or more of the criteria were having a more dominant effect on the relative ranking of the alternatives. The analysis was accomplished in two steps. First, the options were ranked according to individual criteria and compared to the ranking positions using all the criteria as presented in Matrix #2 in Attachment 3-1. Second, each criterion was muted successively and the option ranks were compared to the ranking positions using all the criteria as presented in Matrix #3 in Attachment 3-1. The results of the muted rankings in Matrix #3 use a color coding scheme. If the option rank order increased, it is shown in yellow. If the option rank order remained the same, it is shown in green. If the option rank order decreased, it is shown in blue. The bottom table on Matrix #3 only sorts the upper table to numerically list the six proposed alternatives for further evaluation in this study.

Observations

As a result of the sensitivity analysis, the following observations are noted among alternatives on Matrix #2 and enlarged as the first table on Matrix #3 relative to assessing the influence of each of the nine criteria on the *Rank with All Criteria*:

- Rank without *Hydraulic Capacity* criterion:

  Muting this criterion replaced only one of the top six alternatives, Option 4-8A, with Option 4-1, Underwater Outlet through Midsection of Dam, since Option 4-1 has a lower score of "4" relative to Option 4-8A's score of "10." Muting the lower score of Option 4-1 increased its overall rank.

- Rank without *Effect on Ability of Project to Pass the PMF* criterion:

  Muting this criterion only switched the rankings of two alternatives, Options 3-2 and 4-9, yet all six alternatives remained in the top six rankings. This result assumes that Option 3-2, Roughen Sluice Gate Discharge, will not significantly reduce the current, total discharge capacity of seven gates. Again, Option 3-2's score of "9" was muted relative to Option 4-9's score of "10," causing the switch in rank between 1 and 2.

- Rank without *Potential TDG Benefit* criterion:

  Muting this criterion elevated the ranking of Option 2-1, Spillway Modifications, to the top six alternatives with Option 4-8A dropping to a rank of 8. Option 2-1's score of "2.5" was muted relative to other channel/tunnel options. All scores listed for this criterion are based on industry experience and judgment reflecting on an alternative's

proven ability to reduce TDG. This is the primary criterion to be further evaluated in Phase 1 of the study.

- Rank without *Constructability* criterion:

  Muting this criterion allows the lower scores of Options 4-7A and 4-8 to increase rank into the top six alternatives, yet Option 1-3, Throttle Sluice Gates and Option 4-8A, New Left Abutment Tunnel Intercepts Diversion Tunnel, maintain high ranks. This criterion creates a broad distribution of scores. The apparent consistency of high ranking tunnel options may reflect more confidence in this construction method.

- Rank without *O&M Challenge* criterion:

  Muting this criterion switches the ranking of Option 4-7A with Option 4-8A, and reorders the top 2 through 4 ranking alternatives due to relatively close scores. This option has a broad distribution of scores reflecting the challenge of assessing the O&M impact due to new structures.

- Rank without *Dam Safety* criterion:

  Muting this criterion did not change any of the top six ranks based on all criteria because many alternatives scored a "10" that, when muted, does not appreciably change the overall rank.

- Rank without *Effects on Other Resources* criterion:

  Muting this criterion allowed Option 4-10 to increase in rank due to a lower score relative to Option 3-2, yet both options remain in the top six alternatives. The subtle rank change is perceived as more potential for Option 4-10 to create some impacts at the inlet and/or outlet versus the sluice gate discharge. Option 4-10 has a lower score, indicative of potentially more impacts downstream. The study will assess the potential impacts of tunnel options on other resources including habitats and changing circulation patterns in the forebay and tailrace.

- Rank without *Effects on Fish (exclusion/passage)* criterion:

  Muting this criterion only switched the top six alternative rankings. The two shorter tunnel alternatives, Option 4-9 and Option 4-10, both rank as "1." The apparent rank movement between Option 4-7 and Option 4-8A may indicate a higher sensitivity for tunnels originating in the forebay (left bank) versus tunnels on the right bank.

Conclusions

Based on the sensitivity analysis of the assessment criteria, four criteria have the greatest potential to reorder the options. These include *O&M Challenge*, *Effects on Other Resources*, *Constructability*, and *Effects on Fish*. Currently, only minor changes in ranking are observed when individual criteria are muted. This suggests that no single criterion is keeping any options out of the upper ranking. As more information is developed through the course of the proposed Evaluation of TDG and Potential Abatement Measures, the option sensitivity to specific criteria will be better understood.

Possible Alternatives for TDG Abatement

As a result of the sensitivity analysis and ranking the alternatives (see Attachment 3-1), the following six alternatives (in numerical option order, not rank) appeared most technically promising:

- Option 1-3. Throttle Sluice Gates
- Option 3-2. Roughen Sluice Gate Discharge
- Option 4-7. New Right Abutment Tunnel with Submerged Discharge
- Option 4-8A. New Left Abutment Tunnel Intercepts Diversion Tunnel
- Option 4-9. Penstock/Draft Tube By-Pass
- Option 4-10. New Short Left Abutment Tunnel Next to Unit #51

Conceptual drawings of the six alternatives are presented in Attachment 3-2 to this study plan. Additional alternatives may be added to this shortlist as potential replacements for any alternatives discarded based on further evaluation or to complete a viable combination of alternatives. Reasons for discarding an alternative will result from conducting Phase 1 or Phase 2 activities described in this study plan, as applicable.

The remaining, "undeveloped" options are listed in Attachment 3-3 with reasons for discarding based on preliminary hydraulic capacity assessment, constructability, dam safety, and potential effects on fish similar to the listed criteria in previous sections. None of these options are anticipated to be evaluated in the study; however, the possibility exists that these options could be revisited in the future to create a combination alternative (i.e., two or more options to achieve TDG reduction). Most of the undeveloped alternatives have limited or no practical industry applications at other projects. Unless one of these options can be combined with another option to create a more viable alternative as identified in Phase 1 of this study, SCL will recommend that all of these undeveloped alternatives be discarded from consideration.

The six alternatives on the shortlist, illustrated in Attachment 3-2, are further described in the following sections.

Operational Alternative

Generally, the identified operational alternatives would be simpler to implement than structural alternatives. A detailed description of each option, with conceptual drawings, is presented in the *Alternatives to Reduce Total Dissolved Gas Supersaturation* document. Only the single operational alternative proposed to be further evaluated in this study is described in this study plan.

Option 1-3. Throttle Sluice Gates

As originally designed and constructed, the sluice gates normally operate either fully opened or fully closed. The objective of this operational alternative is to operate a sluice gate at a throttled position to determine the maximum possible flow that may be passed while not causing TDG impairment.

This alternative appears more promising than originally anticipated based on observations during the April through June 2006 testing periods. Generally, sluice gates No. 3, No. 4, and No. 5 were throttled to 2-, 3-, 4-, and 5-foot openings for 2 to 4 hours with fairly consistent plant discharge (cfs). The results of the 2006 testing will be completed by December 2006 and will be available in the Information Library on the Boundary Project relicensing website at: www.seattle.gov/light/news/issues/bndryRelic/). Michael Schneider (USACE) will peer review the 2006 testing protocol, data analysis, and results.

To throttle the sluice gates on a permanent short- or long-term basis, design modifications must be implemented and may require enclosing the sluice gate to minimize vibration and leakage, and installation of a redundant or auxiliary gate on the upstream side of the dam to seal off the existing sluice gate (downstream side of dam). The auxiliary gate is an anticipated modification to prevent an uncontrolled release of water due to a potential malfunction of the existing sluice gate(s) in accordance with the FERC dam safety requirements. The current ranking of this option assumes few or no fish are present at elevation 1,800 feet NGVD 29 (1,804 feet NAVD 88), or approximately 190 feet below the normal pool elevation of 1,990 feet NGVD 29 (1,994 feet NAVD 88).

Structural Alternatives

The shortlist of structural alternatives are generally described below and illustrated in Attachment 3-2. A detailed description of each option with conceptual drawings is presented in the *Alternatives to Reduce Total Dissolved Gas Supersaturation* document. Only the structural alternatives proposed to be further evaluated in this study are described in this study plan.

Option 3-2. Roughen Sluice Gate Discharge

The intended results would be to break up the jet and increase the surface area of the jet impact zone in the tailrace, thereby limiting the depth of plunge. Modifications for this option included adding deflectors. The sluiceways have been designed to enhance flow by minimizing any disturbance to the flowline. The bulbous piers at the entrance to the sluiceways are designed to minimize flow separation. The introduction of roughening blocks and flow deflectors would disrupt the original design capabilities of the sluiceway. Any modification cannot reduce the flow more than approximately 40,000 cfs, which is the difference between the total hydraulic capacity (approximately 360,000 cfs) and the PMF (approximately 316,000 cfs). The current ranking of this option assumes few or no fish are present at elevation 1,800 feet NGVD 29 (1,804 feet NAVD 88).

Option 4-7. New Right Abutment Tunnel with Submerged Discharge

This tunnel alternative[2] would have an inlet on the right side of the lake and discharge at some point below the dam at a submerged elevation. There are many parameters requiring consideration and include, but are not limited to, the following: routing based on structural integrity analysis and abutment geotechnical analysis; inlet and outlet locations and elevations dependent on submergence requirements, topography, and bathymetry; and, optimized hydraulic capacity. Two smaller-diameter, right abutment tunnels may be a variation of this option.

Option 4-8A. New Left Abutment Tunnel Intercepts Diversion Tunnel

The tunnel inlet would be in the existing forebay near the intake tunnel and emergency generator building on the left side of the dam, and discharge would be deeper than the diversion tunnel below the tailwater for submerged discharge. There could be a number of routing alternatives for the tunnel. The outlet for the existing diversion tunnel would require enlargement and re-alignment for optimal submergence and TDG reduction performance.

Option 4-9. Penstock / Draft Tube By-Pass

This option assumes evaluation of different size tunnels that bifurcate from the existing penstock and bypass the water around the turbine within the boundaries of the headgate and the draft tube gate. SCL anticipates modeling of the test turbine bypass option either with a new turbine design or with existing turbines with a new turbine design potentially designed for maximum capacity and flow, not peak efficiency. If implemented, the standard approach is to design (including hydraulic modeling) and construct one bypass, then monitor for TDG reduction performance, followed by potential design modification to further reduce TDG, then construct the second bypass. A plant outage will be required for construction, and if the construction and testing of a new bypass takes longer than approximately 9 months, excess spill may be produced due to the outage.

Option 4-10. New Short Left Abutment Tunnel Next to Unit #51

The tunnel inlet would be in the existing forebay on the left side of the generating unit #51 intake and conceptually be a seventh penstock. This option would require re-sizing the existing forebay to accommodate this new intake. There may be a couple of routing alternatives for the tunnel. This option would require hydraulic modeling to optimize resizing the forebay for all existing generating units including this new tunnel. This option may present an opportunity to improve capacity, efficiency, and reduce TDG production through the penstocks and turbines.

[2] For all tunnel options, it is assumed that conventional drill and shoot methods would be used to excavate the rock from the tunnel outlet. The shafts for the gate controls and accessory equipment would employ the "drop raise" mining technique of drilling closely spaced holes from the ground surface, vertically down to and intersecting the tunnel. The drill holes outline the perimeter of the shaft and are loaded with charge delays from the bottom, then sequentially detonate, moving up the shaft from the tunnel, to release rock material into the tunnel where it can be mucked out.

Proposed Methodology

The methodology proposed for the Evaluation of TDG and Potential Abatement Measures is to describe existing conditions within the study area including hydrology, hydraulics, operations, water quality, and environmental resources as the basis for evaluating the benefits of each alternative. The nine criteria for screening TDG abatement measures discussed above (as presented in Attachment 3-1), provide the basis for the initial comparison of potential benefits of each alternative.

The Phase 1 and Phase 2 components of this study will focus on the six alternatives on the shortlist and identify potential alternative combinations that may be more promising to achieve the highest attainable level of improvement to TDG impairment at the Project, with the goal of determining an alternative or combination of alternatives to maximize gas abatement up to the 7Q10 (108,300 cfs) flow.

Desktop analysis, field studies, hydraulic analysis, and hydraulic modeling efforts are needed to complete Phase 1 and Phase 2 identification and detailed design of the alternatives. These efforts include topographic, bathymetric and geologic surveys; physical and numerical modeling of the Project and specific features of the alternatives; and, constructability analyses that may include geotechnical investigations and sediment sampling.

Depending on review of the Project outage record, SCL may assume that one generating unit (8,000 to 10,000 cfs) has an emergency outage decreasing the total capacity of the plant from approximately 55,000 cfs to 45,000 cfs during high flows. This assumption creates a *design flow rate* of approximately 63,300 cfs, or the difference between the 7Q10 (108,300 cfs) and the assumed plant capacity of 45,000 cfs, for assessing an alternative or combination of alternatives that would not add TDG when the level exceeds the 110 percent standard.

In addition to the documents that have been developed to date (as available on the Boundary Project relicensing website and referenced in this study plan), the study will use the following sources of TDG-related data to further evaluate gas abatement alternatives:

- TDG forebay and tailrace FMS data from mid-1999 through 2005 (USGS 2006) for Gage Nos. 12398550 and 12398600
- Hourly flow data from the U.S. Geological Survey for the Pend Oreille River below Box Canyon Dam (Gage No. 12396500) and below Boundary Dam (Gage No. 12398600) near the U.S.-Canada border.
- Hourly flow data from SCL for total flow release from Boundary Reservoir (power generation plus spill) from 1987 through 2005
- Hydrologic Record (dataset and statistics) for Boundary Project (January 2007) as referenced in section 1.4.2 of this PSP
- 2006 Sluice Gate Operational and TDG Testing Assessment (first quarter of 2007)
- SCL Drawings of Pertinent Project Features such as Plans and Sections of the Dam, Forebay, Powerhouse, Diversion Tunnel, Geology, and Rock Cores.

The Evaluation of TDG and Potential Abatement Measures will be conducted in two phases in close coordination with SCL staff. Together, the Phase 1 and Phase 2 components of the study will represent a progressively more detailed and refined assessment of the operational and structural alternatives for reducing TDG levels downstream of the Boundary Project.

Phase 1 Activities and Content for Study Report

Phase 1 of this study will generally consist of the ongoing, desktop, and fieldwork tasks listed and described below.

Ongoing Activities

- The USGS will continue to collect and perform QA/QC on the forebay and tailrace FMS data. One probe exists at the forebay FMS and two probes exist at the tailrace FMS. One forebay probe and one tailwater probe have recorded hourly data from 1999 to 2005. In 2005, a second tailwater probe was added to provide redundant data in case of meter outage; in addition, the frequency of readings for all three probes changed from hourly to 15-minute intervals. The two tailwater probes are closer to the left bank. A third probe was installed by SCL at the tailrace FMS closer to the right bank in spring 2006 to better assess mixing characteristics across the tailrace transect during high flows and retrieved in late summer 2006. Deployment of a third probe in the tailrace will be repeated in 2007.
- Throttle testing of two or more sluice gates is not anticipated to continue in 2007. Depending on the Phase 1 results and TDG TMDL process, throttle testing may be planned for 2008/9.

Tasks for Phase 1 of Study

Task 1.1 Familiarization with Existing TDG-related Studies and Reports

Review and provide brief summaries of the scope and results of the various TDG-related studies and evaluations that have been conducted since 1998 (through 2006) concerning gas supersaturation at the Boundary Project to serve as part of background information for 2007 study report. The studies and reports will include documents prepared by internal staff and consultants. Study and report references in this document include Parametrix (1998), Lemons (2000), Columbia Basin Environmental (2001, 2003), SCL (2003, 2005), and Schneider (2006). Documents related to the Ecology Pend Oreille River TMDL for TDG will require review and familiarization.

Task 1.2 Detailed Scope of Work for Phase 1 and Phase 2 Tasks

Based on the results of the review conducted in Task 1.1, develop a detailed scope of work for performing the remaining Phase 1 tasks and Phase 2 tasks including deliverables, cost estimates, and schedule in accordance with current SCL requirements relative to FERC, Ecology, and other regulatory processes. Performing Task 1.1 may suggest the need for additional investigations to address unresolved conditions such as: the effect of operational alternatives on spill through the various structures; the effect of the submerged cofferdam in the tailrace from original

construction; and the conditions creating, and the amount of, powerhouse flow entrainment into the spill.

Task 1.3 Existing Conditions – Data Collection, Analysis, Graphs and Tables

This task requires the Technical Contractor to work closely with SCL staff experienced with analyzing spill and non-spill related TDG impairment at the Project.

1.3.1 Analyze hourly and 15-minute interval TDG data reported by the USGS for the forebay and tailrace FMSs relative to Pend Oreille River flow data, Project discharge and spill volumes to provide gas saturation duration, frequency and related statistics for the 2007 study report. Describe and present data and statistics in tables and graphs.

1.3.2 Identify and describe TDG uptake mechanisms and hydrodynamics in the tailrace.

1.3.3 Briefly summarize the Project hydrologic record (January 2007) for the 2007 study report.

1.3.4 Evaluate methods and controls to reduce air admission requirements to decrease total dissolved gas. Under specific operating conditions, generating units #55 and #56 add TDG due to air admission at low gate openings (Lemons 2000; SCL 2003). This potential TDG impairment will be evaluated to identify gas abatement control measures.

1.3.5 Develop and implement 2007 TDG Monitoring Plan. The purpose of this task is to describe and/or verify the TDG exchange process and uptake mechanisms in the forebay, turbine discharge area (afterbay), and tailwater channel. This task will require planning, procuring, installation, collection of TDG data, and retrieval of TDG monitoring transects. The collected TDG data will be properly reduced to comply with or exceed current USGS QA/QC methods for water quality instruments, calibration, maintenance, and precision.

Task 1.4 7Q10 Flow Conditions

Evaluate 7Q10 flow relative to forebay elevations, generation, and tailwater ranges. The powerhouse capacity will decrease during extreme flood events due to increased tailwater elevations. This reduction in capacity will be estimated to refine the estimated required capacity of the TDG abatement alternatives (differences between 7Q10 and plant discharge flow).

Task 1.5 Estimate TDG Performance for Six Alternatives, Identify and Assess Potential Alternative Combinations

Parts A and B of this Task will occur concurrently to identify a potentially reasonable alternative or alternative combination that satisfies particular engineering analysis and design goals.

Task 1.5.A. Estimate TDG Performance for Six Alternatives or Alternative Combinations

Part A of Task 1.5 is to estimate TDG performance for the shortlist of six alternatives.

1.5.A.1 Propose and describe rationale for utilizing a specific method or analytical approach for estimating TDG performance based on existing information considering the unique characteristics of the Boundary Project.

1.5.A.2 Estimate or predict gas abatement performance for the shortlist of six operational and structural alternatives including potential alternative combinations.

1.5.A.2 (1) Briefly describe specific field-testing, surveys, and numerical techniques (DGAS-type of regression analysis, CRiSP methods, etc.) to estimate or predict TDG reduction performance to further assess each alternative based on previous analyses and professional judgment.

1.5.A.2 (2) Provide alternatives comparison of TDG performance relative to existing conditions and variable, forebay TDG levels.

1.5.B. Selecting Gas Abatement Alternatives

Part B of Task 1.5 is to assess whether a selected alternative or combination has a greater potential for gas abatement based on the following design goals defined for Alternative #1, #2, and #3:

Alternative #1 Maximum gas abatement measure to achieve the highest attainable level of improvement resulting in downstream TDG levels that are at least equal to or less than the TDG level at the forebay FMS during the 7Q10 flow, assuming the forebay TDG level is greater than 110 percent. This alternative shall reflect the alternative or alternative combination that comes closest to achieving the 110 percent standard.

Alternative #2 No net increase in TDG relative to forebay FMS TDG levels. This alternative shall pass the *design flow rate* (63,300 cfs) resulting in downstream TDG levels similar to the forebay FMS TDG levels during the 7Q10 flow.

Alternative #3 Account for other potential resource impacts. This alternative shall significantly reduce downstream TDG compared to existing conditions, while minimizing environmental impact, and cost of construction and operation of this alternative.

Task 1.6 Preliminary Design and Construction Approach

For the six alternatives and alternative combinations as a result of performing Task 1.5, briefly identify and describe geologic conditions at the Project, and identify potential location(s) and/or

alignment(s) using existing SCL drawings and related documents, as applicable. Identify and describe design and construction approach, constraints, and limitations associated with each alternative.

Task 1.7 Field Reconnaissance, Surveys, and Hydraulic Analysis

Summarize existing topography, bathymetry, sediment build up, and geologic characteristics where significant construction activities will occur based on assessing alignment or location of an alternative or alternative combination as a result of performing Tasks 1.5 and 1.6. This information is required to better estimate gas abatement performance and cost.

1.7.1 Provide design details required to minimize gas uptake at the discharge of any new alternative.

1.7.2 Estimate survival rates of fish passing through a new alternative to minimize potential negative effects on fish passing through the new structure.

1.7.3 Assess flow interactions downstream during a major flood event due to existing and new alternative discharge.

1.7.4 Assess effects of the new alternative on the operational efficiency of the powerplant.

Task 1.8 Preliminary Cost Estimates for Design and Construction

Prepare preliminary cost estimates for design and construction of the alternatives resulting from Tasks 1.5 through 1.7; identify applicable risk assessment methodologies relative to dam safety concerns (Hartford 2004); and conduct economic feasibility analysis (Ecology 2006b). Identify and describe all assumptions, constraints, and limitations to inform the Phase 2 work effort.

Task 1.9 Proposal for Phase 2 Activities

Propose activities for Phase 2 of this study effort to review with relicensing participants as a result of performing Tasks 1.1 through 1.8. Further refinement of the alternatives developed in Phase 1 are anticipated to require field reconnaissance studies and hydraulic modeling to resolve uncertainties associated with the alternative designs and specific application at the Project.

Task 1.10 Draft and Final Phase 1 Reports

Prepare Draft and Final Phase 1 study reports for review by relicensing participants including photographs, graphs, tables, and other illustrations needed to effectively describe the tasks, methodologies, and their results.

Phase 2 Activities and Content for Study Report

Phase 2 of this study will generally consist of the following ongoing, desktop, and fieldwork tasks as listed and described below. The Phase 1 report will inform refinements to the Phase 2 tasks listed in this study plan and as a result, the Phase 2 tasks will be updated in 2007/2008.

On-going Activities

- The USGS will continue to collect and perform QA/QC on the forebay and tailrace FMS data.
- Results will be developed and made available from other studies in 2007 that inform the TDG study process.

Tasks for Phase 2 of Study

Task 2.1 2008 TDG Monitoring Plan

The purpose of this task is to describe and/or verify the TDG exchange process and uptake mechanisms in the forebay, turbine discharge area (afterbay), tailwater channel, and other locations identified as a selected Alternative Nos. 1, 2, and 3 (refer to Phase 1, Task 1.5). This task will require planning, procuring, installation, collection of TDG data, and retrieval of TDG monitoring transects. The collected TDG data will be properly reduced to comply with or exceed current USGS QA/QC methods for water quality instruments, calibration, maintenance, and precision.

2.1.1 Evaluate mixing zone dynamics for the USGS tailrace FMS based on 2006 and 2007 monitoring data for the two probes.

Task 2.2 Phase 2 Report Content for Executive Summary

Summarize Phase 1 study efforts and existing dissolved gas conditions for 2008/2009 Study report. Identify and describe operational, structural and/or combination of gas abatement measures resulting from Phase 1 efforts.

Task 2.3 Conceptual and Feasibility Analysis of Alternatives

Perform and present results of hydraulic analysis, total dissolved gas evaluation, surveys, specific field testing, and hydraulic modeling for each applicable gas abatement alternative. The hydraulic analyses for the penstock bypass and tunnel alternatives primarily consist of determining acceptable tunnel/pipe, valve, gates, and submergence requirements. Potential cavitation will need to be accounted for in the analysis. The feasibility level of evaluation will include hydraulic model studies to assist with the final feasibility level designs and evaluation of TDG abatement measures.

2.3.1 Field Surveys and Hydraulic Modeling. Computational and/or physical hydraulic modeling is anticipated to characterize existing conditions and to optimize new proposed modifications. The hydraulic modeling will provide a better understanding of gas transfer mechanisms where the powerplant and spill flow interact, and contribute to testing and optimizing the design of an alternative or alternative combination. A reasonable assumption is that model testing continues for at least one year.

Task 2.4 Effects of Alternatives on Other Resources

Describe and estimate potential effects on resources due to gas abatement alternative(s) selected as a result of Phase 1 tasks. Resources include water quality, fish and aquatics, operations, in-river construction, plant and wildlife, air quality, cultural, and aesthetics. (Refer to the criteria used to screen alternatives). Based on other resource study results, the evaluation and determination of a "preferred alternative" may need to assess the effects on fish (Neitzel 2000).

Task 2.5 Cost Estimates for Design and Construction

Refine and update Phase 1 cost estimates for design and construction based on final Phase 1 report and results of Phase 2, Tasks 2.1 through 2.4. An economic feasibility analysis (Ecology 2006b) and/or dam safety risk assessment (Hartford 2004) of alternatives may need to be performed based on Phase 2 study results.

Task 2.6 Planning the TDG Elements of Application for 401 Certification

Discuss evaluation and implementation of TDG alternative(s) relative to 401certification process. This task includes proposed schedule, licensing, permitting, and environmental reviews required by Ecology, USACE, EPA, USFWS, WDFW, SHPO, and other agencies as applicable.

Task 2.7 Gas Abatement Plan

Draft a gas abatement plan for the 401 certification application including monitoring and reporting activities that will be undertaken during the new license term, such as those needed to evaluate the effectiveness of TDG control measures or other mitigation. This is a separate document from the study reports.

Study Implementation Planning

TDG study efforts and associated evaluations may extend into 2009 and beyond during development of the application for 401 certification, Preliminary Licensing Proposal, and License Application.

As described in section 1.2.3 of this PSP, by the end of 2006, SCL plans to have selected and retained the Technical Consultant that will implement the relicensing study program. Following the filing of the Revised Study Plan (RSP) and prior to actual initiation of the studies, the Technical Consultant will participate, with SCL and relicensing participants, in developing and refining any remaining details related to implementation of the studies.

3.2.6. Work Products

The following official work products are required for completion of the Evaluation of TDG and Potential Abatement Measures:

- *Draft and Final Phase 1 study reports for relicensing participant review and comment* — The Phase 1 report is expected to include (but not be limited to) the following contents:

- Section 1: Executive Summary. Background, study goals, and summarize existing and Phase 1 information.
- Section 2: Existing Project Conditions and Facilities. Describe existing hydrologic and TDG conditions relative to Project facilities. Include existing drawings of Project features, graphs and tables showing rating curves, generation, flow and TDG data. Describe TDG uptake mechanisms and hydrodynamics in the tailrace.
- Section 3: Gas Abatement Alternatives. Summarize identification and development of alternatives. Identify and present rationale for determination of top three ranked alternatives (i.e., Alternative Nos. 1, 2, and 3).
- Section 4: Gas Abatement Performance. Describe estimated gas abatement performance for the proposed six alternatives and Alternative Nos. 1, 2, and 3. Describe and graphically provide a comparison and summary of the results.
- Section 5: Field Reconnaissance, Surveys, and Hydraulic Analysis. Summarize existing topography, bathymetry, sediment build up, and geologic characteristics where significant construction activities will occur based on assessing alignments or locations of alternatives listed in Section 3.
- Section 6: Design and Construction Cost Estimates. Preliminary estimates for design and construction costs including O&M will be developed for Alternative Nos. 1, 2, and 3 resulting from performing Phase 1, Task 1.5. All assumptions will be identified and described for each specific cost line item. Line items will include, but not be limited to: (1) survey(s), potential land acquisition, engineering design, analysis and modeling required to design the alternative; (2) construction materials and installation cost including taxes and contingencies; (3) permitting and environmental review document preparation and meetings; and (4) City of Seattle and SCL contracting administration and overhead.

- *Draft and Final Phase 2 study reports for relicensing participant review and comment* — The Phase 2 report is expected to consist of similar contents as the final Phase 1 report, with updates and modifications, and the addition of the following work efforts and report contents:
  - Environmental Effects of Alternative and Alternative Combination
  - Identification of environmental resources and how they may be affected by the alternatives, including potential impacts during construction and longer-term operational effects
  - Field Surveys, Hydraulic Modeling and Prototyping
  - Revised Gas Abatement Performance
  - Revised Design and Construction Estimates
  - Identification of Permits and Environmental Review for the 401 certification process
  - Gas Abatement Plan for the 401 certification application

3.2.7. Consistency with Generally Accepted Scientific Practice

The methods described herein have been developed based on review of regional TDG-related efforts (USBR 1998, Avista 2000, USACE 2000, Grant County PUD 2002, and Chelan County PUD 2003) and in consultation with the resource agencies, tribes, and other stakeholders participating in the Boundary Project relicensing process. The study approach and methods are consistent with Ecology's Water Quality Certifications for Existing Hydropower Dams, Guidance Manual (Ecology 2005).

3.2.8. Consultation with Agencies, Tribes, and Other Stakeholders

As indicated above, SCL met with Ecology in 2005 to identify issues to be addressed as part of the 401 certification process. Workshops on the Boundary Project relicensing were held in Spokane, Washington, on November 30, 2005, and February 16, 2006. Water Quality Workgroup meetings were held in Spokane on May 22, 2006, July 25, 2006 and August 16, 2006, and in Metaline Falls, Washington, on June 29, 2006. Parties attending the Water Quality Workgroup meetings included Ecology, USFS, USFWS, Confederated Tribes of the Colville Reservation, the Kalispel Tribe of Indians, Columbia River Intertribal Fisheries Commission, BC Hydro, Pend Oreille County PUD, and Columbia Power Corporation.

At the May 22, 2006 Water Quality Workgroup meeting, SCL and relicensing participants discussed SCL's proposed TDG monitoring, testing, and study plan development process including 1) existing TDG operational testing and assessment, 2) Ecology's approach to the Pend Oreille River TDG TMDL, 3) gas abatement measures applied at other dams in the region, 4) SCL's TDG abatement measures matrix, and 5) potential PSP study plan elements. SCL confirmed that the eventual solution to TDG abatement at the Project could consist of a combination of structural and operational elements.

At the June 29, 2006 Water Quality Workgroup meeting, SCL and relicensing participants discussed the process by which SCL had developed a series of potential TDG abatement alternatives and preliminarily assessed the application and function of those alternatives. SCL explained that when a shortlist of potential alternatives was identified, study plans would be developed to fully evaluate the effectiveness of the alternatives on the list. SCL provided an overview of potential TDG abatement alternatives from the four following categories: operational alternatives for existing structures, spillway structural modification alternatives, sluice gate structural alternatives, and new structure alternatives. SCL then presented a system developed to rank potential alternatives based on a range of weighted criteria.

At the July 25, 2006 Water Quality Workgroup meeting, SCL and relicensing participants discussed the ongoing preliminary assessment of the concepts and function of potential TDG abatement alternatives identified at the June 29 meeting. SCL described the criteria used to preliminarily evaluate the effectiveness of the alternatives and the ranking of the alternatives based on the criteria. SCL explained that it was currently performing a sensitivity analysis to assess the effect of individual criteria on the overall ranking of alternatives. SCL stated that a proposed shortlist of alternatives — that would be subjected to more detailed analysis — would be presented at the August 2006 workgroup meeting. SCL solicited comments from relicensing participants on the TDG alternatives matrix, including suggestions for additional or improved

criteria for evaluating potential alternatives. SCL suggested that relicensing participants share the matrix of alternatives and assessment criteria with engineers in their respective organizations.

At the August 16, 2006 Water Quality Workgroup meeting, SCL and relicensing participants discussed the process by which a shortlist of potential TDG abatement measures for the Boundary Project was identified. SCL explained that the cost criterion had been muted so that abatement measures had been evaluated solely on the basis of technical merit. SCL outlined the sensitivity analysis undertaken to assess the degree to which individual evaluation criteria had affected the overall ranking of potential measures and noted that the results of the sensitivity analysis showed that the following top six alternatives selected by SCL for further analysis were consistently indicated as the best potential approaches by the ranking criteria:

- Throttle Sluice Gates
- Roughen Sluice Gate Discharge
- New Right Abutment Tunnel with Submerged Discharge
- New Left Abutment Tunnel Intercepts Diversion Tunnel
- Penstock/Draft Tube By-Pass
- New Short Left Abutment Tunnel Next to Unit #51

Comments provided by relicensing participants on the draft study plan are summarized in Attachment 3-5 to this study plan and can also be found in the workgroup meeting summaries, available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/). Written comments provided on this study plan are also included in Attachment 3-5.

In its PAD/Scoping comment letter, filed with FERC on August 31, 2006 (USFS 2006), the USFS requested that "Any fish captured below the dam, in conjunction with other studies and during the spill periods, should be analyzed for characteristics of gas bubble trauma and documented with location, date, species, life stage and photo." SCL plans to conduct this analysis as described in section 3.2.4 of this study plan (under Need for Additional Information) and in the Fish Distribution, Timing, and Abundance Study plan (section 4.3).

3.2.9. Schedule

The schedule for completing the Evaluation of TDG and Potential Abatement Measures is provided in Table 3.2-4 and includes the current FERC deadlines, potential opportunities (tentative dates) for relicensing participants to review study plans and study results with SCL, and Ecology schedule for the Pend Oreille River TMDL for TDG process.

Table 3.2-4. Proposed Project Schedule for Evaluation of Total Dissolved Gas and Potential Gas Abatement Measures. (Subject to change by SCL.)

Phase	Target Date
Ecology files Draft TMDL for public comment	October 15, 2006
SCL submits Proposed Study Plan (PSP) to FERC	October 16, 2006
SCL presents PSP (TDG component) to Transboundary Gas Group	October 19, 2006
Stakeholders and SCL meet to review PSP	November 15, 2006
Ecology files Final TMDL for TDG	December 15, 2006
Stakeholder comments on PSP due to the FERC	January 15, 2007
Stakeholders and SCL meet to review Revised Study Plan	January 22 – 24, 2007 (specific date TBD)
SCL files Revised Study Plan with FERC	February 14, 2007
FERC Study Plan Determination	March 16, 2007
Phase 1 of study — Data Collection and Alternatives Assessment	March 2007 – October 2007
Phase 1 Report, Draft / Final	November 2007 / December 2007
Stakeholder comments Due for Phase 1 Draft Report	November 2007
Phase 2 of study — Evaluation of Alternatives	February 2008 – October 2008
Phase 2 Report, Draft / Final	November 2008 / December 2008
Stakeholder comments due for Phase 2 Draft Report	November 2008

3.2.10. Progress Reports, Information Sharing, and Technical Review

Both the draft and final study reports will be available to agencies, tribes, and interested stakeholders. 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.

3.2.11. Anticipated Level of Effort and Cost

The estimated effort and cost for performing Phase 1 of the study ranges from $450,000 to $600,000, subject to review and revisions as additional details are developed. The estimated effort and cost for performing Phase 2 of the study and developing a gas abatement plan for the Boundary Project ranges from $1,300,000 to $1,800,000.

3.2.12. Literature Cited

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3.3. Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus

During preliminary planning for the relicensing effort in spring 2005, SCL identified toxic substances (toxics) as an issue that needed to be addressed as part of the FERC relicensing and Washington State 401 certification processes. A Toxics Inventory and Screening was conducted by SCL in 2005 to identify toxics of potential concern in the Project area (R2 2006). The Toxics Inventory and Screening primarily focused on water quality data, but also reviewed sediment and fish tissue data and potential sources of contamination. Since the release of this report, an additional evaluation of toxics was conducted by reviewing information contained in the Environmental Protection Agency's (EPA) Preliminary Assessments and Site Investigations Report for the Lower Pend Oreille River Mines and Mills (Ecology and Environment 2002). The review of the EPA data is summarized in Attachment 3-4. Based on the results of these initial reviews, further study has been recommended for six toxics: arsenic, cadmium, lead, mercury, zinc, and PCBs. This study plan describes the next step in understanding the relationship between these toxics of concern and the Boundary Project. The proposed plan calls for a focused evaluation of existing information to determine whether the bioavailability of toxics of concern is influenced by the Boundary Project, i.e., establish a Project nexus, and to determine the need for a Phase 2 Toxics Assessment that would focus on field data collection. This Phase 1 Toxics Assessment is scheduled to begin in early 2007.

3.3.1. Nexus between Project Operations and Effects on Resources

Toxics of potential concern in the lower Pend Oreille River are five metals associated with historical and current mining activity and PCBs. As noted above, a Toxics Inventory and Screening was conducted by SCL in 2005 and additional evaluation of potential contaminants was conducted in 2006. Based on the results of the screening and additional evaluation, six toxics of concern were identified: arsenic, cadmium, lead, mercury, zinc, and PCBs.

Reservoirs can impact the presence and transport of toxics in several ways. The decrease in river velocity due to impoundment tends to increase the accumulation of fine sediment upstream of dams, and thereby the potential for the accumulation of toxics in those sediments (Ecology 2005). In addition, TDG supersaturation may result in the oxidation of dissolved metals into an insoluble particulate form, potentially affecting the bioavailability of toxics through metals precipitation. Lastly, fluctuating water levels within reservoirs may lead to erosion and re-suspension of fine particles containing toxics, thereby increasing the concentration of toxics in the water column, in surface sediments, and at the sediment-water interface. If maintained in these locations, the biological availability of toxics would potentially increase.

To identify any connections between the toxics of concern and Project operations, and to design an appropriate toxics sampling program, additional information on potential contaminant pathways in Boundary Reservoir is required.

3.3.2. Agency Resource Management Goals

In addition to providing information needed to characterize Project effects, the proposed assessment will provide information to help agencies with jurisdiction over water quality resources in the Project area identify appropriate conditions for the new Project license pursuant to their respective mandates. Boundary studies are specifically designed to meet relicensing requirements, but may also be relevant to recent or ongoing management activities by other agencies. A brief description of the related resource management goals, by entity, follows.

Washington Department of Ecology (Ecology)

Ecology's relevant toxic substance surface water quality standards, based on a hardness of 80 mg/L $CaCO_3$ and a pH of 8.0, are presented in Table 3.3-1.

Table 3.3-1. Washington Department of Ecology toxic substance surface water quality standards (WAC 1997).

Toxic Substance	Acute Criteria (µg/L)	Chronic Criteria (µg/L)
Toxic Substances (Aquatic Life/Public Health Category)	Must be below those which have the potential to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon that water, or adversely affect public health.	
Arsenic	360	190
Cadmium	3.7	1.03
Lead dd	51	2.0
Mercury s	2.1[3]	0.012[4]
Polychlorinated Biphenyls (PCBs)	2[2]	0.014[2]
Zinc	94.7[3]	86.5[4]

Notes:

Standards calculations assumes a hardness of 80 mg/L $CaCO_3$ and a pH of 8.0

1 An instantaneous concentration not to be exceeded at any time
2 A 24-hour average not to be exceeded
3 A 1-hr average concentration not to be exceeded more than once every three years on the average.
4 A 4-day average concentration not to be exceeded more than once every three years on the average

There are no specific Washington State standards for toxics in freshwater sediments. Instead, Ecology has established freshwater sediment quality values based on 33 studies and tested the efficiency and sensitivity that sediment quality values have in predicting biological effects. As a result of these studies, two levels of thresholds were developed, the Lowest Apparent Effects Threshold (LAET) and the Second Lowest Apparent Effects Threshold (2LAET), both of which are presented in Table 3.3-2 for relevant toxics. Surface soil guidelines, also provided in Table 3.3-2, are based on the Model Toxics Control Act (MTCA) and Cleanup Regulation (for greater detail on these thresholds and guidelines, refer to Attachment 3-4).

Table 3.3-2. Surface soil and freshwater sediment cleanup levels, effects levels, and sediment quality values.

Constituent	Surface Soil[1]	Freshwater Sediment		
	MTCA Method A Cleanup Level for Unrestricted Land Use (mg/Kg)	Typical Background (mg/Kg)[2]	Lowest Apparent Effects Threshold (mg/Kg)[3]	Second Lowest Apparent Effects Threshold (mg/Kg)[3]
Arsenic	20.0	1.1	31.4	50.9
Cadmium	2.0	0.1-0.3	2.39	2.9
Lead	250	4-17	335	431
Zinc		7-38	683	1080

Notes:

1 Ecology Table 740-1
2 NOAA Screening Quick Reference Table for Inorganics in Solids
3 Ecology Sediment Quality Values (Michelsen 2003)

U.S. 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 River basin and provides a management plan for protection of the basin's water quality. This report identifies management objectives for the Clark-Fork River basin, Lake Pend Oreille, and the Pend Oreille River basin. Only one objective is applicable to toxics in the Pend Oreille River: Improve Pend Oreille River water quality through macrophyte management and tributary nonpoint source controls. Actions as related to this objective and toxics include:

1. Develop and maintain programs to educate the public on their role in protecting and maintaining water quality.
2. Establish and maintain a water quality monitoring network to monitor effectiveness and trends and to better identify sources of pollutants.

Water Resource Inventory Area (WRIA) 62

Numerous agencies and stakeholders in 1998 formed the Water Resource Inventory Area (WRIA) 62 planning unit, the goal of which 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 five goals and related objectives for water quality. The applicable goals and objectives as related to surface water quality and toxics in the Pend Oreille River are described below. This proposed toxics assessment may help in understanding pathways by which toxics might influence water quality and the ability to meet standards.

- WQUAL-1: WRIA-wide coordination of water quality monitoring.
- WQUAL-3a: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for tributary streams that originate within WRIA 62.

  Objective: Remove tributary streams in WRIA 62 from the 303(d) list of impaired waters by meeting State and tribal (where appropriate) water quality standards in impaired tributary streams
- WQUAL-3b: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for the mainstem of the Pend Oreille River.

  Objective: Meet State and tribal (where appropriate) water quality standards in the mainstem Pend Oreille River
- WQUAL-5: Protect water bodies of high water quality and improve water quality of impaired water bodies.

  Objective: Maintain compliance with state water quality standards and prevent degradation of waters that meet or exceed state water quality standards in WRIA 62.

USDA Forest Service (USFS)

Portions of the Boundary Project are located within the Colville National Forest. As such, the USFS is a participating stakeholder in the relicensing of the Boundary Project. The information collected as part of the proposed Boundary toxics assessment will support management goals and objectives identified by the USFS for the Pend Oreille Basin. The Land and Resource Management Plan, completed in 1988, is applicable to water quality and management within the basin (USFS 1988). This plan identifies five management activities in the soil and water division including:

1. Coordinate with other resources to provide support and advice that helps protect the soil and water resource.
2. Monitor the effect of the Forest Plan activities on the soil and water resources.
3. Restore damaged soil and water resources.
4. Work with Washington State Department of Ecology or others as needed to secure water rights.
5. Coordinate with other agencies or interested parties.

3.3.3. Study Goals and Objectives

The goals of the Phase 1 Toxics Assessment are to identify any pathways of contamination and/or mechanisms for changes in bioavailability in Boundary Reservoir for toxics of concern and to evaluate the effect of Boundary Project operations on these pathways and/or mechanisms. Developing a more complete assessment of the effect of Project operations on the availability or conveyance of one or more of the toxics of concern will allow for the development of an appropriate toxics sampling plan (e.g., biota, water column, and/or sediments) for Boundary Reservoir (i.e., Phase 2 of toxics evaluations in Boundary Reservoir). Only after the Phase 1

Toxics Assessment is completed will it be possible to begin constructing more specific triggers related to particular toxics, pathways of contamination, or mechanisms for changes in bioavailability. Specific objectives of the Phase 1 study are listed below.

Objective 1. Update data/information for toxics of concern summarized in the Toxics Inventory and Screening and the EPA data review with any new studies or reports.

Objective 2. Characterize existing conditions in Boundary Reservoir that are relevant to toxics contamination and bioaccumulation.

i) Use existing information to describe reservoir surface elevation changes, flows, velocities, sediment dynamics, temperature, TDG, and DO.
ii) Identify data gaps for information necessary to understand a potential Project nexus.

Objective 3. Determine the potential pathways of contamination and mechanisms affecting bioavailability for arsenic, cadmium, lead, mercury, zinc, and PCBs that could occur in Boundary Reservoir.

i) Document what conditions are conducive to, alter, or prevent leaching of arsenic, cadmium, lead, and/or zinc in nearby waters.
ii) Document what conditions are conducive to, alter, or disrupt the precipitation of arsenic, cadmium, lead, and/or zinc in aquatic environments.
iii) Document factors that influence the rate of methylation of mercury.
iv) Document current sources and probable pathways for PCBs into Project waters and biota present within Project waters.
v) Document what conditions are conducive to the transformation of lead into inert or bioavailable forms.
vi) Document the level of cadmium that begins to disrupt primary production.

Objective 4. Determine areas within Boundary Reservoir where sediments with grain size characteristics similar to mine waste rock and/or tailings are likely to have been deposited.

i) Document historical location, volume, and particle size of mine waste rock and/or tailings supplied to the Pend Oreille River, including potential input from Box Canyon Dam.
ii) Determine the capacity of the Pend Oreille River to transport sediment with similar grain-size characteristics as the mine waste rock and/or tailings over a wide range of flow conditions.
iii) Based on daily flow records for the Pend Oreille River prior to September 1967, determine the capacity of the Pend Oreille River to transport mine waste rock and/or tailings on an annual basis prior to closure of Boundary Dam and the initiation of Boundary Project operations.
iv) Determine if there was potential for the Pend Oreille River in the Project area to have received large deposits of mine waste rock and/or tailings just prior to closure of Boundary Dam and the initiation of Boundary Project operations.

v) Identify zones of sediment deposition within Boundary Reservoir; these zones of deposition will contain sediment from all sources, of which mine waste rock and/or tailings are expected to be a small portion of the total accumulation of sediment.

vi) Determine where sediments with grain-size characteristics similar to mine waste rock and/or tailings are likely to have accumulated in Boundary Reservoir between 1967 and 2006.

Objective 5. Identify any relationship between Boundary Reservoir operations and pathways of contamination and/or mechanisms of bioavailability for the six toxics of concern (Ar, Cd, Pb, Hg, Zn, & PCBs).

i) Describe the conditions identified in Objective 3 that are currently occurring in Boundary Reservoir.

ii) Document the data or factual evidence that indicates a Project-related influence on a pathway of contamination or mechanism of bioavailability (i.e., a Project nexus) or the lack thereof.

Objective 6. Develop an appropriate sampling plan for the toxics of concern (Phase 2 of the overall toxics evaluation) that focuses on conditions specific to Boundary Reservoir. Examples (not an exhaustive list) of sampling considerations that may be relevant for developing plans in Boundary Reservoir follow.

i) Determine the best indicator organism(s) for cadmium and lead based on proposed mechanism of action and conditions in Boundary Reservoir.

ii) Determine the appropriate form of mercury to measure and the best location(s) for making measurements.

iii) Determine the most appropriate method for mercury analysis.

iv) Determine the best indicator organism for bioaccumulation of PCBs, considering the likely mechanism of contamination and potential Project nexus.

3.3.4. Need for Study

Summary of Existing Information

Toxics can potentially enter the Boundary Project area through river and stream point and nonpoint sources, fallout from the atmosphere, and recycling from sediments. Nonpoint source pollution is caused by rainfall or snow melt moving over and through the ground and picking up natural and human-made pollutants in the process. The main contaminant sources of concern are those associated with historical and current mining activities. A detailed summary of available information on location and historical mining activities of the mines in the Project area (the Metaline Mining District) was included in Appendix 4-1 of the Boundary Project relicensing Pre-Application Document (PAD).

Mining in the Pend Oreille River area dates back to 1855 (Ecology and Environment 2002); however, permanent settlement of the area did not occur until 1884. The Lehigh Cement Co. Plant and quarries were developed in 1904 followed by the opening of several lead-zinc mines.

The Lehigh Cement Company operated a cement plant in Metaline Falls from 1914 to 1989. Cement kiln dust from the cement-making process was landfilled on site and capped in 1996. Groundwater contamination below the landfill and downgradient now requires cleanup; contaminants include arsenic, chromium, lead and manganese. Contaminated groundwater flows into Sullivan Creek and Sullivan Creek flows into the Pend Oreille River. Extensive mining did not occur in the area until after dynamiting of the Box Canyon channel in 1906, which allowed for navigation downstream to Metaline Falls. The Pend Oreille River area was home to two of the largest mines in Washington, the Pend Oreille Mine and Grandview Mine. The Pend Oreille Mine is a lead and zinc mine, which by 1964 had produced 63 percent of the total lead and zinc mined (Baltien 1996) in Pend Oreille County. Between 1952 through 1967, mine tailings were discharged directly to the Pend Oreille River, while after 1967 tailings were deposited on land at the mine site (Ecology 2004). The Pend Oreille Mine closed in 1977, but was reopened in early 2004 by Teck Cominco. Claims for the Grandview Mine were patented before 1900 and between 1940 to 1951 production was l.2 million tons of zinc, lead, and traces of silver (Baltien 1996). However, by 1964 the Grandview Mine was reported to be exhausted and the operation was closed.

Historically, metal extraction and processing were relatively inefficient, yielding large volumes of metal-rich tailings that were deposited to nearby streams (Maret and Skinner 2000). Mine tailings in the Boundary Project vicinity typically contain elevated levels of arsenic, cadmium, copper, lead, mercury, and zinc (Ecology and Environment 2002). As described in Appendix 4-1 of the PAD, the Pend Oreille Mine is currently the only active mine in the Project vicinity.

Point sources are authorized discharges to the Pend Oreille River, regulated by the Washington Department of Ecology through the National Pollutant Discharge System (NPDES) permitting process. Any authorized discharge through the NPDES permitting program requires routine monitoring and reporting of all discharges to the river. The Pend Oreille Mine, the wastewater treatment plants associated with the small municipalities along the river and the Ponderay Newsprint Company all manage outfalls to the Pend Oreille River.

A nonpoint toxic of concern is PCBs. PCBs were banned in the United States in the 1970s, but continue to be a problem in the environment. PCBs have been found in the tissue of fish captured in Boundary Reservoir at concentrations above the Ecology/EPA recommended health standard for human consumption of fish (see section 4.4.5.5.3 of the PAD, Toxic Compounds [SCL 2006] for a thorough description of existing information on toxics in the Project area). The source of PCB contamination is unknown.

Other pathways of toxics into the Project area are from atmospheric fallout and recycling from the sediments. No information is available regarding atmospheric fallout. Recycling from sediments has been shown in some cases to be an important pathway. The transport of dissolved chemical species between the water column and the underlying sediment is termed benthic flux (USGS 2000). Benthic flux is considered to be positive when the transport of metals is from the sediment into the water column, but can also be negative when the transport of metals is from the water column into the sediment. Several factors affect the transport of metals between the sediment and water column including advection, diffusion, oxidation-reduction reactions, and several biological processes. At the sediment-water interface, advection is the transport of

metals by the movement of the overlying water. Diffusion refers to the transport of metals between the sediment and water column as a result of a concentration gradient. Metals temporarily stored in sediments may dissolve in pore waters and diffuse to overlying waters due to gradient concentrations (Zago et al. 1999). If the concentration of a metals species is greater in the sediment pore water than in the water column, there is a tendency for the metals to transfer from the sediment into the water, and vice versa.

The geochemistry of the sediment and overlying water is also an important factor in the magnitude of benthic flux by metal species. Metal speciation is a function of pH, redox potential, and the presence of complexing ligands such as carbonate, dissolved organic carbon, and sulfide (IWRRI 2002). One example is the reduction of iron from ferric to ferrous forms under anoxic conditions. In this example, the presence or absence of oxygen influences the benthic flux of iron. Anoxic conditions favor the dissolution of certain metal oxides and can thereby enhance metal desorption and mobilization (IWRRI 2002). In this case, the concentration gradient of one species is interrelated with that of another and the release of one solute only occurs when another solute is depleted. Ligands, molecules that may donate an electron to a metal by a covalent bond, can also be a factor. Both dissolved sulfides and organic molecules are ligands. Sulfides, for example, can inhibit the release of trace elements by the formation of insoluble sulfidic minerals.

Other biological factors may also influence the rate of benthic flux. For example, bioturbation, the mixing of sediment by burrowing, ingestion, and defecation by benthic communities, can increase the sediment-water interface affecting the chemical fluxes between the sediment and water column. Similarly, bioirrigation, the flushing of burrows with overlying waters by benthic organisms, can also enhance the exchange of dissolved solutes.

In order to determine which toxics may be present within Boundary Reservoir, two reviews of toxics have been conducted, as noted above. The first, the Toxics Inventory and Screening was conducted by SCL in 2005 to identify toxics of potential concern in the Project area, i.e., those for which recent exceedances of water quality standards have been documented in the existing literature and for which there is thought to be a potential Project nexus (R2 2006). (The second review, an additional evaluation of potential contaminants, was conducted in 2006 and is discussed in Attachment 3-4.) Based on results of this review of existing information, toxics were grouped into one of two categories: low concern or medium concern (refer to the Toxics Inventory and Screening for more detail). No toxics of high concern were identified. Toxics of low concern will receive no additional evaluation as part of the FERC relicensing and 401 certification processes. The four toxics (cadmium, lead, mercury, and PCBs) determined during the Toxics Inventory and Screening to be of medium concern and with a potential for a Project nexus will be further evaluated in this Phase I Toxics Assessment study. Below is a summary of the initial assessment of these four toxics completed during the Toxics Inventory and Screening (R2 2006).

Cadmium — Cadmium is a natural element found in soils and rocks and is often extracted during the production of other metals such as zinc, lead, and copper. Boundary Reservoir operations could affect cadmium concentrations through toxics accumulation, metals precipitation, or erosion and leaching. There were five dissolved concentrations and three total concentrations

exceeding the cadmium criteria in the 1970s and in 1985 at the Metaline Falls and International Border water quality monitoring stations. Dissolved cadmium data collected in the early 1990s at the Newport station were below detection limits. EPA found elevated levels of cadmium in soils at the Josephine, Grandview, and Oriole abandoned mines and at the Pend Oreille Mine site (Ecology and Environment 2002). Cadmium is considered of medium concern given the lack of recent measurements in the Project area and the potential contamination sources from active and abandoned mines (R2 2006).

Lead — Operations of Boundary Reservoir could influence lead contamination through toxics accumulation and erosion and leaching. Historical measurements collected between 1975 and 1991 at the Newport and International Border stations show exceedances of dissolved lead concentrations beyond the chronic water quality standard. Measurements exceeding the chronic criterion of approximately 2 µg/L were 10 µg/L (7/11/1977), 10 µg/L (10/16/1979), and 7 µg/L (11/6/1985). The measurement exceeding the acute criterion of approximately 51 µg/L was 500 µg/L (12/8/1975). The mean value of recent total lead concentrations collected by the Kalispel Tribe in Box Canyon reservoir is below water quality standards, but the standard deviation of the data suggests a recent exceedance of the chronic standard. However, this measurement is of the total concentration and the standard is based on the dissolved fraction, which may be much lower. Two recent readings of lead collected in Boundary Reservoir did not show water quality exceedances. The current source of lead is assumed to be runoff from abandoned mine sites. Lead may also be discharged in effluent from the Pend Oreille Mine, but these discharges must meet water quality guidelines outlined by Ecology in the mine's NPDES permit. Given the exceedances and the current sources of contamination from abandoned mine sites, lead is considered of medium concern (R2 2006).

Mercury — Mercury is a naturally occurring metal that can take several forms in the environment. In soil and water, bacteria can form methylmercury, a form that can accumulate in fish tissue. The methylation of mercury is found to be more pronounced in wetland areas and to be enhanced by low DO, increased nutrients, and increased temperature. Current sources of mercury contamination include abandoned mine sites and effluent from the Pend Oreille Mine. Boundary Project operations could affect contamination of mercury through increased methylation rates and erosion. Absence of recent data and uncertainty associated with previous data due to historically high method detection limits make qualitative assessment of mercury contamination difficult. Given the lack of recent data, the current sources in the Project area, and the ability of mercury to bioaccumulate, mercury is considered of medium concern (R2 2006). Additional assessment of the potential for mercury contamination in Boundary Reservoir is needed.

Polychlorinated Biphyenyls — PCBs are man-made mixtures of chlorinated compounds used as coolants and lubricants in electrical equipment. Manufacture of PCBs was banned in 1977. PCBs bind strongly to soil and adhere to organic compounds and sediments. They are also taken up by small organisms and can accumulate in fish. The operation of Boundary Reservoir can potentially influence the contamination of PCBs through erosion caused by the daily fluctuation of reservoir levels. An Ecology fish tissue verification study completed in 2004 found PCBs above the recommended health standard for the consumption of fish. In Boundary Reservoir, total PCB fish tissue concentrations were measured at 16.8 µg/Kg ww and 14.5 µg/Kg ww in

largescale suckers, 7.4 µg/Kg ww in northern pike minnows, and less than detection in yellow perch. The NTR criterion for total PCBs is 5.3 µg/Kg wet weight. To address PCB contamination from a regional perspective, this study also compared total PCB concentrations in the Pend Oreille River to other fish tissue samples collected in Washington state. This comparison found total PCBs collected in the Pend Oreille River to fall below the 30th percentile. PCB concentrations of fish tissue samples of largescale suckers collected in the Pend Oreille River are low relative to other samples. As a result, the Ecology report suggested that a TMDL specific to the Pend Oreille River is not necessarily warranted, but that perhaps a statewide approach is better. Despite the documented bioaccumulation of PCBs in fish tissue located in the Project area, PCBs are considered to be of medium concern because levels are low compared to other statewide samples and given the conclusions of the Ecology fish tissue verification study (R2 2006). More information is needed to assess PCBs in Boundary Reservoir.

The Toxics Inventory and Screening reviewed all types of toxics data (water, sediment, and fish tissue), but mainly focused on available water quality data. As described above, SCL has conducted an additional screening effort that reviewed the mine and mills sampling data reported in the Preliminary Assessment and Site Investigation Report prepared by EPA (Ecology and Environment 2002). Unlike the Toxics Inventory and Screening, the EPA review focuses on the toxicity of sediment samples taken from mine sites rather than water samples in the Pend Oreille River. The recent review of EPA toxicity data is described in Attachment 3-4.

In the EPA study, 21 active mines (including Pend Oreille Mine, 2 miles downstream, or north of, Metaline Falls) and abandoned mine sites along the Pend Oreille River from Metaline to the international border were assessed. Of the 21 sites visited, 5 were found to have potential contamination sources. At these five sites, sediment, surface soil, and some water quality samples were collected and their concentrations were evaluated by EPA for determination of those that were "elevated" or "significant" compared to background levels. SCL reviewed the data for elevated/significant toxics identified in the EPA report and compared it to regional toxicity guidelines and contaminant toxicity information in order to determine what contaminants should be considered in more detail as part of SCL's Boundary relicensing studies. Fourteen elevated or significant toxics were found and subsequently evaluated.

A two-tiered system was used to compare elevated/significant toxics with scientific criteria (refer to Table A-1 in Attachment 3-4). The first tier compared concentrations of toxics to Ecology's freshwater sediment and surface soil guidelines (refer to Attachment 3-4 for details and references). If the concentration of a toxic substance within EPA samples was below these guidelines, then the toxic was not considered for further analysis. If the concentration of a toxic within EPA samples exceeded guidelines, then the second tier criteria were evaluated. The second tier consists of three separate criteria: 1) was the constituent detected in a waterway or from a target sample (as defined in Attachment 3-4), 2) was the constituent of medium or high toxicity (as described in Attachment 3-4), and 3) was there documented reoccurrence of elevated/significant levels of the toxic within the basin. If the toxic met the first tier criteria and two or more of the second tier criteria, then it was recommended for further study.

Of the 14 constituents evaluated, 4 (arsenic, cadmium, lead, and zinc) were recommended for further study (Table A-5 in Attachment 3-4). The other 10 (barium, chromium, copper, DDT, manganese, mercury, nickel, selenium, silver, and vanadium) were recommended for omission. Eight of the nine toxics were omitted because their concentrations did not exceed state guidelines. Only one toxic, silver, exceeded state guidelines but was omitted because it did not meet the second tier criteria. A summary of the four toxics recommended for further analysis based on review of data in the EPA report is provided below.

Arsenic — Arsenic is a naturally occurring element that is used to preserve wood and used in some pesticides (US Dept of Health and Human Service 2006). Arsenic can be toxic in the environment. Inorganic forms are more toxic to organisms in the environment than organic forms, and, among inorganic forms, arsenite is more toxic than arsenate (Greenfacts 2006). Arsenite is thought to be toxic because it binds to sulfhydryl groups, which are found on proteins. Arsenate affects the key energy producing process that takes place in all cells. Arsenic compounds can cause short-term and long-term effects in plants and animals including death, inhibition of growth, photosynthesis and reproduction, and behavioral effects (Greenfacts 2006). Arsenic-contaminated environments are characterized by limited species abundance and diversity. Based on the above information, arsenic was classified as having high biological toxicity. Arsenic concentrations were found to have values exceeding surface soil guidelines. Although there was low reoccurrence within the watershed, given the elevated levels of arsenic found in target samples and its high toxicity, it is recommended that arsenic be included in the toxic assessment study.

Cadmium — Cadmium is a natural element found in soils and rocks and is often extracted during the production of other metals such as zinc, lead, and copper. Cadmium is highly toxic and bioaccumulates at all trophic levels, accumulating in the livers and kidneys of fish (Sindayigaya et al. 1994). Cadmium can be toxic to plants at lower soil concentrations than other heavy metals and is more readily taken up than other metals. Based on the information above, cadmium is considered to be of high biological toxicity. Based on the tier 1 and tier 2 assessment criteria, it is recommended that cadmium be included in the toxic assessment. Note that cadmium was already recommended for inclusion in further relicensing studies based on the water quality assessment described in the Toxics Inventory and Screening.

Lead — Lead adversely affects algae, invertebrates, and fish. Fish exposed to high levels of lead exhibit a wide range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988). Lead can cause reduced growth, photosynthesis, mitosis, and water absorption at elevated levels in plants (Eisler 1988). Lead can be bioconcentrated from water, but does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Eisler 1988). Lead partitions primarily to sediments, but becomes more bioavailable under low pH, hardness and organic matter content. Lead bioaccumulates in algae, macrophytes and benthic organisms, but the inorganic forms of lead do not biomagnify. Based on the information above, lead is considered to be of medium biological toxicity. It is recommended that lead be included in the toxic assessment study because it met the tier 1 criteria and three of the tier 2 criteria. Note that lead was already recommended for inclusion in further relicensing studies based on the water quality assessment described in the Toxics Inventory and Screening.

Zinc — Zinc is a common element found in air, soil, and water. Zinc is currently, and was historically, found adjacent to the Project area. It is also used in industry to make paint, dyes, wood preservatives, and ointments. Elevated levels of zinc can adversely affect the growth, survival, and reproduction of aquatic plants and animals (Eisler 1993). Based on the information above, zinc is considered to be of medium biological toxicity. Zinc meets the tier 1 criteria as well as three of the tier 2 criteria and should therefore be included in the toxic assessment study.

Two of the four toxics of concern recommended for further analysis after review of the EPA data were among the four recommended for further analysis in the Toxics Inventory and Screening (R2 2006). Thus there are six total toxics of concern that are recommended for the Phase 1 Toxic Assessment: arsenic, cadmium, lead, mercury, PCBs, and zinc.

Need for Additional Information

The Toxics Inventory and Screening evaluated toxics in the Project area based on water column information, and also reviewed sediment and fish tissue information and potential sources of contamination. Toxics with little or no information, recent exceedances of water quality standards, or potential sources of contamination in the Project area were considered to be of medium concern. The EPA report evaluated toxics in the Project area based on sediment data and the presence of contaminants in waterways. These two assessments identified toxics of concern in the Project area, but neither the screening nor the review of the EPA report identified a nexus between any toxics and specific Project operations. More information is required to assess the potential influence of Project operations on the bioavailability and transport of the six toxics identified for further evaluation.

This Phase 1 Toxic Assessment will develop the information needed to design a Phase 2 study, which would include collection of field samples for toxic analysis within Boundary Reservoir. Given the length of the reservoir (17.5 miles long), the relatively small volume of potentially contaminated sediments from mine sources, and a desire for an accurate assessment of Project conditions, a mechanism to focus any future sampling effort is warranted. In addition to the results of the Phase 1 analysis, three of the studies proposed for implementation in 2007/2008 (the Sediment Transport and Boundary Reservoir Tributary Delta Habitats Study [section 4.2], Mainstem Aquatic Habitat Modeling Study, hydraulic routing model component [section 4.1], and Erosion Study [section 2.1]) may provide information useful to help determine potential sites for collection of sediment samples, if such sampling is deemed appropriate. However, results from the latter three studies will only be available to guide potential sampling in 2008; i.e., the results of these studies will not be available until the end of the 2007 study season. To inform potential sediment sampling in the interim period prior to completion of the three aforementioned studies, Objective 4 has been included in the Phase 1 Assessment to identify areas within Boundary Reservoir where accumulation of sediments similar in size to mine waste rock and/or tailings may have been deposited.

Completing the Phase 1 Assessment will provide the missing information to allow SCL and relicensing participants to assess the Project's potential influence on the bioavailability of the six toxics of concern. Based on the results of the Phase 1 study, a decision will be made as to what field sampling is needed to better understand the potential Project impact, what sampling

protocols would be most appropriate (i.e., water column, biota, or sediment), and where within the reservoir sampling should be focused. It is SCL's intent that the decision regarding the nature and extent of sampling will be made in consultation with relicensing participants and subject to FERC approval and that toxics sampling identified will be initiated in the summer of 2007, although some sampling might have to be conducted in 2008, following completion of the Mainstem Sediment Transport, Hydraulic Routing Model, and Shoreline Erosion studies.

3.3.5. Detailed Description of Study

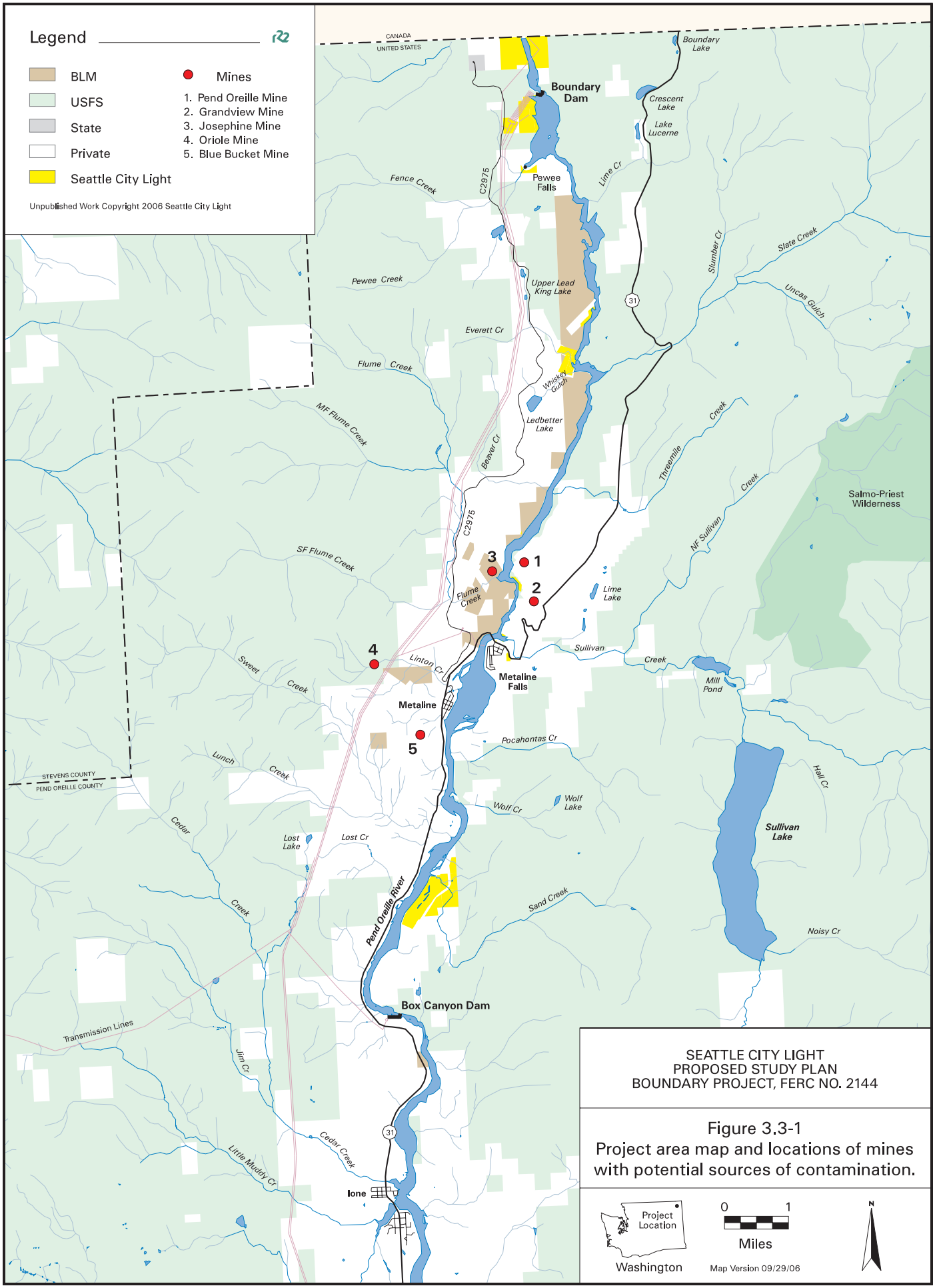
Study Area

The study area encompasses Boundary Reservoir and adjacent potential source areas for toxics. (Refer to section 1.3 of this PSP for a description of the Boundary Project location, facilities, and reservoir.) Potential toxics sources include the five mines identified in the Preliminary Assessments and Site Investigations Report as having potential sources of contamination and historical users of PCBs. PCBs have been banned since 1977, but because they bind tightly to soil and can accumulate in fish, they are still present in the Project vicinity. The five mines identified as having potential sources of contamination include the Pend Oreille, Josephine, Blue Bucket, Oriole, and Grandview mines. The Blue Bucket mine is located less than half a mile from the west side of the Pend Oreille River between river miles 29 and 30. The Oriole mine is located approximately 1.5 miles from the west side of the Pend Oreille River between river miles 27 and 28. The Josephine mine is located less than 0.25 miles from the west side of the Pend Oreille River between river miles 25 and 26 downstream of Flume Creek. The Grandview mine is located less than 0.25 miles from the east side of the Pend Oreille River near river mile 26. The Pend Oreille mine is located less than 0.5 miles from the east side of the Pend Oreille River between river miles 25 and 26. The Lehigh Cement Company landfill is located in Metaline Falls at approximately milepost 14.7 along Highway 31. These potential sources of contamination within the Project vicinity, including tributaries and mines, are shown in Figure 3.3-1.

Proposed Methodology

A detailed literature-based assessment of the toxics of concern identified in the Toxics Inventory and Screening and additional toxics assessment, i.e., arsenic, cadmium, lead, mercury, zinc, and PCBs, will be conducted. The purpose of this assessment is to develop and understanding of the nexus between Project operations and the availability and transport of these toxics. The assessment will focus on researching and answering Objectives 1 through 6 described above. Based on the Phase 1 assessment of the six toxics of concern, the next step will be to develop an appropriate sampling and analysis plan (SAP) to fulfill Objective 6 described above.

To determine whether the relationship between operations of Boundary Reservoir and the potential mobilization of contaminants, several sampling strategies are available. As part of the proposed study, all of the potential sampling strategies will be reviewed and the most appropriate selected. Some of the potential sampling schemes are described below.



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PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144

Figure 3.3-1
Project area map and locations of mines with potential sources of contamination.

Analysis of concentrations of toxics currently occurring in Boundary Reservoir would require sampling of at least one of the possible media where toxics are concentrated including the water, aquatic biota, surface sediments, sediment-water interface, or deep sediments. Collection of water, biota, or sediment samples will all involve analysis of toxic concentrations by a certified laboratory. Sampling these media will provide information on current concentrations of target toxics in the sampling location. Biota sampling can be conducted for either pelagic and/or benthic organisms to evaluate the transportation and accumulation of toxics in the food web and can provide some information on concentration in the water column and/or surface sediments.

To understand the transport of toxics from the sediment into and out of the water column, benthic flux studies can be conducted. Sampling programs to document the occurrence of benthic flux include water column and pore water sampling. Water column sampling at different depths will measure water column gradients and generally would indicate a potential benthic source. However, toxic concentration gradients may also be a result of settling of detrital material from the euphotic zone or a density-driven horizontal source (USGS 2000). Pore water samples also can be tested for toxic concentrations. For this method, devices are inserted into the sediment to collect the pore water and allowed to equilibrate for several weeks. After equilibration, pore water is extracted and measured for metals concentrations.

During the Phase 1 Toxic Assessment the advantages and disadvantages of different sampling options will be considered to identify an appropriate sampling strategy. The sampling strategies selected will be dependent on the target toxics to be analyzed as well as the existing environmental conditions in the reservoir and potential Project effect. Regardless of the sampling strategy, sampling sites should be strategically located in areas with the maximum potential for contamination, such as downstream of historic mining sites, near target sources identified in the EPA PA/SI report, or in areas of specific geochemical conditions that might influence the transport of toxics. To facilitate success of possible future sediment sampling efforts SCL proposes to determine what areas in Boundary Reservoir are likely to have sediments characteristic of mine tailings. The proposed approach incorporates two basic methods: 1) comparison of historic and current bathymetric maps to determine where sediment has been deposited within the reservoir between 1967 and 2006; and 2) development of a one-dimensional hydraulic model to determine where sediment with grain size characteristics similar to mine tailings were likely to have accumulated within the reservoir. Specific tasks associated with this approach include the following:

i) Review available literature to document historical location, volume, and particle size of mine waste rock and/or tailings supplied to the Pend Oreille River (including potential input from Box Canyon Dam).

ii) Develop a one-dimensional, steady-state hydraulic model of the Pend Oreille River from Box Canyon Dam to the international border using bathymetry of the river prior to construction of the dam.

iii) Use the hydraulic model to determine the capacity of the Pend Oreille River to transport sediment with similar grain size characteristics as the mine waste rock and/or tailings for a wide range of flow conditions.

iv) Use daily flow records of the Pend Oreille River prior to September 1967 to determine the capacity of the Pend Oreille River to transport mine waste rock and/or

tailings on an annual basis prior to closure of Boundary Dam and initiation of Project operations.

v) Compare the annual quantities of mine waste rock and/or tailings transport capacity with quantities of mine tailings supplied to the river to determine if there was potential for the Pend Oreille River in the Project area to have large deposits of mine waste rock and/or tailings just prior to closure of Boundary Dam and initiation of Project operations.

vi) Compare bathymetry of the river prior to construction of the dam (USGS 1938 and Seattle City Light 1957) with available current bathymetry (2006) to identify zones of sediment deposition within the reservoir. These zones of deposition will consist of sediment from all sources, of which mine tailings are expected to be a small portion of the total accumulation of sediment.

vii) Use the hydraulic model to help determine where sediments with grain size characteristics similar to mine waste rock and/or tailings were likely to accumulate within the reservoir between 1967 and 2006.

SCL does not intend to conduct field studies to "ground-truth" the results of the Phase 1 sediment deposition analysis. If sediment sampling is identified as the appropriate medium through which to evaluate toxics in the reservoir, on-site verification of the results of the Phase 1 sediment deposition analysis may be required as part of the Phase 2 study.

The Phase 2 sampling and analysis plan would address the type (i.e., water, sediment, fish tissue, etc., and dissolved versus total concentration), frequency, time of year to collect, and location of samples needed to best evaluate the effects of the operation of Boundary Reservoir on the toxics of concern. As part of a sampling and analysis plan, SCL will develop a Quality Assurance Project Plan (QAPP). The QAPP will describe the project team and responsibilities, the sampling locations, sampling frequency, data collection methods, laboratory analysis, including measurement methods and method detection limits, QA/QC measures including quality control sample types and frequency and measurement quality objectives, and data management. The QAPP will be consistent with Ecology and EPA protocols.

3.3.6. Work Products

A draft and final report are the major work products required for completion of this study. The draft report, to be completed by May 1, 2007, will summarize the findings of the Phase 1 Toxic Assessment. Following issuance of the draft Phase 1 report, SCL will meet with relicensing participants to review findings and determine how to proceed with a sampling program. Following the meeting, SCL will produce the final report, which will contain the proposed sampling plan(s) and the Sampling and Analysis and Quality Assurance Project plans, as appropriate. The final Phase 1 report will be completed by June 15, 2007.

The SAP will address the following issues: the goals of the study, steps needed to meet those goals, the type of sampling necessary (i.e., water column, sediment, fish tissue, etc), the specific analyses required, the number of samples, the frequency of sampling, and a schedule of

sampling. The QAPP will address elements specified by Ecology guidelines including the following items.

- Title Page with Approvals
- Table of Contents with Distribution List
- Background
- Project Description
- Organization and schedule
- Quality Objectives
- Sampling Process Design
- Sampling Procedures
- Measurement Procedures
- Quality Control
- Data Management Procedures
- Audits and Reports
- Data Verification and Validation
- Data Quality Assessment

The SAP and QAPP are similar in content except the SAP will focus on what questions need to be answered and how they will be answered through additional field sampling. The QAPP, on the other hand, will focus on the methodology to collect the field data and the QA/QC procedures required to ensure a robust sampling program. These two work products will be combined into a single document.

3.3.7. Consistency with Generally Accepted Scientific Practice

The approach to this literature-based assessment has been developed in consultation with the agencies, tribes and other stakeholders. The sampling and analysis plans and quality assurance project plans referred to herein would follow Ecology guidelines.

3.3.8. Consultation with Agencies, Tribes, and Other Stakeholders

As indicated above, SCL met with Ecology in 2005 to identify issues to be addressed as part of the 401 certification process. The following relicensing participants reviewed the scope of the Toxics Inventory and Screening in 2005: Ecology, USFS, WDFW, Pend Oreille Mine, and Teck Cominco American, Inc. The screen was requested by and provided to the following relicensing participants: Jean Parodi (Ecology), Jon Jones (Ecology), David Knight (Ecology), Tom Shuhda (USFS), Doug Robison (WDFW), Kevin Kinsella (Pend Oreille Mine), and Bill Duncan (Teck Cominco American, Inc.).

Input regarding the literature-based assessment study plan was provided by relicensing participants during Workshops and Workgroup meetings. Workshops were held in Spokane, Washington, on November 30, 2005, and February 16, 2006. Workgroup meetings were held in Spokane on May 22, 2006, and August 16, 2006, and in Metaline Falls on June 29, 2006.

During the May 22 workgroup meeting, an outline for the Assessing Toxics of Concern: Evaluation of Contaminant Pathways and Potential Project Nexus study plan was presented. During the June 29 workgroup meeting, the draft Assessing Toxics of Concern: Evaluation of Contaminant Pathways and Potential Project Nexus study plan was presented. The four toxics of concern included in this plan, which were identified during the Toxics Inventory and Screen (SCL 2005), were cadmium, lead, mercury, and PCBs. During the August 16 workgroup meeting, SCL presented the next iteration (with revised title) of the draft Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus study plan, which was revised based on stakeholder comments provided at the June 29 workgroup meeting. In preparation of this revised study plan, SCL reviewed the EPA's 2002 Preliminary Assessments and Site Investigations Report for the Lower Pend Oreille River Mines and Mills (PASI) to ascertain whether additional toxics should be included in the Phase 1 toxics assessment. Based on evaluation of the PASI document, arsenic (i.e., along with cadmium, lead, mercury, and PCBs) identified by the inventory and screening (for greater detail on study plan development, see section 3.3.4 of this study plan, under Summary of Existing Information).

Relicensing participants providing comments on the study approach at these meetings included Ecology, the USFS, U.S. Fish and Wildlife Service, Confederated Tribes of the Colville Reservation, Kalispel Tribe of Indians, Canadian Columbia River Intertribal Fisheries Commission, BC Hydro, Pend Oreille County Public Utility District, Columbia Power Corporation, Environment Canada, Ponderay Newsprint, and Teck Cominco. Comments provided by relicensing participants are summarized in Attachment 3-5 to this study plan and can also be found in workgroup meeting summaries (available on SCL's relicensing website [http://www.seattle.gov/light/news/issues/bndryRelic/]).

Stakeholders' comments on the PAD, FERC's Scoping Document 1, and SCL's proposed study program were submitted to FERC on or before September 1, 2006. Following review of these comments, SCL revised the Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus study plan to clarify the intent and goals of the overall approach to toxics assessment in Boundary Reservoir. The Project Nexus section of this study plan was revised to reflect that Phase 1 is being conducted to develop an understanding of the connections between the toxics of concern and Project operations, and to design an appropriate Phase-2 toxics sampling program for the reservoir. Similar revisions were made to the Study Goals and Objectives, Need for Additional Information, Proposed Methodology, and Work Products sections of this study plan.

In its PAD/Scoping comments, Ecology asked whether SCL planned to conduct field verifications of the results of its Phase 1 sediment deposition analysis (Ecology 2006). SCL does not intend to conduct field studies to "ground-truth" the results of the Phase 1 sediment deposition analysis. Rather, if sediment sampling is identified as the appropriate medium

through which to evaluate toxics in the reservoir, on-site verification of the results of the Phase 1 sediment deposition analysis may be required as part of the Phase 2 study.

Involvement of relicensing participants in the design and execution of the Phase 1 and Phase 2 toxics studies will be ongoing throughout the study program. SCL will conduct a formal study plan meeting with relicensing participants after filing this PSP. Subsequent study plan meetings may be scheduled to resolve outstanding issues following the initial meeting but prior to the deadline for PSP comments. SCL will consult with relicensing participants on proposed responses to their PSP comments (i.e., revisions for the Revised Study Plan [RSP]). Following issuance of the RSP, SCL will hold workgroup meetings to review and discuss proposed study implementation details. After the RSP is filed, FERC will issue its final study plan determination (for greater detail, refer to section 1.2 of this PSP).

3.3.9. Schedule

The schedule for completing the Phase 1 Toxics Assessment: Evaluation of Contaminant Pathways, Potential Project Nexus study is provided in Table 3.3-3. The final Phase 1 study report is scheduled for release on June 15, 2007. Field sampling, the extent of which will be determined based on the outcome of Phase 1, would be initiated in summer of 2007 and continue through 2008, as necessary.

Table 3.3-3. Proposed project schedule.

Phase	Target Date
Study mobilization/startup	February 2007
Conduct Assessment	March 2007
Draft Phase 1 Study Report	May 1, 2007
SCL communication with stakeholders	May 2007
Final Phase 1 Study Report	June 15, 2007

3.3.10. Progress Reports, Information Sharing, and Technical Review

Prior to release of the Phase 1 Toxics Assessment report, SCL will initiate communication with relicensing participants to discuss the study results. Comments from the relicensing participants will be addressed when preparing the Phase 1 final report. The Phase 1 final report will contain an appendix of water quality data reviewed during the proposed study; these data will also be available in digital format.

In accordance with the results of the Phase 1 evaluation, a detailed Phase 2 sampling plan will be developed and sampling will begin in 2007. Formal reporting requirements related to the Phase 2 approach would include the Initial Study Report (March 2008), the Updated Study Report (March 2009), and corresponding meetings to discuss these reports. Prior to release of these reports, 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, SCL plans to provide updates,

generally on a quarterly basis, to keep relicensing participants apprised of study progress and to communicate significant developments. Following each official Study Report meeting, the FERC ILP regulations provide the opportunity for SCL and/or relicensing participants to request modifications to the study plan in light of the progress of the study program and results to date.

3.3.11. Anticipated Level of Effort and Cost

Based on a cursory review of study needs, the anticipated cost for this proposed study is $95,000, all of which is required in 2007 for the Phase 1 Toxic Assessment and report preparation. Only after the Phase 1 report is completed, will it be possible to assess the extent of a Phase 2 sampling program, from which an estimate of effort and cost would be developed.

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3.4. Water Quality Constituent and Productivity Monitoring

The application for certification under Section 401 of the Clean Water Act (401 certification) requires characterization of existing water quality conditions in the Boundary Project area and an assessment of whether water quality meets Washington Department of Ecology (Ecology) regulatory standards. In addition, water quality parameters, including temperature, pH, dissolved oxygen (DO), nutrients, and primary productivity and zooplankton abundance, are important factors affecting the quality of fish habitat. Water quality issues in Boundary Reservoir appear to be limited to pH, total dissolved gas (TDG), water temperature, and potentially toxics. Existing information does not indicate exceedances of Ecology criteria for other water quality parameters.

3.4.1. Nexus between Project Operations and Effects on Resources

The operation of the Boundary Project has the potential to impact water quality in the Pend Oreille River within the Project area. In support of 401 certification and FERC relicensing processes, potential impacts must be evaluated. Although some historical information exists, additional and ongoing data on specific water quality constituents are needed to evaluate potential Project effects on water quality. In addition, data on the productivity of the reservoir are needed to support evaluations of potential Project effects on aquatic habitat and fauna.

3.4.2. Agency Resource Management Goals

In addition to providing information needed to characterize Project effects, the proposed water quality study will provide information to help agencies with jurisdiction over water quality resources in the Project area identify appropriate conditions for the new Project license pursuant to their respective mandates. Boundary Project studies are specifically designed to meet Federal Energy Regulatory Commission (FERC) relicensing requirements, but may also be relevant to recent or ongoing management activities by other entities. A brief description of the other resource management goals related to water quality, by entity, follows.

Washington Department of Ecology (Ecology)

Washington State water quality standards are summarized in Table 3.4-1. This table presents two sets of standards, the 1997 federally approved standards and revised standards adopted by Ecology in July of 2003.

The 2003 revised standards cannot be used for regulating federal actions pursuant to the Clean Water Act until approved by the U.S. Environmental Protection Agency (EPA). EPA is in the process of reviewing these standards and in February 2005 provided a partial approval. In a letter dated March 23, 2006, EPA formally disapproved of parts of Washington State's 2003 water quality standards because they were considered by EPA to be inadequate for protecting salmon and bull trout in certain streams and rivers. However, this disapproval relates only to temperature standards and does not affect any specific reaches of the Pend Oreille River. Ecology is in the process of proposing a new set of rules to remedy the deficiencies identified by EPA. In the meantime, Ecology is currently using the parts of the 2003 rule that EPA has approved, but employs the 1997 rule for the parts of the 2003 rule that EPA has not yet approved (i.e., temperature). The last column of Table 3.4-1 identifies the standards that are currently

Table 3.4-1. Applicable Washington State surface water quality standards for the Pend Oreille River between the Idaho border and the Canadian border (WAC 1997; WAC 2003).

Parameter	1997 Standard (Class A)[1]	2003 Standard (salmon and trout spawning, non-core rearing, and migration)[2]	Applicable Standard
Dissolved Oxygen	Levels shall exceed 8.0 mg/L	Levels shall exceed 8.0 mg/L	1997 Standard
Fecal Coliform (Primary Contact Recreation category)	Not to exceed a mean value of 100 colonies/100 mL with no more than 10 percent of all samples exceeding 200 colonies/100 mL	Not to exceed a mean value of 100 colonies/100 mL with no more than 10 percent of all samples exceeding 200 colonies/100 mL	2003 Standard
Temperature	Special Condition: Not to exceed 20˚C due to human activities. If natural conditions exceed 20˚C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3˚C; nor shall such temperature increases, at any time, exceed t=34/(T+9)	Not to exceed 1-DMax of 20.0˚C due to human activities. If natural conditions exceed 1-DMax of 20.0˚C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3˚C; nor shall such temperature increases, at any time, exceed t=34/(T+9)	1997 Standard
Total Dissolved Gas	Not to exceed 110 percent of saturation at any point of sample collection	Not to exceed 110 percent of saturation at any point of sample collection	1997 Standards
pH	Within 6.5-8.5 with human caused variation within the above range of less than 0.5 units	Within 6.5-8.5 with human caused variation within the above range of less than 0.5 units	1997 Standards
Toxic Substances (Aquatic Life/Public Health category)	Must be below those which have the potential to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon that water, or adversely affect public health.		1997 Standards
Turbidity	Should not exceed either a 5 NTU increase over background when the background is 50 NTU or less, or a 10 percent increase in turbidity when the background is more than 50 NTU	Should not exceed either a 5 NTU increase over background when the background is 50 NTU or less, or a 10 percent increase in turbidity when the background is more than 50 NTU	1997 Standards

Notes:

1 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. November 1997.

2 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. July 2003.

applicable. Both standards specify that all reservoirs with a mean detention time of 15 days or less are classified the same as the river section in which they are located. Boundary Reservoir has a residence time of less than 4 days, and is therefore categorized under the Pend Oreille River water quality standards.

U.S. 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 River basin and provides a management plan for protection of the basin's water quality. This report identifies management objectives for the Clark Fork River basin, Lake Pend Oreille, and the Pend Oreille River basin. Information from the proposed Boundary Project water quality study will be applicable to the following management plan objective: Improve Pend Oreille River water quality through macrophyte management and tributary nonpoint source controls. 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

Water Resource Inventory Area (WRIA) 62

Numerous agencies and stakeholders in 1998 formed the Water Resource Inventory Area (WRIA) 62 planning unit, the goal of which 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 five goals and related objectives for water quality:

- WQUAL-1: WRIA-wide coordination of water quality monitoring.
- 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
- WQUAL-3a: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for tributary streams that originate within WRIA 62.

  Objective: Remove tributary streams in WRIA 62 from the 3030(d) list of impaired waters by meeting State and tribal (where appropriate) water quality standards in impaired tributary streams.

- WQUAL-3b: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for the mainstem of the Pend Oreille River.

  Objective: Meet State and tribal (where appropriate) water quality standards in the mainstem Pend Oreille River.

- WQUAL-5: Protect water bodies of high water quality and improve water quality of impaired water bodies.

  Objective: Maintain compliance with state water quality standards and prevent degradation of waters that meet or exceed state water quality standards 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 Columbia River subbasins (GEI 2004). The management plan objectives identified in the subbasin plan as related to water quality in the Pend Oreille River are outlined below.

- Subbasin Objective 1B2: Improve water quality to meet or exceed applicable water quality standards in the Subbasin.

  Strategy c: Identify pollution sources, causes, and constituents on tributaries and mainstem Pend Oreille River; determine and implement actions necessary to eliminate or mitigate effects.

  Proposed Strategy e: Continue monitoring the water quality of Lake Pend Oreille, Clark Fork River and Pend Oreille River to insure it meets State and Federal standards.

- 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.

The Boundary water quality study will provide information relevant to the objectives and strategies described above.

USDA Forest Service (USFS)

The Colville National Forest is located within the Pend Oreille River basin and as such, the USFS is a participating stakeholder in the relicensing of the Boundary Project. The Land and Resource Management Plan was developed by the USFS and completed in 1988 (USFS 1988). This plan identifies five management activities in the soil and water division including:

1. Coordinate with other resources to provide support and advice that helps protect the soil and water resources.
2. Monitor the effect of the Forest Plan activities on the soil and water resources.

3. Restore damaged soil and water resources.
4. Work with Washington State Department of Ecology or others as needed to secure water rights.
5. Coordinate with other agencies or interested parties.

Specific standards and guidelines related to surface water quality include:

1. Maintain water quality parameters within the range of good fish habitat conditions, and within State water quality standards:
   - *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 National Forest. 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 turbidity is more than 50 NTU.
2. Complying with State requirements in accordance with the Clean Water Act for protection of waters of the State of Washington through planning, application, and monitoring of Best Management Practices in conformance with the Clean Water Act, regulations, and federal guidance issued thereto.
3. In watersheds where project scoping identifies an issue or concern regarding the cumulative effects of activities on water quality or stream channels, a cumulative effects assessment will be made. This will include land in all ownerships in the watershed. Activities on National Forest System lands in these watersheds should be dispersed in time and space to the extent practicable, and at least to the extent necessary to meet management requirements. On intermingled ownerships, coordinate scheduling efforts to the extent practicable.

3.4.3. Study Goals and Objectives

The goals of the proposed water quality study are to evaluate existing water quality conditions in and immediately downstream of Boundary Reservoir in support of the application for 401 certification and Fish and Aquatic resource studies. These goals will be accomplished by two objectives. The first is to characterize water quality conditions in and immediately downstream of Boundary Reservoir in support of the 401 application to determine if the Project meets Ecology's water quality standards. The second is to collect nutrient, primary productivity, and zooplankton data in support of the assessment of reservoir productivity being conducted as part of the Fish and Aquatic resource studies. To meet this objective, data will be collected in both the pelagic and littoral zones of the reservoir.

3.4.4. Need for Study

Summary of Existing Information

Long-term water quality data are limited for most of Boundary Reservoir, but some long-term water quality data have been collected in the Pend Oreille River upstream of Boundary Reservoir and at Metaline Falls. Data collected in the lower Pend Oreille River during 1962 and 1963 (pre-Boundary Project), show that pH ranged from 7.6 to 8.2 (Pine et al. 1964). Ecology has been collecting pH measurements at Metaline since 1949 (Ecology 2005), and of the 149 readings taken at this site 9 (6 percent) exceeded the state water quality standard of 8.5 pH units.

The Tri-State Water Quality Council compiled a status and trends report summarizing nutrient data collected from 1984 through 2002 in the Clark Fork/Pend Oreille Watershed (Land & Water Consulting 2004). The report's results indicate a slight decreasing trend over the collection period in total phosphorus, soluble reactive phosphorus, total nitrogen, and soluble inorganic nitrogen measured at Newport and a slight decreasing trend for total nitrogen at Metaline.

The majority of nutrient loading in the Pend Oreille River is associated with water exiting Lake Pend Oreille (EPA 1993). Water and nutrient inputs from Washington tributaries account for less than 4 percent of the Pend Oreille River flow and nutrient load (EPA 1993). Of this 4 percent, approximately 75 percent of the nutrient loading comes from three sources: Newport wastewater treatment plant, Calispell Creek, and Trimble Creek (EPA 1993). These three sources are all located upstream of Boundary Reservoir (for more detail on existing nutrient data refer to section 4.4.5.3.7 of the PAD).

Water quality data more specific to Boundary Reservoir have been collected by SCL over the past few years. The first study, Herrera (1999), involved *in situ* and laboratory analyses of water quality constituents in October 1996 and October 1998. Water quality data, including total phosphorus, soluble reactive phosphorus, ammonia, nitrate-nitrite, total Kjeldahl nitrogen, chlorophyll *a*, phaeophyton *a*, secchi depth, and temperature and DO profiles, were collected at four stations longitudinally distributed along the length of the reservoir. The Herrera (1999) study found that Boundary Reservoir has low to moderate nutrient enrichment (phosphorus and nitrogen) and that its trophic status is meso-oligotrophic (Herrera 1999). Comparison of the 1996 and 1998 data indicates that phosphorus levels remained the same, but nitrogen and chlorophyll *a* concentrations increased over the two-year period. The study showed that total phosphorus concentrations were below 20 µg/L. Temperature and DO profile data indicate little variation between surface and bottom waters during fall, and little variation between downstream and upstream monitoring stations.

SCL contracted with Taylor Associates to conduct water quality studies beginning in 2004 (Taylor Associates 2005a, Taylor Associates 2006). Taylor Associates collected water quality data at eight permanent temperature monitoring stations and six water quality monitoring stations in the summer of 2004. Water quality monitoring consisted of profile measurements of temperature, DO, pH, and conductivity. Similar studies were conducted in 2005 and 2006. The 2004 and 2005 studies show that DO concentrations ranged from 8.5 mg/L to 9.5 mg/L and that there was little vertical or longitudinal variation in DO concentrations. These studies showed that pH exceeds water quality standards at many of the sites. In general, the exceedances are

within one tenth of a pH unit of the standard. However, on some occasions pH was measured as high as 9.6. For more detailed information on existing water quality data, refer to section 4.4.5.3.9 of PAD.

In 2000, a WDFW study collected temperature, DO, pH, conductivity, turbidity, chlorophyll *a*, phytoplankton, periphyton, zooplankton, and benthic macroinvertebrates in Boundary Reservoir (McLellan and O'Connor 2001). This study showed that samples collected in August and October 2000 had an average chlorophyll *a* concentration of 1.05 µg/L, a concentration indicative of low productivity. The authors attributed the low productivity to the rapid turnover rate of the reservoir. The phytoplankton species observed were those associated with low zooplankton grazing pressure, indicating that zooplankton abundance in Boundary Reservoir was also low. McLellan and O'Connor (2001) sampled zooplankton in Boundary forebay and at the Metaline Falls Bridge during 2000. They found 20 species of zooplankton and an average density of 5 organisms/L, a low density compared to other Northwest lakes and reservoirs (for more detail on existing chlorophyll *a*, phytoplankton, and zooplankton data refer to section 4.4.5.3.5 of the PAD).

Need for Additional Information

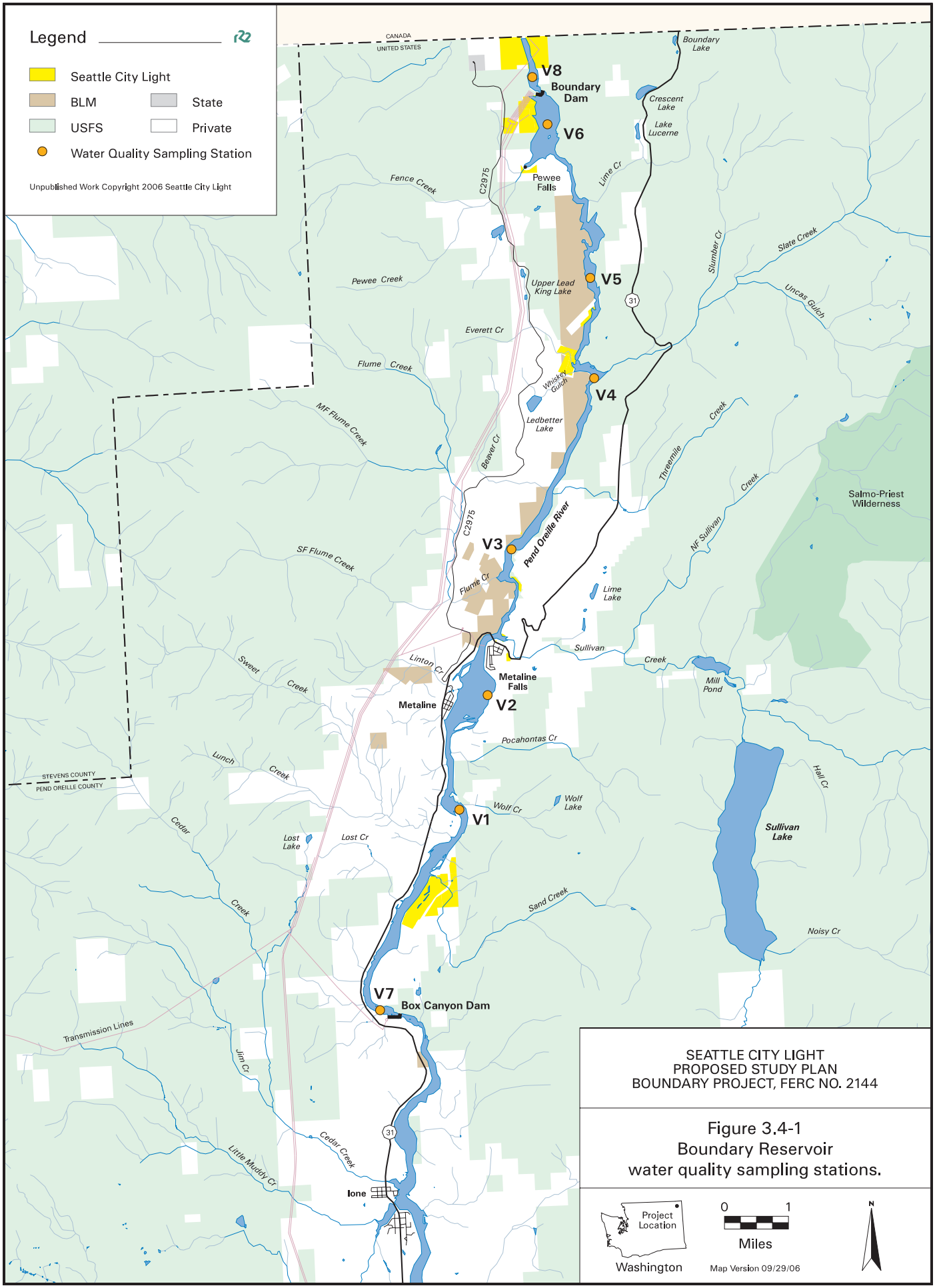
As noted above, the goals of the proposed water quality study are to collect water quality information that will be used to evaluate existing water quality conditions for the 401 certification application and support aquatic resource studies. Although SCL has been collecting water quality data since 2004, nutrient data have only been collected in 2006 and only limited chlorophyll *a*, phytoplankton, and zooplankton data have been collected; these parameters will be addressed as part of the study outlined herein.

Water quality parameters, including pH, DO, nutrients, and phytoplankton/zooplankton abundance, are important factors determining the quality of fish habitat. Additional data are needed to characterize these and other parameters in and immediately downstream of Boundary Reservoir to assess fish habitat suitability. In addition, water quality data are needed to assess Project effects on primary and secondary production in the reservoir.

3.4.5. Detailed Description of Study

Study Area

Water quality monitoring will be conducted in and immediately downstream of Boundary Reservoir. A site map with preliminary sampling locations for sampling in 2007 and 2008 is provided in Figure 3.4-1. (Refer to section 1.3 for a description of the Boundary Project location, facilities, and reservoir.)


Legend
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Water Quality Sampling Station
Unpublished Work Copyright 2006 Seattle City Light
CANADA
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V8
Boundary Dam
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Pewee Falls
V5
V4
V3
V2
V1
V7
Box Canyon Dam
Boundary Lake
Crescent Lake
Lake Lucerne
Fence Creek
C2975
Lime Cr
Pewee Creek
Upper Lead King Lake
Everett Cr
Flume Creek
Whiskey Gulch
Ledbetter Lake
MF Flume Creek
Beaver Cr
Slumber Cr
Slate Creek
Uncas Gulch
Threemile Creek
Salmo-Priest Wilderness
NF Sullivan Creek
Pend Oreille River
SF Flume Creek
Flume Cr
Lime Lake
Sullivan Creek
Linton Cr
Sweet Creek
Metaline Falls
Metaline
Mill Pond
Pocahontas Cr
Lunch Creek
STEVENS COUNTY
PEND OREILLE COUNTY
Wolf Cr
Wolf Lake
Hall Cr
Sullivan Lake
Cedar Creek
Lost Lake
Lost Cr
Sand Creek
Noisy Cr
Transmission Lines
Jim Cr
Little Muddy Cr
Cedar Creek
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31
SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144
Figure 3.4-1
Boundary Reservoir
water quality sampling stations.
Project Location
Washington
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Proposed Methodology

The proposed water quality monitoring will consist of two components, one year of water quality and productivity data collection and seasonal zooplankton drift data collection. Both of these components are described in detail below.

The water quality constituent monitoring will consist of data collection at eight sampling stations during eight months of a one-year period. Monthly samples (grab samples and *in situ* data collection) will be collected from May through September 2007, in November 2007, and in January and March 2008. Water quality monitoring will include the following variables: temperature, pH, DO, conductivity, Secchi depth, chlorophyll *a*, nutrients, zooplankton, hardness, and turbidity.

Water Quality and Productivity Constituents

Chlorophyll *a* measurements will be used as an indicator of phytoplankton productivity. Phytoplankton production is limited when retention time is less than 3 days (Uhlmann 1971). Boundary Reservoir on average has a retention time of less than 2 days. Given this short retention time and the observed low chlorophyll *a* concentrations, phytoplankton productivity appears to be low.

The proposed sampling stations, *in situ* data collection, and laboratory analyses are described in Table 3.4-2 and shown in Figure 3.4-1. The sampling stations were chosen to overlap with those used in the 2004, 2005, and 2006 SCL studies. During these studies, water quality was monitored at six stations within the reservoir that 1) characterized the longitudinal profile of water quality constituents in Boundary Reservoir, 2) represented important sites for assessing water temperatures in the mainstem river, 3) provided an even distribution of sites, and 4) addressed considerations of potential vandalism and security of equipment (Taylor Associates 2006). For this proposed water quality study, two additional sites were added to represent water quality just downstream of Box Canyon Dam, and just downstream of Boundary Dam.

Table 3.4-2. Recommended sampling stations and water quality data collection.

Sample station	Location description	In-situ data collected	Laboratory analysis conducted
Box Canyon Tailrace (V7)	In Boundary Reservoir just downstream of Box Canyon Dam	Temperature, pH, DO, conductivity, Secchi	Chlorophyll *a*, nutrients, zooplankton, hardness
Wolf Creek (V1)	POR adjacent to Wolf Creek inlet (Upstream of Metaline Falls)	Temperature, pH, DO, conductivity, Secchi depth, turbidity	Chlorophyll *a*, nutrients, zooplankton, hardness
Metaline Old (V2)	Old channel of the POR across from the city of Metaline (Upstream of Metaline Falls)	Temperature, pH, DO, conductivity, Secchi depth	Chlorophyll *a*, nutrients, hardness
Pend Oreille Mine (V3)	Downstream of mine tailings (Downstream of Metaline Falls)	Temperature, pH, DO, conductivity, Secchi depth, turbidity	Chlorophyll *a*, nutrients, zooplankton, hardness
Slate Creek (V4)	Downstream of Slate Creek across from campsite on left bank (Downstream of Metaline Falls)	Temperature, pH, DO, conductivity, Secchi depth	Chlorophyll *a*, nutrients, hardness
Everett Creek Island (V5)	Upstream of Everett Creek Island (Downstream of Metaline Falls)	Temperature, pH, DO, conductivity, Secchi depth	Chlorophyll *a*, nutrients, hardness
Boundary Reservoir Forebay (V6)	Boundary Forebay	Temperature, pH, DO, conductivity, Secchi depth, turbidity	Chlorophyll *a*, nutrients, zooplankton, hardness
Boundary Tailrace (V8)	Downstream of Boundary Dam	Temperature, pH, DO, conductivity, Secchi depth, turbidity	Chlorophyll *a*, nutrients, zooplankton, hardness

Brief descriptions of sampling analyses and methods are outlined in Table 3.4-3. Field sampling and measurement protocols will follow established Ecology and EPA guidelines. All laboratory analyses will be conducted by an Ecology- and EPA-accredited laboratory and analyzed in triplicate. Note that zooplankton collection and turbidity measurements will be collected at only five of nine proposed sampling stations, because fewer samples are needed to characterize the system. Zooplankton data will be collected in both the pelagic and littoral regions of the reservoir for use in the productivity analysis being conducted as part of Fish and Aquatic resource studies. In the pelagic region, two full vertical tows will be made from 1 meter above the bottom to the surface using a Wisconsin-style plankton net and bucket. For the littoral region, the water column within the euphotic zone will be sampled following standard methods for shallow areas, with and without vegetation. Zooplankton will be collected within the water column and not on macrophytes themselves.

Table 3.4-3. Recommend sampling parameters and collection methods.

Parameter	Number of analyses required	Method
Temperature	Vertical profile	No fewer than 10 measurements at evenly spaced intervals
Dissolved Oxygen (DO)	Vertical profile	No fewer than 10 measurements at evenly spaced intervals
pH	Vertical profile	No fewer than 10 measurements at evenly spaced intervals
Conductivity	Vertical profile	No fewer than 10 measurements at evenly spaced intervals
Secchi Depth	1 per station	Average of two readings[1]
Chlorophyll *a*	2 per station An additional 1 per zooplankton station	One at surface and one at approximately 15 feet One in the littoral region
Nutrients (Kjeldahl nitrogen, , total phosphorus, orthophosphorus)	1 per station	Surface sample
Hardness	1 per station	Bottom sample
Turbidity	2 per station	One surface sample in the littoral region and one in the pelagic region
Zooplankton	4 tows per station	2 tows in the littoral region and 2 tows in the pelagic region

Note:

1 To maintain consistency throughout the monitoring program, specific guidelines for Secchi depth measurements will be developed. These guidelines will be included in the Quality Assurance Project Plan (QAPP) and will outline such conditions as which side of the boat the measurement should be collected on given the angle of the sun or the use of sunglasses, etc.

Sampling of zooplankton on macrophytes will be conducted as part of the macroinvertebrate study proposed under the Fish and Aquatics resource area. That macroinvertebrate study will collect organisms associated with bottom surfaces (benthos), including aquatic insects, crustaceans (zooplankton, amphipods, isopods), mollusks (snails, bivalves), and some meiobenthos (hydra, turbellarians, annelids). For additional information refer to the plan for the benthic macroinvertebrate component of the Mainstem Aquatic Habitat Modeling Study (section 4.1 of this PSP).

All water column zooplankton samples collected in the proposed study will be sent to a qualified taxonomic laboratory for identification, enumeration, and length measurements. Zooplankton will be identified to at least the genus level and, if possible, to the species level. Resulting data will allow for the calculation of density (organisms per liter) and biomass. Biomass estimates will be made using length-weight regressions, based on information from the literature (Bottrell et al. 1976; Downing and Rigler 1984; Dumont et al. 1975).

Seasonality and Drift of Zooplankton

The second component of the study includes collection of seasonal zooplankton drift data below Box Canyon and Boundary dams to quantify the movement of zooplankton into and out of

Boundary Reservoir. Downstream of Boundary Dam, samples will be collected before, during, and after Project startup to quantify the impact of Project operations on zooplankton movement. Data will be collected at similar times downstream of Box Canyon Dam. Data will be collected in the summer, winter, and spring and will coincide with other water quality monitoring. Summer sampling will be conducted in either July or August, winter sampling in November or January, and spring sampling in March.

A pair of drift nets or plankton nets with 80–153 µm mesh nets will be set below each dam. If possible, nets will be deployed along the shoreline in flowing water at depths of 1–2 m. If no suitable shoreline area exists for deploying nets in this fashion, the nets will be deployed at depths of 1–2 m from a boat in the center of the channel. During each sampling month, nets will be set for 20-minute periods every 2 hours over a 24-hour period. Set times and frequencies will be adjusted as necessary based on the extent to which nets become clogged with drifting debris. Specifics regarding the locations and methods for zooplankton drift sampling will be refined by the technical consultant conducting this study and will be sufficient to meet the requirements of the study given the environmental conditions and restrictions. Laboratory analysis of zooplankton samples will be conducted as described in the previous section.

Quality assurance and control (QA/QC) measures will be observed to ensure that the following objectives are met: data are consistent, correct, and complete, with no errors or omissions; QC sample results have been reviewed and are included; established criteria for QC results were met; measurement quality objectives have been met, or data qualifiers are properly assigned where necessary; data specified in the sampling process design were obtained; and methods and protocols specified in the QAPP were followed.

3.4.6. Work Products

Four official work products are required for completion of the water quality constituent and productivity monitoring study:

- *Quality Assurance Project Plan* — The first work product is a Quality Assurance Project Plan (QAPP), which will be finalized by March 31, 2007, before field sampling begins. The QAPP must address elements specified by Ecology guidelines including the following items:
    1. Title Page with Approvals
    2. Table of Contents with Distribution List
    3. Background
    4. Project Description
    5. Organization and schedule
    6. Quality Objectives
    7. Sampling Process Design
    8. Sampling Procedures
    9. Measurement Procedures
    10. Quality Control
    11. Data Management Procedures

12. Audits and Reports
13. Data Verification and Validation
14. Data Quality Assessment

- *Productivity data compilation* — The second work product is a compilation of productivity data for the reservoir productivity analysis being conducted under the Fish and Aquatic resources study program. Data will be submitted in an electronic format so the information can be easily incorporated into the reservoir productivity analysis. Frequency and format of submittals will be coordinated between the Fish and Aquatics and Water Quality technical consultants.
- *Interim Status Report* — An interim status report must be completed by October 31, 2007. This status report will contain monitoring methods, deviations from the QAPP, a brief summary of 2007 monitoring to date and laboratory data received, and recommendations for any changes to subsequent monitoring.
- *Final Study Report* — A final study report must be prepared by July 15, 2008. This report will describe the monitoring methods, results of the 2007 and 2008 monitoring, and conclusions of the Boundary Project area water quality constituent and productivity monitoring.

3.4.7. Consistency with Generally Accepted Scientific Practice

The methods described herein have been developed in consultation with the resource agencies, tribes, and other stakeholders. The study approach and methods are consistent with Ecology's Water Quality Certification for Existing Hydropower Dams: Preliminary Guidance Manual (September 2004). The QAPP will be consistent with State and federal guidelines including EPA's Quality System for Environmental Data and Technology and Ecology's Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. The laboratory selected to analyze water quality samples will be fully Ecology- and EPA- certified to conduct the analyses included in this study.

3.4.8. Consultation with Agencies, Tribes, and Other Stakeholders

As indicated above, SCL met with Ecology in 2005 to identify issues to be addressed as part of the 401 certification process. Input regarding water quality sampling was also provided by relicensing participants during workshops and workgroup meetings. Workshops were held in Spokane, Washington, on November 30, 2005, and February 16, 2006. Workgroup meetings were held in Spokane on May 22, 2006, and in Metaline Falls on June 29, 2006. During the May 22 workgroup meeting, an outline for this study plan was presented and comments were provided by relicensing participants. During the June workgroup meeting, the draft study plan was presented and relicensing participants provided comments. Relicensing participants attending the workgroup meetings included Ecology, the USGS, Confederated Tribes of the Colville Reservation, Kalispel Tribe of Indians, Columbia River Intertribal Fisheries Commission, BC Hydro, Pend Oreille County Public Utility District, Columbia Power Corporation, Environment Canada, Ponderay Newsprint, and Teck Cominco. Comments provided by relicensing participants on draft versions of this study plan are summarized in Attachment 3-5 and can also be found in meeting summaries for these workgroup meetings and

workshops (available on SCL's relicensing website [http://www.seattle.gov/light/news/issues/bndryRelic/]).

In its PAD/Scoping comments submitted to FERC (Ecology 2006), Ecology noted that, "The first paragraph of the draft [Water Quality Constituent and Productivity Monitoring] study plan stated that water quality issues, and non-compliance with state water quality standards, in the Boundary Reservoir appear to be limited to pH, total dissolved gas and possibly toxics. Temperature should be added to this list." The first paragraph of this study plan was revised in accordance with Ecology's request.

3.4.9. Schedule

The schedule for completing this study is provided in Table 3.4-4.

Table 3.4-4. Proposed study schedule, Water Quality Constituent and Productivity Monitoring.

Phase	Target Date
QAPP	March 31, 2007
Field Collection	May 2007 – March 2008
Interim Status Report	October 31, 2007
Data review and report preparation	May 2008 – June 2008
Final Study Report	July 15, 2008

3.4.10. Progress Reports, Information Sharing, and Technical Review

Both the interim status report and final study report will be available to agencies, tribes, and interested stakeholders. 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. The final report will contain an appendix of the raw water quality data, which will also be available in digital format.

3.4.11. Anticipated Level of Effort and Cost

Based on a cursory review of study needs, the anticipated cost for this study is $215,000. Approximately $140,000 will be required in 2007 and $75,000 in 2008. This estimated cost assumes all laboratory analyses will be conducted in triplicate and that field costs can be minimized by conducting data collection in conjunction with the Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir water quality study (described in section 3.5).

3.4.12. Literature Cited

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WAC Chapter 173-201A. 2003. Water Quality Standards for Surface Waters of the State of Washington. Olympia, Washington.

3.5. Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir

High daytime pH levels have been documented throughout the Pend Oreille River and in Boundary Reservoir (Ecology 2005, SCL 2006b). The cause of these high pH levels is unknown, but both background geologic conditions and the growth of macrophytes appear to be contributing factors. The geology of the Pend Oreille River basin includes limestone, which has the potential to influence the pH of nearby waters by contributing alkalinity (in the form of carbonate). Alkalinity absorbs the acid present in the water, thereby raising the pH. A total maximum daily load (TMDL) was established by the Washington Department of Ecology (Ecology) for pH in streams of the Colville National Forest. A study associated with the TMDL found that pH levels are uniformly elevated in surface waters across the forest as a result of the regional limestone geology.

Invasive macrophytes in Boundary Reservoir, such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curly pondweed (*Potamogeton crispus*), also have the potential to affect water chemistry. Both pH and dissolved oxygen (DO) can be altered through the processes of photosynthesis, respiration, and senescence. Changes in pH and DO have been documented in and around macrophyte beds (Coots and Carey 1991; FERC 2002). Dense macrophyte growth can increase pH through the uptake of carbon dioxide during photosynthesis. Alternatively, with either nighttime respiration or senescence, macrophytes can reduce DO levels and produce carbon dioxide. Under these conditions macrophytes can reduce both DO and pH in surrounding waters.

The goal of this study is to explore the relationship of pH and DO to macrophytes in Boundary Reservoir to learn if macrophytes are contributing to high pH readings and, if so, to explore the indirect effect of the Boundary Project on pH and DO in the reservoir via its influence on macrophyte distribution and growth.

3.5.1. Nexus between Project Operations and Effects on Resources

Reservoirs provide shallow, low-velocity conditions that are conducive to macrophyte growth. Operation of Boundary Dam affects the reservoir's stage and velocity, which can influence macrophyte growth. In turn, the growth of macrophytes can affect water quality conditions, especially pH and DO. The direct effect of the Project on macrophyte distribution and abundance will be addressed under the Aquatic Macrophytes Study being conducted under the Fish and Aquatics resource area. The current study addresses the potential effect of existing macrophyte beds on DO and pH in Boundary Reservoir.

3.5.2. Agency Resource Management Goals

In addition to providing information needed to characterize Project effects, the proposed studies will provide information to help agencies with jurisdiction over water quality resources in the Project area identify appropriate conditions for the new Project license pursuant to their respective mandates. Boundary Project studies are specifically designed to meet FERC relicensing requirements, but may also provide information relevant to recent, or ongoing,

management activities in the Pend Oreille River basin. Brief summaries of relevant water quality regulatory and planning documents follow.

Washington Department of Ecology (Ecology)

The relevant Ecology criteria for DO and pH are shown in Table 3.5-1. Water quality criteria for other parameters are provided in section 4.4.5.4 of the Boundary Project Pre-Application Document (PAD) (SCL 2006a).

Table 3.5-1. Applicable Washington State surface water quality standards for the Pend Oreille River between the Idaho border and the Canadian border (WAC 1997; WAC 2003).

Parameter	1997 Standard (Class A)[1]	2003 Standard (salmon and trout spawning, non-core rearing, and migration)[2]	Applicable Standard
Dissolved Oxygen	Levels shall exceed 8.0 mg/L	Levels shall exceed 8.0 mg/L	1997 Standard
pH	Within 6.5-8.5 with human caused variation within the above range of less than 0.5 units	Within 6.5-8.5 with human caused variation within the above range of less than 0.5 units	1997 Standards

Notes:
1 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. November 1997.
2 Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. July 2003.

In addition to setting water quality standards, Ecology created the Aquatic Plant Technical Assistance Program 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 (Parsons 1995):

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 waterbodies
3. Assist with evaluating Freshwater Aquatic Weed Program grant applications

U.S. 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 River basin and provides a management plan for protection of the basin's water quality. This report identifies management objectives for the Clark-Fork River basin, Lake Pend Oreille, and the Pend Oreille River basin including an objective to improve Pend Oreille River water quality through macrophyte management and tributary nonpoint source controls. Actions 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.

Water Resource Inventory Area (WRIA) 62

Numerous agencies and stakeholders in 1998 formed the Water Resource Inventory Area (WRIA) 62 planning unit, the goal of which 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 five goals and related objectives for water quality:

- WQUAL-1: WRIA-wide coordination of water quality monitoring.
- 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.
- WQUAL-3a: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for tributary streams that originate within WRIA 62.

  Objective: Remove tributary streams in WRIA 62 from the 303(d) list of impaired waters by meeting State and tribal (where appropriate) water quality standards in impaired tributary streams.
- WQUAL-3b: Watershed Planning Implementing Body to participate in (interact and provide input to) the TMDL process for the mainstem of the Pend Oreille River.

  Objective: Meet State and tribal (where appropriate) water quality standards in the mainstem Pend Oreille River.
- WQUAL-5: Protect water bodies of high water quality and improve water quality of impaired water bodies.

  Objective: Maintain compliance with state water quality standards and prevent degradation of waters that meet or exceed state water quality standards 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 objectives identified in this study as related to water quality in the Pend Oreille River are outlined below.

- Subbasin Objective 1B2: Improve water quality to meet or exceed applicable water quality standards in the Subbasin.

  Strategy c: Identify pollution sources, causes, and constituents on tributaries and mainstem Pend Oreille River; determine and implement actions necessary to eliminate or mitigate effects.

  Proposed Strategy e: Continue monitoring the water quality of Lake Pend Oreille, Clark Fork River and Pend Oreille River to insure it meets State and Federal standards.

- 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.

USDA Forest Service (USFS)

The Colville National Forest is located within the Pend Oreille River basin and as such, the USFS is a participating stakeholder in the relicensing of the Boundary Project. The Land and Resource Management Plan was developed by the USFS and completed in 1988 (USFS 1988). This plan identifies five management activities in the soil and water division including:

1. Coordinate with other resources to provide support and advice that helps protect the soil and water resource.
2. Monitor the effect of the Forest Plan activities on the soil and water resources.
3. Restore damaged soil and water resources.
4. Work with Washington State Department of Ecology or others as needed to secure water rights.
5. Coordinate with other agencies or interested parties.

Specific standards and guidelines related to aquatic macrophytes, pH, and DO include:

1. Maintain water quality parameters within the range of good fish habitat conditions, and within State water quality standards. Natural pH levels within the Colville National Forest are normally between 6.5 and 9.0. Any man-caused variation is not to exceed 0.2 units. Dissolved oxygen measurements should be more than 9.5 mg/L.
2. Complying with State requirements in accordance with the Clean Water Act for protection of waters of the State of Washington through planning, application, and monitoring of Best Management Practices in conformance with the Clean Water Act, regulations, and federal guidance issued thereto.
3. In watersheds where project scoping identifies an issue or concern regarding the cumulative effects of activities on water quality or stream channels, a cumulative effects assessment will be made. This will include land in all ownerships in the watershed. Activities on National Forest System lands in these watersheds should be

dispersed in time and space to the extent practicable, and at least to the extent necessary to meet management requirements. On intermingled ownerships, coordinate scheduling efforts to the extent practicable.

3.5.3. Study Goals and Objectives

The goals of this study are 1) to assess whether macrophytes are contributing to high pH and low DO readings in Boundary Reservoir, and 2) to investigate potential indirect effects of Project operations on pH and DO via macrophytes. In order to achieve these goals, the following objectives have been defined:

- *Objective 1*: Document and determine the magnitude of the impact macrophyte respiration/photosynthesis and senescence have on pH and DO levels in Boundary Reservoir.
- *Objective 2*: Assess the effect of varying densities of macrophyte beds on changes in pH and DO in support of the fish habitat analysis.
- *Objective 3*: Assess the effect of Project operations, specifically inundation and frequency of dewatering, on changes in pH and DO in macrophyte beds. This objective is important because it addresses a potential Project nexus, whether reservoir operations influence the physiology of macrophytes and, hence, water chemistry.

3.5.4. Need for Study

Summary of Existing Information

Macrophyte growth has become an increasing problem in the Pend Oreille River. Eurasian watermilfoil, a non-native aquatic plant, has been proliferating in the shallow, low-velocity areas of the river (EPA 1993, Pelletier and Coots 1990). Recent observations indicate the presence of another exotic macrophyte, curly pondweed, in the Project vicinity as well (Colleen McShane, EDAW, personal communication, 2005).

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 or no growth has been found at depths greater than 18 feet. Biomass of macrophytes in the littoral regions is 10 times that in the deepwater zone (Falter et al. 1991). 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).

Studies in the Pend Oreille River have found that aquatic macrophytes impact water quality. The Box Canyon Environmental Impact Statement (EIS) concluded that the highest pH levels observed were recorded in the summer as a result of considerable aquatic macrophyte growth (FERC 2004). The EIS also documents that pH measurements were found to be on average 0.4 units higher in macrophyte beds than in the main channel.

Spot measurement data collected in the lower Pend Oreille River during 1962 and 1963 (pre-Boundary Project) documented that pH measurements ranged from 7.6 to 8.2 (Pine et al. 1964). Ecology has collected pH measurements at Metaline since 1949 (Ecology 2005). Of the 149 readings taken at this site from 1949–1962 and 1994–2006, 9 (6 percent) exceeded the state water quality standard of 8.5 pH units. SCL began collecting pH data in 2004 as part of its water quality monitoring program (Taylor Associates 2005). This program involved collection of pH profiles at six locations in Boundary Reservoir on five dates in 2004. The data show that pH exceeds water quality standards at many of the sites. In general, the exceedances are within one tenth of a pH unit of the standard. However, on some occasions pH was measured as high as 9.6 (for more detail on existing pH data, refer to section 4.4.5.3.9 of the PAD).

As part of the Colville National Forest TMDL, which was completed in April 2005, pH data were reviewed for streams in the Colville National Forest with at least 10 pH measurements collected since 1990 (Whiley et al. 2005). The majority of these streams are within the Pend Oreille watershed. In all, data were collected for 84 sites, including tributaries to Boundary Reservoir. Maximum pH levels observed at the monitoring locations varied between 8.0 and 9.0 with an overall median of 8.5. Of the 84 monitoring locations considered, 32 (38 percent) had maximum pH levels above 8.5, the Ecology pH standard. Forty-three (51 percent) of the measurements fell within a range of less than 1 pH unit. In general, data from these sites showed that pH levels across the forest are uniformly elevated, with relatively low variation in median values. In addition, the pH variation seen was evident among groupings of stations, indicating spatial influences (Whiley et al. 2005). Geologic features were compared with stream pH measurements, and streams with higher median pH values were usually found in areas with carbonate-based geology. As a result of these findings, the TMDL concluded that elevated pH levels and minor variation in pH within the forest were primarily a result of the regional geology and represent a natural condition. For this reason, the expected upper range in pH for forest streams was extended from 8.5 to 8.8 (Whiley et al. 2005).

DO measurements taken in Boundary Reservoir in 1998 (Herrera 1999) and 2004 (Taylor Associates 2005) show that DO concentrations ranged from 8.5 mg/L to 9.5 mg/L and that there was little vertical or longitudinal variation in DO concentrations (for more detail on existing DO data, refer to section 4.4.5.3.10 of the PAD). Historical DO data were collected by Ecology at Metaline Falls between 1959–1962 and 1993–2002 (Ecology 2005). Pre-Project data (1959–1962) ranged from 7.5 mg/L to 13.7 mg/L with an average concentration of 10.9 mg/L. Post-Project data (1993–2002) ranged from 7.8 mg/L to 14.8 mg/L with an average concentration of 10.8 mg/L.

Need for Additional Information

As explained above, the respiration and senescence of invasive macrophytes, such as Eurasian watermilfoil and curly pondweed, in Boundary Reservoir have the potential to affect water chemistry, pH and DO in particular. Excessive macrophyte growth can increase pH through the uptake of carbon dioxide during photosynthesis. High pH levels in Boundary Reservoir have been documented by Ecology and SCL. The cause of these high pH levels is not known. Studies in Box Canyon Reservoir showed elevated pH levels in macrophyte beds (FERC 2004). There are also data from the Project area that suggest background geologic conditions may be the cause

of high pH. To understand the potential for Boundary Reservoir to affect pH/DO, additional data collection is needed.

The goal of this study is to collect water quality information that will be used to assess pH in Boundary Reservoir and the potential effect of macrophytes on pH in the reservoir. Although SCL has been collecting water quality data since 2004, no continuous monitoring of pH has been conducted, and only limited water quality data have been collected for comparing water quality in and around macrophyte beds. A pilot study was conducted in 2006 to preliminarily assess the relationship between macrophytes and pH); however, a more robust study as described below is needed for the purposes of the application for certification under Section 401 of the federal Clean Water Act. The study outlined herein includes collection of pH data in and adjacent to macrophyte beds in Boundary Reservoir to assess the possible relationship between photosynthesis in macrophyte beds and pH in the reservoir, and to assess any potential impacts of the Project on this relationship.

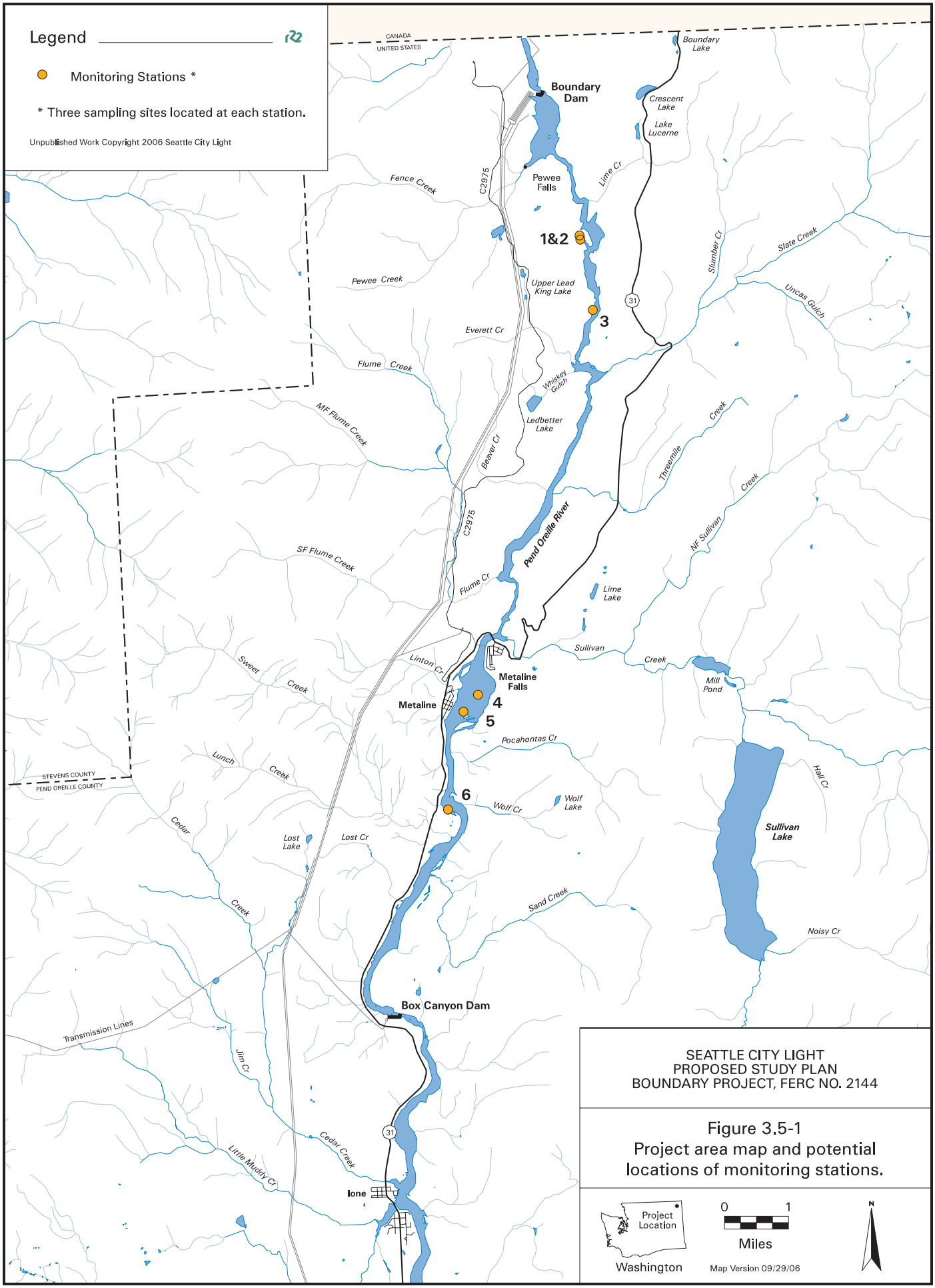
3.5.5. Detailed Description of Study

Study Area

The study area encompasses Boundary Reservoir, including side channels off the main channel (Figure 3.5-1). (Refer to section 1.3 of this PSP for a description of the Boundary Project location, facilities, and reservoir.) Eurasian water milfoil 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. A description of the distribution of macrophytes in Boundary Reservoir can be found in section 4.6 of the PAD (Botanical Resources) and corresponds to the area mapped as Lacustrine Aquatic Bed in the vegetation cover type map presented in Figure 4.6-1 of the PAD (SCL 2006a). This cover type includes shallow water areas, typically below elevation 1,980 feet NGVD 29 (1,984 feet NAVD 88), which are characterized by the presence of aquatic vegetation, primarily milfoil, coonwort (*Ceratophyllum demersum*), and elodea (*Elodea canadensis*) (SCL 2006a).

Proposed Methodology

Data collection to address the three objectives identified above will be based on a similar overall design, but data for each objective will be collected and analyzed separately. To address differences in reservoir morphology and habitat types, data will be collected within two reaches, upstream and downstream of Metaline Falls. Ideally, different macrophyte beds upstream and downstream of Metaline Falls will be used to meet each of the objectives; however, if appropriate based on site conditions, data collection for one or more objectives may occur in the same macrophyte bed.



SEATTLE CITY LIGHT
PROPOSED STUDY PLAN
BOUNDARY PROJECT, FERC NO. 2144

Figure 3.5-1
Project area map and potential locations of monitoring stations.

Prior to any data collection, the first step in this study will be to conduct a site investigation to identify locations for sampling stations. Potential locations of monitoring stations are shown in Figure 3.5-1. For this task and the field efforts described below, Boundary Reservoir has been divided into two distinct reaches, upstream and downstream of Metaline Falls. These two reaches are distinguished by differences in river gradient, depth, habitat types, and geologic features. Multiple sampling stations will be located within each reach and multiple sampling sites will be located within each station to collect data necessary to address study objectives. The site investigation task will locate macrophyte beds in the two reaches for each of the comparisons described in the field sampling efforts below and in Objectives 1 through 3. All sampling sites in and around macrophyte beds will be established far enough from tributary inflows that pH and DO measurements reflect ambient reservoir conditions and not the water chemistry of a nearby tributary.

Additional study design details are described below, by objective, and are summarized in Table 3.5-2.

Objective 1

Description of Objective: Document and determine the magnitude of the impact macrophyte respiration/photosynthesis and senescence have on pH and DO levels in Boundary Reservoir.

Approach: Collect and analyze pH, DO, conductivity, cloud cover, and temperature data within and apart from macrophyte beds. Two different methods will be used to collect and analyze water chemistry data within and apart from macrophyte beds. The first method employs the use of remote monitors. To obtain detailed long-term hourly information, remote water quality monitors will be deployed in the reach upstream of Metaline Falls as follows: one monitor will be located within a dense macrophyte bed, one monitor will be located in the open channel of the reservoir, slightly upstream and out of the localized effect of the macrophyte bed, and one unit will be located in the open channel of the reservoir, slightly downstream and out of the localized effect of the macrophyte bed. The monitors will be installed prior to significant macrophyte growth and will not be removed until after substantial senescence of the macrophyte bed has occurred.

The second method requires the collection of multiple sets of water chemistry profile data. Multiple vertical profile measurements will be taken within and outside macrophyte beds in both reservoir reaches. Each reach will contain nine sites; three within the macrophyte bed, three upstream of the macrophyte bed, and three downstream of the macrophyte bed. The upstream, downstream, and within-bed sites will be located in areas of similar characteristics except for the growth of macrophytes. In order to achieve this similarity, an attempt will be made to locate the upstream and downstream sites on bedrock or gravel surfaces. Sites within macrophyte beds will be located in areas of high density macrophyte growth. All sampling sites for remote water quality monitors and vertical profiles will be established far enough from tributary inflows that pH and DO measurements made in and around the macrophyte beds reflect ambient reservoir conditions and not the water chemistry of a nearby tributary.

Table 3.5-2. pH/DO and macrophyte sampling design.

Objective, Description	Sampling Method	Number, location sampling stations	Number of sampling sites per station	Sampling Schedule	Sampling Duration, Interval	Figure/ Schematic
1, Assess pH/DO within and apart from macrophyte beds.	Remote	1, upstream of Metaline Falls	9 (3 upstream, 3 within, and 3 downstream of the macrophyte bed)	May–November	Every 0.5 hr	NA
	Profile	6, 3 above Metaline Falls and 3 below Metaline Falls	9 (3 upstream, 3 within, and 3 downstream of the macrophyte bed)	Late spring, July, August, November	24 h, 4–6 h 72 h, 4–6 h 72 h, 4–6 h 24 h, 4–6 h	Figure 3.5-2
2, Assess pH/Do at different densities of macrophytes	Profile	6, 3 above Metaline Falls and 3 below Metaline Falls	9 (3 high, 3 medium, and 3 low density sites)	Late spring, July, August, November	24 h, 4–6 h 72 h, 4–6 h 72 h, 4–6 h 24 h, 4–6 h	Figure 3.5-3
3, Assess pH/DO at sites with variable lengths of exposure	Profile	6, 3 above Metaline Falls and 3 below Metaline Falls	6 (3 continuously inundated,4–6 hours exposure, and 3 8–12 hours exposure)	Late spring, July, August, November	24 h, 4–6 h 72 h, 4–6 h 72 h, 4–6 h 24 h, 4–6 h	Figure 3.5-4

Vertical profile measurements will be taken during four periods: one in late spring, two during peak macrophyte growth, and one in the fall. The first field sampling event will be conducted in May or early June, depending on flow conditions, before substantial macrophyte growth. During this period, vertical profile information will be collected over a 24-hour period. More intensive field sampling efforts will be conducted in July and August, when vertical profile data will be collected over a 72-hour period. During November, vertical profile data collection will again occur over a 24-hour period. For each sampling event, vertical profiles will be collected approximately every four to six hours, or with sufficient frequency to capture diurnal fluctuations in pH and DO. A schematic outlining sampling for the region upstream of Metaline Falls (Station #6) is shown in Figure 3.5-2. This figure illustrates example vertical profile sites for within, upstream, and downstream of the macrophyte beds (actual sampling in this reach will occur at nine sites, as specified above). Note that specific locations of sites are dependent on actual macrophyte bed locations and other environmental considerations. If possible, triplicates will be located in different macrophyte beds, with measures taken to ensure that the upstream and downstream sites are not influenced by other nearby macrophyte beds. However, given the limited knowledge of the specific locations and suitability of macrophyte beds, using separate beds for triplicates may not be feasible. Thus, sites can be located within the same bed; however, measures should be taken to place the sites sufficiently far apart to avoid pseudo-replication.

The pH and DO data will be compared to determine whether pH and DO are similar among sites located inside and outside of macrophyte beds. The analysis will also attempt to quantify the magnitude of this effect. The hypotheses to be evaluated and the corresponding statistical tests that will be conducted include the following:

a. To identify whether or not the presence of macrophytes influences pH or DO, both the remote and vertical profile data will need to be reviewed and compared. The hypotheses that macrophyte growth has no impact on pH and DO and that measured maximum or minimum values are the same between the locations will be tested. To test these hypotheses, a time series model will be developed to compare the within-bed, upstream, and downstream remote data. From this test, an estimate of the magnitude of the effect of macrophytes on pH can be quantified by comparing peak and average difference between the sites. For the profile spot measurement data, a multifactor Analysis of Variance (ANOVA) will be used to compare peak, minimum, and average values by time of day, site, and depth.
b. To investigate how the presence of macrophytes influences pH and DO over the sampling season and when the largest impact occurs, the remote data will be compared on a weekly basis. The hypothesis for this test is that measured pH and DO values are the same between locations regardless of the week. Analysis will include a nested ANOVA with time (or week) and location as the factors.

Figure 3.5-2. Schematic Plan view of Station #6 (presence comparison station upstream of Metaline Falls) and example location of profile sites used to address Objective 1.

Tasks:

1. Conduct a site investigation survey to locate monitoring stations.
2. Install three remote water quality monitors at one station upstream of Metaline Falls as described above to measure pH, DO and temperature in half-hour increments.
3. Collect vertical profile measurements of pH, DO, conductivity, and temperature, within and apart from macrophyte beds in the two reaches of Boundary Reservoir (upstream and downstream of Metaline Falls).
4. Analyze and compare data collected within and outside the immediate influence of macrophyte beds to assess if they exhibit an influence on water chemistry in Boundary Reservoir.

Objective 2

Description of Objective: Assess the effect of varying densities of macrophyte beds on changes in pH and DO.

Approach: Collect and analyze water quality data (pH, DO, conductivity, and temperature) at sites with predetermined various degrees of macrophyte density. Multiple vertical profile measurements and macrophyte abundance information in areas of different densities will be collected within two reaches of Boundary Reservoir (above and below Metaline Falls). Nine sites will be located within each reservoir reach, with three each in areas of low, medium, and high macrophyte abundance. The field sampling effort will be identical to that described for Objective 1, with samples collected in May/June, July, August, and November. A schematic cross section showing vertical profile sampling sites at low, medium, and high macrophyte densities at the station upstream of Metaline Falls (Station #4) is shown in Figure 3.5-3. (This figure only shows three sites, not the total nine specified for this reach.) Note that specific locations of sites are dependent on actual macrophyte bed locations and other environmental considerations. If possible, density triplicates will be located in different macrophyte beds. However, given the limited knowledge of the specific locations and suitability of macrophyte beds, this placement may not be feasible. Thus, triplicates may have to be located within the same bed. If they are located within the same macrophyte bed, measures should be taken to place the sites sufficiently far apart to avoid pseudo-replication. All sampling sites will be established far enough from tributary inflows that pH and DO measurements made in and around the macrophyte beds reflect ambient reservoir conditions and not the water chemistry of a nearby tributary.

Data from low, medium, and high macrophyte density sites will be compared to evaluate how macrophyte abundance influences the changes in pH or DO. Data analysis will specifically identify whether macrophyte density influences either the range or extreme pH or DO measurements. Hypotheses include a) extreme pH or DO values are the same between areas of differing macrophyte density, and b) the daily range in pH and DO is the same between areas of differing macrophyte density. To test these hypotheses, a nested ANOVA will be used to evaluate differences by depth, density, and season.

Tasks:

1. Conduct a site investigation survey to locate monitoring stations.
2. Collect vertical profile measurements of pH, DO, conductivity, and temperature in areas of low, medium, and high macrophyte density within the two reservoir reaches, upstream and downstream of Metaline Falls.
3. Estimate macrophyte abundance at all sites. Macrophyte density will be quantified using an aquatic rake or similar sampling technique. In addition, water depth, macrophyte depth, water velocity, and substrate information will be recorded.
4. Analyze and compare data collected at low, medium, and high macrophyte density to assess the impact of macrophyte density on water quality.

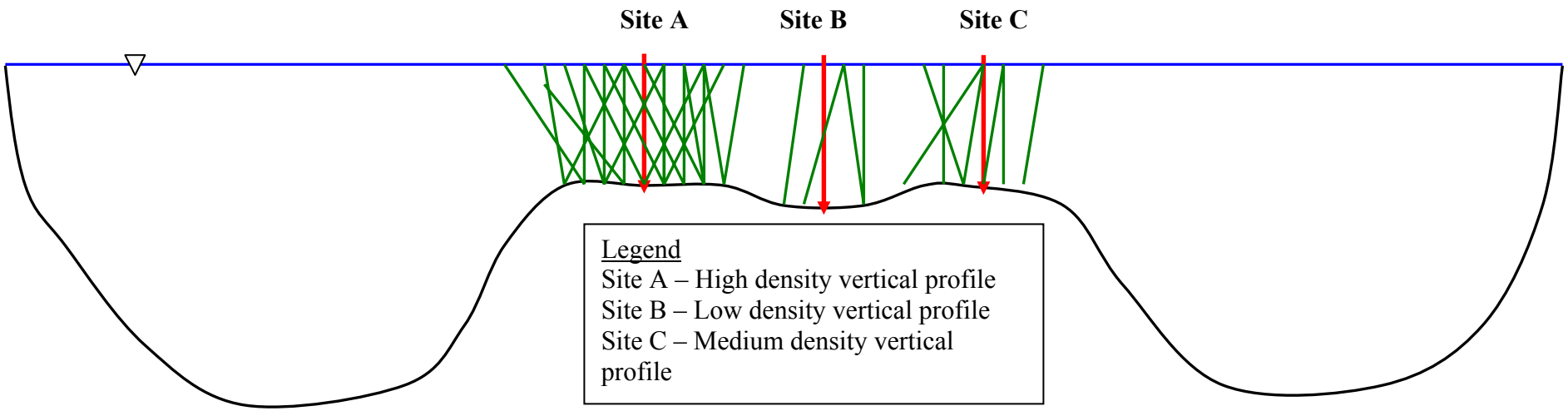


Figure 3.5-3. Schematic cross section of Station #4 density comparison station upstream of Metaline Falls.

Objective 3

Description of Objective: Assess the effect of Project operations, specifically inundation and frequency of dewatering, on changes in pH and DO in macrophyte beds.

Approach: Collect and analyze water quality data (pH, DO, conductivity, and temperature) at different sites with various levels of inundation or dewatering. Multiple vertical profile measurements in areas with varying degrees of dewatering will be collected within the two reservoir reaches, i.e., above and below Metaline Falls. Each reach will contain nine sites, three in macrophyte beds in continuously inundated areas, three in macrophyte beds that are exposed to air for moderate periods (approximately 4–6 hr per day), and three in macrophyte beds that are exposed to air for long periods (approximately 8–12 hours per day). The exact length of exposure will be determined using bathymetric information, typical hourly fluctuations in water surface elevations, and information gathered during the site investigation step.

Field sampling will be identical to that described for Objectives 1 and 2, with samples collected in May/June, July, August, and November. Similar to Objective 2, macrophyte abundance data will be collected at the sampling sites for Objective 3 as a gross indicator of macrophyte growth. A schematic illustrating the sampling strategy for the inundation comparison for the reach upstream of Metaline Falls (Station #5) is shown in Figure 3.5-4. This figure shows an example of vertical profile sites in an area continuously inundated, exposed 4–6 hours per day, and exposed 8–12 hours per day. (This figure only shows three sites, not the total nine specified for this reach.) Note that specific locations of sites are dependent on actual macrophyte bed locations and other environmental considerations. Once again, if feasible, triplicates will be located in different macrophyte beds. However if this is not feasible, sites can be located within the same bed if measures are taken to avoid pseudo-replication. All sampling sites will be established far enough from tributary inflows that pH and DO measurements made in and around the macrophyte beds reflect ambient reservoir conditions and not the water chemistry of a nearby tributary.

The pH/DO data will be compared among macrophyte beds with different lengths of exposure to assess whether the length of inundation influences macrophyte growth and the potential corresponding impact on pH or DO. Hypotheses to answer this question include a) extreme (maximum pH, minimum DO) values are the same in areas with varying levels of dewatering, and b) the daily range in pH and DO is the same in areas with varying levels of dewatering. To test these hypotheses, a nested ANOVA will be used, which includes depth, relative time of exposure, and day as separate factors.

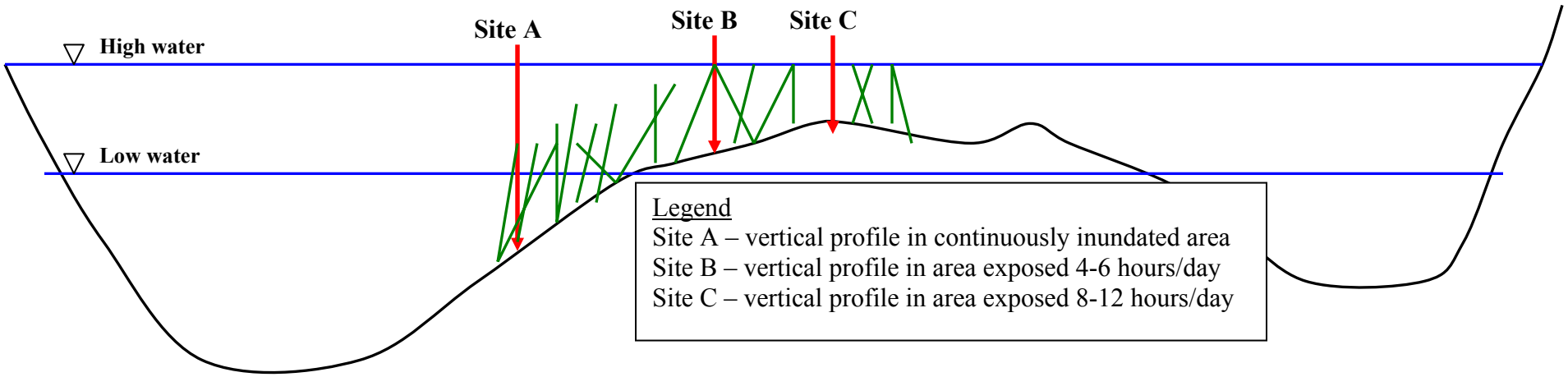


Figure 3.5-4. Schematic cross section of Station #5 inundation comparison station upstream of Metaline Falls.

Tasks:

1. Conduct a site investigation survey to locate monitoring stations.
2. Collect vertical profile measurements of pH, DO, conductivity, and temperature in areas that are continuously inundated, exposed 4–6 hours per day, and exposed 8–12 hours per day within the two reaches of Boundary Reservoir, upstream and downstream of Metaline Falls.
3. Estimate macrophyte abundance at all sites. Macrophyte density will be quantified using an aquatic rake or similar sampling technique. In addition, water depth, macrophyte depth, water velocity, and substrate information will be recorded.
4. Analyze and compare data collected from continuously inundated and variable lengths of exposure to assess the effects of daily reservoir fluctuations on macrophyte respiration and senescence and corresponding water chemistry.

For the field efforts described above, macrophyte growth is assumed to be seasonal between May through November, with peak growth occurring in July and August and senescence occurring in October and November. For planning purposes, data collection will occur between May through November. Data collection methods will follow established Ecology and EPA guidelines. Prior to the data analyses required to meet each of the three objectives, review, verification, and validation of the data collected is required. Specific procedures for data verification and validation will be outlined in the QAPP. Data analysis will also be used to help determine whether additional field efforts will be needed in 2008.

3.5.6. Work Products

Four official work products are required for completion of the study of relationship of pH and DO to macrophytes in Boundary Reservoir:

- *Quality Assurance Project Plan* — The first work product is a Quality Assurance Project Plan (QAPP), which will be finalized by March 31, 2007. The QAPP must address elements specified by Ecology guidelines including the following items:
    1. Title Page with Approvals
    2. Table of Contents with Distribution List
    3. Background
    4. Project Description
    5. Organization and schedule
    6. Quality Objectives
    7. Sampling Process Design
    8. Sampling Procedures
    9. Measurement Procedures
    10. Quality Control
    11. Data Management Procedures
    12. Audits and Reports

13. Data Verification and Validation
14. Data Quality Assessment

- *Interim Status Report* — An interim status report must be completed by December 31, 2007. This status report will contain monitoring methods, any deviations from the QAPP, a brief summary of the 2007 data collected, and a discussion of recommendations for additional monitoring, if needed.
- *Final Study Report* — A final study report must be completed by March 15, 2008. This report will describe the monitoring methods, results of the 2007 monitoring and analysis, and conclusions of the study.
- *Summary* — In addition to the final report, the data collected and a short summary will be compiled for the Aquatic Macrophytes Study being conducted under the Fish and Aquatic resources study program. The summary will include macrophyte abundance, substrate, depth, velocity and corresponding water chemistry collected at different macrophyte densities and varying degrees of inundation. Data will be submitted in an electronic format so the information can be easily incorporated into the macrophyte assessment.

3.5.7. Consistency with Generally Accepted Scientific Practice

The methods described herein have been developed in consultation with the agencies, tribes, and other stakeholders. The study approach and methods are consistent with Ecology's Water Quality Certification for Existing Hydropower Dams: Preliminary Guidance Manual (September 2004). The QAPP will be consistent with State and federal guidelines including EPA's Quality System for Environmental Data and Technology and Ecology's Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies.

3.5.8. Consultation with Agencies, Tribes, and Other Stakeholders

As indicated above, SCL met with Ecology in 2005 to identify issues to be addressed as part of the 401 certification process. Input regarding water quality sampling was also provided by relicensing participants during workshops and workgroup meetings. Workshops were held in Spokane, Washington, on November 30, 2005, and February 16, 2006. Workgroup meetings were held in Spokane on May 22, 2006, and in Metaline Falls on June 29, 2006. During the May 22 workgroup meeting, an outline for this study plan was presented and relicensing participants provided comments. The proposed study plan was revised from the study outline based on comments received from relicensing participants at the May 22 workgroup meeting. During the June workgroup meeting, the draft study plan was presented and comments from relicensing participants were provided. Stakeholders attending these meetings included Ecology, the U.S. Geological Survey (USGS), Confederated Tribes of the Colville Reservation, Kalispel Tribe of Indians, Canadian Columbia River Intertribal Fisheries Commission, BC Hydro, Pend Oreille County Public Utility District, Columbia Power Corporation, Environment Canada, Ponderay Newsprint, and Teck Cominco. Comments provided by relicensing participants on the draft study plan are summarized in Attachment 3-5 to this study plan and can also be found in workgroup meeting summaries, available on SCL's relicensing website (http://www.seattle.gov/light/news/issues/bndryRelic/).

3.5.9. Schedule

The schedule for this study is provided in Table 3.5-3.

Table 3.5-3. Proposed study schedule, Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir.

Phase	Target Date
QAPP	March 31, 2007
Field Collection	May 2007 – November 2007
Interim Status Report with Recommendations for additional 2008 sampling	December 31, 2007
Data review, analysis, and report preparation	November 2007 – March 1, 2008
Final Study Report	March 15, 2008

3.5.10. Progress Reports, Information Sharing, and Technical Review

Both the interim status report and final study report will be available to agencies, tribes, and other interested stakeholders. 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. The final report will contain an appendix of the raw water quality data, which will also be available in digital format.

3.5.11. Anticipated Level of Effort and Cost

Based on a review of the study needs, the anticipated cost for this study totals $200,000. Approximately $160,000 will be required in 2007 for monitoring, the status report, and analysis, and an additional $40,000 will be required in 2008 for additional analyses and report preparation. This estimated cost assumes three remote monitoring units will be purchased for use during the project and that field costs can be minimized by conducting data collection in conjunction with the Water Quality Constituent and Productivity Monitoring Study (described in section 3.4).

3.5.12. Literature Cited

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3.6. Requested Water Resource Study Not Adopted in the PSP — Aquatic Plant Management Control Study

3.6.1. Information Regarding Study Request

The USDA Forest Service (USFS) proposed the following study: Aquatic Plant Management Control Study.

3.6.2. Sponsor's Description of Study Goals and Objectives

The USFS proposed that an Aquatic Plant Management Control Study be conducted as part of the relicensing process for Boundary Project. The proposed study would involve two components: 1) an assessment of the effect of existing Project operations on the distribution of nonnative aquatic macrophytes in the reservoir, and 2) an evaluation of macrophyte control techniques. The influence of Project operations on the distribution of non-native aquatic macrophytes (primarily Eurasian watermilfoil) would be assessed by comparing maps of macrophyte distribution to maps of reservoir surface area under the normal range of Boundary Reservoir operations. Control techniques to reduce the abundance of nonnative macrophytes would include, but not be limited to, evaluation of rotovation and removal of macrophytes from the reservoir and drawdown of the reservoir to desiccate and/or freeze aquatic macrophytes.

3.6.3. Relevant Resource Agency Management Goals

The USFS states that it is required to maintain and enhance habitat for native species on National Forest System (NFS) lands and waters under the National Forest Management Act (USDA 1976) and to participate in the recovery of all life histories of Federally Listed Species, as required in the Endangered Species Act (USFWS 1973). The USFS stated that high densities of Eurasian watermilfoil or other nonnative macrophyte species could have detrimental effects on water quality and physical habitat for fish, ultimately resulting in populations of stunted native salmonids and decreased foraging areas for bull trout. The USFS states that it is also required to comply with water quality standards under the Clean Water Act.

3.6.4. Sponsor's Description of Existing Information and Need for Additional Information

The USFS states that Eurasian watermilfoil has been present in Boundary Reservoir since at least 1980 (personal communication, Kathy Hamel, Ecology).

Nexus Between Project Operations and Effects

The USFS states that bull trout, westslope cutthroat trout, and mountain whitefish occupy the reservoir during parts of their life histories. Littoral habitat, which is limited in Boundary Reservoir, is very important to these species for foraging. Eurasian watermilfoil, which may be affected by Project operations, is known to be present in these littoral areas and may adversely affect native salmonids in the reservoir. The USFS states that understanding continuing effects on macrophyte concentrations and distribution resulting from Project operations would aid in the

development of PMEs intended to benefit native fish and their foraging habitat and improve water quality (reduction of pH) in the study area.

Proposed Study Methodology, Consistency with Accepted Scientific Practice and Consideration of Tribal Values

The USFS's proposed methods are as follows:

> "The reservoir would be inventoried and mapped by boat survey. A total inventory of littoral habitats in the reservoir would be established. Information on acres infested and species present would be collected. Test plots or other delineations would be set up for control studies during the primary growing season (June through September).
>
> "Evaluation of removal methods would include rotovation and drawdown/freezing. Plots would be established and monitored pre-and post treatment for plant density. Aquamogs or other equipment would be used to rotovate and remove EWM from plots once a year. Rotovated vegetal material would be disposed of at agreed upon dry land sites outside of the reservoir. Rotovated sites would be monitored pre and post treatment to determine the effectiveness of removal and to determine any potential reinvasion of the weed into the treated area. Additional plots would be established to evaluate the effect of drawdown and freezing on exotic aquatic plants. Any drawdown (beyond daily operations) would be subject to a forecast of appropriate weather and ground conditions suitable for the freezing and drying of the EWM. Monitoring sites would be selected and monitored both pre and post drawdown to determine the effectiveness of the drawdown and to determine any potential reinvasion of the weed into the monitoring sites. Other control methodologies can also be used as part of this study and should be coordinated with interested agencies and other parties."

Level of Effort and Cost

The USFS estimated that cost of this study to be between $150,000 to $350,000, depending on the scale of control methods and detail of the mapping.

3.6.5. SCL's Rationale for Not Adopting the Proposed Study in the PSP

The current distribution of aquatic macrophytes in the reservoir — as well as the distribution of macrophytes under potential future operating scenarios — will be addressed as part of aquatic habitat mapping studies. The modeling of macrophyte distribution under current and potential future conditions will be based on habitat suitability index (HSI) curves developed for each season; HSI curves will be developed based on depth, velocity, substrate, and frequency of inundation and dewatering. Field surveys of current aquatic plant distribution and abundance will be collected along depth, velocity, and substrate gradients in established macrophyte beds exposed to a range of inundation and dewatering conditions. Water quality and abundance data available from the Evaluation of the Relationship of pH and DO to Macrophytes in Boundary

Reservoir (described in section 3.5 of this PSP) will be used to develop an HSI curve for pH and dissolved oxygen as a function of macrophyte abundance. Relicensing participants — and, if desired, regional experts — will be consulted to confirm whether the macrophyte habitat suitability curves developed for the reservoir are adequate. These curves will be used in the aquatic habitat modeling study to assess the relationship between habitat quantity/quality and macrophyte distribution and abundance under current and alternative Boundary Project operational scenarios.

As part of its Application for 401 Water Quality Certification with the Washington Department of Ecology, SCL will submit an Aquatic Macrophyte Management Plan, which will be developed based on the results of studies conducted during relicensing (e.g., aquatic habitat modeling) and thorough review of the literature (e.g., Gibbons et al. 1987) to identify the most appropriate macrophyte control strategy, including, reservoir drawdown, rotovation, application of herbicides, or other potential measures. SCL intends to test and implement appropriate control strategies for aquatic macrophytes following issuance of the new FERC license for the Project and pursuant to the approved Aquatic Macrophyte Management Plan.

SCL does not believe that a rotovation study in Boundary Reservoir is currently warranted. First, this control method and its results have been documented previously in the western United States, so site-specific tests would likely provide little information beyond what is currently available. Moreover, rotovation can cause plant fragmentation, which in some areas has increased the spread of Eurasian watermilfoil.

It is known that 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 and high temperatures, which can also kill some aquatic plants. Drawdowns that expose large areas of plant beds are most effective, but if drawdowns do not occur on a regular basis, plants often re-colonize such areas. Because of the limited ability to affect reservoir drawdown above Metaline Falls (see the Hydraulic Routing component of the Mainstem Aquatic Habitat Modeling Study, 4.1), drawdown periods sufficient to fully desiccate or freeze nonnative macrophytes may not be achievable in the areas of greatest watermilfoil abundance. The results of the Mainstem Aquatic Habitat Modeling Study will identify the magnitude and duration of potential reservoir drawdown and the areas that can be affected. Conducting tests before the development and application of aquatic habitat modeling could result in inadvertent adverse effects on fish and other organisms. For this reason, it is prudent to conduct tests of macrophyte control measures after relicensing studies have been completed and a management plan is developed.

3.6.6. Literature Cited

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Attachment 3-1: Total Dissolved Gas Abatement Alternatives Matrix and Ranking Criteria

Matrix #1 - Original Matrix with Scores and Overall Rank, and Muted "Cost" Column

Top Six Alternatives Based on "Rank" Column (1 through 6)

No.	Option	Hydraulic Capacity: Percent of 7Q10	Effect on Ability of Project to pass PMF	Potential TDG benefit (no impairment)	Construct-ability	Cost (capital and O&M)	O&M Challenge	Dam Safety	Effect on Other Resources	Effects on Fish (exclusion / passage)	Weighted Score	Normalized Score	Rank
		1	1	1	0.7	0.7	0.5	1	0.5	0.8			
1-1	Existing Spillway Limited Ops	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	0	0.0%	25
1-2	Existing Skimmer Gate Limited Ops	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	0	0.0%	25
1-3	Throttle Sluice Gates	6	10	7	10		8	10	10	9	56.2	96.9%	5
1-4	Operate Gates #1 and #7	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	0	0.0%	25
2-1	Spillway Modifications	10	10	2.5	9		10	10	10	1	49.6	85.5%	10
2-2	Skimmer Gate Modifications	0.5	10	8	7		9	8	10	4	44.1	76.0%	17
2-3A	Raise Plunge Floor--Spillway	10	10	2	5		4	10	10	1	43.3	74.7%	21
2-3B	Raise Plunge Floor--Sluiceway	10	10	2	5		4	10	10	1	43.3	74.7%	21
2-7	Floating Spill Dissipater	10	10	5	3		3	10	9	1	43.9	75.7%	18
3-1	Armor Area Downstream of Sluice #1 and #7	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	0	0.0%	25
3-2	Roughen Sluice Discharge	10	9	7	9		8	10	10	8	57.7	99.5%	2
3-4	Add Fixed-Cone Valves to Sluices	6	10	9	1		4	10	10	7	48.3	83.3%	11
3-5A	Add Branch Outlet to Sluice Liner (submerged discharge)	5	10	10	4		7	1	10	8	43.7	75.3%	20
3-7	Floating Barge Deflector	10	10	5	3		3	10	9	1	43.9	75.7%	18
4-1	Underwater Outlet through Midsection of Dam	4	10	10	4		5	7	7	10	47.8	82.4%	12
4-4	Bridge-type Spillway Apron	10	10	3	3		3	9	10	1	41.4	71.4%	23
4-4A	New Right Abutment Spillway w/Tunnel Outlet	8	10	6	6		8	10	9	1	47.5	81.9%	13
4-4B	New Right Abutment Spillway w/Long Flume	8	10	6	4		8	10	9	2	46.9	80.9%	14
4-4C	New Right Abutment Spillway with Natural Rock Shoot	6	10	10	2		7	9	10	1	45.7	78.8%	16
4-4D	New Right Abutment Long Side-Channel Spillway	3	10	8	2		7	9	10	1	40.7	70.2%	24
4-5	New Left Abutment Spillway w/Flume along Road	10	10	6	2		7	10	7	3	46.8	80.7%	15
4-5B	New Left Abutment Spillway Along Road, Forebay Intake	10	10	6	2		8	10	7	7	50.5	87.1%	9
4-7	New Right Abutment Tunnel w/Submerged Discharge	10	10	10	5		5	10	8	8	56.4	97.2%	4
4-7A	New Right Abutment Tunnel w/Fixed Cone Valve	10	10	10	2		3	10	8	8	53.3	91.9%	7
4-8	Open Existing Diversion Tunnel and Add Control Struct	10	10	10	1		1	10	7	8	51.1	88.1%	8
4-8A	New Left Abutment Tunnel Meeting Diversion Tunnel	10	10	10	5		5	10	7	5	53.5	92.2%	6
4-9	Penstock/Draft Tube ByPass	10	10	10	7		8	10	7	7	58	100.0%	1
4-10	New Short Left Abutment Tunnel Next to U51	10	10	10	7		8	10	7	6	57.2	98.6%	3
											58	100%	

Matrix #2 - Rank of Alternatives Muting Each Criteria Based on Matrix #1

No.	Options	Hydraulic Capacity: Percent of 7Q10	Effect on Ability of Project to pass PMF	Potential TDG benefit (no impairment)	Construct-ability	Cost (capital and O&M)	O&M Challenge	Dam Safety	Effect on Other Resources	Effects on Fish (exclusion / passage)	Weighted Score	Normalized Score	Rank Based on All Criteria, Except Cost	Rank w/o Hydraulic Capacity	Rank w/o PMF	Rank w/o TDG Benefit	Rank w/o Construct-ability	Rank w/o O&M	Rank w/o Dam Safety	Rank w/o Other Resource Effects	Rank w/o Fish Effects
		1	1	1	0.7	0.7	0.5	1	0.5	0.8											
1-1	Existing Spillway Limited Ops	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	0	0.0%	25	25	25	25	25	25	25	25	25
1-2	Existing Skimmer Gate Limited Ops	TBD	TBD	TBD	TBD		TBD	TBD	TBD	TBD	0	0.0%	25	25	25	25	25	25	25	25	25
1-3	Throttle Sluice Gates	6	10	7	10		8	10	10	9	56.2	96.9%	5	1	5	2	8	5	5	5	6
1-4	Operate Gates #1 and #7	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	0	0.0%	25	25	25	25	25	25	25	25	25
2-1	Spillway Modifications	10	10	2.5	9		10	10	10	1	49.6	85.5%	10	14	10	5	15	12	12	10	7
2-2	Skimmer Gate Modifications	0.5	10	8	7		9	8	10	4	44.1	76.0%	17	7	17	21	24	23	18	19	20
2-3A	Raise Plunge Floor--Spillway	10	10	2	5		4	10	10	1	43.3	74.7%	21	22	21	11	20	19	21	21	18
2-3B	Raise Plunge Floor--Sluiceway	10	10	2	5		4	10	10	1	43.3	74.7%	21	22	21	11	20	19	21	21	18
2-7	Floating Spill Dissipater	10	10	5	3		3	10	9	1	43.9	75.7%	18	20	18	17	17	16	19	17	15
3-1	Armor Area Downstream of Sluice #1 and #7	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	0	0.0%	25	25	25	25	25	25	25	25	25
3-2	Roughen Sluice Discharge	10	9	7	9		8	10	10	8	57.7	99.5%	2	3	1	1	5	3	2	3	3
3-4	Add Fixed-Cone Valves to Sluices	6	10	9	1		4	10	10	7	48.3	83.3%	11	10	11	16	10	10	13	12	17
3-5A	Add Branch Outlet to Sluice Liner (submerged discharge)	5	10	10	4		7	1	10	8	43.7	75.3%	20	17	20	23	19	21	8	20	24
3-7	Floating Barge Deflector	10	10	5	3		3	10	9	1	43.9	75.7%	18	20	18	17	17	16	19	17	15
4-1	Underwater Outlet through Midsection of Dam	4	10	10	4		5	7	7	10	47.8	82.4%	12	6	12	20	12	11	10	11	23
4-4	Bridge-type Spillway Apron	10	10	3	3		3	9	10	1	41.4	71.4%	23	24	23	19	22	22	23	23	21
4-4A	New Right Abutment Spillway w/Tunnel Outlet	8	10	6	6		8	10	9	1	47.5	81.9%	13	15	13	10	15	13	14	14	9
4-4B	New Right Abutment Spillway w/Long Flume	8	10	6	4		8	10	9	2	46.9	80.9%	14	16	14	14	14	15	15	15	10
4-4C	New Right Abutment Spillway with Natural Rock Shoot	6	10	10	2		7	9	10	1	45.7	78.8%	16	13	16	22	13	18	17	16	11
4-4D	New Right Abutment Long Side-Channel Spillway	3	10	8	2		7	9	10	1	40.7	70.2%	24	18	24	24	22	24	24	24	22
4-5	New Left Abutment Spillway w/Flume along Road	10	10	6	2		7	10	7	3	46.8	80.7%	15	19	15	15	11	14	16	13	14
4-5B	New Left Abutment Spillway Along Road, Forebay Intake	10	10	6	2		8	10	7	7	50.5	87.1%	9	12	9	7	9	9	11	9	11
4-7	New Right Abutment Tunnel w/Submerged Discharge	10	10	10	5		5	10	8	8	56.4	97.2%	4	5	4	6	2	2	4	4	4
4-7A	New Right Abutment Tunnel w/Fixed Cone Valve	10	10	10	2		3	10	8	8	53.3	91.9%	7	9	7	9	4	6	7	7	8
4-8	Open Existing Diversion Tunnel and Add Control Struct	10	10	10	1		1	10	7	8	51.1	88.1%	8	11	8	13	6	8	9	8	13
4-8A	New Left Abutment Tunnel Intercepts Diversion Tunnel	10	10	10	5		5	10	7	5	53.5	92.2%	6	8	6	8	7	7	6	6	5
4-9	Penstock/Draft Tube ByPass	10	10	10	7		8	10	7	7	58	100.0%	1	2	2	3	1	1	1	1	1
4-10	New Short Left Abutment Tunnel Next to U51	10	10	10	7		8	10	7	6	57.2	98.6%	3	4	3	4	3	4	3	2	1
											58	100%									

Matrix #3 - Rank of Alternatives Muting Each Criteria and Comparison to Overall Rank **Green - Unchanged; Yellow - Increased; Blue - Decreased.**

No.	Option	Rank w/o Hydraulic Capacity	Rank w/o PMF	Rank w/o TDG Benefit	Rank w/o Constructability	Rank w/o Cost	Rank w/o O&M	Rank w/o Dam Safety	Rank w/o Other Resource Effects	Rank w/o Fish Effects	Rank w/all Criteria
1-1	Existing Spillway Limited Ops	25	25	25	25		25	25	25	25	25
1-2	Existing Skimmer Gate Limited Ops	25	25	25	25		25	25	25	25	25
1-3	Throttle Sluice Gates	1	5	2	8		5	5	5	6	5
1-4	Operate Gates #1 and #7	25	25	25	25		25	25	25	25	25
2-1	Spillway Modifications	14	10	5	15		12	12	10	7	10
2-2	Skimmer Gate Modifications	7	17	21	24		23	18	19	20	17
2-3A	Raise Plunge Floor--Spillway	22	21	11	20		19	21	21	18	21
2-3B	Raise Plunge Floor--Sluiceway	22	21	11	20		19	21	21	18	21
2-7	Floating Spill Dissipater	20	18	17	17		16	19	17	15	18
3-1	Armor Area Downstream of Sluice #1 and #7	25	25	25	25		25	25	25	25	25
3-2	Roughen Sluice Discharge	3	1	1	5		3	2	3	3	2
3-4	Add Fixed-Cone Valves to Sluices	10	11	16	10		10	13	12	17	11
3-5A	Add Branch Outlet to Sluice Liner (submerged discharge)	17	20	23	19		21	8	20	24	20
3-7	Floating Barge Deflector	20	18	17	17		16	19	17	15	18
4-1	Underwater Outlet through Midsection of Dam	6	12	20	12		11	10	11	23	12
4-4	Bridge-type Spillway Apron	24	23	19	22		22	23	23	21	23
4-4A	New Right Abutment Spillway w/Tunnel Outlet	15	13	10	15		13	14	14	9	13
4-4B	New Right Abutment Spillway w/Long Flume	16	14	14	14		15	15	15	10	14
4-4C	New Right Abutment Spillway with Natural Rock Shoot	13	16	22	13		18	17	16	11	16
4-4D	New Right Abutment Long Side-Channel Spillway	18	24	24	22		24	24	24	22	24
4-5	New Left Abutment Spillway w/Flume along Road	19	15	15	11		14	16	13	14	15
4-5B	New Left Abutment Spillway Along Road, Forebay Intake	12	9	7	9		9	11	9	11	9
4-7	New Right Abutment Tunnel w/Submerged Discharge	5	4	6	2		2	4	4	4	4
4-7A	New Right Abutment Tunnel w/Fixed Cone Valve	9	7	9	4		6	7	7	8	7
4-8	Open Existing Diversion Tunnel and Add Control Struct	11	8	13	6		8	9	8	13	8
4-8A	New Left Abutment Tunnel Intercepts Diversion Tunnel	8	6	8	7		7	6	6	5	6
4-9	Penstock/Draft Tube ByPass	2	2	3	1		1	1	1	1	1
4-10	New Short Left Abutment Tunnel Next to U51	4	3	4	3		4	3	2	1	3

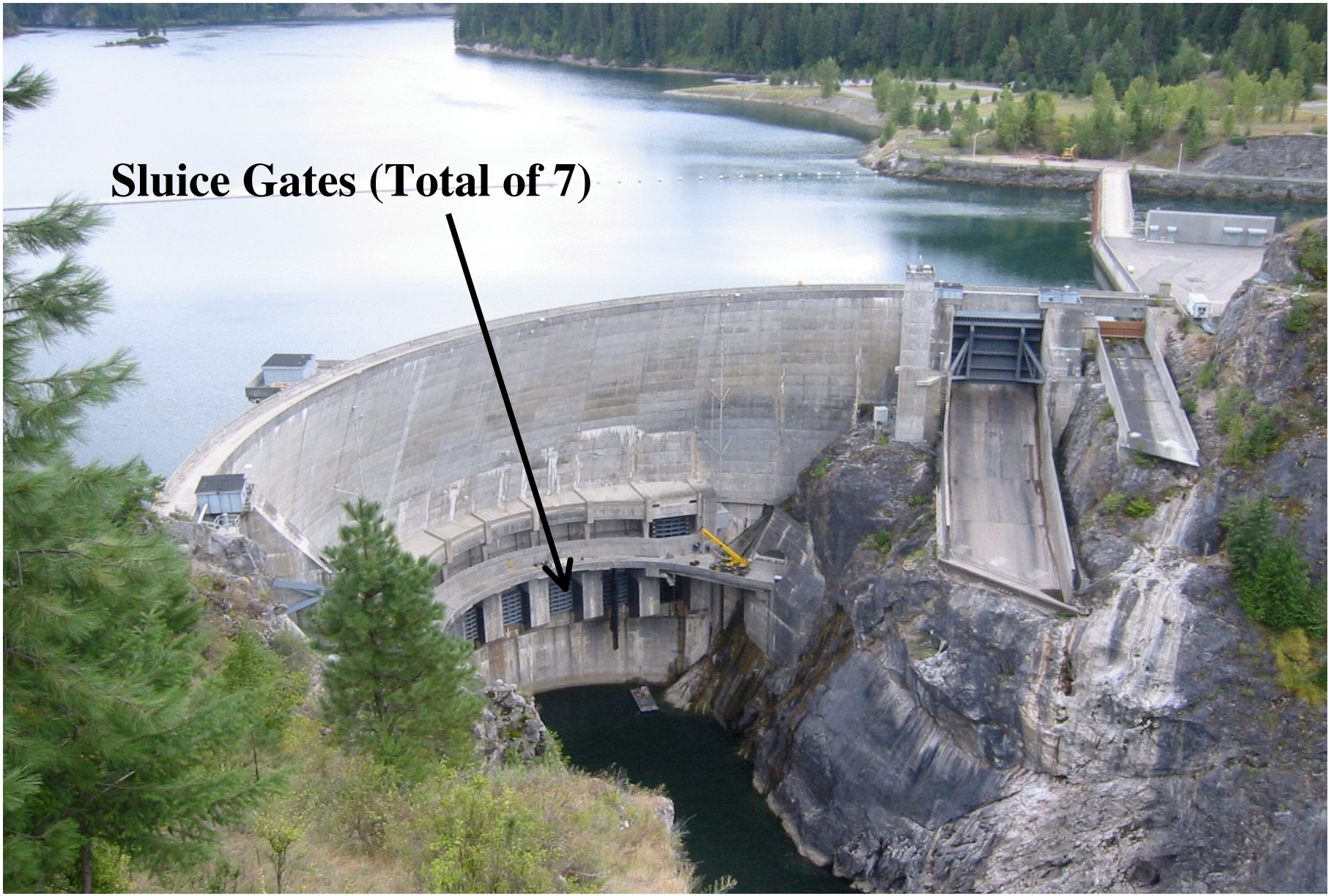
Matrix #3 - Top Six Alternatives from Sorting Matrix #3

No.	Option	Rank w/o Hydraulic Capacity	Rank w/o PMF	Rank w/o TDG Benefit	Rank w/o Constructability	Rank w/o Cost	Rank w/o O&M	Rank w/o Dam Safety	Rank w/o Other Resource Effects	Rank w/o Fish Effects	Rank w/all Criteria
4-9	Penstock/Draft Tube ByPass	2	2	3	1		1	1	1	1	1
3-2	Roughen Sluice Discharge	3	1	1	5		3	2	3	3	2
4-10	New Short Left Abutment Tunnel Next to U51	4	3	4	3		4	3	2	1	3
4-7	New Right Abutment Tunnel w/Submerged Discharge	5	4	6	2		2	4	4	4	4
1-3	Throttle Sluicegates	1	5	2	8		5	5	5	6	5
4-8a	New Left Abutment Tunnel Meeting Diversion Tunnel	8	6	8	7		7	6	6	5	6
4-7A	New Right Abutment Tunnel w/Fixed Cone Valve	9	7	9	4		6	7	7	8	7
4-8	Open Existing Diversion Tunnel and Add Control Struct	11	8	13	6		8	9	8	13	8
4-5B	New Left Abutment Spillway Along Road, Forebay Intake	12	9	7	9		9	11	9	11	9
2-1	Spillway Modifications	14	10	5	15		12	12	10	7	10
3-4	Add Fixed-Cone Valves to Sluices	10	11	16	10		10	13	12	17	11
4-1	Underwater Outlet through Midsection of Dam	6	12	20	12		11	10	11	23	12
4-4A	New Right Abutment Spillway w/Tunnel Outlet	15	13	10	15		13	14	14	9	13
4-4B	New Right Abutment Spillway w/Long Flume	16	14	14	14		15	15	15	10	14
4-5	New Left Abutment Spillway w/Flume along Road	19	15	15	11		14	16	13	14	15
4-4C	New Right Abutment Spillway with Natural Rock Chute	13	16	22	13		18	17	16	11	16
2-2	Skimmer Gate Modifications	7	17	21	24		23	18	19	20	17
2-7	Floating Spill Dissipater	20	18	17	17		16	19	17	15	18
3-7	Floating Barge Deflector	20	18	17	17		16	19	17	15	18
3-5A	Add Branch Outlet to Sluice Liner (submerged discharge)	17	20	23	19		21	8	20	24	20
2-3A	Raise Plunge Floor--Spillway	22	21	11	20		19	21	21	18	21
2-3B	Raise Plunge Floor--Sluiceway	22	21	11	20		19	21	21	18	21
4-4	Bridge-type Spillway Apron	24	23	19	22		22	23	23	21	23
4-4D	New Right Abutment Long Side-Channel Spillway	18	24	24	22		24	24	24	22	24
1-1	Existing Spillway Limited Ops	25	25	25	25		25	25	25	25	25
1-2	Existing Skimmer Gate Limited Ops	25	25	25	25		25	25	25	25	25
1-4	Operate Gates #1 and #7	25	25	25	25		25	25	25	25	25
3-1	Armor Area Downstream of Sluice #1 and #7	25	25	25	25		25	25	25	25	25

Attachment 3-2: Illustrations of Six Total Dissolved Gas Abatement Alternatives

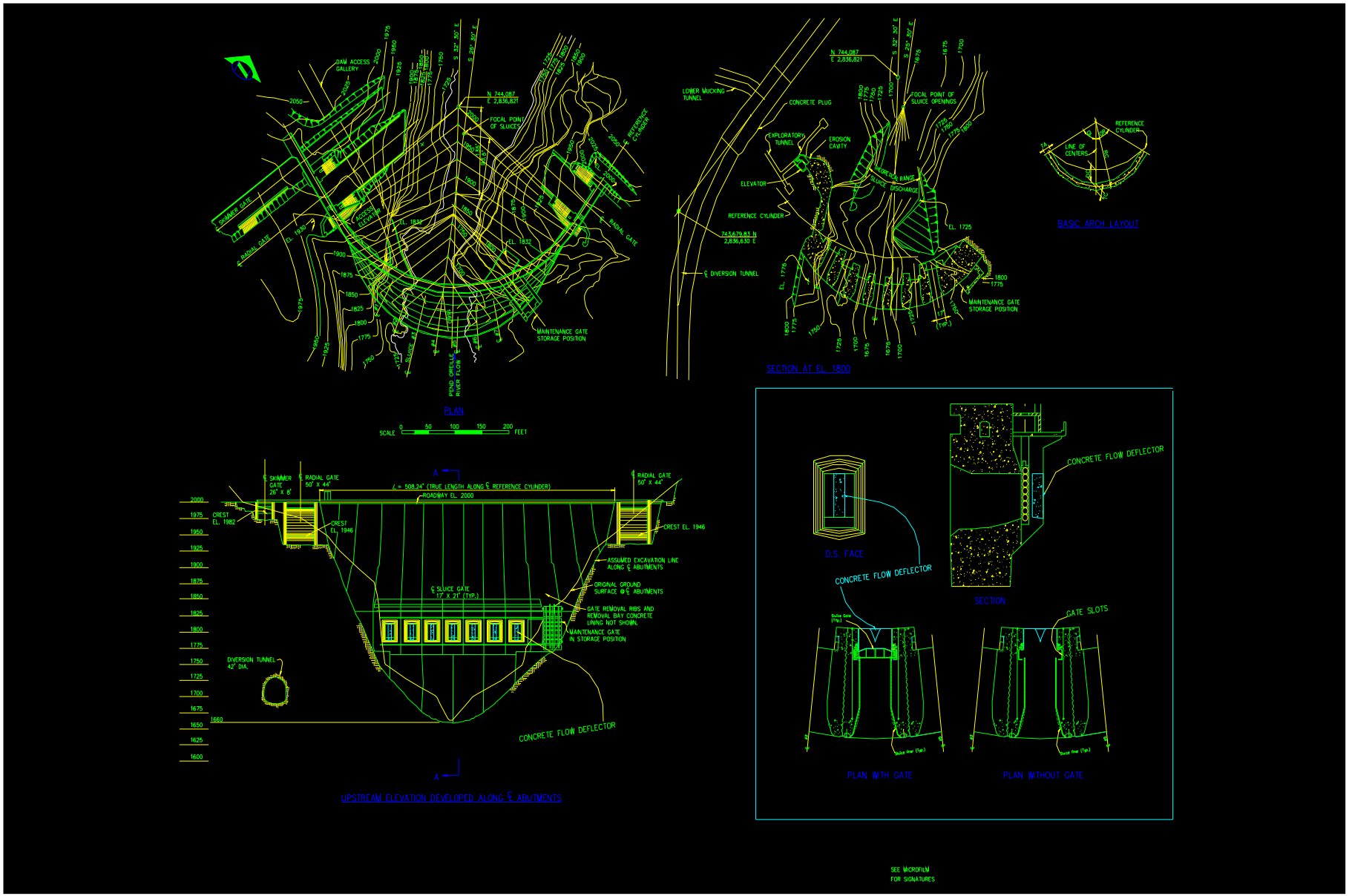
SCL TDG Proposed Study Plan(PSP)
Attachment 3-2: Illustrations of Six Alternatives

Option 1-3. Throttle Sluice Gates



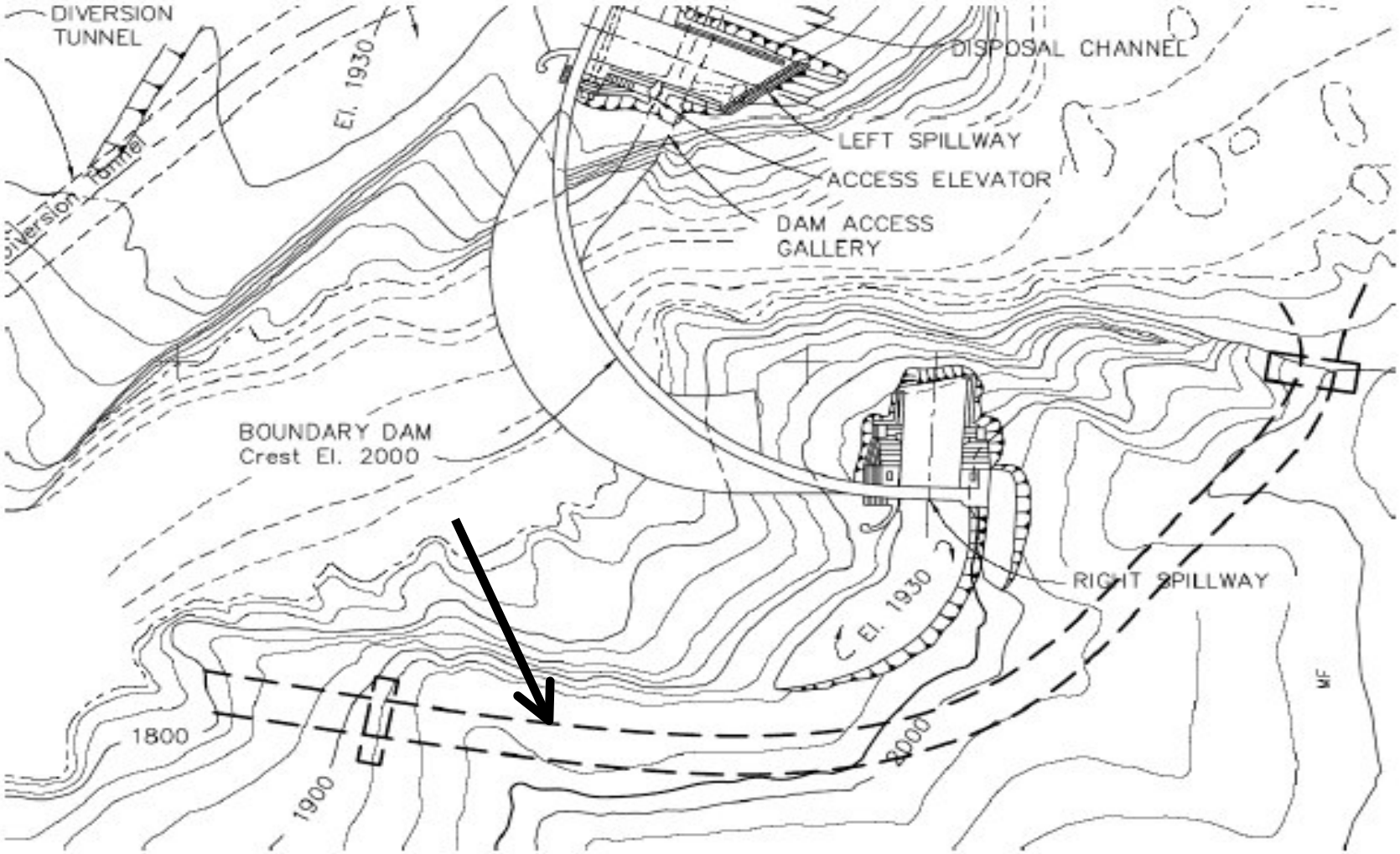
Option 1-3. Throttle Sluice Gates

Option 3-2. Roughen Sluice Gate Discharge

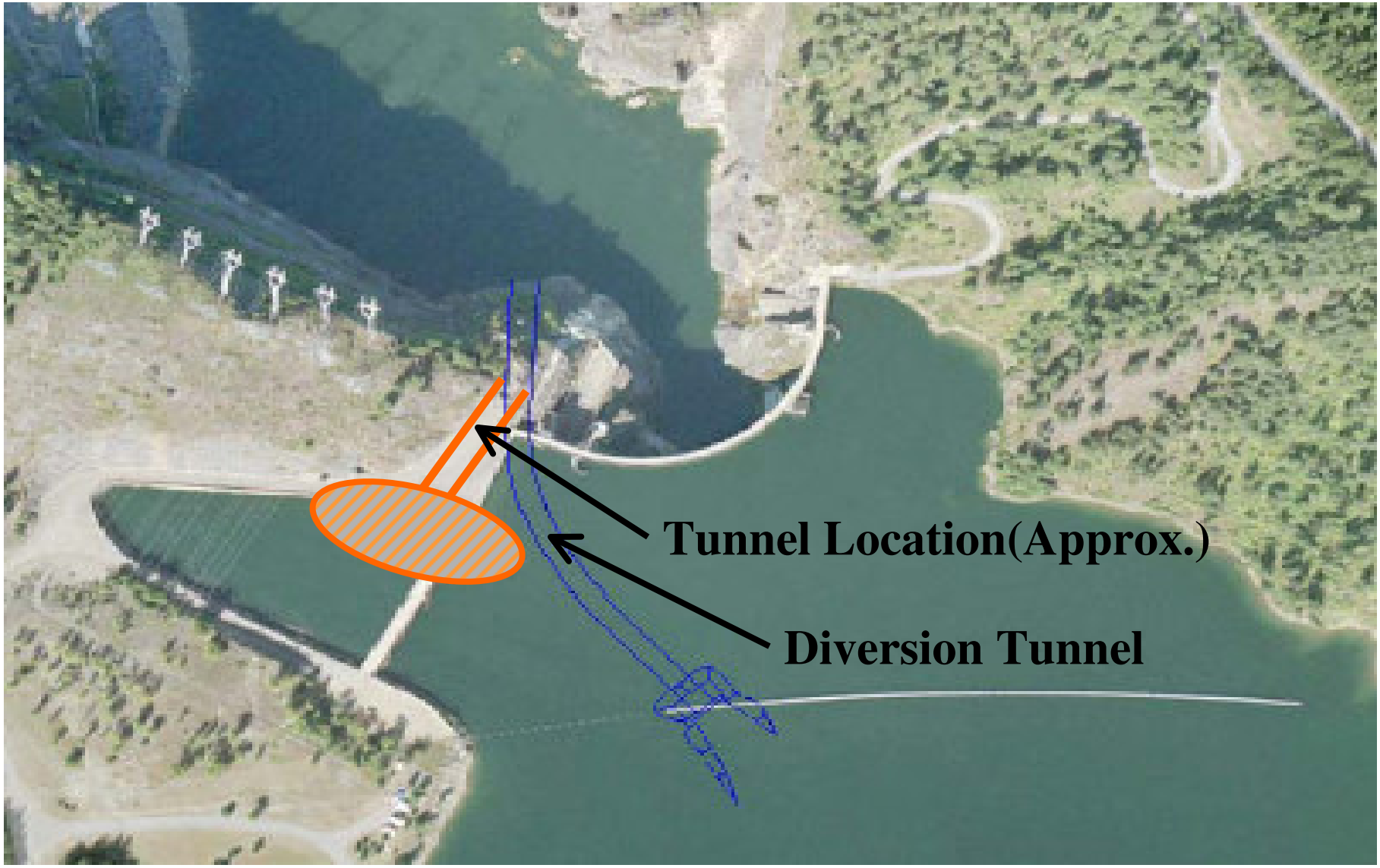


Option 4-7. New Right Abutment Tunnel with Submerged Discharge

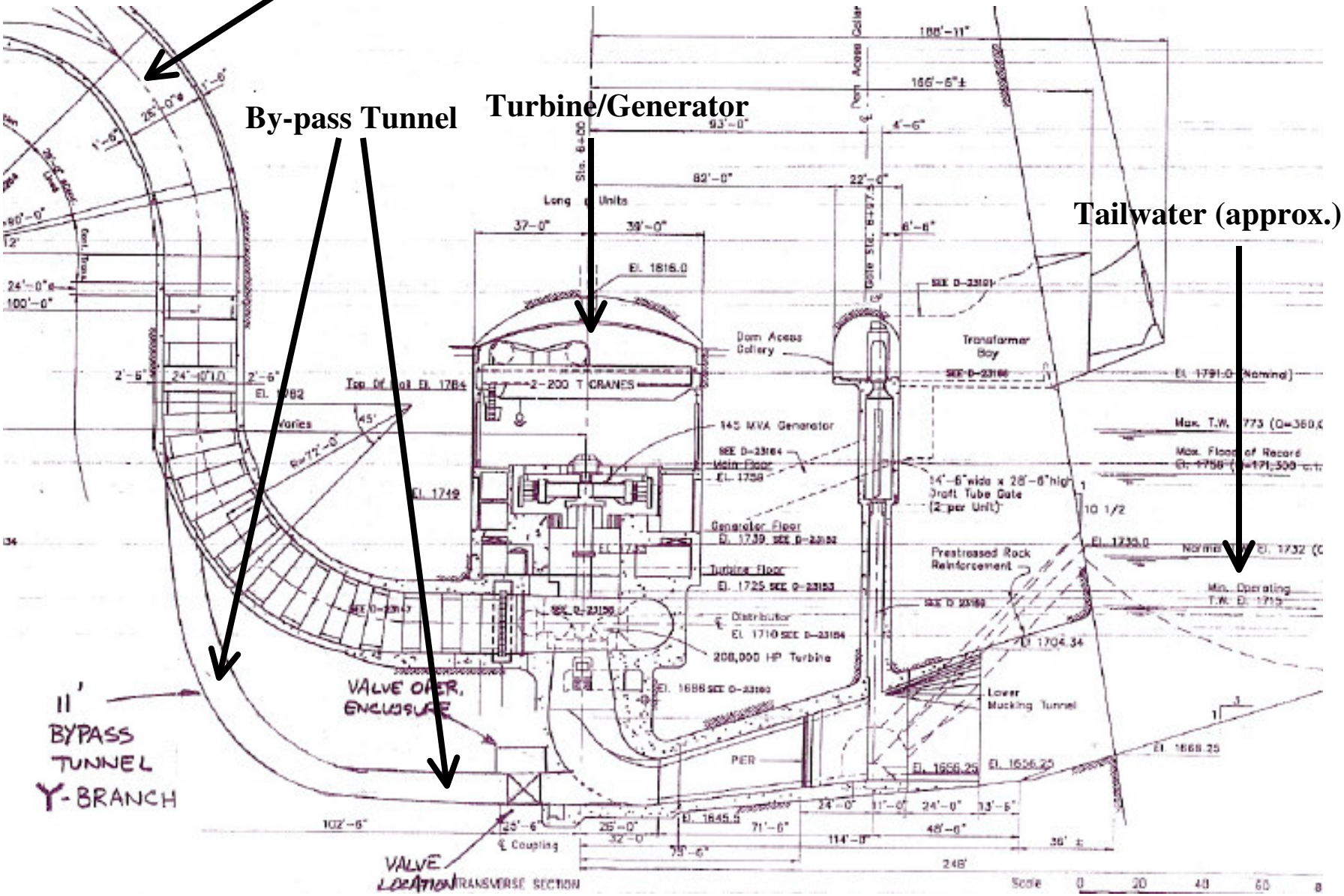
Long curved alternative



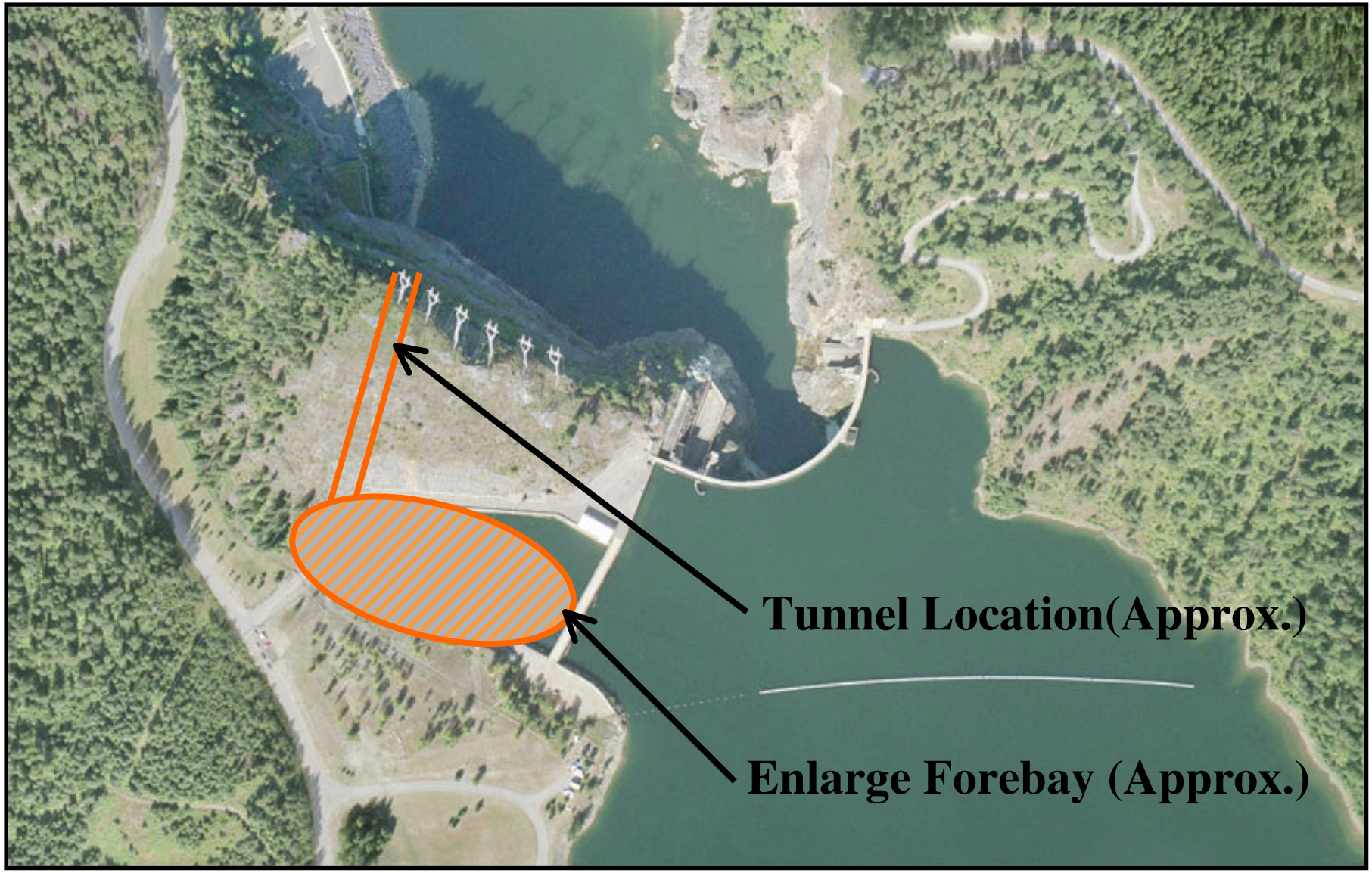
Option 4-8A. New Left Abutment Tunnel Intercepts Diversion Tunnel



Option 4-9. Penstock/Draft Tube By-Pass



Option 4-10. New Left Abutment Tunnel Next to Unit #51 Intake



Attachment 3-3: Undeveloped Total Dissolved Gas Abatement Alternatives

Attachment 3-3, Table 1 - Operational Alternatives for Existing Structures

Alt. No.	Name	Expected capacity, cfs	Potential TDG Benefit (1)	Testing Required to Assess Viability	Constructability and Other Assessment Required to Evaluate	Comments
1	Existing Spillway-Limited Spill Operation	18,000	2 - 3	Yes-Confirm gas levels for a range of flows and gate combinations	1. Assess 2002/2003 Spill Test results. 2. Third party review of 2002 data (CBE 2003 report) by Michael Schneider (ACE).	Possibly work with the spillway modifications to boost total spillway flow
2	Existing Skimmer gate-Limited spill operation	1,800	2	Yes-confirm gas level for range of flows	1. Assess during spill test. 2. Evaluate/verify hydraulic capacity.	Perform with testing of main spillway gates
3	Throttling of sluice gates	unknown	3	Yes-confirm gas levels for a range of flows and gate combinations	1. Assess gate vibration when throttling during a spill test. 2. Assess the potential for foundation erosion due to a steeper diving jet when throttling. This is a potential dam safety issue.	Started (1.) in April 2006. (Note: The 1968 Bechtel Leedshill Design Report, Section VI-8 *design criteria for sluice gates* indicates that the gates may be stopped and held in any position of travel. SCL throttled the sluice gates during a 1972 safety inspection.)
4	Operate sluice gates 1 and 7 (outer gates) in lieu of 3-5 (central gates)	36,000 to 72,000	3	Yes-operate the gates during spill and confirm gas levels	1. Test procedure to protect abutment. 2. Evaluate probable need for armoring of abutments where gate discharge hits. This is a dam safety issue. (Note: This option is may be considered a structural option, i.e., armoring of downstream abutments and this option may be moved to a different table.)	These gates historically not used due to abutment erosion.

(1) Potential benefits rated 1 (best-strips gas) to 5 (worst-adds gas). Benefit of 3 is assumed to pass the upstream gas level (no addition of gas or stripping).

Attachment 3-3, Table 2 - Spillway Structural Modification Alternatives

Alt. No.	Name	Expected capacity, cfs	Potential TDG Benefit (1)	Testing Required to Assess Viability	Constructability and Other Assessment Required to Evaluate	Comments
1	Spillway Modifications: (includes 2004 alternatives) 1a – roughen 1b – deflectors 1c – flared training walls 3a-aim towards shallower area in pool 3b-increase landing area 3c-air entrainment	20,000-60,000	2	Requires prototype modifications of spillways.	1. Hydraulic evaluation of spillway structure needed to predict possible flow rate. 2. Evaluate risk of abutment erosion.	Benefits may be uncertain. All 5 sub-alternatives from April 2004 are really one—modify spillways to spread the flow and reduce the plunge, or to hit the abutments to break fall of water and limit gas uptake. For 3a, add passive air admission towards top of spillway
2	Skimmer gate modification to increase flow capacity (existing is 1,800 cfs)	4,000	2	Use results of testing existing gate. (See Table 1, Alt.#2)	Hydraulic evaluation needed to predict flow rate and shape of flow onto left abutment	4,000 cfs assumes gate sill is cut to double gate height. Very expensive for minor increase in flow.
3A	Raise plunge pool floor, for sluice gate discharge	60,000	4	None possible	Concept development for physical, structural, and hydraulic arrangement	Larger area than for spillway gates, may interfere with spillway flows. Assess interlocking jacks. Potential problems may include erosion, movement, and lateral force.
3B	Raise plunge pool floor, for spillway gate discharge	60,000	4	None possible	Concept development for physical, structural, and hydraulic arrangement	More attractive than sluice gate option (Table 2-3A). Smaller area near dam. (Still need to meet PMF)
6A **Delete**	Modify right abutment spillway to add long flume	52,000	2	None possible	This alternative was **discarded** due to its structural concept being infeasible. The height and length of the flume and problems with sluice gate flows impacting the supports make it unrealistic.	
6B **Delete**	Modify right abutment spillway to add stripping structure	52,000	1-2	None possible	This alternative was **discarded** due to its structural concept being infeasible. The height and length of the downstream structure and problems with sluice gate flows impacting the supports make it unrealistic.	
6C **Delete**	Modify right abutment spillway to shape discharge flows onto the right abutment	2,000 to 5,000	2-3	None possible	This alternative was **discarded.** It is essentially the same as alternative 1c, which is shaping the spillway discharge to hit the abutment.	
7	Floating spill dissipater (Note: Similar to raising plunge pool floor)	60,000?	2-3	None possible	Concept development for physical, structural, and hydraulic arrangement	Added in May 2004. Could be floating pipe sections to limit plunge depth.

(1) Potential benefits rated 1 (best - strips gas) to 5 (worst-adds gas). Benefit of 3 is assumed to pass the upstream gas level (no addition of gas or stripping).

Attachment 3-3, Table 3 - Sluice Gates Structural Modification Alternatives

Alt. No.	Name	Expected capacity, cfs	Potential TDG Benefit (1)	Testing Required to Assess Viability	Constructability and Other Assessment Required to Evaluate	Comments
1	Armor area downstream of sluice gates 1 or 7	36,000	3?	Field test possible, after abutment erosion assessment.	Concept development required for physical, structural, and hydraulic arrangement	Potential problems with abutment impacts. Will sluice stream even reach abutments?
2	Roughen sluice gate discharge to spread flow and limit plunge	6,000 per gate	3?	May be possible to prototype one gate	Concept development required for physical, structural, and hydraulic arrangement	Assumes throttling of gates is feasible and structurally acceptable.
3 **Delete**	Install "tubing" from gate discharge to lower pool	36,000	3	None possible	This alternative **discarded** due to concerns on dam safety, lack of upstream shutoff, and risk in throttling and structural concerns with the "tube" being impacted by spill from other gates.	
4	Modify sluice gates to add fixed cone or jet-flow valves to gate leaf	3,000 to 6,000 per gate	2	None possible	Concept study needed to determine valve configuration on sluice gate	Possibly 2 or 3 valves added to gate. 72 inch valve diameter assumed. • Decreases the capacity of the sluiceways • Add air / energy dissipater
5 **Delete**	Alter sluice gates to be bonneted slide gates and add downstream tube	36,000	3	None possible	This alternative **discarded** due to infeasibility of downstream "tube" and dam safety risks with the gate modification.	
5A	Add branch outlet from sluice liner to point below sluice gates, submerged discharge at bottom of dam	3,000 cfs per gate	2-3	None possible	Concept study needed.	Added this alternative during May 2004 meeting. Downstream conduit would be attached to dam. Possible use of dam sump gallery.
6 **Delete**	Enclose discharge from 2 sluice gates in an open flume	36,000	2-3	None possible	This alternative **discarded** due to concerns on dam safety, risk in throttling and structural concerns with the flume being impacted by spill from other gates.	
7	Floating Barge deflector to shape sluice gate flow, reduce plunge	60,000?	2	None possible	Concept development required for physical, structural, and hydraulic arrangement	Comparable to filling plunge pool (See Table 2).

(1) Potential benefits rated 1 (best-strips gas) to 5 (worst-adds gas). Benefit of 3 is assumed to pass the upstream gas level (no addition of gas or stripping).

Attachment 3-3, Table 4 - New Structure Alternatives

Alt. No.	Name	Expected capacity, cfs	Potential TDG Benefit (1)	Testing Required to Assess Viability	Constructability and Other Assessment Required to Evaluate	Comments
1	Underwater outlet through mid-section of dam	2,800 cfs per 6-ft outlet	3	None possible	Concept analysis required, especially for dam safety	Similar and possibly much less attractive than conduit tapping the sluice gate liners (Table 3, Alt. #5A)
3 **Delete**	Siphon discharge around project	1,500 cfs for 8-ft pipe	2?	None possible	This concept **discarded**. A siphon intake is simply an option for any type of surface release from the reservoir. Other intake options have more capacity and reliability at less cost	
4	Bridge-type spillway apron, span across abutments	60,000	2?	None possible	Concept development required for physical, structural, and hydraulic arrangement	Structure may get blown out (destroyed) in major floods
4A	New right abutment spillway with tunnel outlet gate	40,000	3	None possible	Concept development for physical, structural, and hydraulic arrangement.	Capacity estimated, based on approx 30-ft dia tunnel and 50 fps velocity in tunnel.
4B	New right abutment spillway with long flume	30,000	1-2	None possible	Concept development for physical, structural, and hydraulic arrangement.	Surface intake capacity likely limited by approach flow conditions. Open channel system can degas flows effectively
4C	New right abutment spillway with flow over the right abutment.	30,000	1-2	None possible	Concept development for physical, structural, and hydraulic arrangement.	Abutment shaping and armoring likely required
5	New left abutment spillway with long flume along access road	12,000	1	None possible	Concept development for physical, structural, and hydraulic arrangement.	Capacity limited by space along road. Could effectively strip gas on large flat area below powerhouse.
7	New right abutment tunnel with submerged discharge	40,000	3	None possible	Concept development required for physical, structural, and hydraulic arrangement	
7A	New right abutment tunnel with fixed cone valve discharge	4,000 cfs per valve	2	None possible	Concept development required for physical, structural, and hydraulic arrangement	Valve maximum size estimated at 120 inch dia. Max velocity at valve possibly 50 fps.
7B **Delete**	New right abutment tunnel with powerplant	30,000	3	None possible	This alternative **discarded** based on cost. At $3,000 per kW of capacity a 30,000 cfs option (545 MW), this system's powerplant would cost $1.6 billion	
8	Open existing diversion tunnel and add control structure	27,000	3	None possible	Concept development required for physical, structural, and hydraulic arrangement	Capacity based on limit of 20 fps in unlined 42-ft dia. rock tunnel. May be too optimistic. Need to vent valve to prevent cavitation—TDG increase, or could tunnel to the surface and place valve at intake?

(1) Potential benefits rated 1 (best-strips gas) to 5 (worst-adds gas). Benefit of 3 is assumed to pass the upstream gas level (no addition of gas or stripping).

Attachment 3-3, Table 5 - Lower River Modification Alternatives

Alt. No.	Name	Expected capacity, cfs	Potential TDG Benefit (1)	Testing Required to Assess Viability	Constructability and Other Assessment Required to Evaluate	Comments
1	Add downstream control weir	118,000	3?	None possible	Concept study required. May be infeasible due to foundation and length requirements	Requires fall of about 3 ft (with 1-ft depth) to allow partial degassing. 3 to 5 miles of weir required to attain 1-ft for less of depth over weir (needed to degas).
2A	Add structure to prevent mixing of powerhouse flow and spill gate flow	60,000	3	None possible	Concept study required. May be infeasible due to foundation and length requirements	Only reduces potential powerhouse entrainment
2B	Add structure to prevent mixing of powerhouse flow and spill gate flow, include weir overflow	60,000	2	None possible	Concept study required. May be infeasible due to foundation and length requirements	Requires fall of about 3-ft to allow partial degassing.
3 **Delete**	Add turbulent mixers to surface of downstream river	unknown	2	Mixer could be installed and tested	This alternative **discarded.** It could not treat the river until well below the project, downstream of the water quality monitoring point.	
					Cost and effectiveness of mixers would need evaluation. Small size may make this system unrealistic	Could only install below area where river flow is free of bubbles

(1) Potential benefits rated 1 (best-strips gas) to 5 (worst-adds gas). Benefit of 3 is assumed to pass the upstream gas level (no addition of gas or stripping).

Attachment 3-4: Review of EPA Data for the Lower Pend Oreille Mines and Mills

Review of EPA Data for the Lower Pend Oreille Mines and Mills

Introduction

The Preliminary Assessments and Site Investigations Report for the Lower Pend Oreille River Mines and Mills, prepared by EPA (EPA 2002) was reviewed to determine any potential sources of toxics contamination in the Boundary Project area from historical mining activities. The EPA report investigated potential contaminant sources to the lower reach of the Pend Oreille River from 21 mines and mills in the area. Toxic contaminants were measured in sediment, surface soil, and surface water samples at the five mines that were found to have mechanisms that could potentially transport contaminants to the river. The report summarizes the analytical monitoring results, with emphasis on the constituents found in significant concentrations in source samples and elevated concentrations in target samples. Source samples are those collected at the source of contamination (e.g., mine tailings), whereas target samples are those collected in areas potentially impacted through contaminant migration. Significant/elevated samples were those that were either equal to or greater than the detection limit when a non-Contract Laboratory Program (CLP) was used, equal to or greater than the background level when the background level was below detection limits, or at least three times greater than the background concentration when the background concentration exceeded detection limits.

Methods

The information available in the EPA report, along with regional toxicity criteria or guidelines and contaminant toxicity information, were reviewed to assess what contaminants evident from the EPA report might be important to consider in more detail as part of SCL's Boundary relicensing studies. To assess each constituent, a two-tiered evaluation process was followed. The first tier was comparison with Ecology's freshwater sediment and surface soil guidelines. If none of the source or target samples exceeded these guidelines, then the toxic was not considered for further analysis and it was recommended for omission from further study. If measurements did exceed guidelines, then the second tier criteria were evaluated. The second tier consists of three separate criteria: 1) whether the constituent was detected in the waterways or target samples at elevated concentrations, 2) whether the constituent was of medium or high toxicity, and 3) whether there was documented reoccurrence of the toxic within the basin. If two of these three criteria were met, the toxic was recommended for inclusion in the *Assessing Toxics of Toxics: Phase 1*study plan (toxic assessment study).

The two-tier assessment criteria approach is conservative given that source and target concentrations were used in the rating process, both of which may be located in areas remote from the river floodplain. In addition, the higher-than-threshold concentrations found in soil or sediment would most likely dilute to below levels-of-concern by the flow and sediment load in the river mainstem and do not necessarily represent toxic concentrations within the wetted area influenced by the Boundary Project. This assessment provides information in addition to a previous report prepared for SCL, the *Toxics Inventory and Screening* (R2 2006). The *Toxics Inventory and Screening* focused on water quality data, while the current investigation focuses primarily on sediment and soil contamination resulting from historical or active mines in the Project area.

Results and Conclusions

A summary of each constituent and supporting information is provided in the text and tables below. Table A-1 summarizes the assessment criteria, and Table A-2 summarizes the surface soil and freshwater sediment guidelines and thresholds. The surface soil guidelines provided in Table A-2 are based on the Model Toxics Control Act (MTCA) and Cleanup Regulation. This act sets specific standards for soil cleanup while also providing flexibility for cleanups to be addressed on a site-specific basis. Cleanup standards are selected based on three methods (A through C). Method A, which provides cleanup levels that are protective of human health for 25-30 of the most common hazardous substances found in soil and groundwater at sites, is presented in Table A-2. There are no specific Washington State standards for toxics in freshwater sediments. Instead, criteria are established on a site-by-site basis. However, Ecology established freshwater sediment quality values based on studies conducted in 1997, 2002, and 2003 that reviewed data from 33 studies and tested the efficiency and sensitivity that sediment quality values have in predicting biological effects. As a result of these studies, two levels of thresholds were developed, the Lowest Apparent Effects Threshold (LAET) and the Second Lowest Apparent Effects Threshold (2LAET), both of which are presented in Table A-2. The 2LAET's are used as indications of violations of the Clean Water Act, while the LAET's are used as clean-up screening level (CSL) (Adolphson, 2006).

These guidelines and thresholds were compared to data from the EPA report as summarized in Tables A-3 and A-4. Table A-3 summarizes the constituents found in mine source samples as having significant concentrations, while Table A-4 summarizes the constituents found in mine target samples as having elevated concentrations. A summary of the supporting information is provided in the text below.

Table A-1: Summary of assessment criteria.

Criteria	**Requirement**
Tier 1	
Criterion 1	Measured Values above Thresholds or Guidelines
Tier 2	
Criterion 2	Elevated levels in target samples or detection within waterways
Criterion 3	Toxicity (medium or high)
Criterion 4	Reoccurrence within the watershed (medium or high)

Barium – Barium is a silvery–white metal which exists in nature in ores containing mixtures of elements. It combines with other chemicals to form barium compounds which are used by the oil and gas industries to make drilling muds. Drilling muds make it easier to drill through rock by keeping the drill bit lubricated. The persistence of barium in the environment depends on the form. Some compounds (i.e., barium sulfate and barium carbonate) do not dissolve well in water and are longer lasting. Others (i.e., barium chloride, barium nitrate, or barium hydroxide) dissolve easily in water. The dissolvable forms usually combine with naturally occurring sulfate or carbonate and become the longer lasting forms. Elevated levels of barium can induce a wide range of effects in mammals including gastrointestinal distress, muscular paralysis, and

cardiovascular effects (Moore 1991). No toxic effects have been reported in aquatic plants due to barium at the usual concentrations found in water (WHO 1991). Barium and its compounds have a moderate acute and chronic toxicity to aquatic life. Reproduction and growth in *Daphnia* spp. were impaired by barium concentrations of 5.8 mg/L (WHO 1991). Barium does not bioaccumulate. Based on the information above, barium is considered to be of medium biological toxicity. Barium did not meet the tier 1 criterion with no measurements exceeding guidelines or threshold values. Based on this criteria, it is recommended that barium be omitted from further investigation (Table A-5).

Chromium – Chromium is a naturally occurring element found in soil, rocks, animals, and plants. Chromium is used in industry to make steel, for chrome plating, dyes and pigments, leather tanning, and wood preserving. Chromium attaches strongly to soil and does not accumulate in fish tissue. Based on the information above, chromium is considered to be of medium biological toxicity. Chromium did not meet the tier 1 criteria and therefore it is recommended that it be omitted from further studies (Table A-5).

Copper – Copper is naturally occurring in soils, water, rock, and air and is an essential element in plants and animals. Copper is used in the production of many products and is commonly used in agriculture to treat plant diseases and as a preservative for wood, leather, and fabrics. Copper is highly toxic in aquatic environments and has effects in fish, invertebrates, and amphibians. There is a low potential for bioconcentration in fish and a moderate potential for bioaccumulation in plants. Based on the information provided above, copper is considered to be of high biological toxicity. Since copper did not meet the tier 1 criteria because no values exceeded guidelines or thresholds, it is recommended that it be omitted from further relicensing studies (Table A-5).

DDE/DDT/DDD – DDE, DDT, and DDD are pesticides used to kill insects in agriculture. They are rapidly broken down by sunlight, but adhere strongly to soil and once in soil break down slowly. They will also accumulate in plants and in the fatty tissue of fish and animals. Boundary Reservoir operations can potentially influence DDE/DDT/DDD concentrations through toxicant accumulation, erosion and leaching, and bioaccumulation. Based on the information above, DDE/DDT/DDD were considered to be of high biological toxicity. DDT did not meet the tier 1 criteria and should therefore be omitted from further studies (Table A-5).

Manganese – Manganese is a naturally occurring essential trace element found in many types of rocks. It can combine with other substances such as oxygen, sulfur, or chlorine. Manganese can enter the air from iron, steel, power plants, coke ovens, and from dust from mining operations. Manganese is an essential trace element for microorganisms, plants, and animals and can reduce the hazard posed by other metals. It is only slightly to moderately toxic to aquatic organisms in excessive amounts. Plants in the water can take up some of the manganese from water and concentrate it. Based on the information above, manganese is considered to be of low biological toxicity. Manganese does not have sediment guidelines or thresholds, but based on the low toxicity, the non-detection within target samples or waterways, and the low reoccurrence within the watershed, it is recommended that magnesium be omitted from further studies (Table A-5).

Mercury – Mercury is a naturally occurring metal that can take several forms in the environment. Inorganic mercury compounds include mercuric sulphide, mercuric oxide, and mercuric chloride, while organic mercury is formed when mercury combines with carbon and other elements. The most commonly found form is methylmercury, which is a cation and is the most toxic (Greenfacts 2006). Inorganic mercury can be methylated by bacteria in both anaerobic and aerobic environments. This form can accumulate in living organisms and reach high levels in fish and marine mammals via biomagnification. The methylation of mercury is found to be more pronounced in anoxic areas, such as wetlands, and can be enhanced by increased nutrients, and increased temperature. Current sources of mercury contamination include abandoned mine sites and effluent from the Pend Oreille Mine (Ecology and Environment 2002, Ecology 2001a). Based on the information above, mercury is considered to be of high biological toxicity. Mercury did not meet the tier 1 criterion (Table A-5). However, mercury was recommended for further study in the *Toxics Inventory and Screening* (R2 2006). The combination of a lack of recent water quality data, current sources of mercury in the Project area, the ability of mercury to bioaccumulate, and the potential for reservoir fluctuation to affect mercury methylation has prompted SCL to take a more detailed look at mercury to understand the potential risk of this toxicant in the Project area.

Nickel – Nickel is an abundant natural element used in many industrial processes and products. It attaches to particles with iron or manganese, but does not accumulate in fish, plants, or animals. Observed effects of nickel in aquatic environments include tissue damage, genotoxicity, and growth reduction (Environment Canada 1994a). Based on the information above, nickel is considered to be of medium biological toxicity. Nickel does not meet the tier 1 criterion and is recommended to be omitted from further studies (Table A-5).

Selenium – Selenium is a naturally occurring mineral element distributed widely in nature. It is widely used in industry in electronics, the preparation of pharmaceuticals, pesticides, and fungicides. Some selenium compounds will dissolve in water while others will settle as particles. Selenium can accumulate up the food chain and undergoes bioconcentration, bioaccumulation, and biomagnification as trophic levels increase (Taylor et al 1992). Based on the information above, selenium is considered to be of high biological toxicity. It is recommended that selenium be omitted from further studies given that it is detected below MTCA surface soil guidelines and there are no freshwater sediment thresholds (Table A-5).

Silver – Silver is a naturally occurring element that does not concentrate to significant amounts in aquatic organisms. However, silver is highly toxic to aquatic organisms (EPA 1992). Elevated levels can cause larval mortality, developmental abnormalities, and reduced larval growth in fish. Based on the information above, silver is considered to be of medium biological toxicity. Silver concentrations exceed the tier 1 criterion, but since it was not detected within a waterway or target sample and has low reoccurrence within the watershed, it is recommended that it be omitted from further studies (Table A-5).

Vanadium – Vanadium is a compound that occurs in nature as a white to gray metal. It usually combines with other elements such as oxygen, sodium, sulfur, or chloride. It can be found in the earth's crust, in rocks, some iron ores, and crude petroleum deposits. Vanadium stays in the air, water, and soil for a long time and does not dissolve well in water and does stick to soil

sediments. Low levels have been found in plants, but it is not likely to build up in the tissues of animals. The growth of some aquatic plants is stimulated by trace quantities of vanadium (1–10 µg/L), but concentrations above 100 µg/L are toxic (WHO 1990). Based on the information above, vanadium is considered to be of low biological toxicity. There are no thresholds for vanadium, but since the values are below typical background conditions, there is low reoccurrence within the watershed, and it is of low biological toxicity, it is therefore not recommended for further study (Table A-5).

Arsenic – Arsenic is a naturally occurring element that is used to preserve wood and in some pesticides (U.S. Dept of Health and Human Service 2006). Arsenic can be toxic in the environment. Inorganic forms are more toxic to organisms in the environment than organic forms, and, among inorganic forms, arsenite is more toxic than arsenate (Greenfacts 2006). Arsenite is thought to be toxic because it binds to sulfhydryl groups, which are found on proteins. Arsenate affects the key energy producing process that takes place in all cells. Arsenic compounds can cause short-term and long-term effects in plants and animals including death, inhibition of growth, photosynthesis and reproduction, and behavioral effects (Greenfacts 2006). Arsenic-contaminated environments are characterized by limited species abundance and diversity. Based on the above information, arsenic was classified as having high biological toxicity. Arsenic concentrations were found to have values exceeding surface soil guidelines (Table A-5). Although there was low reoccurrence within the watershed, given the elevated levels of arsenic found in target samples and high toxicity, it is recommended that arsenic be included in the toxic assessment study (Table A-5).

Cadmium – Cadmium is a natural element found in soils and rocks and is often extracted during the production of other metals such as zinc, lead, and copper. Cadmium is highly toxic and bioaccumulates at all trophic levels, accumulating in the livers and kidneys of fish (Sindayigaya et al 1994). Cadmium can be toxic to plants at lower soil concentrations than other heavy metals and is more readily taken up than other metals. Based on the information above, cadmium is considered to be of high biological toxicity. Based on the tier 1 and tier 2 assessment criteria, it is recommended that cadmium be included in further studies (Table A-5). Note that cadmium was already recommended for inclusion in further studies based on the water quality assessment described in the *Toxics Inventory and Screening*.

Lead – Lead adversely affects algae, invertebrates, and fish. Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988). Lead can cause reduced growth, photosynthesis, mitosis, and water absorption at elevated levels in plants (Eisler 1988). Lead can be bioconcentrated from water, but does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Eisler 1988). Lead partitions primarily to sediments, but becomes more bioavailable under low pH, hardness and organic matter content. Lead bioaccumulates in algae, macrophytes and benthic organisms, but the inorganic forms of lead do not biomagnify. Based on the information above, lead is considered to be of medium biological toxicity. It is recommended that lead be included in further studies because it met the tier 1 criterion and three of the tier 2 criteria (Table A-5). Note that lead was already recommended for inclusion in further studies based on the water quality assessment described in the *Toxics Inventory and Screening*.

Zinc – Zinc is a common element found in air, soil, and water. Zinc is currently, and was historically, mined within the Lower Pend Oreille area. It is also used in industry to make paint, dyes, wood preservatives, and ointments. Elevated levels of zinc can adversely affect the growth, survival, and reproduction of aquatic plants and animals (Eisler 1993). Based on the information above, zinc is considered to be of medium biological toxicity. Zinc meets the tier 1 criterion as well as three of the tier 2 criteria and should therefore be included in further studies (Table A-5).

The information used in the assessment of EPA toxics data and the recommendations for inclusion or omission from future studies are summarized in Table A-5. Fourteen toxics found in the source and target samples were evaluated. Of these, ten (barium, chromium, copper, DDT, manganese, mercury, nickel, selenium, silver, and vanadium) were recommended for omission from further study, and four (arsenic, cadmium, lead, and zinc) were recommended for further study based on the criteria specified. Although not recommended based on sediment data, mercury was recommended for inclusion based on water quality data reviewed in the *Toxics Inventory and Screening*. PCBs were not included in the EPA report and were therefore not reviewed in the current assessment, but are also recommended for further study based on the findings in the *Toxics Inventory and Screening*. In total, six toxics (arsenic, cadmium, lead, mercury, zinc, and PCBs) are recommended for inclusion in further studies.

Table A-2: Surface soil and freshwater sediment cleanup levels, effects levels, and sediment quality values.

	Surface Soil[1]	Freshwater Sediment		
Constituent	**MTCA Method A Cleanup Level for Unrestricted Land Use (mg/Kg)**	**Typical Background (mg/Kg)[2]**	**Lowest Apparent Effects Threshold (mg/Kg)[3]**	**Second Lowest Apparent Effects Threshold (mg/Kg)[3]**
Arsenic	20.0	1.1	31.4	50.9
Barium		0.700		
Cadmium	2.0	0.1-0.3	2.39	2.9
Chromium	100	7-13	95	133
Copper		10-25	619	829
Lead	250	4-17	335	431
Manganese		400		
Mercury	2	0.004-0.051	0.8	3.04
Nickel		9.9	53.1	113
Selenium		0.29		
Silver		<0.5	0.545	3.5
Vanadium		50		
Zinc		7-38	683	1080
“4,4’-DDT	3		19	-

[1]Ecology Table 740-1
[2]NOAA Screening Quick Reference Table for Inorganics in Solids
[3]Ecology Sediment Quality Values (Michelsen 2003)

Table A-3: Mine source samples identified in the lower Pend Oreille area as having significant concentrations.

Sample ID	Mine	Sample Type	Location	Constituent	Concentration	Units	Comparison to Guidelines/ Thresholds
01264273	Oriole	Sediment	ORSP02SD	Arsenic	13.8	mg/kg	Below LAET
01264252	Pend Oreille	Surface Soil	POTP01SS	Arsenic	20.6	mg/kg	Above MTCA
01264255	Pend Oreille	Surface Soil	POTP04SS	Arsenic	8.5	mg/kg	Below MTCA
01264256	Pend Oreille	Surface Soil	POTP05SS	Arsenic	40.0	mg/kg	Above MTCA
01264257	Pend Oreille	Surface Soil	POTP06SS	Arsenic	20.8	mg/kg	Above MTCA
01264258	Pend Oreille	Surface Soil	POTP07SS	Arsenic	26.4	mg/kg	Above MTCA
01264259	Pend Oreille	Surface Soil	POTP08SS	Arsenic	22.4	mg/kg	Above MTCA
01264260	Pend Oreille	Surface Soil	POTP09SS	Arsenic	21.1	mg/kg	Above MTCA
01264354	Pend Oreille	Surface Soil	POWP02SS	Arsenic	21.8	mg/kg	Above MTCA
01264355	Pend Oreille	Surface Soil	POWP03SS	Arsenic	35.1	mg/kg	Above MTCA
01264272	Oriole	Sediment	ORSP01SD	Barium	234	mg/kg	
01264267	Blue Bucket	Sediment	BBPP01SD	Cadmium	1.7	mg/kg	Below LAET
01264269	Blue Bucket	Sediment	BBPP02SD	Cadmium	2.8	mg/kg	Above LAET
01264272	Oriole	Sediment	ORSP01SD	Cadmium	8.5	mg/kg	Above 2LAET
01264273	Oriole	Sediment	ORSP02SD	Cadmium	27	mg/kg	Above 2LAET
01264423	Josephine	Sediment	JOPP01SD	Cadmium	9.6	mg/kg	Above 2LAET
01264418	Grandview	Sediment	GMPP05SD	Cadmium	1.6	mg/kg	Below LAET
01264411	Pend Oreille	Sediment	POPP02SD	Cadmium	6.1	mg/kg	Above 2LAET
01264252	Pend Oreille	Surface Soil	POTP01SS	Cadmium	15.0	mg/kg	Above MTCA
01264254	Pend Oreille	Surface Soil	POTP03SS	Cadmium	9.2	mg/kg	Above MTCA
01264258	Pend Oreille	Surface Soil	POTP07SS	Cadmium	30.4	mg/kg	Above MTCA
01264259	Pend Oreille	Surface Soil	POTP08SS	Cadmium	20.1	mg/kg	Above MTCA
01264260	Pend Oreille	Surface Soil	POTP09SS	Cadmium	10.4	mg/kg	Above MTCA
01264353	Pend Oreille	Surface Soil	POWP01SS	Cadmium	4.0	mg/kg	Above MTCA
01264354	Pend Oreille	Surface Soil	POWP02SS	Cadmium	34.2	mg/kg	Above MTCA
01264355	Pend Oreille	Surface Soil	POWP03SS	Cadmium	44.1	mg/kg	Above MTCA
01264256	Pend Oreille	Surface Soil	POTP05SS	Cadmium	8.2	mg/kg	Above MTCA
01264257	Pend Oreille	Surface Soil	POTP06SS	Cadmium	11.9	mg/kg	Above MTCA

Table A-3: Mine source samples identified in the lower Pend Oreille area as having significant concentrations.

Sample ID	Mine	Sample Type	Location	Constituent	Concentration	Units	Comparison to Guidelines/ Thresholds
01264273	Oriole	Sediment	ORSP02SD	Copper	71.7	mg/kg	Below LAET
01264252	Pend Oreille	Surface Soil	POTP01SS	Copper	176	mg/kg	Below LAET
01264255	Pend Oreille	Surface Soil	POTP04SS	Copper	90.0	mg/kg	Below LAET
01264257	Pend Oreille	Surface Soil	POTP06SS	Copper	178	mg/kg	Below LAET
01264258	Pend Oreille	Surface Soil	POTP07SS	Copper	242	mg/kg	Below LAET
01264259	Pend Oreille	Surface Soil	POTP08SS	Copper	113	mg/kg	Below LAET
01264260	Pend Oreille	Surface Soil	POTP09SS	Copper	88.0	mg/kg	Below LAET
01264269	Blue Bucket	Sediment	BBPP02SD	Lead	72.5	mg/kg	Below LAET
01264267	Blue Bucket	Sediment	BBPP01SD	Lead	59.9	mg/kg	Below LAET
01264272	Oriole	Sediment	ORSP01SD	Lead	301	mg/kg	Below LAET
01264273	Oriole	Sediment	ORSP02SD	Lead	714	mg/kg	Above 2LAET
01264356	Josephine	Surface Water	JOSP01SW	Lead	21.5	µg/L	Above Chronic
01264423	Josephine	Sediment	JOPP01SD	Lead	17400	mg/kg	Above 2LAET
01264417	Grandview	Surface Water	GMPP05SW	Lead	4.1	µg/L	Above Chronic
01264418	Grandview	Sediment	GMPP05SD	Lead	449	mg/kg	Above 2LAET
01264252	Pend Oreille	Surface Soil	POTP01SS	Lead	680	mg/kg	Above MTCA
01264254	Pend Oreille	Surface Soil	POTP03SS	Lead	467	mg/kg	Above MTCA
01264255	Pend Oreille	Surface Soil	POTP04SS	Lead	666	mg/kg	Above MTCA
01264256	Pend Oreille	Surface Soil	POTP05SS	Lead	1650	mg/kg	Above MTCA
01264257	Pend Oreille	Surface Soil	POTP06SS	Lead	818	mg/kg	Above MTCA
01264258	Pend Oreille	Surface Soil	POTP07SS	Lead	1760	mg/kg	Above MTCA
01264259	Pend Oreille	Surface Soil	POTP08SS	Lead	1000	mg/kg	Above MTCA
01264260	Pend Oreille	Surface Soil	POTP09SS	Lead	919	mg/kg	Above MTCA
01264353	Pend Oreille	Surface Soil	POWP01SS	Lead	3010	mg/kg	Above MTCA
01264354	Pend Oreille	Surface Soil	POWP02SS	Lead	8100	mg/kg	Above MTCA
01264355	Pend Oreille	Surface Soil	POWP03SS	Lead	6030	mg/kg	Above MTCA
01264401	Pend Oreille	Surface Water	POPP01SW	Lead	8.7	µg/L	Above Chronic
01264410	Pend Oreille	Surface Water	POPP02SW	Lead	9.3	µg/L	Above Chronic

Table A-3: Mine source samples identified in the lower Pend Oreille area as having significant concentrations.

Sample ID	Mine	Sample Type	Location	Constituent	Concentration	Units	Comparison to Guidelines/ Thresholds
01264411	Pend Oreille	Sediment	POPP02SD	Lead	346	mg/kg	Above LAET
01264272	Oriole	Sediment	ORSP01SD	Manganese	4210	mg/kg	
01264273	Oriole	Sediment	ORSP02SD	Manganese	2230	mg/kg	
01264417	Grandview	Surface Water	GMPP05SW	Manganese	25.5	µg/L	NA
01264410	Pend Oreille	Surface Water	POPP02SW	Manganese	33.0	µg/L	NA
01264423	Josephine	Sediment	JOPP01SD	Mercury	0.16	mg/kg	Below LAET
01264252	Pend Oreille	Surface Soil	POTP01SS	Mercury	0.25	mg/kg	Below MTCA
01264254	Pend Oreille	Surface Soil	POTP03SS	Mercury	0.16	mg/kg	Below MTCA
01264255	Pend Oreille	Surface Soil	POTP04SS	Mercury	0.15	mg/kg	Below MTCA
01264256	Pend Oreille	Surface Soil	POTP05SS	Mercury	0.10	mg/kg	Below MTCA
01264257	Pend Oreille	Surface Soil	POTP06SS	Mercury	0.18	mg/kg	Below MTCA
01264258	Pend Oreille	Surface Soil	POTP07SS	Mercury	0.58	mg/kg	Below MTCA
01264259	Pend Oreille	Surface Soil	POTP08SS	Mercury	0.25	mg/kg	Below MTCA
01264260	Pend Oreille	Surface Soil	POTP09SS	Mercury	0.16	mg/kg	Below MTCA
01264354	Pend Oreille	Surface Soil	POWP02SS	Mercury	0.16	mg/kg	Below MTCA
01264355	Pend Oreille	Surface Soil	POWP03SS	Mercury	0.19	mg/kg	Below MTCA
01264353	Pend Oreille	Surface Soil	POWP01SS	Selenium	3.1	mg/kg	Below MTCA
01264355	Pend Oreille	Surface Soil	POWP03SS	Selenium	1.7	mg/kg	Below MTCA
01264423	Josephine	Sediment	JOPP01SD	Silver	2.3	mg/kg	Above LAET
01264272	Oriole	Sediment	ORSP01SD	Silver	2.8	mg/kg	Above LAET
01264273	Oriole	Sediment	ORSP02SD	Silver	5.6	mg/kg	Above 2LAET
01264256	Pend Oreille	Surface Soil	POTP05SS	Silver	2.3	mg/kg	Above LAET
01264269	Blue Bucket	Sediment	BBPP02SD	Zinc	560	mg/kg	Below LAET
01264267	Blue Bucket	Sediment	BBPP01SD	Zinc	329	mg/kg	Below LAET
01264273	Oriole	Sediment	ORSP02SD	Zinc	5740	mg/kg	Above 2LAET
	Oriole	Surface Water	ORSP01SW	Zinc	102	µg/L	Above Acute
01264272	Oriole	Sediment	ORSP01SD	Zinc	784	mg/kg	Above LAET
01264423	Josephine	Sediment	JOPP01SD	Zinc	2040	mg/kg	Above 2LAET

Table A-3: Mine source samples identified in the lower Pend Oreille area as having significant concentrations.

Sample ID	Mine	Sample Type	Location	Constituent	Concentration	Units	Comparison to Guidelines/ Thresholds
01264356	Josephine	Surface Water	JOSP01SW	Zinc	117	µg/L	Below LAET
01264418	Grandview	Sediment	GMPP05SD	Zinc	864	mg/kg	Above LAET
01264417	Grandview	Surface Water	GMPP05SW	Zinc	20.6	µg/L	Below Chronic
01264410	Pend Oreille	Surface Water	POPP02SW	Zinc	62.5	µg/L	Below Chronic
01264401	Pend Oreille	Surface Water	POPP01SW	Zinc	212	µg/L	Above Acute
01264355	Pend Oreille	Surface Soil	POWP03SS	Zinc	9300	mg/kg	
01264354	Pend Oreille	Surface Soil	POWP02SS	Zinc	7420	mg/kg	
01264260	Pend Oreille	Surface Soil	POTP09SS	Zinc	2270	mg/kg	
01264353	Pend Oreille	Surface Soil	POWP01SS	Zinc	890	mg/kg	
01264259	Pend Oreille	Surface Soil	POTP08SS	Zinc	4540	mg/kg	
01264258	Pend Oreille	Surface Soil	POTP07SS	Zinc	6450	mg/kg	
01264257	Pend Oreille	Surface Soil	POTP06SS	Zinc	2520	mg/kg	
01264256	Pend Oreille	Surface Soil	POTP05SS	Zinc	2500	mg/kg	
01264255	Pend Oreille	Surface Soil	POTP04SS	Zinc	1590	mg/kg	
01264254	Pend Oreille	Surface Soil	POTP03SS	Zinc	2190	mg/kg	
01264252	Pend Oreille	Surface Soil	POTP01SS	Zinc	4130	mg/kg	
01264411	Pend Oreille	Sediment	POPP02SD	Zinc	2370	mg/kg	

LAET – Lowest Apparent Effects Threshold
2LAET – Second Lowest Apparent Effects Threshold

Table A-4: Mine target samples identified in the lower Pend Oreille area as having elevated concentrations.

Sample ID	River/Tributary	Sample Type	Location	Constituent	Concentration (µg/L, mg/Kg)	Comparison to Guidelines
01264351	Pend Oreille Mine	Sediment	POSP01SD	Arsenic	17.2	Below LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Arsenic	11.8	Below LAET
01264263	Creek 1	Sediment	POCK01SD	Cadmium	3.5	Above 2LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Cadmium	14.6	Above 2LAET
01264405	Everett Creek	Sediment	PRTB02SD	Cadmium	6.1	Above 2LAET
01264403	Lime Creek	Sediment	PRTB01SD	Chromium	57.7	Below LAET
01264405	Everett Creek	Sediment	PRTB02SD	Chromium	86.2	Below LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Copper	165	Below LAET
01264263	Creek 1	Sediment	POCK01SD	Lead	180	Below LAET
01264351	Pend Oreille Mine	Sediment	POSP01SD	Lead	351	Above LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Lead	1960	Above 2LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Mercury	0.39	Below LAET
01264263	Creek 1	Sediment	POCK01SD	Nickel	44.8	Below LAET
01264403	Lime Creek	Sediment	PRTB01SD	Selenium	4.9	
01264263	Creek 1	Sediment	POCK01SD	Vanadium	26.8	Below normal background
01264352	Pend Oreille Mine	Sediment	POSP02SD	Vanadium	20.8	Below normal background
01264266	Creek 1	Surface Water	POCK01SW	Zinc	63.2	
01264263	Creek 1	Sediment	POCK01SD	Zinc	326	Below LAET
01264351	Pend Oreille Mine	Sediment	POSP01SD	Zinc	3320	Above 2LAET
01264352	Pend Oreille Mine	Sediment	POSP02SD	Zinc	2610	Above 2LAET
01264406	Ledbetter Creek	Sediment	PRTB03SD	“4,4’-DDT”	10	Below LAET

LAET – Lowest Apparent Effects Threshold, 2LAET – Second Lowest Apparent Effects Threshold

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Barium	Medium	Blue Bucket		Not detected in significant concentrations			Omit ▪ First Tier o Thresholds/ guidelines not available ▪ Second Tier o Not detected in target samples o **Medium toxicity** o low reoccurrence
		Oriole	Potential overland flow from waste rock pile to muddy area and eventually Linton Creek	Detected below covered waste rock pile			
		Josephine		Not detected in significant concentrations			
		Grandview		Not detected in significant concentrations			
		Pend Oreille		Not detected in significant concentrations	Not detected in significant concentrations	Not detected in significant concentrations	
		Pend Oreille River		Not detected in significant concentrations			
		Tributaries		Not detected in significant concentrations			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Chrom-ium	Medium	Blue Bucket		Not detected			Omit ▪ First Tier Below guidelines/ thresholds
		Oriole		Not detected			
		Josephine		Not detected			
		Grandview		Not detected			
		Pend Oreille		Not detected	Not detected		
		Tributaries		Detected at mouth of Everett Creek, detected at mouth of Lime Creek			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Copper	High	Blue Bucket		Not detected at significant concentrations			Omit ▪ First Tier o Below guidelines/ threshold
		Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected near covered waste rock pile			
		Josephine		Not detected at significant concentrations			
		Grandview		Not detected at significant concentrations			
		Pend Oreille	Seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2 and surface water runoff from TDF-1 & TDF-2 into the Pend Oreille River	Not detected at significant concentrations	Detected in all tailing disposal facilities		
		Tributaries		Not detected at significant concentrations			
		Pend Oreille River		Not detected at significant concentrations			
DDT	High	Tributaries		Detected at mouth of Ledbetter Creek			Omit ▪ First Tier o Below guidelines/ thresholds

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Manganese	Low	Blue Bucket		Not detected at significant concentrations			Omit ▪ First Tier o No guidelines/ thresholds ▪ Second Tier o not detected in waterways/target samples o Low toxicity o Low reoccurrence within the watershed
		Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected downstream of spring and near covered waste rock pile			
		Josephine		Not detected at significant concentrations			
		Grandview				GMP05SW	
		Pend Oreille	Seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2	Not detected at significant concentrations		Detected at mouth of Creek 2	
		Pend Oreille River		Not detected at significant concentrations			
		Tributaries		Not detected at significant concentrations			
Mercury	High	Josephine	Flow from a spring through a waste rock pile to the Pend Oreille River	Detected at mouth of spring			Omit ▪ First Tier o Below guidelines/thresholds **NOTE: include based on findings in *Toxics Inventory and Screening***
		Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3, and surface water runoff from waste rock	Detected at elevated concentrations	Detected in all tailing disposal facilities and in the waste rock pile		

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Nickel	Medium	Blue Bucket Oriole		Not detected Not detected			Omit ▪ First Tier o Below guidelines/ thresholds
		Josephine		Not detected			
		Grandview		Not detected			
		Pend Oreille	Drainage near Creek 1	Detected at mouth of Creek 1	Not detected		
		Pend Oreille River		Not detected			
		Tributaries		Not detected			
Selenium	High	Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2		Detected at TDF-1		Omit ▪ First Tier o Below MTCA guidelines, no sediment thresholds
		Pend Oreille River		Not detected			
		Tributaries		Detected at mouth of Lime Creek			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Silver	Medium	Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected downstream of spring and near large waste rock pile			Omit ▪ First Tier o **Above guidelines/ thresholds** ▪ Second Tier o Not detected in waterways or target samples o **Medium toxicity** o Low reoccurrence within the watershed
		Josephine	Flow from a spring through a waste rock pile to the Pend Oreille River	Detected at mouth of spring			
		Pend Oreille	seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3		Detected at TDF-3		
Vanadium	Low	Grandview Pend Oreille	seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2 and drainage near Creek 1.	Not detected Detected at Creek 1, TDF-1,	Not detected		Omit ▪ First Tier o Below normal background
		Pend Oreille River		Not detected			
		Tributaries		Not detected			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Arsenic	High	Blue Bucket		Not detected			Include ▪ First Tier o **Soil samples above MTCA guidelines** ▪ Second Tier o **Elevated levels detected in target samples** o **High toxicity** o Medium reoccurrence within the watershed
		Oriole	Potential overland flow from waste rock pile to muddy area and eventually Linton Creek	Detected below covered waste rock pile, not detected at base of spring			
		Josephine		Not detected in significant concentrations			
		Grandview		Not detected in significant concentrations			
		Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2, & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3, surface water runoff from waste rock.	Not detected in significant concentrations	Detected in all tailing disposal facilities and in the waste rock pile		
		Pend Oreille River		Not detected in significant concentrations			
		Tributaries		Not detected in significant concentrations			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Cadmium	High	Blue Bucket	Potential flow from shaft to unnamed creek, potential overland flow from waste rock pile to unnamed creek	Detected upstream and downstream of waste rock pile			Include ▪ First Tier o **Measured values above thresholds/ guidelines** ▪ Second Tier o **Elevated levels in target samples and migration samples** o **High toxicity** o **High reoccurrence within the watershed**
		Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected downstream of spring and below the covered waste rock pile			
		Josephine	Flow from a spring through a waste rock pile to the Pend Oreille River	Detected at mouth of spring			
		Grandview	Potential surface water pathway from suspected tailings pile to Pend Oreille River	Detected downstream of suspected tailings pile			
		Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3, surface water runoff from waste rock, and drainage near Creek 1.	Detected at mouth of Creek 2 and in Creek 1	Detected in all tailing disposal facilities and in the waste rock pile		
		Pend Oreille River		Not detected			
		Tributaries		Detected at mouth of Everett Creek			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Lead	Medium	Blue Bucket	Potential flow from shaft to unnamed creek, potential overland flow from waste rock pile to unnamed creek	Detected upstream and downstream of waste rock pile			Include ▪ First Tier o **Above guidelines/ thresholds** ▪ Second Tier o **Detected in target samples** o **Medium toxicity** o **High reoccurrence within the watershed**
		Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected downstream of spring and near covered waste rock pile			
		Josephine	Flow from a spring through a waste rock pile to the Pend Oreille River	Detected at mouth of spring		Detected at mouth of spring (exceeds chronic criteria)	
		Grandview	Potential surface water pathway from suspected tailings pile to Pend Oreille River	Detected downstream of suspected tailings pile		GMP05SW (exceeds acute and chronic criteria)	
		Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2 & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3, surface water runoff from waste rock, and drainage near Creek 1.	Detected at the mouth of Creek 2 at the Pend Oreille River	Detected at TDF 2 & 3 and in the waste rock pile	Detected at the mouth of Creek 2 and the Pend Oreille River (exceeds chronic criteria)	
		Pend Oreille River		Not detected at significant concentrations			
		Tributaries		Not detected at significant concentrations			

Table A-5: Summary the biological toxicity, transport mechanisms, and significant/elevated concentrations of toxics at the five mine sites identified by the EPA report.

Toxic	Biological Toxicity	Mine	Transport Mechanism	Sediment Results	Surface Soil Results	Surface Water Results	Recommendation/ Comments[1]
Zinc	Medium	Blue Bucket	Potential flow from shaft to unnamed creek, potential overland flow from waste rock pile to unnamed creek	Detected upstream and downstream of waste rock pile			Include ▪ First Tier o **Above guidelines/ thresholds** ▪ Second Tier o **Elevated levels in target samples** o **Medium toxicity** o **High reoccurrence within the watershed**
		Oriole	Potential overland flow from the spring to a muddy area and eventually Linton Creek	Detected downstream of spring and near large waste rock pile		Detected near spring (exceeds acute and chronic criteria)	
		Josephine	Flow from a spring through a waste rock pile to the Pend Oreille River	Detected at mouth of spring		Detected at mouth of spring (exceeds acute and chronic criteria)	
		Grandview	Potential surface water pathway from suspected tailings pile to Pend Oreille River	Detected downstream of suspected tailings pile		GMPP05SW (does not exceed standards)	
		Pend Oreille	Flow from the ventilation shaft, seep areas located by TDF-1, TDF-2, & TDF-3 into Creek 2, surface water runoff from TDF-2 & TDF-3, surface water runoff from waste rock.	Detected at mouth of Creek 2	Detected in all mine tailings piles and in the waste rock pile	Detected in the Pend Oreille River downstream of the ventilation shaft (exceeds standards), at the mouth of Creek 2 (does not exceed standards), and in Creek 1 (does not exceed standards)	
		Pend Oreille River		Not detected			
		Tributaries		Not detected			

[1]Bold indicates criteria of concern; TDF – Tailings Disposal Facility ;Tributaries include Lime Creek, Everett Creek, Ledbetter Creek, Unnamed Tributary, Slate Creek, Peewee Creek, Beaver Creek, Sullivan Creek, Flume Creek, Linton Creek

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Attachment 3-5: Summary of Stakeholder Comments on Draft Water Resources Study Plans

Summary of comments on draft water resources study plans made at the Water Quality Workgroup meetings (2006).

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Water quality constituent and productivity monitoring, study plan outline					
Verbal	05-22-06	Jean Parodi	Ecology	Parodi stated that in addition to the three water quality issues identified in the study plan presentation—i.e., TDG, pH, and toxics—water temperature in the Project area was also an issue.	Water temperature will be addressed as part of the CE-QUAL-W2 modeling being conducted by Battelle.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan asked whether the QAPP would include a detailed study design and characterization of statistical rigor or simply QA/QC measures associated with field sampling and laboratory analysis.	The QAPP will address all aspects of the study, including field and laboratory techniques, study design, and statistical methods needed to evaluate the power of the study.
Verbal	05-22-06	Mark Tiley	CCRFRC	Tiley noted that an introduced 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 asked what studies were planned to assess macroinvertebrate populations and whether these studies would be able to assess Project effects on macroinvertebrates, including the introduced Hydra species.	Potential Project impacts on macroinvertebrates will be addressed by habitat modeling conducted as part of Fish & Aquatics studies.
Relationship of pH and DO to macrophytes in Boundary Reservoir, study plan outline					
Verbal	05-22-06	Bert Wasson	USFS	Wasson stated that pH measurements in tributaries to Boundary Reservoir often exceed the 8.5 pH standard established by Ecology. Wasson noted that macrophytes do not significantly influence pH in these tributaries, which indicates that background geologic conditions are largely responsible for the elevated pH in the region. Wasson stated that he could provide pH grab sample data collected by the USFS.	Comments acknowledged

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan noted that the study design called for installing continuous pH monitors within a macrophyte bed and in the open channel of the reservoir just upstream and downstream of that macrophyte bed. Duncan speculated that such monitoring might be more useful if it were undertaken to characterize system-wide pH changes throughout the season, rather than localized effects within and adjacent to individual macrophyte beds.	The goal of the pH sampling is to isolate the effects of macrophytes on pH, rather than document system-wide trends that might reflect causes other than macrophytes. Also, the overall study design will include diel sampling at multiple locations along the longitudinal profile of the reservoir and the water quality constituent and productivity monitoring study will involve monthly pH sampling along the length of the reservoir. Between the two approaches, system-wide pH dynamics will be characterized.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan asked whether additional study would be conducted beyond 2008, the final year indicated in the study plan schedule.	Based on SCL's current plans, 2008 will be the final year of data collection.
Verbal	05-22-06	John Gross, Jean Parodi	Kalispel Tribe, Ecology	Gross stated that the overall pH sampling period should be reduced from May through November to focus more on the period of significant macrophyte growth, perhaps June through August. Gross said that during these summer months sampling should be conducted more frequently, perhaps for one-week periods instead of single 24-hour periods each month. Parodi stated that it would be useful to have some measurements of pH outside the primary macrophyte growth period, including measurements made in spring.	Beginning sampling in May and ending it in November was proposed to characterize pH prior to the macrophyte growth season, during the SCL agreed that pH measurements for the macrophyte study would be conducted 1) in either May or June, depending on flow conditions, to characterize pH prior to the macrophyte growth season, 2) more intensively in July and August to better understand pH dynamics during the height of macrophyte growth, and 3) in November to characterize pH following macrophyte senescence.
Verbal	05-22-06	John Gross	Kalispel Tribe	Gross stated that pH measurements should also be made in shallow water areas with bedrock substrate to provide a basis of	SCL agreed that pH measurements would be made in shallow water areas with bedrock substrate to

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				comparison for sites with abundant macrophytes.	provide a basis of comparison for sites with abundant macrophytes.
Verbal	05-22-06	Jean Parodi	Ecology	Parodi stated that a schematic of potential sampling sites, by objective, would make the overall study design clearer.	SCL agreed to provide a schematic in the pH/macrophyte study plan.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan asked what kind of management strategies might be undertaken to control macrophytes if sampling demonstrates an adverse effect on reservoir pH.	Potential mitigation measures, if needed, would be explored later in the 401 application process; one potential strategy could involve manipulation of reservoir levels to desiccate or freeze macrophytes; if a macrophyte management solution is needed, it would be designed not to conflict with other resource needs.
Verbal	05-22-06	Don Hurst	Colville Tribe	Hurst stated that sediment toxicity is a factor that influences macrophyte production and noted that no data currently exist to characterize the level of toxic substances in Boundary Reservoir substrates. Hurst asked if any sediment sampling would be conducted as part of the pH/macrophyte study.	No sediment sampling is planned as part of the pH/macrophyte study.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan stated that sediment samples could be collected from macrophyte beds during the sampling periods and archived for later analysis, if such analysis becomes desirable. Duncan stated that it would be useful to install meters to measure light intensity during the sampling periods, as variation in light will affect pH measurements.	Comments acknowledged
Verbal	06-29-06	John Gross / Mark Tiley	Kalispel / CCRIFC	Gross noted that the November sampling period was aimed at measuring pH and DO during the period of macrophyte senescence. Gross stated that the primary period of senescence in Boundary Reservoir could be earlier in the year. Tiley added that macrophyte growth may begin as early	Although May/June and November had been identified in the study plan, the actual sampling periods would be refined based on field reconnaissance, some of which was being conducted as part of 2006 pilot studies.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				as March and that a May/June sampling period might be too late to assess pH and DO in the reservoir prior to the macrophyte growth season.	
Verbal	06-29-06	Mark Tiley	CCRIFC	Tiley asked for clarification regarding steps taken to avoid pseudo-replication and how sampling would be conducted based on a nested study design.	The goal is to sample within two reaches, i.e., above and below Metaline Falls. Within each reach, there will be three sampling stations and three sites within each station, i.e., sites nested within stations nested within reaches. Although the goal is to sample at three stations in each reach, it might be impossible to do so, e.g., there may be fewer than three suitable macrophyte beds downstream of Metaline Falls. Field reconnaissance is needed to ascertain how many stations there will be above and below the falls. If fewer than three stations are available in a reach, more than three sites will be established in a single station. If this is the case, care will be taken to locate sampling sites sufficiently far from each other so that they are not duplicate measurements in the same location, i.e., pseudo-replicates.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda stated that all sampling sites should be located sufficiently far from tributary inflows so that pH and DO data reflect ambient conditions in and adjacent to the macrophyte beds and are not influenced by the water quality of the tributary.	The study plan will be revised to state that sampling sites will be established far enough from tributary inputs so that pH and DO measurements reflect ambient reservoir conditions in and around a macrophyte bed and not the water chemistry of a nearby tributary.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Assessing toxics of concern: evaluation of contaminant pathways and potential Project nexus, study plan					
Verbal	05-22-06	Mark Tiley	CCRIFC	Tiley asked if sampling of benthic macroinvertebrates was planned as part of the assessment of toxics of concern.	The assessment would be based solely on existing information and that field sampling of any kind would take place only if the results of the assessment indicated a potential Project nexus for any of the toxics of concern.
Verbal	05-22-06	Patti Bailey	Colville Tribe	Bailey stated that the Confederated Tribes of the Colville Reservation were concerned about conditions in the Columbia River downstream of its confluence with the Pend Oreille River. Bailey stated that a key issue of concern is the discharge of toxic compounds from the Pend Oreille River into the Columbia River and their potential effects on fish and other aquatic biota in the Tribes' traditional fishing areas. Bailey stated that the Tribes felt that ample evidence exits to warrant a field sampling effort and that SCL's proposed assessment was inadequate for addressing the issue.	Comments acknowledged
Verbal	05-22-06	Don Hurst	Colville Tribe	Hurst stated that the effort described for the assessment of toxics was inconsistent with that established for other water quality parameters, adding that it was unclear why field sampling was considered appropriate for pH and other parameters but not toxics. Don stated that the lack of existing information, particularly sediment data, indicates the need for field sampling. Don stated that in addition, a number of toxic compounds, namely the metals arsenic, magnesium, and copper, were missing from the list of toxics of concern. Don stated that it appeared that a decision had been made in advance that no Project nexus exists for	No decisions had been made about the toxics of concern and the purpose of the assessment is to identify whether or not a Project nexus exists for the toxics of concern. Toxics considered to be of low concern had been designated as such based on evaluation of existing water quality data, data that indicate no recent exceedances of Ecology standards for those toxics. The proposed assessment clearly identifies the possibility of field sampling—water column, biota, or sediment—to further evaluate the toxics of concern

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				toxics.	if a potential Project nexus is established. Sampling undertaken initially, without the focus provided by the assessment, could produce inconclusive results. Establishing Project nexus for any toxic compound is essential for determining SCL's responsibility with regard to that compound, because entities other than SCL are or have been responsible for producing and/or conveying the toxic compounds at issue. SCL was not currently prepared to make a determination regarding sediment sampling for the assessment of toxic substances. SCL agreed to evaluate the issue and convey its position to stakeholders following internal deliberation.
Verbal	06-29-06	Don Hurst	Colville Tribe	Hurst stated that the Colville Tribes had reviewed SCL's PAD and determined that it lacked an appropriate evaluation of sediment sampling and failed to adequately address the extent of historical mining adjacent to the Project area. Hurst stated that in the 1960s the Pend Oreille Mine had discharged up to 3,000 tons/day of flotation tailings into the Pend Oreille River and that these tailings are now trapped behind Boundary Dam. Hurst stated that rather than focusing on the results of water column sampling, it would have been appropriate to also include information in the PAD about the constituents of mine tailings in the area, the Pend Oreille Mine in particular. Hurst suggested that an analysis of toxics in Pend Oreille Mine's existing tailings	Comment acknowledged.

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				impoundment could be used as a surrogate measure of what the mine had discharged into the Pend Oreille River in the past. Hurst stated that water quality sampling alone is insufficient to characterize toxic contamination of a waterbody, adding that studies conducted in the northwest have shown that water column samples collected immediately above contaminated substrates have failed to reveal the contamination. Hurst stated that based on available information—and in some cases the lack of it—the Colville Tribes believe that a greater number of toxics of concern should have been identified in the PAD. Hurst stated that the list of toxics of concern should include all substances identified as significant in EPA's Preliminary Assessment and Site Investigation of the Pend Oreille Mine. Hurst stated that the Colville Tribes believed that sediment sampling should be conducted in Boundary Reservoir to assess the risk to biota and human health. Hurst stated that sediment sampling is particularly warranted in and adjacent to areas with high erosion potential, such as in and immediately below the reservoir's drawdown zone. Hurst concluded by stating that the distribution of sediments in the reservoir and a characterization of the toxic contaminants in the sediments represent data gaps that should be addressed by SCL. Hurst said that sediment sampling—rather than a literature-based assessment of Project nexus—should be the first step undertaken by SCL and that this should be followed, if necessary, by modeling sediment dynamics	

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				in the reservoir.	
Verbal	06-29-06	Jean Parodi	Ecology	Parodi stated that she had spoken with some of Ecology's toxics specialists, who had identified three additional substances that should be included among the toxics of "medium concern" in the literature-based assessment planned by SCL: arsenic, copper, and zinc. Parodi stated that EPA had identified these three toxics at all local mine sites. Parodi stated that Ecology is concerned that toxics in sediments will be conveyed to benthos and then subsequently to fish that feed directly or indirectly on the benthos. Parodi stated that Ecology is primarily concerned with sediment contamination in and immediately below the reservoir drawdown zone.	Comment acknowledged.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda stated that arsenic, which is known to occur in cement piles near Metaline Falls, should be added to the list of toxics of concern. Shuhda stated that contaminants permitted by Ecology (i.e., NPDES) for release into then lower Pend Oreille may be accumulating in Boundary Reservoir. Shuhda stated that the dam, because it slows the river and traps at least some of the permitted toxics, represents a continuing impact. Shuhda stated that the USFS is concerned with the transmission of toxics from the sediment to fish via their macroinvertebrate prey and that toxics in fish tissue could be passed on to tribal members engaged in subsistence fishing and the general public involved in outdoor recreation. Shuhda stated that transmission of toxics to piscivorous wildlife, e.g., Bald Eagles, is also a concern. Shuhda	Comment acknowledged.

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				emphasized that statements about the Project's effects on toxins were at this point conjectural but that information is needed to draw firmer conclusions about toxics in the Project area.	
Verbal	06-29-06	Llewellyn Matthews	Columbia Power	Matthews stated that sediment sampling conducted in 2002 for the Waneta Expansion Project revealed that sediment guidelines were exceeded in the forebay for arsenic, cadmium, lead, and zinc. Matthews stated that sediment removal and remediation measures were planned as the result of these results.	Comment acknowledged.
Verbal	06-29-06	Mark Tiley	CCRIFC	Tiley asked what SCL would do if high concentrations of toxics are found in reservoir sediments.	There are two separate issues, a scientific question as to which toxic compounds, if any, represent a potential environmental or human health risk and how to proceed if specific toxics are considered to be hazards. Before planning any remediation, SCL would be required to seek legal counsel so that responsibility could be assigned to appropriate parties.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst stated that use of bathymetry data to locate a depositional feature or features resulting from the discharge of tailings by the Pend Oreille Mine would be inadequate. Hurst stated that there are many sources of potential mine tailings or waste rock in and adjacent to the reservoir and, therefore, that bathymetry data should be used to assess sediment deposition patterns throughout the reservoir.	Comment acknowledged.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst asked if bathymetry data were available for the Project area prior to construction of Boundary Dam, to which	Pre-Project bathymetry data are available for the portion of the river between Metaline Falls and the

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				current bathymetry could be compared in an attempt to identify areas of sediment deposition.	current location of the dam. No pre-Project bathymetry data are available for the section of the river between Metaline Falls and Box Canyon Dam.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst asked whether bathymetry data collected during 2006 could be used to estimate sediment thickness along the bottom of the reservoir.	The data alone could not be used to assess sediment thickness. The bathymetry analysis would provide profiles of the reservoir's bottom topography along laterally oriented measurement transects.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst stated that studies would be needed to assess sediment deposition patterns throughout the reservoir, as well as studies aimed at estimating sediment volume and quality.	SCL is not limiting its analysis of reservoir sediments to the initial bathymetric evaluation to be conducted as part of the initial phase of toxics assessment. SCL's plan is to first assess Project nexuses for toxics of concern, i.e., whether current Project operations enhance the availability or conveyance of toxics. Following this assessment, if a Project nexus is established for a given toxic or toxics, data collection, analyses of sediment dynamics, or other possible studies will be conducted as needed.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst stated that sediment sampling is clearly needed and that SCL will inevitably conduct such sampling. Because of this, said Hurst, it seemed that developing a sediment sampling plan should begin as soon as possible, rather than delaying it and leaving less time for conducting fieldwork.	Comment acknowledged.
Verbal	07-25-06	Tom Shuhda	USFS	Shuhda stated that the current toxics assessment study plan did not commit to sediment sampling and that because of this the resource agencies might not be able to	SCL believes that an appropriate study design could only be developed following the first phase of the toxics assessment, which will be conducted

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				approve it as written. Shuhda stated that the study plan should identify specific results of the phase-one portion of the toxics assessment that would trigger field sampling, with an indication of what kind of sampling would be undertaken and why. Shuhda stated that the USFS would want sediment cores to be collected so that trends in toxics deposition could be assessed, i.e., whether deeper sediments contain higher or lower concentrations of toxics than more recently deposited sediments. Shuhda stated that it would also be necessary to establish whether or not there are ongoing adverse effects of toxics on macroinvertebrates or fish in the reservoir. Shuhda stated that sediment samples should be collected in a variety of locations in the reservoir, including the areas just upstream of Boundary Dam and Metaline Falls where sediments have accumulated and also in and just below the reservoir drawdown zone, where sediments have the potential to be eroded, which could lead to the re-suspension of toxics in the water column.	in 2007 by a technical consultant that has yet to be selected. Existing information is inadequate for designing a field study, particularly one involving sediment sampling.
Verbal	07-25-06	Jean Parodi	Ecology	Parodi stated that the study plan should identify specific results that would trigger field sampling.	Comment acknowledged.
Verbal	07-25-06	Tom Shuhda	USFS	Shuhda stated that agency comments on the Proposed Study Plan (PSP) would be due in January 2006, before results of the initial phase of the toxics assessment are underway. Shuhda stated that if agencies accepted the current plan, they could miss their opportunity to formally influence the toxics study. Shuhda expressed concern that if agencies disagreed with SCL's	Stakeholders would have opportunities throughout the relicensing process to provide input on how studies are being conducted and that stakeholders should not feel that their opportunity to influence study design and methods is limited to formal comments on the PSP. When the first phase of the toxics

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				approach following completion of the first phase of the toxics assessment (i.e., Project nexus determination), they might have less ability to influence study design than during the formal comment period for the PSP.	study is completed in early 2007, stakeholders will be consulted regarding the proposed approach to addressing toxics. At that time, SCL would not move forward without agency concurrence. The study plan will be modified to include text that characterizes the ongoing consultation with stakeholders regarding study approaches.
Verbal	07-25-06	Patti Bailey	Colville Tribes	Bailey stated that information pertaining to sediment toxicity could be important for developing fish studies, and as such a lack of information on toxics in reservoir sediments could represent a data gap for the Fish and Aquatics Workgroup.	Throughout the process coordination will take place between the Water Quality and Fish and Aquatics workgroups to ensure that appropriate information is gathered. If the need for fish tissue sampling or other fish-related work is indicated, the appropriate crossover between workgroups will occur. Following submittal of the stakeholders' PSP comments in January 2007, SCL planned to hold a meeting at which stakeholders will have the opportunity to meet and question the team of technical consultants contracted to perform the 2007 – 2008 studies. Following that meeting, SCL will produce and file its Revised Study Plan (RSP) in mid February 2007. Barbara said that following this, FERC will make its determination regarding the RSP, after which stakeholders will again have an opportunity to comment on proposed studies. Following this, if studies were still considered

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					unsatisfactory, Mandatory Conditioning Agencies will have the opportunity to file a notice of study dispute.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst stated that in addition to sediment sampling, laboratory bioassays should be conducted to determine the toxicity of Boundary Reservoir sediments on mortality rates of select invertebrate taxa. Hurst added that comparing sediment concentrations of individual toxics to established standards might not accurately characterize the threat to biota, because some combinations of toxics can have synergistic effects resulting in even greater toxicity. Because of this, said Hurst, bioassays would provide information not provided by comparing concentrations of individual toxics to established thresholds or standards.	Comment acknowledged.
Verbal	07-25-06	Julie Campbell	USFWS	Campbell stated that in addition to bioassays, fish tissue samples should be collected to assess whether or not toxics present in invertebrates are accumulating in fish.	Comment acknowledged.
Verbal	07-25-06	Don Hurst	Colville Tribes	Hurst stated that a Sediment Quality Workgroup should immediately be formed to ensure that an appropriate amount of attention is allocated to sediment toxicity issues. Hurst stated that it would be advantageous for SCL to contract a sediment toxicity expert to assist in the design of the toxics study plan.	Given the complexities of SCL's contracting rules it would likely be impossible to have a toxics expert engaged before January 2007. A toxics expert will be integrated into the relicensing process at the beginning of 2007, when the team of technical consultants begins conducting studies. SCL held a preliminary meeting with potential technical consultants on July 24 in

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					Seattle and that SCL would be issuing a formal Request for Proposals (RFP) in late September 2006.
Verbal	07-25-06	Tom Shuhda	USFS	Shuhda stated that when developing a list of toxics to be evaluated it would be important to not only consider substances introduced to the Pend Oreille River via mining but toxics from other potential sources as well, such as the Ponderay Newsprint Company.	Comment acknowledged.
Verbal	08-16-06	Jean Parodi	Ecology	Parodi asked if there would be a field exercise to ground-truth the results of the sediment deposition analysis.	No fieldwork was planned as part of the Phase 1 assessment. Boundary Reservoir is over 17 miles long, so that it would be difficult given the timeframe to conduct representative sampling. The analysis described in Objective 4 would not isolate and track the deposition of waste rock or tailings from any mine or mill sites, but would only reveal where sediments of this approximate size are likely to have been deposited. The purpose of having this information is to provide a basis for Phase 2 sampling, if it is needed.
Verbal	08-16-06	Bill Duncan	Teck Cominco	Duncan clarified that tailings are not associated with mines but rather with mills, and asked how many mills identified in the PASI report were associated with significant/elevated concentrations of metals in nearby soil samples.	Significant/elevated concentrations of metals were only associated with mine sites investigated as part of the report, not with mill sites.
Verbal	08-16-06	Bill Duncan	Teck Cominco	Duncan stated that the size of tailings particles from mills varies by site, according to the processes used at the time the mills were in operation. Duncan added that before identifying areas where mining-	Comment acknowledged.

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				related sediments are likely to have been deposited, it would be important to do some research to ensure that the investigation is aimed at sediment particles of an appropriate size.	
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if there had been a mode of transport to the Pend Oreille River or its tributaries for sediments at all sites sampled by EPA for the PASI.	No metals samples were taken at sites where the waste rock or tailings was considered to be contained, i.e., without a means of being transported to the river or its tributaries.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if any of the sites investigated in the PASI were close enough to Boundary Reservoir to be within the zone of fluctuating flows.	Of the sites investigated by EPA, Pend Oreille Mine is the closest to Boundary Reservoir. However, Pend Oreille Mine's tailings are now isolated from the reservoir, although in the past the mine discharged tailings directly into the river. Mark Brown of the Pend Oreille Mine had stated that no tailings had been discharged into the river since before closure of Boundary Dam in 1967. Evaluation of the interaction between sources of toxics and Project operations, including fluctuation in reservoir surface elevation, will be a major subject of investigation in the Phase 1 assessment.
Verbal	08-16-06	Tom Shuhda/ Jean Parodi	USFS/ Ecology	Shuhda stated that based on his review of the Phase 1 toxics study plan, he could not see how SCL would have the information needed to make an assessment about whether or not fluctuating reservoir elevations are interacting with potential sources of contaminants along the reservoir's shoreline. Parodi also expressed concern about the potential effects of fluctuating reservoir surface elevations on	The Terrestrial Resources Workgroup is conducting a shoreline erosion study during the summer of 2007, in which actively eroding shoreline sites will be identified and documented. This information will be incorporated into the overall assessment of Project effects, although the information from the erosion study will not be available on

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				the mobility of toxics in the reservoir's drawdown zone.	time to be incorporated into the Phase 1 toxics assessment.
Verbal	08-16-06	Jean Parodi	Ecology	Parodi stated that the Phase 1 assessment should provide a detailed review of the chronology of tailing discharges into the Pend Oreille River in relation to the construction and closure of Boundary Dam. In addition, Parodi stated that research should focus on areas of known historic tailings deposition.	Comment acknowledged.
Verbal	08-16-06	Bill Duncan	Teck Cominco	Duncan stated that because tailings near the reservoir would have been deposited in the past, and because fluctuation in reservoir surface elevation occurs daily throughout the year, it is unlikely that any tailings remain within the fluctuation zone of the reservoir.	Comment acknowledged.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda stated that Table A-5 in the Phase 1 toxics assessment study plan indicates that cadmium occurs at elevated concentrations near Josephine Mine, which is located adjacent to Flume Creek. Shuhda asked how SCL would be able to make a determination about transport of cadmium from this site into the reservoir without conducting field sampling.	Potential transport mechanisms, if related to Project operations, would be investigated as part of Objectives 2 and 3 of the Phase 1 assessment.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked how Ecology's LAETs—used in the screening of toxics for the Phase 1 assessment—would be applied in the future to evaluate results of Phase 1 conclusions or sampling within the Project area.	The LAETs had been used as a screening tool and it is unclear what applicability they would have in the Phase 1 analysis. However, if Phase 2 sediment sampling is undertaken, the LAETs could have applicability. Regardless of how thresholds might be applied, SCL's analysis will be geared toward identifying whether or not Project operations are influencing the conveyance or availability of

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					toxics, not whether toxics in the Project area are simply in exceedance of thresholds.
Verbal	08-16-06	Tom Shuhda/ Jean Parodi	USFS/ Ecology	Shuhda stated that fish tissue samples may provide more meaningful information about conditions in Boundary Reservoir than would sediment samples. Parodi added that bioassays would also be more likely than sediment samples to reveal whether or not toxics in the Project represent an environmental concern.	Comment acknowledged.
Verbal	08-16-06	Jean Parodi	Ecology	Parodi stated that some toxics data had been collected in the water column at sites in the Project area. However, said Parodi, no water column toxics data has been collected at depth in the reservoir. Parodi noted that SCL was currently collecting water quality data along vertical profiles at various locations in the reservoir as part of 2006 water quality monitoring. Parodi proposed that while collecting profile water quality samples, SCL might also collect water samples at depth to be analyzed for metals content.	SCL would consider Parodi's request and report back to Ecology and other stakeholders with a decision.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if SCL would be able to hire a contractor in a timely manner for the Phase 2 component of the toxics assessment, if Phase 1 indicates the need for sampling.	The same entity, i.e., the technical consultant hired during late 2006, would conduct the Phase 1 and Phase 2 (if needed) studies.
Verbal	08-16-06	Don Hurst	Colville Tribes	Hurst stated that at some point a decision would need to be made as to whether sediment sampling, or some other form of sampling, was going to occur as part of the relicensing study. Hurst asked what the criteria would be used to make that decision. Hurst asked if the criteria would be numeric, e.g., LAETs, or some form of	The decision would be based on whether there was clear evidence to indicate that the Project is enhancing pathways of contamination and/or mechanisms affecting bioavailability associated with a particular toxic.

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				narrative that links Project operations to the conveyance or availability of toxics in the Project area.	
Verbal	08-16-06	Don Hurst	Colville Tribes	Hurst stated that it was not apparent how decisions could be based on the Phase 1 assessment without some form of sampling and comparison of results to established criteria.	There are many ways in which a toxic substance can interact with its environment and that toxics behave differently when in the presence of other toxics than they would in isolation. Until an expert has thoroughly assessed the current conditions in the Project area and the evaluation of sediment deposition patterns has been completed, it would be impossible to identify a meaningful sampling strategy.
Verbal	08-16-06	Don Hurst	Colville Tribes	Hurst asked if SCL's approach to toxics was part of an attempt to avoid being drawn into a lengthy regulatory process and toxics cleanup program in the Project area.	SCL is prepared to accept responsibility for environmental impacts that it has caused or is causing. However, within the context of the FERC relicensing process, it is essential for SCL to construct its study approach based on Project nexus and the degree to which operations influence potential problems in the reservoir. It may be that it is more appropriate for SCL to address toxics issues in a regulatory process other than FERC relicensing.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda referred to Objective 6 in the toxics assessment study plan and noted that a sub-bullet stated that in the event that sampling is needed, steps would be taken to identify the best indicator organism(s) for detection of cadmium and lead. Shuhda asked why only these toxics were mentioned in the context of identifying indicator organisms.	The sub-bullets under Objective 6 were meant to provide examples of the considerations that would occur if the Phase 1 assessment indicates the need for sampling. All toxics will be evaluated by the technical consultant to ensure that an adequate sampling plan is implemented, if sampling becomes necessary.

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Verbal	08-16-06	Tom Shuhda	USFS	Shuhda noted that proceedings related to the Lehigh Cement Kiln Dust Landfill are underway. Tom stated that the landfill, which is adjacent to Sullivan Creek in the town of Metaline Falls, WA, is known to be a source of arsenic, which has leached into the groundwater. Shuhda stated that this facility should be specifically addressed as part of the Phase 1 toxics assessment.	Comment acknowledged.
Temperature modeling of the Boundary Project area (NOT INCLUDED IN PSP)					
Verbal	05-22-06	Bert Wasson	USFS	Wasson asked if infrared aerial photography of the Project area would be useful for validating the assumption that there is no significant lateral variation in water temperature.	Infrared images are limited because they can only characterize surface conditions. However, the reservoir's high turnover rate would not allow sufficient time for significant lateral variability to develop.
Verbal	05-22-06	Bert Wasson	USFS	Wasson asked if the CE-QUAL model would be able to capture the influence of tributaries on Boundary Reservoir's water temperature.	Tributary inflows to Boundary Reservoir account for less than 10 percent of the total flow through the reservoir, and as a result, tributary effects on temperature would be highly localized.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan stated that Teck Cominco had meteorological data collected at Seven Mile Dam.	SCL agreed to work with Duncan to acquire these data.
Verbal	05-22-06	Bert Wasson	USFS	Wasson asked whether air temperature is the most important of the meteorological parameters dictating water temperatures.	Meteorological parameters affect water temperature in different ways. Long-wave radiation sets the overall average water temperature, but air temperature dictates the amplitude of daily variability.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan asked how many vertical layers of the reservoir would be modeled.	There will be approximately 60 to 70 vertical layers and these will be of equal height at a given point in the reservoir.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan asked how many vertical layers	Shading would influence the surface

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				would be influenced by topographic shading.	layer only.
Verbal	05-22-06	Bert Wasson	USFS	Wasson noted that the USFS could provide additional Remote Automated Weather Stations (RAWS) data.	SCL agreed to acquire these data from the USFS.
Total dissolved gas					
Verbal	05-22-06	Mark Tiley	CCRIFC	Tiley asked whether turbine upgrades—which would allow a greater volume of water to pass through the powerhouse instead of over the spillway—were being considered as a potential TDG abatement measure at Boundary Dam.	Turbine upgrades were being considered and were included in the TDG abatement measures matrix.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan stated that relying on the sluice gates as a long-term solution to TDG abatement could pose significant adverse structural consequences to the dam, due primarily to vibration.	SCL engineers are aware of this potential problem, so sluice gate testing has been conducted in a conservative manner to avoid setting up resonance that could have adverse structural ramifications.
Verbal	05-22-06	Bill Duncan	Teck Cominco	Duncan stated that turbulent mixers (a potential TDG abatement measure) would have to be located well downstream of the dam, conceivably in Canada to function.	Use of turbulent mixers would likely be unacceptable, because measurement of compliance (currently located at the tailwater USGS fixed monitoring station [fms]) must occur in Washington waters.
Verbal	05-22-06	Patti Bailey	Colville Tribe	Bailey asked if the eventual solution to TDG abatement might consist of a combination of structural and operation elements.	A combination of structural and operational TDG abatement measures is possible.
Verbal	06-29-06	Mark Tiley	CCRIFC	Referring to the throttling of the sluice gates to pass high flows, Tiley asked if TDG levels at depth in the forebay are lower than those at the surface.	The objective of releasing flow at depth from the sluice gates was to reduce the depth to which flow plunges relative to that associated with spill flow (i.e., altering the trajectory of flow passing the Project during high flows). Reducing the

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					plunge depth would reduce air entrainment, and therefore TDG concentration, relative to spill flow. SCL had been and would continue measuring forebay TDG levels at the forebay's surface.
Verbal	06-29-06	Patti Bailey	Colville Tribe	Bailey asked if throttling the sluice gates had the potential to result in structural damage to the gates or other aspects of the dam.	Throttling the sluice gates for release of water during high flows is a viable option but that minor modifications to the gates would be needed to control the angle of flow release from the gates. During the summer 2006 sluice gate tests, some water had sprayed out parallel to the face of the dam, something that could weaken the gates' seals after prolonged periods.
Verbal	06-29-06	Llewellyn Matthews	Columbia Power	Matthews asked how far below the reservoir's surface the sluice gates are located and how deep the tailrace plunge pool is.	The sluice gates are located about 180 ft below the reservoir's surface at full pool (El. 1990 feet) and the tailrace plunge pool is about 100 ft deep.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda asked if physical modeling would be undertaken to assess the feasibility and effectiveness of the alternatives—other than those that can be tested, such as throttling the sluice gates.	Physical modeling would likely be a primary evaluation technique for the alternative or alternatives ultimately included in the shortlist.
Verbal	06-29-06	Llewellyn Matthews	Columbia Power	Matthews stated that some of the alternatives, for example roughening the spillway, would result in adverse consequences to fish.	"Fish friendliness" was a criterion included in the ranking of alternatives. Before an alternative is selected for TDG abatement, it would be necessary to show that it either had minimal effects on fish or that fish protection measures could be put in place to prevent injury and mortality.
Verbal	06-29-06	Jean Parodi	Ecology	Referring to the New Right Abutment	The alternative was still in its

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				Spillway with a Tunnel Outlet Gate alternative, Parodi asked where the outflow would be located.	conceptual stages and that although the outlet would be on the right side of the tailrace, its exact location was as yet unknown. The structure of the outlet would need to account for variation in tailrace elevation.
Verbal	06-29-06	Don Hurst	Colville	Don Hurst noted that there are abandoned mine tunnels beneath Boundary Reservoir and asked whether any of these could be used for routing high flows to the tailrace. Hurst also asked what volume of water is lost from the reservoir to the tunnels.	The current FERC license requires the measurement of water levels in a series of wells to assess water loss from the reservoir. Prior to dam construction, geologic analyses were completed to assess the risk of reservoir water entering the abandoned mines and the researchers conducting the analyses concluded that the reservoir was largely sealed off from the mine shafts. Ongoing monitoring supports this conclusion and the results of this ongoing monitoring are included in reports filed every six months with FERC.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda asked if *Opening the Existing Diversion Tunnel and Adding a Control Valve* alternative could affect the structural integrity of the dam, because the tunnel's outlet is so close to the dam's left abutment.	There is concern, because this alternative would involve conducting work very close to the left abutment, near a point where much load is directed outward from the dam.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda noted that the *Opening the Existing Diversion Tunnel and Adding a Control Valve alternative* was ranked 11 in the TDG alternatives matrix and questioned whether this ranking was too high, given the potential for effects on the dam's structural integrity.	The rankings shown in the matrix should be considered provisional, because they were based on incomplete information. Further evaluation by SCL and the TDG expert panel would likely result in a revised ranking of the potential alternatives. However, it is currently SCL's belief that opening of the diversion tunnel could represent a feasible alternative, if appropriate

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					compensatory measures are undertaken.
Verbal	06-29-06	Tom Shuhda	USFS	Referring to the *New Left Abutment Tunnel* alternative, Shuhda asked why SCL was not considering addition of a new turbine unit instead of only a bypass.	SCL had conducted a cost-benefit analysis for adding a new turbine unit and found that doing so was not economically justified. Flows in excess of current powerhouse capacity are infrequent, so the unit would rarely operate.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda noted that throttling of the sluice gates was considered to be a "fish friendly" alternative and asked whether this was because few fish are expected to occupy the reservoir at the depth of the sluice gates or because fish protection measures are assumed to be needed a part of this alternative.	The current assumption is that few fish occupy the reservoir at the depth of the sluice gates (about 180 ft from the reservoir's surface). There were currently no plans to include fish protection measures as part of this alternative; the veracity of this assumption would be evaluated during reservoir fish distribution and biotelemetry studies to be conducted as part of Fish & Aquatics resource evaluations. After the results of the fish studies become available, SCL will better be able to judge the risk of entrainment associated with various alternatives and what protection or passage measures might be needed to make a particular alternative viable.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda referred to the *Penstock/Draft Tube Bypass* alternative and asked why this approach had been considered, given its apparent complexity relative to the tunnel bypass alternatives.	This alternative could be less costly than those that involve extensive tunneling.
Verbal	06-29-06	Mark Tiley	CCRIFC	Tiley stated that it would be undesirable to pass introduced fish species downstream and that perhaps implementation of an alternative with a deep intake would minimize the potential for such passage.	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Verbal	06-29-06	Llewellyn Matthews	Columbia Power	Matthews noted that no potential TDG alternatives had yet been eliminated from consideration and asked how many alternatives were likely to receive more in-depth analysis during the next phase of evaluation.	SCL was not sure how many alternatives would be subject to more detailed analysis but the goal was to reduce the existing number of alternatives and produce a shortlist of potential approaches by late summer of 2006.
Verbal	06-29-06	Patti Bailey	Colville Tribe	Bailey asked what percent reduction in TDG is anticipated as a result of implementing abatement measures at the Project. Bailey also stated that it would be undesirable to eliminate structural alternatives in favor of operational alternatives until the relative effectiveness of all approaches is understood.	Additional work is needed to better estimate performance of the various TDG alternatives but that SCL's goal is to implement a measure or measures that will result in compliance with Ecology's TDG standard. The ultimate approach to TDG abatement could be a combination of both structural and operational measures.
Verbal	06-29-06	Tom Shuhda	USFS	Shuhda asked whether modeling would be used to estimate the potential reduction in TDG associated with alternatives selected for the shortlist.	Computational fluid dynamics (CFD) modeling and physical modeling could both be employed, in addition to performance evaluations of existing TDG abatement facilities, for example measures implemented at Cabinet Gorge Dam.
Verbal	07-25-06	Patti Bailey	Colville Tribe	Referring to the alternatives matrix, Bailey noted that the *Roughen Sluice Discharge* alternative had been assigned a "7" for potential TDG benefit. Bailey asked what this value meant in terms of TDG reduction.	A score of "10" signifies no impairment, i.e., that water passed via this option would either maintain the TDG of incoming water or reduce TDG levels. A score of "7" indicates that some impairment would still likely occur. The rankings are relative, i.e., only meant to serve as a means of comparing alternatives, and the rankings should not be considered definitive, although SCL has more confidence in the rankings for alternatives that have been

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
					applied at other Projects, for example the diversion tunnel underway at Cabinet Gorge Dam. Tests or modeling would have to be conducted before SCL would have more confidence regarding the effectiveness of individual alternatives for reducing TDG concentrations.
Verbal	07-25-06	Bill Duncan	Teck Cominco	Duncan referred to the *Penstock/Draft Tube Bypass* alternative and asked whether this approach would involve construction of a new penstock or penstocks. Duncan also asked how many penstocks would need to be used to allow passage of the 7Q10 flow.	The alternative involves use of existing penstocks, and passing the 7Q10 flow would require modification of most of the units.
Verbal	07-25-06	Patti Bailey	Colville Tribe	Referring to the *Agency Resource Management Goals* section of the TDG study plan, Bailey noted that the focus was on Watershed Resource Inventory Area (WRIA) 62, which encompasses the Pend Oreille River. Bailey stated that limiting management goals to the Pend Oreille River basin fails to account for the full range of the Boundary Project's TDG impacts, which extend downstream to the Columbia River. Bailey recommended expanding the study goals to include addressing TDG impacts in the Columbia River downstream of it's confluence with the Pend Oreille River.	Ecology is addressing TDG impacts in the Pend Oreille and Columbia rivers through the TMDL process. By complying with Ecology's TDG standard at Boundary Dam, SCL would be meeting its regulatory obligation and be contributing to a reduction in system-wide TDG impacts, both in the Pend Oreille River and Columbia River.
Verbal	07-25-06	Patti Bailey	Colville Tribe	Bailey stated that the goal of the Confederated Tribes of the Colville Reservation is to ensure that the TDG standard of 110 percent is met in the Columbia River immediately downstream of the United States-Canada border and that TDG abatement measures implemented at	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				Boundary Dam should be evaluated in a larger context.	
Verbal	07-25-06	Bill Duncan	Teck Cominco	Duncan suggested that making reference to the efforts of the Transboundary Gas Group would indicate that the TDG issue is being addressed at a larger scale, involving both United States and Canadian entities.	Comment acknowledged.
Verbal	07-25-06	Patti Bailey	Colville Tribe	Bailey agreed to submit text to SCL on behalf of the Colville Tribes that could be added to the TDG study plan—if acceptable to SCL and other stakeholders—that would address the Tribes' concerns regarding the scope of the study plan as it reflects Ecology's TDG regulatory standards.	Comment acknowledged.
Verbal	07-25-06	Tom Shuhda	USFS	Shuhda stated that in the case of operational TDG abatement measures, tests could be conducted and empirical data used to assess performance. However, said Shuhda, structural alternatives could only be evaluated through indirect means, such as numerical or physical modeling. Because of this, Shuhda asked whether there might be a bias toward selecting operational solutions over structural solutions.	Empirical data demonstrating the effectiveness of a particular abatement alternative would weigh heavily into decision-making. However, SCL currently does not think that operational solutions alone will result in compliance with Ecology standards. Some structural alternatives can be evaluated by observing the performance of similar facilities at other projects, such as the spill bypass tunnel at Cabinet Gorge Dam. Models are tools needed to provide information but decision-making would be based on more than model results. An operational measure may be instituted as a short-term solution until a structural alternative, perhaps in combination with an operational measure, is implemented as the permanent solution to TDG exceedances.
Verbal	07-25-06	Jean Parodi	Ecology	Parodi stated that the shortlist of potential	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				alternatives indicated by SCL would be suitable for incorporation into the TDG TMDL. Parodi added that by the time the Application for 401 Certification is submitted in 2010 it would be necessary to have a more well-defined compliance approach, with specific measures indicated, although multiple components would still be likely.	
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked whether the TDG abatement measures sensitivity analysis, along with a written description of the steps taken to complete it, was available on SCL's website.	The complete results of the sensitivity analysis were not yet available but would be posted on SCL's website soon. A written description of the sensitivity analysis would be included, along with appropriate spreadsheet tables displaying the results of the analysis.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked why six potential TDG abatement measures were included on the shortlist, instead of a larger or smaller number of measures.	The selection of six potential measures was not arbitrary; the results of the sensitivity analysis consistently indicated that the six selected measures were the best potential approaches. The six measures were ranked at or near the top of the overall list, regardless of which individual ranking criteria were muted in the analysis.
Verbal	08-16-06	Jean Parodi	Ecology	Parodi stated that it would be helpful if the results of the sensitivity analysis and the written description of the steps taken were included as an appendix to the proposed study plan (PSP) for TDG.	The sensitivity analysis results, along with the description of the analysis process, would be included in the PSP for TDG.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda noted that part of the analysis of the *Throttle Sluice Gates* alternative involved additional testing of the ability of the sluice gates to reduce TDG production. Shuhda stated that tests of the sluice gates had been	The sluice gate tests conducted in 2006 were conducted over a limited range of forebay TDG and flow conditions. Before a judgment could be made as to the effectiveness of the

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
				conducted in 2006 and asked why more testing was needed.	sluice gate option, results from tests conducted over a wider range of TDG and flow conditions would be needed.
Verbal	08-16-06	Gary Birch	BC Hydro	Birch noted that the shortlist of six measures included five structural alternatives and only one operational alternative. Birch asked if the ultimate solution to TDG reduction at Boundary Dam might involve a combination of structural and operational measures.	A combination of structural and operational measures is possible, and an operational alternative could also be employed as an interim measure while a structural alternative is under construction. The technical consultant hired to conduct in-depth analyses of measures in 2007 through 2009 might also evaluate something from the set of operational alternatives not included in the shortlist. SCL's approach to selecting a TDG abatement solution will be flexible, so that the most effective option or options can be developed.
Verbal	08-16-06	Gary Birch	BC Hydro	Birch stated that one potential drawback of implementing operational TDG solutions is that doing so often involves using project features in a way that was not intended when they were engineered and constructed. Birch said that unconventional use of existing structures could lead to potential problems.	The sluice gates were not originally designed to be throttled, but were throttle tested in the early 1970s at various openings at various lengths of time. To use more than one sluice gate in a throttled position, the gates will require modifications, such as enclosure to retain high water pressures and new auxiliary gate(s) will need to be designed and installed on the upstream side of the sluiceway. This provision for auxiliary gate(s) is to prevent an uncontrollable release of water if two or more sluice gates cannot completely close, and SCL anticipates that this or a similar

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
					backup measure would be required by FERC.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda stated that inclusion of the sluice gate option on the shortlist is based on the assumption that no fish occur at depth near the sluice gate intakes. Shuhda asked how SCL would proceed if fish distribution studies show that fish do occur at the depth of the gate intakes.	If a significant number of fish are found to occur at the depth of the sluice gate intakes, SCL would either design appropriate fish protection measures or abandon the use of the gates as a TDG reduction measure.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if fish protection was assumed to be necessary for the *Penstock/Draft Tube By-Pass* alternative.	SCL assumes that this alternative would require fish protection. If this measure were selected, it would be installed incrementally, with the design of each unit reflecting improvements based on experience derived from evaluating its predecessor(s).
Verbal	08-16-06	Don Hurst	Colville Tribes	Hurst stated that given the depth of the intake, a tunnel option could result in the downstream transport of sediment, along with its associated toxic substances, that has settled on the bottom of the reservoir since its impoundment.	SCL is aware of this potential problem, and sediment containment or removal measures will be addressed as part of the constructability analysis developed for structural alternatives.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if the next step would be to rank the measures included in the shortlist on the basis of cost.	Cost would not yet be an evaluation criterion; the six identified measures would first be evaluated solely on the basis of technical merit.
Verbal	08-16-06	Jean Parodi	Ecology	Parodi stated that she expected the current USGS FMS in the Boundary tailrace would probably remain the TDG compliance point and that the 7Q10 will be 108,300 cfs. However, Parodi added that the 401 certificate would probably require SCL to be able to accommodate the 7Q10 with a single unit outage, i.e., with a buffer of approximately 10,000 cfs.	Comment acknowledged.

Comment format	Date	Stakeholder	Affiliation	Stakeholder comment	SCL response to comment
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda asked if modeling would be used to evaluate sluice gate performance if no spill occurs during the 2007 – 2008 study period.	SCL could reduce generation to provide flows for the sluice gate tests.
Verbal	08-16-06	Tom Shuhda	USFS	Shuhda noted that unlike other study plans, the TDG plan included no statement of anticipated level of effort and cost. Shuhda added that the version of the TDG study plan provided for the July 25 workgroup meeting stated that the anticipated level of effort and cost would be developed by SCL in consultation with the TDG expert panel.	Estimates of effort and cost for the study program would be incorporated into the version of the study plan included in the PSP. However, the estimate would be highly qualified and subject to potentially significant changes once there is a better understanding of what the tasks will entail.

From: "Lisa Rennie" <Lisa.Rennie@Seattle.Gov>
To: <SDPADULA@aol.com>; "Barbara Greene" <barbara.greene@Seattle.Gov>
Sent: Tuesday, May 16, 2006 11:56 AM
Subject: Fwd: issues and study needs at Boundary

>>> "Don Hurst" <don.hurst@colvilletribes.com> 05/16 11:37 AM >>>
My name is Don Hurst with the Environmental Trust Department of the Colville
Confederated Tribes. I met this morning briefly with Frank Winchell and
David Turner of FERC about the relicensing process at Boundary Dam. Our
History and Archaeology Department had just received a copy of the
PreApplication Document (PAD). David indicated that additional copies could
be made available by contacting the appropriate SCL leads. Accordingly,
would SCL please make available a copy of the PAD to each of the following
CCT contacts:

Don Hurst, Toxics Cleanup Program Manager

Environmental Trust Department

Colville Confederated Tribes

Po box 150

Nespelem WA 99155

Joe Peone, Director

Fish and Wildlife Department

Colville Confederated Tribes

Po box 150

Nespelem WA 99155

David also emphasized that Resource Work Groups were being formed. I was
surprised that the list of RWG's on page 2-18 didn't include Sediment
Quality as a resource area. Based on the background information on page 4-82
of a the PAD, the Boundary Dam reservoir received as much as 16 million tons
of metal-enriched tailings from the PendOrielle Mine in the period between
dam construction in 1960 and construction of upland tailings ponds in the
mid 70's. Based on background info in the PAD, no significant sediment
quality or toxicity investigations on sediments sequestered behind Boundary
Dam have been conducted. It's clear to us that sediment quality warrants a
separate RWG and rigorous study in the relicensing process.

Early in the process, I thought SCL would want to hear ETD's concern for
what appears to be a humongous but previously unrecognized data gap. I am
curious to hear what PCL's thought process has been on the matter.

Don Hurst

From: "Christine Pratt" <Christine.Pratt@Seattle.Gov>
To: <awasson@fs.fed.us>
Sent: Friday, June 02, 2006 3:19 PM
Subject: Re: Minutes

Bert - Thanks for your e-mail about sediment sampling for toxics.

Being the water quality lead on this relicensing effort, you have addressed the right person.

We have duly noted the comments expressed at the 5/22 Water Quality Workgroup Meeting - and invite you to read the DRAFT notes when they are released next week (6/8) and help us ensure accurate description of your comments and review the comments expressed by the Colville Tribe.

In the meantime, I'd invite you to review the "Toxics Inventory and Screen" (our Early Information Development - EID - effort undertaken last year). You can access this 82-page document at the relicensing website at the following link -http://www.seattle.gov/light/news/issues/bndryRelic/br_schedule.asp
This document explains the rationale for Seattle City Light's approach to this matter.

Thanks for your interest in Boundary Relicensing - and look forward to seeing you again at our next Water Quality Workgroup Meeting in June (6/29) at the Project.

Christine
Water Quality Lead
Boundary Relicensing
Seattle City Light
206.386.4571

>>> Albertus H Wasson <awasson@fs.fed.us> 06/02 12:53 PM >>>
The issue I'm struggling with is the need for sediment sampling for toxics.
The toxics inventory and screen was primarily water sample analysis and
some fish tissue analysis for PCBs. With the Boundary reservoir
concentrating and accumulating sediments, it seems there might be a need
for a numerical inventory of toxics concentrations in the sediments to
determine if there might be a health hazard to humans or wildlife
(including T & E species) in consuming fish. I remember folks from the
Spokane tribes expressing concerns about contaminated sediments and wanted
to review what they said.
Is there someone on your staff who is dealing with this issue? Thanks.

Bert Wasson
Forest Hydrologist,
Forest Aviation Officer,
Colville National Forest
email: awasson@fs.fed.us
Phone: 509-684-7213, Fax: 509-684-7280

"Christine Pratt"
<Christine.Pratt@
Seattle.Gov> To

<awasson@fs.fed.us>
06/02/2006 12:07 PM
cc
Subject
Re: Minutes

Bert - Thanks for your interest in the 5/22 Meeting Notes. No, they're not available yet, but here's the process toward finalization -

1. Post the final external draft version of the 5/22 Meeting Notes to the Boundary Relicensing website by COB 6/9

2. Any comments you may have on the draft version of the Meeting Notes could be discussed at the 6/29 Workgroup Meeting and/or written comments DUE to us by 7/6.

Hope to see you on the 29th, Bert.

Christine Pratt
Boundary Relicensing Team
Seattle City Light
Water Quality Lead
206.386.4571

>>> Albertus H Wasson <awasson@fs.fed.us> 06/02 11:16 AM >>>

Christine, I'm looking on your web page for the minutes of the 5/22/06 meeting in Spokane. Are they available yet? Thanks.

Bert Wasson
Forest Hydrologist,
Forest Aviation Officer,
Colville National Forest
email: awasson@fs.fed.us
Phone: 509-684-7213, Fax: 509-684-7280

From: "Christine Pratt" <Christine.Pratt@Seattle.Gov>
To: <randallfilbert@msn.com>; "MaryLouise Keefe" <mkeefe@r2usa.com>
Cc: "Steve Padula" <SDPADULA@aol.com>; <kdemsey@easystreet.com>
Sent: Thursday, June 08, 2006 9:56 AM
Subject: Fwd: RE: Request for short conference call

>>> "Parodi, Jean (ECY)" <JPAR461@ECY.WA.GOV> 06/08 9:38 AM >>>
Barbara- Yes, I think a brief call would be a good idea. I've had some in-house discussions with our Toxics Cleanup program since Don from the Colville Tribes raised the sediment issue at the meeting last week. They thought it would be appropriate for SCL to do at least some analysis of the sediments collected behind Boundary dam.

So, let's talk about that and I can also explain how we'd plan to work with the Ministry of Environment in BC.

My schedule is open next week Monday through Wednesday. I'm not available on either Thursday or Friday.

Thanks,
Jean

-----Original Message-----
From: Barbara Greene [mailto:barbara.greene@Seattle.Gov]
Sent: Friday, 02 June, 2006 09:21
To: Parodi, Jean (ECY); Christine Pratt
Subject: Request for short conference call

Jean,

I have two issues on my mind that I'd like to check in with you about, and wondered if Christine and I could schedule a short (30 mins max) conference call with you sometime after next Thursday June 8.

1 - I'm wondering to what extent you plan to share any information, particularly the 401 but maybe the TMDLs as well, with the BC govt per your MOU (or is it an MOA?).

2 - We are thinking more about the sediments issue raised in the water quality group by the Colville Tribe. While we hadn't heard from WDOE that this would be needed for our 401, and we did not anticipate such a study, we wanted to check in with you about this.

Thanks, let us know what date/time is convenient. I will be out of the office until June 8, so will be unavailable until then.

Barbara

I'm going to email Jean and ask her if the three of us can schedule a call late next week or early the following to discuss these issues.

Barbara Greene
Boundary Relicensing Program Lead
Seattle City Light
206.615.1091
barbara.greene@seattle.gov

Boundary Project Relicensing Conference call between Seattle City Light and WA Dept of Ecology – June 19, 2006

Christine Pratt and Barbara Greene talked with Jean Parodi and Jon Jones (WDOE) on June 19, 2006 regarding comments by the Colville Tribe at the May 22, 2006 Water Quality Work Group meeting on City Light's proposed study on toxics (*Assessing Toxics of Concern: Evaluation of Contaminant Pathways and Potential Project Nexus*). The Tribe stated that the proposed study as outlined in the meeting did not go far enough and should focus on sediment sampling, including core sampling in the reservoir.

Barbara asked for clarification of Ecology's thoughts on potential sediment sampling, including core sampling since Ecology had never identified this as a requirement for a 401 certificate. In an email from Jean Parodi to Barbara (dated June 8, 2006) Jean had reported on some in-house discussions with Ecology toxics Cleanup staff and suggested it may be appropriate for City Light "to do at least some analysis of the sediments collected behind Boundary dam". Barbara asked about the timing of sampling vs. City Light's proposed plan, how to identify sampling locations, and what the nexus to the Project was. Jean acknowledged the Ecology toxics staff were perhaps not as familiar with the relicensing process and, therefore, talked about how they would approach toxics from their perspective. Jean stated that she recognized City Light is not putting any toxics in the water, but was suggesting 10-20 spots in the reservoir for sampling, and suggested the sediments could have traveled downstream if the dam was not there.

Barbara asked what the Project nexus was, and if we were to sample, what would Ecology want us to do with the results. Jean replied that Ecology was not suggesting if we found toxics in the sediments that we clean up the toxics, that this would be a focus of a different regulatory process than relicensing.

Barbara stated her understanding was that toxics in deep, undisturbed sediments are generally considered stable, and asked again for a clearer understanding of a nexus to the Project. Jean stated a nexus might exist with the Project in the potential mobilization and storing of toxics.

This was a good segue for Christine to ask why do core samples, if potential mobilization of toxic sediments getting into the water column and ultimately the food chain is the root of concern here. Threat(s) to human health or wildlife is our understanding of any cause for concern. Jean agreed that the question of core sampling was a good one - she wasn't clear why we'd go there.

We asked what a scope would be for sampling since we don't have sufficient information to sample now. Jean asked for a recap of what our next step in the literature review was. Christine gave a report on our approach and emphasized that sampling, including sediment sampling, had not been ruled out. A literature-based assessment is needed to establish Project nexus through a better understanding of contamination pathways and the bioavailability of these particular toxic materials in this particular environment, and that this assessment would help inform the development of a sampling plan, if sampling is deemed necessary.

Jean appeared more comfortable with our approach, but added that she was puzzled why copper, zinc and arsenic were not flagged as needing more review in our EID.

Barbara stated that she wanted to talk with the Tribe and understand their goals with sediment sampling, and had not decided whether it would be on next week's work group agenda. Jean stated that the USFS also has an interest in this issue.

Seattle City Light

Memorandum

DATE: June 29, 2006

TO: Consultation file

FROM: Barbara Greene

SUBJECT: June 29 meeting with Colville Tribe

I met with the Colville Tribe on June 29 in Metaline Falls prior to the Boundary Relicensing Water Quality Work Group meeting. Steve Padula, strategic consultant on Boundary relicensing, was also in attendance. Tribal representatives included Don Hurst, Hazardous Waste Manager with the Colville Tribe Environmental Trust, and Patti Bailey, Environmental Planner for the Tribe.

The purpose of the meeting was to clarify the Tribe's interest in the Boundary relicensing process, and to better understand the Tribe's concerns around sediments. Tribal staff had first indicated an interest to City Light in sediment issues at the May 22nd Water Quality Work Group meeting. Their concerns appear to be focused on historic mining along the Boundary reservoir, and the potential for toxics to be trapped in sediments along the draw down zone and on the bottom of the reservoir. They had reviewed a 2002 EPA report that concerned them. In reviewing City Light's proposed study of toxics, the Tribe felt the scope of the toxics study was not broad enough. I reassured them that we welcomed them into the process, and would discuss their issues within the Work Group setting to ensure all participants were aware of the potential issues.

Hi Kim- Thanks for sending this. I haven't yet had a chance to compare notes with Paul P. on this, but first impressions are that it'll work for us. I like the fact that you've narrowed down the options to approximately six that you'll analyze in detail. It should help get you to an abatement strategy sooner. I have a few questions, which I'll talk to you about next week. I'll also do my best to chat with Paul before our meeting on Wednesday.

See you then,
Jean Parodi

-----Original Message-----
From: Kim Pate [mailto:Kim.Pate@Seattle.Gov]
Sent: Wednesday, 09 August, 2006 11:55
To: Jones, Jon W. (ECY); Parodi, Jean (ECY); Pickett, Paul
Cc: Steve Padula; Randall Filbert; Barbara Greene
Subject: TDG Study Plan Review by Ecology

Dear Jon, Jean and Paul:

Attached is a preliminary TDG study plan for your review and comment, especially in light of the current TMDL effort and how you envision the application for the
401 certificate.

Some specifics to focus on include the 7Q10, compliance area, and short-list of
6 alternatives that would be the only options further evaluated from the original 24 to 30 options on the 2004/5 matrix. Also, an Appendix A to the study plan illustrates each of the six alternatives.

I would appreciate your thoughts by the end of this week as we will be traveling to Spokane this Sunday and early Monday morning for the stakeholder work groups.

Take care,
Kim
Kimberly Pate, M.S., P.E.
Seattle City Light
700 5th Avenue, Suite 3300
P.O. Box 34023
Seattle, WA 98124-4023
PH: 206.684.3705
FAX: 206.684.3799
kim.pate@seattle.gov

Email from Jean Parodi (ECY) to Kim Pate (SCL) 8-17-06

Hi Kim- It was nice to see everyone yesterday, and continue discussions of TDG and other relicensing issues.

I've attached the e-mail exchange I had with Paul regarding the draft TDG study plan. As I mentioned to Peter yesterday, I tried to highlight the more substantive comments. Paul also had some editing suggestions regarding the TMDL mostly.

Peter gave his large-scale colored print out of the TDG options matrices. They're easy to read and will be helpful for both the TMDL and relicensing work. Thanks.

Jean Parodi (ECY)

Thanks, Paul--I'll forward your comments on to Kim, but wanted to talk to you about the one concerning Page 6, item number 5 first.

Namely, during the last couple of work group meetings, SCL has described and illustrated the various TDG abatement options, with their preliminary evaluations of the pros and cons of each. They have all the options summarized on a spreadsheet with some initial and very fluid rankings based on several factors- I think I sent you a copy of that via the campus mail. Even from this early discussion, it's clear to me that some of the options are more promising than most, some are no-go's because of probable dam safety problems, some would probably be ineffective at reducing gas or might harm fish, quite a few are in a grey betwixt and between sort of spot. These last don't appear to be all that good for one reason or another, but aren't totally hopeless either.

In the interest of moving down the path to developing a workable gas abatement plan, I encouraged Kim to flag a few (6-8) of the most promising of their alternatives and delve into the analysis, modelling etc. as needed. However, I agree SCL should include their spreadsheet, with reasons for dropping some options altogether (e.g. safety, totally ineffective at decreasing gas), and noting that the rest will be kept in the background, and not totally eliminated yet, in case the favored options don't work out for some reason or another. I think appending this information as an attachment to the study plan would be fine.

(Note: Paul indicated he was OK with this approach)

Regarding page 8, 1st paragraph etc.- Based on the temperature TMDL work, we concluded that the 7Q10 should be 108,300 cfs, with some possible adjustments in the long-term future. (Paul also agreed with this.)

Jean

-----Original Message-----
From: Pickett, Paul
Sent: Friday, 11 August, 2006 16:36
To: Parodi, Jean (ECY)
Cc: Maynard, Chris
Subject: RE: TDG Study Plan Review by Ecology

Jean, here are some comments on the documents Kim sent. Let me know if you have any questions. Paul

TDG Study Plan:

Page 2, 1st paragraph after table: "From 2001 through 2004, Ecology has been monitoring TDG at the Idaho state line near Newport and in the forebay and tailrace of Boundary Dam." This is incorrect. The Corps and Pend Oreille PUD have done this monitoring. Ecology did some supplemental monitoring in 2004. See the draft TDG TMDL report for the history of monitoring.

Page 2, 1st paragraph after table: "...and has established the total maximum daily load (TMDL) for TDG in the Pend Oreille River." Ecology is project lead for a TMDL which will be issued by Ecology for Washington's waters and approved and issued for Tribal waters by EPA. The TMDL has not been "established" yet. Suggest: ".....and is in the process of developing the total maximum daily load (TMDL) for TDG in the Pend Oreille River jointly with EPA and the Kalispel Tribe."

Page 4, 1st paragraph below "Nexus...": "...because past monitoring has shown that TDG measurements downstream of Boundary Dam exceeded the Ecology standard (110 percent saturation). Based on this monitoring, it has been determined that during times of spill, the Boundary Project increases TDG concentrations beyond this standard,..." This statement is incomplete. Suggest: "because past monitoring has shown that TDG measurements upstream and downstream of Boundary Dam exceeded the Ecology standard (110 percent saturation). Based on this monitoring, it has been determined that during times of spill, the Boundary Project increases TDG concentrations beyond this standard or increases TDG concentrations above upstream levels when upstream levels already exceed the standard,..."

Page 6, Item number 5: This item appears to set six options. WAC 173-201A-510(5) "Compliance schedules for dams" states that a water quality attainment plan must include: "...Identification of all reasonable and feasible improvements that could be used to meet standards, or if meeting the standards is not attainable, then to achieve the highest attainable level of improvement;..." Later in the document the process is described which resulted in the six options representing the best of "all reasonable and feasible" alternatives. This item should make this context clear. If the six are a subset of "all reasonable and feasible" alternatives, then total list of "all reasonable and feasible" alternatives should be provided and the process described where additional alternatives will be added from the "long list" if the six chosen aren't meeting the standard or if new information makes another alternative look more promising.

Page 8, 1st paragraph in "Pend Oreille River TMDL for TDG": This statement is not quite accurate: "This standard is to be met for all river flows up to the seven-day average, ten-year high flow (7Q10 flow), which is about 118,400 cfs for the Pend Oreille River in Washington state. As a result of this listing, the EPA will take action and will require development of a water cleanup plan..." Suggest: "This standard is to be met for all river flows downstream of the Kalispel Reservation up to the seven-day average, ten-year high flow (7Q10 flow), which is about 118,400 cfs for the Pend Oreille River in Washington state below Boundary Dam. As a result of this listing, Ecology will take action in accordance with its MOA with EPA, and will develop a water cleanup plan..."

Page 9, 1st paragraph under "TDG Objective for the Boundary Project": Instead of "Washington State law requires that the Project pass the 7Q10 flow..." should be "Washington State regulations require that the Project pass the 7Q10 flow...". Also, Ecology usually requires the TDG criterion to be met at 7Q10 flow with one turbine not operating (as a margin of safety for possible equipment outage).

Page 15, 5th bullet: "Estimate or predict gas abatement performance for the short-list of operational and structural alternatives including potential combinations of alternatives and identify

spillgate, sluicegate, and generating unit operating protocols that may reduce exceedences of TDG production at Boundary Dam when water is passed through the Project." I would like to see a more specific description of this task that provides some details on how the estimation or prediction will be done.

Page 16, 1st bullet: "Describe and present results of specific field testing, surveys, hydraulic modeling techniques or methods performed for each applicable gas abatement alternative." Again, for a study plan that will be completed in two years, the details are pretty vague on what these activities would be. I would like to see a more detailed description of how SCL is planning to conduct these activities.

Seattle City Light (SCL)
Boundary Hydroelectric Project (FERC No. 2144)
TDG Study Plan Meeting
August 25, 2006
Washington Department of Ecology (Ecology)
Headquarters (HQ), Room 2B-18
Lacey, Washington

FINAL MEETING SUMMARY

In Attendance (8:30 a.m. to 10 a.m.)

Jon Jones (Ecology-Spokane, by phone)
Marcie Mangold (Ecology-Spokane, by phone)
Chris Maynard (Ecology HQ)
Kim Pate (SCL)
Paul Pickett (Ecology HQ)

Review scope of meeting

Paul Pickett projected the draft Total Dissolved Gas study plan dated August 9, 2006 (draft TDG study plan) on the conference wall to facilitate discussion about the study plan content. Paul Pickett and Kim Pate reviewed the items to discuss for the morning meeting.

- Introductions
- Ecology response to draft TDG proposed study plan (08.09.06) per Paul Pickett email to Jean Parodi (Ecology-Spokane) on August 11, 2006, and Jean Parodi's comments per email to Kim Pate on August 17, 2006.
- Total dissolved gas (TDG):
    - Review Ecology response to draft TDG proposed study plan per above email correspondence between August 11th and August 17, 2006.
    - Review how list of 24 alternatives was filtered to a shortlist of 6 most-promising or proposed TDG abatement measures
    - Review revised TDG proposed study plan
- Closing Remarks and Action Items

Introductions

Everyone introduced themselves and we welcomed Marcie Mangold (Ecology), who will transition into the role and involvement that Jean Parodi (Ecology) has performed with the Pend Oreille River TMDLs, the relicensing of the Boundary Project, and 401 certification processes. Marcie has served as a lead for TMDLs (i.e., Walla Walla and Palouse) and wastewater discharge permits.

Ecology response to draft TDG proposed study plan dated August 9, 2006

Review shortlist of proposed TDG abatement measures

Kim Pate (SCL) distributed color copies of the three (3) alternative matrices (Excel® spreadsheet tables) that represent the filtering process by which a shortlist of six potential TDG abatement measures for the Boundary Project was identified. Kim explained that the cost criterion had been muted so that abatement measures had been evaluated solely on the basis of technical merit and outlined the sensitivity analysis undertaken by SCL to assess the degree to which individual evaluation criteria affected the overall ranking of potential measures. Kim stated that the results of the sensitivity analysis showed that the top six alternatives selected by SCL for further analysis were consistently indicated as the best potential approaches by the ranking criteria. The six TDG abatement measures included on the shortlist—not presented according to overall ranking—are as follows:

- Option 1-3 Throttle Sluice Gates
- Option 3-2 Roughen Sluice Gate Discharge
- Option 4-7 New Right Abutment Tunnel with Submerged Discharge
- Option 4-8A New Left Abutment Tunnel Intercepts Diversion Tunnel
- Option 4-9 Penstock/Draft Tube Bypass
- Option 4-10 New Short Left Abutment Tunnel Next to Unit #51

The selection of six potential measures was not arbitrary, noting that the results of the sensitivity analysis consistently indicated that the six selected measures were the best potential approaches. These six measures were ranked at or near the top of the overall list, regardless of which individual ranking criteria were muted in the analysis. A combination of structural and operational measures are possible and that an operational alternative could also be employed as an interim measure while a structural alternative is under construction.

Review draft TDG proposed study plan

Paul Pickett (Ecology) and Chris Maynard (Ecology) stated that the 7Q10 will be 108,300 cfs for the Boundary Project consistent with the Pend Oreille River TMDL for TDG, but clarified that the 401 certificate would probably require SCL to be able to accommodate the 7Q10 during a single unit outage, i.e., with a buffer of approximately 10,000 cfs. The preferred approach is to demonstrate that the TDG abatement strategies can deal with the excess flow of 7Q10 flows minus the combined powerhouse flows of all but one unit. Michael Schneider (USACOE) recently performed this preferred approach for Grant County PUD. The study plan will be revised to reflect this preferred approach.

Paul noted that, with a few exceptions, the revisions suggested by him in the email correspondence (08/11/2006) were reflected in the draft TDG proposed study plan submitted on August 24, 2006. Paul emphasized the need for more specific descriptions of the TDG prediction task for Phase 1 in the study plan. Paul, Chris, and Kim proceeded to discuss our awareness of the various TDG prediction tools used by other relicensing processes including Grant County PUD, Avista, and Lower Columbia River tools used by the US Army Corps of Engineers and others such as DGAS and CRiSP equations (see Action Items).

Paul asked about the status of the final review report by Michael Schneider (see Action Items). The analysis of previous studies may suggest additional transect studies with improved study design to address unresolved issues such as: the effect of operational choices of spill through the various structures; the effect of the submerged coffer dam in the tailrace; and the conditions creating and amount of powerhouse flow entrainment into the spill. Paul suggested having a discussion in fall 2006 to assess an appropriate 2007 TDG monitoring plan for the Project.

Kim Pate (SCL) explained that a technical consultant team will be awarded a contract to perform most of the study plans including the TDG study plan by December 2006/January 2007. The TDG study plan included in the PSP and filed with the FERC by October 16, 2006 serves as the initial scope of work to discuss with the successful technical consultant team. Revisions to the TDG study plan may result from discussions with the technical consultant, Ecology, and other stakeholders prior to final study plan determination by the FERC in March 2007.

Closing remarks

Kim stated that a written description of the sensitivity analysis will be included in the Proposed Study Plan (PSP) for TDG and posted on SCL's website, along with appropriate Excel® spreadsheet tables displaying the results of the analysis. Kim added that the technical consultant hired to conduct in-depth analyses of measures in 2007 through 2009 might also evaluate something from the set of operational alternatives not included in the shortlist. SCL's approach to selecting a TDG abatement solution will be flexible, so that the most effective option or options could be developed.

The meeting adjourned at 10 a.m.

ACTION ITEMS:

- Kim Pate (SCL) stated that she would send Paul Pickett a copy of Michael Schneider's (USACOE) final review of Columbia Basin Environmental (CBE) 2003 and SCL (2005) spill test data reports, and a copy of Paul Carson's 2003 spreadsheet analysis of TDG performance for the Cabinet Gorge project (Avista).

- Chris Maynard (Ecology) or Paul Pickett (Ecology) will send a copy of Grant County PUD's TDG matrix developed by Michael Schneider (USACOE) to Kim Pate (SCL).

- SCL and Ecology will meet between mid-October and early December, 2006 to draft a 2007 TDG monitoring plan including potentially new transects, partially based on the review performed by Michael Schneider for SCL (USACOE, 2006).